BHARAT HEAVY ELECTRICALS LIMITED
TRANSMISSION PROJECTS ENGINEERING MANAGEMENT

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CUSTOMER	Power Grid Corporation of India Ltd.						
PROJECTS	SUBSTATION PACKAGE SS-19 FOR POWERGRID						

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SECTION I
SCOPE, SPECIFIC TECHNICAL REQUIREMENTS AND QUANTITIES

1.0 SCOPE

This technical specification covers the requirements of design, manufacture and assembly, testing at manufacturer's works, packing and dispatch of Substation Automation system for SUBSTATION PACKAGE SS-19 complete with accessories as listed in BOQ below. Supervision of Erection, Testing and commissioning of all SAS/CRP equipments including Protective relays shall be done by the OEM's Engineer along with on-site local training to Customer engineers as specified in respective sections. The augmentation with existing CRP SAS , Busbar system is also in scope of bidder.
The fitments offered shall be of PGCIL approved make, If any of the make offered by the bidder is not acceptable to M/s PGCIL, the bidder has to supply alternate PGCIL approved make, meeting the specification, with no commercial or delivery implications to BHEL.
All auxiliary relays, timers, counters, aux CTs, switches etc required for completeness of the scheme & good engineering are deemed to be included in the offer and no claim whatsoever shall be entertained at contract stage.

In case of any conflict between the technical details mentioned in this section and the remaining sections of this document, then Section-1 shall prevail and is to be considered as binding requirement.

1.1 The equipment is required for the following Project.

Name of Customer : Power Grid Corporation of India Ltd

Name of the Project : SUBSTATION PACKAGE SS-19

Note: The terms used in this specification namely ,"Employer/Purchaser" refers to PowerGrid , "Contractor " refers to BHEL & "Supplier/Sub-contractor/Manufacturer" refers to successful bidder

Refer Section - 3 for Project Details and General Specifications.

2.0 SPECIFIC TECHNICAL PARTICULARS

2.1 Extension of 765kV Solapur S/s : 765kV Bus Reactor Bay

a) 765kV Bay for one bank of 765kV bus reactors formed with 3 numbers of 80MVAR, 765/√3kV single phase reactors to be used as one bank of 240MVAR. This Bus reactor bank shall also be connected with existing spare unit of Reactor. Please refer SLD attached along with Annexure-1 of Section-01

b) Complete Control, Relay & Protection System for Bays under present scope as per Section-II - Control & Relay Panels and augmentation with existing CRP & SAS.

   Existing 765kV Substation is equipped with SAS of M/s ABB make (based on IEC 61850). BCU for the bay (in existing half diameter) under present scope is required to be supplied and same shall be integrated by the contractor with the control & protection equipment to be provided under present scope of work for completion of the substation automation system for the said 765kV Bay.

Necessary interface & integration work for transferring data to WRLDC (RSCC) & NTAMC, Manesar is also under present scope.

The scope of contractor shall include but not limited to integration of IEDs under present scope of augmentation with existing substation automation and compatibility enhancement of same as required including updation of system database, displays , development of additional displays and reports as per (manesar)/RTAMC. Existing NTAMC SCADA is of M/s Alstom make based on IEC 104 protocol. Bays under present scope are required to be integrated at the existing local NTAMC Gateway as well.

Integration of IEC61850 communication based monitoring equipments like Online dissolved Multi-gas & moisture analyzer, insulating oil drying system, Optical temperature sensors for each unit of 765kV , 1-Ph Reactors of present scope (Reactors are being supplied in separate contract) with sub-station automation system is included under present scope of Bidder.

Site visit required if any for augmentation of new bays to existing SAS for completion of the system shall be in bidder’s scope and are deemed to be included in the quoted price for SAS augmentation. No separate price implication shall be entertained regarding the same during contract stage.

c) The existing 765kV Bus bar protection is of make M/s ABB model REB 500. Busbar bay modules for 1 no. 765kV bay under present scope already exists. Necessary modification, wiring(including shifting of the existing bay modules) & integration of same for completion of the 765kV Busbar protection system are also under present scope of bidder.

   Site visit required if any for augmentation of new bays to the existing Busbar protection scheme for completion of the protection scheme shall be in bidder’s scope and are deemed to be included in the quoted price for Busbar augmentation. No separate price implication shall be entertained regarding the same during contract stage.

d) Any F.O cable required (Estimation & procurement) for augmentation of the Busbar system & SAS system shall be in scope of bidder. The cost of the same shall be included in the price quoted against augmentation of the respective systems. No additional price shall be entertained at contract stage in this regard.

e) Any reconfiguration of existing IEDs required for the complete augmentation of the SAS & Busbar system shall be in scope of bidder.

f) The bidders scope shall include indication of all primary equipment interface with control & relay Panel /SAS in the respective panel schematics.

g) The adequacy of DI & DO in Existing Aux BCU of the station shall be checked by bidder. If any additional DI/ DO cards are required for Fire fighting/ deluge valve operation integration , same shall be deemed included in bidders scope of supply.

h) Existing Tie CRP is provided with CSD (being procured separately). Wiring / scheme modification in existing panels required for incorporation of the CSD shall be in bidders scope. New Bay is provided with CSD (being procured separately) and same shall be incorporated in supplied panels. Mounting of CSD & interfacing with existing Tie CRP & New Bay is in bidder scope.

i) The Bus reactor bank under present scope shall also be connected with existing spare unit of Reactor. The required scheme/ wiring modification for integration of the same shall be deemed included in bidders scope.

j) Wherever bidder offers any spare in lieu of the same being "Built-in feature" of any relay/ fitment or the same being "Not applicable" is subject to approval by POWERGRID. No price implication will be entertained by BHEL at contract stage if any separate item is insisted by POWERGRID to meet the contract requirement.

2.2 Extension of 765kV Aurangabad S/s: 765kV Bus Reactor Bay

a) 765kV Bay for one bank of 765kV bus reactors formed with 3 numbers of 80MVAR, 765/√3kV single phase reactors to be used as one bank of 240MVAR. <u>This Bus reactor bank shall also be connected with existing spare unit of Reactor</u>. Please refer SLD attached along with Annexure-1 of Section-01

b) Complete Control, Relay & Protection System for Bays under present scope as per Section-II - Control & Relay Panels and augmentation with existing CRP & SAS.

Existing 765kV Substation is equipped with SAS of M/s Alstom make (based on IEC 61850). BCU for the bay (in existing half diameter) under present scope is required to be supplied and same shall be integrated by the contractor with the control & protection equipment to be provided under present scope of work for completion of the substation automation system for the said 765kV Bay.

Necessary interface & integration work for transferring data to WRLDC (RSCC) & NTAMC, Manesar is also under present scope.

The scope of contractor shall include but not limited to integration of IEDs under present scope of augmentation with existing substation automation and compatibility enhancement of same as required including updation of system database, displays , development of additional displays and reports as per (manesar)/RTAMC. Existing NTAMC SCADA is of M/s Alstom make based on IEC 104 protocol. Bays under present scope are required to be integrated at the existing local NTAMC Gateway as well.

Integration of IEC61850 communication based monitoring equipments like Online dissolved Multi-gas & moisture analyzer, insulating oil drying system, Optical temperature sensors for each unit of 765kV , 1-Ph Reactors of present scope (Reactors are being supplied in separate contract) with sub-station automation system is included under present scope of Bidder.

Site visit required if any for augmentation of new bays to existing SAS for completion of the system shall be in bidder's scope and are deemed to be included in the quoted price for SAS augmentation. No separate price implication shall be entertained regarding the same during contract stage.

c) The existing 765kV Bus bar protection is of make M/s Alstom make P741. Busbar bay modules for 1 no. 765kV bay under present scope already exists. Necessary modification, wiring(including shifting of the existing bay modules) & integration of same for completion of the 765kV Busbar protection system are also under present scope of bidder.

   Site visit required if any for augmentation of new bays to the existing Busbar protection scheme for completion of the protection scheme shall be in bidder's scope and are deemed to be included in the quoted price for Busbar augmentation. No separate price implication shall be entertained regarding the same during contract stage.

d) Any F.O cable required (Estimation & procurement) for augmentation of the Busbar system & SAS system shall be in scope of bidder. The cost of the same shall be included in the price quoted against augmentation of the respective systems. No additional price shall be entertained at contract stage in this regard.

e) Any reconfiguration of existing IEDs required for the complete augmentation of the SAS & Busbar system shall be in scope of bidder.

f) The bidders scope shall include indication of all primary equipment interface with control & relay Panel /SAS in the respective panel schematics.

g) The adequacy of DI & DO in Existing Aux BCU of the station shall be checked by bidder. If any additional DI/ DO cards are required for Fire fighting/ deluge valve operation integration , same shall be deemed included in bidders scope of supply.

h) Existing Tie CB is provided with CSD (being procured separately). Wiring / scheme modification in existing panels required for incorporation of the CSD shall be in bidders scope. New Bay is provided with CSD (being procured separately) and same shall be incorporated in supplied panels. Mounting of CSD & interfacing with existing Tie CRP & New Bay is in bidder scope.

i) The Bus reactor bank under present scope shall also be connected with existing spare unit of Reactor. The required scheme/ wiring modification for integration of the same shall be deemed included in bidders scope.

j) Wherever bidder offers any spare in lieu of the same being "Built-in feature" of any relay/ fitment or the same being "Not applicable" is subject to approval by POWERGRID. No price implication will be entertained by BHEL at contract stage if any separate item is insisted by POWERGRID to meet the contract requirement.

2.3 Extension of 765kV Wardha S/s : 765kV Bus Reactor Bay

a) 765kV Bay for one bank of 765kV bus reactors formed with 3 numbers of 80MVAR, 765/√3kV single phase reactors to be used as one bank of 240MVAR. This Bus reactor bank shall also be connected with existing spare unit of Reactor. Please refer SLD attached along with Annexure-1 of Section-01

b) Complete Control, Relay & Protection System for Bays under present scope as per Section-II - Control & Relay Panels and augmentation with existing CRP & SAS.

Existing 765kV Substation is equipped with SAS of M/s ABB make (based on IEC 61850). BCU for the bay (in existing half diameter) under present scope is required to be supplied and same shall be integrated by the contractor with the control & protection equipment to be provided under present scope of work for completion of the substation automation system for the said 765kV Bay.

Necessary interface & integration work for transferring data to WRLDC (RSCC) & NTAMC, Manesar is also under present scope.

The scope of contractor shall include but not limited to integration of IEDs under present scope of augmentation with existing substation automation and compatibility enhancement of same as required including updation of system database, displays , development of additional displays and reports as per (manesar)/RTAMC. Existing NTAMC SCADA is of M/s Alstom make based on IEC 104 protocol. Bays under present scope are required to be integrated at the existing local NTAMC Gateway as well.

Integration of IEC61850 communication based monitoring equipments like Online dissolved Multi-gas & moisture analyzer, insulating oil drying system, Optical temperature sensors for each unit of 765kV , 1-Ph Reactors of present scope (Reactors are being supplied in separate contract) with sub-station automation system is included under present scope of Bidder.

Site visit required if any for augmentation of new bays to existing SAS for completion of the system shall be in bidder’s scope and are deemed to be included in the quoted price for SAS augmentation. No separate price implication shall be entertained regarding the same during contract stage.

c) The existing 765kV Bus bar protection is of make M/s ABB model REB 500. Busbar bay modules for 1 no. 765kV bay under present scope already exists. Necessary modification, wiring(including shifting of the existing bay modules) & integration of same for completion of the 765kV Busbar protection system are also under present scope of bidder.

Site visit required if any for augmentation of new bays to the existing Busbar protection scheme for completion of the protection scheme shall be in bidder’s scope and are deemed to be included in the quoted price for Busbar augmentation. No separate price implication shall be entertained regarding the same during contract stage.

d) Any F.O cable required (Estimation & procurement) for augmentation of the Busbar system & SAS system shall be in scope of bidder. The cost of the same shall be included in the price quoted against augmentation of the respective systems. No additional price shall be entertained at contract stage in this regard.

e) Any reconfiguration of existing IEDs required for the complete augmentation of the SAS & Busbar system shall be in scope of bidder.

f) <u>The bidders scope shall include indication of all primary equipment interface with control & relay Panel /SAS in the respective panel schematics.</u>

g) The adequacy of DI & DO in Existing Aux BCU of the station shall be checked by bidder. If any additional DI/ DO cards are required for Fire fighting/ deluge valve operation integration , same shall be deemed included in bidders scope of supply.

h) Existing Tie CRP is provided with CSD (being procured separately). Wiring / scheme modification in existing panels required for incorporation of the CSD shall be in bidders scope. New Bay is provided with CSD (being procured separately) and same shall be incorporated in supplied panels. Mounting of CSD & interfacing with existing Tie CRP & New Bay is in bidder scope.

i) The Bus reactor bank under present scope shall also be connected with existing spare unit of Reactor. The required scheme/ wiring modification for integration of the same shall be deemed included in bidders scope.

j) Wherever bidder offers any spare in lieu of the same being “Built-in feature” of any relay/ fitment or the same being “Not applicable” is subject to approval by POWERGRID. No price implication will be entertained by BHEL at contract stage if any separate item is insisted by POWERGRID to meet the contract requirement.

2.4 Extension of 400kV Khandwa S/s : 765kV Bus Reactor Bay

a) 400kV Bays for 1No. 125MVAR , 3Phase Bus reactor. Please refer SLD attached along with Annexure-1 of Section-01

b) Complete Control, Relay & Protection System for Bays under present scope as per Section-II - Control & Relay Panels and augmentation with existing CRP & SAS.

   Existing 400kV substation is equipped with conventional control system. In case of control panel , no extra panel is required as already existing panel (Panel No. K26) has future scope for the new bus reactor. Only TB and wiring modification needs to be done.

   The scope of contractor shall include but not limited to integration of IEDs under present scope of augmentation with existing NTAMC and compatibility enhancement of same as required including updation of system database, displays , development of additional displays and reports as per requirement of WRLDC and remote control centre NTAMC (manesar)/RTAMC. Existing NTAMC SCADA is of M/s Alstom make based on IEC 104 protocol. Bays under present scope are required to be integrated at the existing local NTAMC Gateway as well. However existing BCU for 425-426-427 is available at site, so there is no need for extra BCU. Only wiring and database modification is required.

   Integration of IEC61850 communication based monitoring equipments like Online dissolved Multi-gas & moisture analyzer, insulating oil drying system, Optical temperature sensors of 400kV Reactor of present scope (Reactors are being supplied in separate contract) with sub-station automation system is included under present scope of Bidder.

   Site visit required if any for augmentation of new bays to existing SAS for completion of the system shall be in bidder’s scope and are deemed to be included in the quoted price for SAS augmentation. No separate price implication shall be entertained regarding the same during contract stage.

c) The busbar protection for 400kV Bays under present scope is existing which is Electro mechanical type BB protection having Main-I / II Current differential relay with BB group master trip relay of Alstom Make Model –FAC34 (High Impedance , differential relay). BB master trip relay (GR. A and Gr. B) are present at site and currently used for 426 Tie bay which is now directly connected to Bus-II. Wiring modification needs to be done at site to augment 427 main bay under present scope.

   The busbar protection relay panels are located in control room. Protection panels under present scope are to be located in control room. Necessary interface, wiring modification, scheme modification, supply of trip relays , auxiliary relays for interfacing with existing busbar protection system is under present scope. The necessary price for the same shall be included in the quoted price.

   Site visit required if any for augmentation of new bays to the existing Busbar protection scheme for completion of the protection scheme shall be in bidder's scope and are deemed to be included in the quoted price for Busbar augmentation. No separate price implication shall be entertained regarding the same during contract stage.

d) LBB & Busbar tripping Relays for main bay shall be in bidders scope of supply.

e) Contact multiplier relays shall be required for the Bus earth switches. Supply of the same and mounting of the same on the panels and schematics modification if any shall be in bidders scope.

f) Any F.O cable required (Estimation & procurement) for augmentation of the Busbar system & SAS system shall be in scope of bidder. The cost of the same shall be included in the price quoted against augmentation of the respective systems. No additional price shall be entertained at contract stage in this regard.

g) Any reconfiguration of existing IEDs required for the complete augmentation of the SAS & Busbar system shall be in scope of bidder.

h) The bidders scope shall include indication of all primary equipment interface with control & relay Panel /SAS in the respective panel schematics.

i) The adequacy of DI & DO in Existing Aux BCU of the station shall be checked by bidder. If any additional DI/ DO cards are required for Fire fighting/ deluge valve operation integration , same shall be deemed included in bidders scope of supply.

j) Existing Tie CB is provided with CSD (being procured separately). Wiring / scheme modification in existing panels required for incorporation of the CSD shall be in bidders scope. New Bay is provided with CSD (being procured separately) and same shall be incorporated in supplied panels. Mounting of CSD & interfacing with existing Tie CRP & New Bay is in bidder scope.

k) Wherever bidder offers any spare in lieu of the same being "Built-in feature" of any relay/ fitment or the same being "Not applicable" is subject to approval by POWERGRID. No price implication will be entertained by BHEL at contract stage if any separate item is insisted by POWERGRID to meet the contract requirement.

2.5 Extension of 400kV Rajgarh S/s : 400kV Bus Reactor Bay

a) 400kV Bays for 1No. 125MVAR , 3Phase Bus reactor. Please refer SLD attached along with Annexure-1 of Section-01

b) Complete Control, Relay & Protection System for Bays under present scope as per Section-II - Control & Relay Panels and augmentation with existing CRP & SAS.

   Existing 400kV Substation is equipped with SAS of M/s ABB make (based on IEC 61850). BCU for the bay (in existing half diameter) under present scope is required to be supplied and same shall be integrated by the contractor with the control & protection equipment to be provided under present scope of work for completion of the substation automation system for the said 400kV Bay.

   Necessary interface & integration work for transferring data to WRLDC (RSCC) & NTAMC, Manesar is also under present scope.

   The scope of contractor shall include but not limited to integration of IEDs under present scope of augmentation with existing substation automation and compatibility enhancement of same as required including updation of system database, displays , development of additional displays and reports as per requirement of WRLDC and remote control centre NTAMC (manesar)/RTAMC. Existing NTAMC SCADA is of M/s Alstom make based on IEC 104 protocol. Bays under present scope are required to be integrated at the existing local NTAMC Gateway as well.

   Integration of IEC61850 communication based monitoring equipments like Online dissolved Multi-gas & moisture analyzer, insulating oil drying system, Optical temperature sensors for each 400kV Reactors of present scope (Reactors are being supplied in separate contract) with sub-station automation system is included under present scope of Bidder.

   Site visit required if any for augmentation of new bays to existing SAS for completion of the system shall be in bidder's scope and are deemed to be included in the quoted price for SAS augmentation. No separate price implication shall be entertained regarding the same during contract stage.

c) The existing 400kV Bus bar protection is of make M/s ABB model REB 500. Necessary Busbar bay modules (peripheral units) for 1 no. 400kV bay under present scope shall be provided by bidder.. Necessary modification, wiring(including shifting of the existing bay modules) & integration of same for completion of the 400kV Busbar protection system are also under present scope of bidder.

   Site visit required if any for augmentation of new bays to the existing Busbar protection scheme for completion of the protection scheme shall be in bidder's scope and are deemed to be included in the quoted price for Busbar augmentation. No separate price implication shall be entertained regarding the same during contract stage.

d) Any F.O cable required (Estimation & procurement) for augmentation of the Busbar system & SAS system shall be in scope of bidder. The cost of the same shall be included in the price quoted against augmentation of the respective systems. No additional price shall be entertained at contract stage in this regard.

e) Any reconfiguration of existing IEDs required for the complete augmentation of the SAS & Busbar system shall be in scope of bidder.

f) The bidders scope shall include indication of all primary equipment interface with control & relay Panel /SAS in the respective panel schematics.

g) The adequacy of DI & DO in Existing Aux BCU of the station shall be checked by bidder. If any additional DI/ DO cards are required for Fire fighting/ deluge valve operation integration , same shall be deemed included in bidders scope of supply.

h) Existing Tie CB is provided with CSD (being procured separately). Wiring / scheme modification in existing panels required for incorporation of the CSD shall be in bidders scope. New Bay is provided with CSD (being procured separately) and same shall be incorporated in supplied panels. Mounting of CSD & interfacing with existing Tie CRP & New Bay is in bidder scope.

i) Wherever bidder offers any spare in lieu of the same being “Built-in feature” of any relay/ fitment or the same being “Not applicable” is subject to approval by POWERGRID. No price implication will be entertained by BHEL at contract stage if any separate item is insisted by POWERGRID to meet the contract requirement.

2.6 Extension of 400kV Champa S/s : 400kV Bus Reactor Bay

a) 400kV Bays for 1No. 125MVAR,3Phase Bus reactor. Please refer SLD attached along with Annexure-1 of Section-01

b) Complete Control, Relay & Protection System for Bays under present scope as per Section-II - Control & Relay Panels and augmentation with existing CRP & SAS.

Existing 400kV Substation is equipped with SAS of M/s ABB make (based on IEC 61850). BCU for the bay (in existing half diameter) under present scope already exists at site and same shall be integrated by the contractor with the control & protection equipment to be provided under present scope of work for completion of substation automation system for said 400kV Bay.

Necessary interface & integration work for transferring data to WRLDC (RSCC) & NTAMC, Manesar is also under present scope.

The scope of contractor shall include but not limited to integration of IEDs under present scope of augmentation with existing substation automation and compatibility enhancement of same as required including updation of system database, displays, development of additional displays and reports as per requirement of WRLDC and remote control centre NTAMC (manesar)/RTAMC. Existing NTAMC SCADA is of M/s Alstom make based on IEC 104 protocol. Bays under present scope are required to be integrated at the existing local NTAMC Gateway as well.

Integration of IEC61850 communication based monitoring equipments like Online dissolved Multi-gas & moisture analyzer, insulating oil drying system, Optical temperature sensors for each unit of 765kV, 1-Ph Reactors of present scope (Reactors are being supplied in separate contract) with sub-station automation system is included under present scope of Bidder.

Site visit required if any for augmentation of new bays to existing SAS for completion of the system shall be in bidder's scope and are deemed to be included in the quoted price for SAS augmentation. No separate price implication shall be entertained regarding the same during contract stage.

c) The existing 400kV Bus bar protection is of make M/s ABB model REB 670. The same shall be augmented by contractor by providing necessary auxiliary relays, trip relays, wiring etc. for completion of busbar protection system for bays under present scope.

   Site visit required if any for augmentation of new bays to the existing Busbar protection scheme for completion of the protection scheme shall be in bidder's scope and are deemed to be included in the quoted price for Busbar augmentation. No separate price implication shall be entertained regarding the same during contract stage.

d) Any F.O cable required (Estimation & procurement) for augmentation of the Busbar system & SAS system shall be in scope of bidder. The cost of the same shall be included in the price quoted against augmentation of the respective systems. No additional price shall be entertained at contract stage in this regard.

e) Any reconfiguration of existing IEDs required for the complete augmentation of the SAS & Busbar system shall be in scope of bidder.

f) <u>The bidders scope shall include indication of all primary equipment interface with control & relay Panel /SAS in the respective panel schematics.</u>

g) The adequacy of DI & DO in Existing Aux BCU of the station shall be checked by bidder. If any additional DI/ DO cards are required for Fire fighting/ deluge valve operation integration , same shall be deemed included in bidders scope of supply.

h) New Bay is provided with CSD (being procured separately) and same shall be incorporated in supplied panels. Mounting of CSD & interfacing with New CRP Bay is in bidder scope.

i) Wherever bidder offers any spare in lieu of the same being "Built-in feature" of any relay/ fitment or the same being "Not applicable" is subject to approval by POWERGRID. No price implication will be entertained by BHEL at contract stage if any separate item is insisted by POWERGRID to meet the contract requirement.

2.7 <u>Extension of 400/220kV Jabalpur S/s :</u>

a) 1x 500VA 400/220kV ICT Bay , 400kV Bay – 2No. & 220kV Bay 1No. Please refer SLD attached along with Annexure-1 of Section-01

b) Complete Control, Relay & Protection System for 400kV & 220kV Bays under present scope as per Section-II - Control & Relay Panels and augmentation with existing CRP & SAS.

Existing 400/220kV Jabalpur substation is equipped with conventional control system. Control panels matching with existing panel are required to be provided for bays under present scope with suitable integration to the existing system.
Necessary interface & integration work for transferring data to WRLDC (RSCC) & NTAMC, Manesar is also under present scope.

Existing BCU for 425-426-427 is available at site so there is no need for extra BCU. Only wiring and data base modification is required.

Necessary CRP interface with digital RTCC (being procured separately) for the ICT shall be in bidders scope.

The scope of contractor shall include but not limited to integration of IEDs under present scope of augmentation with existing substation automation and compatibility enhancement of same as required including updation of system database, displays, development of additional displays and reports as per requirement of WRLDC and remote control centre NTAMC (manesar)/RTAMC. Existing NTAMC SCADA is of M/s Alstom make based on IEC 104 protocol. Bays under present scope are required to be integrated at the existing local NTAMC Gateway as well.

Integration of IEC61850 communication based monitoring equipments like Online dissolved Multi-gas & moisture analyzer, insulating oil drying system, Optical temperature sensors for ICT of present scope (ICTs are being supplied in separate contract) with sub-station automation system is included under present scope of Bidder.

Site visit required if any for augmentation of new bays to existing SAS for completion of the system shall be in bidder's scope and are deemed to be included in the quoted price for SAS augmentation. No separate price implication shall be entertained regarding the same during contract stage.

c) The existing 400kV Bus bar protection is of make M/s ABB model REB 670.Busbar bay modules for 2 Nos. of 400kV bays under present scope already exists. Necessary wiring & integration of same for completion of 400kV Busbar protection sysem are included in present scope of bidder.
Further existing 220kV Busbar protection system needs to be augmented for 1 No. 220kV bay. Necessary interface, supply of trip relays, auxiliary relays, busbar bay modules, modification, wiring & integration of same for completion of 220kV Busbar protection system is also under scope of bidder.

Site visit required if any for augmentation of new bays to the existing Busbar protection scheme for completion of the protection scheme shall be in bidder's scope and are deemed to be included in the quoted price for Busbar augmentation. No separate price implication shall be entertained regarding the same during contract stage.

d) Impedance relay function shall also be provided for Power transformer back-up protection in addition to other protections specified for transformer (HV & IV) protection in technical specification Section –II. Specification of Transformer impedance relay function shall be similar to that specified for reactor back-up impedance protection.

e) Any F.O cable required (Estimation & procurement) for augmentation of the Busbar system & SAS system shall be in scope of bidder. The cost of the same shall be included in the price quoted against augmentation of the respective systems. No additional price shall be entertained at contract stage in this regard.

f) Any reconfiguration of existing IEDs required for the complete augmentation of the SAS & Busbar system shall be in scope of bidder.

g) <u>The bidders scope shall include indication of all primary equipment interface with control & relay Panel /SAS in the respective panel schematics.</u>

h) The adequacy of DI & DO in Existing Aux BCU of the station shall be checked by bidder. If any additional DI/ DO cards are required for Fire fighting/ deluge valve operation integration , same shall be deemed included in bidders scope of supply.

i) Two main CRP bays are provided with CSD (being procured separately). Wiring / scheme modification in existing panels required for incorporation of the CSD shall be in bidders scope. Mounting of CSD & interfacing with New Bays is in bidder scope.

j) Wherever bidder offers any spare in lieu of the same being "Built-in feature" of any relay/ fitment or the same being "Not applicable" is subject to approval by POWERGRID. No price implication will be entertained by BHEL at contract stage if any separate item is insisted by POWERGRID to meet the contract requirement.

2.8 Extension of 400/220kV Itarsi S/s :

a) 1x 500VA 400/220kV ICT Bay , 400kV Bay – 2No. & 220kV Bay 1No. Please refer SLD attached along with Annexure-1 of Section-01

b) Existing 400kV Switchyard at Itarsi S/s is AIS type with One and half breaker switching D-type layout. The proposed bays are to be extended from existing 400kV AIS to GIS system. (being procured separately.) The GIS shall be outdoor metal enclosed type.

c) Complete Control, Relay & Protection System for 400kV & 220kV Bays under present scope as per Section-II - Control & Relay Panels and augmentation with existing CRP & SAS.

Existing 400/220kV Itarsi substation is equipped with substation Automation system of M/s Siemens make (based on IEC 61850) Bidder shall provide BCUs for 2Nos. of 400kV Bays and 1 Nos. 220kV Bays (bays defined in Section-II) under present scope including all necessary hardware and software to integrate the same with existing SAS.

Necessary interface & integration work for transferring data to WRLDC (RSCC) & NTAMC, Manesar is also under present scope.

Necessary CRP interface & integration with existing digital RTCC for the ICT shall be in bidders scope.

The scope of contractor shall include but not limited to integration of IEDs under present scope of augmentation with existing substation automation and compatibility enhancement of same as required including updation of system database, displays, development of additional displays and reports as per requirement of WRLDC and remote control centre NTAMC (manesar)/RTAMC. Existing NTAMC SCADA is of M/s Alstom make based on IEC 104 protocol. Bays under present scope are required to be integrated at the existing local NTAMC Gateway as well.

Integration of IEC61850 communication based monitoring equipments like Online dissolved Multi-gas & moisture analyzer, insulating oil drying system, Optical temperature sensors for ICT of present scope (ICTs are being supplied in separate contract) with sub-station automation system is included under present scope of Bidder.

Site visit required if any for augmentation of new bays to existing SAS for completion of the system shall be in bidder's scope and are deemed to be included in the quoted price for SAS augmentation. No separate price implication shall be entertained regarding the same during contract stage.

d) The existing 400kV & 220kV Bus bar protection is of make M/s ABB model REB 670.Busbar bay modules 400kV bays & 220kV Bays under present scope already exists. The same shall be augmented by the bidder by providing necessary auxiliary relays , trip relays , wiring etc. for completion of busbar protecton system for bays under present scope.

e) Busbar protection relay panels both 400kV & 220kV are located in control room. Protection Panels under present scope are to be located in SPR.

   Site visit required if any for augmentation of new bays to the existing Busbar protection scheme for completion of the protection scheme shall be in bidder's scope and are deemed to be included in the quoted price for Busbar augmentation. No separate price implication shall be entertained regarding the same during contract stage.

f) Impedance relay function shall also be provided for Power transformer back-up protection in addition to other protections specified for transformer (HV & IV) protection in technical specification Section –II. Specification of Transformer impedance relay function shall be similar to that specified for reactor back-up impedance protection.

g) In SAS each gas tight compartment of 400kV GIS shall be monitored individually per phase basis. However for GIS compartment for GIB outside GIS hall 3 Phase monitoring shall be acceptable. In case it is not possible to monitor the gas tight compartment individually in one BCU, bidder shall supply additional BCU for monitoring without any additional cost implication to BHEL.

h) Any F.O cable required (Estimation & procurement) for augmentation of the Busbar system & SAS system shall be in scope of bidder. The cost of the same shall be included in the price quoted against augmentation of the respective systems. No additional price shall be entertained at contract stage in this regard.

i) Any reconfiguration of existing IEDs required for the complete augmentation of the SAS & Busbar system shall be in scope of bidder.

j) The bidders scope shall include indication of all primary equipment interface with control & relay Panel /SAS in the respective panel schematics.

k) The adequacy of DI & DO in Existing Aux BCU of the station shall be checked by bidder. If any additional DI/ DO cards are required for Fire fighting/ deluge valve operation integration , same shall be deemed included in bidders scope of supply.

l) Two main CRP bays are provided provided with CSD (being procured separately). Wiring / scheme modification in existing panels required for incorporation of the CSD shall be in bidders scope. Mounting of CSD & interfacing with New Bays is in bidder scope.

m) Wherever bidder offers any spare in lieu of the same being "Built-in feature" of any relay/ fitment or the same being "Not applicable" is subject to approval by POWERGRID. No price implication will be entertained by BHEL at contract stage if any separate item is insisted by POWERGRID to meet the contract requirement.

3.0 BILL OF QUANTITY:

S. No.	Description	Unit	Total Quantity
I	**EXTENSION OF 765KV SOLAPUR S/s**		
1	765kV Circuit Breaker Relay Panel without Auto reclose (With Automation)	Set	1
2	765kV Reactor Protection Panel (With Automation)	Set	1
3.	Augmentation of existing 765KV Bus Bar protection scheme (No. of Bays as per Technical Specification) (with Automation)	Set	1
4.	Augmentation of Substation Automation system for 765kV Main Bay as per technical specification	Set	1
5.	**Mandatory Spares : C & R panel**		
5.1	Reactor differential protection relay	Nos.	1
5.2	Reactor Back-up Impedance relay (if Standalone)	Nos.	1
5.3	Restricted Earth Fault Protection Relay with Non-Linear resistor	Nos.	1
6.	**Mandatory Spares : Substation Automation System**		
6.1	Bay Control unit (IED) of each type	Nos.	1
6.2	Ethernet switch of each type	Nos.	1

7.	**Common Spares for Busbar protection**		
7.1	Power supply module for Busbar protection.(If applicable)	Nos.	1
7.2	Busbar Bay unit module (If Applicable)	Nos.	1
8.0	Services for EXTENSION OF 765KV SOLAPUR S/s: Supervision of Testing and Commissioning of protection relays, Augmentation of Busbar system & Substation automation system at site. Scope shall be as follows : a) Testing & commissioning of main protection relays and Numerical Busbar protection including Relay parameterization and configuration. b) Testing & commissioning of SAS system including termination of network/optical cables (complete with all end connectors, tees etc as required). c) For network/optical cables which are in the bidder's scope of supply, its laying shall be in BHEL scope. However, Optical cable will be laid under bidder's supervision. Splicing and termination shall be in bidder's scope. d) Site acceptance Tests(SAT), Availability Test as per clauses 8.3,14 of Section II Annexure A. e) Arranging all necessary tools, tackles and equipment for protection and communication testing including automatic relay test kit shall be bidder's responsibility. f) Maintenance services as per clause 13 of Section II Annexure-A g) Site visits for collection of inputs for augmentation of SAS & Busbar System	Lot	1
9.0	Engineering Services: a) Sketch showing routing of F.O Cable & GI Conduit Pipe giving BOQ . b) Relay Setting Calculation , Application checks c) Documentation as per clause 11 of Section –II Annexure-A d) Incorporation of complete primary equipment interface in the CRP Schemes submitted by bidder.	Lot	1

S. No.	Description	Unit	Total Quantity
II	**EXTENSION OF 765KV AURANGABAD S/s**		
1	765kV Circuit Breaker Relay Panel without Auto reclose (With Automation)	Set	1
2	765kV Reactor Protection Panel (With Automation)	Set	1
3.	Augmentation of existing 765KV Bus Bar protection scheme (No. of Bays as per Technical Specification) (with Automation)	Set	1
4.	Augmentation of Substation Automation system for 765kV Main Bay as per technical specification	Set	1
5.	**Mandatory Spares : C & R panel**		
5.1	Reactor differential protection relay	Nos.	1
5.2	Reactor Back-up Impedance relay (if Standalone)	Nos.	1
5.3	Restricted Earth Fault Protection Relay with Non-Linear resistor	Nos.	1
6.	**Mandatory Spares : Substation Automation System**		
6.1	Bay Control unit (IED) of each type	Nos.	1
6.2	Ethernet switch of each type	Nos.	1
7.	**Common Spares for Busbar protection**		
7.1	Power supply module for Busbar protection.(If applicable)	Nos.	1
7.2	Busbar Bay unit module (If Applicable)	Nos.	1
8.0	Services for EXTENSION OF 765KV AURANGABAD S/s: Supervision of Testing and Commissioning of protection relays, Augmentation of Busbar system & Substation automation system at site. Scope shall be as follows : a) Testing & commissioning of main protection relays and Numerical Busbar protection including Relay parameterization and configuration. b) Testing & commissioning of SAS system including termination of network/optical cables (complete	Lot	1

	with all end connectors, tees etc as required). c) For network/optical cables which are in the bidder's scope of supply, its laying shall be in BHEL scope. However, Optical cable will be laid under bidder's supervision. Splicing and termination shall be in bidder's scope. d) Site acceptance Tests(SAT), Availability Test as per clauses 8.3,14 of Section II Annexure A. e) Arranging all necessary tools, tackles and equipment for protection and communication testing including automatic relay test kit shall be bidder's responsibility. f) Maintenance services as per clause 13 of Section II Annexure-A g) Site visits for collection of inputs for augmentation of SAS & Busbar System		
9.0	Engineering Services: a) Sketch showing routing of F.O Cable & GI Conduit Pipe giving BOQ . b) Relay Setting Calculation , Application checks c) Documentation as per clause 11 of Section –II Annexure-A d) Incorporation of complete primary equipment interface in the CRP Schemes submitted by bidder.	Lot	1

S. No.	Description	Unit	Total Quantity
III	**EXTENSION OF 765KV WARDHA S/s**		
1	765kV Circuit Breaker Relay Panel without Auto reclose (With Automation)	Set	1
2	765kV Reactor Protection Panel (With Automation)	Set	1
3.	Augmentation of existing 765KV Bus Bar protection scheme (No. of Bays as per Technical Specification) (with Automation)	Set	1
4.	Augmentation of Substation Automation system for 765kV Main Bay as per technical specification	Set	1
5.	**Mandatory Spares : C & R panel**		

5.1	Reactor differential protection relay	Nos.	1
5.2	Reactor Back-up Impedance relay (if Standalone)	Nos.	1
5.3	Restricted Earth Fault Protection Relay with Non-Linear resistor	Nos.	1
6.	**Mandatory Spares : Substation Automation System**		
6.1	Bay Control unit (IED) of each type	Nos.	1
6.2	Ethernet switch of each type	Nos.	1
7.	**Common Spares for Busbar protection**		
7.1	Power supply module for Busbar protection.(If applicable)	Nos.	1
7.2	Busbar Bay unit module (If Applicable)	Nos.	1
8.0	<u>Services for EXTENSION OF 765KV WARDHA S/s:</u> Supervision of Testing and Commissioning of protection relays, Augmentation of Busbar system & Substation automation system at site. Scope shall be as follows : a) Testing & commissioning of main protection relays and Numerical Busbar protection including Relay parameterization and configuration. b) Testing & commissioning of SAS system including termination of network/optical cables (complete with all end connectors, tees etc as required). c) For network/optical cables which are in the bidder's scope of supply, its laying shall be in BHEL scope. However, Optical cable will be laid under bidder's supervision. Splicing and termination shall be in bidder's scope. d) Site acceptance Tests(SAT), Availability Test as per clauses 8.3,14 of Section II Annexure A. e) Arranging all necessary tools, tackles and equipment for protection and communication testing including automatic relay test kit shall be bidder’s responsibility. f) Maintenance services as per clause 13 of Section II Annexure-A	Lot	1

	g) Site visits for collection of inputs for augmentation of SAS & Busbar System		
9.0	Engineering Services: a) Sketch showing routing of F.O Cable & GI Conduit Pipe giving BOQ . b) Relay Setting Calculation , Application checks c) Documentation as per clause 11 of Section –II Annexure-A d) Incorporation of complete primary equipment interface in the CRP Schemes submitted by bidder.	Lot	1

S. No.	Description	Unit	Total Quantity
IV	**EXTENSION OF 400KV KHANDWA S/s**		
1	400kV Reactor Protection Panel	Set	1
2.	Interfacing with existing 400KV Bus Bar protection scheme (No. of Bays as per Technical Specification) (with Automation)	Set	1
3.	**Mandatory Spares : C & R panel**		
3.1	Reactor differential protection relay	Nos.	1
3.2	Reactor Back-up Impedance relay (if Standalone)	Nos.	1
3.3	Restricted Earth Fault Protection Relay with Non-Linear resistor	Nos.	1
4.	**Common Spares for Busbar protection**		
4.1	Power supply module for Busbar protection.(If applicable)	Nos.	1
4.2	Busbar Bay unit module (If Applicable)	Nos.	1
5.0	Services for EXTENSION OF 400KV Khandwa S/s: Supervision of Testing and Commissioning of protection relays, Augmentation of Busbar system & Substation automation system at site. Scope shall be as follows : a) Testing & commissioning of main protection relays and Numerical Busbar protection including Relay parameterization and configuration. b) Testing & commissioning of SAS system including termination of	Lot	1

	network/optical cables (complete with all end connectors, tees etc as required). c) For network/optical cables which are in the bidder's scope of supply, its laying shall be in BHEL scope. However, Optical cable will be laid under bidder's supervision. Splicing and termination shall be in bidder's scope. d) Site acceptance Tests(SAT), Availability Test as per clauses 8.3,14 of Section II Annexure A. e) Arranging all necessary tools, tackles and equipment for protection and communication testing including automatic relay test kit shall be bidder's responsibility. f) Maintenance services as per clause 13 of Section II Annexure-A g) Site visits for collection of inputs for augmentation of SAS & Busbar System		
6.0	Engineering Services: a) Sketch showing routing of F.O Cable & GI Conduit Pipe giving BOQ . b) Relay Setting Calculation , Application checks c) Documentation as per clause 11 of Section –II Annexure-A d) Incorporation of complete primary equipment interface in the CRP Schemes submitted by bidder.	Lot	1

S. No.	**Description**	**Unit**	**Total Quantity**
V	**EXTENSION OF 400KV RAJGARH S/s**		
1	400kV Circuit Breaker Relay Panel without Auto reclose (With Automation)	Set	1
2.	400kV Reactor Protection Panel	Set	1
3.	Augmentation of existing 400KV Bus Bar protection scheme (No. of Bays as per Technical Specification) (with Automation)	Set	1
4.	Augmentation of Substation Automation system for 400kV Main Bay as per technical specification	Set	1
5.	**Mandatory Spares : C & R panel**		

5.1	Reactor differential protection relay	Nos.	1
5.2	Reactor Back-up Impedance relay (if Standalone)	Nos.	1
5.3	Restricted Earth Fault Protection Relay with Non-Linear resistor	Nos.	1
6.	**Mandatory Spares : Substation Automation System**		
6.1	Bay Control unit (IED) of each type	Nos.	1
6.2	Ethernet switch of each type	Nos.	1
7.	**Common Spares for Busbar protection**		
7.1	Power supply module for Busbar protection.(If applicable)	Nos.	1
7.2	Busbar Bay unit module (If Applicable)	Nos.	1
8.0	<u>Services for EXTENSION OF 400KV Rajgarh S/s:</u> Supervision of Testing and Commissioning of protection relays, Augmentation of Busbar system & Substation automation system at site. Scope shall be as follows : a) Testing & commissioning of main protection relays and Numerical Busbar protection including Relay parameterization and configuration. b) Testing & commissioning of SAS system including termination of network/optical cables (complete with all end connectors, tees etc as required). c) For network/optical cables which are in the bidder's scope of supply, its laying shall be in BHEL scope. However, Optical cable will be laid under bidder's supervision. Splicing and termination shall be in bidder's scope. d) Site acceptance Tests(SAT), Availability Test as per clauses 8.3,14 of Section II Annexure A. e) Arranging all necessary tools, tackles and equipment for protection and communication testing including automatic relay test kit shall be bidder's responsibility. f) Maintenance services as per clause 13 of Section II Annexure-A	Lot	1

	g) Site visits for collection of inputs for augmentation of SAS & Busbar System		
9.0	Engineering Services: a) Sketch showing routing of F.O Cable & GI Conduit Pipe giving BOQ . b) Relay Setting Calculation , Application checks c) Documentation as per clause 11 of Section –II Annexure-A d) Incorporation of complete primary equipment interface in the CRP Schemes submitted by bidder.	Lot	1

S. No.	Description	Unit	Total Quantity
VI	**EXTENSION OF 400KV CHAMPA S/s**		
1	400kV Circuit Breaker Relay Panel without Auto reclose (With Automation)	Set	1
2.	400kV Reactor Protection Panel	Set	1
3.	Augmentation of existing 400KV Bus Bar protection scheme (No. of Bays as per Technical Specification) (with Automation)	Set	1
4.	Augmentation of Substation Automation system for 400kV Main Bay as per technical specification	Set	1
5.	**Mandatory Spares : C & R panel**		
5.1	Reactor differential protection relay	Nos.	1
5.2	Reactor Back-up Impedance relay (if Standalone)	Nos.	1
5.3	Restricted Earth Fault Protection Relay with Non-Linear resistor	Nos.	1
6.	**Mandatory Spares : Substation Automation System**		
6.1	Bay Control unit (IED) of each type	Nos.	1
6.2	Ethernet switch of each type	Nos.	1
7.	**Common Spares for Busbar protection**		
7.1	Power supply module for Busbar protection.(If applicable)	Nos.	1
7.2	Busbar Bay unit module (If Applicable)	Nos.	1

8.0	Services for EXTENSION OF 400KV Champa S/s: Supervision of Testing and Commissioning of protection relays, Augmentation of Busbar system & Substation automation system at site. Scope shall be as follows : a) Testing & commissioning of main protection relays and Numerical Busbar protection including Relay parameterization and configuration. b) Testing & commissioning of SAS system including termination of network/optical cables (complete with all end connectors, tees etc as required). c) For network/optical cables which are in the bidder's scope of supply, its laying shall be in BHEL scope. However, Optical cable will be laid under bidder's supervision. Splicing and termination shall be in bidder's scope. d) Site acceptance Tests(SAT), Availability Test as per clauses 8.3,14 of Section II Annexure A. e) Arranging all necessary tools, tackles and equipment for protection and communication testing including automatic relay test kit shall be bidder's responsibility. f) Maintenance services as per clause 13 of Section II Annexure-A g) Site visits for collection of inputs for augmentation of SAS & Busbar System	Lot	1
9.0	Engineering Services: a) Sketch showing routing of F.O Cable & GI Conduit Pipe giving BOQ . b) Relay Setting Calculation , Application checks c) Documentation as per clause 11 of Section –II Annexure-A d) Incorporation of complete primary equipment interface in the CRP Schemes submitted by bidder.	Lot	1

S. No.	Description	Unit	Total Quantity

VII	**EXTENSION OF 400/220KV JABALPUR S/s**		
1	400kV Circuit Breaker Relay Panel without Auto reclose	Set.	2
2.	400kV Transformer Protection Panel (For Both HV & MV side)	Set	1
3.	220kV Circuit breaker relay panel without Auto reclose.	No.	1
4.	Augmentation of existing 400KV Bus Bar protection scheme (No. of Bays as per Technical Specification)	Set	1
5.	Augmentation of existing 220KV Bus Bar protection scheme (No. of Bays as per Technical Specification)	Set	1
6.	**Mandatory Spares : C & R panel**		
6.1	Transformer differential protection relay	Nos.	1
6.2	Restricted Earth Fault Protection Relay with Non-Linear resistor	Nos.	1
6.3	Bay Control unit (IED) (if applicable)	Nos.	3
6.4	Ethernet switch (if applicable)	Nos.	1
7.	**Common Spares for Busbar protection**		
7.1	Power supply module for Busbar protection.(If applicable)	Nos.	1
7.2	Busbar Bay unit module (If Applicable)	Nos.	1
8.0	<u>Services for EXTENSION OF 400/220KV JABALPUR S/s</u> Supervision of Testing and Commissioning of protection relays, Augmentation of Busbar system & Substation automation system at site. Scope shall be as follows : a) Testing & commissioning of main protection relays and Numerical Busbar protection including Relay parameterization and configuration. b) Testing & commissioning of BCU (02Nos for 400kV bays and 01no. for 220kV bay) for remote communication network with NTAMC/RTAMC along with necessary interface & integration.system, including termination of network/optical cables (complete with all end connectors, tees etc as required).	Lot	1

	c) For network/optical cables which are in the bidder's scope of supply, its laying shall be in BHEL scope. However, Optical cable will be laid under bidder's supervision. Splicing and termination shall be in bidder's scope. d) Site acceptance Tests(SAT), Availability Test as per clauses 8.3,14 of Section II Annexure A. e) Arranging all necessary tools, tackles and equipment for protection and communication testing including automatic relay test kit shall be bidder's responsibility. f) Maintenance services as per clause 13 of Section II Annexure-A g) Site visits for collection of inputs for augmentation of SAS & Busbar System		
9.0	Engineering Services: a) Sketch showing routing of F.O Cable & GI Conduit Pipe giving BOQ . b) Relay Setting Calculation , Application checks c) Documentation as per clause 11 of Section –II Annexure-A d) Incorporation of complete primary equipment interface in the CRP Schemes submitted by bidder.	Lot	1
S. No.	Description	Unit	Total Quantity
VIII	**EXTENSION OF 400/220KV ITARSI S/s**		
1	400kV Circuit Breaker Relay Panel without Auto reclose (With Automation)	Set.	2
2.	400kV Transformer Protection Panel (For Both HV & MV side)	Set	1
3.	220kV Circuit breaker relay panel without Auto reclose.	Set	1
4.	Augmentation of existing 400KV Bus Bar protection scheme (No. of Bays as per Technical Specification)	Set	1
5.	Augmentation of existing 220KV Bus Bar protection scheme (No. of Bays as per Technical Specification)	Set	1
6.	Augmentation of Substation Automation system for 400kV Main Bay as per technical specification	Set	1

7.	Augmentation of Substation Automation system for 220kV Main Bay as per technical specification	Set	1
8.	**Mandatory Spares : C & R panel**		
8.1	Transformer differential protection relay	Nos.	1
8.2	Restricted Earth Fault Protection Relay with Non-Linear resistor	Nos.	1
9.	**Mandatory Spares : Substation Automation System**		
9.1	Bay Control unit (IED) of each type	Nos.	1
9.2	Ethernet switch of each type	Nos.	1
10.	**Common Spares for Busbar protection**		
10.1	Power supply module for Busbar protection.(If applicable)	Nos.	1
10.2	Busbar Bay unit module (If Applicable)	Nos.	1
11.0	Services for EXTENSION OF 400/220KV ITARSI S/s Supervision of Testing and Commissioning of protection relays, Augmentation of Busbar system & Substation automation system at site. Scope shall be as follows : a) Testing & commissioning of main protection relays and Numerical Busbar protection including Relay parameterization and configuration. b) Testing & commissioning of SAS system including termination of network/optical cables (complete with all end connectors, tees etc as required). c) For network/optical cables which are in the bidder's scope of supply, its laying shall be in BHEL scope. However, Optical cable will be laid under bidder's supervision. Splicing and termination shall be in bidder's scope. d) Site acceptance Tests(SAT), Availability Test as per clauses 8.3,14 of Section II Annexure A. e) Arranging all necessary tools, tackles and equipment for protection and communication testing including automatic relay test kit shall be	Lot	1

	bidder's responsibility. f) Maintenance services as per clause 13 of Section II Annexure-A g) Site visits for collection of inputs for augmentation of SAS & Busbar System		
12.0	Engineering Services: a) Sketch showing routing of F.O Cable & GI Conduit Pipe giving BOQ . b) Relay Setting Calculation , Application checks c) Documentation as per clause 11 of Section –II Annexure-A d) Incorporation of complete primary equipment interface in the CRP Schemes submitted by bidder.	Lot	1

Note:

a) Any additional item as per the specification for Substation Automation System (Section-II and its Annexures) is required to be supplied for completion of the system over and above the items indicated the same shall be indicated clearly in the offer. Otherwise, the same will be deemed to be included in the offer.

b) Itemized price for the breakup of Substation Automation System to be submitted when required by TBMM.

c) BCUs shall be offered as part of respective protection panel.

d) During contract stage any additional quantity required in this regard for completion of the SAS/Busbar system shall be supplied by successful bidder free of cost.

e) Total Contract value may vary by ± 10% during contract execution stage.

4.0 TYPE TESTING, INSPECTION, TESTING & INSPECTION CERTIFICATE

The equipments supplied shall be type tested as per type tests specified in Section II. The type testing requirements shall be in line with clause 9.0 of Section III of this technical specification. Date of NOA:29.07.19.

5.0 MANUFACTURING QUALITY PLAN:

Bidder has to follow Powergrid approved Manufacturing Quality Plan , SAT /FAT procedure at contract stage.

6.0 DRAWINGS and SCHEME

The documentation requirements detailed under Section-III shall be submitted to BHEL at various stages of contract. Softcopy of the drawings and schemes are to be submitted at contract stage. Preparation of AS- BUILT drawings is also in the scope of the bidder.

7.0 DOCUMENTS REQUIRED WITH OFFER

a) Clause-wise confirmation/ comments.
b) Bill of Material.
c) Un-priced schedule as per BOQ at clause 3.0
d) Documentary proof against Qualifying requirement.(Annexure-TQR)

SECTION -PROJECT (SECTION I)

SECTION -PROJECT

1. GENERAL

1.1 Preamble:

Power Grid Corporation of India Ltd. (POWERGRID), a Govt. of India Enterprise is responsible for bulk Power transmission of electrical energy from various Central Govt. Power Projects to various utilities/beneficiaries and interconnecting regional grids, operating and maintaining the National electrical grid of India. It is established with mandate of "We will become a Global Transmission Company with Dominant Leadership in Emerging Power Markets with World Class Capabilities by:

- World Class: Setting superior standards in capital project management and operations for the industry and ourselves.
- Global: Leveraging capabilities to consistently generate maximum value for all stakeholders in India and in emerging and growing economies.
- Inspiring, nurturing and empowering the next generation of professionals.
- Achieving continuous improvements through innovation and state of the art technology.
- Committing to highest standards in health, safety, security and environment." as its mission.

1.2 POWERGRID is executing extension of 765kV Solapur, 765kV Aurangabad, 765kV Wardha, 400kV Khandwa, 400kV Rajgarh, 400kV Champa, 400/220kV Itarsi & 400/220kV Jabalpur substations under Western Region System Strengthening Scheme (WRSS-20).

1.3 Associated Transmission System:

Western Region System Strengthening Scheme (WRSS-20)

(A): Provision of Bus Reactors at High Voltage Nodes in Western Region

Sl. No.	Name of the Substation	Proposed Bus Reactor (MVAr)
1	Aurangabad 765kV	1x240 along with 765 kV bay
2	Solapur 765kV	1x240 along with 765 kV bay
3	Wardha 765kV	1x330 along with 765 kV bay
4	Khandwa 400kV	1x125 along with 400 kV bay
5	Rajgarh 400kV	1x125 along with 400 kV bay

(B): Provision of Bus Reactor at Champa Pool Split Section –Part A

Transmission Scheme	Detailed scope of works
Provision of Bus Reactor at Champa Pool Split Bus Section –A 400 kV, 1x125 MVAR Bus reactor Champa Pool Split Section –Part A	• 400 kV, 1x125MVAR along with 400 kV bay

(C): Augmentation of transformation capacity in Western Region

Transmission Scheme	Detailed scope of works
Augmentation of transformation capacity in Western Region	**Jabalpur 400/220 kV S/s** • 400/220kV, 500MVA, ICT along with associated 400kV & 220kV bays
	Itarsi 400/220 kV S/s • 400/220kV, 500MVA, ICT along with associated 400kV & 220kV bays

2 SCOPE

2.1 The scope of this specification covers the following;

2.1.1 Western Region System Strengthening Scheme (WRSS-20)

(I) Extension of 765kV Solapur S/S with provision of following bays as per single line diagram:

a) 765kV bay for one bank of 765 kV bus reactors formed with 3 numbers of 80 MVAR, 765/√3kV single phase reactors to be used as one (1) bank of 240MVAR. This Bus Reactor bank shall also be connected with existing spare unit of Reactor.

(II) Extension of 765kV Aurangabad S/S with provision of following bays as per single line diagram:

a) 765kV bay for one bank of 765 kV bus reactors formed with 3 numbers of 80 MVAR, 765/√3kV single phase reactors to be used as one (1) bank of 240MVAR. This Bus Reactor bank shall also be connected with existing spare unit of Reactor.

(III) Extension of 765kV Wardha S/S with provision of following bays as per single line diagram:

a) 765kV bay for one bank of 765 kV bus reactors formed with 3 numbers of 80 MVAR, 765/√3kV single phase reactors to be used as one (1) bank of 240MVAR. This Bus Reactor bank shall also be connected with existing spare unit of Reactor.

(IV) Extension of 400kV Khandwa S/S with provision of following bays as per single line diagram:

a) 400kV bays for 01 no. 125MVAR, 3-Phase Bus Reactor.

(V) Extension of 400kV Rajgarh S/S with provision of following bays as per single line diagram:

a) 400kV bays for 01 no. 125MVAR, 3-Phase Bus Reactor.

(VI) Extension of 400kV Champa S/S (Bus Sec-A) with provision of following bays as per single line diagram:

a) 400kV bays for 01 no. 125MVAR, 3-Phase Bus Reactor.

(VII) Extension of 400/220kV Itarsi S/S with provision of following bays along with ICT as per single line diagram:

a) 500MVA 400/220kV ICT
b) 400kV bays for 01 no. 500MVA 400/220kV, 3-Phase ICT.
c) 220kV bays for 01 no. 500MVA 400/220kV, 3-Phase ICT.

(VIII) Extension of 400/220kV Jabalpur S/S with provision of following bays along with ICT as per single line diagram:

a) 500MVA 400/220kV ICT
b) 400kV bays for 01 no. 500MVA 400/220kV, 3-Phase ICT.
c) 220kV bays for 01 no. 500MVA 400/220kV, 3-phase ICT.

2.1.2 Supply, erection, testing and commissioning of 765kV Reactors (along with 33kV Neutral CT) & 400kV Reactors are covered under separate package. However, following associated works are covered under the scope of this package:

a) Civil works of 765kV & 400kV Reactors and ICTs.

b) Overhead connection of HV bushings of 765kV & 400kV Reactors and ICTs to substation equipment.

c) Formation of 765kV Auxiliary Bus and 145kV Neutral Bus of 765kV Reactors and their extension upto existing Auxiliary and neutral bus. Overhead connection of substation equipment with 765kV auxiliary bus & Neutral bus of 765kV Reactors.

d) Connection of 765kV three phase Reactor bank with the existing spare reactor

e) Supply, laying and termination of cables alongwith associated accessories from common marshalling box of 765kV Reactors to bay kiosks /Switchyard Panel Rooms/Control Room.

2.2 The detailed scope of work is brought out in subsequent clauses of this section.

2.2.1 <u>Extension of 765kV Solapur Substation</u>

2.2.1.1 Design, engineering, manufacture, testing and supply, including transportation & insurance, storage, erection, testing and commissioning of the following equipment/items, complete in all respects.

a) 765kV Circuit Breakers, Isolators, Current Transformers, Bus Post Insulators, 624kV Surge Arresters.

b) Auxiliary bus arrangement for HV connection, neutral formation and connection arrangement with spare reactor unit as detailed in the specification. Overhead connection of HV bushings of 765kV Reactors to substation equipment. Overhead connection of substation equipment with 765kV auxiliary bus of 765kV Reactors.

c) Control Switching Device (as per BPS). CSD for existing tie bay Circuit Breaker is also in present scope.

d) Complete Relay & Protection System as per Section-'Control and Relay Panels' for 765kV bays under present scope. Existing 765kV bus bar protection system is of make M/s ABB model REB 500. Bus bar bay modules for 1 no. 765kV bay under present scope already exist. Necessary modification, wiring & integration of same for completion of 765kV bus bar protection system are also under present scope.

e) Existing 765kV substation is equipped with substation Automation system of M/s ABB make (based on IEC 61850). BCU for the bay (in existing half diameter) under present scope is required to be supplied and same shall be integrated by the contractor with the control & protection equipment to be provided under present scope of work for completion of substation automation system for said 765kV bay.

Necessary interface & integration work for transferring data to WRLDC (RSCC) & NTAMC, Manesar is also under present scope.

The scope of contractor shall include but not limited to integration of IEDs under present scope of augmentation with existing substation automation and compatibility enhancement of same as required including updating of system database, displays, development of additional displays and reports as per requirement of WRLDC and Remote Control Centre NTAMC (Manesar)/RTAMC. Existing NTAMC SCADA is of M/s Alstom make (based on IEC 104 protocol). Bays under present scope are required to be integrated at the existing local NTAMC Gateway well.

Further, the integration of IEC61850 communication based monitoring equipment like On line dissolved Multi-Gas & Moisture analyzer, Insulating Oil drying system, Optical temperature sensor, for each unit of 765kV Reactor (to be provided in a separate contract) with substation automation system is also included in the present scope. Contractor shall also make available 220V DC redundant supply in 765kV Reactors Common MB for supply to Ethernet Switch.

f) 1.1kV grade Power & Control cables along with complete accessories, including cabling from common marshaling box of 765kV Reactors to BMK/ Switchyard panel room.

g) Fire protection system (HVW spray and hydrant system) for 765 kV, 1-Phase Reactors including extension of main water header from adjacent existing header.

h) Lattice and pipe structures (galvanized): Towers, Beams and Equipment support structures except CB support structure, shall be provided as per Employer's drawings to be provided during detailed engineering. CB support structure shall be as per CB manufacturer's design. Design and drawings of non-standard items not covered above shall be prepared and put up for approval by the vendor during detailed engineering.

i) Erection Hardware: Insulator strings hardware, Disc Insulators/Long Rod Insulators (as applicable), conductor(s), Al tube, bus-bar materials, cable trays & covers, Bay MB, spacers, clamps & connectors including equipment connectors, Junction box, earthwire, earthing material risers, auxiliary earthmat (excluding main earth mat), buried cable trenches/pipes for equipment & lighting, cable supporting angles/channels, Insulating mats, cable sealing arrangement, insulator guy arrangement, all accessories etc. as required.

j) Earthmat already exists in the switchyard area under present scope (existing Earthmat layout drawing is enclosed). All the equipment (including 765kV Reactors), structures, cable trenches, auxiliary earthmat for isolators etc. shall be earthed by connecting them to the main Earthmat by the contractor.

k) Earthing of Employer supplied 765kV Reactor along with associated equipment to employer's earthmat.

l) Complete lighting and illumination for the switchyard area under present scope shall be provided by the contractor as per Bid price schedule (BPS).

m) Augmentation of Visual Monitoring system for 765kV bays under the present scope. Existing system is of M/s Sony make. The provided system has to be integrated with existing system. The bidder shall provide 2 nos. Color IP camera with PAN, Tilt & Zoom facility suitably located in switchyard for monitoring of 765kV bay & equipment. The scope of bidder shall include providing all Items, Accessories, Line Interface units, Fiber patch cords, Power supply units, Junction Boxes, Cables, Fiber Optic Cables, Hardware and Software, etc. as are applicable to the product design, to meet functional requirements. Compatibility enhancement of exiting VMS system, as needed, shall be done to integrate visual monitoring for 765kV bays under present scope with existing Visual monitoring system of the station. A copy of specification for Visual Monitoring system is enclosed at Annexure-III, which shall be read only for the Augmentation scope of existing VMS system.

n) Any other equipment/material required to complete the specified scope.

2.2.1.2 Design, engineering, manufacture, testing and supply including transportation & insurance, storage at site of mandatory spares.

2.2.1.3 Civil works - The scope of work shall include but shall not be limited to the following based on Employer supplied drawings -

a) Foundation of 3X80MVAR, 765kV, 1-Phase Bus Reactor.
b) Fire resistant walls between 765kV Reactors.
c) Foundation of 765kV Towers and 765kV & 145kV Equipment Support Structures.
d) Cable trenches along with covers including road/rail crossing, sump pits, culverts etc. However, cable trench layout including invert levels shall be prepared by the contractor. Existing Cable Trench layout drawings is enclosed at Annexure-I.
e) All roads as shown in GA drawing including culverts. All roads shall be Concrete road.

2.2.1.4 Civil Work as per contractor's design and drawings for:

a) Foundations for lighting panels, bay marshaling boxes, panels & control cubicles of equipments wherever required.

b) (i) Removal, cleaning and washing of existing stone and re-spreading after doing anti-weed treatment as per Section-Civil Works is in the scope of contractor wherever stone is laid in the area under present scope.

(ii) In the area under present scope where stone spreading does not exist, the same shall be provided after doing anti-weed treatment and PCC as per Section-Civil Works.

c) Any other item/design/drawing for completion of scope of works.

2.2.2 <u>Extension of 765kV Aurangabad Substation</u>

2.2.2.1 Design, engineering, manufacture, testing and supply, including transportation & insurance, storage, erection, testing and commissioning of the following equipment/items, complete in all respects.

a) 765kV Circuit Breakers, Isolators, Current Transformers, Bus Post Insulators, 624kV Surge Arresters.

b) Auxiliary bus arrangement for HV connection, neutral formation and connection arrangement with spare reactor unit as detailed in the specification. Overhead connection of HV bushings of 765kV Reactors to substation equipment. Overhead connection of substation equipment with 765kV auxiliary bus of 765kV Reactors.

c) Control Switching Device (as per BPS). CSD for existing tie bay Circuit Breaker is also in present scope.

d) Complete Relay & Protection System as per Section-'Control and Relay Panels' for 765kV bays under present scope. Existing 765kV bus bar protection system is M/s Alstom make P741. Bus bar bay modules for 1 no. 765kV bay under present scope already exist. Necessary modification, wiring

& integration of same for completion of 765kV bus bar protection system is also under present scope.

e) Existing 765kV substation is equipped with substation Automation system of M/s Alstom make (based on IEC 61850). BCU for the bay (in existing half diameter) under present scope is required to be supplied and same shall be integrated by the contractor with the control & protection equipment to be provided under present scope of work for completion of substation automation system for said 765kV bay.

Necessary interface & integration work for transferring data to WRLDC (RSCC) & NTAMC, Manesar is also under present scope.

The scope of contractor shall include but not limited to integration of IEDs under present scope of augmentation with existing substation automation and compatibility enhancement of same as required including updating of system database, displays, development of additional displays and reports as per requirement of WRLDC and Remote Control Centre NTAMC (Manesar)/RTAMC. Existing NTAMC SCADA is of M/s Alstom make (based on IEC 104 protocol). Bays under present scope are required to be integrated at the existing local NTAMC Gateway well.

Further, the integration of IEC61850 communication based monitoring equipment like On line dissolved Multi-Gas & Moisture analyzer, Insulating Oil drying system, Optical temperature sensor, for each unit of 765kV Reactor (to be provided in a separate contract) with substation automation system is also included in the present scope. Contractor shall also make available 220V DC redundant supply in 765kV Reactors Common MB for supply to Ethernet Switch.

f) 1.1kV grade Power & Control cables along with complete accessories, including cabling from common marshaling box of 765kV Reactors to BMK/ Switchyard panel room.

g) Fire protection system (HVW spray and hydrant system) for 765 kV, 1-Phase Reactors including extension of main water header from adjacent existing header.

h) Lattice and pipe structures (galvanized): Towers, Beams and Equipment support structures except CB support structure, shall be provided as per Employer’s drawings to be provided during detailed engineering. CB support structure shall be as per CB manufacturer’s design. Design and drawings of non-standard items not covered above shall be prepared and put up for approval by the vendor during detailed engineering.

i) **Erection Hardware:** Insulator strings hardware, Disc Insulators/Long Rod Insulators (as applicable), conductor(s), Al tube, bus-bar materials, cable trays & covers, Bay MB, spacers, clamps & connectors including equipment connectors, Junction box, earthwire, earthing material risers, auxiliary earthmat (excluding main earth mat), buried cable trenches/pipes for equipment & lighting, cable supporting angles/channels, Insulating mats, cable sealing arrangement, insulator guy arrangement, all accessories etc. as required.

j) Earthmat already exists in the switchyard area under present scope (existing Earthmat layout drawing is enclosed). All the equipment (including 765kV Reactors), structures, cable trenches, auxiliary earthmat for isolators etc. shall be earthed by connecting them to the main Earthmat by the contractor.

k) Earthing of Employer supplied 765kV Reactor alongwith associated equipment to employer's earthmat.

l) Complete lighting and illumination for the switchyard area under present scope shall be provided by the contractor as per Bid price schedule (BPS).

m) Augmentation of Visual Monitoring system for 765kV bays under the present scope. Existing system is of M/s Sony make. The provided system has to be integrated with existing system. The bidder shall provide 2 nos. Color IP camera with PAN, Tilt & Zoom facility suitably located in switchyard for monitoring of 765kV bays & equipment. The scope of bidder shall include providing all Items, Accessories, Line Interface units, Fiber patch cords, Power supply units, Junction Boxes, Cables, Fiber Optic Cables, Hardware and Software, etc. as are applicable to the product design, to meet functional requirements. Compatibility enhancement of exiting VMS system, as needed, shall be done to integrate visual monitoring for 765kV bays under present scope with existing Visual monitoring system of the station. A copy of specification for Visual Monitoring system is enclosed at Annexure-III, which shall be read only for the Augmentation scope of existing VMS system.

n) Any other equipment/material required to complete the specified scope.

2.2.2.2 Design, engineering, manufacture, testing and supply including transportation & insurance, storage at site of mandatory spares.

2.2.2.3 Civil works - The scope of work shall include but shall not be limited to the following based on Employer supplied drawings -

a) Foundation of 3X80MVAR, 765kV, 1-Phase Bus Reactor.
b) Fire resistant walls between 765kV Reactors.
c) Foundation of 765kV Towers and 765kV & 145kV Equipment Support Structures.
d) Cable trenches along with covers including road/rail crossing, sump pits, culverts etc. However, cable trench layout including invert levels shall be prepared by the contractor. Existing Cable Trench layout drawings is enclosed at Annexure-I.
e) All roads as shown in GA drawing including culverts. All roads shall be Concrete road.

2.2.2.4 Civil Work as per contractor's design and drawings for:

a) Foundations for lighting panels, bay marshaling boxes, panels & control cubicles of equipments wherever required.

b) (i) Removal, cleaning and washing of existing stone and re-spreading after doing anti-weed treatment as per Section-Civil Works is in the scope of contractor wherever stone is laid in the area under present scope.

(ii) In the area under present scope where stone spreading does not exist, the same shall be provided after doing anti-weed treatment and PCC as per Section-Civil Works.

c) Any other item/design/drawing for completion of scope of works.

2.2.3 Extension of 765kV Wardha Substation

2.2.3.1 Design, engineering, manufacture, testing and supply, including transportation & insurance, storage, erection, testing and commissioning of the following equipment/items, complete in all respects.

a) 765kV Circuit Breakers, Isolators, Current Transformers, Bus Post Insulators, 624kV Surge Arresters.

b) Auxiliary bus arrangement for HV connection, neutral formation and connection arrangement with spare reactor unit as detailed in the specification. Overhead connection of HV bushings of 765kV Reactors to substation equipment. Overhead connection of substation equipment with 765kV auxiliary bus of 765kV Reactors.

c) Control Switching Device (as per BPS). CSD for existing tie bay Circuit Breaker is also in present scope.

d) Complete Relay & Protection System as per Section-'Control and Relay Panels' for 765kV bays under present scope. Existing 765kV bus bar protection system is M/s ABB make REB 500. Bus bar bay modules for 1 no. 765kV bay under present scope already exist. Necessary modification, wiring & integration of same for completion of 765kV bus bar protection system is also under present scope.

e) Existing 765kV substation is equipped with substation Automation system of M/s ABB make (based on IEC 61850). BCU for the bay (in existing half diameter) under present scope is required to be supplied and same shall be integrated by the contractor with the control & protection equipment to be provided under present scope of work for completion of substation automation system for said 765kV bay.

Necessary interface & integration work for transferring data to WRLDC (RSCC) & NTAMC, Manesar is also under present scope.

The scope of contractor shall include but not limited to integration of IEDs under present scope of augmentation with existing substation automation and compatibility enhancement of same as required including updating of system database, displays, development of additional displays and reports as per requirement of WRLDC and Remote Control Centre NTAMC (Manesar)/RTAMC. Existing NTAMC SCADA is of M/s Alstom make (based on IEC 104 protocol). Bays under present scope are required to be integrated at the existing local NTAMC Gateway well.

Further, the integration of IEC61850 communication based monitoring equipment like On line dissolved Multi-Gas & Moisture analyzer, Insulating Oil drying system, Optical temperature sensor, for each unit of 765kV Reactor (to be provided in a separate contract) with substation automation system is also included in the present scope. Contractor shall also make available 220V DC redundant supply in 765kV Reactors Common MB for supply to Ethernet Switch.

f) 1.1kV grade Power & Control cables along with complete accessories, including cabling from common marshaling box of 765kV Reactors to BMK/ Switchyard panel room.

g) Fire protection system (HVW spray and hydrant system) for 765 kV, 1-Phase Reactors including extension of main water header from adjacent existing header.

h) Lattice and pipe structures (galvanized): Towers, Beams and Equipment support structures except CB support structure, shall be provided as per Employer's drawings to be provided during detailed engineering. CB support structure shall be as per CB manufacturer's design. Design and drawings of non-standard items not covered above shall be prepared and put up for approval by the vendor during detailed engineering.

i) Erection Hardware: Insulator strings hardware, Disc Insulators/Long Rod Insulators (as applicable), conductor(s), Al tube, bus-bar materials, cable trays & covers, Bay MB, spacers, clamps & connectors including equipment connectors, Junction box, earthwire, earthing material risers, auxiliary earthmat (excluding main earth mat), buried cable trenches/pipes for equipment & lighting, cable supporting angles/channels, Insulating mats, cable sealing arrangement, insulator guy arrangement, all accessories etc. as required.

j) Earthmat already exists in the switchyard area under present scope (existing Earthmat layout drawing is enclosed). All the equipment (including 765kV Reactors), structures, cable trenches, auxiliary earthmat for isolators etc. shall be earthed by connecting them to the main Earthmat by the contractor.

k) Earthing of Employer supplied 765kV Reactor alongwith associated equipment to employer's earthmat.

l) Complete lighting and illumination for the switchyard area under present scope shall be provided by the contractor as per Bid price schedule (BPS).

m) Augmentation of Visual Monitoring system for 765kV bays under the present scope. Existing system is of M/s Sony make. The provided system has to be integrated with existing system. The bidder shall provide 2 nos. Color IP camera with PAN, Tilt & Zoom facility suitably located in switchyard for monitoring of 400kV bays & equipment. The scope of bidder shall include providing all Items, Accessories, Line Interface units, Fiber patch cords, Power supply units, Junction Boxes, Cables, Fiber Optic Cables, Hardware and Software, etc. as are applicable to the product design, to meet functional requirements. Compatibility enhancement of exiting VMS system, as needed, shall be done to integrate visual monitoring for 765kV bays under present scope with existing Visual monitoring system of the station. A copy of specification for Visual Monitoring system is enclosed at Annexure-III, which shall be read only for the Augmentation scope of existing VMS system.

n) Any other equipment/material required to complete the specified scope.

2.2.3.2 Design, engineering, manufacture, testing and supply including transportation & insurance, storage at site of mandatory spares.

2.2.3.3 Civil works - The scope of work shall include but shall not be limited to the following based on Employer supplied drawings -

a) Foundation of 3X110MVAR, 765kV, 1-Phase Bus Reactor.
b) Fire resistant walls between 765kV Reactors.
c) Foundation of 765kV Towers and 765kV & 145kV Equipment Support Structures.
d) Cable trenches along with covers including road/rail crossing, sump pits, culverts etc. However, cable trench layout including invert levels shall be prepared by the contractor. Existing Cable Trench layout drawings is enclosed at Annexure-I.
e) All roads as shown in GA drawing including culverts. All roads shall be Concrete road.

2.2.3.4 Civil Work as per contractor's design and drawings for:

a) Foundations for lighting panels, bay marshaling boxes, panels & control cubicles of equipments wherever required.

b) (i) Removal, cleaning and washing of existing stone and re-spreading after doing anti-weed treatment as per Section-Civil Works is in the scope of contractor wherever stone is laid in the area under present scope.

(ii) In the area under present scope where stone spreading does not exist, the same shall be provided after doing anti-weed treatment and PCC as per Section-Civil Works.

c) Any other item/design/drawing for completion of scope of works.

2.2.4 <u>Extension of 400kV Khandwa Substation</u>

2.2.4.1 Design, engineering, manufacture, testing and supply, including transportation & insurance, storage, erection, testing and commissioning of the following equipment/items, complete in all respects.

a) 400kV Circuit Breakers, Isolators, Current Transformers, Bus Post Insulators, 336kV Surge Arresters.

b) Overhead connection of HV bushings of 400kV Reactor to substation equipment. Supply, laying and termination of cables alongwith associated accessories from marshalling box of 400kV Reactor to bay kiosks /Switchyard Panel Rooms/Control Room.

c) Control Switching Device (as per BPS). CSD for existing tie bay Circuit Breaker is also in present scope.

d) Complete Relay & Protection System as per Section-'Control and Relay Panels' for 400kV bay under present scope.

The Bus Bar protection for 400 kV Bays under present scope is existing, which is Electro-mechanical type BB protection having Main-I/ II current differential relay with BB group master trip relay of Alstom make Model-FAC34 (High Impedance, differential Relay). BB master trip relay (Gr A and Gr B) are present at site and currently used for 426 Tie bay which is now directly connected to Bus-II. Wiring modification needs to be done at site to augment 427 main bay under present scope.
Bus bar Protection relays panels are located in control Room. Protection panels under present scope are to be located in control room. Necessary interface, wiring, supply of trip relays, auxiliary relays for interfacing with existing bus bar protection system is under present scope of work

e) Existing 400kV substation is equipped with conventional control system. In case of control panel, no extra panel is required as already existing panel (Panel No K26) has future scope for the new Bus Reactor. Only TB and wiring modification needs to be done.
The scope of contractor shall include but not limited to integration of IEDs under present scope of augmentation with existing NTAMC and compatibility enhancement of same as required including updating of system database, displays, development of additional displays and reports as per requirement of WRLDC and Remote Control Centre NTAMC (Manesar)/RTAMC. Existing NTAMC SCADA is of M/s Alstom make (based on IEC 104 protocol). Bays under present scope are required to be integrated at the existing local NTAMC Gateway as well. However existing BCU (for 425-426-427) is available at site so there is no need for extra BCU. Only wiring and database modification is required.

f) 1.1kV grade Power & Control cables along with complete accessories, including cabling from marshaling box of 400kV Reactor to BMK/ Switchyard panel room.

g) Fire protection system (HVW spray and hydrant system) for 400kV, 3-Phase Reactor including extension of main water header from adjacent existing header.

h) Lattice and pipe structures (galvanized): Towers, Beams and Equipment support structures except CB support structure, shall be provided as per Employer's drawings to be provided during detailed engineering. CB support structure shall be as per CB manufacturer's design. Design and drawings of non-standard items not covered above shall be prepared and put up for approval by the vendor during detailed engineering.

i) Erection Hardware: Insulator strings hardware, Disc Insulators/Long Rod Insulators (as applicable), conductor(s), Al tube, bus-bar materials, cable trays & covers, Bay MB, spacers, clamps & connectors including equipment connectors, Junction box, earthwire, earthing material risers, auxiliary earthmat (excluding main earth mat), buried cable trenches/pipes for equipment & lighting, cable supporting angles/channels, Insulating mats, cable sealing arrangement, insulator guy arrangement, all accessories etc. as required.

j) Earthmat already exists in the switchyard area under present scope (existing Earthmat layout drawing is enclosed). All the equipment (including 400kV Reactor), structures, cable trenches, auxiliary earthmat for isolators etc. shall be earthed by connecting them to the main Earthmat by the contractor.

k) Earthing of Employer supplied 400kV Reactor alongwith associated equipment to employer's earthmat.

l) Complete lighting and illumination for the switchyard area under present scope shall be provided by the contractor as per Bid price schedule (BPS).

m) Augmentation of Visual Monitoring system for 400kV bays under the present scope. Existing system is of M/s Pelco make. The provided system has to be integrated with existing system. The bidder shall provide 2 nos. Color IP camera with PAN, Tilt & Zoom facility suitably located in switchyard for monitoring of 400kV bays & equipment. The scope of bidder shall include providing all Items, Accessories, Line Interface units, Fiber patch cords, Power supply units, Junction Boxes, Cables, Fiber Optic Cables, Hardware and Software, etc. as are applicable to the product design, to meet functional requirements. Compatibility enhancement of exiting VMS system, as needed, shall be done to integrate visual monitoring for 400kV bays under present scope with existing Visual monitoring system of the station. A copy of specification for Visual Monitoring system is enclosed at Annexure-III, which shall be read only for the Augmentation scope of existing VMS system.

n) Any other equipment/material required to complete the specified scope.

2.2.4.2 Design, engineering, manufacture, testing and supply including transportation & insurance, storage at site of mandatory spares.

2.2.4.3 Civil works - The scope of work shall include but shall not be limited to the following based on Employer supplied drawings -

a) Foundation of 125MVAR, 400kV, 3-Phase Bus Reactor.
b) Fire resistant walls between 400kV Reactors.
c) Foundation for lattice & pipe structures.
d) Cable trenches along with covers including road/rail crossing, sump pits, culverts etc. However, cable trench layout including invert levels shall be

prepared by the contractor. Existing Cable Trench layout drawings is enclosed at Annexure-I.

e) All roads as shown in GA drawing including culverts. All roads shall be Concrete road.

2.2.4.4 Civil Work as per contractor's design and drawings for:

a) Foundations for lighting panels, bay marshaling boxes, panels & control cubicles of equipments wherever required.

b) (i) Removal, cleaning and washing of existing stone and re-spreading after doing anti-weed treatment as per Section-Civil Works is in the scope of contractor wherever stone is laid in the area under present scope.

(ii) In the area under present scope where stone spreading does not exist, the same shall be provided after doing anti-weed treatment and PCC as per Section-Civil Works.

c) Any other item/design/drawing for completion of scope of works.

2.2.5 <u>Extension of 400kV Rajgarh Substation</u>

2.2.5.1 Design, engineering, manufacture, testing and supply, including transportation & insurance, storage, erection, testing and commissioning of the following equipment/items, complete in all respects.

a) 400kV Circuit Breakers, Isolators, Current Transformers, Bus Post Insulators, 336kV Surge Arresters.

b) Overhead connection of HV bushings of 400kV Reactor to substation equipment. Supply, laying and termination of cables alongwith associated accessories from marshalling box of 400kV Reactor to bay kiosks /Switchyard Panel Rooms/Control Room.

c) Control Switching Device (as per BPS). CSD for existing tie bay Circuit Breaker is also in present scope.

d) Complete Relay & Protection System as per Section-'Control and Relay Panels' for 400kV bays under present scope. Existing 400kV bus bar protection system is of make M/s ABB, model REB 500. Necessary bus bar bay modules (peripheral units) for 1 no. of 400kV bay under present scope shall be provided by contractor under present scope. Necessary modification, wiring & integration of same for completion of 400kV bus bar protection system is also under present scope.

e) Existing 400kV substation is equipped with substation Automation system of M/s ABB make (based on IEC 61850). BCU for the bay (in existing half diameter) under present scope is required to be supplied and same shall be integrated by the contractor with the control & protection equipment to be provided under present scope of work for completion of substation automation system for said 400kV bay.

Necessary interface & integration work for transferring data to WRLDC (RSCC) & NTAMC, Manesar is also under present scope.

The scope of contractor shall include but not limited to integration of IEDs under present scope of augmentation with existing substation automation and compatibility enhancement of same as required including updating of system database, displays, development of additional displays and reports as per requirement of WRLDC and Remote Control Centre NTAMC (Manesar)/RTAMC. Existing NTAMC SCADA is of M/s Alstom make (based on IEC 104 protocol). Bays under present scope are required to be integrated at the existing local NTAMC Gateway well.

Further, the integration of IEC61850 communication based monitoring equipment like On line dissolved Multi-Gas & Moisture analyzer, Insulating Oil drying system, Optical temperature sensor, for each unit of 400kV Reactor (to be provided in a separate contract) with substation automation system is also included in the present scope. Contractor shall also make available 220V DC redundant supply in 400kV Reactors Common MB for supply to Ethernet Switch.

f) 1.1kV grade Power & Control cables along with complete accessories, including cabling from marshaling box of 400kV Reactor to BMK/ Switchyard panel room.

g) Fire protection system (HVW spray and hydrant system) for 400kV, 3-Phase Reactor including extension of main water header from adjacent existing header.

h) Lattice and pipe structures (galvanized): Towers, Beams and Equipment support structures except CB support structure, shall be provided as per Employer's drawings to be provided during detailed engineering. CB support structure shall be as per CB manufacturer's design. Design and drawings of non-standard items not covered above shall be prepared and put up for approval by the vendor during detailed engineering.

i) Erection Hardware: Insulator strings hardware, Disc Insulators/Long Rod Insulators (as applicable), conductor(s), Al tube, bus-bar materials, cable trays & covers, Bay MB, spacers, clamps & connectors including equipment connectors, Junction box, earthwire, earthing material risers, auxiliary earthmat (excluding main earth mat), buried cable trenches/pipes for equipment & lighting, cable supporting angles/channels, Insulating mats, cable sealing arrangement, insulator guy arrangement, all accessories etc. as required.

j) Earthmat already exists in the switchyard area under present scope (existing Earthmat layout drawing is enclosed). All the equipment (including 400kV Reactor), structures, cable trenches, auxiliary earthmat for isolators etc. shall be earthed by connecting them to the main Earthmat by the contractor.

k) Earthing of Employer supplied 400kV Reactor alongwith associated equipment to employer's earthmat.

l) Complete lighting and illumination for the switchyard area under present scope shall be provided by the contractor as per Bid price schedule (BPS).

m) Augmentation of Visual Monitoring system for 400kV bays under the present scope. Existing system is of M/s Pelco make. The provided system has to be integrated with existing system. The bidder shall provide 2 nos. Color IP camera with PAN, Tilt & Zoom facility suitably located in switchyard for monitoring of 400kV bays & equipment. The scope of bidder shall include providing all Items, Accessories, Line Interface units, Fiber patch cords, Power supply units, Junction Boxes, Cables, Fiber Optic Cables, Hardware and Software, etc. as are applicable to the product design, to meet functional requirements. Compatibility enhancement of exiting VMS system, as needed, shall be done to integrate visual monitoring for 400kV bays under present scope with existing Visual monitoring system of the station. A copy of specification for Visual Monitoring system is enclosed at Annexure-III, which shall be read only for the Augmentation scope of existing VMS system.

n) Any other equipment/material required to complete the specified scope.

2.2.5.2 Design, engineering, manufacture, testing and supply including transportation & insurance, storage at site of mandatory spares.

2.2.5.3 Civil works - The scope of work shall include but shall not be limited to the following based on Employer supplied drawings -

a) Foundation of 125MVAR, 400kV, 3-Phase Bus Reactor.
b) Fire resistant walls between 400kV Reactors.
c) Foundation for lattice & pipe structures.
d) Cable trenches along with covers including road/rail crossing, sump pits, culverts etc. However, cable trench layout including invert levels shall be prepared by the contractor. Existing Cable Trench layout drawings is enclosed at Annexure-I.
e) All roads as shown in GA drawing including culverts. All roads shall be Concrete road.

2.2.5.4 Civil Work as per contractor's design and drawings for:

a) Foundations for lighting panels, bay marshaling boxes, panels & control cubicles of equipments wherever required.

b) (i) Removal, cleaning and washing of existing stone and re-spreading after doing anti-weed treatment as per Section-Civil Works is in the scope of contractor wherever stone is laid in the area under present scope.

(ii) In the area under present scope where stone spreading does not exist, the same shall be provided after doing anti-weed treatment and PCC as per Section-Civil Works.

c) Any other item/design/drawing for completion of scope of works.

2.2.6 Extension of 400kV Champa Substation

2.2.6.1 Design, engineering, manufacture, testing and supply, including transportation & insurance, storage, erection, testing and commissioning of the following equipment/items, complete in all respects.

a) 400kV Circuit Breakers, Isolators, Current Transformers, Bus Post Insulators, 336kV Surge Arresters.

b) Overhead connection of HV bushings of 400kV Reactor to substation equipment. Supply, laying and termination of cables alongwith associated accessories from marshalling box of 400kV Reactor to bay kiosks /Switchyard Panel Rooms/Control Room.

c) Control Switching Device (as per BPS). CSD for existing tie bay Circuit Breaker is also in present scope.

d) Complete Relay & Protection System as per Section-'Control and Relay Panels' for 400kV bays under present scope. Existing 400kV bus bar protection system is of make M/s ABB, model REB 670. The same shall be augmented by the contractor by providing necessary auxiliary relays, trip relays, wiring etc. for completion of bus bar protection system for bays under present scope of work.

e) Existing 400kV substation is equipped with substation Automation system of M/s ABB make (based on IEC 61850). BCU for the bay (in existing half diameter) under present scope already exists at site and same shall be integrated by the contractor with the control & protection equipment to be provided under present scope of work for completion of substation automation system for said 400kV bay.

Necessary interface & integration work for transferring data to WRLDC (RSCC) & NTAMC, Manesar is also under present scope.

The scope of contractor shall include but not limited to integration of IEDs under present scope of augmentation with existing substation automation and compatibility enhancement of same as required including updating of system database, displays, development of additional displays and reports as per requirement of WRLDC and Remote Control Centre NTAMC (Manesar)/RTAMC. Existing NTAMC SCADA is of M/s Alstom make (based on IEC 104 protocol). Bays under present scope are required to be integrated at the existing local NTAMC Gateway well.

Further, the integration of IEC61850 communication based monitoring equipment like On line dissolved Multi-Gas & Moisture analyzer, Insulating Oil drying system, Optical temperature sensor, for each unit of 400kV Reactor (to be provided in a separate contract) with substation automation system is also included in the present scope. Contractor shall also make available 220V DC redundant supply in 400kV Reactors Common MB for supply to Ethernet Switch.

f) 1.1kV grade Power & Control cables along with complete accessories, including cabling from marshaling box of 400kV Reactor to BMK/ Switchyard panel room.

g) Fire protection system (HVW spray and hydrant system) for 400kV, 3-Phase Reactor including extension of main water header from adjacent existing header.

h) Lattice and pipe structures (galvanized): Towers, Beams and Equipment support structures except CB support structure, shall be provided as per Employer's drawings to be provided during detailed engineering. CB support structure shall be as per CB manufacturer's design. Design and drawings of non-standard items not covered above shall be prepared and put up for approval by the vendor during detailed engineering.

i) Erection Hardware: Insulator strings hardware, Disc Insulators/Long Rod Insulators (as applicable), conductor(s), Al tube, bus-bar materials, cable trays & covers, Bay MB, spacers, clamps & connectors including equipment connectors, Junction box, earthwire, earthing material risers, auxiliary earthmat (excluding main earth mat), buried cable trenches/pipes for equipment & lighting, cable supporting angles/channels, Insulating mats, cable sealing arrangement, insulator guy arrangement, all accessories etc. as required.

j) Earthmat already exists in the switchyard area under present scope (existing Earthmat layout drawing is enclosed). All the equipment (including 400kV Reactor), structures, cable trenches, auxiliary earthmat for isolators etc. shall be earthed by connecting them to the main Earthmat by the contractor.

k) Earthing of Employer supplied 400kV Reactor alongwith associated equipment to employer's earthmat.

l) Complete lighting and illumination for the switchyard area under present scope shall be provided by the contractor as per Bid price schedule (BPS).

m) Augmentation of Visual Monitoring system for 400kV bays under the present scope. Existing system is of M/s Sony make. The provided system has to be integrated with existing system. The bidder shall provide 2 nos. Color IP camera with PAN, Tilt & Zoom facility suitably located in switchyard for monitoring of 400kV bays & equipment. The scope of bidder shall include providing all Items, Accessories, Line Interface units, Fiber patch cords, Power supply units, Junction Boxes, Cables, Fiber Optic Cables, Hardware and Software, etc. as are applicable to the product design, to meet functional requirements. Compatibility enhancement of exiting VMS system, as needed, shall be done to integrate visual monitoring for 400kV bays under present scope with existing Visual monitoring system of the station. A copy of specification for Visual Monitoring system is enclosed at Annexure-III, which shall be read only for the Augmentation scope of existing VMS system.

n) Any other equipment/material required to complete the specified scope.

2.2.6.2 Design, engineering, manufacture, testing and supply including transportation & insurance, storage at site of mandatory spares.

2.2.6.3 Civil works - The scope of work shall include but shall not be limited to the following based on Employer supplied drawings -

a) Foundation of 125MVAR, 400kV, 3-Phase Bus Reactor.
b) Fire resistant walls between 400kV Reactors.
c) Foundation for lattice & pipe structures.
d) Cable trenches along with covers including road/rail crossing, sump pits, culverts etc. However, cable trench layout including invert levels shall be prepared by the contractor. Existing Cable Trench layout drawings is enclosed at Annexure-I.
e) All roads as shown in GA drawing including culverts. All roads shall be Concrete road.

2.2.6.4 Civil Work as per contractor's design and drawings for:

a) Foundations for lighting panels, bay marshaling boxes, panels & control cubicles of equipments wherever required.

b) (i) Removal, cleaning and washing of existing stone and re-spreading after doing anti-weed treatment as per Section-Civil Works is in the scope of contractor wherever stone is laid in the area under present scope.

(ii) In the area under present scope where stone spreading does not exist, the same shall be provided after doing anti-weed treatment and PCC as per Section-Civil Works.

c) Any other item/design/drawing for completion of scope of works.

2.2.7 <u>Extension of 400/220kV Jabalpur Substation</u>

2.2.7.1 Design, engineering, manufacture, testing and supply, including transportation & insurance, storage, erection, testing and commissioning of the following equipment/items, complete in all respects.

a) 500 MVA, 400/220/33kV, 3-Phase Autotransformer.

b) 400kV & 220kV Circuit Breakers, Isolators, Current Transformers, BPIs and 336kV & 216kV Surge Arresters.

c) Control Switching Device (as per BPS).

d) Complete Relay & Protection System as per Section-'Control and Relay Panels' for 400kV & 220kV bays under present scope. Existing 400kV bus bar protection system is of make M/s ABB model REB 670. Bus bar bay modules for 2 nos. 400kV bays under present scope already exist. Necessary modification, wiring & integration of same for completion of 400kV bus bar protection system are also under present scope. Further, existing 220kV Bus bar protection system needs to be augmented for 01 no 220kV bay under present scope. Necessary interface, supply of trip relays, auxiliary relays, bus bar bay modules, modification, wiring & integration of same for completion of 220kV bus bar protection system is also under present scope.

e) Existing 400/220kV Jabalpur substation is equipped with conventional control system. Control panels matching with existing panel are required to be provided for bays under present scope with suitable integration to the existing system.
The scope of contractor shall include but not limited to integration of IEDs under present scope of augmentation with existing NTAMC and compatibility enhancement of same as required including updating of system database, displays, development of additional displays and reports as per requirement of WRLDC and Remote Control Centre NTAMC (Manesar)/RTAMC. Existing NTAMC SCADA is of M/s Alstom make (based on IEC 104 protocol). Bays under present scope are required to be integrated at the existing local NTAMC Gateway as well. However existing BCU (for 425-426-427) is available at site so there is no need for extra BCU. Only wiring and database modification is required.

f) Digital RTCC panel with 5 Nos. digital RTCC relays. The scope includes integration of present scope ICT and existing two nos. 400/220kV ICTs with this RTCC panel.

g) 1.1kV grade Power & Control cables along with complete accessories, including cabling from marshaling box of 400/220kV Transformer to bay kiosks /Switchyard panel room /control room and 3.5CX300 Sqmm XLPE Cable for oil filtration socket near 400/220 kV ICT .

h) Fire protection system including HVWS & Hydrant system for 400/220kV, 3-Phase Autotransformers and Smoke detection, Fire alarm & Annunciation System for Switchyard panel Rooms. The piping for firefighting protection system shall be extended from piping near existing 400/220 kV ICT#2.

i) Air Conditioning System for Switchyard Panel Room.

j) Lattice and pipe structures (galvanized): Towers, Beams and Equipment support structures except CB support structure, shall be provided as per Employer's drawings to be provided during detailed engineering. CB support structure shall be as per CB manufacturer's design. Design and drawings of non-standard items not covered above shall be prepared and put up for approval by the vendor during detailed engineering.

k) Erection Hardware: Insulator strings hardware, Disc Insulators/Long Rod Insulators (as applicable), conductor(s), Al tube, bus-bar materials, cable trays & covers, Bay MB, spacers, clamps & connectors including equipment connectors, Junction box, earthwire, earthing material risers, auxiliary earthmat (excluding main earth mat), buried cable trenches/pipes for equipment & lighting, cable supporting angles/channels, Insulating mats, cable sealing arrangement, insulator guy arrangement, all accessories etc. as required.

l) Earthing of bays & ICT under present scope. Main earthing grid of already existing switchyard area is to be extended to the bays under present scope (existing Earthmat layout drawing is enclosed). All the equipment (including 400/220kV ICT), structures, cable trenches, auxiliary earthmat for isolators etc. shall be earthed by connecting them to the main Earthmat by the contractor.

m) Complete lighting and illumination for the switchyard area under present scope shall be provided by the contractor as per Bid price schedule (BPS). Illumination for the switchyard Panel Rooms, shall be provided by the contractor as per Bid price schedule (BPS).

n) Augmentation of Visual Monitoring system for 400kV bays under the present scope. Existing system is of M/s Pelco make. The provided system has to be integrated with existing Video Monitoring software. The bidder shall provide 2 nos. Color IP camera with PAN, Tilt & Zoom facility suitably located in switchyard for monitoring of 400kV bays & equipment. The scope of bidder shall include providing all Items, Accessories, Line Interface units, Fiber patch cords, Power supply units, Junction Boxes, Cables, Fiber Optic Cables, Hardware and Software, etc. as are applicable to the product design, to meet functional requirements. Compatibility enhancement of exiting VMS system, as needed, shall be done to integrate visual monitoring for 400kV bays under present scope with existing Visual monitoring system of the station. A copy of specification for Visual Monitoring system is enclosed at Annexure-III, which shall be read only for the Augmentation scope of existing VMS system.

o) Any other equipment/material required to complete the specified scope.

p) Jabalpur Substation has space constraints and the present scope of work as shown in GA & SLD is to be executed in the available space as per the site conditions. Bidders are advised to visit the site so as to acquaint themselves of the site conditions.

2.2.7.2 Design, engineering, manufacture, testing and supply including transportation & insurance, storage at site of mandatory spares.

2.2.7.3 Civil works - The scope of work shall include but shall not be limited to the following based on Employer supplied drawings -

a) Foundation of 500MVA, 400/220kV, 3-Phase Auto Transformer.
b) Fire resistant walls between 400/220kV Auto Transformer.
c) Foundation of 400kV & 220 kV Equipment Support Structures, 400kV & 220 kV Towers
d) Cable trenches along with covers including road/rail crossing, sump pits, culverts etc. However, cable trench layout including invert levels shall be prepared by the contractor. Existing Cable Trench layout drawings is enclosed at Annexure-I.
e) All roads as shown in GA drawing including culverts. All roads shall be Concrete road.

2.2.7.4 Civil Work as per contractor's design and drawings for:

a) Foundations for lighting panels, bay marshaling boxes, panels & control cubicles of equipments wherever required.

b) (i) Removal, cleaning and washing of existing stone and re-spreading after doing anti-weed treatment as per Section-Civil Works is in the scope of contractor wherever stone is laid in the area under present scope.

(ii) In the area under present scope where stone spreading does not exist, the same shall be provided after doing anti-weed treatment and PCC as per Section-Civil Works.

c) Any other item/design/drawing for completion of scope of works.

2.2.8 Extension of 400/220kV Itarsi Substation

2.2.8.1 Design, engineering, manufacture, testing and supply, including transportation & insurance, storage, erection, testing and commissioning of the following equipment/items, complete in all respects.

I. 400kV Gas Insulated Switchgear & other associated equipments

The existing 400kV switchyard at Itarsi S/S is AIS type with one and a half breaker Switching Scheme, D-type layout. The proposed bays are to be extended from existing 400kV AIS system to GIS system as per the tender GA & SLD drawings enclosed at Annexure-I.

420 kV SF6 gas insulated switch gear shall be of **outdoor** type having arrangement and switching scheme as indicated in the tender drawings. The outdoor type Switchgear (50 Hz) shall be complete with all necessary terminal boxes, SF6 gas filling, interconnecting power and control wiring, grounding connections, gas monitoring equipment & piping and support structures along with necessary base plate & foundation bolts.

The SF6 gas insulated switch gear (50 Hz) shall be of the outdoor metal- enclosed type, comprising of following modules:-

(a) **420kV, 40kA** for 1 second, SF6 gas-insulated metal enclosed **Outdoor ICT bay module** (Main/Tie), each set comprising of the following:-

(i) One (1) number 3-phase, 3150A, SF_6 insulated circuit breaker without PIR complete with operating mechanism.

(ii) Three (3) numbers 1-phase, 3000A, 5-core, multi ratio, current transformers duly distributed on both side of circuit breaker.

(iii) Two (2) numbers 3-phase, 3150A, group operated isolator switches, complete with manual and motor driven operating mechanisms.

(iv) Two (2) numbers 3-phase, group operated safety grounding switches, complete with manual and motor driven operating mechanisms.

(v) 3150A, single phase SF6 ducts for interconnection of above mentioned elements.

(vi) Gas monitoring devices, barriers, pressure switches, UHF PD sensors etc. as required.

(vii) Local Control Cubicle (if applicable).

One end of this module should be capable of connecting with 420kV, 4000A GIB

(Main Bus) and other end to the Tie/Main Bay module mentioned above as applicable (Refer Tender GA drawing).

In addition all necessary supports, ladders etc. for operation & maintenance work shall also be supplied.

(b) **420kV Gas Insulated Bus (GIB) Ducts:-**

420 kV, 3000A, single phase enclosure SF6 gas ducts including support structure from GIS module to center line of SF6/Air Bushing shall be three single phase (isolated) for interconnection for extension of 400kV AIS Main Bus-I & II and for interconnection to switchyard equipment (AIS) associated with ICT bay as shown in GA/ SLD drawing.

The 420kV SF6 gas insulated bus (GIB) ducts shall be complete with all necessary SF_6 gas filling, interconnecting power and control wiring, grounding connections, gas monitoring devices, barriers, pressure switches, UHF PD sensors, piping & support structures.

SF6 gas ducts used outside the GIS modules are covered under this item. The GIB duct length shall be optimized further without affecting the switchyard arrangement and bay orientation and also any of the functional requirements specified.

(c) **420kV Gas Insulated SF6 to Air Termination:-**

420 kV 3000A, 1-Ph SF6/air bushings along with terminal connectors & support structure for outdoor connections to connect GIS bay with ICT and for outdoor connections to extend 400kV AIS Main Bus I & II to GIS as per SLD and GA drawing.

(d) Testing and Maintenance Equipments as per **BPS** (Bid Price Schedule).

(e) Mandatory Spares for GIS as per **Technical Specification Section GIS: Rev 5.**

(f) Any other equipment/material required to complete the specified GIS scope of work.

(II) <u>Air Insulated Switchgear & other associated equipments</u>

a) 500 MVA, 400/220/33kV, 3-Phase Autotransformer.

b) 400kV Isolator, 220kV Circuit Breakers, Isolators, Current Transformers, 400kV & 220kV BPI and 336kV & 216kV Surge Arresters.

c) Control Switching Device (as per BPS).

d) Complete Relay & Protection System as per Section-'Control and Relay Panels' for 400kV & 220kV bays under present scope. Existing 400kV & 220kV bus bar protection system is of make M/s ABB, model REB 670. The bay units for the bays under present scope already exist. The same shall be augmented by the contractor by providing necessary auxiliary relays, trip relays, wiring etc. for completion of bus bar protection system for bays under present scope of work.

Bus bar Protection relays panels (both 400 kV & 220 kV) are located in Control Room. Protection panels under present scope are to be located in Switchyard panel room.

e) Existing 400kV substation is equipped with substation Automation system of M/s Siemens make (based on IEC 61850). Contractor shall provide BCUs for 2 nos. of 400kV bays and 1 no. 220 kV bays (bay as defined in technical specification, Section - Substation Automation System) under the present scope including all necessary hardware and software to integrate the same with existing Substation Automation System.

Necessary interface & integration work for transferring data to WRLDC (RSCC) & NTAMC, Manesar is also under present scope.

The scope of contractor shall include but not limited to integration of IEDs under present scope of augmentation with existing substation automation and compatibility enhancement of same as required including updating of system database, displays, development of additional displays and reports as per requirement of WRLDC and Remote Control Centre NTAMC (Manesar)/RTAMC. Existing NTAMC SCADA is of M/s Alstom make (based on IEC 104 protocol). Bays under present scope are required to be integrated at the existing local NTAMC Gateway well.

Further, the integration of IEC61850 communication based monitoring equipment like On line dissolved Multi-Gas & Moisture analyzer, Insulating Oil drying system, Optical temperature sensor, for the 400/220kV Transformer with substation automation system is also included in the present scope.

f) The integration of present scope ICT with existing Digital RTCC panel is in present scope. All required cabling, wiring for the same shall be included in the scope.

g) 1.1kV grade Power & Control cables along with complete accessories, including cabling from marshaling box of 400/220kV Transformer to bay kiosks /Switchyard panel room /control room and 3.5CX300 Sqmm XLPE Cable for oil filtration socket near 400/220 kV ICT .

h) Fire protection system including HVWS & Hydrant system for 400/220kV, 3-Phase Autotransformers and Smoke detection, Fire alarm & Annunciation System for Switchyard panel Rooms. The piping for firefighting protection system shall be extended from piping near existing 400/220 kV ICT#2.

i) Air Conditioning System for Switchyard Panel Room.

j) Lattice and pipe structures (galvanized): Towers, Beams and Equipment support structures except CB support structure, shall be provided as per Employer's drawings to be provided during detailed engineering. CB support structure shall be as per CB manufacturer's design. Design and drawings of non-standard items not covered above shall be prepared and put up for approval by the vendor during detailed engineering.

k) Insulator strings hardware, Disc Insulators/Long Rod Insulators (as applicable), conductor(s), Al tube, bus-bar materials, cable trays & covers, Bay MB, spacers, clamps & connectors including equipment connectors, Junction box, earthwire, earthing material risers, auxiliary earthmat (excluding main earth mat), buried cable trenches/pipes for equipment & lighting, cable supporting angles/channels, Insulating mats, cable sealing arrangement, insulator guy arrangement, all accessories etc. as required.

l) Earthing of bays & ICT under present scope. Main earthing grid of already existing switchyard area is to be extended to the bays under present scope (existing Earthmat layout drawing is enclosed). All the equipment (including 400/220kV ICT), structures, cable trenches, auxiliary earthmat for isolators etc. shall be earthed by connecting them to the main Earthmat by the contractor.

m) Complete lighting and illumination for the switchyard area under present scope shall be provided by the contractor as per Bid price schedule (BPS). Illumination for the switchyard Panel Rooms, shall be provided by the contractor as per Bid price schedule (BPS).

n) Augmentation of Visual Monitoring system for 400kV & 220 bays under the present scope. Existing system is of M/s PELCO make. The provided system has to be integrated with existing Video Monitoring software. The bidder shall provide 3 nos. Color IP camera with PAN, Tilt & Zoom facility suitably located in switchyard for monitoring of 400kV & 220kV bays & equipment. The scope of bidder shall include providing all Items, Accessories, Line Interface units, Fiber patch cords, Power supply units, Junction Boxes, Cables, Fiber Optic Cables, Hardware and Software, etc. as are applicable to the product design, to meet functional requirements. Compatibility enhancement of exiting VMS system, as needed, shall be done to integrate visual monitoring for 400kV & 220kV bays under present scope with existing Visual monitoring system of the station. A copy of specification for Visual Monitoring system is enclosed at Annexure-III, which shall be read only for the Augmentation scope of existing VMS system.

o) Any other equipment/material required to complete the specified scope.

2.2.8.2 Design, engineering, manufacture, testing and supply including transportation & insurance, storage at site of mandatory spares.

2.2.8.3 Civil works - The scope of work shall include but shall not be limited to the following based on Employer supplied drawings -

a) Foundation of 500MVA, 400/220kV, 3-Phase Auto Transformer.
b) Fire resistant walls between 400/220kV Auto Transformer.
c) Foundation of 400kV & 220 kV Equipment Support Structures, 400kV & 220 kV Towers.
d) Cable trenches along with covers including road/rail crossing, sump pits, culverts etc. However, cable trench layout including invert levels shall be prepared by the contractor. Existing Cable Trench layout drawings is enclosed at Annexure-I.
e) All roads as shown in GA drawing including culverts. All roads shall be Concrete road.
f) Switchyard Panel Rooms

2.2.8.4 Civil Work as per contractor's design and drawings for:

a) Foundations for lighting panels, bay marshaling boxes, panels & control cubicles of equipments wherever required.

b) (i) Removal, cleaning and washing of existing stone and re-spreading after doing anti-weed treatment as per Section-Civil Works is in the scope of contractor wherever stone is laid in the area under present scope.

(ii) In the area under present scope where stone spreading does not exist, the same shall be provided after doing anti-weed treatment and PCC as per Section-Civil Works.

c) Any other item/design/drawing for completion of scope of works.

2.3 Design, engineering, manufacture, testing, supply on FOR destination site basis including transportation & insurance, storage at site of mandatory spares for items mentioned in the bid price schedule (BPS) & as per break-up at Annexure-III.

2.4 Before proceeding with the construction work the Contractor shall fully familiarize himself with the site conditions and General arrangements & scheme etc. Though the Employer shall endeavor to provide the information, it shall not be binding for the Employer to provide the same. The bidders are advised to visit the substation sites and acquaint themselves with the topography, infrastructure and also the design philosophy. The bidder shall be fully responsible for providing all equipment, materials, system and services specified or otherwise which are required to complete the construction and successful commissioning, operation & maintenance of the substation in all respects. All materials required for the Civil and construction/installation work including cement and steel shall be supplied by the Contractor.

Complete design (unless specified otherwise in specification elsewhere) and detailed engineering shall be done by the Contractor based on conceptual tender drawings.

2.5 The Contractor shall also be responsible for the overall co-ordination with internal/external agencies, project management, training of Employer's manpower, loading, unloading, handling, moving to final destination for successful erection, testing and commissioning of the substation/switchyard.

2.6 Design of substation and its associated electrical & mechanical auxiliaries systems includes preparation of single line diagram, electrical layout, foundation & cable trench layouts (including invert levels), erection key diagrams, direct stroke lightning protection, electrical and physical clearance diagrams, Control and protection schematics, wiring and termination schedules, design of fire fighting system, outdoor lighting/illumination and other relevant drawings & documents required for engineering of all facilities within the fencing to be provided under this contract, are covered under the scope of the Contractor.

2.7 Any other items not specifically mentioned in the specification but which are required for erection, testing and commissioning and satisfactory operation of the substation are deemed to be included in the scope of the specification unless specifically excluded.

2.8 Employer has standardized its technical specification for various equipments and works for different voltage levels. Items, which are not applicable for the scope of this package as per schedule of quantities described in BPS, the technical specification for the items should not be referred to.

3 Specific exclusions

The following items of work are specifically excluded from the scope of the specifications

a) Employer's site office and stores.
b) Contouring & Site Leveling.
c) Boundary wall along substation property line
d) Approach Road upto Sub-station boundary.
e) Soil Investigation & Measurement of soil resistivity
f) Supply & Installation of 765kV & 400kV Reactors
g) Cabling from Individual MB to Common MB of 765kV Reactors

4 PHYSICAL AND OTHER PARAMETERS

4.1 **Location of the Substation** - The location of substation is indicated below:

S. No	Name of Substation	Name of State	Nearest Rail Head
1	Solapur	Maharashtra	Solapur
2.	Aurangabad	Maharashtra	Aurangabad
3.	Wardha	Maharashtra	Wardha
4.	Khandwa	M.P.	Khandwa
5.	Rajgarh	M.P	Rajgarh
6.	Champa	Chhattisgarh	Champa
7.	Jabalpur	M.P.	Jabalpur
8.	Itarsi	M.P.	Itarsi

4.2 Meteorological data

The meteorological data of the substations shall be furnished to successful bidder. However, for design purposes, ambient temperature should be considered as 50 degree centigrade and altitude to be considered as 1000 mtrs.

5 SCHEDULE OF QUANTITIES

The requirement of various items/equipments and civil works are indicated in Bid price Schedules.

All equipments/items and civil works for which quantities has been given in the BPS shall be payable on unit rate basis. During actual execution, any variation in such quantities shall be paid based on the unit rate under each item incorporated in Letter of award.

Wherever the quantities of items/works are indicated in Lot/Set, the bidder is required to estimate the quantity required for entire execution and completion of works and incorporate their price in respective Bid price schedules. For erection hardware items, Bidders shall estimate the total requirement of the works and indicate module-wise lump sum price bay wise and include the same in relevant Bid price schedules. Any material/works for the modules not specifically mentioned in the description in BPS, as may be required shall be deemed to be included in the module itself.

The detailed bill of quantities of the mandatory spares for which break up is not given in the bid price Schedules are indicated at Annexure-II of this part.

Bidder should include all such items in the bid proposal sheets, which are not specifically mentioned but are essential for the execution of the contract. Item which explicitly may not appear in various schedules and required for successful commissioning of substation shall be included in the bid price and shall be provided at no extra cost to Employer.

6 BASIC REFERENCE DRAWINGS

6.1 765kV Aurangabad, 765kV Solapur, 765kV Wardha, 400kV Khandwa, 400kV Rajgarh, 400kV Champa, 400/220kV Itarsi, 400/220kV Jabalpur substations are with breaker and half switching scheme having I type layout arrangement at Aurangabad, Solapur, Wardha, Khandwa & Rajgarh substation, while D-type arrangement at 400kV Champa, Itarsi & Jabalpur substation. 220kV Itarsi & Jabalpur have DMT scheme.

6.2 The reference drawings, which form a part of the specifications, are given at Annexure-I. The bidder shall maintain the phase to earth clearance, phase to phase clearance and sectional clearances, clearances between buses, bus heights but may alter the locations of equipment to obtain the statutory electrical clearances required for the substation.

The enclosed drawings give the basic scheme, layout of substation, substation buildings, associated services etc. In case of any discrepancy between the drawings and text of specification, the requirements of text shall prevail in general. However, the Bidder is advised to get these clarified from Employer.

7 DIFFERENT SECTIONS OF TECHNICAL SPECIFICATION

For the purpose of present scope of work, technical specification (Vol. II) shall consist of following sections and they should be read in conjunction with each other.

a) Section-Project. (Rev.00)

b) Section-General Technical Requirements (Rev.14)

c) Section- 400kV Transformer (Rev 11)

d) Section- Switchgear- CB (Rev 11)

e) Section- Switchgear- ISO (Rev 11A)

f) Section- Switchgear-INST (Instrument Transformer) (Rev 11)

g) Section- Switchgear- Surge Arrester (Rev 11)

h)	Section-Gas Insulated Switchgear	(Rev.05)
i)	Section-Power and Control Cables	(Rev.06)
j)	Section-Lighting System	(Rev.07)
k)	Section-Fire Protection System	(Rev.06)
l)	Section-Air Conditioning System	(Rev.04)
m)	Section-Switchyard Erection	(Rev.10)
n)	Section-Structure	(Rev.06)
o)	Section- LT Switchgear	(Rev.05)
p)	Section-Sub-Station Civil Works	(Rev.11A)
q)	Section-Control, Relay & Protection Panels	(Rev.09)
r)	Section-Substation Automation System	(Rev.04)

In case of any discrepancy between Section-PROJECT and Section-GTR and other technical specifications on scope of works, Section-PROJECT shall prevail over all other sections.

In case of any discrepancy between Section-GTR and individual sections for various equipments, requirement of individual equipment section shall prevail.

8 MANDATORY SPARES

The Mandatory Spares shall be included in the bid proposal by the bidder. The prices of these spares shall be given by the Bidder in the relevant schedule of BPS and shall be considered for evaluation of bid. It shall not be binding on the Employer to procure all of these mandatory spares.

The bidder is clarified that no mandatory spares shall generally be used during the commissioning of the equipment. Any spares required for commissioning purpose shall be arranged by the Contractor. The unutilized spares if any brought for commissioning purpose shall be taken back by the contractor.

9 SPECIFIC REQUIREMENT

9.1 For locking of Reactor tank on foundation, two parallel plates of 200mm wide and 32mm thick shall be embedded on both sides of outer rail.

9.2 The bidder is required to quote the price of isolator(s) with the insulator as an integral part of the Isolator(s). In case the price of insulators and metallics for isolator(s) are quoted separately by the bidder, the total price quoted by the bidder for such insulators shall be considered as the lump sum price of insulators required for the specified quantity of isolator(s) under the subject package(s). In such an event the quantity of insulators indicated by the bidder shall be treated as the quantity estimated by the bidder.

9.3 Erection, testing and commissioning of Reactors, Transformers, Circuit breakers, Isolators, Substation automation system, Control & protection panels, etc. shall be done by the contractor under the supervision of respective equipment manufacturers. Charges for the above supervision shall be included by the bidder in the erection charges for the respective equipment in the BPS.

9.4 The layout drawing for connection arrangement of 765kV Reactors shall be made in such a way that existing spare unit of Reactor can be connected in place of faulty unit without physically shifting it from its location. For this purpose, HV Auxiliary bus & neutral bus of existing spare unit are to be extended upto the units under present scope which could be connected through flexible conductor / rigid bus and connectors when spare unit is required to be connected.

9.5 Cabling of already existing spare unit of 765kV Rectors with isolator switching arrangement shall be in such a way that spare unit of reactor can be connected in place of faulty unit without physically shifting and all the control, protection, indication signals of spare unit shall be brought in common marshaling box of all the banks by the reactor supplier. From CMB all the control, protection and indication signals of R, Y, B and Spare units shall be transferred to Control panels/SCADA under the present scope. Change-over of spare unit signals with faulty unit shall be done through C & R panels / SCADA level by substation contractor under the present scope.

9.6 Impedance relay function shall also be provided for Power transformer back –up protection in addition to other protections specified for Transformer (HV & IV) protection in technical specification, Section-CRP, Rev-09. Specification of Transformer impedance relay function shall be similar to that specified for Reactor back-up impedance protection.

9.7 Nuts, Bolts and washers for all non standard structures shall be payable as per BPS.

9.8 The architecture drawing & details of the Switchyard panel room is enclosed along with tender drawing. The civil construction drawing for above shall be furnished during detail engineering.

9.9 In case of 765kV Quad jumpers from 39m height to Isolators, guy insulator assembly consisting of composite insulator alongwith necessary hardware is to be installed and anchored with the ground to reduce the load on isolator (wherever applicable) as per the drawing enclosed with tender document.

9.10 The cable sizes specified at clause no. 1.1.4 of Section-Power & Control Cables Rev-6 are minimum required. In case, more nos. of runs or larger sizes of cables are required between two points based on design calculations, same shall deemed to be included by bidder

9.11 Clause No. 4.2 of Section: Power & Control Cables (Rev 6) is amended as: "Standard lengths for each size of power and control cables shall be 500/1000 meters. However, to avoid cable wastage and cable jointing at site , non-standard lengths of each size of Power & control cable may also be acceptable subject to maximum length of 1000 meters(+ 5% tolerance)."

9.12 Appendix-V "Vendor List for Fire Protection Package" of section Fire Protection (Rev 6) stands deleted.

9.13 The diameter of main header pipe to be extended for fire protection system shall be same as that of the existing pipe in case of extension wherever required.

9.14 The lighting fixtures for switchyard may be mounted on Gantry structures/Lighting mast or on lighting poles to be provided by the contractor.

9.15 The fault level of all the equipments to be supplied under present scope shall be following:-

S. No.	Name of Substation	Fault level
1.	765kV Solapur	40kA for 1sec
2.	765kV Aurangabad	40kA for 1sec
3.	765kV Wardha	40kA for 1sec
4.	400kV Khandwa	40kA for 1sec
5.	400kV Rajgarh	40kA for 1sec
6.	400kV Champa	50kA for 1sec
7.	400/220kV Jabalpur	40kA for 1sec
8.	400/220kV Itarsi	40kA for 1sec

9.16 The short description has been used in the bid price schedule. The details of all such short description are given in Annexure-V of this Section-Project. The bidder shall refer these detailed descriptions for clarity.

9.17 In the Sub-station automation system, each gas tight compartments of 400kV GIS shall be monitored individually per phase basis. However, for GIS compartment for GIB outside GIS hall 3-phase monitoring is acceptable. In case it is not possible to monitor the gas tight compartment individually in one BCU, the contractor shall supply additional BCU for the monitoring without any additional cost implication to POWERGRID.

9.18 New clause 24.21 added under Section "GTR Rev 14" as mentioned below:

Technical requirement for 400kV GIS bays at 400kV Itarsi S/S:

(i) The manufacturer whose 400kV GIS bays are offered must have designed, manufactured, type tested (as per IEC or equivalent standard), supplied and supervised erection & commissioning of at least two (2) nos. Gas Insulated Switchgear (GIS) circuit breaker bays@ of 345kV or above voltage class in one (1) GIS Substation or Switchyard during the last seven (7) years and these bays must be in satisfactory operation# for at least two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirements stipulated in (i) above, can also be considered provide that

(a) Atleast one no. 400kV or above voltage level GIS Circuit Breaker bay@ must have been manufactured in the above Indian works based on the technological support of the Collaborator(s) and either supplied or type tested the above GIS bay (as per IEC) as on the date of NOA.

(b) The collaborator(s) meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer / license to design, manufacture, test and supply 400kV or above voltage level GIS equipment in India, shall be submitted.

(c) The Collaborator(s) shall furnish performance guarantee for an amount of 10 % of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to Contract Performance Guarantee to be submitted by the bidder.

Note :-

In case of an Indian GIS manufacturer who has not conducted the type testing of 400kV GIS manufactured in India but the parent company or subsidiary company or group company have conducted the type testing of 400kV GIS manufactured at their works, the type test reports of the parent company or subsidiary company or group company shall be acceptable provided that the design is same.

Bidder needs to meets the following technical requirements as stipulated here under:

Technical Qualifying Requirements for Control, Relay & Protection System and Sub-station Automation System

The manufacturer whose Control, Relay & Protection System (Control & protection Intelligent Electronic Devices (IEDs)), and Sub-station Automation System (as applicable) are offered, must have designed, manufactured, tested, installed and commissioned Control, Relay & Protection system along with Sub-station Automation System which must have been in satisfactory operation# on (i) 400 kV system [applicable for 765kV substation] & (ii) specified voltage level or above [applicable For 400kV & below substation] for atleast two (2) years as on the date of NOA.

AND

The Manufacturer or their joint venture or subsidiary company or parent company must be a manufacturer of control and protection IEDs and must have established repair, testing and integration (atleast for 4 bays) facilities for Control, Relay & Protection System and Sub-station Automation System in India.

Legend:

: satisfactory operation means certificate issued by the Employer/Utility certifying the operation without any adverse remark.

NOA: Date of NOA for reference project is 29.07.2019.

13/02/20
PREPARED BY
Y. Lakshmi Kumari
Sr. Mgr (TBEM)

REVIEWED BY 13/02/20

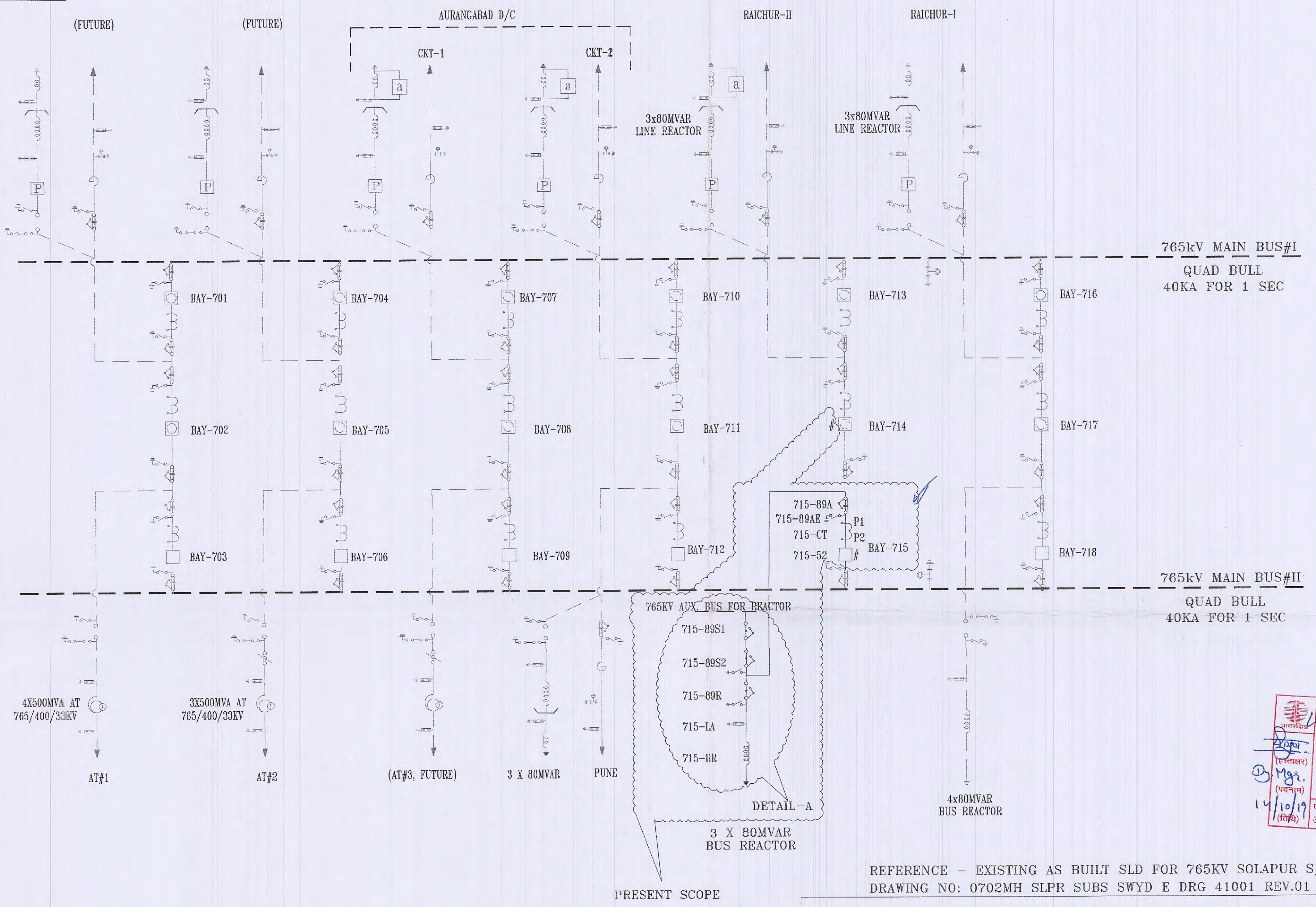
अनुमोदित 22/02/20
APPROVED BY

62

ANNEXURE-1

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM.)

DRAWING No. TB-408-510-S01



Gt I

पावर ग्रिड कॉरपोरेशन ऑफ इंडिया लि०

14/10/19

REFERENCE - EXISTING AS BUILT SLD FOR 765KV SOLAPUR S/S,
DRAWING NO: 0702MH SLPR SUBS SWYD E DRG 41001 REV.01 SHEET 1 OF 2

NOA NO. : CC-CS/901-WR2/SS-3931/3/G3/NOA-I/8864 & 8865 DT. 29.07.19

EQUIPMENT IDENTIFICATION:-

7 19 - 89 R E

- EQUIPMENT ID — 'E' REPRESENTS EARTH SWITCH
- EQUIPMENT ID —
  - A FOR EQUIPMENT IDENTIFICATION ON BUS-2 SIDE
  - B FOR EQUIPMENT IDENTIFICATION ON BUS-1 SIDE
  - L FOR LINE SIDE
  - R FOR REACTOR SIDE
  - T FOR TRANSFORMER SIDE
  - S FOR SPARE
- STANDARD EQUIPMENT NO. —
  - 89 FOR ISOLATOR
  - 52 FOR CIRCUT BREAKER
  - CT FOR CURRENT TRANSFORMER
  - CVT FOR CAPACITOR VOLTAGE TRANSFORMER
  - LA FOR LIGHTNING ARRESTOR
  - WT FOR WAVE TRAP
- BAY NUMBER — 01, 02, 03 . . . .
- VOLTAGE LEVEL — 7 FOR 765kV SYSTEM

LEGENDS:-

————	PRESENT SCOPE
— — — —	EXISTING / FUTURE

ADDITIONAL INFORMATION W.O.No.	I19TB00001
STATUS OF DRAWING	CONTRACT
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ग्राहक/परियोजना का नाम / NAME OF CUSTOMER/PROJECT: POWER GRID CORPORATION OF INDIA LIMITED
Substation Package-SS19 for extension of (i) 765kV Solapur S/S; (ii) 765kV Aurangabad S/S; (iii) 765kV Wardha S/S; (iv) 400kV Khandwa S/S; (v) 400kV Rajgarh S/S; (vi) 400kV Champa S/S; (vii) 400/220kV Itarsi S/S & (viii) 400/220kV Jabalpur Substation under WRSS-20.

भारत हेवी इलेक्ट्रिकल्स लिमिटेड
ट्रांसमिशन परियोजना विभाग
BHARAT HEAVY ELECTRICALS LTD.
TRANSMISSION PROJECTS DIVISION

	नाम /NAME	हस्ता./SIGN.	दि./DATE
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जाँचा CHECKED	JK		25.09.19
स्वीकृत APPROVED	SKS		25.09.19

REV.	DATE	ALTERED / CHECKED / APPROVED
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कोड CODE 422
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कार्ड कोड CARD CODE

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Date: 2019.09.25 15:20:17 +05'30'

शीर्षक/TITLE
SINGLE LINE DIAGRAM FOR
EXTN. OF 765KV SOLAPUR SUBSTATION

ड्राईग.क्र./DRAWING NO. TB-408-510-S01
पुनः/REV. 00
पृष्ठ क्र./SHEET No. 01 | अगला पृष्ठ /NEXT SHEET 02

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FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM.)

DRAWING No. TB-408-510-S01

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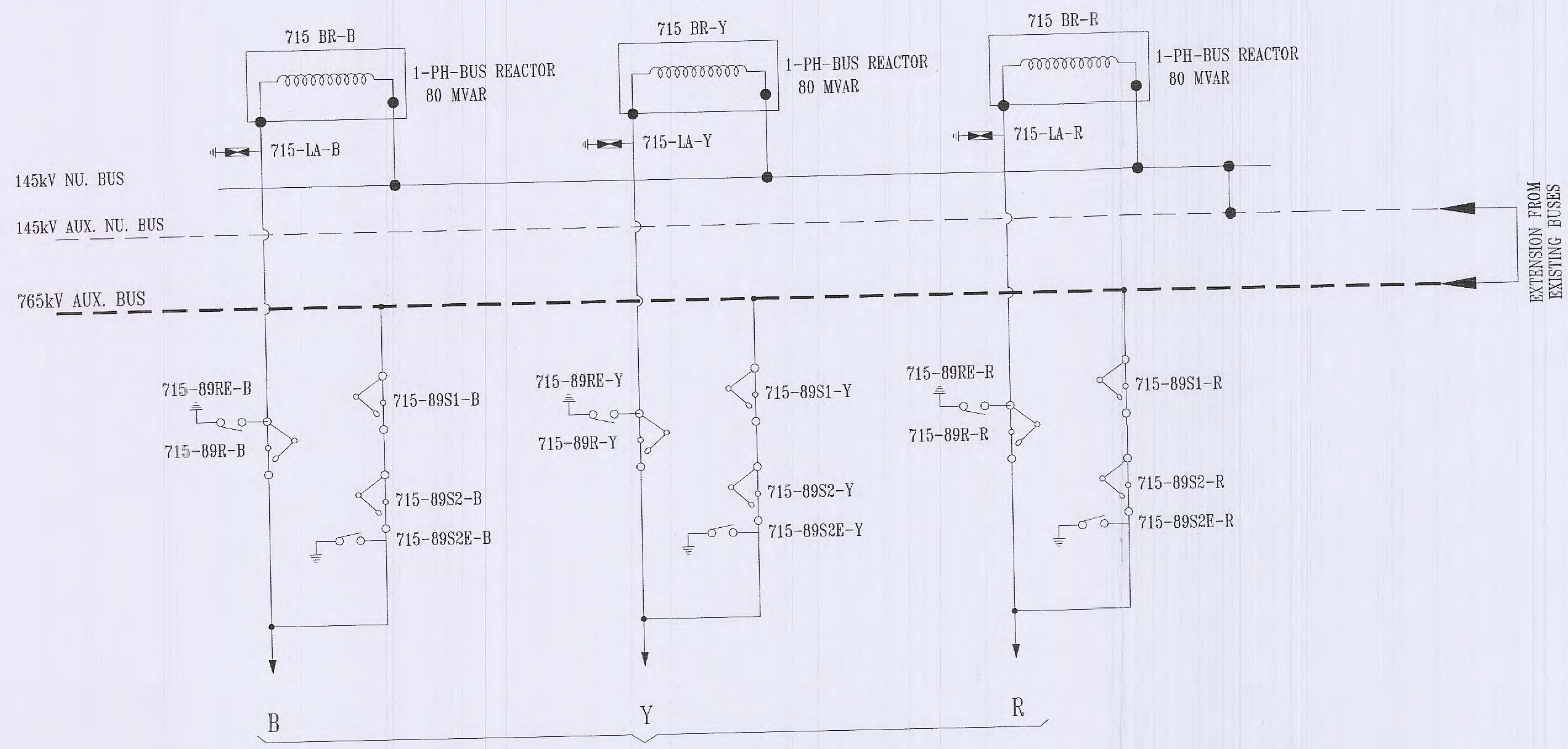

765KV BUS REACTOR BAY
BAY-715

(ARRANGEMENT OF 765kV BUS REACTOR AND AUX. BUS.)

DETAIL-A

→ Phase sequence to be confirmed at site.

BILL OF QTY. FOR 765kV MAIN EQUIPMENTS (40KA, 1 SEC):

SL.NO.	DESCRIPTION RATING	QTY. (NO.)	SYMBOL	LEGEND
1	765KV, 80MVAR, 1-PH BUS REACTOR NOT IN BHEL SCOPE OF SUPPLY	3		BR
2	765KV, 3150A, 3-PH, SF6 CIRCUIT BREAKER WITHOUR PIR)	1		52
3	765KV, 3150A, 3-PH, ISOLATOR WITH ONE E/S, VERTICAL KNEE TYPE	1		89A
4	765KV, 3150A, 1-PH, ISOLATOR WITH ONE E/S, VERTICAL KNEE TYPE	6		89R 89S2
5	765KV, 3150A, 1-PH, ~~HDB~~ ISOLATOR WITHOUT E/S, VERTICAL KNEE TYPE	3		89S1
6	765KV, 3000A, 1-PH CURRENT TRANSFORMER WITH 120% EXTENDED CURRENT RATING	3		CT
7	624KV, 1-PH, SURGE ARRESTER (1 PH.)	3		LA
8	CONTROLLED SWITCHING DEVICE FOR 765KV, 3 PHASE CIRCUIT BREAKER	2	#	

SYSTEM PARAMETERS:

S.NO.	DESCRIPTION	765KV
01	SYSTEM OPERATING VOLTAGE	765kV
02	MAXIMUM OPERATING VOLTAGE OF THE SYSTEM (rms)	800kV
03	RATED FREQUENCY	50Hz
04	FULL WAVE IMPULSE WITHSTAND VOLTAGE (1.2/50 MICROSES.)	2100kVp
05	SWITCHING IMPULSE WITHSTAND VOLTAGE (250/2500 MICRO SEC.) DRY AND WRT	1550kVp
06	ONE MINUTE POWER FREQUENCY DRY WITHSTAND VOLTAGE (rms)	830kV
07	ONE MINUTE POWER FREQUENCY DRY AND WET WITHSTAND VOLTAGE (rms)	--
08	CORONA EXTINCTION VOLTAGE	508kV
09	MAX. RADIO INTERFERENCE VOLRAGE FOR FREQUENCY BETWEEN 0.5 MHz AND 2 MHz	2500uV AT 508kV rms
10	MINIMUM CREEPAGE DISTANCE-FOR EQUIPMENT OTHER THAN INSULATOR STRING	20000mm
11	SYSTEM FAULT LEVEL	40 KA FOR 1SEC

Gt I

पावर ग्रिड कॉरपोरेशन ऑफ इंडिया लि० अभियांत्रिकी (उपकेन्द्र), गुड़गांव, हरियाणा

Dy. Mgr.
1/10/19

LEGENDS:–

———————	PRESENT SCOPE
— — — —	EXISTING / FUTURE

-अंशुल

REFERENCE - EXISTING AS BUILT SLD FOR 765KV SOLAPUR S/S,
DRAWING NO: 0702MH SLPR SUBS SWYD E DRG 41001, SHEET 2 OF 2

CT DETAILS:

765 kV, 3000A, CT (6 CORE)

Core No.	Current Ratio	Accuracy Class	Output Burden VA	Min kPV (V)	Max RCT in Ohms	Max Im at kPV (mA)	Purpose
1	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	BUS DIFF CHECK
2	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	BUS DIFF MAIN
3	3000-2000-500/1	0.2S	20	-	-	-	METERING
4	3000-2000-500/1	0.2S	20	-	-	-	METERING
5	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	REACTOR BACKUP
6	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	REACTOR DIFF.

NOA NO. : CC-CS/901-WR2/SS-3931/3/G3/NOA-I/8864 & 8865 DT. 29.07.19

ADDITIONAL INFORMATION
W.O.No. I19TB00001

STATUS OF DRAWING CONTRACT

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ग्राहक/परियोजना का नाम POWER GRID CORPORATION OF INDIA LIMITED
NAME OF CUSTOMER/PROJECT Substation Package-SS19 for extension of (i) 765kV Solapur S/S; (ii) 765kV Aurangabad S/S; (iii) 765kV Wardha S/S; (iv) 400kV Khandwa S/S; (v) 400kV Rajgarh S/S; (vi) 400kV Champa S/S; (vii) 400/220kV Itarsi S/S & (viii) 400/220kV Jabalpur Substation under WRSS-20.

बीएचईएल
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ट्रांसमिशन परियोजना विभाग
BHARAT HEAVY ELECTRICALS LTD.
TRANSMISSION PROJECTS DIVISION

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जाँचा CHECKED	JK		25.09.19
स्वीकृत APPROVED	SKS		25.09.19

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शीर्षक/TITLE
SINGLE LINE DIAGRAM FOR
EXTN. OF 765KV SOLAPUR SUBSTATION

ड्राईग.क्र./DRAWING NO. TB-408-510-S01
पुनः/REV. 00
पृष्ठ क्र./SHEET No. 02 अगला पृष्ठ /NEXT SHEET –

COMPUTER DRG. PATH NAME :
REF. DRG. No.
SIGN. & DATE
INVENTORY No.

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM.)

DRAWING No. TB-408-510-A01

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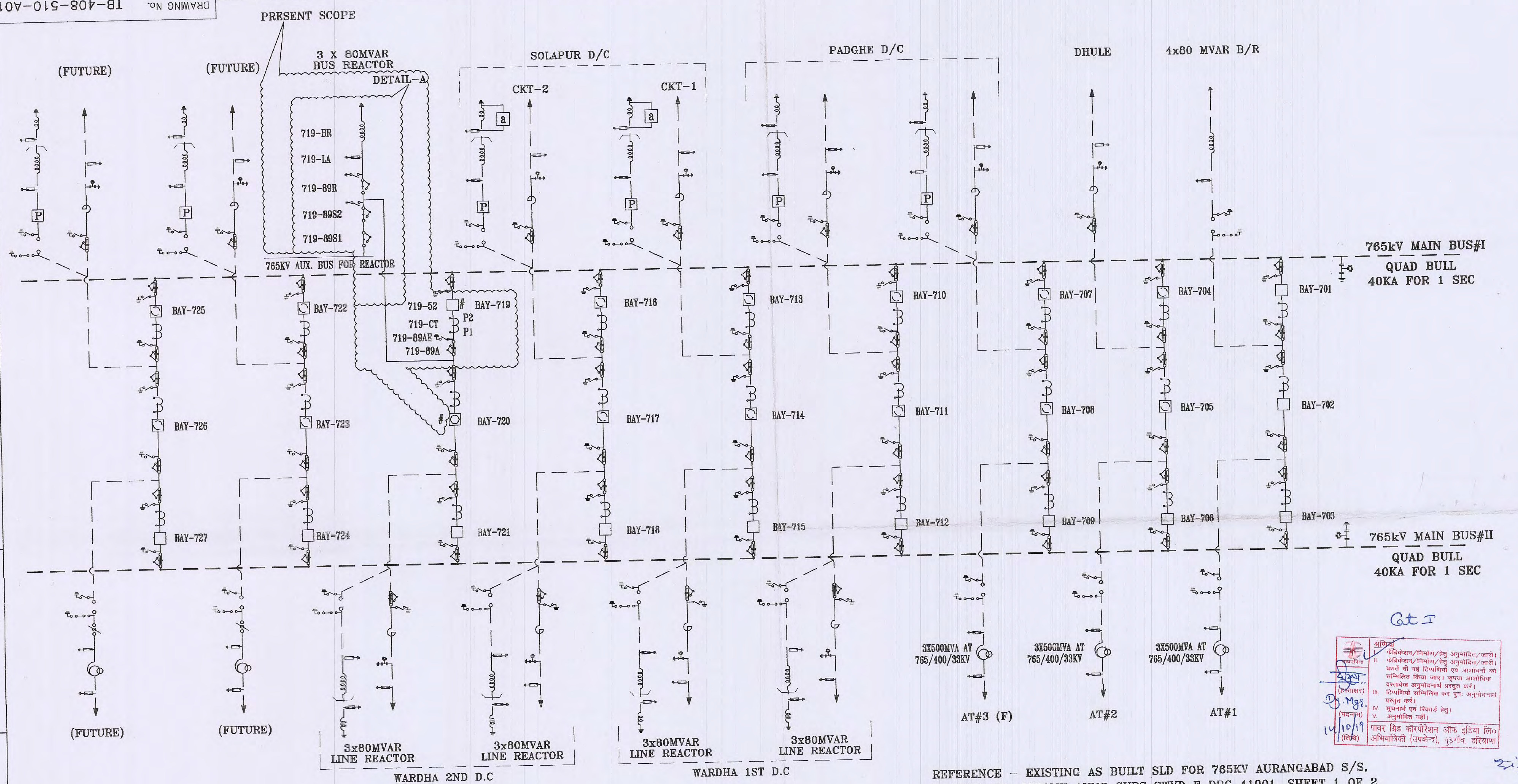

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पावर ग्रिड कॉरपोरेशन ऑफ इंडिया लि० अभियांत्रिकी (उपकेन्द्र), गुड़गाँव, हरियाणा

REFERENCE - EXISTING AS BUILT SLD FOR 765KV AURANGABAD S/S,
DRAWING NO: 0702MH AUNG SUBS SWYD E DRG 41001, SHEET 1 OF 2

NOA NO. : CC-CS/901-WR2/SS-3931/3/G3/NOA-I/8864 & 8865 DT. 29.07.19

EQUIPMENT IDENTIFICATION:-

7 19 - 89 R E

- EQUIPMENT ID — 'E' REPRESENTS EARTH SWITCH
- EQUIPMENT ID —
  - A FOR EQUIPMENT IDENTIFICATION ON BUS-2 SIDE
  - B FOR EQUIPMENT IDENTIFICATION ON BUS-1 SIDE
  - L FOR LINE SIDE
  - R FOR REACTOR SIDE
  - T FOR TRANSFORMER SIDE
  - S FOR SPARE
- STANDARD EQUIPMENT NO. —
  - 89 FOR ISOLATOR
  - 52 FOR CIRCUIT BREAKER
  - CT FOR CURRENT TRANSFORMER
  - CVT FOR CAPACITOR VOLTAGE TRANSFORMER
  - LA FOR LIGHTNING ARRESTOR
  - WT FOR WAVE TRAP
- BAY NUMBER — 01, 02, 03 . . . .
- VOLTAGE LEVEL — 7 FOR 765kV SYSTEM

LEGENDS:-

———	PRESENT SCOPE
———	EXISTING / FUTURE

JAI KUMAR

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Substation Package-SS19 for extension of (i) 765kV Solapur S/S; (ii) 765kV Aurangabad S/S; (iii) 765kV Wardha S/S; (iv) 400kV Khandwa S/S; (v) 400kV Rajgarh S/S; (vi) 400kV Champa S/S; (vii) 400/220kV Itarsi S/S & (viii) 400/220kV Jabalpur Substation under WRSS-20.

बीएचईएल BHEL
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ट्रांसमिशन परियोजना विभाग
BHARAT HEAVY ELECTRICALS LTD.
TRANSMISSION PROJECTS DIVISION

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जाँचा CHECKED	JK		21.09.19
स्वीकृत APPROVED	SKS		21.09.19

REV.	DATE	ALTERED / CHECKED / APPROVED
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कार्ड कोड CARD CODE

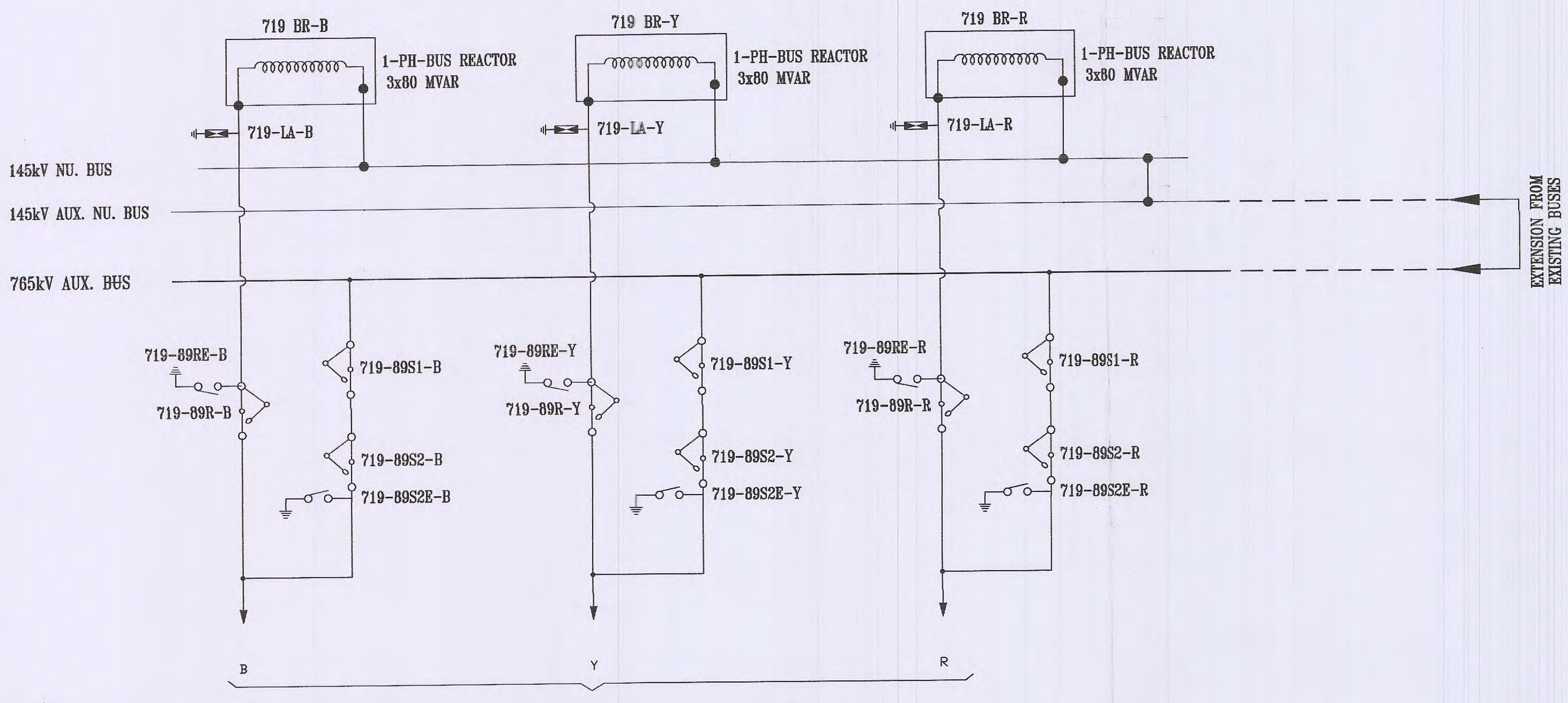
शीर्षक/TITLE
SINGLE LINE DIAGRAM FOR
EXTN. OF 765KV AURANGABAD SUBSTATION

ड्राइंग.क्र./DRAWING NO. TB-408-510-A01
पुनः/REV. 00
पृष्ठ क्र./SHEET No. 01 अगला पृष्ठ/NEXT SHEET 02

INVENTORY No. | SIGN. & DATE | REF. DRG. No. | COMPUTER DRG. PATH NAME :

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM.)

DRAWING No. TB-408-510-A01



765KV BUS REACTOR BAY
BAY-719

(ARRANGEMENT OF 765kV BUS REACTOR AND AUX. BUS.)

DETAIL-A

→ Phase sequence to be checked at site.

BILL OF QTY. FOR 765kV MAIN EQUIPMENTS (40KA, 1 SEC):

SL.NO.	DESCRIPTION RATING	QTY. (NO.)	SYMBOL	LEGEND
1	765KV, 80MVAR, 1-PH BUS REACTOR NOT IN BHEL SCOPE OF SUPPLY	3		BR
2	765KV, 3150A, 3-PH, SF6 CIRCUIT BREAKER WITHOUR PIR)	1		52
3	765KV, 3150A, 3-PH, ISOLATOR WITH ONE E/S, VERTICAL KNEE TYPE	1		89A
4	765KV, 3150A, 1-PH, ISOLATOR WITH ONE E/S, VERTICAL KNEE TYPE	6		89R 89S2
5	765KV, 3150A, 1-PH, HDB ISOLATOR WITHOUT E/S, VERTICAL KNEE TYPE	3		89S1
6	765KV, 3000A, 1-PH CURRENT TRANSFORMER WITH 120% EXTENDED CURRENT RATING	3		CT
7	624KV, 1-PH, SURGE ARRESTER (1 PH.)	3		LA
8	CONTROLLED SWITCHING DEVICE FOR 765KV, 3 PHASE CIRCUIT BREAKER	2	#	

SYSTEM PARAMETERS:

S.NO.	DESCRIPTION	765KV
01	SYSTEM OPERATING VOLTAGE	765kV
02	MAXIMUM OPERATING VOLTAGE OF THE SYSTEM (rms)	800kV
03	RATED FREQUENCY	50Hz
04	FULL WAVE IMPULSE WITHSTAND VOLTAGE (1.2/50 MICROSES.)	2100kVp
05	SWITCHING IMPULSE WITHSTAND VOLTAGE (250/2500 MICRO SEC.) DRY AND WET	1550kVp
06	ONE MINUTE POWER FREQUENCY DRY WITHSTAND VOLTAGE (rms)	830kV
07	ONE MINUTE POWER FREQUENCY DRY AND WET WITHSTAND VOLTAGE (rms)	--
08	CORONA EXTINCTION VOLTAGE	508kV
09	MAX. RADIO INTERFERENCE VOLTAGE FOR FREQUENCY BETWEEN 0.5 MHz AND 2 MHz	2500uV AT 508kV rms
10	MINIMUM CREEPAGE DISTANCE-FOR EQUIPMENT OTHER THAN INSULATOR STRING	20000mm

Cat I

पावरग्रिड
श्रेणियां
I. फेब्रिकेशन/निर्माण/हेतु अनुमोदित/जारी।
II. फेब्रिकेशन/निर्माण/हेतु अनुमोदित/जारी। बशर्ते दी गई टिप्पणियों एवं आशोधनों को सम्मिलित किया जाए। कृपया आशोधिक दस्तावेज अनुमोदनार्थ प्रस्तुत करें।
III. टिप्पणियाँ सम्मिलित कर पुनः अनुमोदनार्थ प्रस्तुत करें।
IV. सूचनार्थ एवं रिकार्ड हेतु।
V. अनुमोदित नहीं।
(हस्ताक्षर)
Dy. Mgr.
(पदनाम)
14/10/19
(तिथि)
पावर ग्रिड कॉरपोरेशन ऑफ इंडिया लि० अभियांत्रिकी (उपकेन्द्र), गुड़गाँव, हरियाणा

LEGENDS:-

————	PRESENT SCOPE
————	EXISTING / FUTURE

REFERENCE - EXISTING AS BUILT SLD FOR 765KV AURANGABAD S/S, DRAWING NO: 0702MH AUNG SUBS SWYD E DRG 41001, SHEET 2 OF 2

CT DETAILS:

765 kV, 3000A, CT (6 CORE)

Core No.	Current Ratio	Accuracy Class	Output Burden VA	Min kPV (V)	Max RCT in Ohms	Max Im at kPV (mA)	Purpose
1	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	BUS DIFF CHECK
2	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	BUS DIFF MAIN
3	3000-2000-500/1	0.2S	20	-	-	-	METERING
4	3000-2000-500/1	0.2S	20	-	-	-	METERING
5	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	REACTOR BACKUP
6	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	REACTOR DIFF.

NOA NO. : CC-CS/901-WR2/SS-3931/3/G3/NOA-I/8864 & 8865 DT. 29.07.19

ADDITIONAL INFORMATION
W.O.No. I19TB00001
STATUS OF DRAWING CONTRACT
DISTRIBUTION OF PRINTS

ग्राहक/परियोजना का नाम / NAME OF CUSTOMER/PROJECT: POWER GRID CORPORATION OF INDIA LIMITED
Substation Package-SS19 for extension of (i) 765kV Solapur S/S; (ii) 765kV Aurangabad S/S; (iii) 765kV Wardha S/S; (iv) 400kV Khandwa S/S; (v) 400kV Rajgarh S/S; (vi) 400kV Champa S/S; (vii) 400/220kV Itarsi S/S & (viii) 400/220kV Jabalpur Substation under WRSS-20.

बीएचईएल BHEL
भारत हेवी इलेक्ट्रिकल्स लिमिटेड
ट्रांसमिशन परियोजना विभाग
BHARAT HEAVY ELECTRICALS LTD.
TRANSMISSION PROJECTS DIVISION

	नाम /NAME	हस्ता./SIGN.	दि./DATE
बनाया DRAWN	DS		21.09.19
जाँचा CHECKED	JK		21.09.19
स्वीकृत APPROVED	SKS		21.09.19

REV.	DATE	ALTERED / CHECKED / APPROVED
ZONE		

विभाग DEPT. TBEM
कोड CODE 422
अनुपात / SCALE NTS
कार्ड कोड CARD CODE

शीर्षक/TITLE
SINGLE LINE DIAGRAM FOR EXTN. OF 765KV AURANGABAD SUBSTATION

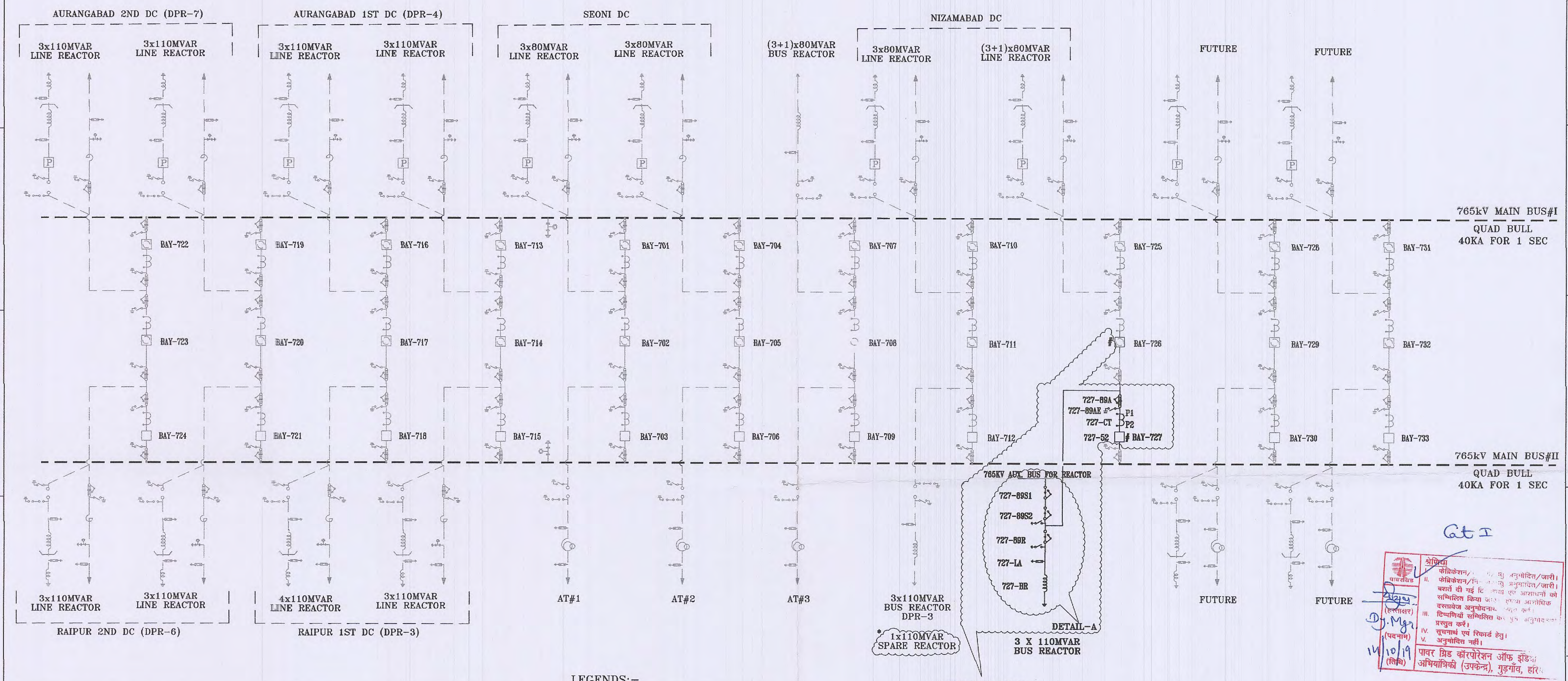
ड्राईग.क्र./DRAWING NO. TB-408-510-A01
पुनः/REV. 00
पृष्ठ क्र./SHEET No. 02 अगला पृष्ठ /NEXT SHEET —

COMPUTER DRG. PATH NAME :
REF. DRG. No.
SIGN. & DATE
INVENTORY No.

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM.)

DRAWING No. TB-408-510-W01

PRESENT SCOPE



LEGENDS:-

————	PRESENT SCOPE
— — — —	EXISTING / FUTURE

EQUIPMENT IDENTIFICATION:-

7 27 - 89 R E

- EQUIPMENT ID — 'E' REPRESENTS EARTH SWITCH
- EQUIPMENT ID —
  - A FOR EQUIPMENT IDENTIFICATION ON BUS-2 SIDE
  - B FOR EQUIPMENT IDENTIFICATION ON BUS-1 SIDE
  - L FOR LINE SIDE
  - R FOR REACTOR SIDE
  - T FOR TRANSFORMER SIDE
  - S FOR SPARE
- STANDARD EQUIPMENT NO. —
  - 89 FOR ISOLATOR
  - 52 FOR CIRCUIT BREAKER
  - CT FOR CURRENT TRANSFORMER
  - CVT FOR CAPACITOR VOLTAGE TRANSFORMER
  - LA FOR LIGHTNING ARRESTOR
  - WT FOR WAVE TRAP
- BAY NUMBER — 01, 02, 03 . . . .
- VOLTAGE LEVEL — 7 FOR 765kV SYSTEM

Cat I

श्रेणी
I. केकियोजन/... अनुमोदित/जारी।
II. केकियोजन/... अनुमोदित/जारी। बशर्ते की गई टिप्पणियाँ ... सम्मिलित किया ...
III. टिप्पणियाँ सम्मिलित कर ... प्रस्तुत करें।
IV. सूचनार्थ एवं रिकार्ड हेतु।
V. अनुमोदित नहीं।
(हस्ताक्षर) (पदनाम) Dy. Mgr (तिथि) 14/10/19
पावर ग्रिड कॉरपोरेशन ऑफ इंडिया ... अभियांत्रिकी (उपकेन्द्र), गुड़गाँव, हरि...

REFERENCE -
(1.) EXISTING SLD FOR 765KV WARDHA S/S EXTN., DRAWING NO: 5427PS087-WAR-E-SYD-SYS-0201-SL REV 01
(2.) * SPARE REACTOR IS NOT IN SLD, BUT SEEN ON MAP

NOA NO. : CC-CS/901-WR2/SS-3931/3/G3/NOA-I/8864 & 8865 DT. 29.07.19

ADDITIONAL INFORMATION
W.O.No. I19TB00001

STATUS OF DRAWING: CONTRACT

DISTRIBUTION OF PRINTS

ग्राहक/परियोजना का नाम / NAME OF CUSTOMER/PROJECT: POWER GRID CORPORATION OF INDIA LIMITED
Substation Package-SS19 for extension of (i) 765kV Solapur S/S; (ii) 765kV Aurangabad S/S; (iii) 765kV Wardha S/S; (iv) 400kV Khandwa S/S; (v) 400kV Rajgarh S/S; (vi) 400kV Champa S/S; (vii) 400/220kV Itarsi S/S & (viii) 400/220kV Jabalpur Substation under WRSS-20.

बीएचईएल
भारत हेवी इलेक्ट्रिकल्स लिमिटेड
ट्रांसमिशन परियोजना विभाग
BHARAT HEAVY ELECTRICALS LTD.
TRANSMISSION PROJECTS DIVISION

	नाम /NAME	हस्ता./SIGN.	दि./DATE
बनाया DRAWN	DS		26.09.19
जाँचा CHECKED	JK		26.09.19
स्वीकृत APPROVED	SKS		26.09.19

REV.	DATE	ALTERED / CHECKED / APPROVED

ZONE

विभाग DEPT. TBEM
कोड CODE 422
अनुपात / SCALE NTS
कार्ड कोड CARD CODE
JAI KUMAR (Digitally signed by JAI KUMAR, Date: 2019.09.26)

शीर्षक/TITLE: SINGLE LINE DIAGRAM FOR EXTN. OF 765KV WARDHA SUBSTATION

ड्राइंग.क्र./DRAWING NO. TB-408-510-W01
पुन:/REV. 00
पृष्ठ क्र./SHEET No. 01
अगला पृष्ठ/NEXT SHEET 02

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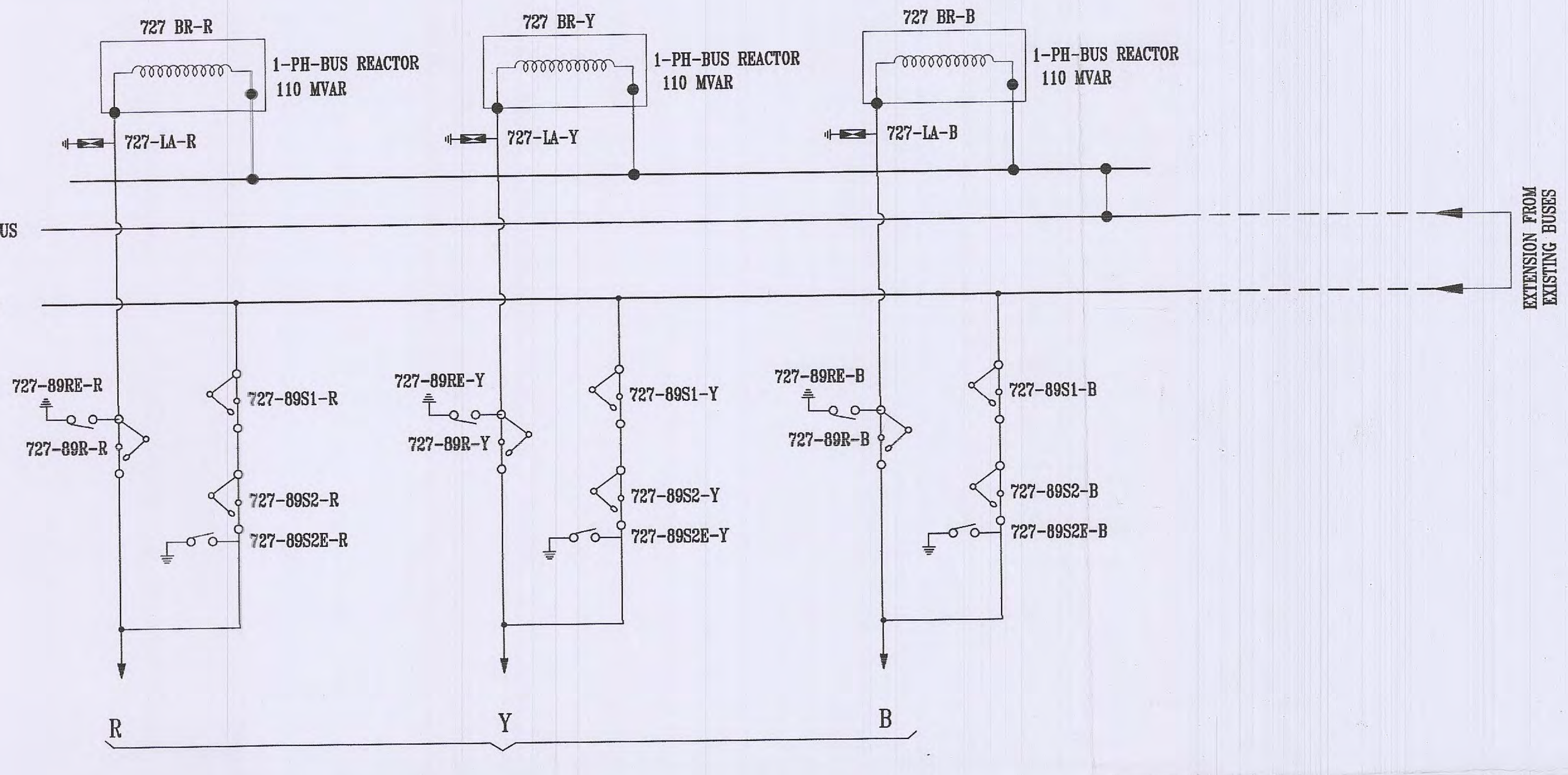
COMPUTER DRG. PATH NAME :
REF. DRG. No.
SIGN. & DATE
INVENTORY No.

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM.)

DRAWING No. TB-408-510-W01



765KV BUS REACTOR BAY
BAY-727

(ARRANGEMENT OF 765kV BUS REACTOR AND AUX. BUS.)

DETAIL-A

BILL OF QTY. FOR 765kV MAIN EQUIPMENTS (40KA, 1 SEC):

SL.NO.	DESCRIPTION RATING	QTY. (NO.)	SYMBOL	LEGEND
1	765KV, 110MVAR, 1-PH BUS REACTOR NOT IN BHEL SCOPE OF SUPPLY	3		BR
2	765KV, 3150A, 3-PH, SF6 CIRCUIT BREAKER WITHOUR PIR)	1		52
3	765KV, 3150A, 3-PH, ISOLATOR WITH ONE E/S, VERTICAL KNEE TYPE	1		89A
4	765KV, 3150A, 1-PH, ISOLATOR WITH ONE E/S, VERTICAL KNEE TYPE	6		89R 89S2
5	765KV, 3150A, 1-PH, HDB ISOLATOR WITHOUT E/S, VERTICAL KNEE TYPE	3		89S1
6	765KV, 3000A, 1-PH CURRENT TRANSFORMER WITH 120% EXTENDED CURRENT RATING	3		CT
7	624KV, 1-PH, SURGE ARRESTER (1 PH.)	3		LA
8	CONTROLLED SWITCHING DEVICE FOR 765KV, 3 PHASE CIRCUIT BREAKER	2	#	

SYSTEM PARAMETERS:

S.NO.	DESCRIPTION	765KV
01	SYSTEM OPERATING VOLTAGE	765kV
02	MAXIMUM OPERATING VOLTAGE OF THE SYSTEM (rms)	800kV
03	RATED FREQUENCY	50Hz
04	FULL WAVE IMPULSE WITHSTAND VOLTAGE (1.2/50 MICROSES.)	2100kVp
05	SWITCHING IMPULSE WITHSTAND VOLTAGE (250/2500 MICRO SEC.) DRY AND WRT	1550kVp
06	ONE MINUTE POWER FREQUENCY DRY WITHSTAND VOLTAGE (rms)	830kV
07	ONE MINUTE POWER FREQUENCY DRY AND WET WITHSTAND VOLTAGE (rms)	--
08	CORONA EXTINCTION VOLTAGE	508kV
09	MAX. RADIO INTERFERENCE VOLRAGE FOR FREQUENCY BETWEEN 0.5 MHz AND 2 MHz	2500uV AT 508kV rms
10	MINIMUM CREEPAGE DISTANCE-FOR EQUIPMENT OTHER THAN INSULATOR STRING	20000mm
11	FAULT LEVEL	40KV FOR 1SEC

Cat I

श्रेणियां
I. फेब्रिकेशन/निर्माण/हेतु अनुमोदित/जारी।
II. फेब्रिकेशन/निर्माण/हेतु अनुमोदित/जारी। बशर्ते दी गई टिप्पणियां एवं आशोधनों को सम्मिलित किया जाए। कृपया आशोधित दस्तावेज अनुमोदनार्थ प्रस्तुत करें।
III. टिप्पणियां सम्मिलित कर पुनः अनुमोदनार्थ प्रस्तुत करें।
IV. सूचनार्थ एवं रिकार्ड हेतु।
V. अनुमोदित नहीं।
Dy. Mgr.
14/10/19
पावर ग्रिड कॉरपोरेशन ऑफ इंडिया लि० अभियांत्रिकी (उपकेन्द्र), गुड़गाँव, हरियाणा

LEGENDS:-

————	PRESENT SCOPE
— — — — —	EXISTING / FUTURE

REFERENCE - EXISTING SLD FOR 765KV WARDHA S/S EXTN.,
DRAWING NO: 5427PS087-WAR-E-SYD-SYS-0201-SL REV 01

CT DETAILS:

765 kV, 3000A, CT (6 CORE)

Core No.	Current Ratio	Accuracy Class	Output Burden VA	Min kPV (V)	Max RCT in Ohms	Max Im at kPV (mA)	Purpose
1	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	BUS DIFF CHECK
2	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	BUS DIFF MAIN
3	3000-2000-500/1	0.2S	20	-	-	-	METERING
4	3000-2000-500/1	0.2S	20	-	-	-	METERING
5	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	REACTOR BACKUP
6	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	REACTOR DIFF.

NOA NO. : CC-CS/901-WR2/SS-3931/3/G3/NOA-I/8864 & 8865 DT. 29.07.19

ADDITIONAL INFORMATION
W.O.No. I19TB00001
STATUS OF DRAWING CONTRACT
DISTRIBUTION OF PRINTS

ग्राहक/परियोजना का नाम / NAME OF CUSTOMER/PROJECT: POWER GRID CORPORATION OF INDIA LIMITED
Substation Package-SS19 for extension of (i) 765kV Solapur S/S; (ii) 765kV Aurangabad S/S; (iii) 765kV Wardha S/S; (iv) 400kV Khandwa S/S; (v) 400kV Rajgarh S/S; (vi) 400kV Champa S/S; (vii) 400/220kV Itarsi S/S & (viii) 400/220kV Jabalpur Substation under WRSS-20.

बीएचईएल BHEL
भारत हेवी इलेक्ट्रिकल्स लिमिटेड
ट्रांसमिशन परियोजना विभाग
BHARAT HEAVY ELECTRICALS LTD.
TRANSMISSION PROJECTS DIVISION

	नाम /NAME	हस्ता./SIGN.	दि./DATE
बनाया DRAWN	DS		26.09.19
जाँचा CHECKED	JK		26.09.19
स्वीकृत APPROVED	SKS		26.09.19

REV. | DATE | ALTERED | CHECKED | APPROVED
ZONE

विभाग DEPT. TBEM
कोड CODE 422
अनुपात / SCALE NTS
कार्ड कोड CARD CODE

JAI KUMAR
Digitally signed by JAI KUMAR
Date: 2019.09.26 12:29:49 +05'30'

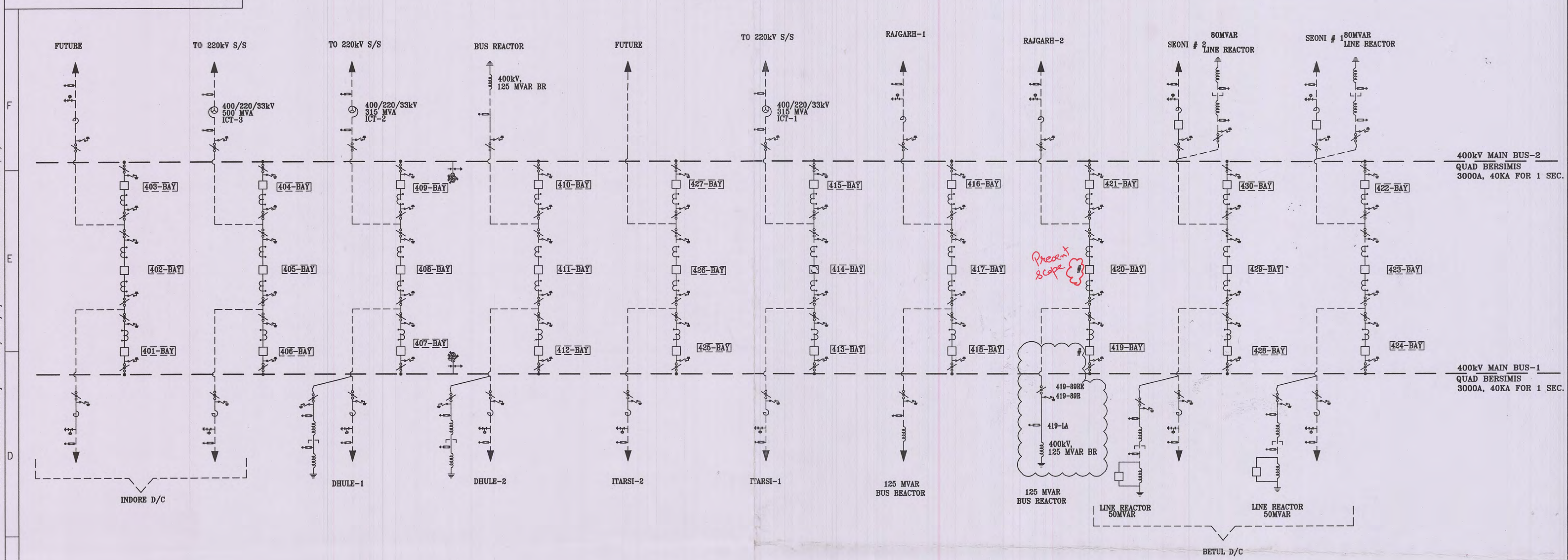
शीर्षक/TITLE
SINGLE LINE DIAGRAM FOR
EXTN. OF 765KV WARDHA SUBSTATION

ड्राईग.क्र./DRAWING NO. TB-408-510-W01
पुनः/REV. 00
पृष्ठ क्र./SHEET No. 02 अगला पृष्ठ /NEXT SHEET -

COMPUTER DRG. PATH NAME :
REF. DRG. No.
SIGN. & DATE
INVENTORY No.

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM.)

DRAWING No. TB-408-510-K01



400KV SINGLE LINE DIAGRAM

Cat I

श्रेणिया
I. फेब्रिकेशन / निर्माण / हेतु अनुमोदित / जारी।
II. फेब्रिकेशन / निर्माण / हेतु अनुमोदित / जारी। बशर्ते दी गई टिप्पणियों एवं आशोधनों को सम्मिलित किया जाए। कृपया आशोधित दस्तावेज अनुमोदनार्थ प्रस्तुत करें।
III. टिप्पणियाँ सम्मिलित कर पुनः अनुमोदनार्थ प्रस्तुत करें।
IV. सूचनार्थ एवं रिकार्ड हेतु।
V. अनुमोदित नहीं।
पावरग्रिड
(हस्ताक्षर)
Dy. Mgr.
(पदनाम)
20/12/19
(दिनांक)
पावर ग्रिड कॉरपोरेशन ऑफ इंडिया लि०
अभियात्रिकी (उपकेन्द्र) गुड़गाँव, हरियाणा

BILL OF QUANTITIES-400KV:

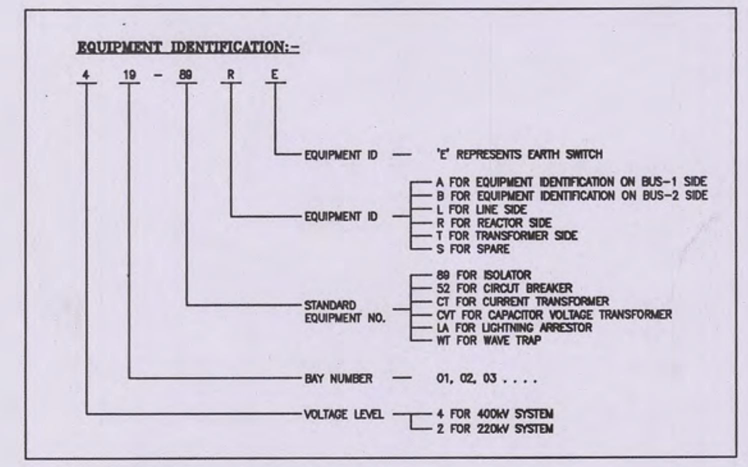
S.NO.	SYMBOL	LEGEND	DESCRIPTION	QTY. AS PER NOA (NOS.)	QTY. AS PER PRESENT SCOPE(NOS.)
01		BR	125MVAR 400kV, 3-PH BUS REACTOR (SUPPLY AND ETC IS NOT IN BHEL SCOPE)	01	01
02		52	400KV, 3150A, 3-PH, 40KA FOR 1 SEC, CIRCUIT BREAKER WITHOUT CLOSING RESISTOR	01	00
03	#		CONTROLLED SWITCHING DEVICE (SUITABLE FOR 3 PHASE CIRCUIT BREAKER)	02	02
04		89	400KV, 3150A, 3-PH, 40KA FOR 1 SEC, HORIZONTAL DOUBLE BREAK ISOLATOR WITH 1 E/S	02	01
05		CT	400KV. 3000A, 1-PH, 40KA FOR 1 SEC, CURRENT TRANSFORMER WITH 120% EXT. CURRENT RATING	03	00
06		LA	336KV, 1-PH, SURGE ARRESTER	03	03

SYSTEM PARAMETERS:

S.NO.	DESCRIPTION	400KV
01	SYSTEM OPERATING VOLTAGE	400kV
02	MAXIMUM OPERATING VOLTAGE OF THE SYSTEM (rms)	420kV
03	RATED FREQUENCY	50Hz
04	FULL WAVE IMPULSE WITHSTAND VOLTAGE (1.2/50 MICROSES.)	1550kVp
05	SWITCHING IMPULSE WITHSTAND VOLTAGE (250/2500 MICRO SEC.) DRY AND WRT	1050kVp
06	ONE MINUTE POWER FREQUENCY DRY WITHSTAND VOLTAGE (rms)	630kV
07	ONE MINUTE POWER FREQUENCY DRY AND WET WITHSTAND VOLTAGE (rms)	--
08	CORONA EXTINCTION VOLTAGE	320kV
09	MAX. RADIO INTERFERENCE VOLRAGE FOR FREQUENCY BETWEEN 0.5 MHz AND 2 MHz	1000μV AT 266kV rms
10	MINIMUM CREEPAGE DISTANCE-FOR EQUIPMENT OTHER THAN INSULATOR STRING	10500mm
11	SYSTEM FAULT LEVEL	40kA FOR 1 SEC

LEGENDS:-

————	PRESENT SCOPE
- - - - - -	EXISTING / FUTURE



REFERENCE DRAWING:
1. G&B-SS01-KHA-E-SLD-001 REV.03

NOA NO. : CC-CS/901-WR2/SS-3931/3/G3/NOA-I/8864 & 8865 DT. 29.07.19

ग्राहक/परियोजना का नाम
NAME OF CUSTOMER/PROJECT

POWER GRID CORPORATION OF INDIA LIMITED
Substation Package-SS19 for extension of (i) 765kV Solapur S/S; (ii) 765kV Aurangabad S/S; (iii) 765kV Wardha S/S; (iv) 400kV Khandwa S/S; (v) 400kV Rajgarh S/S; (vi) 400kV Champa S/S; (vii) 400/220kV Itarsi S/S & (viii) 400/220kV Jabalpur Substation under WRSS-20.

ADDITIONAL INFORMATION
W.O.No. I19TB00001

STATUS OF DRAWING CONTRACT

DISTRIBUTION OF PRINTS

बीएचईएल BHEL
भारत हेवी इलेक्ट्रिकल्स लिमिटेड
ट्रांसमिशन परियोजना विभाग
BHARAT HEAVY ELECTRICALS LTD.
TRANSMISSION PROJECTS DIVISION

	नाम /NAME	हस्ता./SIGN.	दि./DATE
बनाया DRAWN	DS		19.09.19
जँचा CHECKED	JK		19.09.19
स्वीकृत APPROVED	SKS		19.09.19

REV.	DATE		
00	06.11.19	ALTERED	DS
		CHECKED	JK
		APPROVED	SKS

ZONE
1. DRAWING REVISED AS PER M/S POWERGRID COMMENTS VIDE EMAIL DTD. 25.11.19

विभाग DEPT. TBEM
कोड CODE 422
अनुपात / SCALE NTS
कार्ड कोड CARD CODE

DEEPALI SHARMA
Digitally signed by DEEPALI SHARMA
DN: c=IN, o=BHARAT HEAVY ELECTRICALS LIMITED, ou=TBG- Noida, postalCode=201305, st=Uttar Pradesh, 2.5.4.20=0274c402e19e3ff8cdac3a07e309ce8f0f86249d9bb20cb43a1789e4d05c40cc, cn=DEEPALI SHARMA
Date: 2019.12.06 17:15:39 +05'30'

शीर्षक/TITLE
SINGLE LINE DIAGRAM
FOR EXTN. OF 400KV KHANDWA S/S

ड्राईग.क्र./DRAWING NO. TB-408-510-K01
पुनः/REV. 01
पृष्ठ क्र./SHEET No. 01
अगला पृष्ठ /NEXT SHEET --

COMPUTER DRG. PATH NAME :
REF. DRG. No.
SIGN. & DATE
INVENTORY No.

SIZE-A2

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM.)

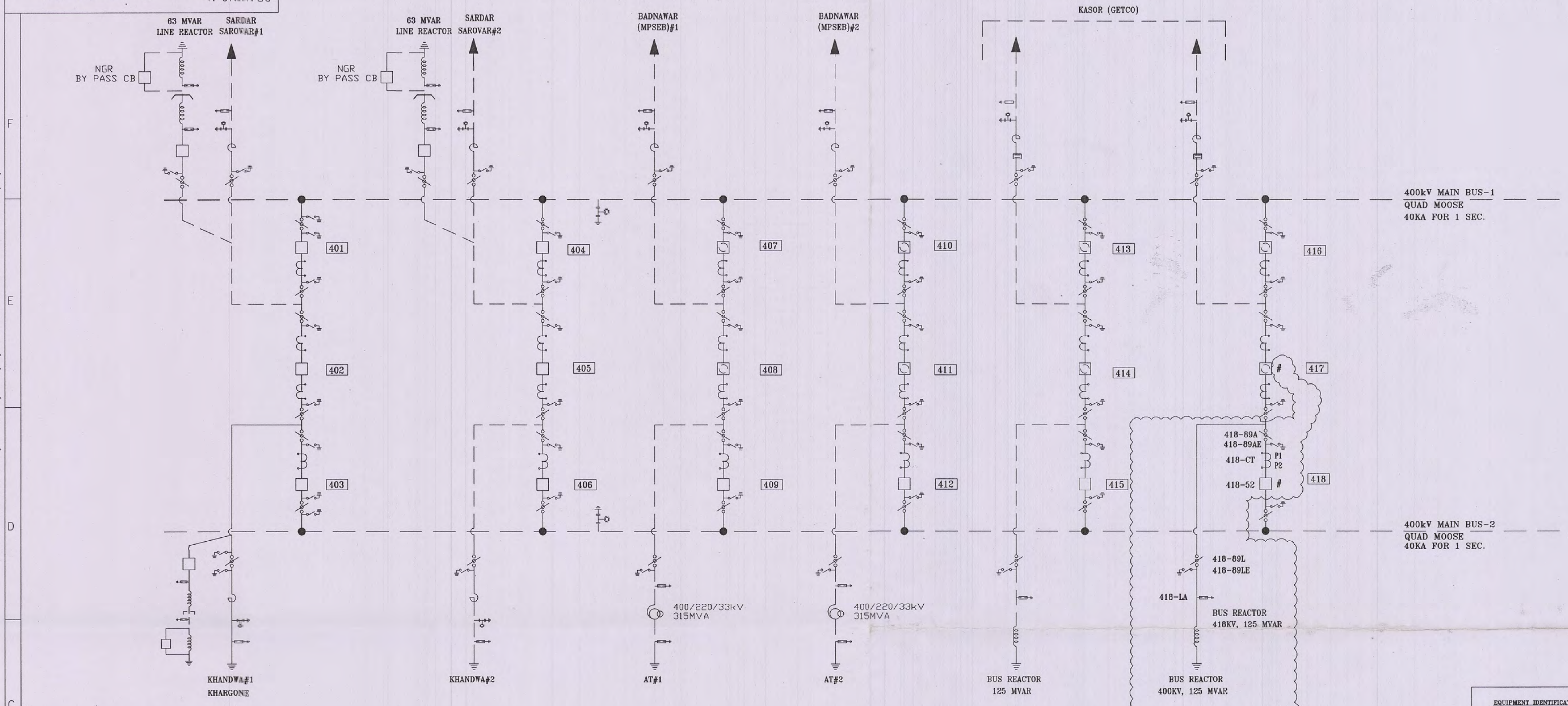
DRAWING No. TB-408-510-R01

COMPUTER DRG. PATH NAME :

REF. DRG. No.

SIGN. & DATE

INVENTORY No.



400KV SINGLE LINE DIAGRAM

BILL OF QUANTITIES-400KV:

S.NO.	SYMBOL	LEGEND	DECCRIPTION	QTY. (NOS)
01		BR	125MVAR 400kV, 3-PH BUS REACTOR (NOT IN BHEL SCOPE)	1
02		52	400KV, 3150A, 3-PH, 40KA FOR 1 SEC CIRCUIT BREAKER WITHOUT CLOSING RESISTOR	1
03	#		CONTROLLED SWITCHING DEVICE (SUITABLE FOR 3 PHASE CIRCUIT BREAKER)	2
03		89	400KV, 3150A, 3-PH, 40KA FOR 1 SEC HORIZONTAL DOUBLE BREAK ISOLATOR WITH 1 E/S	2
04		CT	400KV. 3000A, 1-PH ,40KA FOR 1 SEC, CURRENT TRANSFORMER WITH 120% EXT. CURRENT RATING	3
05		LA	336KV, 1-PH, SURGE ARRESTER	3

SYSTEM PARAMETERS:

S.NO.	DESCRIPTION	400KV
01	SYSTEM OPERATING VOLTAGE	400kV
02	MAXIMUM OPERATING VOLTAGE OF THE SYSTEM (rms)	420kV
03	RATED FREQUENCY	50Hz
04	FULL WAVE IMPULSE WITHSTAND VOLTAGE (1.2/50 MICROSES.)	1550kVp
05	SWITCHING IMPULSE WITHSTAND VOLTAGE (250/2500 MICRO SEC.) DRY AND WRT	1050kVp
06	ONE MINUTE POWER FREQUENCY DRY WITHSTAND VOLTAGE (rms)	630kV
07	ONE MINUTE POWER FREQUENCY DRY AND WET WITHSTAND VOLTAGE (rms)	--
08	CORONA EXTINCTION VOLTAGE	320kV
09	MAX. RADIO INTERFERENCE VOLRAGE FOR FREQUENCY BETWEEN 0.5 MHz AND 2 MHz	1000μV AT 266kV rms
10	MINIMUM CREEPAGE DISTANCE-FOR EQUIPMENT OTHER THAN INSULATOR STRING	10500mm
11	SYSTEM FAULT LEVEL	40kA FOR 1 SEC

CT DETAILS:

420 kV, 3000A, CT (6 CORE)

Core	Current Ratio	Accuracy Class	Output Burden VA	Min kPV (V)	Max RCT in Ohms	Max Im at kPV (mA)	Purpose
1	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	BUS DIFF CHECK
2	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	BUS DIFF MAIN
3	3000-2000-500/1	0.2S	20	-	-	-	METERING
4	3000-2000-500/1	0.2S	20	-	-	-	METERING
5	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	REACTOR BACKUP
6	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	REACTOR DIFF

Ct-I

पावरग्रिड
(हस्ताक्षर)
Dy. Mgr.
(पदनाम)
25/11/19
(दिनांक)

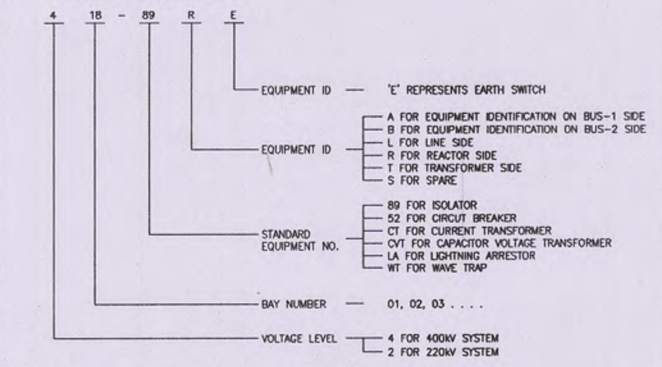
श्रेणियां
I. फेब्रिकेशन / निर्माण / हेतु अनुमोदित / जारी।
II. फेब्रिकेशन / निर्माण / हेतु अनुमोदित / जारी। बशर्ते दी गई टिप्पणियों एवं आशोधनों को सम्मिलित किया जाए। कृपया आशोधित दस्तावेज अनुमोदनार्थ प्रस्तुत करें।
III. टिप्पणियाँ सम्मिलित कर पुनः अनुमोदनार्थ प्रस्तुत करें।
IV. सूचनार्थ एवं रिकार्ड हेतु।
V. अनुमोदित नहीं।
पावर ग्रिड कॉरपोरेशन ऑफ इंडिया लि०
अभियांत्रिकी (उपकेन्द्र) गुड़गाँव, हरियाणा

PRESENT SCOPE

LEGENDS:-

————	PRESENT SCOPE
- - - - - -	EXISTING / FUTURE

EQUIPMENT IDENTIFICATION:-



REFERENCE DRAWING:
1. xxxxxx

NOA NO. : CC-CS/901-WR2/SS-3931/3/G3/NOA-I/8864 & 8865 DT. 29.07.19

ADDITIONAL INFORMATION
W.O.No. I19TB00001

STATUS OF DRAWING CONTRACT

DISTRIBUTION OF PRINTS

ग्राहक/परियोजना का नाम
NAME OF CUSTOMER/PROJECT

POWER GRID CORPORATION OF INDIA LIMITED

Substation Package-SS19 for extension of (i) 765kV Solapur S/S; (ii) 765kV Aurangabad S/S; (iii) 765kV Wardha S/S; (iv) 400kV Khandwa S/S; (v) 400kV Rajgarh S/S; (vi) 400kV Champa S/S; (vii) 400/220kV Itarsi S/S & (viii) 400/220kV Jabalpur Substation under WRSS-20.

बीएचईएल BHEL

भारत हेवी इलेक्ट्रिकल्स लिमिटेड
ट्रांसमिशन परियोजना विभाग
BHARAT HEAVY ELECTRICALS LTD.
TRANSMISSION PROJECTS DIVISION

	नाम /NAME	हस्ता./SIGN.	दि./DATE
बनाया DRAWN	DS		19.09.19
जाँचा CHECKED	JK		19.09.19
स्वीकृत APPROVED	SKS		19.09.19

REV.	DATE		
00	07.11.19	ALTERED	DS
		CHECKED	JK
		APPROVED	SKS

ZONE

1. DRAWING REVISED AS PER M/S POWERGRID COMMENTS VIDE LETTER NO. VIDE LETTER REF NO. C-ENGG-WR-WRSS-20/BHEL/02 DT. 04.10.19.

विभाग DEPT. TBEM
कोड CODE 422
अनुपात / SCALE NTS
कार्ड कोड CARD CODE

DEEPALI SHARMA
Digitally signed by DEEPALI SHARMA
DN: c=IN, o=BHARAT HEAVY ELECTRICALS LIMITED, ou=TBG- Noida, postalCode=201305, st=Uttar Pradesh, 2.5.4.20=0274c402e19e3ff8cdac3a07e309ce8f 0f86249d9bb20cb43a1789e4d05c40cc, cn=DEEPALI SHARMA
Date: 2019.11.07 17:43:19 +05'30'

शीर्षक/TITLE
SINGLE LINE DIAGRAM
FOR EXTN. OF 400KV RAJGARH S/S

ड्राईंग.क्र./DRAWING NO. TB-408-510-R01

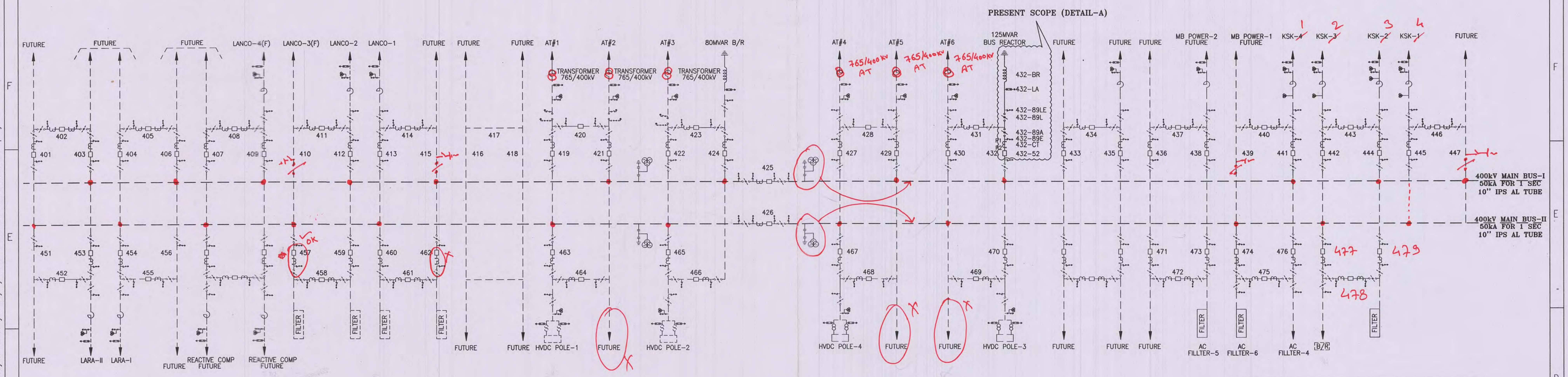
पुनः/REV. 01

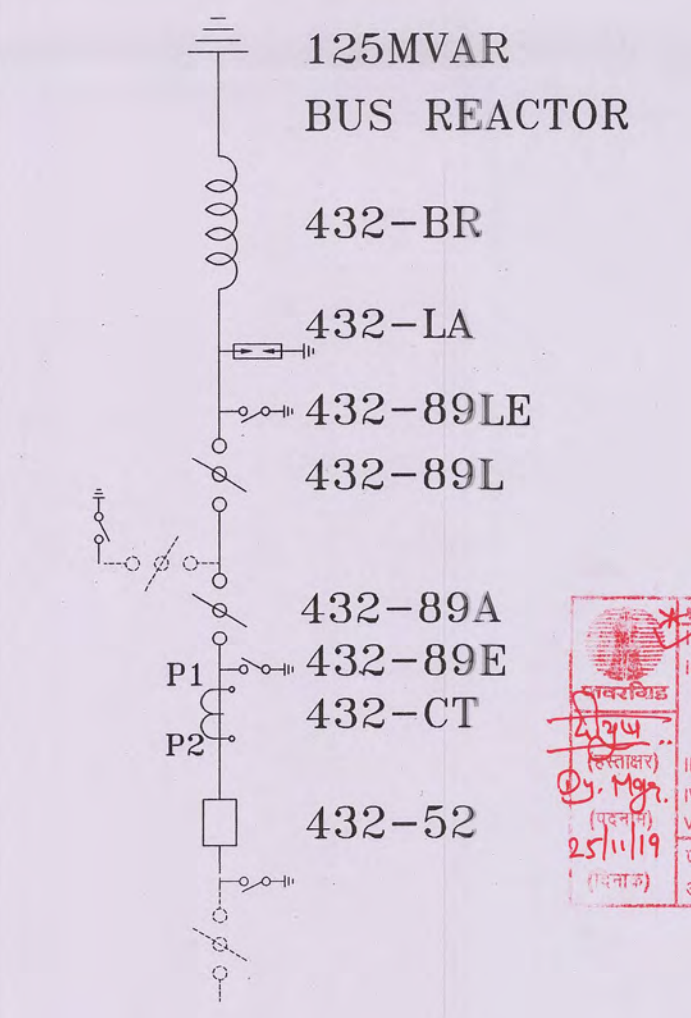
पृष्ठ क्र./SHEET No. 01 अगला पृष्ठ /NEXT SHEET --

SIZE-A2

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM.)

DRAWING No. TB-408-510-C01



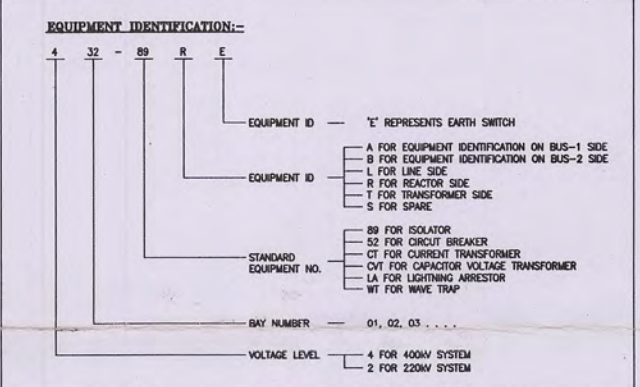


PRESENT SCOPE (DETAIL A)

Gt I*

LEGENDS:-

———	PRESENT SCOPE
— — —	EXISTING / FUTURE



SYSTEM PARAMETERS:

S.NO.	DESCRIPTION	400KV
01	SYSTEM OPERATING VOLTAGE	400kV
02	MAXIMUM OPERATING VOLTAGE OF THE SYSTEM (rms)	420kV
03	RATED FREQUENCY	50Hz
04	FULL WAVE IMPULSE WITHSTAND VOLTAGE (1.2/50 MICROSES.)	1550kVp
05	SWITCHING IMPULSE WITHSTAND VOLTAGE (250/2500 MICRO SEC.) DRY AND WRT	1050kVp
06	ONE MINUTE POWER FREQUENCY DRY WITHSTAND VOLTAGE (rms)	630kV
07	ONE MINUTE POWER FREQUENCY DRY AND WET WITHSTAND VOLTAGE (rms)	--
08	CORONA EXTINCTION VOLTAGE	320kV
09	MAX. RADIO INTERFERENCE VOLRAGE FOR FREQUENCY BETWEEN 0.5 MHz AND 2 MHz	1000µV AT 266kV rms
10	MINIMUM CREEPAGE DISTANCE-FOR EQUIPMENT OTHER THAN INSULATOR STRING	10500mm
11	FAULT LEVEL	50KA FOR 1 SEC

BILL OF QUANTITIES-400KV:

S.NO.	SYMBOL	LEGEND	DECCRIPTION	QTY. (NOS)
01		BR	125MVAR 400kV, 3-PH BUS REACTOR (NOT IN BHEL SCOPE OF SUPPLY)	1
02		52	400KV, 3150A, 50KA FOR 1 SEC. 3-PH CIRCUIT BREAKER WITHOUT CLOSING RESISTOR & WITH CSD	1
03		89	400KV, 3150A, 50KA FOR 1 SEC. 3-PH, HORIZONTAL DOUBLE BREAK ISOLATOR WITH 1 E/S	2
04		CT	400KV. 3000A, 50KA FOR 1 SEC. 1-PH CURRENT TRANSFORMER WITH 120% EXTENDED CURRENT RATING	3
05		LA	336KV, 1-PH, SURGE ARRESTER	3

CT DETAILS:

420 kV, 3000A, CT (6 CORE)

Core	Current Ratio	Accuracy Class	Output Burden VA	Min kPV (V)	Max RCT in Ohms	Max Im at kPV (mA)	Purpose
1	3000-2000-500/1	PX	–	3000-2000-500	15/10/2.5	20-30-120	BUS DIFF CHECK
2	3000-2000-500/1	PX	–	3000-2000-500	15/10/2.5	20-30-120	BUS DIFF MAIN
3	3000-2000-500/1	0.2S	20	–	–	–	METERING
4	3000-2000-500/1	0.2S	20	–	–	–	METERING
5	3000-2000-500/1	PX	–	3000-2000-500	15/10/2.5	20-30-120	REACTOR BACKUP
6	3000-2000-500/1	PX	–	3000-2000-500	15/10/2.5	20-30-120	REACTOR DIFF

REFERENCE DRAWING:
1. TENDER SLD: C/ENGG/WR/WRSS-20/ CHAMPA-EXTN/SLD/ 01 REV.00
2. EXISTING SLD: 5427PS082-CHA-E-SYD-SYS-401-SL REV 01 DTD. 28.03.15

NOA NO. : CC-CS/901-WR2/SS-3931/3/G3/NOA-I/8864 & 8865 DT. 29.07.19

ADDITIONAL INFORMATION
W.O.No. I19TB00001

STATUS OF DRAWING CONTRACT

DISTRIBUTION OF PRINTS

ग्राहक/परियोजना का नाम
NAME OF CUSTOMER/PROJECT
POWER GRID CORPORATION OF INDIA LIMITED
Substation Package-SS19 for extension of (i) 765kV Solapur S/S; (ii) 765kV Aurangabad S/S; (iii) 765kV Wardha S/S; (iv) 400kV Khandwa S/S; (v) 400kV Rajgarh S/S; (vi) 400kV Champa S/S; (vii) 400/220kV Itarsi S/S & (viii) 400/220kV Jabalpur Substation under WRSS-20.

भारत हेवी इलेक्ट्रिकल्स लिमिटेड
ट्रांसमिशन परियोजना विभाग
BHARAT HEAVY ELECTRICALS LTD.
TRANSMISSION PROJECTS DIVISION

	नाम /NAME	हस्ता./SIGN.	दि./DATE
बनाया DRAWN	DS		28.09.19
जाँचा CHECKED	JK		28.09.19
स्वीकृत APPROVED	SKS		28.09.19

REV.	DATE		
00	13.11.19	ALTERED	DS
		CHECKED	JK
		APPROVED	SKS

ZONE
1. DRAWING REVISED AS PER M/S POWERGRID COMMENTS VIDE LETTER NO. VIDE LETTER REF NO. C-ENGG-WR-WRSS-20/BHEL/06 DT. 01.11.19.

विभाग DEPT. TBEM
कोड CODE 422
अनुपात / SCALE NTS
कार्ड कोड CARD CODE

DEEPALI SHARMA
Digitally signed by DEEPALI SHARMA DN: c=IN, o=BHARAT HEAVY ELECTRICALS LIMITED, ou=TBG-Noida, postalCode=201305, st=Uttar Pradesh, 2.5.4.20=0274c402e19e3ff8cdac3a07e309ce8f0f86249d9bb20cb43a1789e4d05c40cc, cn=DEEPALI SHARMA Date: 2019.11.13 17:38:46 +05'30'

शीर्षक/TITLE
SINGLE LINE DIAGRAM
FOR EXTN. OF 400KV CHAMPA S/S

ड्राईग.क्र./DRAWING NO. TB-408-510-C01
पुनः/REV. 01
पृष्ठ क्र./SHEET No. 01
अगला पृष्ठ/NEXT SHEET --

SIZE-A1

COMPUTER DRG. PATH NAME :
REF. DRG. No.
SIGN. & DATE
INVENTORY No.

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM.)

DRAWING No. TB-408-510-J01

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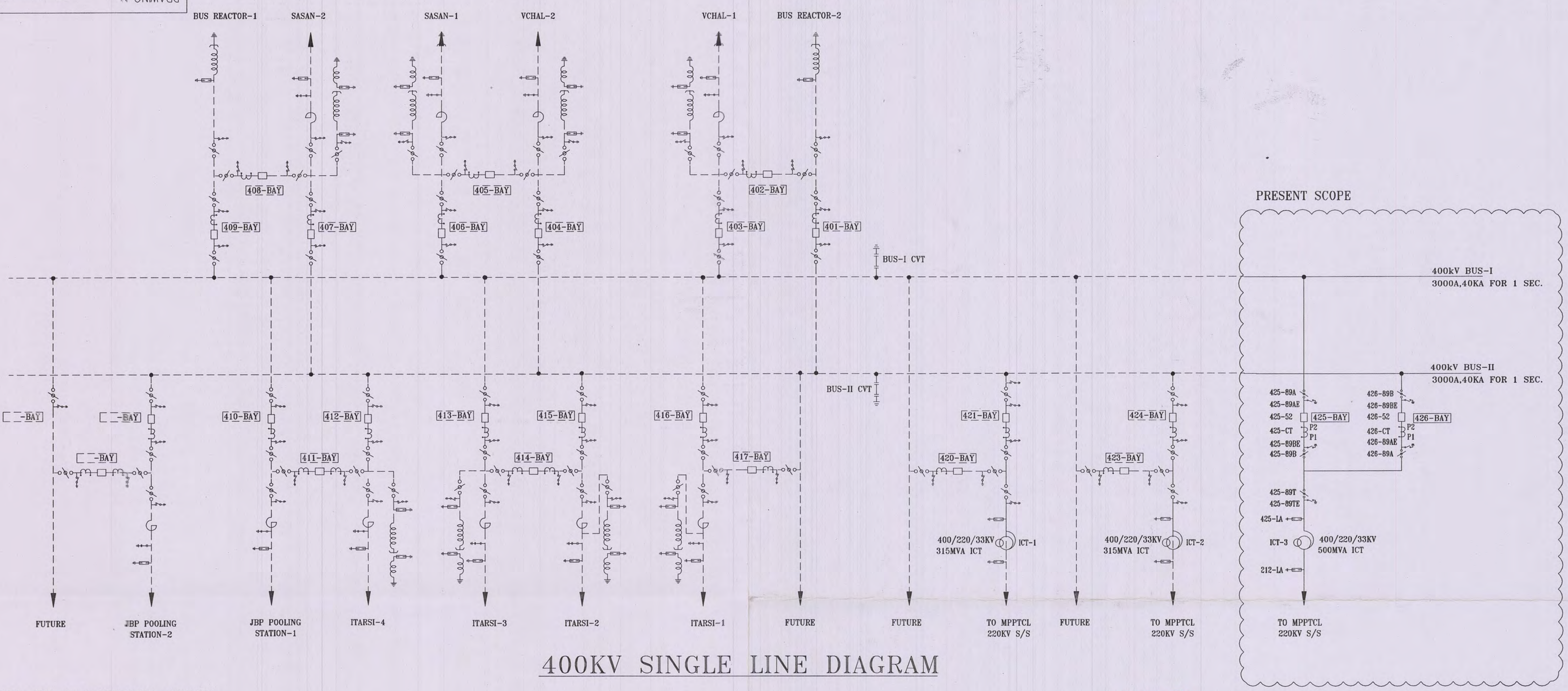

400KV SINGLE LINE DIAGRAM

BILL OF QUANTITIES-400KV:

S.NO.	SYMBOL	LEGEND	DECCRIPTION	QTY. (NOS)
01		ICT	500MVA, 400/220/33kV, 3-PH AUTO TRANSFORMER	1
02		52	400KV, 3150A, 3-PH, 40KA FOR 1 SEC CIRCUIT BREAKER WITHOUT CLOSING RESISTOR	~~5~~ 2
03	#		CONTROLLED SWITCHING DEVICE (SUITABLE FOR 3 PHASE CIRCUIT BREAKER)	2
03		89	400KV, 3150A, 3-PH, 40KA FOR 1 SEC HORIZONTAL DOUBLE BREAK ISOLATOR WITH 1 E/S	5
04		CT	400KV. 3000A, 1-PH ,40KA FOR 1 SEC, CURRENT TRANSFORMER WITH 120% EXT. CURRENT RATING	6
05		LA	336KV, 1-PH, SURGE ARRESTER	3

SYSTEM PARAMETERS:

S.NO.	DESCRIPTION	400KV	220KV
01	SYSTEM OPERATING VOLTAGE	400kV	220kV
02	MAXIMUM OPERATING VOLTAGE OF THE SYSTEM (rms)	420kV	245kv
03	RATED FREQUENCY	50Hz	50Hz
04	FULL WAVE IMPULSE WITHSTAND VOLTAGE (1.2/50 MICROSES.)	1550kVp	1050kVp
05	SWITCHING IMPULSE WITHSTAND VOLTAGE (250/2500 MICRO SEC.) DRY AND WRT	1050kVp	--
06	ONE MINUTE POWER FREQUENCY DRY WITHSTAND VOLTAGE (rms)	630kV	--
07	ONE MINUTE POWER FREQUENCY DRY AND WET WITHSTAND VOLTAGE (rms)	--	460kV
08	CORONA EXTINCTION VOLTAGE	320kV	--
09	MAX. RADIO INTERFERENCE VOLRAGE FOR FREQUENCY BETWEEN 0.5 MHz AND 2 MHz	1000μV AT 266kV rms	1000μV AT 156kV rms
10	MINIMUM CREEPAGE DISTANCE-FOR EQUIPMENT OTHER THAN INSULATOR STRING	10500mm	6125mm

CT DETAILS:

420 kV, 3000A, CT (6 CORE)

Core No.	Current Ratio	Accuracy Class	Output Burden VA	Min kPV (V)	Max RCT in Ohms	Max Im at kPV (mA)	Purpose
1	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	BUS DIFF CHECK
2	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	BUS DIFF MAIN
3	3000-2000-500/1	0.2S	20	-	-	-	METERING
4	3000-2000-500/1	0.2S	20	-	-	-	METERING
5	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	TRANS. BACKUP/LINE MAIN-2
6	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	TRANS. DIFF/LINE MAIN-1

Cat I

Dy. Mgr.
25/11/19
(दिनांक)

पावर ग्रिड कॉरपोरेशन ऑफ इंडिया लि०
अभियांत्रिकी (उपकेन्द्र) गुड़गाँव, हरियाणा

LEGENDS:-

————	PRESENT SCOPE
- - - - - - -	EXISTING/FUTURE SCOPE

NOA NO. : CC-CS/901-WR2/SS-3931/3/G3/NOA-I/8864 & 8865 DT. 29.07.19

ADDITIONAL INFORMATION
W.O.No. I19TB00001

STATUS OF DRAWING CONTRACT

DISTRIBUTION OF PRINTS

ग्राहक/परियोजना का नाम
NAME OF CUSTOMER/PROJECT

POWER GRID CORPORATION OF INDIA LIMITED
Substation Package-SS19 for extension of (i) 765kV Solapur S/S; (ii) 765kV Aurangabad S/S; (iii) 765kV Wardha S/S; (iv) 400kV Khandwa S/S; (v) 400kV Rajgarh S/S; (vi) 400kV Champa S/S; (vii) 400/220kV Itarsi S/S & (viii) 400/220kV Jabalpur Substation under WRSS-20.

भारत हेवी इलेक्ट्रिकल्स लिमिटेड
ट्रांसमिशन परियोजना विभाग
BHARAT HEAVY ELECTRICALS LTD.
TRANSMISSION PROJECTS DIVISION

	नाम /NAME	हस्ता./SIGN.	दि./DATE
बनाया DRAWN	DS		12.09.19
जँचा CHECKED	JK		12.09.19
स्वीकृत APPROVED	SKS		12.09.19

REV.	DATE		
00	08.11.19	ALTERED	DS
		CHECKED	JK
		APPROVED	SKS

ZONE

1. DRAWING REVISED AS PER M/S POWERGRID COMMENTS VIDE LETTER NO. VIDE LETTER REF NO. C-ENGG-WR-WRSS-20/BHEL/01 DT. 27.09.19.

विभाग DEPT. TBEM
कोड CODE 422
अनुपात / SCALE NTS
कार्ड कोड CARD CODE

DEEPALI SHARMA
Digitally signed by DEEPALI SHARMA DN: c=IN, o=BHARAT HEAVY ELECTRICALS LIMITED, ou=TBG-Noida, postalCode=201305, st=Uttar Pradesh, 2.5.4.20=0274c402e19e3ff8cdac3a07e309ce8f0f86249d9bb20cb43a1789e4d05c40cc, cn=DEEPALI SHARMA Date: 2019.11.08 18:01:33 +05'30'

शीर्षक/TITLE
SINGLE LINE DIAGRAM
FOR EXTN. OF 400KV JABALPUR S/S

ड्राईग.क्र./DRAWING NO. TB-408-510-J01
पुनः/REV. 01
पृष्ठ क्र./SHEET No. 01 अगला पृष्ठ/NEXT SHEET --

COMPUTER DRG. PATH NAME :
REF. DRG. No.
SIGN. & DATE
INVENTORY No.

SIZE-A2

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM.)

DRAWING No. TB-408-510-J11

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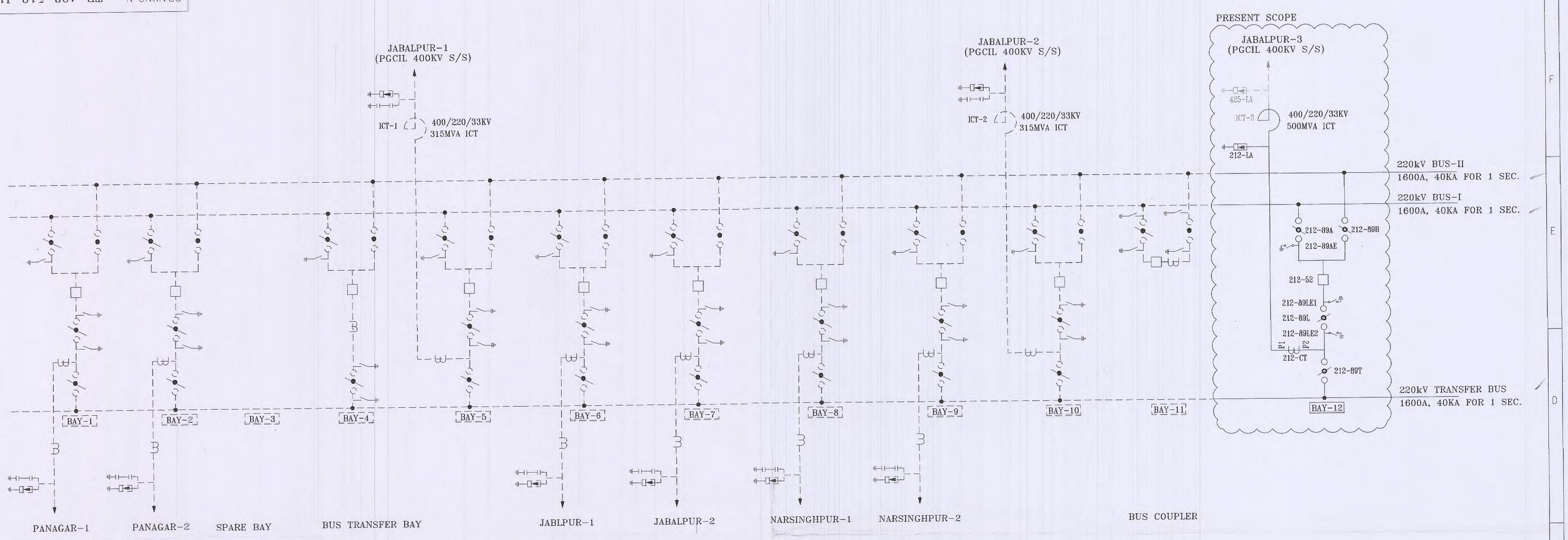


220KV SINGLE LINE DIAGRAM

BILL OF QUANTITIES-220KV: 40KA for 1 sec.

S.NO.	SYMBOL	LEGEND	DECCRIPTION	QTY. (NOS)
01		52	220KV, 1600A, 3-PH CIRCUIT BREAKER	1
02		89	220KV, 1600A, 3-PH, HORIZONTAL DOUBLE BREAK ISOLATOR WITH 2 E/S	1
03		89	220KV, 1600A, 3-PH, HORIZONTAL DOUBLE BREAK ISOLATOR WITH 1 E/S	1
04		89	220KV, 1600A, 3-PH, HORIZONTAL DOUBLE BREAK ISOLATOR WITHOUT E/S	2
05		CT	220KV, 1600A, 3-PH CURRENT TRANSFORMER WITH 120% EXTENDED CURRENT RATING	3
06		LA	216KV, 1-PH, SURGE ARRESTER	3

SYSTEM PARAMETERS:

S.NO.	DESCRIPTION	400KV	220KV
01	SYSTEM OPERAYING VOLTAGE	400kV	220kV
02	MAXIMUM OPERATING VOLRAGE OF THE SYSTEM (rms)	420kV	245kv
03	RATED FREQUENCY	50Hz	50Hz
04	FULL WAVE IMPULSE WITHSTAND VOLTAGE (1.2/50 MICROSES.)	1550kVp	1050kVp
05	SWITCHING IMPULSE WITHSTAND VOLTAGE (250/2500 MICRO SEC.) DRY AND WRT	1050kVp	--
06	ONE MINUTE POWER FREQUENCY DRY WITHSTAND VOLTAGE (rms)	630kV	--
07	ONE MINUTE POWER FREQUENCY DRY AND WET WITHSTAND VOLTAGE (rms)	--	460kV
08	CORONA EXTINCTION VOLTAGE	320kV	--
09	MAX. RADIO INTERFERENCE VOLRAGE FOR FREQUENCY BETWEEN 0.5 MHz AND 2 MHz	1000μV AT 266kV rms	1000μV AT 156kV rms
10	MINIMUM CREEPAGE DISTANCE-FOR EQUIPMENT OTHER THAN INSULATOR STRING	10500mm	6125mm

CT DETAILS:

245 kV, 1600A, CT (5 CORE)

Core No.	Current Ratio	Accuracy Class	Output Burden VA	Min kPV (V)	Max RCT in Ohms	Max Im at kPV (mA)	Purpose
1	1600-800/1	PX	-	1600-800	8/4	25-50	BUS DIFF CHECK
2	1600-800/1	PX	-	1600-800	8/4	25-50	BUS DIFF MAIN
3	1600-800/1	0.2S	20	-	-	-	METERING
4	1600-800/1	PX	-	1600-800	8/4	25-50	TRANS. BACKUP
5	1600-800/1	PX	-	1600-800	8/4	25-50	TRANS. DIFF

LEGENDS:-

PRESENT SCOPE
EXISTING SCOPE

Cat I*
27/9/19
पावर ग्रिड कार्पोरेशन ऑफ इंडिया लि०
अभियांत्रिकी (उपकेन्द्र) गुड़गाँव, हरियाणा

NOA NO. : CC-CS/901-WR2/SS-3931/3/G3/NOA-I/8864 & 8865 DT. 29.07.19

ADDITIONAL INFORMATION
W.O.No. I19TB00001
STATUS OF DRAWING CONTRACT
DISTRIBUTION OF PRINTS

ग्राहक/परियोजना का नाम / NAME OF CUSTOMER/PROJECT: POWER GRID CORPORATION OF INDIA LIMITED
Substation Package-SS19 for extension of (i) 765kV Solapur S/S; (ii) 765kV Aurangabad S/S; (iii) 765kV Wardha S/S; (iv) 400kV Khandwa S/S; (v) 400kV Rajgarh S/S; (vi) 400kV Champa S/S; (vii) 400/220kV Itarsi S/S & (viii) 400/220kV Jabalpur Substation under WRSS-20.

बीएचईएल
भारत हेवी इलेक्ट्रिकल्स लिमिटेड
ट्रांसमिशन परियोजना विभाग
BHARAT HEAVY ELECTRICALS LTD.
TRANSMISSION PROJECTS DIVISION

	नाम /NAME	हस्ता./SIGN.	दि./DATE
बनाया DRAWN	DS		12.09.19
जाँचा CHECKED	JK		12.09.19
स्वीकृत APPROVED	SKS		12.09.19

REV. | DATE | ALTERED | CHECKED | APPROVED
ZONE

विभाग DEPT. TBEM
कोड CODE 422
अनुपात / SCALE NTS
कार्ड कोड CARD CODE

शीर्षक/TITLE
SINGLE LINE DIAGRAM
FOR EXTN. OF 220KV JABALPUR S/S

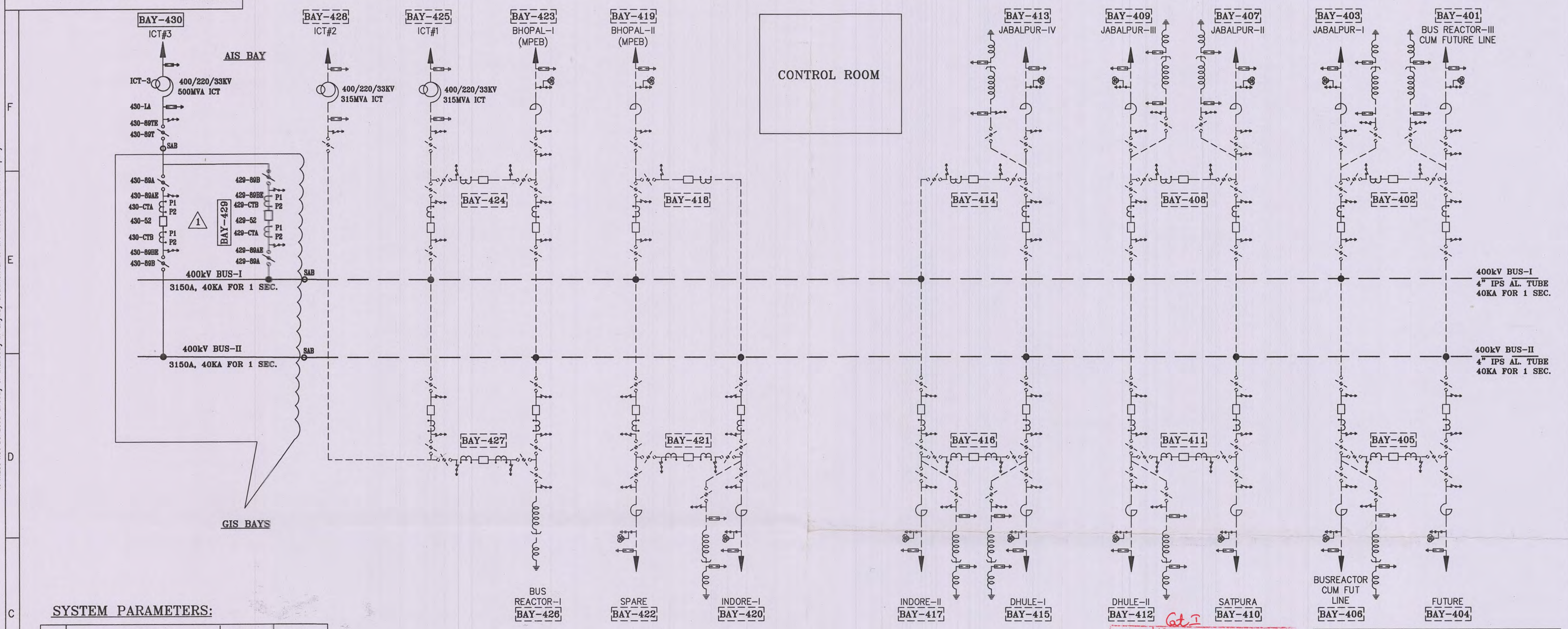
ड्राईग.क्र./DRAWING NO. TB-408-510-J11
पुनः/REV. 00
पृष्ठ क्र./SHEET No. 01 अगला पृष्ठ /NEXT SHEET -

COMPUTER DRG. PATH NAME :
REF. DRG. No.
SIGN. & DATE
INVENTORY No.

SIZE-A2

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM.)

DRAWING NO. TB-408-510-I01



400KV SINGLE LINE DIAGRAM

SYSTEM PARAMETERS:

S.NO.	DESCRIPTION	400KV	220KV
01	SYSTEM OPERATING VOLTAGE	400kV	220kV
02	MAXIMUM OPERATING VOLTAGE OF THE SYSTEM (rms)	420kV	245kv
03	RATED FREQUENCY	50Hz	50Hz
04	FULL WAVE IMPULSE WITHSTAND VOLTAGE (1.2/50 MICROSES.)	1550kVp	1050kVp
05	SWITCHING IMPULSE WITHSTAND VOLTAGE (250/2500 MICRO SEC.) DRY AND WRT	1050kVp	--
06	ONE MINUTE POWER FREQUENCY DRY WITHSTAND VOLTAGE (rms)	630kV	--
07	ONE MINUTE POWER FREQUENCY DRY AND WET WITHSTAND VOLTAGE (rms)	--	460kV
08	CORONA EXTINCTION VOLTAGE	320kV	--
09	MAX. RADIO INTERFERENCE VOLRAGE FOR FREQUENCY BETWEEN 0.5 MHz AND 2 MHz	1000μV AT 266kV rms	1000μV AT 156kV rms
10	MINIMUM CREEPAGE DISTANCE-FOR EQUIPMENT OTHER THAN INSULATOR STRING	10500mm	6125mm
11	SYSTEM FAULT LEVEL	40kA for 1 sec	40kA for 1 sec

BILL OF QUANTITIES-400KV:

S.NO.	SYMBOL	LEGEND	DECRIPTION	QTY. (NOS)	REMARK
01		ICT	500MVA, 400/220/33kV, 3-PH AUTO TRANSFORMER	1	--
02		52	400KV, 3150A, 3-PH CIRCUIT BREAKER WITHOUT CLOSING RESISTOR & WITH CSD	2	GIS
03		89	400KV, 3150A, 3-PH, ISOLATOR WITH 1 E/S	4	GIS
04		CT	400KV. 3000A, 1-PH CURRENT TRANSFORMER (DISTRIBUTED ON BOTH SIDE OF CIRCUIT BREAKER)	6	GIS
05		LA	336KV, 1-PH, SURGE ARRESTER	3	AIS
06		89	400KV, 3150A, 40KA 3-PH, HORIZONTAL DOUBLE BREAK ISOLATOR WITH 1 E/S	1	AIS
07	o	SAB	SF6 TO AIR BUSHING	9	--

CT DETAILS: 1

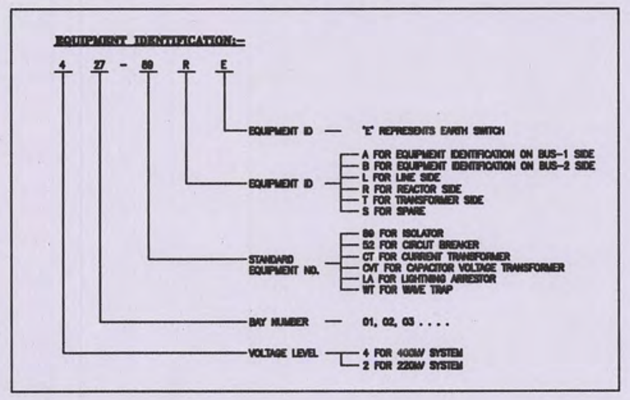
420 kV, 3000A, CT (6 CORE)

Core No.	Current Ratio	Accuracy Class	Output Burden VA	Min kPV (V)	Max RCT in Ohms	Max Im at kPV (mA)	Purpose
1,5	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	BUS DIFF CHECK/TRANS. BACKUP
2,6	3000-2000-500/1	PX	-	3000-2000-500	15/10/2.5	20-30-120	BUS DIFF MAIN/ TRANS. DIFF
3,4	3000-2000-500/1	0.2S	20	-	-	-	METERING

LEGENDS:-

——— PRESENT SCOPE

- - - - - EXISTING / FUTURE



पावर ग्रिड कॉर्पोरेशन ऑफ इंडिया लि. अभियांत्रिकी (उपकेन्द्र) गुड़गाँव, हरियाणा

REFERENCE - EXISTING AS BUILT SLD FOR 400KV STATION ITARSI, DRAWING NO: 0716MP_ITARSI_SUBS_SWYD_E_DWG_41_001 SHEET 1 OF 2

NOA NO. : CC-CS/901-WR2/SS-3931/3/G3/NOA-I/8864 & 8865 DT. 29.07.19

ADDITIONAL INFORMATION
W.O.No. I19TB00001

STATUS OF DRAWING CONTRACT

DISTRIBUTION OF PRINTS

ग्राहक/परियोजना का नाम POWER GRID CORPORATION OF INDIA LIMITED

NAME OF CUSTOMER/PROJECT Substation Package-SS19 for extension of (i) 765kV Solapur S/S; (ii) 765kV Aurangabad S/S; (iii) 765kV Wardha S/S; (iv) 400kV Khandwa S/S; (v) 400kV Rajgarh S/S; (vi) 400kV Champa S/S; (vii) 400/220kV Itarsi S/S & (viii) 400/220kV Jabalpur Substation under WRSS-20.

भारत हेवी इलेक्ट्रिकल्स लिमिटेड
ट्रांसमिशन परियोजना विभाग
BHARAT HEAVY ELECTRICALS LTD.
TRANSMISSION PROJECTS DIVISION

	नाम /NAME	हस्ता./SIGN.	दि./DATE
बनाया DRAWN	DS		17.09.19
जाँचा CHECKED	JK		17.09.19
स्वीकृत APPROVED	SKS		17.09.19

REV.	DATE		
00	07.11.19	ALTERED	DS
		CHECKED	JK
		APPROVED	SKS

ZONE

1. DRAWING REVISED AS PER POWERGRID COMMENTS VIDE LETTER NO. VIDE LETTER REF NO. C-ENGG-WR-WRSS-20/BHEL/01 DT. 27.09.19.

विभाग DEPT. TBEM
कोड CODE 422 17.09.19
अनुपात / SCALE NTS
कार्ड कोड CARD CODE

DEEPALI SHARMA
Digitally signed by DEEPALI SHARMA DN: c=IN, o=BHARAT HEAVY ELECTRICALS LIMITED, ou=TBG- Noida, postalCode=201305, st=Uttar Pradesh, 2.5.4.20=0274c402e19e3ff8cdac3a07e309ce8f0f86249d9bb20cb43a1789e4d05c40cc, cn=DEEPALI SHARMA Date: 2019.11.07 15:34:44 +05'30'

शीर्षक/TITLE
SINGLE LINE DIAGRAM
FOR EXTN. OF 400 KV ITARSI S/S

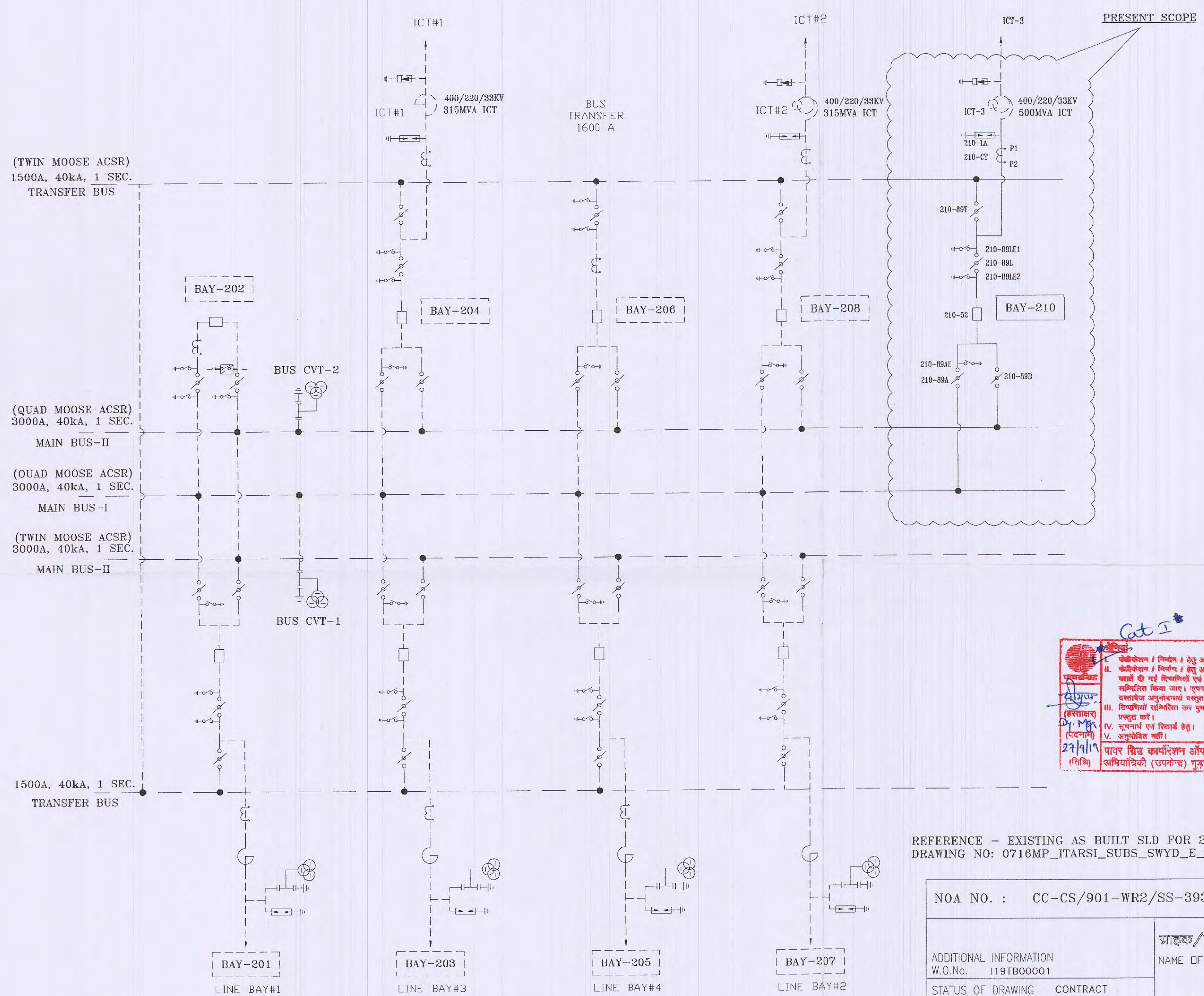
ड्राईंग.क्र./DRAWING NO. TB-408-510-I01
पुन:/REV. 01
पृष्ठ क्र./SHEET No. 01 अगला पृष्ठ/NEXT SHEET --

SIZE-A2

COMPUTER DRG. PATH NAME :
REF. DRG. No.
SIGN. & DATE
INVENTORY No.

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM.)

DRAWING No. TB-408-510-I11

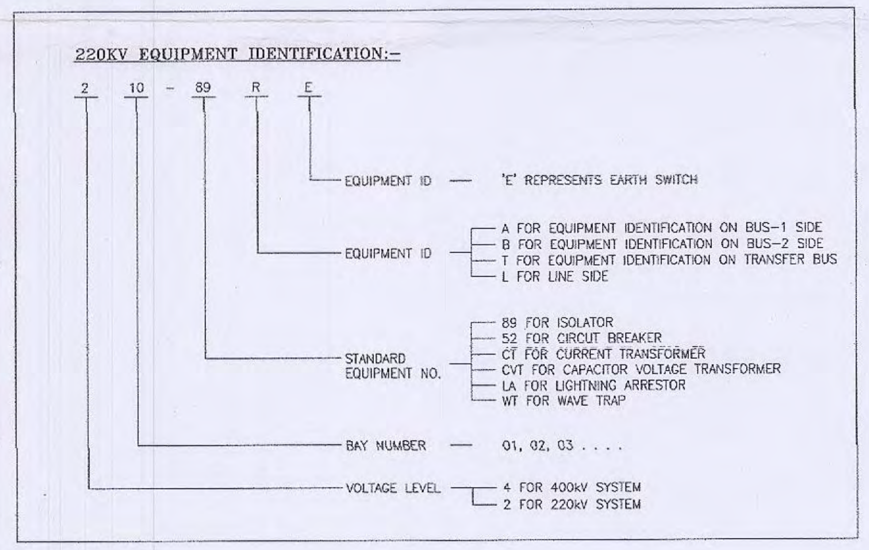


SYSTEM PARAMETERS:

S.NO.	DESCRIPTION	400KV	220KV
01	SYSTEM OPERAYING VOLTAGE	400kV	220kV
02	MAXIMUM OPERATING VOLRAGE OF THE SYSTEM (rms)	420kV	245kv
03	RATED FREQUENCY	50Hz	50Hz
04	FULL WAVE IMPULSE WITHSTAND VOLTAGE (1.2/50 MICROSES.)	1550kVp	1050kVp
05	SWITCHING IMPULSE WITHSTAND VOLTAGE (250/2500 MICRO SEC.) DRY AND WRT	1050kVp	--
06	ONE MINUTE POWER FREQUENCY DRY WITHSTAND VOLTAGE (rms)	630kV	--
07	ONE MINUTE POWER FREQUENCY DRY AND WET WITHSTAND VOLTAGE (rms)	--	460kV
08	CORONA EXTINCTION VOLTAGE	320kV	--
09	MAX. RADIO INTERFERENCE VOLRAGE FOR FREQUENCY BETWEEN 0.5 MHz AND 2 MHz	1000µV AT 266kV rms	1000µV AT 156kV rms
10	MINIMUM CREEPAGE DISTANCE-FOR EQUIPMENT OTHER THAN INSULATOR STRING	10500mm	6125mm
11	SYSTEM FAULT LEVEL	40kA for 1 sec	40kA for 1 sec

BILL OF QUANTITIES-220KV; 40KA for 1 sec.

S.NO.	SYMBOL	LEGEND	DECCRIPTION	QTY. (NOS)
01		52	220KV, 1600A, 3-PH CIRCUIT BREAKER	1
02		89	220KV, 1600A, 3-PH, HORIZONTAL DOUBLE BREAK ISOLATOR WITH 2 E/S	1
03		89	220KV, 1600A, 3-PH, HORIZONTAL DOUBLE BREAK ISOLATOR WITH 1 E/S	1
04		89	220KV, 1600A, 3-PH, HORIZONTAL DOUBLE BREAK ISOLATOR (TANDEM TYPE) WITHOUT E/S	2
05		CT	220KV, 1600A, 3-PH CURRENT TRANSFORMER WITH 120% EXTENDED CURRENT RATING	3
06		LA	216KV, 1-PH, SURGE ARRESTER	3



Cat I*

पावर ग्रिड कार्पोरेशन ऑफ इंडिया लि०
अभियांत्रिकी (उपकेन्द्र) गुडगाँव, हरियाणा

Dy. Mgr
27/9/19

REFERENCE - EXISTING AS BUILT SLD FOR 220KV STATION ITARSI,
DRAWING NO: 0716MP_ITARSI_SUBS_SWYD_E_DWG_41_001 SHEET 2 OF 2

220KV SINGLE LINE DIAGRAM

CT DETAILS:

245 kV, 1600A, CT (5 CORE)

Core No.	Current Ratio	Accuracy Class	Output Burden VA	Min kPV (V)	Max RCT in Ohms	Max Im at kPV (mA)	Purpose
1	1600-800/1	PX	–	1600-800	8/4	25-50	BUS DIFF CHECK
2	1600-800/1	PX	–	1600-800	8/4	25-50	BUS DIFF MAIN
3	1600-800/1	0.2S	20	–	–	–	METERING
4	1600-800/1	PX	–	1600-800	8/4	25-50	TRANS. BACKUP
5	1600-800/1	PX	–	1600-800	8/4	25-50	TRANS. DIFF

LEGENDS:-

————	PRESENT SCOPE
- - - - - -	EXISTING / FUTURE

NOA NO. : CC-CS/901-WR2/SS-3931/3/G3/NOA-I/8864 & 8865 DT. 29.07.19

ADDITIONAL INFORMATION
W.O.No. I19TB00001

STATUS OF DRAWING CONTRACT

DISTRIBUTION OF PRINTS

ग्राहक/परियोजना का नाम POWER GRID CORPORATION OF INDIA LIMITED

NAME OF CUSTOMER/PROJECT Substation Package-SS19 for extension of (i) 765kV Solapur S/S; (ii) 765kV Aurangabad S/S; (iii) 765kV Wardha S/S; (iv) 400kV Khandwa S/S; (v) 400kV Rajgarh S/S; (vi) 400kV Champa S/S; (vii) 400/220kV Itarsi S/S & (viii) 400/220kV Jabalpur Substation under WRSS-20.

बीएचईएल BHEL
भारत हेवी इलेक्ट्रिकल्स लिमिटेड
ट्रांसमिशन परियोजना विभाग
BHARAT HEAVY ELECTRICALS LTD.
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ZONE

विभाग DEPT. TBEM
कोड CODE 422
अनुपात / SCALE NTS
कार्ड कोड CARD CODE

JAI KUMAR
Digitally signed by JAI KUMAR

शीर्षक/TITLE
SINGLE LINE DIAGRAM
FOR EXTN. OF 220 KV ITARSI S/S

ड्राईंग.क्र./DRAWING NO. TB-408-510-I11
पुनः/REV. 00
पृष्ठ क्र./SHEET No. 01
अगला पृष्ठ /NEXT SHEET –

SIZE-A2

COMPUTER DRG. PATH NAME :
REF. DRG. No.
SIGN. & DATE
INVENTORY No.

SECTION: CONTROL, RELAY & PROTECTION PANELS

1. TYPE OF PANELS

1.1 Simplex Panel

Simplex panel shall consist of a vertical front panel with equipment mounted thereon and having wiring access from rear for control panels & front for relay/protection/**Interface** panels. In case of panel having width more than 800mm, double leaf-doors shall be provided. Doors shall have handles with built-in locking facility.

1.2 Duplex Panel

Duplex panel shall be walk-in tunnel type comprising two vertical front and rear panel sections connected back-on-back by formed sheet steel roof tie members and a central corridor in between. The corridor shall facilitate access to internal wiring and external cable connections. In case of number of duplex panels located in a row side by side, the central corridor shall be aligned to form a continuous passage. Both ends of the corridor shall be provided with double leaf doors with lift off hinges. Doors shall have handles with built-in locking facility. Separate cable entries shall be provided for the front and rear panels. However, inter-connections between front and back panels shall be by means of inter panel wiring at the top of the panel.

2. CONSTRUCTIONAL FEATURES

2.1. Control and Relay Board shall be **simplex type unless otherwise indicated in section-project / bill of quantity as duplex type**. It is the responsibility of the Contractor to ensure that the equipment specified and such unspecified complementary equipment required for completeness of the protective/control schemes be properly accommodated in the panels without congestion and if necessary, either more number of panels or panels with larger dimensions **shall be provided (as per panel layout requirement)**. No price increase at a later date on this account shall be allowed. However, the width of panels that are being offered to be placed in existing switchyard control rooms, should be in conformity with the space availability in the control room.

2.2. Panels shall be completely metal enclosed and shall be dust, moisture and vermin proof. The enclosure shall provide a degree of protection not less than IP-31 in accordance with IS: 2147.

2.3. Panels shall be free standing, floor mounting type and shall comprise structural frames completely enclosed with specially selected smooth finished, cold rolled sheet steel of thickness not less than 3 mm for weight bearing members of the panels such as base frame, front sheet and door frames, and 2.0mm for sides, door, top and bottom portions. There shall be sufficient reinforcement to provide level transportation and installation.

2.4. All doors, removable covers of panels shall be gasketed all around with synthetic gaskets Neoprene/EPDM generally conforming with provision of

IS 11149. However, XLPE gaskets can also be used for fixing protective glass doors. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh.

2.5. Design, materials selection and workmanship shall be such as to result in neat appearance, inside and outside with no welds, rivets or bolt head apparent from outside, with all exterior surfaces tune and smooth.

2.6. Panels shall have base frame with smooth bearing surface, which shall be fixed on the embedded foundation channels/insert plates. Anti vibration strips made of shock absorbing materials that shall be supplied by the contractor, which shall be placed between panel & base frame.

2.7. Cable entries to the panels shall be from the bottom. Cable gland plate fitted on the bottom of the panel shall be connected to earthing of the panel/station through a flexible braided copper conductor rigidly.

2.8. Relay/protection panels of modern modular construction **meeting the functional requirement** would also be acceptable.

3. MOUNTING

3.1. All equipment on and in panels shall be mounted and completely wired to the terminal blocks ready for external connections. The equipment on front of panel shall be mounted flush.

3.2. Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent devices and are readily accessible without use of special tools. Terminal marking on the equipment shall be clearly visible.

3.3. The Contractor shall carry out cut out, mounting and wiring of the free issue items supplied by others which are to be mounted in his panel in accordance with the corresponding equipment manufacturer's drawings. Cut outs if any, provided for future mounting of equipment shall be properly blanked off with blanking plate.

3.4. The centre lines of switches, push buttons and indicating lamps shall be **preferably** not less than 750mm from the bottom of the panel. The centre lines of relays, meters and recorders shall be **preferably** not less than 450mm from the bottom of the panel.

3.5. The centre lines of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Like wise the top lines of all meters, relays and recorders etc. shall be matched.

3.6. No equipment shall be mounted on the doors.

3.7. At existing station, panels shall be matched with other panels in the control room in respect of dimensions, colour, appearance and arrangement of equipment (centre lines of switches, push buttons and other equipment) on the front of the panel.

4. PANEL INTERNAL WIRING

4.1. Panels shall be supplied complete with interconnecting wiring provided between all electrical devices mounted and wired in the panels and between the devices and terminal blocks for the devices to be connected to equipment outside the panels. When panels are arranged to be located adjacent to each other all inter panel wiring and connections between the panels shall be carried out internally.

4.2. All wiring shall be carried out with 650V grade, single core, stranded copper conductor wires with PVC insulation. The minimum size of the multi-stranded copper conductor used for internal wiring shall be as follows:

- All circuits except current transformer circuits and voltage **transformer** circuits meant for energy metering - one 1.5mm sq. per lead.
- All current transformer circuits - one 2.5 sq.mm per lead.
- Voltage transformer circuit (for energy meters): Two 2.5 mm sq. per lead.

4.3. All internal wiring including FO patch cords shall be securely supported, neatly arranged, readily accessible and connected to equipment terminals and terminal blocks. Wiring gutters & troughs shall be used for this purpose.

4.4. Void

4.5. Wire termination shall be made with solderless crimping type and tinned copper lugs, which firmly grip the conductor. Insulated sleeves shall be provided at all the wire terminations. Core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wire and shall not fall off when the wire is disconnected from terminal blocks. All wires directly connected to trip circuit breaker or device shall be distinguished by the addition of red coloured unlettered ferrule.

4.6. Longitudinal troughs extending throughout the full length of the panel shall be preferred for inter panel wiring. Inter-connections to adjacent panel shall be brought out to a separate set of terminal blocks located near the slots of holes meant for taking the inter-connecting wires. **Wiring termination at interface panel end shall be through prefabricated plug-in type connectors.**

4.7. Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipments.

5. TERMINAL BLOCKS

5.1. All internal wiring to be connected to external equipment shall terminate on terminal blocks. Terminal blocks shall be 650 V grade and have 10 Amps. Continuous rating, moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Markings on the terminal blocks shall correspond to wire number and terminal numbers on the wiring diagrams. All terminal blocks shall have shrouding with transparent unbreakable material.

5.2. Disconnecting type terminal blocks for current transformer and voltage transformer secondary leads shall be provided. Also current transformer secondary leads shall be provided with short circuiting and earthing facilities.

5.3. At least 20% spare terminals shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks.

5.4. Unless otherwise specified, terminal blocks shall be suitable for connecting the following conductors of external cable on each side

- All CT & PT circuits: minimum of two no. of 2.5mm Sq. copper.
- AC/DC Power Supply Circuits: **two** no. of **16mm** Sq. Aluminium.
- All other circuits: minimum of one no. of 2.5mm Sq. Copper.

5.5. There shall be an **approximate clearance** of 250mm between the first row of terminal blocks and the associated cable gland plate or panel side wall. **Similarly** the clearance between two rows of terminal blocks edges shall be of 150mm **approximate**.

5.6. Arrangement of the terminal block assemblies and the wiring channel within the enclosure shall be such that a row of terminal blocks is run in parallel and close proximity along each side of the wiring-duct to provide for convenient attachment of internal panel wiring. The side of the terminal block opposite the wiring duct shall be reserved for the external cable connections. All adjacent terminal blocks shall also share this field wiring corridor. All wiring shall be provided with adequate support inside the panels to hold them firmly and to enable free and flexible termination without causing strain on terminals.

5.7. The number and sizes of the Owner's multi core incoming external cables will be furnished to the Contractor after placement of the order. All necessary cable terminating accessories such as gland plates, supporting clamps & brackets, wiring troughs and gutters etc. (except glands & lugs) for external cables shall be included in the scope of supply. **Terminal blocks provided on Interface panel used for external wiring from switchyard shall be provided with necessary surge protection device to safeguard IEDs from transient voltage surges, spikes.**

6. PAINTING

The painting shall be carried out as detailed in Section–GTR.

7. MIMIC DIAGRAM (FOR CONTROL PANELS)

7.1. Coloured mimic diagram and symbols showing the exact representation of the system shall be provided in the front of control panels.

7.2. Mimic diagram shall be made preferably of anodised aluminium or plastic of approved fast colour material, which shall be screwed on to the panel and can be easily cleaned. The mimic bus shall be 2mm thick. The width of the mimic bus shall be 10mm for bus bars and 7mm for other connections. Painted overlaid mimic is also acceptable.

7.3. Mimic bus colour will be decided during detailed Engineering by the **EMPLOYER**.

7.4. When semaphore indicators are used for equipment position, they shall be so mounted in the mimic that the equipment in close position shall complete the continuity of mimic.

7.5. Indicating lamp, one for each phase, for each bus shall be provided on the mimic to indicate bus charged condition

8. NAME PLATES AND MARKINGS

8.1. All equipment mounted on front and rear side as well as equipment mounted inside the panels shall be provided with individual name plates with equipment designation engraved. Also on the top of each panel on front as well as rear side, large and bold nameplates shall be provided for circuit/feeder designation.

8.2. All front mounted equipment shall also be provided at the rear with individual name plates engraved with tag numbers corresponding to the one shown in the panel internal wiring to facilitate easy tracing of the wiring.

8.3. Each instrument and meter shall be prominently marked with the quantity measured e.g. kV, A, MW, etc. All relays and other devices shall be clearly marked with manufacturer's name, manufacturer's type and electrical rating data.

8.4. Name Plates shall be made of non-rusting metal or 3 ply lamicoid. Name plates shall be black with white engraving lettering.

8.5. Each switch shall bear clear inscription identifying its function e.g. 'BREAKER' '52A', "SYNCHRONISING" etc. Similar inscription shall also be provided on each device whose function is not other-wise identified. If any switch device does not bear this inscription separate name plate giving its function shall be provided for it. Switch shall also have clear inscription for each position indication e.g. "Trip- Neutral-Close", "ON-OFF", "R-Y-B-OFF" etc

8.6. All the panels shall be provided with name plate mounted inside the panel bearing LOA No & Date, Name of the Substation & feeder and reference drawing number.

9. MISCELLANEOUS ACCESSORIES

9.1. **Plug Point**: 240V, Single phase 50Hz, AC socket with switch suitable to accept 5 Amps and 15 Amps pin round standard Indian plug, shall be provided in the interior of each cubicle with ON-OFF switch.

9.2. **Interior Lighting**: Each panel shall be provided with a **LED type lighting fixture (Min 7 Watt)** rated for 240 Volts, single phase, 50 Hz supply for the interior illumination of the panel controlled by the respective panel door switch. Adequate lighting shall also be provided for the corridor in Duplex panels.

9.3. **Switches and Fuses**: Each panel shall be provided with necessary arrangements for receiving, distributing and isolating of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with Fuses. Selection of the main and sub-circuit Fuses rating shall be such as to ensure selective clearance of sub-circuit faults. Voltage transformer circuits for relaying and metering shall be protected by fuses. All fuses shall be HRC cartridge type conforming to IS: 13703 mounted on plug-in type fuse bases. The short time fuse rating of Fuses shall be not less than 9 KA. Fuse carrier base shall have imprints of the fuse 'rating' and 'voltage'.

9.4. **Space Heater**: Each panel shall be provided with a thermostatically **controlled** space heater rated for 240V, single phase, 50 Hz AC supply for the internal heating of the panel to prevent condensation of moisture. The fittings shall be complete with switch unit.

10. EARTHING

10.1. All panels shall be equipped with an earth bus securely fixed. Location of earth bus shall ensure no radiation interference from earth systems under various switching conditions of isolators and breakers. The material and the sizes of the bus bar shall be at least 25 X 6 sq.mm copper with threaded holes at a gap of 50 mm with provision of bolts and nuts for connection with cable armours and mounted equipment etc for effective earthing. When several panels are mounted adjoining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply of Contractor. Provision shall be made for extending the earth bus bars to future adjoining panels on either side.

10.2. Provision shall be made on each bus bar of the end panels for connecting Substation earthing grid. Necessary terminal clamps and connectors for this purpose shall be included in the scope of supply of Contractor.

10.3. All metallic cases of relays, instruments and other panel mounted equipment including gland plate, shall be connected to the earth bus by copper wires of size not less than 2.5 sq. mm. The colour code of earthing wires shall be green.

10.4. Looping of earth connections which would result in loss of earth connection to other devices when the loop is broken, shall not be permitted. However, looping of earth connections between equipment to provide alternative paths to earth bus shall be provided.

10.5. VT and CT secondary neutral or common lead shall be earthed at one place only at the terminal blocks where they enter the panel. Such earthing shall be made through links so that earthing may be removed from one group without disturbing continuity of earthing system for other groups.

10.6. An electrostatic discharge arrangement shall be provided in each panel so as to discharge human body before he handles the equipments inside the panels.

11. INDICATING INSTRUMENTS & TRANSDUCERS FOR CONTROL

PANEL:

All instruments, meters and transducers shall be enclosed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. All Megawatt, Megavar, voltage and frequency indicating instruments shall be provided with individual transducers and these shall be calibrated along with transducers to read directly the primary quantities. They shall be accurately adjusted and calibrated at works and shall have means of calibration check and adjustment at site. The supplier shall submit calibration certificates at the time of delivery. However no separate transducers are envisaged for digital bus voltmeters and digital frequency meters and the indicating meters provided in the synchronising equipment.

11.1. Indicating Instruments

11.1.1. Unless otherwise specified, all electrical indicating instruments shall be of digital type suitable for flush mounting.

11.1.2. Instruments shall have 4-digit display; display height being not less than 25 mm.

11.1.3. Instrument shall confirm to relevant IS and shall have an accuracy class of 1.5 or better. Watt and Var meters shall have an indication of (+) and (-) to indicate EXPORT and IMPORT respectively.

11.1.4. Digital voltage and frequency meters shall be of class: 0.5 and shall have digital display of **4** and ***4.5*** digits respectively, with display size, not less than 25mm (height).

11.2. Transducers

11.2.1. Transducers (for use with Indicating Instruments and Telemetry/Data Communication application) shall in general conform to IEC:60688-1.

11.2.2. The transducers shall be suitable for measurement of active power, reactive power, voltage, current and frequency in three phase four wire unbalanced system.

11.2.3. The input to the transducers will be from sub-station current & potential transformers. The output shall be in milli ampere D.C. proportional to the input & it shall be possible to feed the output current directly to the telemetry terminal or indicating instruments.

11.2.4. The transducer characteristic shall be linear throughout the measuring range.

11.2.5. The transducer output shall be load independent.

11.2.6. The input & output of the transducer shall be galvanically isolated.

11.2.7. Each transducer shall be housed in a separate compact case and have suitable terminals for inputs & outputs.

11.2.8. The transducers shall be suitably protected against transient high peaks of voltage & current.

11.2.9. The transducer shall withstand indefinitely without damage and work satisfactorily at 120% of the rated voltage and 120% of the rated input current as applicable.

11.2.10. All the transducers shall have an output of 4-20 mA.

11.2.11. The response time of the transducers shall be less than 1 second.

11.2.12. The accuracy class of transducers shall be 1.0 or better for voltage/current transducer, 0.5 or better for watt/VAR transducer and 0.2 or better for frequency transducer.

11.2.13. The transducers shall have a low AC ripple on output less than 1%.

11.2.14. The transducer shall have dual output.

12. ANNUNCIATION SYSTEM for Control Panel

12.1. Alarm annunciation system shall be provided in the control board by means of visual and audible alarm in order to draw the attention of the operator to the abnormal operating conditions or the operation of some protective devices. The annunciation equipment shall be suitable for operation on the voltages specified in this specification.

12.2. The visual annunciation shall be provided by annunciation facia, mounted flush on the top of the control panels.

12.3. The annunciation facia shall be provided with translucent plastic window for alarm point with approximate size of 35mm x 50mm. The facia plates shall be engraved in black lettering with respective inscriptions. Alarm inscriptions shall be engraved on each window in not more than three lines and size of the lettering shall not be less than 5 mm.

12.4. Each annunciation window shall be provided with two white lamps in parallel to provide safety against lamp failure. Long life lamps shall be used. The transparency of cover plates and wattage of the lamps provided in the facia windows shall be adequate to ensure clear visibility of the inscriptions in the control room having high illumination intensity (350 Lux), from the location of the operator's desk.

12.5. All Trip facia shall have red colour and all Non-trip facia shall have white colour.

12.6. The audible alarm shall be provided by Buzzer/ Hooter /Bell having different sounds and shall be used as follows.

Hooter	Alarm Annunciation
Bell	Annunciation DC failure
Buzzer	AC supply failure

12.7. Sequence of operation of the annunciator shall be as follows :

Sl. NO.	Alarm Condition	Fault Contact	Visual Annunciation	Audible Annunciation
1.	Normal	Open	OFF	OFF
2.	Abnormal	Close	Flashing	ON
3.	Accept Push	Close	Steady On	OFF

	Button Pressed	Open	Steady On	OFF
4.	Reset Push Button Pressed	Close	On	OFF
		Open	Off	OFF
5.	Lamp Test Push Button Pressed	Open	Steady On	OFF

12.8. Audible annunciation for the failure of DC supply to the annunciation system shall be provided and this annunciation shall operate on 240 Volts AC supply. On failure of the DC to the annunciation system for more than 2 or 3 seconds (adjustable setting), a bell shall sound. A separate push button shall be provided for the cancellation of this audible alarm alone but the facia window shall remain steadily lighted till the supply to annunciation system is restored.

12.9. A separate voltage check relay shall be provided to monitor the failure of supply (240V AC) to the scheme mentioned in Clause above. If the failure of supply exists for more than 2 to 3 seconds, this relay shall initiate visual and audible annunciation. Visual and audible annunciation for the failure of AC supply to the annunciation system shall be provided and this annunciation shall operate on Annunciation DC and buzzer shall sound.

12.10. The annunciation system described above shall meet the following additional requirements :

a) The annunciation system shall be capable of catering to at least 20 simultaneous signals at a time.

b) One set of the following push buttons shall be provided on each control panel:

- Reset push button for annunciation system
- Accept push button for annunciation system
- Lamp test push button for testing the facia windows

c) One set of the following items shall be provided common for all the control panel (not applicable for extension of substation) :

- Flasher relay for annunciation system
- Push button for Flasher test
- Three Push buttons for test of all audible alarm systems

d) These testing circuits shall be so connected that while testing is being done, it shall not prevent the registering of any new annunciation that may land during the test.

e) The annunciation shall be repetitive type and shall be capable of registering the fleeting signal. Minimum duration of the fleeting signal registered by the system shall be 15 milli seconds.

f) In case of static annunciator scheme, special precaution shall be taken to ensure that spurious alarm condition does not appear due to influence of external electromagnetic/ electrostatic interference on the annunciator wiring and switching disturbances from the neighbouring circuits within the panels and the static annunciator shall meet the high voltage susceptibility test , impulse voltage with stand test , high frequency disturbance test– class III and fast transient disturbance test –level III as per IEC 60255.

12.11. The annunciation system to be supplied for existing sub-stations shall be engineered as an extension to the existing scheme.

12.12. For the Control panel with BCU (if envisaged in section-Project), only common alarm lamp shall be provided for each Control panel. Each BCU of the control panel shall energize this common alarm lamp on occurrence of alarms/Trips. All alarms shall be available in the BCU mimic/HMI.

13. SWITCHES

13.1. Control and instrument switches shall be rotary operated type with escutcheon plates clearly marked to show operating position and circuit designation plates and suitable for flush mounting with only switch front plate and operating handle projecting out.

13.2. The selection of operating handles for the different types of switches shall be as follows :

Breaker, Isolator control switches	:	Pistol grip, black
Synchronising switches	:	Oval, Black, Keyed handle (one common removable handle for a group of switches or locking facility having common key)
synchronising Selector switches	:	Oval or knob, black
Instrument switches	:	Round, knurled, black
Protection Transfer switch, **Local / remote selector switch**	:	Pistol grip, lockable and black.

13.3. The control switch of breaker and isolator shall be of spring return to neutral type. The switch shall have spring return from close and trip positions to "after close" and "after trip" positions respectively.

13.4. Protection Transfer switch / BCU will energise a bi-stable relay for protection transfer function from local/ remote HMI.

13.5. Instrument selection switches shall be of maintained contact (stay put) type. Ammeter selection switches shall have make-before-break type contacts so as to prevent open circuiting of CT secondary when changing the position of the switch. Voltmeter transfer switches for AC shall be suitable for reading all line- to-line and line-to-neutral voltages for non- effectively earthed systems and for reading all line to line voltages for effectively earthed systems.

13.6. Synchronising switches shall be of maintained contact (stay put) type having a common removable handle for a group of switches. The handle shall be removable only in the OFF position and it shall be co-ordinated to fit in to all the synchronising switches. These switches shall be arranged to connect the synchronising equipment when turned to the 'ON' position. One contact of each switch shall be connected in the closing circuit of the respective breaker so that the breaker cannot be closed until the switch is turned to the 'ON' position.

13.7. Lockable type of switches which can be locked in particular positions shall be provided when specified. The key locks shall be fitted on the operating handles.

13.8. The contacts of all switches shall preferably open and close with snap action to minimise arcing. Contacts of switches shall be spring assisted and contact faces shall be with rivets of pure silver or silver alloy. Springs shall not be used as current carrying parts

13.9. The contact combination and their operation shall be such as to give completeness to the interlock and function of the scheme.

13.10. The contact rating of the switches shall be as follows :

Description	**Contact Rating in Amps**		
	220V DC	**50V DC**	**240V AC**
Make and carry continuously	10	10	10
Make and carry for 0.5 sec.	30	30	30
Break for Resistive load	3	20	7
Break for Inductive load with L/R = 40m sec.	0.2	-	-

14. INDICATING LAMPS

14.1. Indicating lamps shall be of cluster LED type suitable for panel mounting with rear terminal connections. Lamps shall be provided with series connected resistors preferably built in the lamp assembly. Lamps shall have translucent lamp covers to diffuse lights coloured red, green, amber, clear white or blue as specified. The lamp cover shall be preferably of screwed type, unbreakable and moulded from heat resisting material.

14.2. The lamps shall be provided with suitable resistors.

14.3. Lamps and lenses shall be interchangeable and easily replaceable from the front of the panel. Tools, if required for replacing the bulbs and lenses shall also be included in the scope of the supply.

14.4. The indicating lamps with resistors shall withstand 120% of rated voltage on a continuous basis.

15. POSITION INDICATORS (if Applicable)

15.1. Position indicators of "SEMAPHORE" type shall be provided when specified as part of the mimic diagrams on panels for indicating the position of circuit breakers, isolating/earthing switches etc. The indicator shall be suitable for semi-flush mounting with only the front disc projecting out and with terminal connection from the rear.

15.2. Position indicator shall be suitable for DC Voltage as specified. When the supervised object is in the closed position, the pointer of the indicator shall take up a position in line with the mimic bus bars, and at right angles to them when the object is in the open position. When the supply failure to the indicator occurs, the pointer shall take up an intermediate position to indicate the supply failure.

15.3. The rating of the indicator shall not exceed 2.5 W.

15.4. The position indicators shall withstand 120% of rated voltage on a continuous basis.

16. SYNCHRONISING EQUIPMENT

16.1. For sub-station equipped with sub-station Automation system, the requirement of synchronisation is specified in section Sub-station Automation System and the same shall prevail. For other sub-station which is not equipped with sub-station automation system following shall be applicable as per requirement.

16.2. The synchronising instruments shall be mounted either on a synchronising trolley or on a synchronising panel. The panel/ trolley shall be equipped with double analog voltmeters and double analog frequency meters, synchroscope and lamps fully wired. The size of voltmeters and frequency meters provided in the synchronising panel shall not be less than 144 X 144 sq. mm. Suitable auxiliary voltage transformers wherever necessary shall also be provided for synchronising condition. In case the synchroscope is not continuously rated, a synchroscope cut-off switch shall be provided and an indicating lamp to indicate that the synchroscope is energised, shall also be provided.

16.3. Synchronising check relay with necessary ancillary equipment’s shall be provided which shall permit breakers to close after checking the requirements of synchronising of incoming and running supply. The phase angle setting shall not exceed 35 degree and have voltage difference setting not exceeding 10%. This relay shall have a response time of less than 200 milliseconds when the two system conditions are met within present limits and with the timer disconnected. The relay shall have a frequency difference setting not exceeding 0.45% at rated value and at the minimum time setting. A guard relay shall be provided to prevent the closing attempt by means of synchronising check relay when control switch is kept in closed position long before the two systems are in synchronism

16.4. The synchronising panel shall be draw out and swing type which can be swivelled in left and right direction. The synchronising panel shall be placed along with control panels and the number of synchronising panel shall be as indicated in BPS. The incoming and running bus wires of VT secondary shall be connected and run as bus wires in the control panels and will be extended to synchronising panel for synchronisation of circuit breakers. The selector switch provided for each circuit breaker in respective control panels shall be lockable type with a common key so that only one selector switch is kept in synchronising mode at a time.

16.5. Alternatively, the trolley shall be of mobile type with four rubber-padding wheels capable of rotating in 360 degree around the vertical axis. Suitable bumpers with rubber padding shall be provided all around the trolley to prevent any accidental damage to any panel in the control room while the trolley is in movement. The trolley shall have two meter long flexible cord fully wired to the instruments and terminated in a plug in order to facilitate connecting the trolley to any of the panels. The receptacle to accept the plug shall be provided on the panel.

16.6. At existing sub-stations, the synchronising scheme shall be engineered to be compatible with the existing synchronising scheme and synchronising socket/switch on the panel. In substations, where synchronising panels are available, the bidder shall carry out the shifting of the above panels, if required, to facilitate the extension of control panel placement.

17. RELAYS

17.1. All relays shall conform to the requirements of IS: 3231/IEC-60255/IEC 61000 or other applicable standards. Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear.

17.2. All protective relays shall be of numerical type and communication protocol shall be as per IEC 61850. **Protective relays shall also fulfil the requirements specified for Protection IEDs in Section-Substation automation system**

17.3. All protective relays shall be in draw out or plug-in type/modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied loose and shall be included in contractor's scope of supply.

17.4. All AC operated relays shall be suitable for operation at 50 Hz. AC Voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for 1 amp CT secondary. All DC operated relays and timers shall be designed for the DC voltage specified, and shall operate satisfactorily between 80% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.

17.5. The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of protective relays and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. also required for the complete protection schemes described in the specification shall be provided. All protective relays shall be provided with at least two pairs of potential free isolated output contacts. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme; contacts shall be silver faced with spring action. Relay case shall have adequate number of terminals for making potential free external connections to the relay coils and contacts, including spare contacts.

17.6. Timers shall be of solid state/numerical type. Time delay in terms of milliseconds obtained by the external capacitor resistor combination is not preferred and shall be avoided.

17.7. No control relay, which shall trip the power circuit breaker when the relay is de-energised, shall be employed in the circuits.

17.8. Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.

17.9. Auxiliary seal-in-units provided on the protective relays shall preferably be of shunt reinforcement type. If series relays are used the following shall be strictly ensured:

(a) The operating time of the series seal-in-unit shall be sufficiently shorter than that of the trip coil or trip relay in series with which it operates to ensure definite operation of the flag indicator of the relay.

(b) Seal-in-unit shall obtain adequate current for operation when one or more relays operate simultaneously.

(c) Impedance of the seal-in-unit shall be small enough to permit satisfactory operation of the trip coil on trip relays when the D.C. Supply Voltage is minimum.

(d) Trip-circuit seal-in is required for all trip outputs, irrespective of the magnitude of the interrupted current. The trip-circuit seal-in logic shall not only seal-in the trip output(s),but also the relevant initiation signals to other scheme functions, (e.g. initiate signals to the circuit-breaker failure function, reclosing function etc.), and the alarm output signals.

(e) Two methods of seal-in are required, one based on the measurement of AC current, catering for those circumstances for which the interrupted current is above a set threshold, and one based on a fixed time duration, catering for those circumstances for which the interrupted current is small (below the set threshold).

(f) For the current seal-in method, the seal-in shall be maintained until the circuit-breaker opens, at which time the seal-in shall reset and the seal-in method shall not now revert to the fixed time duration method. For this seal-in method, the seal-in shall be maintained for the set time duration. For the line protection schemes, this time duration shall be independently settable for single- and three-pole tripping.

(g) Seal-in by way of current or by way of the fixed duration timer shall occur irrespective of whether the trip command originates from within the main protection device itself (from any of the internal protection functions), or from an external device with its trip output routed through the main protection device for tripping. Trip-circuit seal-in shall not take place under sub-harmonic conditions (e.g. reactor ring down).

17.10. The setting ranges of the relays offered, if different from the ones specified shall also be acceptable if they meet the functional requirements.

17.11. Any alternative/additional protections or relays considered necessary for providing complete effective and reliable protection shall also be offered separately. The acceptance of this alternative/ additional equipment shall lie with the POWERGRID/Employer.

17.12. All relays and their drawings shall have phase indications as R-Red, Y-yellow, B-blue

17.13. For numerical relays, the scope shall include the following:

a) Necessary software and hardware to up/down load the data to/from the relay from/to the personal computer installed in the substation. However, the supply of PC is not covered under this clause.

b) The relay shall have suitable communication facility for future connectivity to SCADA. The relay shall be capable of supporting IEC 61850 protocol.

c) In case of line protection and transformer/reactor protection, the features like fault recorder and event logging function as available including available as optional feature in these relays shall be supplied and activated at no extra cost to the owner. Also necessary software/ hardware for automatic uploading to station HMI/DR work station (as applicable) shall be supplied. It is to be clearly understood that these shall be in addition to Fault recorder function as specified at clause no. 28.

18. TRANSMISSION LINE PROTECTION

18.1. All relays shall be suitable for series compensated line.

18.2. The line protection relays are required to protect the line and clear the faults on line within shortest possible time with reliability, selectivity and full sensitivity to all type of faults on lines. The general concept is to have two main protections having equal performance requirement specially in respect of time as called Main-I and Main-II for 765kV, 400KV and 220KV transmission lines and Main and back up protection for 132 KV transmission lines.

18.3. The Transmission system for which the protection equipment are required is indicated in Section – Project.

18.4. The maximum fault current could be as high as 63kA but the minimum fault current could be as low as 20% of rated current of CT secondary. The starting & measuring relays characteristics should be satisfactory under these extremely varying conditions.

18.5. The protective relays shall be suitable for use with capacitor voltage transformers having non-electronic damping and transient response as per IEC.

18.6. Fault Recorder, Distance to fault Locator and Over voltage relay (stage - 1/2) functions if offered as an integral part of line protection relays, shall be acceptable provided these meet the technical requirements as specified in the respective clauses.

18.7. Auto reclose relay function if offered as an integral part of line distance protection relay, shall be acceptable for **132kV & below lines** only provided the auto reclose relay feature meets the technical requirements as specified in the respective clause.

18.8. The following protections shall be provided for each of the Transmission lines:

For 765kV, 400kV & 220kV Lines

Main-I: Distance protection scheme**.**

Main-II: Distance protection scheme

- **If specified in Section-Project, Main-I and / or Main-II relay shall be provided as Line differential protection relay with built in distance function. Further, matching Line differential protection relays for remote ends shall be provided as per Bid Price Schedule (BPS).**
- **Main-I & Main-II relay shall be of different make & model. Same make relay shall be acceptable only if they are of different hardware & manufacturing platform.**
- If specified in the "Section- Project, "back up Over current and Earth fault protection shall be provided instead of Main -II protection scheme for 220KV lines to match with requirements at the remote ends.

For 132KV

Main: Distance protection scheme

Back up: Directional Over Current and Earth fault Protection

The detailed description of line protections is given here under.

18.9. **Main-I and Main-II Distance Protection scheme**:

(a) shall have continuous self monitoring and diagnostic feature

(b) shall be non-switched type with separate measurements for all phase to phase and phase to ground faults

(c) shall have stepped time-distance characteristics and independent **three forward zones and one reverse/offset** zone

(d) shall have mho or quadrilateral or other suitably shaped characteristics for **all zones**.

(e) shall have following maximum operating time (including trip relay time, if any) under given set of conditions and with CVT being used on line (with all filters included)

(i) for 765 KV, 400 KV & 220 KV lines:		
For Source to Impedance ratio:	**4**	**15**
Relay setting (Ohms)	(10 or 20) and 2	2
Fault Locations (as % of relay setting)	50	50
Fault resistance (Ohms)	0	0
Maximum operating time (Milliseconds)	40 for all faults	45 for 3 ph. Faults & 60 for all other faults
(ii) for 132 KV lines:		
A relaxation of 5 ms in above timings is allowed for 132 KV lines.		

(f) The relay shall have an adjustable characteristics angle setting range of 30-85 degree or shall have independent resistance(R) and reactance (X) setting.

(g) shall have two independent continuously variable time setting range of 0-3 seconds for zone-2 and 0-5 seconds for zone-3/reverse zone.

(h) shall have resetting time of less than 55 milli-seconds (including the resetting time of trip relays)

(i) shall have variable residual compensation for each zone

(j) shall have memory techniques with defined characteristics in all three phases to ensure correct operation during close-up 3 phase faults and other adverse conditions and shall operate instantaneously when circuit breaker is closed to zero-volt 3 phase fault

(k) shall have weak end in-feed feature

(l) shall be suitable for single & three phase tripping

(m) shall have a continuous current rating of two times of rated current. The voltage circuit shall be capable of operation at 1.2 times rated voltage. The relay shall also be capable of carrying a high short time current of 70 times rated current without damage for a period of 1 sec.

(n) shall be provided with necessary self reset type trip duty contacts for completion of the scheme (Minimum number of these trip duty contacts shall be four per phase) either through built in or through separate high speed trip relays. Making capacity of these trip contacts shall be 30 amp for 0.2 seconds with an inductive load of L/R > 10 milli seconds. If separate high speed trip relays are used , the operating time of the same shall not be more than 10 milliseconds

(o) shall be suitable for use in permissive under reach/ over reach/ blocking communication mode

(p) shall have suitable number of potential free contacts for Carrier aided Tripping, Auto reclosing, CB failure, Disturbance/**Fault** recorder & Data acquisition system

(q) include power swing blocking **and out-of-step** protection which shall

- have suitable setting range to encircle the distance protection described above
- block tripping **of distance function zones** during power swing conditions
- release blocking in the event of actual fault
- **release tripping on detection of out-of-step power swing condition**

Alternatively standalone relay for out of step protection shall also be acceptable, if the same is not part of main protection relays.

(r) include fuse failure protection which shall monitor all the three fuses of C.V.T. and associated cable against open circuit

- inhibit trip circuits on operation and initiate annunciation
- have an operating time less than 7 milliseconds
- remain inoperative for system earth faults

(s) include a directional back up Inverse Definite Minimum Time (IDMT) earth fault relay with normal inverse characteristics as per IEC 60255-3 as a built in feature or as a separate unit for 765kV, 400 KV and 220KV transmission lines

(t) Must have a current reversal guard feature.

(u) **Shall have Stub protection function with current setting minimum range of 1 to 3 pu with definite time delay setting minimum range of 0 to 100msec.**

(v) **have feature of load encroachment blinder to safeguard the protection trip during heavy line loading condition.**

18.10. **Line Differential Relay protection scheme (If applicable)**

The line current differential relay with built-in distance protection function shall be capable of being selected to differential function with back up distance function or shall activate back up distance automatically when the differential relay is out of service. The relay shall fulfil the requirement specified above at clause 18.9 for distance relay function.

Further, the line current differential function shall conform to the following main requirements:

- **i.** The current differential shall be a unit system of protection.
- **ii.** The line Current differential Protection shall comprise a well-proven high-speed phase segregated numerical current differential protection scheme, which shall be designed for the selective protection of the EHV network.
- **iii.** The High speed numerical current differential protection shall be suitable to work through directly connected fiber optics and the relay shall have the requisite teleprotection communication capability.
- **iv.** Shall have built-in signalling modules for communication with the remote end relay via direct optical fiber cables.
- **v.** The contractor shall coordinate the requirements of the current differential relay with the communication system in order to ensure compatibility between the two.
- **vi.** The relay shall incorporate inter-tripping, VT Supervision functions and heavy duty contacts for tripping of the feeder circuit breaker as well as provide all flagging, alarms etc.
- **vii.** Shall have high-speed fault detection capability with typical relay operation time of less than **30** ms for 765kV/400kV/220kV line faults and less than 40 ms for 132kV & below.
- **viii.** Shall have high sensitivity for all types of faults.
- **ix.** Shall detect and clear faults along the whole length of the feeder within the specified operating time when the remote end breaker is open or there is a weak in feed.
- **x.** Shall remain stable for fault on a parallel feeder under subsequent current reversal in the healthy feeder due to slow opening of one of the faulty feeder's circuit breakers.
- **xi.** Shall not be affected by heavy load transfer, power swings, CT saturation, distorted primary currents and voltages, VT fuse failure, line charging currents external switching, arc or tower footing resistance, sudden power reversal, zero sequence mutual coupling, fault resistance and out of phase source at the two line terminals producing misleading apparent fault reactance, power frequency variations, collapse of voltage on the faulted phase(s), etc.
- **xii.** Shall have features to clear close in faults at high speed in the event of failure of signalling channel.
- **xiii.** Shall have features to test at one end all the functions associated with the protection, without the presence of personnel at the remote end.
- **xiv.** Shall have features to block relay in case of signalling channel

failure or remote relay out of service / block or setting mismatch or dc failure etc., to avoid inadvertent tripping and shall produce alarm during blocking.

xv. Shall have inter-tripping compliant with IEC60834-1 and IEC60834–2 respectively for signalling as appropriate.

xvi. The line differential device address shall be settable and shall be suitable to set for no. of feeders shown in SLD.

xvii. CT supervision / VT Supervision shall be configured to initiate alarm locally and to sub-station automation system or event recorder as per requirement.

xviii. Shall have single pole/three pole tripping feature.

xix. Shall have built-in SOTF logic feature.

xx. Shall have features to block auto-reclose internally or externally at local end and facility to send blocking signals to remote end relay internally (through FO communication channels) during SOTF trips.

xxi. Shall have facility to configure signal transferred between local and remote end relays in the internal event recorder and disturbance recorder.

xxii. Shall have configurable time delayed thermal protection element and back up earth fault protection element.

xxiii. Shall have following features:

- Satisfactory Performance of relay under CT saturation during through faults.
- Satisfactory Performance of relay under conditions of CT saturation for in zone faults.
- Satisfactory Performance of relay during transient (jitter) and permanent changes in signalling propagation delays.

xxiv. Shall include necessary Optical fibre cable & associated accessories for connection between the current differential relay panel and existing Fibre optic distribution panel (FODP).

18.11. **Back-up Directional Over Current and Earth fault protection scheme**

(a) shall have three over current and one earth fault element(s) which shall be either independent or composite unit(s)

(b) shall include necessary VT fuse failure relays for alarm purposes

(c) **over current elements** shall

- have IDMT characteristic (normal inverse as per IEC)
- have a variable setting range of 50-200% of rated current
- have a characteristic angle of 30/45 degree lead
- include hand reset flag indicators or LEDs

(d) **earth fault element** shall

- have IDMT characteristic (normal inverse as per IEC)
- have a variable setting range of 20-80% of rated current
- have a characteristic angle of 45/60 degree lag
- include hand reset flag indicators or LEDs
- include necessary separate interposing voltage transformers or have internal feature in the relay for open delta voltage to the relay

18.12. **LINE OVER VOLTAGE PROTECTION RELAY** shall

(a) monitor all three phases

(b) have two independent stages

(c) **be either a standalone relay for both stage-I & II or as built in function of Main-I & Main-II distance relay for both stage-I & II.**

(d) have an adjustable setting range of 100-170% of rated voltage **with a setting least count of 0.1V (Secondary volts) and** an adjustable time delay range of 1 to 60 seconds for the first stage.

(e) have an adjustable setting range of 100-170% of rated voltage with a time delay of 100-200 mill seconds for the second stage.

(f) be tuned to power frequency

(g) provided with separate operation indicators (flag target) and **signal** for each stage relays **with phase indication for event logging**.

(h) have a drop-off to pick-up ratio greater than **97%**

18.13. All trip relays used in transmission line protection scheme shall be of self/electrical reset type depending on application requirement.

19. **CIRCUIT BREAKER PROTECTION:**

This shall include following functions:

19.1. **Numerical AUTO RECLOSING** function shall

(a) have single phase reclosing facilities

(b) have a continuously variable single phase dead time range of 0.1-2 seconds

(c) have a continuously variable reclaim time range of 5-300 seconds

(d) Incorporate a two position selector switch, from which single phase auto-reclosure and non-auto reclosure mode can be selected. Alternatively, the mode of auto reclosing can be selected through **HMI of the relay or BCU & SAS**.

(e) be of single shot type

(f) have priority circuit for closing of both circuit breakers in case of one and half breaker arrangements to allow sequential closing of breakers

(g) However, Auto-reclose as in built function of bay controller unit (BCU) (if supplied) is also acceptable **provided the signal exchange for auto-reclose function from BCU to main Relays & vice-versa is achieved through hardwiring**.

19.2. **LOCAL BREAKER BACK-UP (LBB) PROTECTION SCHEME** shall

(a) be triple pole type

(b) have an operating time of less than 15 milli seconds

(c) have a resetting time of less than 15 milli seconds

(d) have three over current elements

(e) be arranged to get individual initiation from the corresponding phase of main protections of line for each over current element. However, common three phase initiation is acceptable for other protections and transformer /reactor equipment protections

(f) have a setting range of 10-80% of rated current

(g) have a continuous thermal withstand two times rated current irrespective of the setting

(h) have a timer with continuously adjustable setting range of 0.1-1 seconds

(i) have necessary auxiliary relays to make a comprehensive scheme

(j) Shall have re-trip feature for tripping its own CB after initiation with a set time delay.

(k) be acceptable as Built-in protection function of distributed bus bar protection scheme only; however in that case separate LBB relay shall be provided for tie bays.

(l) be similar relays for complete scope of work as per specification **(if provided as standalone relay unit).**

20. REACTOR PROTECTION

20.1. **Differential Protection Relay shall**

(a) be triple pole type

(b) have operation time less than 25 milli-seconds at 5 times setting

(c) be tuned to system frequency

(d) have current setting range of 10 to 40% of 1 Amp. or a suitable voltage setting range

(e) be high impedance / biased differential type

(f) be stable for all external faults, CT saturation.

20.2. **Restricted Earth Fault Protection Relay** shall

(a) be single pole type

(b) be of current/voltage operated high impedance type

(c) have a current setting of **05**-40% of 1 Amp./have a suitable voltage setting range

(d) be tuned to system frequency

(e) have a suitable non-linear resistor to limit the peak voltage to 1000 Volts

(f) Separate relay shall be provided for 1-phase spare reactor unit (if envisaged).

20.3. **Back up impedance protection Relay** shall

(a) be triple pole type, with faulty phase identification/ indication

(b) be single step polarised 'mho' distance/ impedance relay suitable for measuring phase to ground and phase to phase faults

(c) have adequate ohmic setting range to cover at least 60% of the impedance of the reactor and shall be continuously variable

(d) have an adjustable characteristic angle of 30-80 degree

(e) have a definite time delay relay with a continuously adjustable setting range of 0.2-2.0 seconds

(f) include VT failure relay which shall block the tripping during VT fuse failure condition

(g) have Back-up over current and earth fault protection as built in function

20.4. Further, Reactor auxiliary protections contacts (Buchholz, PRV, Oil Temperature, Winding Temperature etc.) can be wired suitably in above protections or provide separate Flag relays/Auxiliary relays as per scheme requirements. **Further reactor protections shall be grouped such that Differential protection, Buchholz-I trip and Winding temperature trip are on DC-A while REF protection, Back-up Impedance protection, PRD-I and Oil temperature trip are on DC-B. In case multiple trip contacts for Buchholz relay / PRD relays are available, then their contacts shall be wired to both Group of Protection.**

21. TRANSFORMER PROTECTION

21.1. **Transformer differential protection** scheme shall

(a) be triple pole type, with faulty phase identification/ indication

(b) have an operating time not greater than 30 milli seconds at 5 times the rated current

(c) have three instantaneous high set over-current units

(d) **be bias differential type having** an adjustable bias setting range of 10-50%

(e) be suitable for **04 nos. of 3-ph CT input** with rated **CT secondary** current of 1 Amp.

(f) have second harmonic or other inrush proof features and also should be stable under normal over fluxing conditions. Magnetising inrush proof feature shall not be achieved through any intentional time delay e.g. use of timers to block relay operation or using disc operated relays

(g) have an operating current setting of 15% or less

(h) include necessary separate interposing current transformers for angle and ratio correction or have internal feature in the relay to take care of the angle & ratio correction

(i) have a fault recording feature to record graphic form of instantaneous values of following analogue channels during faults and disturbances for the pre fault and post fault period:

Current in all three windings in nine / **twelve** analogue channels in case of 400kV class / **765kV class** respectively or 6 analogue channels for lower voltage transformers and Voltage in one channel

The disturbance recorder **function built in the Differential protection IED** shall have the facility to record the following external digital channel signals associated with transformer **which shall be wired to differential relay** apart from the digital signals pertaining to differential relay:

1. REF protection operated
2. HV Breaker status (Main & tie/transfer both separately)
3. IV Breaker status (Main & tie/transfer both separately)
4. **Bucholz / OLTC/ WTI/ OTI alarm**
5. **Bucholz / PRD / SPR/ Trip**
6. **Group-A, Group-B lock-out relay trip**

Necessary hardware and software, for automatic up-loading the data captured by disturbance recorder to the personal computer (DR Work Station) available in the substation, shall be included in the scope.

21.2. **Over Fluxing Protection Relays** shall

(a) operate on the principle of Voltage to frequency ratio and shall be phase to phase connected

(b) have inverse time characteristics, matching with transformer over fluxing withstand capability curve

(c) provide an independent 'alarm' with the time delay continuously adjustable between 0.1 to 6.0 seconds at values of 'v/f' between 100% to 130% of rated values

(d) tripping time shall be governed by 'v/f' Versus time characteristics of the relay

(e) have a set of characteristics for Various time multiplier settings. The maximum operating time of the relay shall not exceed 3 seconds and 1.5 seconds at 'v/f' values of 1.4 and 1.5 times, the rated values, respectively.

(f) have an accuracy of operating time, better than ±10%

(g) have a resetting ratio of **97 %** or better.

21.3. **Restricted Earth Fault Protection** shall

(a) be single pole type

(b) be of current/voltage operated type

(c) have a current setting range **of 5-40%** of 1 Amp./ have a suitable voltage setting range

(d) be tuned to the system frequency

(e) be phase segregated type for 1-ph transformer units

(f) Separate relay shall be provided for 1-phase spare transformer unit (if envisaged).

21.4. **Back-up Over Current and Earth fault protection scheme with high set feature**

(a) Shall have three over current and one earth fault element(s) which shall be either independent or composite unit(s).

(b) The scheme shall include necessary VT fuse failure relays for alarm purposes

(c) Over current relay shall

- have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 50-200% of rated current
- have low transient, over reach high set instantaneous unit of continuously variable setting range 500-2000 % of rated current
- have a characteristic angle of 30/45 degree lead
- include hand reset flag indicators or LEDs.

(d) Earth fault relay shall

- have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current
- have low transient, over reach high set instantaneous unit of continuously variable setting range 200-800 % of rated current
- have a characteristic angle of 45/60 degree lag
- include hand reset flag indicators or LEDs
- include necessary separate interposing voltage

transformers or have internal feature in the relay for open delta voltage to the relay

21.5. **Transformer Overload Protection Relay** shall

(a) be of single pole type

(b) be of definite time over-current type

(c) have one set of over-current relay element, with continuously adjustable setting range of 50-200% of rated current

(d) have one adjustable time delay relay for alarm having setting range of 1 to 10.0 seconds, continuously.

(e) have a drop-off/pick-up ratio greater **than 95%.**

21.6. **Transformer Neutral Current Protection relay** (for 1-Phase transformer bank neutral) shall

(a) have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current.

21.7. Further, Transformer auxiliary protections contacts (Buchholz, PRD, **SPRD**, Oil Temperature, Winding Temperature, OLTC Buchholz etc. can be wired suitably in above protections or provide separate Flag relays/Auxiliary relays as per scheme requirements. **Further, transformer protections shall be grouped such that Differential trip, Buchholz-I trip, Oil temperature alarm and Winding temperature trip are on DC source-A while REF trip, Buchholz alarm, PRD-I trip, winding temperature alarm and Oil temperature trip are on DC source-B. In case multiple trip contacts for Buchholz relay / PRD relays are available, then their contacts shall be wired to both Group of Protection.**

22. TEE DIFFERENTIAL PROTECTION RELAYS (If Applicable)

22.1. **TEE-1 Differential (Bias) protection relay** shall

(a) be triple pole type

(b) have an operating time less than 30 milliseconds at 5 times the rated current

(c) have three instantaneous high set over current units

(d) have an adjustable bias setting range of 20-50%

(e) have an operating current setting of 15% of 1 Amp or less

22.2. **TEE-2 Differential (High Impedance) Protection relay** shall

(a) be triple pole type

(b) have operating time less than 25 milliseconds at 5 times setting

(c) be tuned to system frequency

(d) have current setting range of 20 to 80% of 1 Amp

(e) be voltage operated, high impedance type

(f) be stable for all external faults

(g) be provided with suitable non linear resistors across the relay to limit the peak voltage to 1000 volts

23. **TRIP CIRCUIT SUPERVISION RELAY**

(a) The relay shall be capable of monitoring the healthiness of each 'phase' trip-coil and associated circuit of circuit breaker during 'ON' and 'OFF' conditions.

(b) The relay shall have adequate contacts for providing connection to alarm and event logging.

(c) The relay shall have time delay on drop-off of not less than 200 milli seconds and be provided with operation indications for each phase

24. **TRIPPING RELAY**

High Speed Tripping Relay shall

(a) be instantaneous (operating time not to exceed 10 milli-seconds).

(b) reset within 20 milli seconds

(c) be D.C. operated

(d) have adequate contacts to meet the requirement of scheme, other functions like auto-reclose relay, LBB relay as well as cater to associated equipment like event logger (SAS), Disturbance recorder, fault Locator, etc.

(e) be provided with operation indicators for each element/coil.

25. **DC SUPPLY SUPERIVISION RELAY**

(a) The relay shall be capable of monitoring the failure of D.C. supply to which, it is connected.

(b) It shall have adequate potential free contacts to meet the scheme requirement.

(c) The relay shall have a 'time delay on drop-off' of not less than 100 milli seconds and be provided with operation indicator/flag.

26. **BUS BAR PROTECTION**

26.1. Redundant (1+1) numerical **low impedance biased differential** Bus Bar protection scheme for each Main bus (Bus1 / Bus2) & Transfer Bus (as applicable) for 400kV and 765kV shall be provided**.** The scheme shall be engineered so as to ensure that operation of any one out of two schemes connected to faulty bus shall result in tripping of the same.

26.2. Single bus bar protection scheme shall be provided for each main bus and transfer bus (as applicable) for 220KV and 132 KV voltage levels.

26.3. Each Bus Bar protection scheme shall

(a) have maximum operating time up to trip impulse to trip relay of 25 milli seconds at 5 times setting value for all types of faults.

(b) operate selectively for each bus bar

(c) give hundred percent security up to 63 KA fault level for 400KV and 220KV and 31.5 KA for 132 KV system.

(d) incorporate continuous supervision for CT secondary against any possible open circuit and if it occurs, shall render the relevant zone of protection inoperative and initiate an alarm.

(e) not give false operation during normal load flow in bus bars

(f) not cause tripping for the differential current below the load current of heaviest loaded feeder. Contractor shall submit application check for the same.

(g) be of phase segregated and triple pole type

(h) incorporate clear zone indication

(i) provide independent zones of protection (including transfer bus if any). If the bus section is provided then each side of bus section shall have separate set of bus bar protection schemes

(j) include protection 'IN/OUT' switch for each zone

(k) include individual high speed electrically reset tripping relays for each feeder. However, in case of distributed Bus bar protection, individual trip relay shall not be required if bay unit is having trip duty contacts for breaker tripping.

(l) be transient free in operation

(m) include continuous D.C. supplies supervision

(n) shall include necessary C.T. switching relays wherever C.T. switching is involved and have 'CT' selection incomplete alarm

(o) shall include trip relays, CT switching relays (if applicable), auxiliary CTs (if applicable) as well as additional power supply modules, input modules etc. as may be required to provide a Bus-bar protection scheme for the complete bus arrangement i.e. for all the bays or breakers including future bays as per the Single line diagram for new substations. However for extension of bus bar protection scheme in existing substations, scope shall be limited to the bay or breakers **covered in the scope of work**. Suitable panels (if required) to mount these are also included in the scope of the work.

(p) In case of distributed Bus bar Protection, the bay units for future bays may be installed in a separate panel and the same shall be located in switchyard panel room where bus bar protection panel shall be installed.

26.4. At existing substations, Bus-bar protection scheme with independent zones for each bus, will be available. All necessary co-ordination for

'AC' and 'DC' interconnections between existing schemes (Panels) and the bays proposed under the scope of this contract shall be fully covered by the bidder. Any auxiliary relay, trip relay, flag relay and multi tap auxiliary CTs (in case of biased differential protection) required to facilitate the operation of the bays covered under this contract shall be fully covered in the scope of the bidder.. .

26.5. The test terminal blocks (TTB) to be provided shall be fully enclosed with removable covers and made of moulded, non-inflammable plastic material with boxes and barriers moulded integrally. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring. Terminal block shall have shorting, disconnecting and testing facilities for CT circuits.

27. WEATHER PROOF RELAY PANELS (**For CT switching**, If Applicable)

(a) This panel shall include necessary number of electrically reset relays each with at least eight contacts for isolator auxiliary contacts multiplication and for changing the CT and DC circuits to relevant zones of bus bar protection.

(b) The panel shall be sheet steel enclosed and shall be dust, weather and vermin proof. Sheet steel used shall be at least 2.0 mm thick and properly braced to prevent wobbling.

(c) The enclosures of the panel shall provide a degree of protection of not less than IP-55 (as per IS: 2147).

(d) The panel shall be of free standing floor mounting type or pedestal mounting type as per requirement.

(e) The panel shall be provided with double hinged doors with padlocking arrangement.

(f) All doors, removable covers and panels shall be gasketed all around with synthetic Neoprene/EPDM gaskets generally conforming with provision of IS 11149. However, XLPE gaskets can also be used for fixing protective glass doors. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh.

(g) Cable entries shall be from bottom. Suitable removable cable gland plate shall be provided on the cabinet for this purpose.

(h) All sheet steel work shall be degreased, pickled, phosphated and then applied with two coats of zinc chromates primer and two coats of finishing synthetic enamel paint, both inside and outside. The colour of the finishing paint shall be light grey in accordance with shade no.697 of IS: 5.

(i) Suitable heaters shall be mounted in the panel to prevent condensation. Heaters shall be controlled by thermostats so that the cubicle temperature does not exceed 30^{o}C. On-off switch and fuse shall be provided. Heater shall be suitable for 240V AC supply Voltage.

(j) The test terminal blocks (TTB) to be provided shall be fully enclosed with removable covers and made of moulded, non-inflammable plastic material with boxes and barriers moulded integrally. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring. Terminal block shall have shorting, disconnecting and testing facilities for CT circuits.

28. FAULT RECORDER

28.1. The fault recorder shall be provided for transmission lines. The fault recorder as in-built feature of line distance relay is also acceptable provided the requirements of following clauses are met.

28.2. Fault recorder shall be microprocessor based and shall be used to record the graphic form of instantaneous values of voltage and current in all three phases, open delta voltage & neutral current, open or closed position of relay contacts and breakers during the system disturbances.

28.3. The Fault recorder shall consist of individual acquisition units, one for each feeder and an Evaluation unit which is common for the entire Substation. Whenever, more than one acquisition units are connected to an Evaluation unit, necessary hardware and software shall also be supplied for on line transfer of data from all acquisition units to Evaluation unit.

28.4. The acquisition unit is connected with evaluation unit being supplied as described in section sub-station automation through bus conforming to IEC 61850. In case of extension sub-station which is equipped with Sub-station Automation System based on IEC 61850, one set of evaluation software shall be supplied and loaded in existing fault recorder evaluation unit. Automatic uploading of disturbance files from acquisition unit to evaluation unit shall be done through existing station bus only conforming to IEC 61850. Necessary configuration/updation including hardware if any shall be in the scope of the contractor.

28.5. In case of extension of existing substation(s) which are without sub-station automation system, one set of Evaluation unit shall be supplied for each substation where ever disturbance recorders are required **(as per section-Project)** to be supplied along with necessary evaluation software as specified above. The Evaluation unit shall consist of a desktop personal computer (including at least 17” TFT colour monitor, mouse and keyboard) and **A4 size colour** printer. The desktop PC shall have **I5** processor or better and having a clock speed **2.0** GHz or better. The hard disk capacity of PC shall not be less than **1000** GB and RAM capacity shall not be less than **4** GB.

28.6. The evaluation unit hardware, for substations having SAS, shall be as described in section sub-station automation system.

28.7. Fault recorder shall have atleast 8 analogue and 16 digital channels for each feeder.

28.8. Acquisition units shall acquire the Disturbance data for the pre fault and post fault period and transfer them to Evaluation unit automatically to store in the hard disk. The acquisition units shall be located in the protection panels of the respective feeders.

28.9. The acquisition unit shall be suitable for inputs from current transformers with 1A rated secondary and capacitive voltage transformers with 63.5V (phase to neutral voltage) rated secondary. Any device required for processing of input signals in order to make the signals compatible to the Fault recorder equipment shall form an integral part of it. However, such processing of input signals shall in no way distort its waveform.

28.10. The equipment shall be carefully screened, shielded, earthed and protected as may be required for its safe functioning. Also, the Fault recorder shall have stable software, reliable hardware, simplicity of maintenance and immunity from the effects of the hostile environment of EHV switchyard which are prone to various interference signals typically from large switching transients.

28.11. Void

28.12. Evaluation software shall be provided for the analysis and evaluation of the recorded data made available in the PC under WINDOWS environment. The Software features shall include repositioning of analog and digital signals, selection and amplification of time and amplitude scales of each analogue and digital channel, calculation of MAX/MIN frequency, phase difference values, recording of MAX/MIN values etc. of analogue channel, group of signal to be drawn on the same axis etc, listing and numbering of all analogue and digital channels and current, voltage, frequency and phase difference values at the time of fault/tripping. Also, the software should be capable of carrying out Fourier /Harmonic analysis of the current and voltage wave forms. The Disturbance records shall also be available in COMTRADE format (IEEE standard- Common Format for Transient data Exchange for Power System)

28.13. The Evaluation unit shall be connected to the color printer to obtain the graphic form of disturbances whenever desired by the operator.

28.14. Fault recorder acquisition units shall be suitable to operate from 220V DC or 110V DC as available at sub-station. Evaluation unit along with the printer shall normally be connected to 230V, single phase AC supply. In case of failure of AC supply, Evaluation unit and printer shall be switched automatically to the station DC through Inverter of adequate capacity which shall form a part of Fault recorder system. The inverter of adequate capacity shall be provided to cater the requirement specified in section - sub-station automation and DR evaluation unit.

28.15. The acquisition unit shall have the following features

(a) Facility shall exist to alarm operator in case of any internal faults in the acquisition units such as power supply fail, processor / memory fail etc and same shall be wired to annunciation system /**SAS**.

(b) The frequency response shall be 5 Hz on lower side and 250 Hz or better on upper side.

(c) Scan rate shall be 1000 Hz/channel or better.

(d) Pre-fault time shall not be less than **500** milliseconds and the post fault time shall not be less than 2 seconds (adjustable). If another system fault occurs during one post-fault run time, the recorder shall also be able to record the same. **However, the total memory of acquisition unit shall not be less than 5.0 seconds.**

(e) The open delta voltage and neutral current shall be derived either through software or externally by providing necessary auxiliary transformers.

(f) The acquisition unit for line fault recorder shall be typically used to record **at least** the following digital channels :

1 Main CB R phase open

2 Main CB Y phase open

3 Main CB B phase open

4 Tie/TBC CB R phase open

5 Tie/TBC CB Y phase open

6 Tie/TBC CB B phase open

7 Main-1 carrier received

8 Main-1 protection operated

9 Main/Tie /TBC Auto reclosed operated

10 Over Voltage -Stage-1 /2 operated

11 Reactor / Stub/TEE-1/2/UF protection operated

12 Direct Trip received

13 Main-2 carrier received

14 Main- 2/ Back Up protection operated

15 Bus bar protection operated

16 LBB operated of main /tie/TBC circuit breaker

(g) In case the Fault recorder is in-built part of line distance protection, above digital channels may be interfaced either externally or internally.

(h) The sequence of digital channels shall be as per above list and which shall be ensured by the contractor. Digital channels shall be named suitably for easy identification of signals in the fault recordings.

(i) Any digital signal can be programmed to act as trigger for the acquisition unit. Analog channels should have programmable threshold levels for triggers and selection for over or under levels should be possible.

28.16. The **colour laser** printer **(A4 size)** shall be provided which shall be compatible with the desktop PC and shall use Plain paper. The print out shall contain the Feeder identity, Date and time (in hour, minute and second up to 100th of a second), identity of trigger source and Graphic form of analogue and digital signals of all the channels.

28.17. Each Fault recorder shall have its own time generator and the clock of the time generator shall be such that the drift is limited to ±0.5 seconds/day, if allowed to run without synchronisation. Further, Fault recorder shall have facility to synchronise its time generator from Time Synchronisation Equipment having output of following types :

- Voltage signal : (0-5V continuously settable, with 50m Sec. minimum pulse duration)
- Potential free contact (Minimum pulse duration of 50 m Sec.)
- IRIG-B
- RS232C
- **SNTP**

The recorder shall give annunciation in case of absence of synchronising within a specified time.

28.18. Substations where Time Synchronisation Equipment is not available, time generator of any one of the Fault recorders can be taken as master and time generators of other Fault recorders and Event loggers in that station shall be synchronised to follow the master.

29. STANDALONE DISTURBANCE RECORDER (for 765 KV Feeders only)

A separate numerical disturbance recording function shall be provided for each 765kV lines. The following requirements shall be met:

29.1. The disturbance recorder shall record the analogue values form of the instantaneous values of voltage and current in all three phases, the open delta voltage and the neutral current. The open or closed position of relay contacts and circuit breakers during system disturbances shall also be recorded.

29.2. The disturbance recorder shall comprise distributed individual acquisition units, one for each feeder and an evaluation unit which is common for the entire substation. The acquisition units shall acquire the disturbance data for the pre-fault, fault and post-fault periods and transfer them to the evaluation unit automatically for storage on a mass storage device. The acquisition unit shall be suitable for inputs from current transformers with 1 A rated secondaries and capacitive voltage transformers with 63.5 V (phase-to-neutral voltage) rated secondaries.

29.3. The acquisition units shall have the following features:

(a) A facility to alert the operator in the case of any internal faults (such as power supply fail, processor/memory fail etc.) in any of the acquisition units and this alarm shall be wired to the station annunciation system.

(b) The pre-fault time shall not be less than 200 milliseconds and the post fault time shall not be less than 2 seconds (adjustable). If another system disturbance occurs during a post-fault run time, the recorder shall also be able to record this subsequent disturbance. The scan rate should be selectable in the range from 1000 Hz to 5000 Hz.

(c) The open delta voltage and neutral current shall be derived either through software or externally by providing necessary auxiliary transformers.

(d) The acquisition unit shall be typically used to record **at least** the following digital channels:

1. Main circuit-breaker R-phase open
2. Main circuit-breaker Y-phase open
3. Main circuit-breaker B-phase open
4. Main 1 carrier received
5. Main 1 protection operated
6. Main/Tie auto-reclose operated
7. Overvoltage stage 1/2 operated
8. Reactor/Stub-1/2 protection operated
9. Direct trip received
10. Main 2 carrier received
11. Main 2 protection operated
12. Busbar protection operated
13. Breaker failure protection of main/tie circuit-breaker operated
14. Tie circuit-breaker R-phase open
15. Tie circuit-breaker Y-phase open
16. Tie circuit-breaker B-phase open

The sequence of digital channels shall be as per above list and which shall be ensured by the contractor. Digital channels shall be named suitably for easy identification of signals in the fault recordings.

29.4. The necessary hardware and software shall also be supplied for the on-line transfer of data from all acquisition units to the evaluation unit. The disturbance recording system shall be capable of handling the full complement of feeders in the substation.

In case of extension of existing substation(s), one set of Evaluation unit shall be supplied for each substation wherever required (as per section-Project) along with necessary evaluation software as specified above.

29.5. The disturbance recording equipment shall be screened, shielded, earthed and protected as may be required for its safe and proper functioning. Also, the disturbance recorder shall have stable software, reliable hardware, simplicity of maintenance and immunity from the effects of the hostile environment of a 765 kV EHV switchyard which is prone to numerous interference signals such as large switching transients.

29.6. The evaluation unit shall comprise all the necessary hardware and software for the proper evaluation of disturbances. The hardware would typically consist of a desktop personal computer (including a large high resolution colour monitor, mouse and keyboard) and a high-speed colour printer **(A4 size).** The desktop PC shall have **I5** processor or better and shall have a clock speed of **2.0 GHz** or better. The mass storage capacity of PC shall not be less than **1000GB** and the RAM capacity shall not be less than **4 GB**. The evaluation software required for the analysis and evaluation of the recorded data shall run on the PC under Microsoft Windows environment. The software features shall provide:

- clear and unambiguous display of all channels;
- the ability to reposition the analog and digital traces;
- recording of maximum/minimum values etc. of the analog channels;
- calculation of maximum/minimum frequency and phase difference values;
- grouping of signals for drawing on the same axis;
- listing and identification of all analog and digital channels as well as and current, voltage, frequency and phase difference values at the time of fault/tripping;
- the capability of carrying out Fourier/Harmonic analysis of the current and voltage waveforms; and,
- the availability of the disturbance records in COMTRADE format

29.7. The evaluation unit shall be permanently connected to the printer so as to obtain the graphic display of disturbances whenever desired by the operator. The printer shall be compatible with the desktop PC and shall use plain paper. The print out shall contain the feeder identity, date and time (in hour, minute and second up to 100th of a second), identity of the trigger source and graphic representation of the analog and digital signals of all the channels.

29.8. The disturbance recorder acquisition units shall be suitable to operate from the station DC. The evaluation unit along and the printer shall normally be connected to the 230 V, single phase AC supply. In the case of a failure of the AC supply, the evaluation unit and printer shall be automatically switched to the station DC through an inverter of adequate capacity and which shall form part of disturbance recording system.

29.9. The disturbance recorder shall be capable of being triggered by the following user-specified quantities:

(a) external start, both software and hardware

(b) cross triggering of groups of channels, either software or hardware or both

(c) binary channel (NO and NC contacts)

(d) over voltage and under voltage

(e) over current

(f) negative sequence voltage

(g) zero sequence voltage

(h) rate of change, voltage or current

(i) over frequency or under frequency

(j) logical or Boolean expressions, programmable

(k) power swing

(l) rate of change of active or reactive power

29.10. The disturbance recorder shall have its own time generator and the clock of the time generator shall be such that the drift is limited to less than ± 0.5 seconds per day, if allowed to run without synchronisation. Further, the disturbance recorder shall have the facility to synchronise its time generator from the station Time Synchronisation Equipment using IRIG-B. The recorder shall give an alarm in the case of the absence of the synchronising pulse for a pre-determined time.

30. **DISTANCE TO FAULT LOCATOR** shall

a. be electronic or microprocessor based type

b. be 'On-line' type

c. be suitable for breaker operating time of 2 cycles

d. have built-in display unit

e. the display shall be directly in percent of line length or kilometres without requiring any further calculations

f. have an accuracy of 3% or better for the typical conditions defined for operating timings measurement of distance relays

g. The above accuracy should not be impaired under the following conditions:

- presence of remote end infeed
- predominant D.C. component in fault current
- high fault arc resistance
- severe CVT transients

h. shall have mutual zero sequence compensation unit if fault locator is to be used on double circuit transmission line

i. built in feature of line distance relay is acceptable provided the requirements of above clauses are met.

31. **DISTANCE TO FAULT LOCATOR-Travelling Wave type (TWFL):**

Distance to Fault locator, based on Traveling wave detection method, shall

a. be microprocessor based, On-line type

b. have programmable triggering thresholds

c. be suitable for breaker operating time of minimum 2 cycles

d. consist of acquisition unit and one central unit

e. provide fault location reading directly in kilo-meter without requiring any further calculations

f. have fault location accuracy of + 150 Meter or better with a least count of atleast 50 meter for fault locator readings

g. The above accuracy should not be affected by followings:

- Line length
- Presence of remote end in-feed
- Series compensation
- Non-uniform line (having Cable & Over head line both)
- Mutual coupling
- Transposition of line
- Fault resistance
- Severe CVT transients

h. Acquisition units shall:

i. be either standalone for each line
or
with the capability to cater to a number of lines emanating from a substation. Incase more than one lines are to be accommodated in one acquisition unit then suitable coupler unit/measuring unit shall be provided in individual line bay C&R panels and only secondary wiring shall be brought to common acquisition unit. While offering this option, bidders are advised to take care of maximum distance between Acquisition unit & line bays C&R panels. In the BPS, total no. of line bays envisaged for Travelling Wave type Fault Locators is mentioned for further assessment by the bidder for no. of Acquisition units required for total functional requirements based on equipment design.

ii. include all required accessories (like couplers, cables, connectors etc) to connect to the secondary wiring of the Instrument transformers (in C&R panels) for detection of traveling wave

iii. have built-in backlit display unit and keypad

iv. have the facility to locally download the data in case of communication failure

v. have minimum 02 nos. binary input per line for line protection trip input. Binary input shall be rated for 220V DC and it shall be possible to set the de-bounce time of the binary input.

vi. have minimum **1GB** of storage space

vii. have facility to transmit the fault record to the Central unit by dialing mode, IEC60870-5-103 or IEC60870-5-104 or TCP/IP net protocol etc. Scope shall include dialup modem, if required with each Acquisition unit.

i. include required GPS time synchronizing units for each substation (internal or external to Acquisition unit)

j. Central data processing unit shall:

i. Consist of a desktop personal computer (including at least 17" TFT color monitor, mouse and keyboard), colour laser jet multi-function printer (A4 size), LAN switches (as required), all special cables and other required accessories. The desktop PC shall have Intel Dual core processor or better. The hard disk capacity of PC shall not be less than 1000 GB and RAM capacity shall not be less than 4 GB.

ii. have all necessary hardware & software for data download from Acquisition units, storage, processing, device (acquisition unit) creation and configuration, and comprehensive viewer for manual analysis of waveform. It will also have diagnostic feature to check the healthiness of connected devices & communication link.

iii. calculate & report the fault location based on the traveling wave data acquired from acquisition units of both end of the line. However, Central data processing unit shall have the facility to calculate the fault location even with only one end acquisition unit data of the line.

iv. be able to communicate to the Master station (Control centre) through IEC60870-5-104 net protocol. Alternate Standard protocol shall also be acceptable subject to fulfilling the functional requirements.

v. be located at local or any remote end based on the availability of communication link. End to end communication link shall be provided by POWERGRID. However Scope shall also include a dialup modem with central data processing unit.

k. In cases, Central data processing unit of Travelling wave fault locator is existing at a location the Acquisition units under present scope can be integrated with the existing Central data processing unit (Make & Model of existing unit should be mentioned in section-Project) by required augmentation (configuration and up gradation of data base including supply of any additional hardware / software etc.). Alternatively, bidder may offer separate Central data processing unit & associated hardware & software as may be required under the head of augmentation of Central data processing unit.

l. **Include required no. of panels to house the offered equipments at various substations & central location. Acquisition units can also be mounted in respective line protection panels.**

m. **TWFL as built-in feature of Standalone fault recorder or Line Protection IED shall also be acceptable subject to meeting the functional requirement specified.**

n. **Type test (EMI/EMC) and additional functional test for accuracy shall be submitted for TWFL for review and approval.**

32. TIME SYNCHRONISATION EQUPMENT

32.1. The Time synchronisation equipment shall receive the co-ordinated Universal Time (UTC) transmitted through Geo Positioning Satellite System (GPS) and synchronise equipments to the Indian Standard Time in a substation.

32.2. Time synchronisation equipment shall include antenna, all special cables and processing equipment etc.

32.3. It shall be compatible for synchronisation of Event Loggers, Disturbance recorders and SCADA at a substation through individual port or through Ethernet realised through optic fibre bus.

32.4. Equipment shall operate up to the ambient temperature of 50 degree centigrade and 80% humidity.

32.5. The synchronisation equipment shall have 2 micro-second accuracy. Equipment shall give real time corresponding to IST (taking into consideration all factors like voltage, & temperature variations, propagation & processing delays etc).

32.6. Equipment shall meet the requirement of IEC 60255 for storage & operation.

32.7. The system shall be able to track the satellites to ensure no interruption of synchronisation signal.

32.8. The output signal from each port shall be programmable at site for either one hour, half hour, minute or second pulse, as per requirement.

32.9. The equipment offered shall have six (6) output ports. Various combinations of output ports shall be selected by the customer, during detailed engineering, from the following :

- Potential free contact (Minimum pulse duration of 50 milli Seconds.)
- IRIG-B
- RS232C
- SNTP Port
- **IEEE 1588 PTP (*Applicable only for Process bus automation station*)**

32.10. The equipment shall have a periodic time correction facility of one second periodicity.

32.11. Time synchronisation equipment shall be suitable to operate from 220V DC or 110V DC as available at Substation.

32.12. Equipment shall have real time digital display in hour, minute, second (24 hour mode) & have a separate time display unit to be mounted on the top of control panels/**SAS panel** having display size of approx. 100 mm height.

33. Bay Control Unit (BCU): BCU supplied shall meet the requirements mentioned under technical specification Section- Substation automation.

34. INTERFACE PANEL (If specified in BPS)

a) Interface panel is envisaged to minimize cabling/termination time during erection stage at site, minimize hindrance in protection panel and also ease of trouble shooting. This panel shall be installed in Switchyard panel room and one no. interface panel shall be provided for each feeder. Tie bay can be accommodated in the Interface unit of any one of the associated feeder.

b) All control wiring from switchyard except CTs & CVTs shall be terminated in the interface panel. CTs and CVTs wiring shall be directly connected to the relay panel as per scheme requirements.

c) All wiring from Interface panel to relay panels or other panels (Inter-panel wiring) in the switchyard panel room shall be factory fitted / terminated through Plug-in type termination arrangement. Plug-in type termination shall be heavy duty industrial grade with double locking latch or screw locking arrangement with IP65 protection.

d) Minimum one number spare Plug-in type connector duly terminated on each side per inter-panel wiring circuit shall be provided for future use.

35. MONITORING, CONTROL & PROTECTION FOR AUXILIARY TRANSFORMER

Suitable monitoring, control (operation of associated circuit breaker & isolator) and protection for LT auxiliary transformer, connected to tertiary winding of auto transformer for the purpose of auxiliary supply shall be provided by the contractor. Over current and open delta protection is required to be provided for the auxiliary transformer. These protection and control shall be also be acceptable as built in feature either in the bay controller to be provided for the auxiliary system or in the control & protection IEDs to be provided for autotransformer.

36. RELAY Test KIT

36.1. One relay test kit shall comprise of the following equipment as detailed here under

3 sets	Relay tools kits
2 nos.	Test plugs **for each type of** TTB
2 nos.	Test plugs for using with modular type relays (if applicable)

37. CONFIGURATION OF RELAY AND PROTECTION PANELS

The following is the general criteria for the selection of the equipments to be provided in each type of panel. However, contractor can optimise the requirement of panels by suitably clubbing the feeder protection and CB relay panels. It may be noted that Main-I and Main-II protections for line can not be provided in single panel. Similarly, Group-I & Group-II protections for transformer can not be provided in single panel.

I) LINE PROTECTION PANEL: The Line Protection panel for transmission lines shall consist of following protection features/schemes

Sl. No.	Description	765kV	400kV	220kV	132kV
1.	Main-1 protection scheme	1 Set	1 Set	1 Set	1 Set
2.	Main-2 protection scheme	1 Set	1 Set	1 Set	NIL*
3.	Over Voltage Protection Scheme	1 Set	1 Set	NIL	NIL
4.	Fault Recorder	1 Set	1 Set	1 Set	NIL
5.	Standalone Disturbance Recorder	1 Set	NIL	NIL	NIL
6.	Distance to fault Locator	1 Set	1 Set	1 Set	1 Set
7.	**Cut out for mounting of Distance to fault Locator (TWFL)**	**1 Set#**	**1 Set#**	NIL	NIL
8.	3 Phase Trip Relays	2 Nos.	2 Nos.	2 Nos.	2 Nos.
9.	Flag relays, carrier receive relays, aux. Relays, timers etc as per scheme requirements	As required	As required	As required	As required
10.	Under Voltage protection relay for isolator/earth switch **Interlock**	2 Nos	2 Nos	2 Nos	2 Nos

Sl. No.	Description	765kV	400kV	220kV	132kV
11..	Cut-out and wiring with TTB for **Employer** supplied energy meter	1 Set	1 Set	1 Set	1 Set
12.	Directional Back up Over current and E/F protection scheme	NIL	NIL	NIL	1 Set
Note- 1)	*Back up –directional O/c & E/F protection is specified for 132kV system in place of Main-II				
Note- 2)	In a substation where 765kV, 400kV and 220 KV lines are under the scope of the contract, bidder is required to give identical Main-1 and Main-2 distance protection schemes for all voltage levels.				
Note- 3)	Cut out & mounting arrangement provided for POWERGRID supplied energy meter shall be suitable for mounting of energy meter unit of 4” thickness				
Note-IV	# **Cut out for mounting of Distance to Fault locator (Travelling wave type) shall be provided.**				

II) TRANSFORMER PROTECTION PANEL: The protection panel for Auto transformer/Transformer shall consists of the following features/schemes:

Sl. No.	Description	HV side	MV/LV side
1.	Transformer Differential Protection scheme	1 Nos.	Nil
2.	Restricted Earth fault protection scheme	1 no.	1 no@
	@ Not applicable for auto-transformer		
3.	Directional back up O/C and E/F relay with non-directional high set feature	1 set	1 set
4.	Over Fluxing Protection scheme	1 no.	1 no.$
	$ Applicable only for 400/220kV Transformer & 765/400kV Transformer		

5.	Overload protection scheme	1 nos.	NIL
6.	Three phase trip relays	2 nos.	2 nos.
7.	CVT selection relays as per scheme requirement	Lot	Lot
8.	Cut-out and wiring with TTB for POWERGRID supplied energy meter	1 set	1 set
9.	Transformer Neutral Current relay for 1-Phase transformer bank	1 Set	
10.	**Tertiary side O/C and Open delta Voltage protection**	**1 Set**	
11.	Flag Relays/Aux. Relays for wiring Transformer auxiliary protection contacts such as Buchholz, Oil Temperature, Winding Temperature, PRV, SPRD, OLTC Buchholz etc. as per scheme requirements	As required	
Note- 1)	**Tertiary side protections, over fluxing protection and overload protection can be clubbed in other transformer protection relay, however, over fluxing protection of HV and MV/LV side cannot be clubbed together. Further, tertiary side protection, if provided in auxiliary BCU, shall be excluded from this panel.** **This protection shall be applicable only for the transformer whose tertiary side is connected to LT transformer for station auxiliary supply.**		
Note- 2)	Cut out & mounting arrangement provided for POWERGRID supplied energy meter shall be suitable for mounting of energy meter unit of 4" thickness		

III) REACTOR PROTECTION PANEL: The protection panel for Reactor shall consist of the following features/schemes:

Sl. No.	**Description**	**Qty.**
1.	Reactor Differential Protection scheme	1 no.
2.	Restricted Earth fault Protection scheme	1 no.
3.	Reactor back up impedance protection scheme	1 set
4.	Three phase trip relays	2 nos.
5.	CVT selection relay as per scheme requirement	Lot
6.	Flag Relays/Aux. Relays for wiring Reactor auxiliary protection contacts such as Buchholz, Oil Temperature, Winding Temperature, PRV, SPRD etc. as per scheme requirements	As required

IV) BREAKER RELAY PANEL: The breaker relay panel shall consist of the following:

Sl. No.	Description	With A/R	Without A/R
1.	Breaker failure Protection Scheme *	1 No.	1 No.
2.	DC supply Supervision relay	2 Nos.	2 Nos.
3.	Trip Circuit supervision relays#	6 Nos.	6 Nos.
4.	Auto-reclose scheme (if standalone)	1 Nos.	NIL
5.	Flag relays, aux relays, timers, trip relays as per scheme requirements	As required	As required
Note- 1)	# Trip supervision relays shall be 2 **or 6** numbers **as per no. of trip coils** for each 132KV Circuit breaker		
Note- 2)	**Equipment/relays to be provided under CB Relay Panel may be accommodated in the Protection Panels to be provided for Transmission Line/Transformer/Reactor as applicable.**		
Note- 3)	*** In case of bay extension in existing half diameter, breaker failure relay for main CB / Tie CB shall be supplied only if BFR built-in Bus Bar protection bay unit is not available or Tie CB standalone BFR relay is not available in the existing protection scheme.**		

V) CONTROL PANEL: Various types of control panels shall consist of the following:

a.	Ammeter	3 set	for each Line, BC, TBC Bus section, Bus Reactor and Transformer
b.	Ammeter with Selector switch	1 set	for each line reactor
c.	Wattmeter with transducer	1 set	for each line, transformer
d.	Varmeter with transducer	1 set	for each line, transformer, Bus reactor
e.	Varmeter with transducer	1 set	for each Line Reactor
f.	CB Control switch	1 no.	for each Circuit breaker
g.	Isolator Control switch	1 no.	for each isolator
h.	Semaphore	1 no.	for each earth switch
i.	Red indicating lamp	1 no.	for each Circuit breaker
j.	Red indicating lamp	1 no.	for each isolator
k.	Green indicating lamp	1 no.	for each Circuit breaker
l.	Green indicating lamp	1 no.	for each isolator

m.	White indicating lamp (DC healthy lamp)	2 nos.	for each feeder
n.	Annunciation windows with associated annunciation relays	18 nos.	for each feeder
o.	Push button for alarm Accept/reset/lamp test	3 nos.	for each control panel
p.	Synchronising Socket	1 no.	for each Circuit Breaker, if required
q.	Synchronising selector Switch	1 no.	for each Circuit Breaker switch, if required
r.	Protection Transfer Switch	1 no.	for each breaker in case of DMT /DM with bypass isolator / SMT schemes (Except TBC and BC breaker)
s.	Mimic to represent SLD	Lot	in all control panels
t.	Voltmeter with selector Switch	1 no.	for each line, transformer, bus reactor
u.	Cut out, mounting and wiring for RWTI and selector switch	Lot	for transformers/reactors

Notes:

1 For transformer feeders, all equipments of control panel shall be provided separately for HV and MV sides.

2. In case of incomplete diameter (D and I type layouts), control panel shall be equipped fully as if the diameter is complete, unless otherwise specified. Annunciation relays shall also be provided for the same and if required, necessary panel shall be supplied to accommodate the same.

3. The above list of equipments mentioned for control panel is generally applicable unless it is defined elsewhere and in case of bay extension in existing substations, necessary equipments for matching the existing control panel shall be supplied.

4. Each line /HV side of transformer/MV/LV side of transformer /Bus reactor /TBC /**Tie** / BC/ Bus Section shall be considered as one feeder for above purpose.

VI) **CONTROL PANEL WITH BAY CONTROL UNIT (BCU):** Various types of control panels shall consist of the following:

a.	Bay Control Unit (BCU)	1 set	for each Circuit Breaker

b.	Ethernet switch complying IEC61850	1 no.	for each control panel
c.	Selector switch for Local/Remote bay control	1 no.	for each Circuit Breaker
d.	Ammeter with transducer & Selector switch	1 set	for each Line, BC, TBC, Bus section, Bus reactor, Transformer and line reactor
e.	CB Control switch	1 no.	for each Circuit breaker
f.	Red indicating lamp	1 no.	for each Circuit breaker
g.	Green indicating lamp	1 no.	for each Circuit breaker
h.	White indicating lamp (DC healthy lamp)	2 nos	for each feeder
i.	Common Annunciation lamp	1 no.	for each control panel
j.	Common hooter	1 no.	for each control panel
k.	Synchronising Socket	1 no.	for each Circuit Breaker if required
l.	Synchronising selector Switch	1 no.	for each Circuit Breaker switch if required
m.	Protection Transfer Switch	1 no.	for each breaker in case of DMT /DM with bypass isolator/ SMT schemes (Except TBC and BC breaker)
n.	Mimic to represent SLD	Lot	in all control panels
o.	Voltmeter with selector Switch	1 no.	for each line, transformer, bus reactor

Notes:

1 For transformer feeders, all equipments of control panel shall be provided separately for HV and MV sides.

2. In case of incomplete diameter (D and I type layouts), control panel shall be equipped fully as if the diameter is complete, unless otherwise specified. Annunciation relays shall also be provided for the same and if required, necessary panel shall be supplied to accommodate the same.

3. The above list of equipments mentioned for control panel is generally applicable unless it is defined elsewhere and in case of bay extension in existing substations, necessary equipments for matching the existing control panel, if applicable, shall be supplied.

4. Each line /HV side of transformer/MV/LV side of transformer /Bus reactor /TBC /BC/ Bus Section shall be considered as one feeder for above purpose.

6. **Control panel with BCU can be combined in the CB relay panels being supplied under present scope.**

7. The Bay Control unit and the numerical relays supplied under present scope shall be connected to the Ethernet switch. The ethernet switch shall comply with IEC 61850-3 requirements. It shall have sufficient number of ports to accommodate all the IEDs of the new bays and at least 6 spare ports for integrating the numerical Relays/BCUs with NTAMC system i.e. redundant Gateways/RTU and redundant SDC and two spare ports. The IP addressing scheme for the devices shall be provided by POWERGRID.

9. Selector switch for Local/Remote bay control shall be provided to transfer the control between the BCU and the Control panel. The control shall be available to either the BCU or from the Control panel however data monitoring shall be available at both the devices

10. The Bay control unit shall be flush mounted in the panel with their mimic displays accessible from the front of the panel. The Bay control unit mimic shall dynamically represent the current value of the measurements, state of the devices and control of devices. The Bay control unit shall provide telemetry and tele-control for remote operation from control centres (NTAMC). The Bay control unit shall acquire all the analog measurements, Status of Circuit breakers, Isolators and Earth switches, status of alarms, and provide Control of devices (Circuit breaker/Isolators/Reset of Relays/position selection for Auto reclose etc). The Bay control unit shall also provide synchronization check facility for the circuit breakers suitable for the bus bar scheme.

11. For Protection transfer switch function in Transfer bus schemes- The High Speed Bi-stable relays for protection transfer from 'Normal' to 'Transfer' and vice versa, whose position can be controlled locally as well as from remote via BCU shall be provided. The position once selected should not change in case of Power cycling.

12. In case the control panel is being provided in switchyard panel room, its common alarm signal shall also initiate an alarm facia in any of the existing control panel in control room building.

38. ERECTION AND MAINTENANCE TOOL EQUIPMENTS

All special testing equipment required for the installation and maintenance of the apparatus, instruments devices shall be furnished in relevant schedule.

39. TROPICALISATION

Control room/ **Panel room** will be normally air-cooled/air- conditioned. All equipments shall however be suitable for installation in a tropical monsoon area having hot, humid climate and dry and dusty seasons with ambient conditions specified in the specification. All control wiring, equipment and accessories shall be protected against fungus growth, condensation, vermin and other harmful effects due to tropical environment.

40. TYPE TESTS

40.1. The reports for following type tests shall be submitted during detailed engineering for the Protective relays, Fault Recorder, Fault locator and Disturbance recorder:

a) Insulation tests as per IEC 60255-5

b) DC Voltage dips and interruptions/Variation as per IEC 61000-4-29 **or IEC 60255-11**

c) High frequency (1MHz burst) disturbance test **as per IEC 60255-22-1** (Not applicable for electromechanical relays)

d) Electrostatic discharges as per IEC 61000-4-2, level; 4 **or IEC 60255-22-2 with severity Class III** (not applicable for Electromechanical relays)

e) Fast transient test as per IEC 61000, Level IV **or IEC 60255-22-4 with severity level IV** (Not applicable for electromechanical relays)

f) Relay characteristics, performance and accuracy test as per IEC 60255

- Steady state Characteristics and operating time
- Dynamic Characteristics and operating time for distance protection relays and current differential protection relays
- Conformance test as per IEC 61850-10.

For Fault recorder, Disturbance recorder; only performance tests are intended under this item.

g) Tests for thermal requirements as per IEC 60255-6

h) Tests for rated burden as per IEC 60255-6

i) Contact performance test as per IEC 60255-0-20 **or IEC61810-2** (not applicable for Distance to fault locator and Disturbance recorder)

j) **Tests for mechanical requirements (Vibration, shock & bumps and seismic) as per IEC 60255-21-1, 2 & 3 with severity class-I**

k) **Test for Radiated Electromagnetic Field Disturbance as per IEC 60255-22-3 with severity class III** (not applicable for electromechanical relays)

In case there is a change either in version or in model (Except firmware) of the relay, the contractor shall submit the type test reports for the offered revision/model.

40.2. Steady state & Dynamic characteristics test reports on the distance protection relays, as type test, shall be based on test programme specified in Appendix A on simulator/network analyser/PTL. Alternatively, the files generated using Electromagnetic transient Programme (EMTP) can also be used for carrying out the above tests. Single source dynamic tests on transformer differential relay shall be/ should have been conducted based on general guidelines specified in CIGRE committee 34 report on

Evaluation of characteristics and performance of Power system protection relays and protective systems.

41. Other general requirement for Protection IEDs:

a. Relay setting template (in editable document format) shall be provided by the contractor for each typical protection IEDs for relay setting purpose.

b. POWERGRID has standardised binary input/output details, indication details, DR signals texts etc. of protection IEDs & Protection Panels CT/VT circuit termination detail and same shall be provided to contractor during detail engineering for preparation of schematics. Panel nomenclature, terminal blocks identification, as applicable, shall be according to typical detail given at APPENDIX-B.

42. Requirement for GIS substations:

GIS Gas zone trip signals, if provided, for each gas tight compartments (gas zone) in the GIS LCC shall be integrated in the protection schematics to provide electrical isolation of faulty Gas zone by tripping/ inter-tripping its adjacent circuit breakers. The scheme shall be implemented through protection IEDs and auxiliary relay as required.

Test programme for distance relays

General Comments:

1. These test cases are evolved from the report of working group 04 of study committee 34 (Protection) on evaluation of characteristics and performance of power system protection relays and protective systems. For any further guidelines required for carrying out the tests, reference may be made to the above document.
2. The test shall be carried out using network configuration and system parameters as shown in the figure-1
3. All denotations regarding fault location, breakers etc are referred in figure –1
4. The fault inception angles are referred to R- N voltage for all types of faults
5. The fault inception angle is zero degree unless otherwise specified
6. Where not stated specifically, the fault resistance (Rf) shall be zero or minimum as possible in simulator
7. Single pole circuit breakers are to be used
8. The power flow in double source test is 500 MW

System parameters

System voltage =400KV

CTR= 1000/1

PTR = 400000/110 (with CVT, the parameters of CVT model are shown in figure –2)

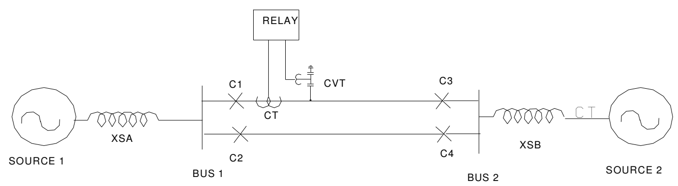


FIGURE 1

Line parameters/km

Positive Sequence Resistance, (r1)	= 0. 02897 Ω
Positive Sequence Reactance (x1)	= 0.3072 Ω
Zero Sequence Resistance (r0)	= 0.2597 Ω
Zero Sequence Reactance (x1)	= 1.0223 Ω
Zero Sequence Mutual Resistance (rm)	= 0.2281 Ω
Zero Sequence Mutual Reactance (xm)	= 0.6221 Ω
Zero Sequence succeptance (bo)	= 2.347 µ mho
Positive Sequence succeptance (b1)	=3.630 µ mho

Type of line	Short		Long
Secondary line impedance	2 Ω		20 Ω*
Length of line in Kms	23.57		235.7
SIR	4	15	4
Source impedance (pry) (at a time constant of 50 ms)	29.09 Ω (5500 MVA)	109.09 Ω (1467 MVA)	290.9 Ω (550 MVA)

* Alternatively, the tests can be done with 10 Ω secondary impedance and source impedance may accordingly be modified

CVT Model

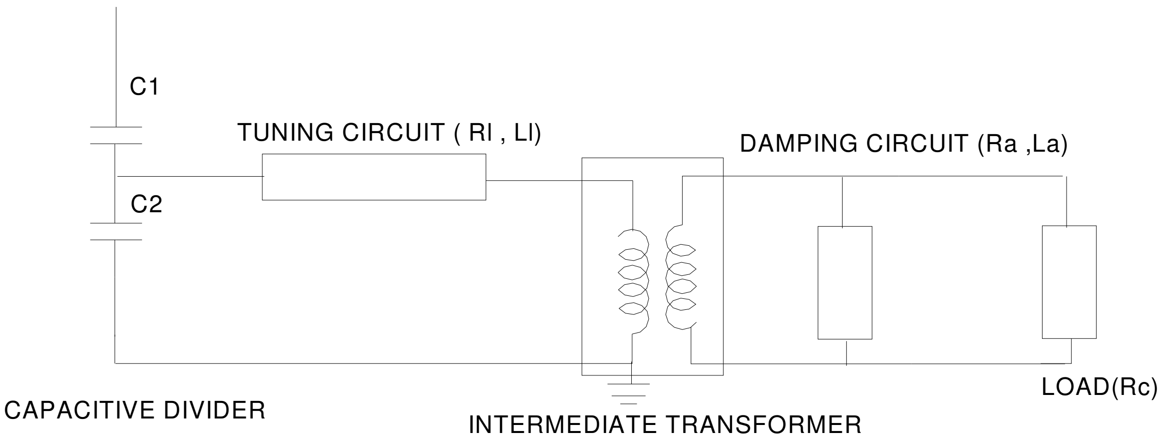


Figure-2

XC1	1.455 µ mho
XC2	27.646 µ mho
Rl	320 Ω
XLl	34243 Ω
Ra	4.200 Ω
Xla	197.92 Ω
Rc	14.00 Ω
Transformation ratio of Intermediate transformer	181.8

Details of fault cases to be done

Sl no	Description	Single source with short line (2 Ω)		Single source long line (20 Ω)	Double source with short double line (2 Ω)	Double source with long single line (20 Ω)
		CLOSE C1, OPEN C2,C3,C4		CLOSE C1, OPEN C2,C3,C4	CLOSE C1, C2,C3,C4	CLOSE C1,C3 OPEN C2,C4
		SIR=4	SIR=15	SIR =4	SIR = 4	SIR=4
1	Dynamic accuracy for zone 1	Tests to be done at 2 locations (84 % and 76 % of line length) X 4 faults (RN , YB, YBN, RYB) X 2 fault inception angle (0°, 90°)= 16 cases	Tests to be done at 2 locations (84 % and 76 % of line length) X 4 faults (RN , YB, YBN, RYB) X 2 fault inception angle (0°,90°)= 16 cases	Tests to be done at 2 locations (84 % and 76 % of line length) X 4 faults (RN , YB, YBN, RYB) X 2 fault inception angle (0°,90°)= 16 cases		Tests to be done at 2 locations (84% and 76% of line length) X 4 faults (RN , YB, YBN, RYB) X 2 fault inception angle (0°, 90°)= 16 cases
2	Operating time for zone 1 at SIR =4	Tests to be done at 3 locations (0% , 40% and 64% of line length) X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°, 30°,60° and 90°) = 48 cases	Tests to be done at 3 locations (0 % , 40 % and 64 % of line length) X 4 faults (RN , YB, YBN, RYB) X 4 fault inception angle (0°,30°,60°and 90°)= 48 cases	Tests to be done at 3 locations (0 % , 40 % and 64 % of line length) X 4 faults (RN , YB, YBN, RYB) X 4 fault inception angle (0°, 30°,60° and 90°)= 48 cases	Tests to be done at 1 location (40 % of line length) X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°,30°,60° and 90 °)= 16 cases	Tests to be done at 1 location (40 % of line length) X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°,30°,60° and 90°)= 16cases
3	Operating time for zone II and Zone III	Tests to be done at 1 location (100 % of line length) X 1 faults (RN, YB, YBN, RYB) X 2 zones (II and III) = 2 cases	Tests to be done at 1 location (100 % of line length) X 1 faults (RN , YB, YBN, RYB) X 2 zones (II and III) = 2 cases	Tests to be done at 1 location (100 % of line length) X 1 faults (RN , YB, YBN, RYB) X 2 Zones (II and III) = 2 cases		

Sl no	Description	Single source with short line (2 Ω)		Single source long line (20 Ω)	Double source with short double line (2 Ω)	Double source with long single line (20 Ω)
4	Switch on to fault feature			Tests to be done at 2 location (0 % and 32 %) X 1 faults (RYB) Any fault inception angle = 2 cases		
5	Operation during current reversal				Tests to be done at 2 location (0 % and 80 % of line length) X 1 faults (RN) X 1 fault inception angle (0 degrees) = 2 cases	
		CLOSE C1, OPEN C2,C3,C4		CLOSE C1, OPEN C2,C3,C4	CLOSE C1, C2,C3,C4	CLOSE C1,C3 OPEN C2,C4
		SIR=4	SIR=15	SIR =4	SIR = 4	SIR=4
6	Operation at simultaneous faults				Tests to be done at 2 location (8 % and 64 % of line length) X 2 faults (RN in circuit 1 to BN in circuit 2 and RN in circuit 1 to RYN in circuit 2 in 10 ms) X 1 fault inception angle (0 °) = 4 cases (*1)	
7	Directional sensitivity					Tests to be done at 1 location (0% reverse) X 6 faults (RN

Sl no	**Description**	**Single source with short line (2 Ω)**		**Single source long line (20 Ω)**	**Double source with short double line (2 Ω)**	**Double source with long single line (20 Ω)**
						,YB, YBN , RYB,RN with Rf=13.75 ohm(sec) and RYN with Rf= 13.75 Ohm (sec) X 2 fault inception angle (0° ,90°) = 12cases
8	Limit for fault resistance					Tests to be done at 2 location (0% and 68 % of line length) X 1 fault (RN with Rf=13.75 ohm(sec) X 2 fault inception angle (0°,90°) = 4 cases
9	Operation at evolving faults					Tests to be done at 2 location (32 % and 0% of line length) X 2 faults (RN to RYN) x in 2 timings (10 ms and 30 ms) X 2 load direction (from A to B and from B to A) = 16 cases
9	Fault locator function , in case the same is offered as built in feature	Measure fault location for all cases under 1 and 2	Measure fault location for all cases under 1 and 2	Measure fault location for all cases under 1 and 2	Measure fault location for all cases under 2 and 6	Measure fault location for all cases under 2, 7 and 9

Terminal Block (TB) Nomenclature for Relay & interface panels

Circuit type	TB for external connections	TB for Interpanel connections
CT	X:CT	XI:CT
PT	X:VT	XI:VT
AC Auxiliary	X:AC	XI:AC
DC Auxiliary	X:DC	XI:DC
Trip Circuit 1	X:TC1	XI:TC1
Trip Circuit 2	X:TC2	XI:TC2
LBB & BB	X:LBB	XI:LBB
CB	X:CB/X:CBT	XI:X
ISOLATOR	X:ISA/ISB/ISL/ISR	XI:X
EARTH SWITCH	X:ES	XI:X
PROTECTION COUPLER	X:PC	XI:PC
ENERGY METER	X:EM	---
Reactor	X:SR	XI:SR
Transformer	X:AT	XI:AT
Others Control & status signals	X:X	XI:X

Feeder relay Panels designation:

Typical Bay / Busbar	Panel Ref.
765kV Bay no. 1 (701)	7R1A, 7R1B and so on
400kV Bay no. 1 (401)	4R1A, 4R1B and so on
220kV Bay no. 1 (201)	2R1A, 2R1B and so on
132kV Bay no. 1 (101)	1R1A, 1R1B and so on
Bus 765kV	7BB1, 7BB2 and so on
Bus 400kV	4BB1, 4BB2 and so on
Bus220kV	2BB1, 2BB2 and so on
Bus132kV	1BB1, 1BB2 and so on

SECTION: SUBSTATION AUTOMATION SYSTEM

1.0 GENERAL

1.1. The Substation Automation System (SAS) shall be installed to control and monitor all the sub-station equipment from Remote Control Centres (RCC) & Remote Control and Supervision Centre (RSCC), as well as from local control centre.

1.2. The SAS shall contain the following main functional parts:

- Bay Control Unit (BCU) Intelligence Electronic Devices (IEDs) for control and monitoring.
- Merging Units & Switchgear Controller IEDs (applicable for Process Bus based SAS only)
- Station Human Machine Interface (HMI) with industrial grade servers
- Redundant managed switched Ethernet Local Area Network communication infrastructure with hot standby.
- Redundant Gateway for remote monitoring and control via industrial grade hardware (to RCC) through **Secure IEC 60870-5-104 protocol. There will be at least 3 RCCs.**
- Redundant Gateway for remote monitoring and control via industrial grade hardware (to RSCC), the gateway should be able to communicate with RSCC on IEC 60870-5-104 protocol. It shall be the bidder’s responsibility to integrate his offered system with existing RSCC system for exchange of desired data.
- DR / Engineering PCs, as specified.
- Remote HMI and work station along with necessary printers, only if specified in Section Project.
- Peripheral equipment like printers, display units, key boards, Mouse etc.

1.3. It shall enable local station control via a PC by means of human machine interface (HMI) and control software package, which shall contain an extensive range of supervisory control and data acquisition (SCADA) functions.

1.4. It shall include communication gateway, intelligent electronic devices (IED) for bay control and inter IED communication infrastructure. An architecture drawing for SAS is enclosed.

1.5. The communication gateway shall facilitate the information flow with remote control centres. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions. However, in case of Process Bus based SAS, Switchgear Controllers (SGCs) shall be used as digital interfaces between switchgear and bay level IEDs.

1.6. The Sub-station Automation system being offered shall generally conform to provision of IEC 62351, IEEE1686 and NERC CIP (applicable part such as CIP 003, CIP-005, and CIP-007) for cyber security.

1.7. **Process bus based SAS shall be applicable only if specifically envisaged in Section-Project**.

2. System design

2.1 General system design

The Substation Automation System (SAS) shall be suitable for operation and monitoring of the complete substation including future extensions as given in Section-Project.

The systems shall be of the state-of-the art suitable for operation under electrical environment present in Extra high voltage substations, follow the latest engineering practice, ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

The offered SAS shall support remote control and monitoring from Remote Control centres via gateways.

The system shall be designed such that personnel without any background knowledge in Microprocessor-based technology are able to operate the system. The operator interface shall be intuitive such that operating personnel shall be able to operate the system easily after having received some basic training.

The system shall incorporate the control, monitoring and protection functions specified, self-monitoring, signalling and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records. It shall also have provisions for inhibiting control on any or all devices for purpose of maintenance. The devices under maintenance shall be provided with tags which shall include provision for entering text (256 characters).

Maintenance, modification or extension of components may not cause a shutdown of the whole substation automation system. Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.

IP addressing of the system shall be as per the IP plan provided by the owner.

The system shall be remotely accessed for collection of disturbance records and hence shall be provided with a firewall/router to comply at least with the requirements of CIP-005, CIP-007 (Critical infrastructure protection) standard as per NERC (North American Electric Reliability Council).

Bidder shall house the Bay level unit (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer), bay mimic along with relay and protection panels and PLCC panels (described in other sections of technical specifications) in air-conditioned Switchyard Panel Room suitably located in switchyard (GIS hall relay room in case of GIS s/s) and Station HMI in Control Room building for overall optimisation in respect of cabling and control room building.

In case of Process bus based SAS, both bay level unit and station bus level components can also be placed at a centralised location like control room.

2.2 System architecture

The SAS shall be based on a decentralized architecture and on a concept of bay-oriented, distributed intelligence.

Functions shall be decentralized, object-oriented and located as close as possible to the process.

The main process information of the station shall be stored in distributed databases. The typical SAS architecture shall be structured in three levels, i.e. process level, bay level and station level. Process Level will be applicable only in Process Bus based SAS.

At **Process Level** (applicable, only in IEC 61850 Process Bus based SAS) is at the switchyard level where instrument transformers, switchgear, transformers/reactor are located, and employs IEC 61850 part 9-2 for communicating Sampled Measured Values (SMV) to the Bay Level IEDs and GOOSE messaging for binary values exchange.

At **Bay Level**, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions. However, in case of Process Bus based SAS, Switchgear Controllers (SGCs) shall be used as digital interfaces between switchgear and bay level IEDs.

Each bay control IED shall be independent from each other and its functioning shall not be affected by any fault occurring in any of the other bay control units of the station.

The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using fibre-optic cables, thereby guaranteeing disturbance free communication. The fibre optic cables shall be run in G. I. conduit pipes. Data exchange is to be realised using the protocols defined and standardized in the latest edition of IEC 61850 with a redundant managed switched Ethernet communication infrastructure. The modelling of various aspects of Substation Automation System, like, Data Objects, Data Attributes, Logical Nodes, etc. shall be according to the latest edition of IEC 61850.

The communication shall be made in fault tolerant ring, excluding the links between individual bay IEDs to switch wherein the redundant connections are not envisaged, such that failure of one set of fiber shall not affect the normal operation of the SAS. However failure of fiber shall be alarmed in SAS. Each fiber optic cable shall have four (4) spare fibers.

The typical architecture for SAS is enclosed as Annexure.

At **Station Level**, the entire station shall be controlled and supervised from the station HMI. It shall also be possible to control and monitor the bay from the bay level equipment at all times.

Clear control priorities shall prevent operation of a single switch at the same time from more than one of the various control levels, i.e. RCC, station HMI, bay level or apparatus level. The priority shall always be on the lowest enabled control level.

The station level contains the station-oriented functions, which cannot be realised at bay level, e.g. alarm list or event list related to the entire substation, gateway for the communication with remote control centres.

The GPS time synchronising signal (as specified in the section relay & protection) for the synchronization of the entire system shall be provided.

The SAS shall contain the functional parts as described in para 1.2 above.

2.3 FUNCTIONAL REQUIREMENTS

The high-voltage apparatus within the station shall be operated from different places:

- Remote control centres
- Station HMI
- Local Bay controller IED (in the bays)

Operation shall be possible by only one operator at a time with the priority to the lowest enabled control level.

The operation shall depend on the conditions of other functions, such as interlocking, synchro-check, control-inhibit tags etc. (see description in ``Bay level control function'').

2.3.1 Select-before-execute

For security reasons the command is always to be given in two stages: selection of the object and command for operation under all mode of operation except emergency operation. Final execution shall take place only when selection and command are actuated.

2.3.2 Command supervision

Bay/station interlocking and blocking

Software Interlocking is to be provided to ensure that inadvertent incorrect operation of switchgear causing damage and accidents in case of false operation does not take place.

In addition to software interlocking hardwired interlocking are to be provided for:

(a) Bus Earth switch Interlocking

(b) Transfer Bus interlocking (if applicable)

It shall be a simple layout, easy to test and simple to handle when upgrading the station with future bays. For software interlocking the bidder shall describe the scenario while an IED of another bay is switched off or fails.

A software interlock override function shall be provided which can be enabled to bypass the interlocking function.

2.3.3 Run Time Command cancellation

Command execution timer (configurable) must be available for each control level connection. If the control action is not completed within a specified time, the command should get cancelled and an alarm shall be generated to indicate the failure of command.

2.3.4 Self-supervision

Continuous self-supervision function with self-diagnostic feature shall be included. The redundant components such as servers, gateway shall monitor each other for availability and the active device shall takeover all the functions of the failed device. This failover shall happen within 30 seconds. The events occurring when a server is in failed state shall be synchronised from the active server.

3 User configuration

The monitoring, controlling and configuration of all input and output logical signals and binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely.

It shall also be possible to interconnect and derive input and output signals, logic functions, using built-In functions, complex voltage and currents, additional logics (AND-gates, OR gates and timers). (Multi-activation of these additional functions should be possible).

3.1. Bay level functions

In a decentralized architecture the functionality shall be as close to the process as possible. In this respect, the following functions can be allocated at bay level:

- Bay control functions including data collection functionality in bay control/protection unit.
- Bay protection functions

Separate IEDs shall be provided for bay control function and bay protection function.

3.1.1. Bay control functions

3.1.1.1. Overview of Functions

- Control mode selection
- Select-before-execute principle
- Command supervision:
  - Interlocking and blocking
  - Double command
- Synchrocheck, voltage selection
- Run Time Command cancellation
- Transformer tap changer control (Raise and lower of tap) (for power transformer bays)
- Transformer Master/follower selection
- Operation counters for circuit breakers and pumps

- Hydraulic pump/ Air compressor runtime supervision
- Operating pressure supervision through digital contacts only
- Breaker position indication per phase
- Alarm annunciation
- Measurement display
- Local HMI (local guided, emergency mode)
- Interface to the station HMI.
- Data storage for at least 200 events
- Auto-reclose mode selection (Non-Auto/1-phase etc.)
- Protection transfer switch control (for Transfer Bus scheme arrangement)
- Monitoring of Gas Tight Chambers in GIS
- Monitoring of temperature of Transformer and Reactor
- Monitoring of Multi-gas output of Transformer and Reactor
- Any other requirement specified elsewhere in the specification.

3.1.1.2. Control mode selection

Bay level Operation:

As soon as the operator receives the operation access at bay level the operation is normally performed via bay control IED. During normal operation bay control unit allows the safe operation of all switching devices via the bay control IED.

EMERGENCY Operation

It shall be possible to close or open the selected Circuit Breaker with ON or OFF push buttons even during the outage of bay IED**.** All the interlocks shall be get bypassed under such circumstances.

REMOTE mode

Control authority in this mode is given to a higher level (Remote Control Centre/Station HMI) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

3.1.1.3. Synchronism and energizing check

The synchronism and energizing check functions shall be bay-oriented and distributed to the bay control and/or protection devices. These features are:

- Settable voltage, phase angle, and frequency difference.
- Energizing for dead line - live bus, live line - dead bus or dead line – dead bus with no synchro-check function.
- Synchronising between live line and live bus with synchro-check function

3.1.1.4. Voltage selection

The voltages relevant for the Synchro check functions are dependent on the station topology, i.e. on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronizing and energizing is derived from the auxiliary switches of the circuit breakers, the isolator, and earthing switch and shall be selected automatically by the bay control and protection IEDs.

3.1.1.5. Transformer tap changer control

Digital RTCCs shall be integrated with the SAS to provide Tap Changer Control functions.

3.1.1.6. Auto-reclose mode selection

Auto –reclose mode selection for each of the Circuit breaker shall be facilitated through bay controller IED.

3.1.1.7. Protection transfer switch control (As applicable)

Based on selection of isolator for double main with transfer switching scheme or single main with transfer switching scheme for the switchyard, the protection shall be transferred automatically with an alarm indication that protection is successfully transferred.

3.1.1.8. Monitoring of Gas Chambers in GIS Sub-stations:

In case of a GIS sub-stations, all the gas tight chambers are required to be monitored individually phase wise for their SF6 gas density status by the bay control unit in a bay. Sufficient numbers of inputs are required to be provided in the BCU. In case there is any limitation of number of inputs in the BCU, additional BCUs are required to be provided without any cost implication to POWERGRID. These inputs shall be used for necessary monitoring, control and protection purpose.

3.1.2. Bay protection functions

3.1.2.1. General

The protection functions are independent of bay control function. The protection shall be provided by separate protection IEDs (numerical relays) and other protection devices as per section Relay & Protection.

IEDs, shall be connected to the communication infrastructure for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.

Event and disturbance recording function

Each IED should contain an event recorder capable of storing at least 200 time-tagged events. The disturbance recorder (DR) function shall be as per detailed in section CRP. The DR(s) shall be integrated with the SAS.

3.1.2.2. Bay Monitoring Function:

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers or through merging units. The values of active power (W), reactive power (VAR), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated in the Bay control/protection unit.

3.2. Station Level Functions

3.2.1. Status supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, transformer tap changer, Transformer/Reactor Temperature, Transformer/Reactor Multi-gas conditions, Temperature of Switchyard Panel Room, Ambient Temperature etc., shall be supervised continuously. Every detected change of position shall be immediately displayed in the single-line diagram on the station HMI screen, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in the case of spontaneous position changes.

The switchgear positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which shall give ambivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.

The SAS shall also monitor the status of sub-station auxiliaries. The status and control of auxiliaries shall be done through separate one or more IED and all alarm and analogue values shall be monitored and recoded through this IED.

3.2.2. Measurements

The analogue values acquired/calculated in bay control/protection unit shall be displayed locally on the station HMI and in the control centre. The abnormal values must be discarded. **The analogue values shall be updated based on the dead band settings and the same shall be demonstrated during FAT of the system.**

Threshold limit values shall be selectable for alarm indications.

3.2.3. Event and alarm handling

Events and alarms are generated either by the switchgear, by the control IEDs, or by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All, or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time-tagged with a time resolution of 1 ms. The tentative list for various feeders and systems are enclosed as Annexure-I.

3.2.4. Station HMI

3.2.4.1. Substation HMI Operation:

On the HMI the object has to be selected first. In case of a blocking or interlocking conditions are not met, the selection shall not be possible and an appropriate alarm/annunciation/notification shall occur. If a selection is valid the position indication will show the possible direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object.

Control operation from other places (e.g. RCCs) shall not be possible in this operating mode.

3.2.4.2. Presentation and dialogues

The operator station HMI shall be a redundant with hot standby and shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear on the screen via mouse clicks.

The HMI shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log.

An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from the screen selected by the operator.

The following standard pictures shall be available from the HMI:

- Dynamic Single-line diagram showing the switchgear status and measured values
- Control dialogues with interlocking or blocking information details. This control dialogue shall tell the operator whether the device operation is permitted or blocked and also show the Interlocking logic with status**.**
- Measurement dialogues
- Alarm list, station / bay-oriented
- Event list, station / bay-oriented
- System status

3.2.4.3. HMI design principles

Consistent design principles shall be adopted with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.

The object status shall be indicated using different status colours for:

- Selected object under command
- Selected on the screen
- Not updated, obsolete values, not in use or not sampled
- Alarm or faulty state
- Warning or blocked
- Update blocked or manually updated
- Control blocked
- Normal state
- **Energised or denergised state (based on substation topology)**

3.2.4.4. Process status displays and command procedures

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, isolators and transformer tap-changers shall be displayed in the station single-line diagram.

In order to ensure a high degree of security against undesired operation, a "select-before-execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen, and all other switchgear shall be blocked. As communication between control centre and device to be controlled is established, the operator shall be prompted to confirm the control action and only then final execute command shall be accepted**.** After the "execution" of the command the operated switching symbol shall flash until the switch has reached its new position.

The operator shall be in a position to execute a command only, if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay and station level.

After command execution the operator shall receive a confirmation that the new switching position has been reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

3.2.4.5. System supervision & display

The SAS system shall be comprehensively self-monitored such that faults are immediately indicated to the operator, possibly before they develop into serious situations. Such faults are recorded as a faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IEDs, communication infrastructure and remote communication links, and printers at the station level, etc.

3.2.4.6. Event list

The event list shall contain events that are important for the control and monitoring of the substation.

The event and associated time (with1 ms resolution) of its occurrence has to be displayed for each event.

The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.

A printout of each display shall be possible on the hard copy printer.

The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer for at least one month. The information shall be obtainable also from a printed event log.

The chronological event list shall contain:

- Position changes of circuit breakers, isolators and earthing devices
- Indication of protective relay operations
- Fault signals from the switchgear
- Indication when analogue measured values exceed upper and lower limits. Suitable provision shall be made in the system to define two

level of alarm on either side of the value or which shall be user defined for each measurands.

- Loss of communication.
- User actions (control/Tag placement/manual update) with USER identity
- System messages (Operator logging info, System supervision and device monitoring, failure of supervisory control etc.)

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

- Date and time
- Bay
- Device
- Function e.g. trips, protection operations etc.
- Alarm class

3.2.4.7. Alarm list

Faults and errors occurring in the substation shall be listed in an alarm list and must be displayed in a flashing state along with an audible alarm. After acknowledgement of the alarm, it should appear in a steady (i.e. not flashing) state and the audible alarm shall stop. The alarm should disappear only if the alarm condition has physically cleared and the operator has reset the alarm with a reset command. The state of the alarms shall be shown in the alarm list (Unacknowledged and persistent, Unacknowledged and cleared, Acknowledged and persistent).

Filters for selection of a certain type or group of alarms shall be available as for events.

In addition to the regular alarms, following alarms shall also be displayed and logged:

- Alarms shall be displayed on the HMI, for each device of SAS when they lose time synchronization.
- 'GOOSE Fail Alarm' shall be configured which shall be generated when any of the subscriber IEDs fails to receive any of the GOOSE messages. These alarms shall be mapped IED-wise in the station HMI.

3.2.4.8. Object picture

When selecting an object such as a circuit breaker or isolator in the single-line diagram, the associated bay picture shall be presented first. In the selected object picture, all attributes like

- Type of blocking/Control inhibit Tag
- Authority
- Local / remote control mode
- RCC / SAS control

- Errors
- etc.,

shall be displayed.

3.2.4.9. Control dialogues

The operator shall give commands to the system by means of mouse click located on the single-line diagram. Data entry is performed with the keyboard. Dedicated control dialogues for controlling at least the following devices shall be available:

- Breaker and disconnector
- Transformer tap-changer
- Mode selection (L/R, Non-Auto/1-ph, Auto/Manual etc.)

3.2.5. User-authority levels

It shall be possible to restrict activation of the process pictures of each object (bays, apparatus...) within a certain user authorisation group. Each user shall then be given access rights to each group of objects, e.g.:

- Display only
- Normal operation (e.g. open/close of switchgear)
- Restricted operation (e.g. by-passed interlocking)
- System administrator

For maintenance and engineering purposes of the station HMI, the following authorisation levels shall be available:

- No engineering allowed
- Engineering/configuration allowed
- Entire system management allowed

The access rights shall be defined by passwords assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.
In case of non-activity for a pre-determined period (say 30 minutes), the system will automatically logged out the user and user has to log in again for doing any operation. Further each operation must be logged in in the event/alarm list along with the user name.

3.2.6. Reports

The reports shall provide time-related follow-ups of measured and calculated values. The data displayed shall comprise:

- Trend reports:
    - Day (mean, peak)
    - Month (mean, peak)
    - Semi-annual (mean, peak)
    - Year (mean, peak)

- Historical reports of selected analogue Values:
    - Day (at 15 minutes interval)
    - Week
    - Month
    - Year

It shall be possible to select stored values from the database in the process display on-line. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are stored in the memory.

Following printouts shall be available from the printer and shall be printed on demand:

i. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.

ii. Weekly trend curves for real and derived analogue values.

iii. Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.

iv. Provision shall be made for logging information about breaker status like number of operation with date and time indications along with the current vale it interrupts (in both condition i.e. manual opening and fault tripping)

v. Equipment operation details shift wise and during 24 hours.

vi. Printout on adjustable time period as well as on demand for MW, MVAR, Current, Voltage on each feeder and transformer as well as Tap Positions, temperature and status of pumps and fans for transformers.

vii. Printout on adjustable time period as well as on demand system frequency and average frequency.

viii. Reports in specified formats which shall be handed over to successful bidder. The bidder has to develop these reports. The reports are limited to the formats for which data is available in the SAS database.

ix. It shall be possible to generate user made reports based on measured/recorded values of various combination of parameters particularly for transformer and reactors for healthiness of equipment depending upon defined criterion. These generation of reports must be user friendly and shall be easy to define.

All the utilities/tools used for building a report shall be provided with the system so that the owner is able to build new reports. The tools shall be user friendly with 'drag & drop' or 'menu based selection' features and shall not require any knowledge of programming.

The reports utility shall be configured such that reports requiring long duration data (yearly) shall not take more than 2 minutes and does not impact the other applications running in the system.

3.2.7. Trend display (historical data)

It shall be possible to illustrate all types of process data as trends - input and output data, binary and analogue data. The trends shall be displayed in graphical form as column or curve diagrams with a maximum of 10 trends per screen. Adjustable time span and scaling ranges must be provided.

It shall be possible to change the type of value logging (direct, mean, sum, or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.

3.2.8. Automatic disturbance file transfer

All recorded data from the IEDs with integrated disturbance recorder as well as dedicated disturbance recording systems shall be automatically uploaded (event triggered and once per day in case no event during the day) to a dedicated computer and be stored on the hard disc in specified folders.

3.2.9. Disturbance analysis

The PC-based work station shall have necessary software to evaluate all the required information for proper fault analysis.

3.2.10. IED parameter setting

It shall be possible to access all protection and control IEDs for reading the parameters (settings) from the station HMI or from a dedicated monitoring computer. The setting of parameters or the activation of parameter sets shall only be allowed after entering a password.

3.2.11. Automatic sequences

The available automatic sequences in the system should be listed and described, (e.g. sequences related to the bus transfer in a GIS). It must be possible to initiate pre-defined automatic sequences by the operator and also define new automatic sequences. **The automatic sequencing is required to be developed at SCADA level.**

3.3. Gateway

3.3.1 Communication Interface

The Substation Automation System shall have the capability to support simultaneous communications with multiple independent remote master stations,

The Substation Automation System shall have communication ports on **each gateway (two gateways per station)** as follows:

(a) **Three** ports for Remote Control Centres **on Secure IEC 60870-5-104 protocol.**

(b) One port **on IEC 60870-5-104** for Regional System Coordination Centre (RSCC)

The communication interface to the SAS shall allow scanning and control of defined points within the substation automation system independently for each control centre. The substation automation system shall simultaneously respond to independent scans and commands from employer's control centres (RCCs & RSCC). The substation automation system shall support the use of a different communication data exchange rate (bits per second), scanning cycle, and/or communication protocol to each remote control centre. Also, each control centre's data scan and control commands may be different for different data points within the substation automation system's database.

The Gateway shall collect the IEC 61850 data directly from the IEDs through Ethernet switches, without using any other intermediate interface or network device, and should be implemented in a separate hardware, so that the failure of the local SCADA Server would not impact the remote communication through the Gateway.

The Gateway shall identify the actions performed by the each of the remote masters individually and log it in its database. The logs for last 30 days shall be stored and accessible at the Station HMI.

3.3.2 Remote Control Centre Communication Interface

Employer will supply communication channels between the Substation Automation System and the remote control centre. The communication channels provided by Employer will consist either of power line carrier, optical fibre, or leased line, the details of which shall be provided during detailed Engineering.

3.3.3 Interface equipment

The Contractor shall provide interface equipment for communicating between Substation Automation system and Remote control centres and between Substation Automation system and Regional System Coordination Centre (RSCC). However, the communication channels available for this purpose are specified in section project.

The communication interface with the RCCs is an Ethernet interface. In case of PLCC communication any modem supplied shall not require manual equalization and shall include self-test features such as manual mark/space keying, analogue loop-back, and digital loop-back. The modems shall provide for convenient adjustment of output level and receive sensitivity. The modem should be stand alone complete in all respects including power supply to interface the SAS with communication channel. The configuration of tones and speed shall be programmable and maintained in non-volatile memory in the modem. All necessary hardware and software shall also be in the scope of bidder except the communication link along with communication equipment between substation control room and Remote Control Centre.

3.3.4 Communication Protocol

The communication protocol for gateway to control centre must be open protocol and shall support **IEC 60870-5-104** and IEC 61850 for all levels of communication for sub-station automation such as Bay to station HMI, bay to bay etc. based on requirement specified. The protocol shall support the features such as Report by exception; Periodic reporting so that the data update times at the RCC/RSCC can be optimised.

4.0 System hardware:

4.1 Redundant Station HMI, Remote HMI (Remote HMI only if mentioned in section project) and Disturbance Recorder Work station:

The contractor shall provide redundant station HMI in hot standby mode. The servers used in these work stations shall be of industrial grade**.**

It shall be capable to perform all functions for entire substation including future requirements as indicated in the SLD. It shall use industrial grade components. Processor and RAM shall be selected in such a manner that during normal operation not more than 30% capacity of processing and memory are used. Supplier shall demonstrate these features.

The capacity of hard disk shall be selected such that the following requirement should occupy less than 50% of disk space:

1. Storage of all analogue data (at 15 Minutes interval)and digital data including alarm , event **for two years** and trend data for thirty(30) days,
2. Storage of all necessary software,
3. 500GB space for OWNER'S use.

Supplier shall demonstrate that the capacity of hard disk is sufficient to meet the above requirement.

4.1.1 HMI (Human Machine Interface)

The VDU shall show overview diagrams (Single Line Diagrams) and complete details of the switchgear with a colour display. All event and alarm annunciation shall be selectable in the form of lists. Operation shall be by a user friendly function keyboard and a cursor positioning device. The user interface shall be based on WINDOWS concepts with graphics & facility for panning, scrolling, zooming, decluttering etc.

4.1.2 Visual Display Units/TFT's (Thin Film Technology)

The display units shall have high resolution and reflection protected picture screen. High stability of the picture geometry shall be ensured. The screen shall be at least 21" diagonally in size and capable of colour graphic displays.

The display shall accommodate resolution of 1280 X 1024 pixels.

4.1.3 Printer

It shall be robust & suitable for operation with a minimum of 132 characters per line. The printing operation shall be quiet with a noise level of less than 45 dB suitable for location in the control room. Printer shall accept and print all ASCII characters via master control computer unit interface.

The printer shall have in built testing facility. Failure of the printer shall be indicated in the Station HMI. The printer shall have an off line mode selector switch to enable safe maintenance. The maintenance should be simple with provisions for ease of change of print head, ribbon changing, paper insertion etc.

All reports and graphics prints shall be printed on laser printer. One dot matrix printer shall be exclusively used for hourly log printing.

All printers shall be continuously online.

4.1.4 Mass Storage Unit

The mass storage unit shall be built-in to the Station HMI. All operational measured values, and indications shall be stored in a mass-storage unit **in form** of **DVD RW** The unit should support at least Read (48X), Write(24X), and Re-Write (10X) operations, with Multi-Session capability. It should support ISO9660, Rockridge and Joliet Filesystems. It should support formatting and use under the operating system provided for Station HMI. The monthly back up of data shall be taken on disc. The facility of back up of data shall be inherent in the software**.**

4.1.5 Switched Ethernet Communication Infrastructure:

The bidder shall provide the redundant switched optical Ethernet communication infrastructure for SAS. One switch shall be provided to connect all IEDs in one diameter of each 765 and 400kV yard and for two bays of 220kV yard to communication infrastructure. Each switch shall have at least two spare ports for connecting bay level IEDs and one spare port for connecting station bus.

The Ethernet Fast Switches shall be compliant to IEC 61850. These Switches shall be suitable for the substation environment and shall conform to type tests as per IEC 61850-3.

4.1.6 Firewall and Router

There shall be two sets of Firewall and Routers which shall be connected to a LAN. This LAN shall be different than the IEC 61850 LAN. The substation firewall and router shall be suitable for the substation environment and shall comply with the requirements for IEC 61850-3.

The substation firewall shall have the following features:

- IP firewall features such as Address/port inspection and filtering
- Shall be stateful firewall
- Shall support upto 4 Ethernet switches 10/100 Mbps
- Shall support IPv4 and IPv6
- Shall have IP sec/VPN with 3DES/AES encryption
- Shall have NAT
- Shall have syslog capability
- Shall be NERC compliant
- Shall have hot- standby operation with similar router

The substation routers shall have the following features:

- Routing protocols such as OSPF and support for IPv4 and IPv6
- 4 Ethernet interfaces of 10/100 Mbps
- 2 E1 interfaces
- Hot standby operation with a similar router
- Support IEEE 802.3u, 802.1p, 802.1Q, 802.1d, 802.1w,
- Traffic prioritization for routed IP flows/ports

The substation firewall and router can be a single device.

4.2 Bay level unit or Bay control unit (BCU)

4.2.1 General

- Bay Control Unit (BCU) shall be provided for each Bays (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer, Number of bays shall be as per Section-Project) for control and monitoring of the bay equipment. Separate BCU (as per section-project) shall be provided for the monitoring of substation auxiliaries.
- The BCUs shall have adequate capacity for the estimated hardwired Inputs & Outputs plus a minimum of two Inputs and a minimum of two outputs as spare capacity per BCU. Requirement for external IO modules shall be avoided as far as possible.
- BCUs shall have redundant DC Power Supply or with automatic changeover scheme, to be fed from the two station DC power supplies. Each power supply shall be supervised separately and alarmed.
- Each BCU shall be equipped with Local HMI (display) facilities, enabling control of each particular bay from BCU whenever required. The Local HMI facilities shall be accomplished by means of Graphical LCD display embedded into the front panel of the BCU. Display will show the SLD (with device identification number) showing status of bay switching equipment (such as circuit breaker, isolators, earth switches) and enabling issuance of switching controls. Other display type will be multiple displays of analog values readings / reports, displays for controls other than switching, Alarm panel displays, Diagnostic/ on-line configuration displays etc.
- In the event of switchgear apparatus controls, the software-interlocking scheme should be applied based on hardwired analog/digital inputs or Process Bus signals. In the event of closing control for circuit breakers requiring checking of synchronization conditions, software synchro-check scheme should be applied as well. Auto-reclose functions mentioned elsewhere in the specification, if required, can also be applied.

4.2.2 Design

- The bay unit shall use industrial grade components. The bay level unit, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. They shall incorporate select-before-operate control principles as safety measures for operation via the HMI. Following power interruption and/or communications failure, the BCU shall be capable to restart automatically. Time synchronisation of BCUs with UTC time shall be done over the IEC 61850 field LAN for Substation with SAS. For conventional substation, Time synchronisation of BCU shall be done by other suitable Time synch input like IRIG-B, RS232 etc.

- They shall perform all bay related functions, such as control commands, bay interlocking, data acquisition, data storage, event recording and shall provide inputs for status indication and outputs for commands. They shall be directly connected to the switchgear. However, in case of Process Bus based SAS, Switchgear Controllers (SGCs)/Merging Units (MUs) shall be used as digital interfaces between switchgear/instrument transformers and bay level IEDs. The bay unit shall acquire and process all data for the bay (Equipment status, fault indications, measured values, alarms etc.) and transmit these to the other devices in sub-station automation system. In addition, this shall receive the operation commands from station HMI and control centre.

- One no. Bay Control unit shall be provided for supervision and control of each 765, 400, 220, 132 kV bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer). The Bay level unit shall be equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. All bay level interlocks are to be incorporated in the Bay level unit so as to permit control from the Bay level unit/ local bay mimic panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Station HMI is out of service.

- The bay control unit to be provided for the bays shall be preferably installed in the CB relay panel/feeder protection panel for respective bay. Further in case of one and half breaker schemes, the BCU for Tie CB shall be provided in Tie CB relay panel. The tie CB relay panel shall also house the Ethernet switch(es) to be provided for the diameter. The bay control unit for future bay (if required as per section project) shall be installed in a separate panel.

- The Bay level unit shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 61850. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.

4.2.3 Input/ Output (I/O) modules (applicable for non-Process Bus SAS)

- The I/O modules shall form a part of the bay level unit / Bay control unit and shall provide coupling to the substation equipment. The I/O modules shall acquire all switchgear information (i.e. data coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear.

- It shall be suitable for analog inputs from secondary of instrument transformers.
- The BCU/IED shall be able to integrate at least 10 analog input channels as a minimum and digital input / output channel to meet the control & monitoring scheme requirement.
- Plant alarms and indications will be derived as digital input. Plant contacts shall change state to register the specified status change or alarm, and each input shall be configurable to register a positive input from either a closed or open contact, i.e. input signals may be either a normally open or a normally closed contact. Alarm contacts may be either fleeting or sustained inputs. Digital filtering to suppress plant contact bounce shall be provided for each input. Time tagging to a resolution of 1 ms shall be provided.
- The pulse counting inputs shall be provided as per scheme requirement. These inputs shall acquire and count impulses produced by potential free contacts, which can be either, normally open or normally closed. Pulse counting inputs shall be provided as either a separate input module or using digital inputs. These inputs shall meet the same requirements specified for digital inputs; additionally they shall be able to cater for pulse rates up to 10 per second.
- Where DC analogue measurement inputs are provided as per the scheme requirement, they shall be capable of accepting unipolar and bipolar current of range 0-10/4-20mA and -10 to +10 mA (range as applicable for the project), with over/under range detection.
- The command outputs shall be designed to provide select and execute outputs. The period of the command pulse shall be configurable between 0.1 second and 15 seconds on point basis. The command pulses shall reset immediately after the command is executed. Controls transmitted between the operator workstation of SAS / SCADA and the BCU shall comprise a select, check back & execute sequence (or other means of providing high message security).

4.2.4 The BCU supplied for substation automation system shall further meet the requirements mentioned elsewhere in the specification

4.3 Extendibility in future

Offered substation automation system shall be suitable for extension in future for additional bays. During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed in such a manner that its extension shall be easily performed by the employer. During such event, normal operation of the existing substation shall be unaffected and system shall not require a complete shutdown. The contractor shall provide all necessary software tools along with details to perform addition of bays in future and complete integration with SAS by the user. These software tools shall be able to configure IED, add additional analogue variable, alarm list, event list, modify interlocking logics etc. for additional bays/equipment which shall be added in future. **Following is to be ensured during initial supply of system:**

- **All the licenses for various components such as SCADA, servers,**

configuration tools for various IEDs, Gateways etc. shall be for complete system i.e. system as per single line diagram including both present and future scope. The contractor shall submit the list of equipment and Inputs/Outputs covered under the licences provided.

- **All the servers shall be capable of handling total system (present and future).**

In case of extension packages, the interoperability between devices compliant to IEC 61850 Edition 2 (or latest) and existing devices compliant to IEC 61850 Edition 1 should be ensured.

5.0 Software structure

The software package shall be structured according to the SAS architecture and strictly divided in various levels. Necessary firewall shall be provided at suitable points in software to protect the system. An extension of the station shall be possible with lowest possible efforts. Maintenance, modification or an extension of components of any feeder may not force a shut-down of the parts of the system which are not affected by the system adaptation.

5.1 Station level software

5.1.1 Human-machine interface (HMI)

The base HMI software package for the operator station shall include the main SAS functions and it shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. Systems shall contain a library with standard functions and applications.

5.2 Bay level software

5.2.1 System software

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. The lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance engineer for modifications. The system shall support the generation of typical control macros and a process database for user specific data storage. In case of restoration of links after failure, the software along with hardware shall be capable of automatically synchronising with the remaining system without any manual interface. This shall be demonstrated by contractor during integrated system test.

5.2.2 Application software

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They form part of a library.
The application software within the control/protection devices shall be programmed in a functional block language.

5.3 Network Management System:

The contractor shall provide network management system software for following management functions:

a. Configuration Management
b. Fault Management
c. Performance Monitoring

This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in DR work-station and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any communication fault/problem in the monitored devices. The NMS shall

(a) Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demand reports.
(b) Maintain a graphical display of SAS connectivity and device status.
(c) Issue alarms when error conditions occurs
(d) Provide facility to add and delete addresses and links

5.4 Operating System

The Operating system of the Servers, HMIs and Gateways shall be hardened in line with the following suggested guidelines to reduce its vulnerability to cyber-attacks.

5.4.1 Secure Build Strategy

Packages unnecessary for system operation are not to be installed during the initial build of the servers and workstations, reducing the amount of post-build hardening required. Any package that must be installed but is not required to be actively running have to be disabled.

The software to be removed and/or disabled includes, but is not limited to:

- Games
- Messaging services
- Servers or clients for unused Internet services
- Software compilers (except where required, i.e. development platform)
- Unused networking and communication protocols
- Unused operating system features
- free utilities delivered with OS

5.4.2 Generic and Default Accounts

Disable or remove all unnecessary generic and default user accounts from the operating system and third party applications. Application accounts (such as daemon) that exist strictly for identification and ownership are disabled from all interactive, network, or other access to prevent unauthorized access. Required accounts and their functions have to be documented.

5.4.3 Insecure Protocol

Insecure protocols such as telnet, FTP, RSH, and RCP have to be disabled from operation.

5.4.4 Malicious Software Prevention

Implementation of anti-virus and other malicious software prevention tools to detect, prevent, deter, and mitigate the introduction, exposure, and propagation of malware. Supplier shall verify that commercially available anti-malware products do not cause harm to the product.

Provide procedures on how to update the signature database of the anti-malware software, if provided.

5.4.5 System Whitelisting

System whitelisting is to be done i.e. the software takes an inventory of the host in a known good state, and any applications not present at that time (such as viruses, malware, games, portable applications, etc.) are prevented from executing.

5.4.6 Ports and Services

The system shall be configured by the supplier to only use those ports and services required for normal and emergency operations. The ports and services required for operation are documented and supplied to the customer as part of the deliverable system documentation.

5.4.7 Host-Based Firewalls

The host-based firewalls shall be configured with a standardized set of rules as an additional layer of security if the network firewall to fail. The host-based firewalls are configured with a default deny rule that logs any traffic not explicitly allowed.

In the case where a service cannot be disabled but does not require communication with hosts external to itself, this host-based firewall also serves to prevent any communication to the port(s) used by that service.

5.4.8 Removable Media

Removable media (CD and DVD, USB Drives, etc.) is not required for the operation
of the SAS and may be inhibited from operation except in case of data back up on CD/DVD as per specification.

5.5 The contractor shall provide each software in two copies in CD to load into the system in case of any problem related with Hardware/Communication etc.

6.0 General Guidelines for IEC 61850 SAS Engineering:

i. Data exchange is to be realised using the protocols defined and standardized in the latest edition of IEC 61850 with a redundant managed switched Ethernet communication infrastructure. The modelling of various aspects of

Substation Automation System, like, Data Objects, Data Attributes, Logical Nodes, etc. shall be according to the latest edition of IEC 61850.

ii. During the GOOSE communication engineering, it shall be ensured that the publishing IEDs shall have the quality attribute included invariably for each GOOSE message in the GOOSE dataset. Further, the subscriber IEDs shall not use any GOOSE message which it receives without the quality attribute.

iii. The GOOSE subscribing IEDs shall have the feature of detecting duplicate GOOSE message and intrusion using State Number (StNum), Sequence Number (SqNum) fields of a GOOSE message. Once duplicate GOOSE messages or intrusion is detected, the subscribing device shall discard the GOOSE messages from that particular publishing device and shall generate an alarm.

iv. If the association between the publisher and subscriber is lost (please refer Sec. 6.2 of IEC 61850 part 7-3), the 'validity' field of the quality will be set to questionable, and the detailQual 'oldData' will be set. The rest of quality fields will not be changed.

v. Separate VLANs shall be created for multicast communication between IEDs belonging to different voltage levels. Also, a 'Cross-VLAN' shall be created which will include the IEDs of different voltage levels together as per the requirement of the cross communication for control/protection schemes.

vi. A guideline over usage of logical nodes for Report Control/ GOOSE control engineering shall be issued during the detailed engineering.

vii. In the control and protection schemes, wherever GOOSE messages are used, the schematic documents submitted by the vendor should indicate the communication between LNs used in the indicating the source and destination LNs.

7.0 Additional Requirements for IEC 61850 based Process Bus Projects (Applicable only if Process Bus SAS is specified in Section Project):

(i) Switchgear Controllers (SGC) IED

- SGCs shall function as digital interface between switchgear and control and protection IEDs (bay level IEDs) and shall be installed near the switchgear in the switchyard.
- SGCs shall be able to withstand the electrical and environmental conditions of the switchyard, like, temperature (preferably in the range of -25˚C to 70˚C temperature), humidity, electromagnetic interference (EMI/EMC) conditions, radio interference etc. SGCs shall be installed in panels designed with IP55 protection (or better) for outdoor use. The SGCs shall be suitable for the hostile substation environment and shall comply with the requirements for IEC 61850-3.
- Modelling of SGCs shall adhere to the IEC 61850 standard. Logical nodes, such as, XCBR and XSWI shall be used as the interfaces to Circuit Breaker and Isolator respectively. Engineering of the device shall comply with IEC 61850 Part 6 (Substation Configuration Language). Further, to accommodate supervision inputs and other 4-20mA inputs, Logical Nodes, as defined in the standard (the latest edition of IEC 61850) shall be used.
- The devices shall use Parallel Redundancy Protocol (PRP), and be High-availability Seamless Redundancy (HSR) capable. SGC devices should be time synchronized via SNTP or IEEE 1588v2 (Precision Time Protocol – PTP). No separate cable shall be used for time synchronization purpose.

Ethernet based Data Network which will be used for GOOSE communication shall also be used for time synchronization purpose.

- The user shall be able to configure/access the device from the Engineering PC in the Control Room.
- The number of binary inputs and binary outputs along with 4-20mA inputs shall be as per the requirement of the project. These mA inputs can either be provided in SGCs or can be provided in separate IEDs mounted near the equipment.
- Each bay shall have at least one SGC.
- SGCs should be powered by redundant Station DC power supplies and if the same is not available, then external changeover circuit shall be used.

(ii) Merging Units (MU) for Conventional CT and VT

- Merging Units (MU) shall digitize the conventional CT and VT values as per IEC 61850 Sampled Measured Values (SMV).
- MUs shall be able to withstand the electrical and environmental conditions of the switchyard, like, temperature (preferably in the range of -25˚C to 70˚C temperature), humidity, electromagnetic interference (EMI/EMC) conditions, radio interference etc. MUs shall be installed in panels designed with IP55 protection (or better) for outdoor use. The SGCs shall be suitable for the hostile substation environment and shall comply with the requirements for IEC 61850-3.
- Modelling of MUs shall adhere to IEC 61850 standard. Logical nodes, such as, TCTR and TVTR shall be used as the interfaces to Current Transformer and Voltage Transformer respectively. Engineering of the device shall comply with IEC 61850 Part 6 (Substation Configuration Language).
- The devices shall use Parallel Redundancy Protocol (PRP), or/and High-availability Seamless Redundancy (HSR) capable as applicable to meet the SAS architecture requirement. Also, these devices should have the capability to be time synchronized via IEEE 1588v2 (Precision Time Protocol – PTP). No separate cable is envisaged for time synchronization purpose. Ethernet based Data Network which will be used for SMV transmission shall also be used for time synchronization purpose.
- The user shall be able to configure/access the device from a separate Engineering PC in the Control Room.
- Each bay shall have 2 nos. MUs, each having CT and CVT inputs from different cores. For Bus CVTs, separate MUs shall be provided.
- MUs should be powered from Station DC power supplies, one from source-1 & other from source-2.

(iii) Specific Requirement for Control & Protection IEDs to be used in Process Bus SAS:

- The control and protection IEDs shall have 4 optical ports (2 each for connection with Process Bus LAN and Station Bus LAN). In case of insufficient availability of number of ports natively in the IED, then Redundancy Boxes (RedBox) shall be used. However, atleast 2 ports shall compulsorily be available natively on the IED (with one port having the capability to get connected with Process Bus LAN and other to get connected with Station Bus LAN).
- The IEDs, wherever required, shall have the capability to internally summate the Sampled Values (SV) streams from two or more instrument transformers.

(iv) For Transformers and Reactors, sufficient (redundant)SGCs/MUs shall be provided in the Transformer/Reactor MB (or in a separate panel near the Transformer/Reactor MB as per the site specific conditions) for interfacing bushing CTs, Online DGA, PPM Monitor, Optical Temperature Sensor and other annunciation/data of Transformer/Reactor with the process bus / station bus of SAS.

(v) Following alarms shall be generated by devices subscribing to SMV streams in the following two cases:

Firstly, when a subscribing IED stops receiving SMV streams from the Merging Unit(s), alarms shall be generated.

Secondly, there shall be a mechanism in the IEDs to detect using the SMV streams, the loss of time synchronization of Merging Units*.*

In case, the IEDs are not receiving the Sampled Values or are receiving improper Sampled Values from the Merging Unit, the IEDs shall not process their functions which utilize those Sampled Values.

(vi) In addition to the requirements specified at Section 4.1.5 for Switched Ethernet Communication Infrastructure, the Ethernet Fast Switches shall be PRP (IEC 62439 - 3), HSR (IEC 62439 - 3) and PTP (IEEE 1588v2) capable.

(vii) A suggested architecture for Process bus based SAS is enclosed. The architecture of Process Bus based SAS shall be such that the failure of any one Ethernet switch or any one fibre section of the SAS LAN (either in Process Bus LAN or in Station Bus LAN) shall not result into any communication interruption.

(viii) All the control and protection schemes/functions shall be designed and implemented with GOOSE messages and Sampled Values, unless specifically desired by POWERGRID to be implemented using hardwiring. For energy metering, hardwiring between CT & CVT and meters shall be done. For signal exchange between PLCC and Protection IEDs and between CT/CVT and Control Switching Devices (CSDs), hardwiring shall also be acceptable. For integration of analog and binary signals from station auxiliaries (DG, FFPH, Air Conditioning, AC and DC LT etc.), hardwiring to IEDs shall also be acceptable.

8.0 TESTS

The substation automation system offered by the bidder shall be subjected to following tests to establish compliance with IEC 61850 for EHV sub-station equipment installed in sheltered area in the outdoor switchyard and specified ambient conditions:

8.1 Type Tests:

8.1.1 Control IEDs /BCU and Communication Equipment:

The above equipment shall conform to following type tests as per IEC 61850-3 (latest Revision)

a. Power Input:

i. Auxiliary Voltage
ii. Current Circuits
iii. Voltage Circuits

iv. Indications

b. Accuracy Tests:

i. Operational Measured Values
ii. Currents
iii. Voltages
iv. Time resolution

c. Insulation Tests:

i. Dielectric Tests
ii. Impulse Voltage withstand Test

d. Influencing Quantities

i. Limits of operation
ii. Permissible ripples
iii. Interruption of input voltage

e. Electromagnetic Compatibility Test:

i. 1 MHZ. burst disturbance test
ii. Electrostatic Discharge Test
iii. Radiated Electromagnetic Field Disturbance Test
iv. Electrical Fast transient Disturbance Test
v. Conducted Disturbances Tests induced by Radio Frequency Field
vi. Magnetic Field Test
vii. Emission (Radio interference level) Test.
viii. Conducted Interference Test

f. Function Tests:

i. Indication
ii. Commands
iii. Measured value Acquisition
iv. Display Indications

g. Environmental tests:

i. Cold Temperature
ii. Dry Heat
iii. Wet heat
iv. Humidity (Damp heat Cycle)
v. Vibration
vi. Bump
vii. Shock

8.1.2 All the IEDs, other communication equipment including Ethernet switches and SCADA/SAS software shall be compliant with the latest edition of IEC 61850 and should conform to conformance tests as per IEC 61850-10.

8.2 Factory Acceptance Tests:

The supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval based on the standard SAS FAT procedure of POWERGRID. **The Standard SAS FAT format & procedure is provided at Appendix-II for reference guideline**. For the individual bay level IED's applicable type test certificates shall be submitted**.**

The manufacturing and configuration phase of the SAS shall be concluded by the factory acceptance test (FAT). The purpose is to ensure that the

Contractor has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the user. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab. During FAT the entire Sub-station Automation System including complete control and protection system to be supplied under present scope shall be tested for complete functionality and configuration in factory itself. The extensive testing shall be carried out during FAT. The purpose of Factory Acceptance Testing is to ensure trouble free installation at site. No major configuration setting of system is envisaged at site.

The bidder shall provide the SCD file after FAT to site so that any intermittent issues with FAT configuration and changed site configuration (if any) can be analysed.

If the complete system consists of parts from various suppliers or some parts are already installed on site, the FAT shall be limited to sub-system tests. In such a case, the complete system test shall be performed on site together as part of site acceptance test (SAT).

In case of an extension of sub-station, Factory Acceptance Test shall be carried out with the help of a demo system owned by supplier. However, the complete system is to be tested along with SCADA at site by the supplier after complete integration of the system as part of SAT.

8.2.1 Hardware Integration Tests:

The hardware integration test shall be performed on the specified systems to be used for Factory tests when the hardware has been installed in the factory. The operation of each item shall be verified as an integral part of system. Applicable hardware diagnostics shall be used to verify that each hardware component is completely operational and assembled into a configuration capable of supporting software integration and factory testing of the system. The equipment expansion capability shall also be verified during the hardware integration tests. The vendor specifically demonstrates how to add a device in future in SAS during FAT. The device shall be from a different manufacturer than the SAS supplier.

8.2.2 Integrated System Tests:

Integrated system tests shall verify the stability of the hardware and the software. During the tests all functions shall run concurrently and all equipment shall operate a continuous 100 Hours period. The integrated system test shall ensure the SAS is free of improper interactions between software and hardware while the system is operating as a whole.

8.3 Site Acceptance Tests:

The site acceptance tests (SAT) shall completely verify all the features of SAS hardware and software. The contractor shall submit the detailed SAT procedure and SAT procedure shall be read in conjunction with the specification.

9.0 SYSTEM OPERATION

9.1 Substation Operation

9.1.1 NORMAL OPERATION

Operation of the system by the operator from the remote RCC or at the substation shall take place via industry standard HMI (Human Machine interface) subsystem consisting of graphic colour VDU , a standard keyboard and a cursor positioning device (mouse).

The coloured screen shall be divided into 3 fields:

i) Message field with display of present time and date
ii) Display field for single line diagrams
iii) Navigation bar with alarm/condition indication

For display of alarm annunciation, lists of events etc a separate HMI View node shall be provided.

All operations shall be performed with mouse and/or a minimum number of function keys and cursor keys. The function keys shall have different meanings depending on the operation. The operator shall see the relevant meanings as function tests displayed in the command field (i.e. operator prompting). For control actions, the switchgear (i.e. circuit breaker etc.) requested shall be selectable on the display by means of the cursor keys. The switching element selected shall then appear on the background that shall be flashing in a different color. The operator prompting shall distinguish between:-

- Prompting of indications e.g. fault indications in the switchgear, and

- prompting of operational sequences e.g. execution of switching operations

The summary information displayed in the message field shall give a rapid display of alarm/message of the system in which a fault has occurred and alarm annunciation lists in which the fault is described more fully.

Each operational sequence shall be divided into single operation steps which are initiated by means of the function keys/WINDOW command by mouse. Operator prompting shall be designed in such a manner that only the permissible keys are available in the command field related to the specific operation step. Only those switching elements shall be accessed for which control actions are possible. If the operation step is rejected by the system, the operator prompting shall be supported by additional comments in the message field. The operation status shall be reset to the corresponding preceding step in the operation sequence by pressing one of the function keys. All operations shall be verified. Incorrect operations shall be indicated by comments in the message field and must not be executed.

The offer shall include a comprehensive description of the system. The above operation shall also be possible via WINDOWS based system by mouse.

10.0 POWER SUPPLY

Power for the substation automation system shall be derived from station DC power supplies.
Inverter of suitable capacity shall be provided for station HMI disturbance recorder evaluation unit and its peripheral devices e.g. printer etc. In the event of Power failure, necessary safeguard software shall be built for proper shutdown. Separate Inverters powered from separate station DC supplies shall be provided for Main & hot standby SAS system. Separate Inverter shall also be supplied for Remote HMI & Workstation only if applicable.

11.0 DOCUMENTATION

The following documents shall be submitted for employer's approval during detailed engineering:

(a) System Architecture Drawing
(b) Hardware Specification
(c) Functional Design Document
(d) Clear procedure describing how to add an IED/bay/diameter in future covering all major supplier
(e) VLAN architecture drawing

The following documentation to be provided for the system in the course of the project shall be consistent, CAD supported, and of similar look/feel. All CAD drawings to be provide in "dxf" format.

- List of Drawings
- Substation automation system architecture
- Block Diagram
- Guaranteed technical parameters, Functional Design Specification and Guaranteed availability and reliability
- Calculation for power supply dimensioning
- I/O Signal lists
- Schematic diagrams
- List of Apparatus
- List of Labels
- Logic Diagram (hardware & software)
- Switchyard Panel Room layout drawing
- Control Room Lay-out
- Test Specification for Factory Acceptance Test (FAT)
- Test Specification for Site Acceptance Test (SAT)
- The SCD files of the station's project shall be submitted by the vendor during the FAT and after successful commissioning of SAS.
- A GOOSE matrix sheet with publisher and subscriber IEDs.
- Product Manuals (Installation, Configuration, maintenance, Troubleshooting, detailed diagnostics etc.)
- Assembly Drawing
- Operator's Manual
- Complete documentation of implemented protocols between various elements
- Listing of software and loadable in CD ROM

- Other documents as may be required during detailed engineering

Two sets of hard copy and Four sets of CD ROM/USB drive containing all the as built documents/drawings shall be provided.

12.0 TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES

12.1 Training

Contractor personnel who are experienced instructors and who speak understandable English shall conduct training. The contractor shall arrange on its own cost all hardware training platform required for successful training and understanding in India. The Contractor shall provide all necessary training material. Each trainee shall receive individual copies of all technical manuals and all other documents used for training. These materials shall be sent to Employer at least two months before the scheduled commencement of the particular training course. Class materials, including the documents sent before the training courses as well as class handouts, shall become the property of Employer. Employer reserves the right to copy such materials, but for in-house training and use only. Hands-on training shall utilize equipment identical to that being supplied to Employer.

For all training courses, the travel (e.g., airfare) and per-diem expenses will be borne by the participants.

The Contractor shall quote training prices as indicated in BPS.

The schedule, location, and detailed contents of each course will be finalized during Employer and Contractor discussions.

12.2 Computer System Hardware Course

A computer system hardware course shall be offered, but at the system level only. The training course shall be designed to give Employer hardware personnel sufficient knowledge of the overall design and operation of the system so that they can correct obvious problems, configure the hardware, perform preventive maintenance, run diagnostic programs, and communicate with contract maintenance personnel. The following subjects shall be covered:

(a) System Hardware Overview: Configuration of the system hardware.

(b) Equipment Maintenance: Basic theory of operation, maintenance techniques and diagnostic procedures for each element of the computer system, e.g., processors, auxiliary memories, LANs, routers and printers. Configuration of all the hardware equipment.

(c) System Expansion: Techniques and procedures to expand and add equipment such as loggers, monitors, and communication channels.

(d) System Maintenance: Theory of operation and maintenance of the redundant hardware configuration, failover hardware, configuration control panels, and failover switches. Maintenance of protective devices and power supplies.

(e) Subsystem Maintenance: Theory of design and operation, maintenance techniques and practices, diagnostic procedures, and (where applicable) expansion techniques and procedures. Classes shall include hands-on training for the specific subsystems that are part of Employer's equipment or part of similarly designed and configured subsystems. All interfaces to the computing equipment shall be taught in detail.

(f) Operational Training: Practical training on preventive and corrective maintenance of all equipment, including use of special tools and instruments. This training shall be provided on Employer equipment, or on similarly configured systems.

12.3 Computer System Software Course

The Contractor shall provide a computer system software course that covers the following subjects:

(a) System Programming: Including all applicable programming languages and all stand-alone service and utility packages provided with the system. An introduction to software architecture, Effect of tuning parameters (OS software, Network software, database software etc.) on the performance of the system.

(b) Operating System: Including the user aspects of the operating system, such as program loading and integrating procedures; scheduling, management, service, and utility functions; and system expansion techniques and procedures

(c) System Initialization and Failover: Including design, theory of operation, and practice

(d) Diagnostics: Including the execution of diagnostic procedures and the interpretation of diagnostic outputs,

(e) Software Documentation: Orientation in the organization and use of system software documentation.

(f) Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

12.4 Application Software Course

The Contractor shall provide a comprehensive application software courses covering all applications including the database and display building course. The training shall include:

a) Overview: Block diagrams of the application software and data flows. Programming standards and program interface conventions.
b) Application Functions: Functional capabilities, design, and major algorithms. Associated maintenance and expansion techniques.
c) Software Development: Techniques and conventions to be used for the preparation and integration of new software functions.
d) Software Documentation: Orientation in the organization and use of functional and detailed design documentation and of programmer and user manuals.
e) Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

12.5 Requirement of training:

The contractor shall provide training for POWERGRID personnel comprehensively covering following courses.

S. No.	Name of Course
1	Computer System Hardware
2	Computer System Software
3	Application Software

13.0 Maintenance

13.1 Maintenance Responsibility during the Guaranteed Availability Period.

During Guaranteed Availability Period, the Contractor shall take continual actions to ensure the guaranteed availability and shall make available all the necessary resources such as specialist personnel, spare parts, tools, test devices etc. for replacement or repair of all defective parts and shall have prime responsibility for keeping the system operational. During guarantee period as specified in tender document, contractor shall arrange visit of SAS manufacturer's representative to site as per requirement to review the performance of system and in case any defect/shortcoming etc. is observed during the period, the same shall be set right by the contractor within 15 days.

14.0 RELIABILITY AND AVAILABILITY

The SAS shall be designed so that the failure of any single component, processor, or device shall not render the system unavailable. The SAS shall be designed to satisfy the very high demands for reliability and availability concerning:

- Mechanical and electrical design
- Security against electrical interference (EMI)
- High quality components and boards
- Modular, well-tested hardware
- Thoroughly developed and tested modular software
- Easy-to-understand programming language for application programming
- Detailed graphical documentation and application software
- Built-in supervision and diagnostic functions
- Security
  - Experience of security requirements
  - Process know-how
  - Select before execute at operation
  - Process status representation as double indications
- Distributed solution
- Independent units connected to the local area network
- Back-up functions
- Panel design appropriate to the harsh electrical environment and ambient conditions
- Panel grounding immune against transient ground potential rise

Outage terms

1) **Outage**

The state in which substation automation system or a unit of SAS is unavailable for Normal Operation as defined in the clause 9.1.1 due to an event directly related to the SAS or unit of SAS. In the event, the owner has taken any equipment/system other than Sub-station Automation System for schedule/forced maintenance, the consequent outage to SAS shall not be considered as outage for the purpose of availability.

2) **Actual outage duration (AOD)**

The time elapsed in hours between the start and the end of an outage. The time shall be counted to the nearest $1/4^{th}$ of an hour. Time less than $1/4^{th}$ of an hour shall be counted as having duration of $1/4^{th}$ of an hour.

3) **Period Hours (PH)**

The number of hours in the reporting period. In a full year the period hour are 8760h (8784h for a leap year).

4) **Actual Outage hours (AOH)**

The sum of actual outage duration within the reporting period

$AOH = \sum AOD$

5) **Availability:**

Each SAS shall have a total availability of 99.98 % i.e. the ratio of total time duration minus the actual outage duration to total time duration.

14.1 Guarantees Required

The availability for the complete SAS shall be guaranteed by the Contractor. The contractor shall demonstrate their availability guaranteed by conducting the availability test on the total sub-station automation system as a whole after commissioning of total Sub-station Automation system. The test shall verify the reliability and integrity of all sub-systems. Under these conditions the test shall establish an overall availability of 99.98%. After the lapse of 1000 Hours of cumulative test time, test records shall be examined to determine the conformance with availability criterion. In case of any outage during the availability test, the contractor shall rectify the problem and after rectification, the 1000 Hours period start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved.
The contractor has to establish the availability in a maximum period of three months from the date of commencement of the availability test.
After the satisfactory conclusion of test both contractor and employer shall mutually agree to the test results and if these results satisfy the availability criterion, the test is considered to be completed successfully. After that the system shall be taken over by the employer and then the guarantee period shall start.

15.0 Spares

15.1 Consumables:

All consumables such as paper, cartridges shall be supplied by the contractor till the SAS is taken over by the owner. .

15.2 Availability Spares:

In addition to mandatory spares as listed in section project for SAS/BPS, the bidder is required to list the spares, which may be required for ensuring the guaranteed availability during the guaranteed availability period.

During the guaranteed availability period, the spare parts supplied by the Contractor shall be made available to the Contractor for usage subject to replenishment at the earliest. Thus, at the end of availability period the inventory of mandatory spares with the Employer shall be fully replenished by the Contractor. However, any additional spares required to meet the availability of the system (which are not a part of the above spares supplied by the Contractor) would have to be supplied immediately by the Contractor free of cost to the Employer.

The price of above availability spare, as assessed by the SAS vendor, shall be deemed to be included in the complete SAS price.

15.3 Special Tools for IEC 61850 based SAS:

The contractor shall supply a GOOSE Inspection and Simulation Tool. The tool(s) shall have the capability to sniff and inspect the GOOSE in the data network. The tool(s) shall also have the capability to extract the GOOSE information from .cid/.scd file(s) and simulate them.

For IEC 61850 based Process Bus Projects, the bidder also shall supply a SV (IEC 61850 Sampled Values) Inspection and Simulation Tool. The tool(s) shall have the capability to sniff and inspect the SV in the data network. The tool(s) shall also have the capability to extract the SV information from .cid/.scd file(s) and simulate them.

The price of above shall be deemed to be included in the complete SAS.

16.0 LIST OF EQUIPMENTS

Quantity of following equipment shall be decided by bidder in order to achieve guaranteed reliability and availability as declared by bidder.

i) Station HMI workstation
ii) Redundant Station HMI (in Hot-stand by mode) workstation
iii) Bay level units along with bay mimic for number of bays as detailed in section Project.
iv) Bay Level Unit for Auxiliary system (as per requirement)
v) Disturbance Recorder Work Station(Maintenance HMI)
vi) Engineering PC for Merging Units (applicable in case of Process Bus Projects)
vii) Colour Laser Printer – 1 No. (For Reports & Disturbance records)
viii) Dot matrix printers - (one each for Alarms and log sheets)
ix) All interface equipment for gateway to RCC and RSCC
x) Communication infrastructure between Bay level units, Station HMI, Printers, gateways, redundant LAN etc. as required
xi) Remote disturbance recorder workstation and remote HMI and along with one colour laser A4 printer (Remote HMI, only if specified in Section Project).
xii) Modems as per requirement.
xiii) Routers – 2 Nos.
xiv) Merging Units (MUs) [applicable for Process Bus SAS], as per requirement.

xv) Switchgear Controllers (SGCs) [applicable for Process Bus SAS], as per requirement.

xvi) Any other equipment as necessary.

List of Analogue and Digital Inputs

Basic Monitoring requirements are:

- Switchgear status indication
- Measurements (U, I, P, Q, f)
- Event
- Alarm
- **Oil &** Winding temperature of transformer & reactor individual units
- ambient temperature
- Status and display of 415V LT system, 220V & 48V DC system
- Status of display of Fire protection system and Air conditioning system.
- Acquisition of all counters in PLCC panels through potential free contacts from PLCC or independently by counting the receive/send commands.
- Acquisition of alarm and fault record from protection relays
- Disturbance records
- Monitoring the state of batteries by displaying DC voltage, charging current and load current etc.
- Tap-position of Power Transformer
- Temperature measured with Optical Temperature sensor (being provided by Transformer/Reactor manufacturer)
- **Dissolved Hydrogen / multi-gas & Moisture Content monitor of Transformer**
- **Status and display of LT transformer & its associated switchgear for station auxiliary supply**

List of Inputs

The list of input for typical bays is as below:-

Analogue inputs

i) For Each line
Current R phase
Y phase
B phase
Voltage R-Y phase
Y-B phase
B-R phase

ii) For each transformer/reactor
Current R phase
Y phase
B phase

WTI (Winding Wise)
OTI
Multi-gas DGA parameters
Tap position (for transformer only)

iii) For TBC and bus coupler

Current	R phase
	Y phase
	B phase

iv) Common

a) Voltage for Bus-I, Bus-II and Transfer bus wherever applicable

Voltage	R-Y phase
	Y-B phase
	B-R phase

b) Frequency for Bus-I and Bus-II

c) Ambient temperature (switchyard)
d) Switchyard Panel Room Temperature.
e) LT system
   i) Voltage R-Y, Y-B, B-R of Main Switch Board section-I
   ii) Voltage R-Y, Y-B, B-R of Main Switch Board section-II
   iii) Voltage R-Y, Y-B, B-R of Diesel Generator
   iv) Current from LT transformer-I
   v) Current from LT transformer-II
   vi) Current from Diesel Generator
   vii) Voltage of 220V DCDB-I
   viii) Voltage of 220V DCDB-II
   ix) Current from 220V Battery set-I
   x) Current from 220V Battery set-II
   xi) Current from 220V Battery charger-I
   xii) Current from 220V Battery charger-I
   xiii) Voltage of 48V DCDB-I
   xiv) Voltage of 48V DCDB-II
   xv) Current from 48V Battery set-I
   xvi) Current from 48V Battery set-II
   xvii) Current from 48V Battery charger-I
   xviii) Current from 48V Battery charger-I

Digital Inputs
The list of input for various bays/SYSTEM is as follows:

1. **Line bays**
   i) Status of each pole of CB.
   ii) Status of Isolator, Earth switch
   iii) CB trouble
   iv) CB operation/closing lockout
   v) Pole discrepancy optd
   vi) Trip coil faulty
   vii) LBB optd
   viii) Bus bar protn trip relay optd
   ix) Main bkr auto recloser operated

x) Tie/transfer auto recloser operated
xi) A/r lockout
xii) Tie/transfer bkr a/r lockout
xiii) Direct trip-I/II sent
xiv) Direct trip-I/II received
xv) Main I/II blocking
xvi) Main I/II-Inter trip send
xvii) Main I/II-Inter trip received
xviii) O/V STAGE – I operated
xix) O/V STAGE – II operated
xx) FAULT LOCATOR FAULTY
xxi) MAIN-I/II CVT FUSE FAIL
xxii) MAIN-I PROTN TRIP
xxiii) MAIN-II PROTN TRIP
xxiv) MAIN-I PSB ALARM
xxv) MAIN-I SOTF TRIP
xxvi) MAIN-I R-PH TRIP
xxvii) MAIN-I Y-PH TRIP
xxviii) MAIN-I B-PH TRIP
xxix) MAIN-I START
xxx) MAIN-I/II Carrier aided trip
xxxi) MAIN-I/II fault in reverse direction
xxxii) MAIN-I/II ZONE-2 TRIP
xxxiii) MAIN-I/II ZONE-3 TRIP
xxxiv) MAIN-I/II weak end infeed optd
xxxv) MAIN-II PSB alarm
xxxvi) MAIN-II SOTF TRIP
xxxvii) MAIN-II R-PH TRIP
xxxviii) MAIN-II Y-PH TRIP
xxxix) MAIN-II B-PH TRIP
xl) MAIN-II start
xli) MAIN-II aided trip
xlii) MAIN-I/II fault in reverse direction
xliii) Back-up o/c optd
xliv) Back-up e/f optd
xlv) 220V DC-I/II source fail
xlvi) SPEECH CHANNEL FAIL
xlvii) PLCC Protection Channel-I FAIL
xlviii) PLCC Protection Channel-II FAIL

2. **Transformer bays (HV Side)**

i) Status of each pole of CB,
ii) Status of Isolator, Earth switch
iii) CB trouble
iv) CB operation/closing lockout
v) Pole discrepancy optd
vi) Trip coil faulty
vii) LBB optd
viii) Bus bar protn trip relay optd
ix) REF OPTD
x) DIF OPTD (Phase Wise)
xi) OVERFLUX ALARM (MV)
xii) OVERFLUX TRIP (MV)

xiii) OVERFLUX ALARM (HV)
xiv) OVERFLUX TRIP (HV)
xv) HV BUS CVT ½ FUSE FAIL
xvi) MV BUS CVT ½ FUSE FAIL
xvii) OTI ALARM/TRIP
xviii) PRD OPTD (each PRD)
xix) OVERLOAD ALARM
xx) BUCHOLZ TRIP
xxi) BUCHOLZ ALARM
xxii) OLTC BUCHOLZ ALARM
xxiii) OLTC BUCHOLZ TRIP
xxiv) OIL LOW ALARM
xxv) back-up O/C (HV) optd
xxvi) back-up E/F (HV) optd
xxvii) 220V DC-I/II source fail
xxviii) TAP MISMATCH
xxix) GR-A PROTN OPTD
xxx) GR-B PROTN OPTD
xxxi) back-up O/C (MV) optd
xxxii) back-up E/F (MV)optd
xxxiii) Healthiness of each Protection Relay through watchdog contact.

3. **Transformer bays (MV Side)**

i) Status of each pole of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd
v) Trip coil faulty
vi) LBB optd
vii) Bus bar protn trip relay optd
viii) Back-up impedance relay
ix) 220V DC-I/II source fail
x) GR-A PROTN OPTD
xi) GR-B PROTN OPTD

4. **Line/Bus Reactor bays (as applicable):**

i) Status of each pole of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd
v) Trip coil faulty
vi) LBB optd
vii) Bus bar protn trip relay optd
viii) REF OPTD
ix) DIF OPTD (Phase wise)
x) Line/ BUS CVT ½ FUSE FAIL
xi) OTI ALARM/TRIP
xii) PRD OPTD
xiii) BUCHOLZ TRIP
xiv) BUCHOLZ ALARM
xv) OIL LOW ALARM
xvi) Back-up impedance relay

xvii) 220V DC-I/II source fail
xviii) GR-A PROTN OPTD
xix) GR-B PROTN OPTD

5 **Bus bar Protection**

i) Bus bar main-I trip
ii) Bus bar main-II trip
iii) Bus bar zone-I CT open
iv) Bus bar zone-II CT open
v) Bus transfer CT sup. Optd
vi) Bus transfer bus bar protn optd
vii) Bus protection relay fail

6. **Auxiliary system**

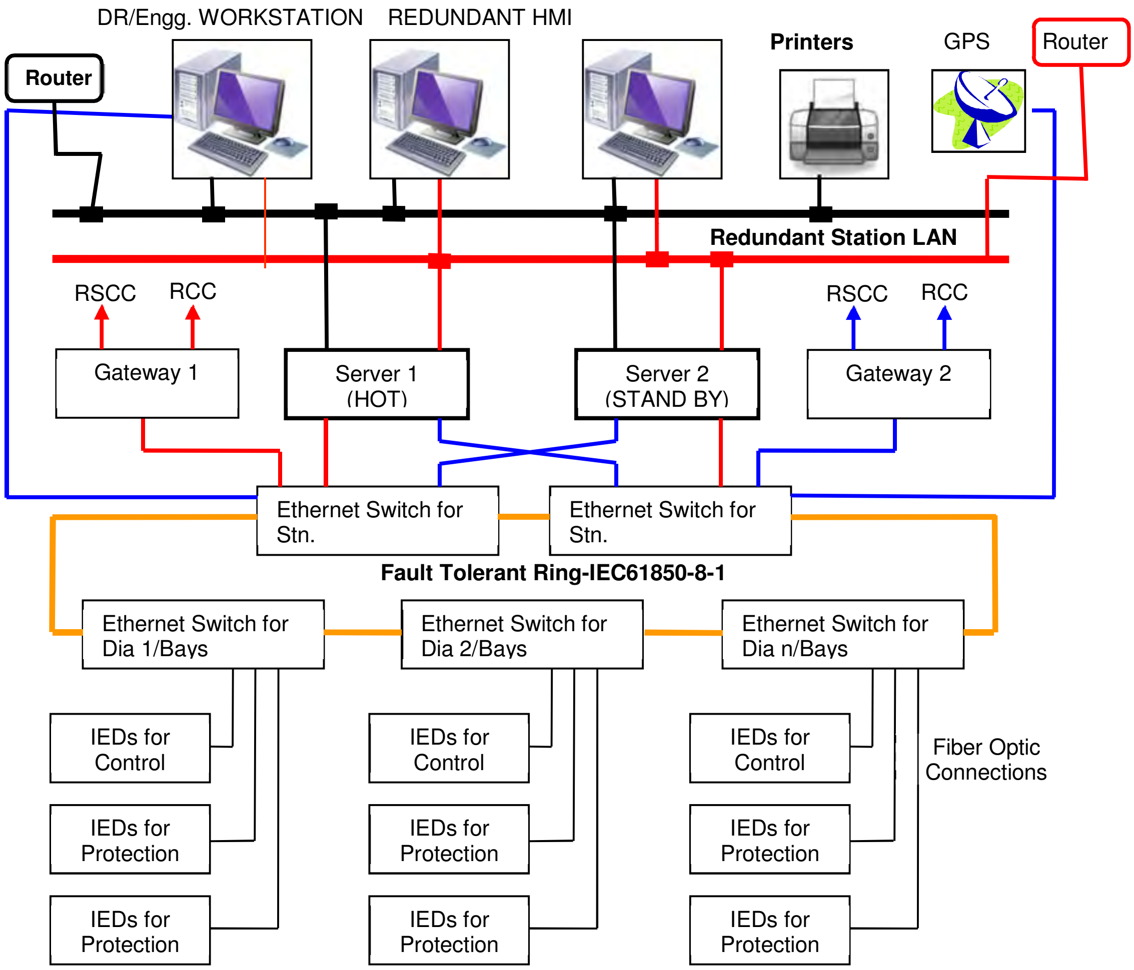
i) Incomer-I On/Off
ii) Incomer-II On/Off
iii) 415V Bus-I/II U/V
iv) 415v bus coupler breaker on/off
v) DG set bkr on/off
vi) Alarm/trip signals as listed in Section: DG set
vii) LT transformer-I Bunchholz Alarm & trip
viii) LT transformer-II Buchloz Alarm & trip
ix) LT transformer-I WTI Alarm & trip
x) LT transformer-II WTI Alarm & trip
xi) LT transformer-I OTI Alarm & trip
xii) LT transformer-II OTI Alarm & trip
xiii) PLCC exchange fail
xiv) Time sync. Signal absent
xv) Alarm/trip signals as listed in Section: Battery and Battery charger
xvi) 220v DC-I earth fault
xvii) 220v DC-II earth fault
xviii) Alarm/trip signals as listed in Section: Fire protection system

7. Switchyard Panel Room:

i) AC Compressor 1 ON/OFF
ii) AC Compressor 2 ON/OFF
iii) Fire Detection 1 ON/OFF
iv) Fire Detection 2 On/OFF
v) Switchyard Panel Room Temperature High Alarm

The exact number and description of digital inputs shall be as per detailed engineering requirement. Apart from the above mentioned digital inputs, minimum of 200 inputs shall be kept for employer's/owner's use in future for new substations. For extension substations, minimum 04 nos. digital inputs per bay shall be kept for future use.

TYPICAL ARCHITECTURAL DRAWING
OF
SUBSTATION AUTOMATION SYSTEM (Without Process Bus)



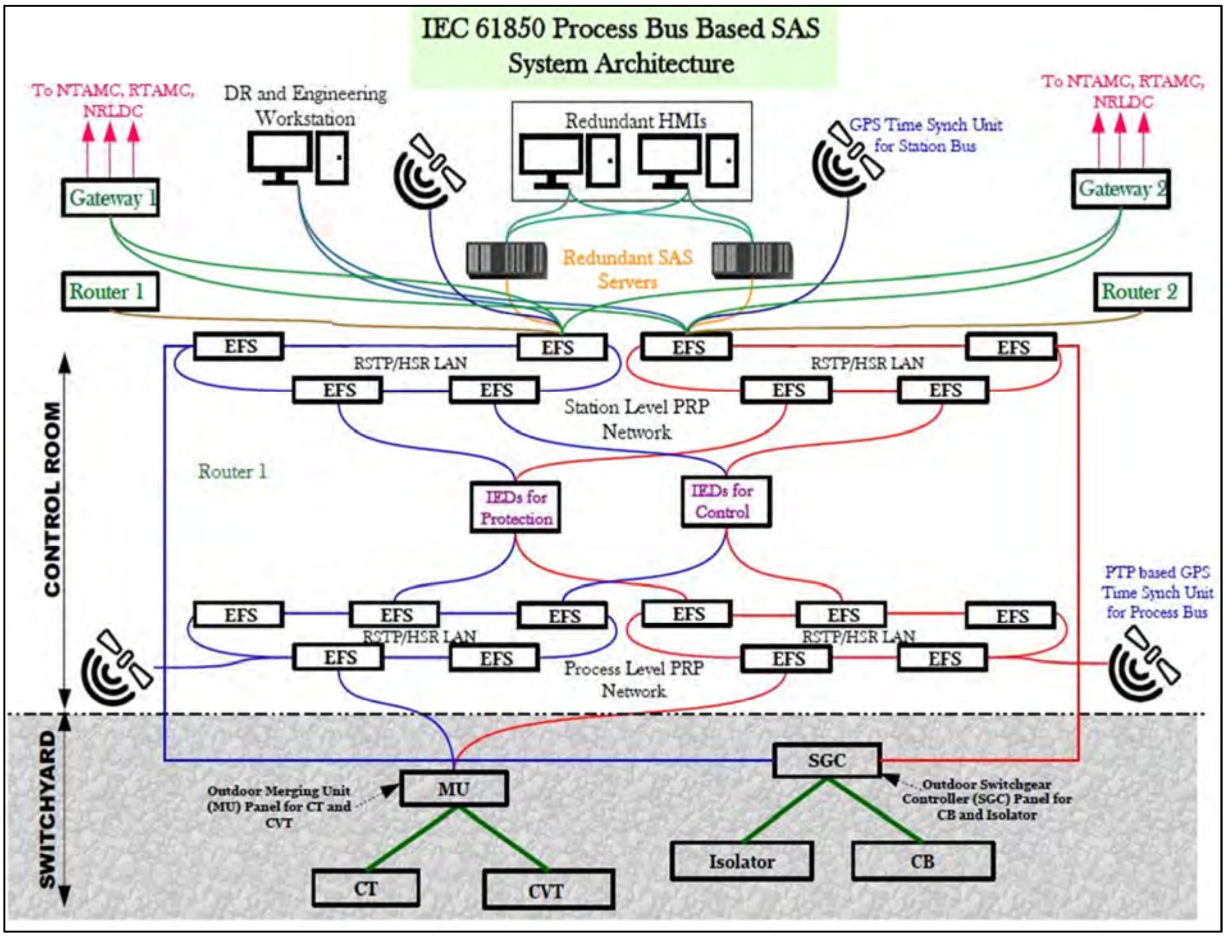
Note:

1. The redundant managed bus (station LAN) shall be realized by high speed optical bus using industrial grade components and shall be as per IEC 61850.
2. Inside the sub-station, all connections shall be realized as per IEC 61850 protocol.
3. For gateway, it shall communicate with Remote Supervisory Control Centre (RSCC) on IEC 60870-104 protocol. The number of ports required shall be as per clause no. 1.1 and 3.3 of this specification.
4. The printer as required shall be connected to station bus directly and can be managed either from station HMI, HMI view node or disturbance recorder work station.
5. The above layout is typical. However if any contractor offers slightly modified architecture based on their standard practice without compromising the working, the same shall be subject to approval during detailed engineering.
6. RCC means NTAMC/RTAMC. Similarly, RSCC could be SLDC for state owned substations/bays.

TYPICAL ARCHITECTURAL DRAWING

OF

SUBSTATION AUTOMATION SYSTEM (with Process Bus)



List of IO Points to be transmitted to RSCC

a) MW and MVAR for all lines , transformers ,reactors and Capacitors
b) Voltage of all buses
c) Frequency of all 400Kv and 765kV Buses
d) Frequency of one 220Kv Bus
e) All Breakers
f) All isolators
g) Tap Position for all transformers
h) Master protection signal for all feeders, transformers Units and Bus Bar
i) Loss of Voltage signal for Bus bar
j) All the points identified in point (e), (h) and (i) above as GPS Time stamped.
k) Temperature value per substation.
l) Any other point decided during detailed engineering

STANDARD FACTORY ACCEPTANCE TEST (FAT) PROCEDURE

FOR SAS AND C&P of _____________S/S

LOA No :

PROJECT NAME :

DOCUMENT NAME : FACTORY ACCEPTANCE TEST (FAT)/ FACTORY SYSTEM TEST (FST)/FUNCTIONAL PERFORMANCE TEST (FPT) PROCEDURE

DOCUMENT NO. : PG/CC/SAS/C&P/FAT, Rev0

ISSUE & DATE :

	NAME	DESIGNATION	SIGNATURE
Prepared by :			
Reviewed by :			
Recommended by :			
Approved by:			

Contents

General:

This document is used as a standard test protocol of all tests to be done at the Factory Acceptance Test (FAT) for the typical Substation Automation System (SAS) and Control &Protection system of every substation.

Aim of the Factory Acceptance Test (FAT) is to demonstrate equipment and functionality as well as the approval of the system-parameterization by POWERGRID to reduce the change requests during commissioning at site. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab. During FAT the entire Sub-station Automation System including complete control and protection system to be supplied shall be tested for complete functionality and configuration in factory itself. The extensive testing shall be carried out during FAT. The purpose of Factory Acceptance Testing is to ensure trouble free installation at site. No major configuration setting of system is envisaged at site.

This document details the equipment and functions under test and the corresponding test methods as well as the test documentation.

1 Test Configuration

1.1 Equipment

For the FAT configuration the following equipment will be present:

Computer type:	**Quantity (complete SW installed)**			
(Make e.g. Advantech)	Engg./DR PC	Server PC	Client/HMI PC	Gateway PC
(Model)				

Network components:	**Quantity**			
	Station Level		**Bay/Dia Level**	
	Make/Model	**Nos.**	**Make/Model**	**Nos.**
Ethernet Switch				
GPS Time server				
Router cum Firewall				
Networking Panel				
Auxiliary BCU Panel				
Protection & Relay Panels	NA	NA		

Peripheral	**Quantity**	
	Make/Model	**Nos.**
Event Printer		
DR Printer (Color)		
Logbook Printer		
Auto-Changeover switch for redundant UPS supply		
UPS (5 kVA)		

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

Note: These equipment quantities shall be verified w.r.t. Engg. approved SAS Architecture and BOM.

S.NO.	IEDs	Used For Functions	IED Make	IED Model	Quantity
1.	Main-1 Distance Relay	21M1			
2.	Main-2 Distance Relay	21M2			
3.	Transformer Diff. Relay	87T			
4.	Transformer REF Relay	64			
5.	Reactor Differential Relay	87R			
6.	Reactor REF Relay	64R			
7.	Bay Control Unit	BCU			
8.	BB Diff. Relay	87CU/MCU			
9.	Peripheral Unit	87PU/ BU			
10.	LBB Relay	50BF			
11.	Backup Impedance Relay	21R			
12.	Master Trip relay	86A/B			
13.	Auto-reclose Relay	79			
14.	Stand-alone DR	21DR			
15.	TEED Differential Relay				
16.	Over Flux Relay				
17.	Controlled Switching Device				
18.	Transformer B/U O/C				
19.					

Notes:1) Typical units will be present which can be loaded with different configurations
For an overview drawing of the equipment installed for the FAT please refer to the Appendix.

1.2 Engineering documents

Purpose

This test verifies that the correct manufacturing drawings and documentation for the equipment/system under test will be used during the Factory Acceptance Test.

Procedure

1. Verify that approved drawings (printed and soft copies) of all assembled equipment are present.
2. Verify that the detailed signal list for SCADA as per POWERGRID specimen signal list is available with IEC 61850 addresses and display text as per the list.
3. Verify that the detailed GOOSE matrix with publisher and subscriber details are available.
4. Verify all required hardware and software manuals are present.

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

5. Guaranteed Technical Particulars (GTPs) as approved by POWERGRID are included in Appendix A for reference.
6. Copy of Customer Technical Specification for reference is made available in the FAT room.

Drawing Verification Log:

Cubicle	Document Title	Approved Drawing/ Doc. No.	Checked
	Overall System Architecture		☐
	Standard General Technical Particulars for SAS		☐
	Functional Design Specification		☐
	Signal List for SCADA		
	Matrix for GOOSE messages (with publisher & subscriber details)		
	GA & Scheme of Networking Panel		☐
	Bill of Quantity		☐
	Server 1		☐
	Server 2		☐
	Gateway 1		☐
	Gateway 2		☐
	OPERATOR WORKSTATION 1		☐
	OPERATOR WORKSTATION 2		☐
	ENGINEERING/DR PC		☐
	ICT Feeder		☐
	Line Feeder		☐
	Line Reactor Feeder		☐
	Bus Reactor Feeder		☐
	Tie Bay of all type		☐
	Bus Coupler		☐
	Bus Sectionalizer		☐
	Bus-bar		☐
	GPS		☐
	UPS		☐
	Other applicable drgs (not listed above)	Attach the list as annexure	☐

Hardcopy & Softcopy Manuals Verification Log:

Cubicle	Document Title	Doc. No.	Checked
	Signal List for SCADA		☐
	Matrix for GOOSE messages (with publisher & subscriber details)		☐
	Operation and Technical Guide of BCU, GATEWAY, SERVER/CLIENT SOFTWARE		☐
	Relay Configuration Software for Main-1		☐

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

	Relay Configuration Software for Main-2		☐
	NMS Software		☐
	Ethernet Switch		☐
	Time Synchronizing Equipment		☐
	Router cum Firewall		☐
	UPS		☐

1.3 Station level equipment:

Soft- and hardware components are checked to ensure required functionalities. Versions are recorded for later support purposes.

1.3.1 **Hardware Component**

The following hardware equipments are to be present during FAT:

- All Bay Control Units as per approved BOQ.
- All Protection Relays as per approved BOQ.
- HMI/Redundant HMI system consisting of redundant servers.
- Time Synchronizing Equipment consisting of GPS Receiver Unit, Antenna, Time Display Unit.
- Substation Controller/Gateway Subsystem
- Color Printer
- LAN switch equipment
- Auxiliary Panel
- UPS

The above equipment are to be as per approved standard GTP

Purpose

To verify that all hardware equipment required in the contract are available in the FAT room for testing.

Procedure

1. Visually inspect units and individual modules for cleanliness and ensure that they are free from damage.
2. Visually inspect the units for correct wiring practices and ensure that they are free from insulation damage.
3. Ensure the equipment is configured for proper point capacity as per approved drawings.
4. Ensure all modules, terminations and cables have the proper location labels as per approved drawings.
5. Ensure that all earth ground and shield connections are correctly bonded in the panels.
6. Ensure all equipment is free from all foreign material (Dust, Solder, droppings etc.)

Hardware Visual Inspections Log:

S.NO.	Equipment	Hardware Specification (CPU/RAM/HDD)	Serial No.	Checked
1	Server Workstation-1			☐
2	Server Workstation-2			☐
3	Operator Workstation-1			☐
4	Operator Workstation-2			☐
5	Gateway #1			☐

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

6	Gateway #2			☐
7	Disturbance Recorder PC			☐
8	Color Laser JET Printer	NA		☐
9	Dot Matrix printer	NA		☐
10	GPS Receiver Unit	NA		☐

<u>Panel Visual Inspections Log:</u>

S.NO.	Equipment	Serial No.	Circuit Name	Quality of Wiring	Checked
1.	Networking Panel		Networking Panel		☐
2.	Aux. Panel		Aux. Panel		☐
3.	Inverter				☐
4.	Modem				☐
5.	----				☐
6.	----				☐

1.3.2 Software Components:

The Software to be used will include the following applications:

- The BCU/IED with IEC 61850 (Server/Client) capability.
- HMI & Server with latest Version with IEC 61850 (Client) capability.
- Gateway with latest Version with IEC 60870-5-101 & 104 capability.

Configuration files shall be downloaded prior to commencement of tests and shall be the actual configuration files for individual S/S.

1.3.2.1 Firmware Verification

Purpose

To verify and record that the Equipment Firmware used in the FAT.

Procedure

Using Device Display verify all BCU/IED equipment firmware version.

<u>Firmware Verification Log.</u>

S.NO.	Equipment	Model	Operating System/Firmware	Checked
1	HMI-1			☐
2	HMI-2			☐
3	DR PC			☐
4	Color Laser JET Printer			☐
5	Dot Matrix Printer			☐
6	Gateway-1&2			☐
7	Ethernet Switches			☐

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

8	Voltage Level_BCU_BAY No.			☐
9	Voltage Level IED's (IEC61850 Compliant) for Dia			☐
				☐

SCADA Devices - IP Addresses

Will be checked at each device user interface.

System Devices

Designation	N/W Name	GOOSE ID	IP Address				Checked
SERVER 1			172	16	55	1	☐
SERVER 2							☐
OWS1							☐
OWS2							☐
EWS/DR PC							☐
SDC1							☐
SDC2							☐
GATEWAY1							☐
GATEWAY2							☐
GPS Time Server 1							☐
GPS Time Server 2							☐
Ethernet Switch 1							☐
Ethernet Switch 2							☐
Event Printer							☐
Color Laserjet Printer							☐
Router cum Firewall 1							☐
Router cum Firewall 2							☐
19 Port Managed LAN Switch							☐

RELAY'S NAME	N/W NAME	GOOSE ID	IP Address	Checked

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

P444 _____ LINE	#01_21M1		172	16	55	101	☐
							☐
							☐
							☐

1.3 Test Equipment

The following equipment are required to conduct the test.

- EWS/DR PC to be used for Configuration Applications for different IEDs.
- Hand-held Digital Multi-meter suitable for AC/DC with peak-hold and continuity tester.
- Digital Clamp-on Meter suitable range for secondary current measurement.
- Three phase injection KIT (Relay Test Kit) for supplying 3 phase current and voltage.
- 4-20 mA Injection Kit.
- Protocol Analyser as applicable.

1.4.1 Test Equipment Inspection

Purpose

To ensure that the Test Equipment to be used is operational and have valid calibration.

Procedure

Visual inspection of calibration stickers and certificates. Power up and verification that units are operational.

Test Equipment Inspection Log:

S.NO.	Equipment	Calibration Check	Device Power On	Checked
1	3 Phase Injection Kit			☐
2	Precision Hand-held Digital Multi Meters			☐
3	Digital Clamp-on meter			☐
3	Insulation Resistance Tester			☐
4	220V DC Source for powering up all SAS Panels			☐
5	4-20 ma Injection Kit			☐

1.5 Power Checks

Purpose

To ensure that the SAS equipments installed in the panels & control rooms are operating when connected to the nominal specified power supply (220 V AC/DC).

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

Setup/Program

Perform the steps below to confirm correct operation of all equipment connected to the power supplies.

Procedure

1. Verify that all 220V AC/DC equipments are powered at the nominal AC/DC supply voltage input. Using a Digital Multimeter verify that the nominal AC/DC supply voltage is present.
2. Verify that there are no abnormalities seen when the equipment are turned ON.

Power Checks Log:

S.NO.	Panel	Equipment	Device Power ON	Checked
1	NA	Server-1		☐
2	NA	Server-2		☐
3	NA	HMI-1		☐
4	NA	HMI-2		☐
5	NA	DR PC		☐
6		Gateway-1		☐
7		Gateway-2		☐
8	NA	Laser JET Printer		☐
9	NA	Dot Matrix Printer		☐
10	Networking Panel	Auxiliaries (Lighting etc), LAN Switches, Gateway		☐
11	Relay Panel	Relays and Wiring diagram		☐

2. Functional testing

General Substation Automation System (SAS) is a combination of different bay control units and protection devices with a central operator placed as Human-Machine-Interface (HMI) and central data storage and acquisition. These components and its connections are shown in the System Architecture. For SAS-FAT a configuration is selected to check the basic system functions and the co-operation between the different components. The test procedure will show the proper function of the system in general. All of decentralized I/O devices (bay control units and protection devices) is provided for this test. A complete test of all I/O signals (see SAS signal list) is objective of this test. All modules are tested by type tests in general and by test routines during manufacturing.

2.1 Start-up and SAS system availability

For following equipment the start – up times are measured to check the performance. The timing of the station controllers starts with switching on the power supply and finishes after reaching the working condition “RUN”. The timing of the Operator Workstation starts with switching on the power supply. The computer will then start - up automatically without registering to Windows or manual start of any software. The timing finishes after reaching the start picture of the application software where

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

the user has to register with his password. The timing of the Engineering PC and Protection Interface PC starts with switching on the power supply and finishes after successful achievement of the working condition.

System Start-up	checked	Time	Comments see log sheet no.
Server-1	☐		
Server-2	☐		
Operator Workstation 1	☐		
Operator Workstation 2	☐		
Engineering/DR PC	☐		
Gateway 1	☐		Data Transmission to RCC/RLDC should resume automatically
Gateway 2	☐		Data Transmission to RCC/RLDC should resume automatically
Complete system start up	☐		Black Start

After start-up of all devices the error free operation, communication and time synchronization of components is checked on the SCADA displays.

S.NO.	**System Start-up**	Checked
1.	Time synchronization of Substation controllers / PCs	☐
2.	Time synchronization of connected IEDs	☐
3.	Communication to Bay Control Unit	☐
4.	Communication to Protection Devices	☐
5.	Event list printer	☐
6.	Hardcopy color/ Logbook printer	☐
7.	Communication with remote control centres	☐

2.2 Monitoring and control

2.2.1 BCU – displays and handling

General layout, handling and control of typical feeder BCUs is demonstrated and checked under this chapter. The displayed SLD is cross checked against the approved SLD/ Mimic SLD.

BCUs for _____kV Level	checked	Comments see log sheet no.

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

Basic/control display for OHL FEEDER	☐	
Basic/control display for TRANSFORMER FEEDER	☐	
Basic/control display for LINE REACTOR FEEDER	☐	
Basic/control display for BUS REACTOR FEEDER	☐	
Basic/control display for TIE BAY/TBC	☐	
Basic/control display for AUXILIARY System		
Basic/control display for BUS COUPLER	☐	
Basic/control display for BUS SECTION	☐	
Event list	☐	
Alarm list	☐	
Analogue measurement list	☐	
Metering list	☐	
Alarm limits	☐	
Handling of displays, control and menu	☐	
Changing V,I,f – limits: - current >limit 1 - current >limit 2 - voltage >limit 1 - voltage <limit 1 - frequency >limit 1 - frequency <limit 1	☐	
BCUs for _____kV Level	☐	

2.2.2 HMI – modes of operation and user management

A multi-level login is implemented in SCADA. There are 4 different levels of access. Without login, there is no possibility to open any display. The different access levels are implemented as shown in following table:

Purpose

To verify that the OWS/HMI system has Security Classes, that are enabled and configured properly.

Setup

1. Ensure that the HMI Servers are running.

Procedure

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

1. Start Client, by default the user will be logged in as blank.
2. Verify that this user class has proper access level as per HMI Security Classification.
3. Go to any bay detail screen. Verify if access to tool bar and object controls are according to that allowed in the access level logged in.
4. Repeat steps 1 to 3 for the other HMI Usernames (Operator, Protection, Administrator)
5. Repeat steps 1 to 4 for the other Workstations
6. Function is tested by clicking on the corresponding buttons or switching devices and checking of SCADA "No permission" – notifications.

HMI Access Level:

Access Level	Monitor	Operator	Engineer	Administrator	Checked	Comments see log sheet no.
Display System Status & View Screens	Yes	Yes	Yes	Yes	☐	
Controls – CB, Isolators	No	Yes	Yes	Yes	☐	
Acknowledge/Clear Alarms	No	Yes	Yes	Yes	☐	
Change HMI Config.	No	No	No	Yes	☐	
Create/Disable/Delete User Account	No	No	No	Yes	☐	
Change User Profile/Access Level	No	No	No	Yes	☐	
Maintenance mode	No	No	Yes	Yes	☐	
Reset lockout relay	No	Yes	Yes	Yes	☐	
Interlocking bypass	No	No	Yes	Yes	☐	
Sync. Check Bypass	No	No	Yes	Yes	☐	
Auto-reclosure	No	No	Yes	Yes	☐	
Auto sequence	No	No	No	Yes	☐	
Shut down the system	No	No	Yes	Yes	☐	

2.2.3 HMI – Displays and Handling

Check that the displays are in accordance with POWERGRID requirements. General layout and handling is demonstrated and checked. Overview and control pictures are cross-checked against the approved substation SLD.

Purpose

To verify that the Single Line Diagram and Bay Detail Screens on the OWS system are configured properly and are in correct operating condition.

Setup

1. Ensure that the HMI Servers are running.
2. Log in as an "Operator".

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

Procedure

1. Verify the layout of each SLD on the OWS.
2. Verify the device number, device description and device symbol for each device.
3. Verify all displayed analog and digital values on the detailed bay view screens.
4. Click on each device object and confirm that the respective popup screen or bay/view detail screen is displayed.
5. Repeat steps 1 to 4 for each SLD / Detailed Bay View.

	Checked	**Comments see log sheet no.**
Handling of screen/picture selection	☐	
Display for Station overall SLD	☐	
Display for ______kV overview:	☐	
- ______kV substation overview	☐	
- ______kV single line diagram view	☐	
Display for _____kV overview:	☐	
- ______kV substation overview	☐	
- ______kV single line diagram view	☐	
Display of Measurement Trends (Real-time and Historical)	☐	
Display of maintenance mode	☐	
Display of safety tagging	☐	
Display of Operations counter for PLCC & CB	☐	
Display of Network/LAN overview	☐	
Display of typical bay communication (Ring)	☐	
Display for Auxiliary System views	☐	
Display of event list	☐	
Display of alarm list	☐	
Handling of screen/picture selection	☐	
Basic/ Control display for Kiosk Air Conditioning System	☐	
Basic Control display for Online Monitoring System for Transformers & Reactors	☐	
Basic /Control display for Control Switching Device	☐	
Display of Counter for LA & PLCC	☐	
CVT/CT Monitoring	☐	
Visual Monitoring System	☐	
Transformer Bank with Tap changer Operation	☐	

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

(In case of extension packages, the existing make SCADA system of the substation where extension is proposed shall be used to carry out the validation of extension bays signals, control commands, etc., with the extension bays configured as the only bays that exist in the substation. For this purpose, the existing SCADA system can be installed in a laptop. Further after completion of FAT, the verified SCADA configuration shall be used for addition into the existing SCADA at site.)

2.2.4 Inspections of HMI typical bay screens

Validation of electrical views

Purpose

To verify that the Single Line Diagram and Bay Detail Screens on the OWS system are configured properly and are in correct operating condition.

Setup

1. Ensure that the HMI Servers are running.
2. Log in as an "Operator".

Procedure

1. Verify the layout of each SLD on the OWS.
2. Verify the device number and device description for each device.
3. Verify all displayed analog and digital values on the detailed bay view screens.
4. Click on each device object and confirm that the respective popup screen or bay/view detail screen is displayed.
5. Repeat steps 1 to 4 for each SLD / Detailed Bay View.

Bay screens ________kV Naming, SCADA numbers, status indications, measurement items to be checked	**Checked**	**Comments see log sheet no.**
_______kV LINE FEEDER	☐	
_______kV TRANSFORMER FEEDER	☐	
_______kV BUS REACTOR	☐	
_______kV LINE REACTOR	☐	

Bay screens ________kV Naming, SCADA numbers, status indications, Measurement to be checked		
_______kV LINE FEEDER	☐	
_______kV TRANSFORMER FEEDER	☐	
_______kV SHUNT REACTOR	☐	
_______kV BUS REACTOR	☐	

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

________kV LINE REACTOR	☐	
------	☐	

Validation & Verification of Signals on SCADA HMI

Purpose

To verify that the signals as per the specimen signal list provided by POWERGRID has been correctly configured and are appearing on SCADA HMI as desired.

Setup

The Detailed signal list based on which the SCADA configuration has been prepared shall be taken and each signal shall first be validated (e.g appearance of “Valid”, Reset/ Set/operated/Healthy, etc status as per the appearance of on screen validity shall be checked). Any signal appearing as “unknown” / “invalid” shall be flagged and configuration shall be modified for proper validation.

After validation of signals under SCADA configuration, various protection functions and appearance of the desired signals on SCADA HMI shall be verified.

For certain signals (having Integer type attribute), the on-screen display of text displayed depends on the value fetched from IED, (e.g. Auto-reclose status from function RREC wherein the value of AutoRecSt 1 denotes ready, 2 denotes Auto-reclosure in-progress, etc). All types of text displays with different inputs shall be verified by simulation of the state.

For all the IEDs subscribing to GOOSE messages from other IEDs (e.g. BCUs), which are used to perform logical actions, the appearance of GOOSE fail / GOOSE trouble alarm shall be configured and verified by making one of the GOOSE message absent, to which the IED subscribes.

The Voltage selection logics for ICTs & Rector feeders, utilizing GOOSE messages shall also be verified by simulating various switchgear status, which change the selected voltage.

Validation of Historical Trend

Purpose

To verify that the Trending in the OWS system are configured properly and are in correct operating condition.

Setup

Ensure that the HMI servers are running.

Go to Trend Screen.

Validation of Historical Trend on OWS

S.No.	Activity	Checked
1	Verify the all Analog signals on trend screen.	☐
3	Verify that the trend curve on HMI screen for different analog signal has different colors.	☐

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

4	Verify that the Time Scale for trend curves are user settable.	☐
5	Verify that EHV Lines have Predefined trend of active and reactive power, ICT have Predefined trend of current, active and reactive power. Bus have Predefined trend of voltage and frequency.	☐
6	Data archive retrieval is to be checked for proper display of old records	☐

Validation of Reports Function

Purpose

To verify that the Reports Functions (Historical Report) in the OWS/HMI system are configured properly and are in correct operating condition.

Setup

1. Ensure that the Client & Server is running.

Procedure

Historical Event Report

1. Generate some Digital / Analog events in the BCU.
2. Click on the Reports button present on the HMI Screen.
3. Select the Range of date by selecting the Start Date and End Date.
4. Verify whether the same generated events have been produced in the Historical Report.

Daily Report (Hourly Instantaneous Value of Analog Data Points)

1. Inject Voltage & Current through 3 Phase Injection Kit to any BCU.
2. Verify the values on the detailed view of the selected BCU.
3. Select the daily Report Button of line BCU.
4. Verify the daily Report have produced Hourly instantaneous Value of the selected BCU. The Maximum and minimum instantaneous value of each selected parameter (with time) shall also be included in the report. This time-tagged max and min data shall be generated from the Trend data of the BCU.
5. Data archive retrieval is to be checked for proper display of old records

Operation Reports:

Apart from Historical and trend reports of analog values, reports in specified formats as per the requirement of POWERGRID system operation is also to be generated in the standard format provided by POWERGRID. The reports will be periodic logging (01 hourly/ 04 hourly/ 08 hourly etc) of analog/ digital values and mainly cover the EHV feeder , Transformer & Reactors temperatures, AC & DC Auxiliary supply system, Battery chargers, CB operation counter readings, PLCC counter readings etc.

2.2.5 SCADA connection

In this chapter the communication to SCADA via IEC101/IEC104/IEC 61850 will be checked. Detailed information test (control authority, command and indication) will be done in the chapter followed to this. SCADA-interface is simulated with test program IEC-Test running on two laptops. With the test program the protocols IEC-101/IEC-104 as well as IEC-61850 can be simulated. Detailed redundancy tests will be performed under chapter 2.2.20.4/3.2.20.5.

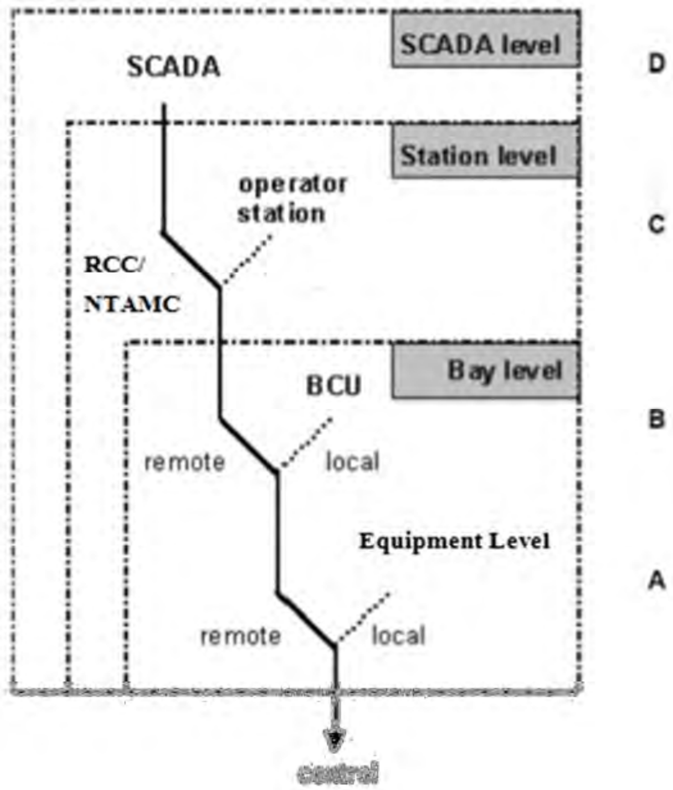
	Checked	**Comments see log sheet no.**
Communication check for	☐	

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

- spontaneous information - general interrogation	☐	
- time stamping of indications	☐	

2.2.6 Control tests

Control is possible from Relay Panel/MIMIC Board, BCU, Operator Workstation (1 or 2) and NTAMC/Backup NTAMC/RTAMC. During the test all check back indications from switchgear devices will be simulated by an I/O simulation box. Preconditions for controls are correct switching conditions (synch-check and interlocking). Switching the relevant local/remote switch will be displayed in event list.



	Checked	Comments see log sheet no.
A. Control from mimic board The mimic board is implemented in the cubicle	☐	
B. Control from BCU Changing status of local/remote switch on BCU raises an event on event list. Control from BCU is only possible if local/remote switch on BCU is in local position and local/remote switch on mimic board is in remote position. In this position no control from Operator Workstation and SCADA is possible.	☐	
C. Control from Operator Workstation Changing status of local (SCADA) / remote (SCC/ECC) button on Software screen raises an event on event list. Control from Operator	☐	

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

Workstation is only possible if control is switched to local position and local/remote switch on BCU and mimic board is in remote position. In this position no control from SCADA is possible.		
D. Control from SCADA Control from SCADA is only possible if all local/remote switches per bay (on bay- and station level) are in remote position. SCADA interface is simulated with test program IEC Test.	☐	

2.2.7 Control method

Control of switchgear shall be done from the detailed bay display diagrams in OWS. The method of man machine dialogue shall be a multi-stage procedure with verification to ensure security of control.

	Checked	Comments see log sheet no.
- Selection of switching device	☐	
- Appearance of selected device control window	☐	
- Selection of switching direction (open/close)	☐	
Change of the selected device symbol(flashing in selected control direction)	☐	
- Execution of the control	☐	
- Possibility of cancellation at any time	☐	
- Time out of control mode if operator fails to respond	☐	
- Source of control appearance in event list	☐	
- Double object control blocking function for control from HMI/ SCADA level	☐	

2.2.8 Control of dummy circuit breaker

	Checked	Comments see log sheet no.
- Check of dummy circuit breaker function	☐	

2.2.9 Control of circuit breaker

"CLOSE" and "OPEN" operation of 765/400kV typical circuit breaker is tested by giving a command from BCU or HMI and checking of the command execution. At the same time, the respective check back indication of switching position is checked at the BCU and HMI. The correct registration in the event list will also be tested. All the bays for each voltage level will be checked. Furthermore some faults will be simulated (e. g. control authority, CMD interlocked, CMD monitoring time). SCADA-interface is simulated with test program IEC-Test.

	Command	Checked typical				Comments see log sheet no.
		701-52	**702-52**	**703-52**	**704-52**	
765kV	Circuit breaker Control/Display BCU Control/Display HMI Control/Display SCADA	☐ ☐	☐ ☐	☐ ☐	☐ ☐	

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

	HMI/SCADA Display event list	☐ ☐	☐ ☐	☐ ☐	☐ ☐	
400kV	Circuit breaker Control/Display BCU Control/Display HMI Control/Display SCADA HMI/SCADA Display event list	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	

2.2.10 Synch-check

Synchro check-function is parameterized in the BCU. Therefore control is demonstrated from bay control unit for functionality-check. Positions of bus bar voltage transformer disconnecting switch are simulated by an I/O simulation box and bus bar voltage by a test set (e.g., Relay Test Kit).

Purpose

To verify that Incoming and Running (Reference) voltages are within the synchronizing range before the circuit breaker can close. The circuit breaker will not close if any of the limiting parameters is not within the check synchronizing range. For practical reasons this FAT will not include the testing of Running Voltage selection for the Synchronization.

Setup

1. Set up the BCU to check synchronizing ranges as follows:
   - Phase Differences Specification requirement states Phase Difference shall not exceed 30° (1º Hysterisis).
   - Voltage Difference Specification requirement states Voltage Difference shall not exceed 10% (2% Hysterisis).
   - Frequency difference 0.1 Hz (Connected System).
2. Set up the 3 Phase Injection Kit to supply the Running Voltage & Selected Voltage to BCU TMU card (CT/VT card).
3. Set up the 3 Phase Injection Kit to the following test cases:

Check Synchronization Test Settings

Test Case	Voltage Difference in pu	Phase Y Difference in Degrees	Expected Sync Close Results	Checked
1	0.20	40.0	No	☐
2	0.12	40.0	No	☐
3	0.10	20.0	No	☐
4	0.09	20.0	No	☐
5	0.09	17.0	No	☐
6	0.10	16.0	No	☐
7	0.10	15.0	Yes	☐

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

8	0.05	10.0	Yes	☐

Procedure

1. Select a BCU and corresponding Circuit Breaker to Test.
2. Using the 3 Phase Injection kit, inject the Running & Selected Voltage to the BCU and apply the differences as shown in the above table.
3. Open the Detailed view of the selected Bay on the HMI and verify the voltage references.
4. Initiate the CB Close Request.
5. Verify that the Circuit Breaker closes only when the configured settings are satisfied.

CB	CB Condition	Checked
765KV Circuit Breakers		
		☐
		☐
		☐
400KV Circuit Breakers		
		☐
		☐
		☐

The above check sync verification is to be carried out for all possible voltage selection logics for synchronization (e.g, for main bay breaker connected to Bus 1 in one and half scheme, Bus 1 Voltage-Bus 2 Voltage, Bus 1 Voltage - Feeder 1 Voltage, Bus 1 Voltage – Feeder 2 voltage, as may be required in the scheme). These possible voltage selection conditions are required to be simulated either by simulated switchgear or by simulating GOOSE messages published by other BCUs, which are required in the selection logic.

Dead Source Condition

Purpose

To verify that when the following conditions are met, the Synchrocheck logic permits the Immediate closure of the Circuit Breaker.

- Dead Line-Dead Bus
- Dead Line-Live Bus
- Live Line-Dead Bus

Setup

1. Set up the BCU to check synchronizing settings as follows:

- Presence of Line Voltage (Param1) – 70%
- Absence of Line Voltage (Param2)– 20%
- Presence of Bus Voltage (Param3)– 70%
- Absence of Bus Voltage (Param4)– 20%

Procedure

The absolute values of the two voltages (Vline and Vbusbar) must be above or below settable thresholds, to permit the circuit breaker closing. The following voltage controls are available:

• not (Vline) and not(Vbusbar) – (Dead Line-Dead Bus)

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

- not (Vline) and Vbusbar – (Dead Line-Live Bus)
- Vline and not (Vbusbar) – (Live Line-Dead Bus)
- Vline and Vbusbar – (Live Line-Live Bus)

With Vline and Vbusbar TRUE if the measured voltage is above the threshold V> (param 1 and param 3), and not(Vline) and not(Vbusbar) TRUE if the measured voltage is below the threshold V< (param 2 and param 4). These threshold are given in % of the nominal voltage value, updated at TMU220 board level

The selection of the voltage control is made during the configuration phase.

Test Case	Description	Expected Sync Close Results	Checked
DL-DB	In case of the absence of both voltages i.e. **not(Vline) or not(Vbusbar)**	Yes	☐
DL-LB	In case of the absence of one of the two voltages i.e. **not(Vline) and Vbusbar**	Yes	☐
LL-DB	In case of the absence of one of the two voltages i.e. **Vline and not(Vbusbar)**	Yes	☐
LL-LB	In Case of the presence of both voltages i.e. **Vline and Vbusbar**, Set beyond ranges	No	☐
LL-LB	In Case of the presence of both voltages **Vline and Vbusbar**, Set good ranges	Yes	☐

	Checked	Comments see log sheet no.
Displaying and handling - BCU - HMI	☐ ☐	

	Checked	Comments see log sheet no.
Live line – dead bus	☐	
Dead line – live bus	☐	
Dead line – dead bus	☐	
Live line – live bus with fulfilled sync	☐	
conditions (Vdiff, fdiff, angle)	☐	

2.2.11 Control of isolator and earthing switch

“CLOSE” and “OPEN” operation of high voltage switching devices are tested by giving a command from BCU or HMI and checking of the command execution. At the same time, the respective check back indication of switching position is checked at the BCU and HMI. The correct registration in the event

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

list will also be tested. One bay for each voltage level will be checked (400kV-station: "C03" and for 132kV-station: "E05"). Furthermore some faults will be simulated (e.g. control authority, CMD interlocked, CMD monitoring time).

SCADA-interface is simulated with test program IEC-Test.

2.2.12 Interlocking (bay and station based)

Control of switchgear devices is only possible if all interlocking conditions are fulfilled. Interlocking conditions are shown in circuit manuals of local control cubicles (For drawing nos. see chapter 1.2). Generally for demonstration of interlocking the control can be done from bay control unit. As the complete feeder interlocking is checked during SAT of BCU together with primary switchgear, only some selected general functions are shown. Positions of relevant breakers/isolators are simulated by a hardwired I/O simulation box. The interlocking logic and status for each switchgear should be visible to the operator on operator HMI beforehand while going to operate the respective switchgear. The validation of interlock condition shall be performed based on the interlock logic visible on the screen.

	Checked	Comments see log sheet no.
Maintenance mode	☐	
Switchgear interlocking	☐	
HMI – display of interlocking conditions along with signals for each switchgear device	☐	

2.2.13 Switching sequences for GIS

Switching sequences are initiated and controlled from Station Controller. The preconditions for switching sequences are parameterized in BCU. The interruption of the switching sequence can occur due to missing of one of the preconditions, either synch-check or interlocking. Correct switching and the corresponding feedback indications will be checked. Randomly, some interlocking conditions will be done in such a way that the switching sequence will be interrupted. The effect will be that the system will wait for the command running time to terminate. In the event list a negative feedback will be recorded indicating the reason for not executing the command.

CONNECT OHL FEEDER TO BB1:		
closing of Isolators & CB		
CONNECT OHL FEEDER TO BB2:		
closing of Isolators &CB		
DISCONNECT OHL FEEDER (Bay):		
opening of		
CHANGE BUSBAR:		
closing/opening of Isolators		
CLOSE BUS COUPLER :		
closing of Isolators & CB		
OPEN BUS COUPLER :		

2.2.14 Digital RTCC Functions (if applicable))

The Digital RTCC Functions view shows information about the transformer feeder (ICT1-ICTn) of the station. Information about: the tap position. Using the control button a tap position control window will appear. It can be chosen between the automatic and manual mode. The tap position of each

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Signature :	Signature :
Name :	Name :
Date :	Date :

transformer feeder can be changed with the top/down slider by using the manual mode. The exit button closes the window.

Properties of Digital RTCC	Checked	Comments see log sheet no.
- Selection of transformer feeder	☐	
- Appearance of selected window	☐	
- Selection of control mode (auto/manual)	☐	
- Send TAP rise/ lower command in manual	☐	
-Checking of Master-Follower/ independent mode	☐	
-Checking of Other RTCC Functions	☐	

2.2.15 Event processing

Events are displayed in chronological order in event list. All events have date and time tag. Selection of event list on Operator Workstation will show the latest page with the newest event on top. Event list shows all events including the alarms. Events are coloured in white. The creation of a reduced list is possible by filter function. Transient conditions (i.e.00/11) will not generate an event, unless a time delay is exceeded.

Purpose

To verify that the Events Points are configured properly and in correct operating condition.

Setup

1. Ensure that the HMI Servers are running.
2. Display the Event Screen.

Procedure

1. Select a Digital Input Point from one of the BCUs configured as an Event.
2. Change the state of the Selected Input
3. Verify that an Event is displayed in the Event Screen with proper description and Time Stamp.
4. Acknowledge this alarm.
5. Go to Event Screen and verify that this alarm is displayed in the list.
6. Verify that the same has been printed on the Dot Matrix Printer.
7. Repeat Steps 1 to 6 for the several Digital Input

Validation of the Events and Alarm Management on OWS

S.No.	Activity	Checked
1	Verify that separate logs are available for alarm and events	☐
2	Verify that suitable filters (sorting by date, time etc) are provided for both alarms and events	☐
3	Verify that an Alarm and Event is displayed in the Alarm and Event Screen with proper description and Time Stamp	☐
4	Verify the alarm acknowledgement facility and verify that their display changes in alarm viewer according to the alarm status	☐

	Checked	Comments see log sheet no.
Event processing - BCU - HMI	☐ ☐	

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

Time tagging - BCU - HMI	☐ ☐	
Filter function - date/time - message group - message text - alarm group	☐ ☐ ☐ ☐	
Check naming convention of one typical feeder according signal list - hierarchical name - signal name	☐ ☐	

2.2.16 Alarm processing

Alarms are displayed in chronological order in alarm list. Selection of alarm list on Operator Workstation will show the latest page with the newest alarm on top of the line. Coloring depends on alarms status (raised, cleared and acknowledged). Acknowledgement of alarms dependents on permissions level (see 2.2.2 "HMI – modes of operation and use)

Purpose

To verify that the Alarms are configured properly and in correct operating condition.

Setup

1. Ensure that the HMI Servers are running.
2. Display the Alarm Screen.

Procedure

1. Select a Digital Input Point from one of the BCUs configured as an Alarm.
2. Change the state of the Selected Input
3. Verify that an Alarm is displayed in the Alarm Screen with proper description and Time Stamp.
4. Acknowledge this alarm.
5. Verify that the same has been printed on the log Printer.
6. Repeat Steps 1 to 6 for the several Digital Input

	Checked	**Comments see log sheet no.**
Alarm processing - BCU - HMI Time tagging - BCU - HMI - Time stamp quality field	☐ ☐ ☐ ☐	
Filter function - date/time - message group - message text - alarm group	☐ ☐ ☐ ☐	
Permission of acknowledgement	☐	
Alarm raised: YELLOW FLASHING	☐	

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

Alarm cleared: GREEN	☐	
Alarm acknowledged: YELLOW	☐	
Alarm list filtering function (Date & Time, Bay No.)	☐	

2.2.17 Analogue measurement handling

Correct displaying of analogue values is checked on the screens of BCU and HMI. A change of analogue quantity is reported to the SCADA master system. Correct displaying of power flow convention is defined and checked. Measurements will be tested from BCU (in feed by a relay test set) as well as from BCU :

	Checked	**Comments see log sheet no.**
Displaying of analogue values - BCU - HMI	☐ ☐	
Power flow convention	☐	
Real time trends	☐	

Measurement of each Bay: **For e.g.** **Checked**

CT Ratio:	3000A/1A *	☐
VT Ratio:	400KV/110V *	☐

Current Measurement:

Injected second. Current	Expected measured value	Dead band	Indicated Value					
			R		Y		B	
			BCU	HMI	BCU	HMI	BCU	HMI
0.0A								
0.05A								
0.5A								
1.0A								
1.1A								

Voltage Measurement:

Injected second. Voltage	Expected measured value	Dead band	Indicated Value					
			R		Y		B	
			BCU	HMI	BCU	HMI	BCU	HMI
6.35V								
31.75V								
63.5V								
70V								

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

110V								

Frequency Measurement:

Injected Frequency	Dead band	48Hz		50Hz		52Hz	
		BCU	HMI	BCU	HMI	BCU	HMI
Indicated Value							

Comments see log sheet no.

***CT & PT Ratio as per approved drawing**

Injected Value	**Phase Angle**												
		Active Power				**Reactive Power**				**Power Factor**			
	V with ref. to I	Calculated Value	BCU	HMI	Err. (%)	Expected Value	BCU	HMI	Err. (%)	Calculated Value	BCU	HMI	Err.(%)
I = U =	0°									1			
	60°									0.5			
	90°									0			
	120°									-0.5			
	-120°									0.5			
	-60°									-0.5			

Transformer Measurement Values

Injected	**Measured**			**Checked**
Simulator	**HMI**	**Error (%)**	**Remote Control Center**	
Oil Temperature................................ °C				
Winding Temperature HV.................. °C				
Winding Temperature IV .... °C				
Winding Temperature LV................... °C				
Oil Temperature................................ °C				
Winding Temperature HV.................. °C				
Winding Temperature IV .... °C				
Winding Temperature LV................... °C				
....°C				

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

....°C				

General Station Analogue Values

Injected	**HMI**	**Measured SUPERVISORY**		**Checked**	**Comments see log sheet no.**
Simulator	**Display**	**Error (%)**	**Transmitted**		
Outside Temp………. ...°C				☐	
Outside Humidity…….. ...%				☐	
SCADA Room Temp……. ...°C				☐	
Telecom Room Temp…. ...°C				☐	
Battery Room Temp….. ...°C					
SPR… Temp…… ...°C					
SPR… Temp…… ...°C					

Injected		**HMI**	**Measured SUPERVISORY**	**Checked**		**Comments see log sheet no.**
Simulator		**Display**	**Error (%)**	**Transmitted**		
Current 220V DC 1 O/P	....A				☐	
Voltage 220V DC 1 O/P	... V				☐	
Current 220V DC 2 O/P	....A				☐	
Voltage 220V DC 2 O/P	... V				☐	
Current 48V DC 1 O/P	....A					
Voltage 48V DC 1 O/P	... V					
Current 48V DC 2 O/P	....A					
Voltage 48V DC 2 O/P	... V					
Diesel Generator Voltage	... V					
Diesel Generator Current	..A					

2.2.18 Changing of alarm limits

For supervising the analogue values each measured value shall have high and low alarm limits available. It shall be possible to set each limit independently at the BCU stage. When an alarm limit is detected as

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

having been transgressed an alarm shall be generated and the value displayed on the VDU shall be identified as in alarm status by use of color or other means to the approval of engineer.

	Set point	Checked	Comments see log sheet no.
Voltage	- upper limit: 107% of nominal value	☐	
	- lower limit: 95% of nominal value	☐	
	- processing of alarm limits (color)	☐	
	- hysteresis	☐	
	- alarm dead band	☐	
Current	- first upper limit: **1000A for 400&765kV level**	☐	
	- second upper limit: 1500A for 400&765kV Level	☐	
	- processing of alarm limits (color)	☐	
	- hysteresis	☐	
Frequency	- upper limit: 105% of nominal value	☐	
	- lower limit: 95% of nominal value	☐	
	- processing of alarm limits (color)	☐	
	- hysteresis	☐	

2.2.19 Redundancy/Availability and diagnostic function

The SAS system is designed for a hot/hot configuration. In order to fulfil this functionality following test will be performed:

2.2.19.1 SAS – SERVER Redundancy

Purpose

In case of server failure the connected HMI operator workstations must switch to the healthy server.

Setup

Ensure setup as per approved SAS Architecture Drawing.

Procedure

1. With both Servers operational, verify that Clients are connected with their respective servers & can perform normal function i.e. open different screens, alarm & trend screen.
2. On OWS-1 (Server1), Close the Server1 Application.
3. Check that Alarm appear on the client.
4. Observe that Client1 are now connected with the Server2

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

5. Start the Server1 application on OWS1, Observe that Client1 are now connected with the OWS1 after some defined period of interval.
6. On OWS-2 (Server2), Close the Server2 Application.
7. Observe that Client2 are now connected with the Server1.
8. Check that Alarm appear on the client.
9. Start the Server2 application on OWS2, Observe that Client2 are now connected with the OWS2 after some defined period of interval.

Shutdown & Startup of Servers

Purpose

To verify that the HMI Redundancy is operational during the shutdown of the active server.

Setup

Ensure setup as per approved SAS Architecture Drawing.

Procedure

1. With both Servers operational, verify that Clients are connected with OWS-1.
2. Shutdown OWS-1. Observe that Client is now connected with the OWS-2 and receives communications from the remote devices.
3. Startup OWS-1 . Observe that there is no interruption to the Bay Level Devices. Restart the Client.
4. Observe that Client is now connected with the OWS-1 (Primary Server) and receives communications from the remote devices.
5. Shutdown OWS-2. Observe that Client is still connected with OWS-1.
6. Startup OWS-2. Observe that there is no interruption to the Bay Level Devices.

Voltage Level substation controller/Servers	**Checked**	**Switch over time**	**Comments see log sheet no.**
Server1 faulty: Disconnect Server1 from LAN and generate new inputs (events and alarms) on BCU. Initiate control of any switching device. • *Check switchover of connected HMIs to SC 2* • *Check updating of information event/alarm/analogue appearance on HMI 1 & 2* • *Check execution of command* • *Check event/alarm appearance on dot printer* • *Check fault indication of SC 1*	☐ ☐ ☐ ☐ ☐		
Server2 faulty: (Server1 healthy again) Disconnect Server2 from LAN and generate new inputs (events and alarms) on BCU. Initiate control of any switching device. • *Check switchover of connected HMIs to Server 1* • *Check updating of information event/alarm/analogue appearance on HMI 1 & 2*	☐ ☐ ☐ ☐ ☐		

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

• *Check execution of command* • *Check appearance on dot printer* • *Check fault indication of Server 2*			

2.2.19.2 SAS– HMI Operator workstation redundancy

Each HMI operator workstation is independent of the other operator workstation and in case of failure the second workstation remains operational

	Comments see log sheet no.	**Comments see log sheet no.**
HMI 1 faulty Disconnect HMI1 from LAN and generate new inputs (events and alarms) on BCU. Initiate control of any switching device. • *Check updating of information on HMI 2* • *Check execution of command* • *Check appearance on dot printer* • *Check fault indication of HMI 1*	☐ ☐ ☐ ☐ ☐	
HMI 2 faulty (HMI 1 healthy again) Disconnect HMI2 from LAN and generate new inputs (events and alarms) on BCU. Initiate control of any switching device. • *Check updating of information on HMI 2* • *Check execution of command* • *Check appearance on dot printer* • *Check fault indication of HMI 1*	☐ ☐ ☐ ☐ ☐	
HMI 1 and HMI 2 healthy again *Check database synchronizing*	☐	

2.2.19.3 SAS – Network redundancy

Reliability and security of the redundant LAN configuration will be checked.

Purpose

To verify that

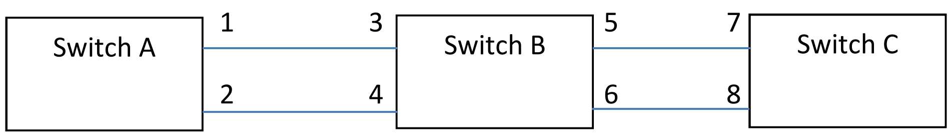
- Ethernet connections in the Substation Automation System are functional and running.
- LAN Switch Redundancy is functional.

To establish that in the event of a loss in communications, the SAS device are OFFLINE. When communications link is restored, the SAS device are automatically back to ON-LINE.

Typical Procedure:

ETHERNET LAN REDUNDANCY CHECK

1. Choose a Switch in the LAN. Let it be Switch B in below fig having switches A & B adjacent to it. There are two ports, 3 & 4 of switch B connected to two ports, 1 & 2 of switch A. Similarly there are 2 other ports in switch B, 5 & 6 connected to ports 7 & 8 of switch C (as shown in figure).



Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

2. On switch B Disconnect port 3 LAN cable. Verify that no device in the entire system fails to communicate.
3. On switch B Disconnect port 4 LAN cable. Verify that no device in the entire system fails to communicate.
4. On switch B Disconnect port 5 LAN cable. Verify that no device in the entire system fails to communicate.
5. On switch B Disconnect port 6 LAN cable. Verify that only those devices, which are connected to switch B, fail to communicate.
6. Restore the LAN cables in reverse order and check that communication of the devices above gets restored.
7. Repeat the above for all other switches in the Redundant RING LAN.

LAN Communication Functional Check test Results Log

S.NO.	Panel	Equipment	Communication check	Redundancy check
1	____KV BCU (Bay 01/02/03---)			
2	____KV BCU (Bay 01/02/03---)			
3	Networking Panel			

	Comments see log sheet no.	Comments see log sheet no.
Checking Station Ethernet ring Checking functionality in case of disconnecting and connecting the ring at several points. Initiate control of any switching device. • *Check redundancy* • *Check fault indication from adjacent units* • *Check appearance on HMI 1 & 2* • *Check execution of command* • *Check dynamic animation of SCADA pictures (Communication ports status etc.)*	☐ ☐ ☐ ☐ ☐	
Checking Bay Ethernet ring Checking functionality in case of disconnecting and connecting the ring at several points. Initiate control of any switching device. • *Check redundancy* • *Check fault indication from adjacent units*	☐ ☐ ☐	

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

• *Check appearance on HMI 1 & 2* • *Check execution of command* • *Check dynamic animation of SCADA pictures (communication ports status etc.)*	☐ ☐	
Checking the communication of switches Checking functionality in case of disconnecting and connecting the Ethernet switches and router at several points. Initiate control of any switching device. (1x optical, 1x electrical, 1x 1GB port) • *Check redundancy* • *Check fault indication from adjacent units* • *Check appearance on HMI 1 & 2* • *Check execution of command* • *Check dynamic animation of SCADA pictures (communication ports status etc.)*	☐ ☐ ☐ ☐ ☐	

2.2.19.4 Gateway redundancy (IEC 104 & IEC101 Ports)

The redundancy of the IEC 101 communication interface from the Gateways will be checked. As the real SCADA system is not available 2 Laptops with the IEC TEST – Software are used to simulate the RCC& RSCC.

2.2.19.5 Time synchronization redundancy

Redundancy of GPS time synchronization is tested. One clock will be disconnected from the network. It is checked that the various devices are still time synchronized (i.e. by changing the time manually for a device and check that it gets synchronized again).

Time synchronization redundancy	Checked	Comments see log sheet no.
Disconnect GPS time server 1 from the network Check availability of correct time synchronization Reconnect GPS time server 1 and disconnect time server 2 (any one of the IED/OWS internal clock) from the network Check availability of correct time synchronization	☐	

2.2.19.6 Safety tag facility

It is checked that safety tag facility is realized in SCADA. A triangle with exclamation mark is set on the respective switching device.

	Checked	Comments see log sheet no.
Processing of safety tag facility	☐	
Properties of safety tagging - 3 different types of safety tags - notebook facility (date, time, user, ...) - prevent of SCADA control	☐	
Display on the - overview picture	☐	

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

- individual bay display		
Check appearance on redundant server/operator	☐	

2.2.19.7 Maintenance mode

It is checked that individual feeders can be set into maintenance mode. No control is possible and no alarms/events can come up during the feeder is in maintenance mode, which is indicated by annunciation “MAINTENANCE MODE.”

	Checked	Comments see log sheet no.
Feeder is in “Maintenance Mode”	☐	
Check appearance on HMI Display	☐	
Check control blocking	☐	
Check suppression of data transmission	☐	

2.2.19.8 Import and export of archived process data

The backup/ archiving function will be checked under this chapter. Data, which was outsourced as backup files will be imported into the runtime and displayed in the event list in conjunction with the filter function. During import mode no changes of any other archive type or date is possible. The “Archive” button starts blinking when an import succeeded. Afterwards the imported messages can be saved into a readable format (as *.csv or *.txt). The export button function will remove the backup database from the eventlist and the “Archive” button stops blinking.

	Checked	Comments see log sheet no.
Import from archive	☐	
Export data to readable format to Excel (*.csv or *.txt)	☐	
Export to archive	☐	

2.2.20 Additional Tests

In this chapter the remote access to bay control unit and protection relays will be checked. In addition some protection tests will be simulated for checking information recording in SAS-system.

	Checked	Comments see log sheet no.
Remote access to IED devices via DR PC: - Password security - Access/Load function with ability to change relay settings - Download of fault records - Automatic download of DR (Built-in & Stand-alone) fault record with necessary S/w - Evaluation of Fault records with evaluation S/w - Connection to 3rd party relays	☐ ☐ ☐ ☐ ☐ ☐	
Remote access to BCUs and via DR PC: - Password security - Access/Load function with ability to	☐ ☐	

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

change relay settings	☐	
Information recording in SAS-system - Reset of trip lockout relay - Autoreclosing ON/OFF selection - Reporting of fault location	☐ ☐	
- Hardcopy print (to paper and file)	☐	

2.2.21 Remote Desktop

The remote desktop function is a feature of Windows. It is shown as an icon on the desktop of all PCs of this station. Press this button and a window will appear. Choose the desired PC by selecting its IP address; the remote desktop function opens the desktop of the desired PC. It is mainly used for configuring the station controllers and HMI servers from the Engineering PC.

Remote desktop	**Checked**	**Comments see log sheet no.**
Remote desktop functionality	☐	

2.2.22 Time synchronization

The time synchronization is checked under this chapter. The antenna of the GPS clock is disconnected. An alarm should be generated. Then the times of the devices is changed by hand for a few minutes only. Connect the antenna again. The devices have to synchronize again by themselves after some minutes and the alarm has to disappear. The time synchronization test shall be performed by making GPS as the master clock for synchronizing all IED's present on ring network.

Procedure

1. Disconnect the GPS Receiver Antenna. Set the GPS Receiver to send Local Time.
2. Confirm that the External Time Display Unit displays this local time.
3. Confirm that IEDs Operator Workstations and Substation Gateway Times match this local time. This confirms that the SNTP packets are broadcasted by the GPS receiver.
4. Confirm that GPS Receiver unsynchronized alarm is received in the workstations.
5. Power off the GPS receiver.
6. Verify that all IEDs are synchronized with any of the IED/OWS designated as redundant Time server.
7. Power on the GPS receiver.
8. Connect the GPS receiver Antenna. Verify that the GPS receiver is locked with satellite and GPS is updated to satellite time.
9. Confirm that the External Time Display Unit, The IEDs, Operator Workstations and the Substation Gateway are updated to the correct time of GPS.

Time synchronization	Checked	**Comments see log sheet no.**
OWS-1 & Server-1	☐	
OWS-2 & Server-2	☐	
DR PC	☐	
Auxiliary System	☐	
Time synchronization of connected IEDs	☐	

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

Bay Control Unit	☐	
Event list printer/ Hardcopy/ Logbook printer	☐	

2.3.1 Validation of OWS Memory and Disk Utilization

Purpose

To verify that the OWS have Memory and Disk Usage and allocation those are within the specification requirements.

Setup

Ensure that the Servers are running and functioning properly.

Validation of OWS Memory and Disk Utilization

Computer	Physical Memory	Hard Drive Free Space	PASS/FAIL
SERVER-1			
SERVER-2			
OWS-1			
OWS-2			
DR/EWS PC			
GATEWAY-1			
GATEWAY-2			

2.3 EWS TEST

2.4.1 Setting and Configuring of BCUs

Purpose

To verify that the BCU database is configured in necessary software and download is possible. Settings of BCU like Change of IP Address etc are possible.

Setup

1. Ensure that DR PC is running.

Procedure

1. Change some parameters in S/W for the BCU to test. Compile the Database for which parameters have been changed.
2. Run S/w on the DR and select the compiled Database. Connect the BCU for which the parameters have been changed.
3. Upload the database.
4. Verify that the download is successful and check the DB version on the BCU.

2.4.2 Network Monitoring System

Purpose

To verify that the Network Monitoring System (NMS) application software can perform the following functions on the LAN devices:

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

- Configuration Management
- Fault Management
- Performance Monitoring

Note that the Network Management System is based on Simple Network Monitoring Protocol (SNMP). Some background on this protocol is needed to understand how the application software works.

Procedure

1. Verify that NMS software used monitors LAN devices statistics and present these using displays.
2. Verify that it maintains connectivity and device status, issues alarms on errors conditions. This can be verified in the OI client screens.
3. Verify that it has tools for maintenance of addressed and links.

2.5 Auto Reclose Test

2.5.1 Test for Auto-Reclose Successful case:-

1. Select the Circuit Breakers of Main & Tie on which Auto reclose has to be tested.
2. Ensure that the Circuit Breakers are in closed condition and Auto-recloser is in ON state and all interlock conditions for closing the breaker are satisfied.
3. Simulate 1-Phase trip, ensure that the corresponding phase of the Main & tie breakers open.
4. Ensure that the Main Circuit Breaker Auto recloses first with predefined dead time (1sec) and Tie breaker auto recloses once the main breaker reclose cycle is completed. (2sec)
5. Ensure that once Auto-recloser is successful for main, the respective reclaim timer starts and Auto-reclose State goes back to Normal once the reclaim time is over and the same is applicable for Tie bay.
6. Put Auto-recloser of main CB in off position. Repeat steps 1 to 3. In this case ensure that Main CB does not go for Auto-reclose and tie CB Auto-reclosers without priority.(1 sec)
7. Check that Auto-reclose does not take place for CB which are already in open condition. Check this for both main & tie CB.
8. Check that A/R does not take place for CB having A/R lockout condition (SF6 gas pressure/Oil pressure/spring discharge). The healthy CB associated with the feeder shall A/R successfully.

2.5.2 Test for Auto-Reclose Failure case:-

1. Repeat steps 1to 5 of successful case, Once the reclaim time starts, simulate another 1-Phase trip.
2. Ensure that the Auto-reclose enters Locking State and a 3-Ph tripping is issued to the both Main and Tie Breaker and all the 3-phases of the breaker open.
3. Repeat steps 1to 3 of successful case, Once the Auto-recloser cycle starts, before the dead time is over and close command is issued to the Main and Tie Breaker, Simulate another 1-ph trip. In this case also Auto-recloser enters Locking State and a 3-Ph tripping is issued to the both Main and Tie Breaker and all the 3-phases of the breaker open.
4. Repeat steps 1to 3 of successful case, Once the Auto-recloser cycle starts, before the dead time is over and close command is issued to the breaker, simulate the AR blocking signal, Ensure that the Auto-reclose does not take place and Auto-recloser goes back to its Initial state.

2.6 Setting of Protection Relays

2.6.1 Setting of Main-1 Protection Relays

Purpose

To verify that the Setting of Main-1 Protection Relays can be changed via the Rear Port of Protection Relays.

Setup

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

1. Ensure that DR PC is running.
2. Relay Configuration software is properly installed on DR PC.

Procedure

4. Verify that Protection relay rear Port for which test to be performed are connected via rear port.
5. Run Relay Software on DR PC and open the Protection relay file. Verify that the connection is successful.
6. Extract the settings from the connected Protection Relay. After extracting, select the parameter needs to be modified. Upload the changes to the connected relay.
7. Verify that the parameter is changed again by opening the setting file of Protection Relay from DR PC.

2.6.2 Setting of Main-2 Protection Relays

Purpose

To verify that the Setting of Main-2 Protection Relay can be changed via the Ethernet Port of Protection Relays.

Setup

1. Ensure that DR PC is running.
2. Relay software is properly installed on DR PC.

Procedure

1. Connect the Ethernet cable between Ethernet switch and Protection relay for which test to be performed.
2. Run software and connect with the Protection relay. Verify that the connection is successful.
3. Extract the settings from the connected Protection Relay. After extracting, select the parameter needs to be modified. Upload the changes to the connected relay.
4. Verify that the parameter is changed by using the front display of Protection Relay.

2.7 **DR Configuration :** Check DR is configured as per TS as per following

i. Analog triggering level
ii. Signal name and order
iii. Pre-& Post fault time (Pre-fault time: min 500ms)
iv. Triggering Channel
v. Re-trigger option etc.

2.8 Disturbance File Retrieval

Purpose

To verify that the automatic disturbance file is uploaded to DR PC when the disturbance is created.

Setup

1. Ensure that DR PC is running.
2. System Software should be running on the DR PC.

Procedure

1. Create the Disturbance on Main-1 &2, Verify that the disturbance has been created in the relay.
2. Observe that the Disturbance File (.cfg/.dat etc.) is automatically created in the DR PC.
3. Open the Disturbance file with DR software.

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

Testing of Typical Relays & BCU (One number of each type and function) is to be verified in Factory Acceptance Test.

3.2 BCU Input/output Data Retrieval

The following are the procedures in the BCU I/O Data retrieval. The individual BCU Test result logs are to be filled up in the following sections.

Digital Input Retrieval

Purpose

To verify that the change of state of Digital Input points are updated in the BCU MMI, the Operator Workstations and Master Station Simulator.

To verify that the Digital Inputs are mapped correctly as per the approved drawing.

Setup/Program

1. Connect the test jig to the BCU under test.
2. Go to the BCU MMI Digital Inputs Display screen.
3. On the OWS-1 go to relevant HMI screen.
4. On the OWS-2 go to Alarm/Event list.
   Procedure

1. Select a Digital Input point on the BCU under test.
2. Change its state from 'OFF' to 'ON' (single points) or from 'OPEN' to 'CLOSED' (double points) by toggling the corresponding jig.
3. Verify that the state of this point in the BCU MMI and HMI is changed correctly.
4. Verify that the state of this point in the OWS-2 event list screen is changed correctly.
5. For points configured with alarm, verify that alarms are displayed in the Alarm Screen of the OWS-2 with correct time stamp.
6. For points considered in the IEC 60870-101 List, verify that the state of this point in the Master Station Simulator is changed correctly with correct time stamp.
7. Change its state from 'ON' to 'OFF' (single points) or from 'CLOSED' to 'OPEN' (double points) by toggling the corresponding jig.
8. Repeats step 3 to 6
9. Repeat 1 to 8 for all Digital Input points to be tested on this BCU.
10. Repeat steps 1 to 9 for all BCU's.

Digital Output

Purpose

To verify that digital output operations are successfully executed.

To verify that the Digital Output points are mapped correctly according to the approved drawings & Data List.

Setup/Program

1. Connect the test jig to the BCU under test.
2. Go to the BCU MMI Digital Outputs Display screen.
3. On the OWS-1 go to relevant HMI screen.
4. On the OWS-2 go to Alarm/Event list.

Procedure

1. Choose a BCU to test. From the HMI workstation initiate digital output requests.

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

2. Verify that the corresponding output activated.

Software Interlock Logic

Purpose

To verify that software interlock logic for CBs and Isolators are operational based on simulated conditions.

Note: Since not all interlock conditions can be tested during FAT, other interlock inputs shall be simulated by shorting auxiliary contacts at the terminal blocks of the panels.

Setup

1. Set up the test jig to simulate software interlock positive and negative test conditions.
2. Set up shorting links to simulate other auxiliary contacts.
3. Refer approved drawings.

Procedure

1. Select a BCU to test.
2. Refer to the interlock conditions for testing. First set up a negative condition. Attempt to operate controls related to the interlock logic being tested. Verify that the interlock is successful.
3. Set up for a positive test condition. Verify that interlock is successful when control operation is performed on related to the interlock logic being tested.

CB/ Isolators	**CB/Isolators Interlock Negative Test Result**	**CB/Isolators Interlock Positive Test Result**	**CB/Isolator Condition**	**Checked**

Interlock involving GOOSE signal shall also be checked. It shall be ensured that absence of required GOOSE signal does not enable any interlocking condition.

Spare switching arrangement for Single phase reactor and transformer banks shall be verified by simulation and software interlocks to be verified.

3.3 Substation Controller Device Reporting

Purpose

To verify that the Substation Controller (Server/Client) is successfully communicating with the bay level devices using IEC 61850 protocol.

Setup

1. Ensure that the Server/Clients are running.
2. Go to the System Architecture Screen on Client.

Procedure

1. On the System Architecture screen, verify that the bay device status is Normal.

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

2. Go to a remote device and disconnect the LAN cable, verify that the System Architecture screen shows the bay device is Failed.
3. Connect the LAN cable. Monitor the communication between Server and remote device and verify that the IEC 61850 packets between the two TCP/IP addresses are passing through.
4. Verify that the System Architecture Screen shows that the device is Normal.
5. Repeat the above procedures for other devices.

3.3.1 IEC 60870-5-101 Data Retrieval

Purpose

To perform preliminary verification that the IEC 60870-5-101 Communication Ports are functional.

Setup/Program

- Ensure that the test equipment is in FAT room.
- Use a Protocol Analyzer Test set to simulate an IEC 60870-5-101 Master Station polling with General Interrogation and data changes. Use the Protocol Analyzer Test set to Monitor IEC 60870-5-101 datagram on the redundant serial communications links.

Procedure

1. Verify that communication is established with the simulator Protocol Analyzer Test set.
2. Verify that the simulator is sending request on the primary channel and that the SAS Gateways is responding on both the primary (Main) and the secondary (Standby) channels.
3. Disconnect the simulator from the primary channel and connect it to the secondary channel; verify that the SAS Gateway will respond on both channels to requests received on the secondary channel.
4. Verify that data present at HMI should be same at Protocol Analyzer Test also.
5. Verify that all the configured required data points are sent by the gateway to the simulator.

3.3.2 Master Digital Inputs Retrieval

Purpose

To verify that the Substation Gateway is polled for Digital Input data correctly by the Master Simulator.

Procedure

1. Inject digital input changes to single point and double point inputs.
2. Verify change of the state in the Gateway Machine and Protocol Analyzer.

3.4 Master Analog Inputs Retrieval

Purpose

To verify that substation gateway is polled for Analog Input data correctly by the Master Simulator.

Procedure

Inject Analog Inputs and verify that the Analog data are correctly received by the Master Simulator.

3.5 Statement of System Acceptance

Upon satisfactory completion of all applicable tests specified in this document and the proper disposition of all properly documented and witnessed discrepancies resulting from tests specified in the procedure, the system, tested and witnessed by the POWERGRID is functionally accepted by POWERGRID.

3.6 Duration of Factory Acceptance Test

The duration of Factory Acceptance Testing will be mutually agreed depending upon the size of the substation (normally one to two weeks).

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

4. Comments

Any comments should be added in "log sheets"; a pattern is attached on next page.

SAS-FAT LOG SHEET

No.	Reference	Author	Date

Description

5. Glossary:

BCU: Bay Control Unit
DR: Disturbance Recorder
EWS: Engineering Work Station
FAT: Factory Acceptance Test
FPT: Functional Performance Test
FST: Factory Simulation Test
GTW: Gateway
GPS : Global Positioning System
IED: Intelligent Electronic Device
NMS: Network Management (Monitoring) System
OWS: Operator Workstation
RCC: Remote Control Centre
RSCC: Regional System Co-ordination Centre
SAS: Sub-station Automation System
SAT: Site Acceptance Test
SCADA: System Control & Monitoring System

Verify by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

SECTION-3

PROJECT DETAILS & GENERAL SPECIFICATION

SITE INFORMATION

Sl	Particular	Details
a)	Owner	POWERGRID
b)	Customer	POWERGRID
c)	Project Title	Substation package-SS19: Extension of 765kV Solapur, 765kV Aurangabad, 765kV Wardha, 400kV Khandwa, 400kV Rajgarh, 400kV Champa, 400/220kV Itarsi & 400/220kV Jabalpur substations. Under Western Region System Strengthening Scheme (WRSS-20)
d)	Location	

SL	Name of Substation	Name of State	Nearest Rail / Road Head
1	Solapur	Maharashtra	Solapur
2	Aurangabad	Maharashtra	Aurangabad
3	Wardha	Maharashtra	Wardha
4	Khandwa	M.P.	Khandwa
5	Rajgarh	M.P	Rajgarh
6	Champa	Chhattisgarh	Champa
7	Jabalpur	M.P.	Jabalpur
8	Itarsi	M.P.	Itarsi

Sl	Particular	Details
e)	Transport Facilities	As above
SITE CONDITIONS		
a)	Max. ambient air temp.	50°C
b)	Min. ambient air temp.	0°C
c)	Max. design ambient emp.	50°C
d)	Design reference temp.	50°C
e)	Average Humidity	Max. 100%
f)	Special corrosion conditions	No

g)	Solar Radiation	1.2kW/sqmtr
h)	Atmospheric UV radiation	High
i)	Altitude above sea level	Less than 1000meter
j)	Pollution Severity	Normal Pollution level
k)	Seismic Zone	As per the seismic zone defined in the relevant BIS / IEC-62271-300 but not less than 0.3g horrizontal
	WIND DATA	
	Wind velocity	As per IS
	Average No. of thunderstorm days per annum	As per IS
	Main Electrical Parameters:	
	Fault Levels:	

SL	Name of Substation	Fault level
1	765kV Solapur	40kA for 1sec
2	765kV Aurangabad	40kA for 1sec
3	765kV Wardha	40kA for 1sec
4	400kV Khandwa	40kA for 1sec
5	400kV Rajgarh	40kA for 1sec
6	400kV Champa	50kA for 1sec
7	400/220kV Jabalpur	40kA for 1sec
8	400/220kV Itarsi	40kA for 1sec

	Minimum Creepage Distance	25mm/kV for all equipments i.e. BPI / Bushing, CB, Isolator, CT, CVT, LA, NCT etc. 31mm/kV. For string insulators

ENCLOSED – “SECTION-GTR (GENERAL TECHNICAL REQUIREMENT) REV.14” FOR DETAILS OF GENERAL TECHNICAL SPECIFICATION.

PLEASE READ TERMINOLOGY AS FOLLOWS -
1. Read "GTR" as "Section-3 of technical specification"
2. Read "Powergrid" as "BHEL/Powergrid".
3. Read "Employer" as "Powergrid".
4. Read "Contractor" as bidder

SECTION- GENERAL TECHNICAL REQUIRMENT (GTR)

INDEX

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

1.0 FOREWORD

The provisions under this section are intended to supplement requirements for the materials, equipments and services covered under other sections of tender documents and are not exclusive.

2.0 GENERAL REQUIREMENT

2.1 The contractor shall furnish catalogues, engineering data, technical information, design documents, drawings etc., fully in conformity with the technical specification during detailed engineering.

2.2 It is recognised that the Contractor may have standardised on the use of certain components, materials, processes or procedures different from those specified herein. Alternate proposals offering similar equipment based on the manufacturer's standard practice will also be considered provided such proposals meet the specified designs, standard and performance requirements and are acceptable to Employer.

2.3 Wherever a material or article is specified or defined by the name of a particular brand, Manufacturer or Vendor, the specific name mentioned shall be understood as establishing type, function and quality and not as limiting competition.

2.4 Equipment furnished shall be complete in every respect with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or needed for erection, completion and safe operation of the equipment as required by applicable codes though they may not have been specifically detailed in the Technical Specifications unless included in the list of exclusions. Materials and components which are minor in nature and incidental to the requirement but not specifically stated in the specification and bid price schedule, which are necessary for commissioning and satisfactory operation of the switchyard/ substation unless specifically excluded shall be deemed to be included in the scope of the specification and shall be supplied without any extra cost. All similar standard components/parts of similar standard equipment provided, shall be inter-changeable with one another.

~~2.5 The Contractor shall also be responsible for the overall co-ordination with internal /external agencies; Supplier of Employer's supplied equipments, project management, training of Employer's manpower, loading, unloading, handling, insurance, moving to final destination for successful erection, testing and commissioning of the substation /switchyard.~~

~~2.6 The bidder shall be responsible for safety of human and equipment during the working. It will be the responsibility of the Contractor to co-ordinate and obtain Electrical Inspector's clearance before commissioning. Any additional items, modification due to observation of such statutory authorities shall be provided by the Contractor at no extra cost to the Employer.~~

3.0 STANDARDS

3.1 The works covered by the specification shall be designed, engineered, manufactured, built, tested and commissioned in accordance with the Acts, Rules, Laws and Regulations of India.

3.2 The equipment to be furnished under this specification shall conform to latest issue with all amendments (as on the originally scheduled date of bid opening) of standard specified under Annexure-C of this section, unless specifically mentioned in the specification.

3.3 The Bidder shall note that standards mentioned in the specification are not mutually exclusive or complete in themselves, but intended to compliment each other.

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

3.4 The Contractor shall also note that list of standards presented in this specification is not complete. Whenever necessary the list of standards shall be considered in conjunction with specific IS/IEC.

3.5 When the specific requirements stipulated in the specifications exceed or differ than those required by the applicable standards, the stipulation of the specification shall take precedence.

3.6 Other internationally accepted standards which ensure equivalent or better performance than that specified in the standards specified under Annexure-C/ individual sections for various equipments shall also, be accepted, however the salient points of difference shall be clearly brought out during detailed engineering along with English language version of such standard. The equipment conforming to standards other than specified under Annexure-C/individual sections for various equipments shall be subject to Employer's approval.

4.0 SERVICES TO BE PERFORMED BY THE EQUIPMENT BEING FURNISHED

4.1 The 800kV and 420kV system is being designed to limit the switching surge over voltage of 1.9 p.u. and 2.5 p.u., respectively and the power frequency over voltage of 1.4 p.u. and 1.5 p.u., respectively. In case of the 420kV system, the initial value of the temporary overvoltages could be 2.0 p.u. for 1-2 cycles. The equipment furnished under this specification shall perform all its functions and operate satisfactorily without showing undue strain, restrike etc under such over voltage conditions.

4.2 All equipments shall also perform satisfactorily under various other electrical, electromechanical and meteorological conditions of the site of installation.

4.3 All equipment shall be able to withstand all external and internal mechanical, thermal and electromechanical forces due to various factors like wind load, temperature variation, ice & snow, (wherever applicable) short circuit etc for the equipment.

4.4 The bidder shall design terminal connectors of the equipment taking into account various forces that are required to withstand.

4.5 The equipment shall also comply to the following:

a) To facilitate erection of equipment, all items to be assembled at site shall be "match marked".

b) All piping, if any between equipment control cabinet/operating mechanism to marshalling box of the equipment, shall bear proper identification to facilitate the connection at site.

4.6 **System Parameter**

765kV, 400kV & 220kV System

SL No	Description of parameters	765kV System	400kV System	220kV System
1.	System operating voltage	765kV	400kV	220kV
2.	Maximum operating voltage of the system (rms)	800kV	420kV	245kV
3.	Rated frequency	50HZ	50Hz	50Hz
4.	No. of phase	3	3	3
5.	Rated Insulation levels			

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

SL No	Description of parameters	765kV System	400kV System	220kV System
i)	Full wave impulse withstand voltage (1.2/50 microsec.)	2100kVp	1550kVp	1050 kVp
ii)	Switching impulse withstand voltage (250/2500 micro sec.) dry and wet	1550kVp	1050kVp	-
iii)	One minute power frequency dry withstand voltage (rms)	830kV	630kV	-
iv)	One minute power frequency dry and wet withstand voltage (rms)	-	-	460kV
6.	Corona extinction voltage	508 kV	320kV	-
7.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz	2500 µV at 508 kV rms	1000 µV at 266kV rms	1000 µV at 156kV rms
8.	Minimum creepage distance - for Equipment other than Insulator string	20000 mm (24800 mm for coastal area)	10500 mm (13020 mm for coastal area)	6125 mm (7595 mm for coastal area)
	Minimum creepage distance - for Insulator String	As specified in Section-Switchyard Erection		
9.	Min. clearances			
i.	Phase to phase	7600mm (for conductor-conductor configuration) 9400mm (for rod-conductor configuration)	4000mm (for conductor-conductor configuration) 4200mm (for rod -conductor configuration)	2100 mm
ii.	Phase to earth	4900mm (for conductor-structure) 6400mm (for rod- structure)	3500 mm	2100 mm
iii)	Sectional clearances	10300 mm	6500 mm	5000 mm
10.	Rated short circuit current for 1 sec. duration	40kA/50kA (as applicable)	40kA/~~50kA~~/ 63 ~~kA~~ (as applicable)	40kA/ 50kA(as applicable)
11.	System neutral earthing	Effectively earthed	Effectively earthed	Effectively earthed

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

132kV, 66kV, 33kV & 11kV System

SL No	Description of parameters	132 kV System	66kV System	33 kV System	11kV System
1.	System operating voltage	132kV	66kV	33kV	11kV
2.	Maximum operating voltage of the system(rms)	145kV	72.5kV	36kV	12kV
3.	Rated frequency	50Hz	50Hz	50Hz	50Hz
4.	No. of phase	3	3	3	3
5.	Rated Insulation levels				
i)	Full wave impulse withstand voltage (1.2/50 microsec.)	650 kVp	325 kVp	170 kVp	75 kVp
ii)	One minute power frequency dry and wet withstand voltage (rms)	275kV	140kV	70kV	28kV
6.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz	500 µV at 92kV rms	-	-	-
7.	Minimum creepage distance	3625 mm (4495mm for coastal area)	1813 mm (2248mm for coastal area)	900 mm (1116mm for coastal area)	300 mm (372mm for coastal area)
8.	Min. clearances				
i.	Phase to phase	1300 mm	750 mm	320 mm	280 mm
ii.	Phase to earth	1300 mm	630 mm	320 mm	140 mm
iii.	Sectional clearances	4000 mm	3000 mm	2800 mm	2800 mm
9.	Rated short circuit current	40kA/ 31.5 kA (as applicable) for 1 sec	31.5 kA for 3 sec	25 kA for 3 sec	25 kA for 3 sec
10.	System neutral earthing	Effectively earthed	Effectively earthed	Effectively earthed	Effectively earthed

Notes:

1. The above parameters are applicable for installations up to an altitude of 1000m above mean sea level. For altitude exceeding 1000m, necessary altitude correction factor shall be applicable as per relevant IEC.
2. The insulation and RIV levels of the equipments shall be as per values given in the Technical Specification of respective equipment.
3. Corona and radio interference voltage test and seismic withstand test procedures for equipments shall be in line with the procedure given at **Annexure-A** and **Annexure-B** respectively.

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

5.0 ENGINEERING DATA AND DRAWINGS

5.1 The list of drawings/documents which are to be submitted to the Employer is enclosed in **Annexure-E**. In case any additional drawings/documents are required, the same shall also be submitted during execution of the contract.

5.2 The Contractor shall submit 4 (four) sets of drawings/ design documents /data / detailed bill of quantity and 1 (one) set of test reports for the approval of the Employer. The contractor shall also submit the softcopy of the above documents in addition to hardcopy.

5.3 Drawings

5.3.1 All drawings submitted by the Contractor shall be in sufficient detail to indicate the type, size, arrangement, material description, Bill of Materials, weight of each component, break-up for packing and shipment, dimensions, internal & the external connections, fixing arrangement required and any other information specifically requested in the specifications.

5.3.2 Drawings submitted by the Contractor shall be clearly marked with the name of the Employer, the unit designation, the specifications title, the specification number and the name of the Project. POWERGRID has standardized a large number of drawings/documents of various make including type test reports which can be used for all projects having similar requirements and in such cases no project specific approval (except for list of applicable drawings alongwith type test reports) is required. However, distribution copies of standard drawings/documents shall be submitted as per provision of the contract. All titles, noting, markings and writings on the drawing shall be in English. All the dimensions should be in SI units.

5.3.3 The review of these data by the Employer will cover only general conformance of the data to the specifications and documents, interfaces with the equipment provided under the specifications, external connections and of the dimensions which might affect substation layout. This review by the Employer may not indicate a thorough review of all dimensions, quantities and details of the equipment, materials, any devices or items indicated or the accuracy of the information submitted. This review and/or approval by the Employer shall not be considered by the Contractor, as limiting any of his responsibilities and liabilities for mistakes and deviations from the requirements, specified under these specifications and documents.

5.5 All manufacturing and fabrication work in connection with the equipment prior to the approval of the drawings shall be at the Contractor's risk. The Contractor may make any changes in the design which are necessary to make the equipment conform to the provisions and intent of the Contract and such changes will again be subject to approval by the Employer. Approval of Contractor's drawing or work by the Employer shall not relieve the contractor of any of his responsibilities and liabilities under the Contract.

5.6 All engineering data submitted by the Contractor after final process including review and approval by the Employer shall form part of the Contract Document and the entire works performed under these specifications shall be performed in strict conformity, unless otherwise expressly requested by the Employer in Writing.

5.7 Approval Procedure

The following schedule shall be followed generally for approval and for providing final documentation.

i)	Approval/comments/ by Employer on initial submission	As per L2 schedule

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ii)	Resubmission (whenever required)	Within 3 (three) weeks from date of comments
iii)	Approval or comments	Within 3 (three) weeks of receipt of resubmission.
iv)	Furnishing of distribution copies (2 hard copies to each substation and one scanned copy (pdf format)	2 weeks from the date of approval
v)	Furnishing of distribution copies of test reports	
	(a) Type test reports (one scanned softcopy in pdf format to each substation plus one for corporate centre & one hardcopy per substation)	2 weeks from the date of final approval
	(b) Routine Test Reports (one copy for each substation)	-do-
vi)	Furnishing of instruction/ operation manuals (2 copies per substation and one softcopy (pdf format) for corporate centre & per substation)	On completion of Engineering
(vii)	As built drawings (two sets of hardcopy per substation & one softcopy (pdf format) for corporate centre & per substation)	On completion of entire works

NOTE :

(1) The contractor may please note that all resubmissions must incorporate all comments given in the earlier submission by the Employer or adequate justification for not incorporating the same must be submitted failing which the submission of documents is likely to be returned.

(2) All drawings should be submitted in softcopy form, however substation design drawings like SLD, GA, all layouts etc. shall also be submitted in AutoCAD Version. SLD, GA & layout drawings shall be submitted for the entire substation in case of substation extension also.

(3) The instruction Manuals shall contain full details of drawings of all equipment being supplied under this contract, their exploded diagrams with complete instructions for storage, handling, erection, commissioning, testing, operation, trouble shooting, servicing and overhauling procedures.

(4) If after the commissioning and initial operation of the substation, the instruction manuals require any modifications/additions/changes, the same shall be incorporated and the updated final instruction manuals shall be submitted by the Contractor to the Employer.

(5) The Contractor shall furnish to the Employer catalogues of spare parts.

(6) All As-built drawings/documents shall be certified by site indicating the changes before final submission.

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

5.8 The list of major drawings/documents to be approved to qualify for second advance as per Section SCC, shall be as per **Annexure–D**.

6.0 MATERIAL/ WORKMANSHIP

6.1 General Requirement

6.1.1 Where the specification does not contain references to workmanship, equipment, materials and components of the covered equipment, it is essential that the same must be new, of highest grade of the best quality of their kind, conforming to best engineering practice and suitable for the purpose for which they are intended.

6.1.2 In case where the equipment, materials or components are indicated in the specification as "similar" to any special standard, the Employer shall decide upon the question of similarity. When required by the specification or when required by the Employer the Contractor shall submit, for approval, all the information concerning the materials or components to be used in manufacture. Machinery, equipment, materials and components supplied, installed or used without such approval shall run the risk of subsequent rejection, it is to be understood that the cost as well as the time delay associated with the rejection shall be borne by the Contractor.

6.1.3 The design of the Works shall be such that installation, future expansions, replacements and general maintenance may be undertaken with a minimum of time and expenses. Each component shall be designed to be consistent with its duty and suitable factors of safety, subject to mutual agreements. All joints and fastenings shall be devised, constructed and documented so that the component parts shall be accurately positioned and restrained to fulfill their required function. In general, screw threads shall be standard metric threads. The use of other thread forms will only be permitted when prior approval has been obtained from the Employer.

6.1.4 Whenever possible, all similar part of the Works shall be made to gauge and shall also be made interchangeable with similar parts. All spare parts shall also be interchangeable and shall be made of the same materials and workmanship as the corresponding parts of the Equipment supplied under the Specification. Where feasible, common component units shall be employed in different pieces of equipment in order to minimize spare parts stocking requirements. All equipment of the same type and rating shall be physically and electrically interchangeable.

6.1.5 All materials and equipment shall be installed in strict accordance with the manufacturer's recommendation(s). Only first-class work in accordance with the best modern practices will be accepted. Installation shall be considered as being the erection of equipment at its permanent location. This, unless otherwise specified, shall include unpacking, cleaning and lifting into position, grouting, levelling, aligning, coupling of or bolting down to previously installed equipment bases/foundations, performing the alignment check and final adjustment prior to initial operation, testing and commissioning in accordance with the manufacturer's tolerances, instructions and the Specification. All factory assembled rotating machinery shall be checked for alignment and adjustments made as necessary to re-establish the manufacturer's limits suitable guards shall be provided for the protection of personnel on all exposed rotating and / or moving machine parts and shall be designed for easy installation and removal for maintenance purposes. The spare equipment(s) shall be installed at designated locations and tested for healthiness.

6.1.6 The Contractor shall apply oil and grease of the proper specification to suit the machinery, as is necessary for the installation of the equipment. Lubricants used for installation purposes shall be drained out and the system flushed through where necessary for applying the lubricant required for operation. The Contractor shall apply all operational lubricants to the equipment installed by him.

6.1.7 All oil, grease and other consumables used in the Works/Equipment shall be purchased in India unless the Contractor has any special requirement for the specific application of a type of oil or grease not available in India. If such is the case, he shall declare in the proposal, where such oil or grease is available. He shall help Employer in establishing equivalent Indian make and Indian Contractor. The same shall be applicable to other consumables too.

6.2 Provisions For Exposure to Hot and Humid climate

Outdoor equipment supplied under the specification shall be suitable for service and storage under tropical conditions of high temperature, high humidity, heavy rainfall and environment favourable to the growth of fungi and mildew. The indoor equipments located in non-air conditioned areas shall also be of same type.

6.2.1 Space Heaters

6.2.1.1 The heaters shall be suitable for continuous operation at 240V as supply voltage. On-off switch and fuse shall be provided.

6.2.1.2 One or more adequately rated thermostatically connected heaters shall be supplied to prevent condensation in any compartment. The heaters shall be installed in the compartment and electrical connections shall be made sufficiently away from below the heaters to minimize deterioration of supply wire insulation. The heaters shall be suitable to maintain the compartment temperature to prevent condensation.

6.2.2 FUNGI STATIC VARNISH

Besides the space heaters, special moisture and fungus resistant varnish shall be applied on parts which may be subjected or predisposed to the formation of fungi due to the presence or deposit of nutrient substances. The varnish shall not be applied to any surface of part where the treatment will interfere with the operation or performance of the equipment. Such surfaces or parts shall be protected against the application of the varnish.

6.2.3 Ventilation opening

Wherever ventilation is provided, the compartments shall have ventilation openings with fine wire mesh of brass to prevent the entry of insects and to reduce to a minimum the entry of dirt and dust.

6.2.4 Degree of Protection

The enclosures of the Control Cabinets, Junction boxes and Marshalling Boxes, panels etc. to be installed shall comply with following degree of protection as detailed here under:

a) Installed out door: IP- 55
b) Installed indoor in air conditioned area: IP-31
c) Installed in covered area: IP-52
d) Installed indoor in non-air conditioned area where possibility of entry of water is limited: IP-41.
e) For LT Switchgear (AC & DC distribution Boards): IP-52

The degree of protection shall be in accordance with IS:13947 (Part-I)/IEC-60947 (Part-I)/IS 12063/IEC-60529. Type test report for IP-55 or higher degree of protection test, shall be submitted for approval.

6.3 RATING PLATES, NAME PLATES AND LABELS

6.3.1 Each main and auxiliary item of substation is to have permanently attached to it in a conspicuous position a rating plate of non-corrosive material upon which is to be engraved manufacturer's name, year of manufacture, equipment name, type or serial number together with details of the loading conditions under which the item of substation in question has been designed to operate, and such diagram plates as may be required by the Employer. The rating plate of each equipment shall be according to IEC requirement.

6.3.2 All such nameplates, instruction plates, rating plates of transformers, reactors, CB, CT, CVT, SA, Isolators, C & R panels and PLCC equipments shall be bilingual with Hindi inscription first followed by English. Alternatively two separate plates one with Hindi and the other with English inscriptions may be provided.

6.4 FIRST FILL OF CONSUMABLES, OIL AND LUBRICANTS

All the first fill of consumables such as oils, lubricants, filling compounds, touch up paints, soldering/brazing material for all copper piping of circuit breakers and essential chemicals etc. which will be required to put the equipment covered under the scope of the specifications, into operation, shall be furnished by the Contractor unless specifically excluded under the exclusions in these specifications and documents.

7.0 DESIGN IMPROVEMENTS / COORDINATION

7.1 The bidder shall offer the equipment meeting the requirement of the technical specification. However, the Employer or the Contractor may propose changes in the specification of the equipment or quality thereof and if the contractor & Employer agree upon any such changes, the specification shall be modified accordingly.

7.2 If any such agreed upon change is such that it affects the price and schedule of completion, the parties shall agree in writing as to the extent of any change in the price and/or schedule of completion before the Contractor proceeds with the change. Following such agreement, the provision thereof, shall be deemed to have been amended accordingly.

7.3 The Contractor shall be responsible for the selection and design of appropriate equipments to provide the best co-ordinated performance of the entire system. The basic design requirements are detailed out in this Specification. The design of various components, sub-assemblies and assemblies shall be so done that it facilitates easy field assembly and maintenance.

7.4 The Contractor has to coordinate designs and terminations with the agencies (if any) who are Consultants/Contractor for the Employer. The names of agencies shall be intimated to the successful bidders.

7.5 The Contractor will be called upon to attend design co-ordination meetings with the Engineer, other Contractor's and the Consultants of the Employer (if any) during the period of Contract. The Contractor shall attend such meetings at his own cost at POWERGRID Corporate Centre, Gurgaon (Haryana) or at mutually agreed venue as and when required and fully cooperate with such persons and agencies involved during those discussions.

8.0 QUALITY ASSURANCE PROGRAMME

8.1 To ensure that the equipment and services under the scope of this Contract, whether manufactured or performed within the Contractor's Works or at his Sub-Contractor's premises or at the Employer's site or at any other place of Work as applicable, are in accordance with the specifications, the Contractor shall ensure suitable quality assurance programme to control such activities at all points necessary. A quality assurance programme of the Contractor shall be in line with ISO requirements & shall generally cover the following:

a) The organisation structure for the management and implementation of the proposed quality assurance programme.

b) System for Document and Data Control.

c) Qualification and Experience data of Bidder's key personnel.

d) The procedure for purchases of materials, parts, components and selection of sub-Contractor's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.

e) System for shop manufacturing and site erection controls including process controls, fabrication and assembly control.

f) System for Control of non-conforming products including deviation dispositioning, if any and system for corrective and preventive actions based on the feedback received from the Customers and also internally documented system for Customer complaints.

g) Inspection and test procedure both for manufacture and field activities.

h) System for Control of calibration of testing and measuring equipment and the indication of calibration status on the instruments.

i) System for indication and appraisal of inspection status.

j) System of Internal Quality Audits, Management review and initiation of corrective and Preventive actions based on the above.

k) System for authorising release of manufactured product to the Employer.

l) System for maintenance of records.

m) System for handling, storage and delivery.

n) A quality plan detailing out the specific quality control measures and procedure adopted for controlling the quality characteristics relevant to each item of equipment furnished and /or service rendered.

o) System for various field activities i.e. unloading, receipt at site, proper storage, erection, testing and commissioning of various equipment and maintenance of records. In this regard, the Employer has already prepared Standard Field Quality Plan for transmission line/substation equipments as applicable, Civil/erection Works which is required to be followed for associated works.

The Employer or his duly authorised representative reserves the right to carry out quality audit and quality surveillance of the system and procedure of the Contractor/his vendor's quality management and control activities.

8.2 **Quality Assurance Documents**

The Contractor shall ensure availability of the following Quality Assurance Documents:

i) All Non-Destructive Examination procedures, stress relief and weld repair procedure actually used during fabrication, and reports including radiography interpretation reports.

ii) Welder and welding operator qualification certificates.

iii) Welder's identification list, welding operator's qualification procedure and welding identification symbols.

iv) Raw Material test reports on components as specified by the specification and in the quality plan.

v) The Manufacturing Quality Plan(MQP) indicating Customer Inspection Points (CIPs) at various stages of manufacturing and methods used to verify that the inspection and testing points in the quality plan were performed satisfactorily.

vi) Factory test results for testing required as per applicable quality plan/technical specifications/GTP/Drawings etc.

vii) Stress relief time temperature charts/oil impregnation time temperature charts, wherever applicable.

8.3 INSPECTION, TESTING & INSPECTION CERTIFICATE

8.3.1 Contractor shall procure bought out items from sub-vendors as per the list in "Compendium of Vendors" available on POWERGRID web-site www.powergridindia.com after ensuring compliance to the requirements/conditions mentioned therein. Contractor shall explore first the possibilities of procuring the bought out items from POWERGRID approved existing vendors. In case of their unavailability / non-response, Contractor may approach POWERGRID for additional sub-vendor approval. In that case, the assessment report of proposed sub vendor by Contractor along with the enclosures as per **Annexure-F** shall be submitted within 60 days of the award. The proposal shall be reviewed and approval will be accorded based on the verification of the document submitted and/or after the physical assessment of the works as the case may be. The physical assessment conducted by POWERGRID, if required, shall be on chargeable basis. Charges shall be as per the POWERGRID norms prevailing at that time, which shall be intimated by POWERGRID separately. If proposal for sub-vendor is submitted after 60 days, the Contractor's proposal normally will not be considered for current LOA. However, POWERGRID may process the case for developing more vendors for referred items, if found relevant. In all cases, It is the responsibility of the Contractor that Project activities do not suffer on account of delay in approval/non approval of a new sub-vendor.

The responsibility and the basis of inspection for various items & equipment is placed at **Annexure-G** along with the requirement of MQP (Manufacturing Quality Plan), ITP(Inspection & Test Plan), FAT(Factory Acceptance Test) which should be valid & POWERGRID approved and Level of inspection envisaged against each item.

Contractor shall ensure that order for items where MQP/ITP/FAT is required will be placed only on vendors having valid MQP/ITP/FAT and where the supplier's MQP/ITP/FAT is either not valid or has not been approved by POWERGRID, MQP shall be generally submitted as per POWERGRID format before placing order.

Items not covered under MQP/ITP/FAT shall be offered for inspection as per POWERGRID LOA/technical Specifications/POWERGRID approved data sheets/ POWERGRID approved drawings and relevant Indian/International standards.

Inspection **Levels**: For implementation of projects in a time bound manner and to avoid any delay in deputation of POWERGRID or its authorized representative, involvement of POWERGRID for inspection of various items / equipment will be based on the level below:

Level –I: Contractor to raise all inspection calls and review the report of tests carried out by the manufacturer, on his own, as per applicable standards/ POWERGRID specification, and submit to concerned POWERGRID inspection office/Inspection Engineer. CIP/MICC will be issued by POWERGRID based on review of test reports/certificates of manufacturers.

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Level – II: Contractor to raise all inspection calls and carry out the inspection on behalf of POWERGRID on the proposed date of inspection as per applicable standards/specification. However, in case POWERGRID wishes to associate itself during inspection, the same would be intimated to Contractor and CIP/MICC will be issued by POWERGRID. Else, Contractor would submit their test reports/certificates to POWERGRID. CIP/MICC will be issued by POWERGRID based on review of test reports/ certificates.

Level - III: Contractor to raise inspection calls for both, stage (as applicable) & final inspection and carry out the stage inspections (if applicable) on behalf of POWERGRID on the proposed date of inspection as per applicable standards/specification. However, in case POWERGRID wishes to associate itself during stage inspection, the same would be intimated to Contractor and CIP will be issued by POWERGRID. Else, Contractor would submit the test reports / certificates of stage inspection after their own review and CIP will be issued by POWERGRID based on review of test reports / certificates. Final inspection will be carried out by POWERGRID and CIP/MICC will be issued by POWERGRID.

Level – IV: Contractor to raise inspection calls for both, stage (as applicable) & final inspections. POWERGRID will carry out the inspection for both stage & final inspection as per applicable standards/specification and CIP/MICC will be issued by POWERGRID.

8.3.2 Contractor shall ensure that to implement the above inspection levels, particularly for the quality control and inspection at sub-vendor's works, they would depute sufficient qualified & experienced manpower in their Quality Control and Inspection department. Further, to assure quality of construction, Contractor shall have a separate workforce having appropriate qualification & experience and deploy suitable tools and plant for maintaining quality requirement during construction in line with applicable Field Quality Plan (FQP).

8.3.3 The Employer, his duly authorised representative and/or outside inspection agency acting on behalf of the Employer shall have at all reasonable times access to the Contractor's premises or Works and shall have the power at all reasonable times to ensure that proper Quality Management practices / norms are adhered to, inspect and examine the materials & workmanship of the Works, to carry out Quality/Surveillance Audit during manufacture or erection and if part of the Works is being manufactured or assembled at other premises or works. The Contractor shall obtain for the Employer and for his duly authorised representative permission to inspect as if the works were manufactured or assembled on the Contractor's own premises or works. The item/equipment, if found unsatisfactory with respect to workmanship or material is liable to be rejected. The observations for improvements during product/ process inspection by POWERGRID shall be recorded in Quality Improvement Register (available & maintained at works) for review & timely compliance of observations.

8.3.4 Contractor shall submit inspection calls over internet through POWERGRID website. The required vendor code and password to enable raising inspection call will be furnished to the main Contractor within 30 days of award of contract on submission of documents by Contractor. After raising the inspection calls, Contractor shall then proceed as per the message of that particular call which is available on the message board.

8.3.5 The Employer reserves the right to witness any or all type, acceptance and routine tests specified for which the Contractor shall give the Employer/Inspector Twenty one (21) days written notice of any material being ready for testing for each stage of testing as identified in the approved quality plan as customer inspection point(CIP) for indigenous inspections. All inspection calls for overseas material shall be given at least forty five (45) days in advance. Such tests shall be to the Contractor's account except for the expenses of the Inspection Engineer. The Employer/inspector, unless witnessing of the tests is waived by Employer, will attend such tests within Twenty one (21) days of the date of which the equipment is notified as being ready for test/inspection, failing which the Contractor may proceed with the test which shall be deemed to have been made in the Inspector's presence and he shall forthwith forward to the Inspector three copies of tests, duly certified. Contractor shall ensure, before giving notice for type test, that all drawings and quality plans have been got approved. The equipment shall be dispatched to site only after approval of Routine and Acceptance test results and Issuance of Dispatch Clearance in writing by the Employer. CIP/Material Inspection clearance certificate (MICC) shall be issued by the Employer after inspection of the equipment or review of test reports as applicable. Employer may waive off the presence of Employer's inspecting engineer. In that case test will be carried out as per approved QP and test certificate will be furnished by the supplier for approval. CIP/MICC will be issued only after review and approval of the test reports.

8.3.6 Contractor shall generally offer material for inspection as per supply bar chart approved by POWERGRID and not before 30 days from schedule indicated in the bar chart. In case Contractor offers material(s) for inspection prior to 30 days from the scheduled date with necessary approval of POWERGRID, POWERGRID shall inspect the material and issue CIP only. However, in such an exceptional case, MICC shall be issued only as per provision of original / revised approved supply schedule.

8.3.7 Contractor shall minimize the number of inspection calls by offering optimum quantities in each inspection call at the respective manufacturer's works.

8.3.8 Contractor shall inspect the material themselves and only after they are fully convinced about the Quality, they shall offer the material for POWERGRID inspection and shall also ensure that relevant portion of LOA/NOA, approved drawing and data sheets along with applicable Quality Plans are available at the works of Contractor or their Sub-vendor before the material is offered for inspection.

8.3.9 Contractor shall ensure that material which has been cleared for dispatch after inspection will be dispatched within 30 days in case of domestic supplies and within 60 days in case of Off-shore supplies from the date of issuance of CIP. Material which is not dispatched within stipulated time as above will be reoffered for POWERGRID inspection or specific approval of POWERGRID QA&I shall be obtained for delayed dispatch.

8.3.10 The Employer or IE shall give notice in writing to the Contractor, of any objection either to conformance to any drawings or to any equipment and workmanship which in his opinion is not in accordance with the Contract. The Contractor shall give due consideration to such objections and shall either make the modifications that may be necessary to meet the said objections or shall confirm in writing to the Employer/Inspection Engineer giving reasons therein, that no modifications are necessary to comply with the Contract.

8.3.11 All Test Reports and documents to be submitted in English during final inspection of equipment by POWERGRID or as and when required for submission.

8.3.12 When the factory tests have been completed at the Contractor's or Sub-Contractor's works, the Employer/Inspection Engineer(IE) shall issue a certificate to this effect within fifteen (15) days after completion of tests & submission of documents by Contractor/manufacturer but if the tests are not witnessed by the Employer/IE, the certificate shall be issued within fifteen (15) days of receipt of the Contractor's Test certificate by the Employer/IE. Contractor shall, on completion of all tests, submit test reports within Ten (10) days to POWERGRID IE. Failure of the Employer/IE to issue such a certificate shall not prevent the Contractor from proceeding with the Works. The completion of these tests or the issue of the certificate shall not bind the Employer to accept the equipment should, it, on further tests after erection, be found not to comply with the Contract.

8.3.13 In all cases, where the Contract provides for tests whether at the premises or works of the Contractor or of any Sub- Contractor, the Contractor, except where otherwise specified, shall provide free of charge such items as labour, materials, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Employer/Inspector or his authorised representative to carry out effectively such tests of the equipment in accordance with the Contract and shall give facilities to the Employer/Inspection Engineer or to his authorised representative to accomplish testing.

8.3.14 The inspection and acceptance by Employer and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed quality assurance programme forming a part of the Contract, or if such equipment is found to be defective at a later stage.

8.3.15 The Employer will have the right of having at his own expenses any other test(s) of reasonable nature carried out at Contractor's premises or at site or in any other place in addition of aforesaid type and routine tests, to satisfy that the material comply with the specification.

8.3.16 The Employer reserves the right for getting any additional field tests conducted on the completely assembled equipment at site to satisfy that material complies with specifications.

8.3.17 Rework/ Re-engineering, if any, on any item/equipment shall be carried out only after mutual discussions and in accordance with mutually agreed procedure. Contractor shall submit Joint Inspection Report of equipments under Re-Work/Re-Engineering alongwith procedure for the same to POWERGRID for approval, before taking up the Re-Work/Re-Engineering, failing which POWERGRID reserves the right to reject the equipment.

8.3.18 Contractor may establish a field test Laboratory to execute Civil Construction testing requirements at site with the condition that all testing equipment shall be calibrated from POWERGRID approved accredited Testing laboratories, with calibration certificates kept available at site and all testing personnel employed in the Field Testing Laboratories to be qualified and experienced Engineers or testing to be carried out at POWERGRID approved Third Party Laboratories.

8.3.19 Contractor shall ensure that all possible steps are taken to avoid damages to the equipment during transport, storage and erection.

8.3.20 Contractor shall implement additional stringent quality checks and preparation during installation of GIS at site (if applicable) as per POWERGRID approved guidelines/Technical specifications.

8.3.21 Contractor shall ensure commissioning of all CSDs along with Circuit Breakers wherever applicable.

8.3.22 For EHV transformers/reactors:

Insulation oil shall be as per POWERGRID Technical specifications and same grade shall be used for impregnation of the active part & testing at the works of Transformer/Reactor Manufacturer and as well as for filling the Transformer/Reactors at site. Contractor to ensure that windings for Transformer/Reactors are made in air-conditioned environment. Core-coil assembly shall be performed in positive pressurized dust controlled environment. Dust measurements shall be monitored regularly at Transformer / Reactor Manufacturer works. Contractor shall ensure that respective civil foundations & Fire walls for Transformer/Reactors units to be commissioned, shall be made ready at concerned sites before receipt of Transformer/Reactors units. All the requisite material for Neutral & Delta Bus formation required for charging of complete bank of 765KV class 1-ph Transformer/Reactor units shall be made available at the concerned sites before receipt of the Transformer/Reactor units at site.

8.3.23 The Employer reserves the right to increase or decrease their involvement in inspections at Contractor's Works or at his Sub-Contractor's premises or at the Employer's site or at any other place of Work based on performance of Contractor/sub-Contractor.

9.0 TYPE TESTING & CLEARANCE CERTIFICATE

9.1 All equipment being supplied shall conform to type tests as per technical specification and shall be subject to routine tests in accordance with requirements stipulated under respective sections.

9.2 The reports for all type tests as per technical specification shall be furnished by the Contractor alongwith equipment / material drawings. However, type test reports of similar equipments/ material already accepted in POWERGRID shall be applicable for all projects with similar requirement. The type tests conducted earlier should have either been conducted in accredited laboratory (accredited based on ISO / IEC Guide 25 / 17025 or EN 45001 by the national accreditation body of the country where laboratory is located) or witnessed by POWERGRID or representative authorized by POWERGRID or Utility or representative of accredited test lab.

Unless otherwise specified elsewhere, the type test reports submitted shall be of the tests conducted within last 10 (ten) years from the date of NOA. In case the test reports are of the test conducted earlier than 10 (ten) years from the date of NOA, the contractor shall repeat these test(s) at no extra cost to the Employer.

Further, in the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design/manufacturing changes or due to non-compliance with the requirement stipulated in the Technical Specification or any/all type tests not carried out, same shall be carried out without any additional cost implication to the Employer.

The Contractor shall intimate the Employer the detailed program about the type tests atleast two (2) weeks in advance in case of domestic supplies & six (6) weeks in advance in case of foreign supplies.

9.3 The Employer intends to repeat those type tests which are indicated in the price schedule and the same shall be payable as per provision of contract. The price of conducting type tests shall be included in Bid price and break up of these shall be given in the relevant schedule of Bid Proposal Sheets. These Type test charges would be considered in bid evaluation. In case Bidder does not indicate charges for any of the type tests or does not mention the name of any test in the price schedules, it will be presumed that the particular test has been offered free of charge. Further, in case any Bidder indicates that he shall not carry out a particular test, his offer shall be considered incomplete and shall be liable to be rejected. The Employer reserves the right to waive the repeating of type tests partly or fully and in case of waival, test charges for the same shall not be payable.

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9.4 The Employer reserves the right to witness any or all the type tests. The Employer shall bear all expenses for deputation of Employer's representative(s) for witnessing the type tests.

9.5 The list of makes of various items, for which Type test reports are not required to be submitted are specified in Compendium of Vendors (COV).

10.0 TESTS

10.1 Pre-commissioning Tests

On completion of erection of the equipment and before charging, each item of the equipment shall be thoroughly cleaned and then inspected jointly by the Employer and the Contractor for correctness and completeness of installation and acceptability for charging, leading to initial pre-commissioning tests at Site. The list of pre-commissioning tests to be performed are given in respective chapters and shall be included in the Contractor's quality assurance programme.

10.2 Commissioning Tests

10.2.1 The available instrumentation and control equipment will to be used during such tests and the Employer will calibrate, all such measuring equipment and devices as far as practicable.

10.2.2 Any special equipment, tools and tackles required for the successful completion of the Commissioning Tests shall be arranged by the Contractor at his own cost.

10.2.3 The specific tests requirement on equipment have been brought out in the respective chapters of the technical specification.

10.3.4 **PRECOMMISSIONING, COMMISSIONING, TRIAL-RUN & COMPLETION**

As soon as the Facilities covered by these specifications are physically completed in all respects, the Pre commissioning, Commissioning, Trial-run and Completion of the Facilities, as mentioned below, shall be attained in accordance with the procedure given in the Conditions of Contract, Vol.-I of the Bidding Documents.

(i) Pre commissioning : As per relevant Sections
(ii) Commissioning : Charging of the Facilities at rated voltage.

Further, wherever appearing in these specifications, the words–'commissioning checks', 'installation checks', 'site tests', 'performance guarantee tests for fire protection system', are to be considered as 'pre commissioning checks'.

(iii) Trial-run : Operation of the Facilities or any part thereof by the Contractor immediately after the Commissioning for a continuous period of 72 (Seventy two) hours continuously. In case of interruption due to problem/ failure in the respective equipment, the contractor shall rectify the problem and after rectification, continuous 72 (Seventy two) hours period start after such rectification.
(iv) Completion : Upon successful completion of Trial-run.

'Guarantee Test(s)' and/or 'Functional Guarantees' are applicable only for Substation Automation System as specified in Section-'Substation Automation System.'

10.3. The Contractor shall be responsible for obtaining statutory clearances from the concerned authorities for commissioning the equipment and the switchyard. However necessary fee shall be reimbursed by POWERGRID on production of requisite documents.

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11.0 PACKAGING & PROTECTION

11.1 All the equipments shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. On request of the Employer, the Contractor shall also submit packing details/associated drawing for any equipment/material under his scope of supply, to facilitate the Employer to repack any equipment/material at a later date, in case the need arises. While packing all the materials, the limitation from the point of view of availability of Railway wagon sizes in India should be taken into account. The Contractor shall be responsible for any loss or damage during transportation, handling and storage due to improper packing. Any demurrage, wharfage and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor. Employer takes no responsibility of the availability of the wagons.

11.2 All coated surfaces shall be protected against abrasion, impact, discolouration and any other damages. All exposed threaded portions shall be suitably protected with either a metallic or a non-metallic protecting device. All ends of all valves and pipings and conduit equipment connections shall be properly sealed with suitable devices to protect them from damage.

12.0 FINISHING OF METAL SURFACES

12.1 All metal surfaces shall be subjected to treatment for anti-corrosion protection. All ferrous surfaces for external use unless otherwise stated elsewhere in the specification or specifically agreed, shall be hot-dip galvanized after fabrication. All steel conductors including those used for earthing/grounding (above ground level) shall also be galvanized according to IS: 2629.

12.2 HOT DIP GALVANISING

12.2.1 The minimum weight of the zinc coating shall be 610 gm/sq.m and minimum average thickness of coating shall be 86 microns for all items having thickness 6mm and above **and 900 gm/sq.m for coastal area (30km from sea shore approximately) or as specified in Section-Project**. For items lower than 6mm thickness requirement of coating thickness shall be as per relevant ASTM. For surface which shall be embedded in concrete, the zinc coating shall be 610 gm/sq.m minimum **and 900 gm/sq.m for coastal area as specified in Section-Project.**

12.2.2 The galvanized surfaces shall consist of a continuous and uniform thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be clean and smooth and shall be free from defects like discoloured patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel globules, spiky deposits, blistered surface, flaking or peeling off, etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

12.2.3 After galvanizing, no drilling or welding shall be performed on the galvanized parts of the equipment excepting that nuts may be threaded after galvanizing. Sodium dichromate or alternate approved treatment shall be provided to avoid formation of white rust after hot dip galvanization.

12.2.4 The galvanized steel shall be subjected to four numbers of one minute dips in copper sulphate solution as per IS-2633.

12.2.5 Sharp edges with radii less than 2.5 mm shall be able to withstand four immersions of the Standard Preece test. All other coatings shall withstand six immersions. The following galvanizing tests should essentially be performed as per relevant Indian Standards.

- Coating thickness
- Uniformity of zinc

- Adhesion test
- Mass of zinc coating

12.2.6 Galvanised material must be transported properly to ensure that galvanised surfaces are not damaged during transit. Application of touch-up zinc rich paint at site shall be allowed with approval of Engineer Incharge.

12.3 PAINTING

12.3.1 All sheet steel work shall be degreased, pickled, phosphated in accordance with the IS-6005 "Code of practice for phosphating iron and sheet". All surfaces, which will not be easily accessible after shop assembly, shall beforehand be treated and protected for the life of the equipment. The surfaces, which are to be finished painted after installation or require corrosion protection until installation, shall be shop painted with at least two coats of primer. Oil, grease, dirt and swaf shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

12.3.2 After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying. The phosphate coating shall be sealed with application of two coats of ready mixed, stoving type zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved.

12.3.3 After application of the primer, two coats of finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after inspection of first coat of painting.

12.3.4 The exterior and interior colour of the paint in case of new substations shall preferably be RAL 7032 for all equipment, marshalling boxes, junction boxes, control cabinets, panels etc. unless specifically mentioned under respective sections of the equipments. Glossy white colour inside the equipments /boards /panels/junction boxes is also acceptable. The exterior colour for panels shall be matching with the existing panels in case of extension of a substation. Each coat of primer and finishing paint shall be of slightly different shade to enable inspection of the painting. A small quantity of finishing paint shall be supplied for minor touching up required at site after installation of the equipments.

12.3.5 In case the contractor proposes to follow his own standard surface finish and protection procedures or any other established painting procedures, like electrostatic painting etc., the procedure shall be submitted during detailed engineering for Employer's review & approval.

12.3.6 The colour scheme as given below shall be followed for Fire Protection and Air Conditioning systems

S.No.	PIPE LINE	Base colour	Band colour
Fire Protection System			
1	Hydrant and Emulsifier system pipeline	FIRE RED	-
2	Emulsifier system detection line – water	FIRE RED	Sea Green
3	Emulsifier system detection line –Air	FIRE RED	Sky Blue
4	Pylon support pipes	FIRE RED	
Air Conditioning Plant			
5	Refrigerant gas pipeline – at compressor suction	Canary Yellow	-

S.No.	PIPE LINE	Base colour	Band colour
6	Refrigerant gas pipeline – at compressor discharge	Canary Yellow	Red
7	Refrigerant liquid pipeline	Dark Admiralty Green	-
8	Chilled water pipeline	Sea Green	-
9	Condenser water pipeline	Sea Green	Dark Blue

The direction of flow shall be marked by → (arrow) in black colour.

Base Colour Direction of flow Band Colour

12.3.7 For aluminium casted surfaces, the surface shall be with smooth finish. Further, in case of aluminium enclosures, the surface shall be coated with powder (coating thickness of 60 microns) after surface preparation for painting. For stainless steel surfaces, no painting is envisaged.

13.0 HANDLING, STORING AND INSTALLATION

13.1 In accordance with the specific installation instructions as shown on manufacturer's drawings or as directed by the Employer or his representative, the Contractor shall unload, store, erect, install, wire, test and place into commercial use all the equipment included in the contract. Equipment shall be installed in a neat, workmanlike manner so that it is level, plumb, square and properly aligned and oriented. Commercial use of switchyard equipment means completion of all site tests specified and energisation at rated voltage.

13.2 Contractor may engage manufacturer's Engineers to supervise the unloading, transportation to site, storing, testing and commissioning of the various equipment being procured by them separately. Contractor shall unload, transport, store, erect, test and commission the equipment as per instructions of the manufacturer's supervisory Engineer(s) and shall extend full cooperation to them.

13.3 The contractor must ensure that the open storage platform (as per Drawing No. C-ENGG-CVL-STD-PLATFORM-01, Rev.0) is constructed for storage of outdoor type equipment/material prior to commencement of delivery at site. Outdoor equipment shall be stored on open storage platform, properly covered with waterproof and dustproof covers to protect them from water seepage and moisture ingress.

However, all indoor equipments including control & protection panels, Communication equipments and operating mechanism boxes etc. of outdoor equipments shall be stored indoors.

Storage of equipment on top of another one is not permitted if the wooden packing is used and there is possibility of equipment/packing damage. Material opened for joint inspection shall be repacked properly as per manufacturer's recommendations.

During storage of material regular periodic monitoring of important parameters like oil level / leakage, SF6 / Nitrogen pressure etc. shall be ensured by the contractor.

13.4 In case of any doubt/misunderstanding as to the correct interpretation of manufacturer's drawings or instructions, necessary clarifications shall be obtained from the Employer. Contractor shall be held responsible for any damage to the equipment consequent to not following manufacturer's drawings/instructions correctly.

13.5 Where assemblies are supplied in more than one section, Contractor shall make all necessary mechanical and electrical connections between sections including the connection between buses. Contractor shall also do necessary adjustments/alignments for proper operation of circuit breakers, isolators and their operating mechanisms. All components shall be protected against damage during unloading, transportation, storage, installation, testing and commissioning. Any equipment damaged due to negligence or carelessness or otherwise shall be replaced by the Contractor at his own expense.

13.6 Contractor shall be responsible for examining all the shipment and notify the Employer immediately of any damage, shortage, discrepancy etc. for the purpose of Employer's information only. The Contractor shall submit to the Employer every week a report detailing all the receipts during the weeks. However, the Contractor shall be solely responsible for any shortages or damages in transit, handling and/or in storage and erection of the equipment at Site. Any demurrage, wharfage and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor.

13.7 The Contractor shall be fully responsible for the equipment/material until the same is handed over to the Employer in an operating condition after commissioning. Contractor shall be responsible for the maintenance of the equipment/material while in storage as well as after erection until taken over by Employer, as well as protection of the same against theft, element of nature, corrosion, damages etc.

13.8 Where material / equipment is unloaded by Employer before the Contractor arrives at site or even when he is at site, Employer by right can hand over the same to Contractor and there upon it will be the responsibility of Contractor to store the material in an orderly and proper manner.

13.9 The Contractor shall be responsible for making suitable indoor storage facilities, to store all equipment which requires indoor storage.

13.10 The words 'erection' and 'installation' used in the specification are synonymous.

13.11 Exposed live parts shall be placed high enough above ground to meet the requirements of electrical and other statutory safety codes.

13.12 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life. If at any stage during the execution of the Contract, it is observed that the erected equipment(s) do not meet the above minimum clearances the Contractor shall immediately proceed to correct the discrepancy at his risks and cost.

13.13 Equipment Bases

A cast iron or welded steel base plate shall be provided for all rotating equipment which is to be installed on a concrete base unless otherwise agreed to by the Employer. Each base plate shall support the unit and its drive assembly, shall be of a neat design with pads for anchoring the units, shall have a raised lip all around, and shall have threaded drain connections.

14.0 TOOLS

14.1 TOOLS & PLANTS (T&P)

The Contractor shall arrange all T&P (such as necessary supports, cranes, ladders, platforms etc.) for erection, testing & commissioning of the system at his own cost. Further, all consumables, wastage and damages shall be to the account of contractor.

All such T&P shall be taken back by the contractor after commissioning of the system.

14.2 SPECIAL TOOLS AND TACKLES

The contractor shall supply all special tools and tackles required for Operation and maintenance of equipment. The special tools and tackles shall only cover items which are specifically required for the equipment offered and are proprietary in nature. The list of special tools and tackles, if any, shall be finalized during detail engineering and the same shall be supplied without any additional cost implication to the Employer.

14.3 FACILITIES TO BE PROVIDED BY THE EMPLOYER

14.3.1 Employer shall make available the auxiliary supplies at a single point in the substation on chargeable basis. The prevailing energy rates of the state shall be applicable. All further distribution from the same for construction supply shall be made by the contractor. However, in case of failure of power due to any unavoidable circumstances, the contractor shall make his own necessary arrangements like diesel generator sets etc. at his own cost so that progress of work is not affected and Employer shall in no case be responsible for any delay in works because of non-availability of power.

14.3.2 Employer shall make available construction water supply at a single point in the substation. All further distribution for the same shall be made by the Contractor. In case of non-availability or inadequate availability of water for construction work, the contractor shall make his own arrangement at his own cost and the Employer shall in no case be responsible for any delay in works because of non-availability or inadequate availability of water.

15.0 AUXILIARY SUPPLY

15.1 The auxiliary power for station supply, including the equipment drive, cooling system of any equipment, air-conditioning, lighting etc shall be designed for the specified Parameters as under. The DC supply for the instrumentation and PLCC system shall also conform the parameters as indicated in the following table:

Normal Voltage	Variation in Voltage	Frequency in HZ	Phase/Wire	Neutral connection
415V	± 10%	50 ± 5%	3/4 Wire	Solidly Earthed.
240V	± 10%	50 ± 5%	1/2 Wire	Solidly Earthed.
220V	190V to 240V	DC	Isolated 2 wire System	-
110V	95V to 120V	DC	Isolated 2 wire System	-
48V	--	DC	2 wire system (+) earthed	-

Combined variation of voltage and frequency shall be limited to ± 10%.

16.0 SUPPORT STRUCTURE

16.1 The equipment support structures shall be suitable for equipment connections at the first level i.e 14.0 meter, 8.0 meter, 5.9 meter and 4.6 meter from plinth level for 765kV, 400kV, 220kV and 132kV substations respectively. All equipment support structures shall be supplied alongwith brackets, angles, stools etc. for attaching the operating mechanism, control cabinets & marshalling box (wherever applicable) etc.

16.2 The minimum vertical distance from the bottom of the lowest porcelain part of the bushing, porcelain enclosures or supporting insulators to the bottom of the equipment base, where it rests on the foundation pad shall be 2.55 metres.

17.0 CLAMPS AND CONNECTORS INCLUDING TERMINAL CONNECTORS

17.1 All power clamps and connectors shall conform to IS:5561 or other equivalent international standard and shall be made of materials listed below :

Sl. No.	Description	Materials
a)	For connecting ACSR conductors/AAC conductors/ Aluminium tube	Aluminum alloy casting, conforming to designation A6 of IS:617 and all test shall conform to IS:617
b)	For connecting equipment terminals mad of copper with ACSR conductors/AAC conductors/ Aluminium tube	Bimetallic connectors made from aluminum alloy casting, conforming to designation A6 of IS:617 with 2mm thick bimetallic liner/strip and all test shall conform to IS:617
c)	For connecting G.I	Galvanised mild steel shield wire
d)	Bolts, nuts & plain washers	Electro-galvanised for sizes below M12, for others hot dip galvanised.
e)	Spring washers	Electro-galvanised mild steel suitable for atleast service condition-3 as per IS:1573

17.2 Necessary clamps and connectors shall be supplied for all equipment and connections. If corona rings are required to meet these requirements they shall be considered as part of that equipment and included in the scope of work.

17.3 Where copper to aluminum connections are required, bi-metallic clamps shall be used, which shall be properly designed to ensure that any deterioration of the connection is kept to a minimum and restricted to parts which are not current carrying or subjected to stress.

17.4 Low voltage connectors, grounding connectors and accessories for grounding all equipment as specified in each particular case, are also included in the scope of Work.

17.5 No current carrying part of any clamp shall be less than 10 mm thick. All ferrous parts shall be hot dip galvanised. Copper alloy liner/strip of minimum 2 mm thickness shall be cast integral with aluminum body or 2 mm thick bi-metallic liner/strips shall be provided for Bi-metallic clamps.

17.6 All casting shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be blurred and rounded off.

17.7 Flexible connectors, braids or laminated straps made for the terminal clamps for bus posts shall be suitable for both expansion or through (fixed/sliding) type connection of IPS AL tube as required. In both the cases the clamp height (top of the mounting pad to centre line of the tube) should be same.

17.8 Current carrying parts (500A and above) of the clamp/connector shall be provided with minimum four numbers of bolts preferably for 132kV & above.

17.9 All current carrying parts shall be designed and manufactured to have minimum contact resistance.

17.10 Power Clamps and connectors shall be designed to control corona as per requirement.

17.11 Tests

Clamps and connectors should be type tested as per IS:5561 and shall also be subjected to routine tests as per IS:5561. Following type test reports shall be submitted for approval. Type test once conducted shall hold good. The requirement of test conducted within last ten years, shall not be applicable.

i) Temperature rise test (maximum temperature rise allowed is 35°C over 50°C ambient)

ii) Short time current test

iii) Corona (dry) [for 400kV and above] and RIV (dry) test [for 132kV and above voltage level clamps]

iv) Resistance test and tensile test

18.0 CONTROL CABINETS, JUNCTION BOXES, TERMINAL BOXES & MARSHALLING BOXES FOR OUTDOOR EQUIPMENT

18.1 All types of boxes, cabinets etc. shall generally conform to & be tested in accordance with IS-5039/IS-8623, IEC-60439, as applicable, and the clauses given below:

18.2 Control cabinets, junction boxes, Marshalling boxes & terminal boxes shall be made of stainless steel of atleast 1.5 mm thick or aluminum enclosure of atleast 1.6 mm thick and shall be dust, water and vermin proof. Stainless steel used shall be of grade SS304 (SS316 for coastal area) or better. The box shall be properly braced to prevent wobbling. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation. In case of aluminum enclosed box the thickness of aluminum shall be such that it provides adequate rigidity and long life as comparable with sheet steel of specified thickness.

18.3 A canopy and sealing arrangements for operating rods shall be provided in marshalling boxes / Control cabinets to prevent ingress of rain water.

18.4 Cabinet/boxes shall be provided with double hinged doors with padlocking arrangements. The distance between two hinges shall be adequate to ensure uniform sealing pressure against atmosphere.

18.5 All doors, removable covers and plates shall be gasketed all around with suitably profiled EPDM/Neoprene/PU gaskets. The gasket shall be tested in accordance with approved quality plan, IS:11149 and IS:3400. Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh made of brass.

Further, the gasketing arrangement shall be such that gaskets are pasted in slots (in door fabrication/gasket itself) in order to prevent ingression of dust and moisture inside the panels so that no internal rusting occurs in panels during the operation of the equipment.

18.6 All boxes/cabinets shall be designed for the entry of cables by means of weather proof and dust-proof connections. Boxes and cabinets shall be designed with generous clearances to avoid interference between the wiring entering from below and any terminal blocks or accessories mounted within the box or cabinet. Suitable cable gland plate above the base of the marshalling kiosk/box shall be provided for this purpose along with the proper blanking plates. Necessary number of cable glands shall be supplied and fitted on this gland plate. Gland plate shall have provision for some future glands to be provided later, if required. The Nickel plated glands shall be dust proof, screw on & double compression type and made of brass. The gland shall have provision for securing armour of the cable separately and shall be provided with earthing tag. The glands shall conform to BS:6121.

18.7 A 240V, single phase, 50 Hz, 15 amp AC plug and socket shall be provided in the cabinet with ON-OFF switch for connection of hand lamps. Plug and socket shall be of industrial grade.

18.8 LED based illumination of minimum 9 watts shall be provided. The switching of the fittings shall be controlled by the door switch.

For junction boxes of smaller sizes such as lighting junction box, manual operated earth switch mechanism box etc., plug socket, heater and illumination is not required to be provided.

18.9 All control switches shall be of MCB/rotary switch type and Toggle/piano switches shall not be accepted.

18.10 Earthing of the cabinet shall be ensured by providing two separate earthing pads. The earth wire shall be terminated on to the earthing pad and secured by the use of self etching washer. Earthing of hinged door shall be done by using a separate earth wire.

18.11 The bay marshalling kiosks shall be provided with danger plate and a diagram showing the numbering/connection/feruling by pasting the same on the inside of the door.

18.12 The following routine tests alongwith the routine tests as per IS:5039 shall also be conducted:

i) Check for wiring

ii) Visual and dimension check

18.13 The enclosure of bay marshalling kiosk, junction box, terminal box and control cabinets shall conform to IP-55 as per IS:13947 including application of 2KV rms for 1 (one) minute, insulation resistance and functional test after IP-55 test.

19.0 DISPOSAL OF PACKING MATERIAL & WASTE FROM CONSTRUCTION SITE

After completion of the work, Contractor shall dispose-off all the packing & waste materials including empty conductor drums, cable drums, wooden containers, oil drums, gas cylinders and other waste/scrapped materials from construction site at his own cost and shall make the substation area properly cleaned.

20.0 TERMINAL BLOCKS AND WIRING

20.1 Control and instrument leads from the switchboards or from other equipment will be brought to terminal boxes or control cabinets in conduits. All interphase and external connections to equipment or to control cubicles will be made through terminal blocks.

20.2 Terminal blocks shall be 650V grade and have continuous rating to carry the maximum expected current on the terminals and non-breakable type. These shall be of moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Screw clamp, overall insulated, insertion type, rail mounted terminals can be used in place of stud type terminals. But the terminal blocks shall be non-disconnecting stud type except for the secondary junction boxes of Current Transformer and Voltage Transformer.

20.3 Terminal blocks for current transformer and voltage transformer secondary leads shall be provided with test links and isolating facilities. The current transformer secondary leads shall also be provided with short circuiting and earthing facilities.

20.4 The terminal shall be such that maximum contact area is achieved when a cable is terminated. The terminal shall have a locking characteristic to prevent cable from escaping from the terminal clamp unless it is done intentionally.

20.5 The conducting part in contact with cable shall preferably be tinned or silver plated however Nickel plated copper or zinc plated steel shall also be acceptable.

20.6 The terminal blocks shall be of extensible design, multilayer terminal arrangement is not allowed in any junction box (Common MB, Individual MB, JB etc.). There should be sufficient space at both sides of terminals so that ferrule number of wires / TB numbers are clearly visible during wire removal or insertion.

20.7 The terminal blocks shall have locking arrangement to prevent its escape from the mounting rails.

20.8 The terminal blocks shall be fully enclosed with removable covers of transparent, non-deteriorating type plastic material. Insulating barriers shall be provided between the terminal blocks. These barriers shall not hinder the operator from carrying out the wiring without removing the barriers.

20.9 Unless otherwise specified terminal blocks shall be suitable for connecting the following conductors on each side.

a)	All circuits except CT/PT circuits	Minimum of two of 2.5 sq mm copper flexible.
b)	All CT/PT circuits	Minimum of 4 nos. of 2.5 sq mm copper flexible.

20.10 The arrangements shall be in such a manner so that it is possible to safely connect or disconnect terminals on live circuits and replace fuse links when the cabinet is live.

20.11 Atleast 20 % spare terminals shall be provided on each panel/cubicle/box and these spare terminals shall be uniformly distributed on all terminals rows.

20.12 There shall be a minimum clearance of 250 mm between the First/bottom row of terminal block and the associated cable gland plate for outdoor ground mounted marshalling box and the clearance between two rows of terminal blocks shall be a minimum of 150 mm.

20.13 The Contractor shall furnish all wire, conduits and terminals for the necessary interphase electrical connections (where applicable) as well as between phases and common terminal boxes or control cabinets. For equipments rated for 400 kV and above the wiring required in these items shall be run in metallic ducts or shielded cables in order to avoid surge overvoltages either transferred through the equipment or due to transients induced from the EHV circuits.

20.14 All input and output terminals of each control cubicle shall be tested for surge withstand capability in accordance with the relevant IEC Publications, in both longitudinal and transverse modes. The Contractor shall also provide all necessary filtering, surge protection, interface relays and any other measures necessary to achieve an impulse withstand level at the cable interfaces of the equipment.

21.0 LAMPS & SOCKETS

21.1 Lamps & Sockets

All lamps shall use a socket base as per IS-1258, except in the case of signal lamps.

All sockets (convenience outlets) shall be suitable to accept both 5 Amp & 15 Amp pin round Standard Indian plugs. They shall be switched sockets with shutters.

21.2 Hand Lamp:

A 240 Volts, single Phase, 50 Hz AC plug point shall be provided in the interior of each cubicle with ON-OFF Switch for connection of hand lamps.

21.3 Switches and Fuses:

21.3.1 Each panel shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with miniature circuit breaker / switch fuse units. Selection of the main and Sub-circuit fuse ratings shall be such as to ensure selective clearance of sub-circuit faults. Potential circuits for relaying and metering shall be protected by HRC fuses.

21.3.2 All fuses shall be of HRC cartridge type conforming to IS:9228 mounted on plug-in type fuse bases. Miniature circuit breakers with thermal protection and alarm contacts will also be accepted. All accessible live connection to fuse bases shall be adequately shrouded. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage.

22.0 Bushings, Hollow Column Insulators, Support Insulators:

22.1 Bushings shall be manufactured and tested in accordance with IS:2099 & IEC-60137 while hollow column insulators shall be manufactured and tested in accordance with IEC-62155/IS:5621.The support insulators shall be manufactured and tested as per IS:2544/IEC-60168 and IEC-60273. The insulators shall also conform to IEC-60815 as applicable.

The bidder may also offer composite hollow insulators, conforming to IEC-61462.

22.2 Support insulators, bushings and hollow column insulators shall be manufactured from high quality porcelain. Porcelain used shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified tough and impervious to moisture.

22.3 Glazing of the porcelain shall be uniform brown in colour, free from blisters, burrs and similar other defects.

22.4 Support insulators/bushings/hollow column insulators shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which they will be used.

22.5 When operating at normal rated voltage there shall be no electric discharge between the conductors and bushing which would cause corrosion or injury to conductors, insulators or supports by the formation of substances produced by chemical action. No radio interference shall be caused by the insulators/bushings when operating at the normal rated voltage.

22.6 Bushing porcelain shall be robust and capable of withstanding the internal pressures likely to occur in service. The design and location of clamps and the shape and the strength of the porcelain flange securing the bushing to the tank shall be such that there is no risk of fracture. All portions of the assembled porcelain enclosures and supports other than gaskets, which may in any way be exposed to the atmosphere shall be composed of completely non hygroscopic material such as metal or glazed porcelain.

22.7 All iron parts shall be hot dip galvanised and all joints shall be air tight. Surface of joints shall be trued up porcelain parts by grinding and metal parts by machining. Insulator/bushing design shall be such as to ensure a uniform compressive pressure on the joints.

22.8 Tests

In bushing, hollow column insulators and support insulators shall conform to type tests and shall be subjected to routine tests in accordance with IS:2099 & IS:2544 & IS:5621.

~~22.9~~ **~~RTV Coating on porcelain insulators (for coastal area)~~**

~~RTV coating shall be done at site on all porcelain insulators (i.e. bushings, hollow and solid insulators, disc insulators etc.) for substation(s) in coastal area as defined elsewhere. The cost of RTV coating shall be deemed to be included in the respective~~

~~equipment/items' erection cost. The technical details of RTV coating is attached in Annexure-H.~~

23.0 MOTORS

Motors shall be "Squirrel Cage" three phase induction motors of sufficient size capable of satisfactory operation for the application and duty as required for the driven equipment and shall be subjected to routine tests as per applicable standards. The motors shall be of approved make.

23.1 Enclosures

a) Motors to be installed outdoor without enclosure shall have hose proof enclosure equivalent to IP-55 as per IS: 4691. For motors to be installed indoor i.e. inside a box, the motor enclosure, shall be dust proof equivalent to IP-44 as per IS: 4691.

b) Two independent earthing points shall be provided on opposite sides of the motor for bolted connection of earthing conductor.

c) Motors shall have drain plugs so located that they will drain water resulting from condensation or other causes from all pockets in the motor casing.

d) Motors weighing more than 25 Kg. shall be provided with eyebolts, lugs or other means to facilitate lifting.

23.2 Operational Features

a) Continuous motor rating (name plate rating) shall be at least ten (10) percent above the maximum load demand of the driven equipment at design duty point and the motor shall not be over loaded at any operating point of driven equipment that will rise in service.

b) Motor shall be capable at giving rated output without reduction in the expected life span when operated continuously in the system having the particulars as given in Clause 15.0 of this Section.

23.3 Starting Requirements:

a) All induction motors shall be suitable for full voltage direct-on-line starting. These shall be capable of starting and accelerating to the rated speed alongwith the driven equipment without exceeding the acceptable winding temperature even when the supply voltage drops down to 80% of the rated voltage.

b) Motors shall be capable of withstanding the electrodynamic stresses and heating imposed if it is started at a voltage of 110% of the rated value.

c) The locked rotor current shall not exceed six (6) times the rated full load current for all motors, subject to tolerance as given in IS:325.

d) Motors when started with the driven equipment imposing full starting torque under the supply voltage conditions specified under Clause 15.0 shall be capable of withstanding atleast two successive starts from cold condition at room temperature and one start from hot condition without injurious heating of winding. The motors shall also be suitable for three equally spread starts per hour under the above referred supply condition.

e) The locked rotor withstand time under hot condition at 110% of rated voltage shall be more than starting time with the driven equipment of minimum permissible voltage by at least two seconds or 15% of the accelerating time whichever is greater. In case it is not possible to meet the above requirement, the Bidder shall offer centrifugal type speed switch mounted on the motor shaft which shall remain closed for speed lower than 20% and open for speeds above

20% of the rated speed. The speed switch shall be capable of withstanding 120% of the rated speed in either direction of rotation.

23.4 Running Requirements:

a) The maximum permissible temperature rise over the ambient temperature of 50 degree C shall be within the limits specified in IS:325 (for 3-phase induction motors) after adjustment due to increased ambient temperature specified.

b) The double amplitude of motor vibration shall be within the limits specified in IS: 4729. Vibration shall also be within the limits specified by the relevant standard for the driven equipment when measured at the motor bearings.

c) All the induction motors shall be capable of running at 80% of rated voltage for a period of 5 minutes with rated load commencing from hot condition.

23.5 TESTING AND COMMISSIONING

An indicative list of tests is given below. Contractor shall perform any additional test based on specialities of the items as per the field Q.P./Instructions of the equipment Contractor or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates and shall furnish the list of instruments to the Employer for approval.

(a) Insulation resistance.

(b) Phase sequence and proper direction of rotation.

(c) Any motor operating incorrectly shall be checked to determine the cause and the conditions corrected.

24.

24.1

ANNEXURE-A

CORONA AND RADIO INTERFERENCE VOLTAGE (RIV) TEST

1. General

Unless otherwise stipulated, all equipment together with its associated connectors, where applicable, shall be tested for external corona (for 400kV & above) both by observing the voltage level for the extinction of visible corona under falling power frequency voltage and by measurement of radio interference voltage (RIV) for 132kV and above.

2. Test Levels:

The test voltage levels for measurement of external RIV and for corona extinction voltage are listed under the relevant clauses of the specification.

3. Test Methods for RIV:

3.1 RIV tests shall be made according to measuring circuit as per International Special-Committee on Radio Interference (CISPR) Publication 16-1(1993) Part -1. The measuring circuit shall preferably be tuned to frequency with 10% of 0.5 Mhz but other frequencies in the range of 0.5 MHz to 2 MHz may be used, the measuring frequency being recorded. The results shall be in microvolts.

3.2 Alternatively, RIV tests shall be carried out in accordance with relevant IEC of respective equipment or NEMA standard Publication No. 107-1964.

3.3 In measurement of, RIV, temporary additional external corona shielding may be provided. In measurements of RIV only standard fittings of identical type supplied with the equipment and a simulation of the connections as used in the actual installation will be permitted in the vicinity within 3.5 meters of terminals.

3.4 Ambient noise shall be measured before and after each series of tests to ensure that there is no variation in ambient noise level. If variation is present, the lowest ambient noise level will form basis for the measurements. RIV levels shall be measured at increasing and decreasing voltages of 85%, 100%, and 110% of the specified RIV test voltage for all equipment unless otherwise specified. The specified RIV test voltage for 765kV, 400 kV, 220 KV is listed in the detailed specification together with maximum permissible RIV level in microvolts.

3.5 The metering instruments shall be as per CISPR recommendation or equivalent device so long as it has been used by other testing authorities.

3.6 The RIV measurement may be made with a noise meter. A calibration procedure of the frequency to which noise meter shall be tuned shall establish the ratio of voltage at the high voltage terminal to voltage read by noise meter.

4. Test Methods for Visible Corona

The purpose of this test is to determine the corona extinction voltage of apparatus, connectors etc. The test shall be carried out in the same manner as RIV test described above with the exception that RIV measurements are not required during test and a search technique shall be used near the onset and extinction voltage, when the test voltage is raised and lowered to determine their precise values. The test voltage shall be raised to 110% of specified corona extinction voltage and maintained there for five minutes. In case corona inception does not take place at 110%, test shall be stopped, otherwise test shall be continued and the voltage will then be decreased slowly until all visible corona disappears. The procedure shall be repeated at least 4 times with corona inception and extinction voltage recorded each time. The corona extinction voltage for purposes of determining compliance with the specification shall be the lowest of the four values at which visible corona (negative or positive polarity) disappears. Photographs with laboratory in complete darkness shall be taken under test conditions, at all voltage steps i.e. 85%, 100%, and 110%. Additional photographs shall be taken at corona inception and extinction voltages. At least two views shall be photographed in each case using Panchromatic film with an ASA daylight rating of 400 with an exposure of two minutes at a lens aperture of f/5.6 or equivalent. The photographic process shall be such that prints are available for inspection and comparison with conditions as determined from direct observation. Photographs shall be taken from above and below the level of connector so as to show corona on bushing, insulators and all parts of energised connectors. The photographs shall be framed such that test object essentially, fills the frame with no cut-off.

For recording purpose, modern devices utilizing UV recording methods such as image intensifier may also be used.

4.1 The test shall be recorded on each photograph. Additional photograph shall be taken from each camera position with lights on to show the relative position of test object to facilitate precise corona location from the photographic evidence.

4.2 In addition to photographs of the test object preferably four photographs shall be taken of the complete test assembly showing relative positions of all the test equipment and test objects. These four photographs shall be taken from four points equally spaced around the test arrangement to show its features from all sides. Drawings of the laboratory and test set up locations shall be provided to indicate camera positions and angles. The precise location of camera shall be approved by Employer's inspector, after determining the best camera locations by trial energisation of test object at a voltage which results in corona.

4.3 The test to determine the visible corona extinction voltage need not be carried out simultaneously with test to determine RIV levels.

4.4 However, both test shall be carried out with the same test set up and as little time duration between tests as possible. No modification on treatment of the sample between tests will be allowed. Simultaneous RIV and visible corona extinction voltage testing may be permitted at the discretion of Employer's inspector if, in his opinion, it will not prejudice other test.

5. Test Records:

In addition to the information previously mentioned and the requirements specified as per CISPR or NEMA 107-1964 the following data shall be included in test report:

a) Background noise before and after test.

b) Detailed procedure of application of test voltage.

c) Measurements of RIV levels expressed in micro volts at each level.

d) Results and observations with regard to location and type of interference sources detected at each step.

e) Test voltage shall be recorded when measured RIV passes through 100 microvolts in each direction.

f) Onset and extinction of visual corona for each of the four tests required shall be recorded.

SEISMIC WITHSTAND TEST PROCEDURE

The seismic withstanding test on the complete equipment (for 132kV and above) shall be carried out alongwith supporting structure.

The Bidder shall arrange to transport the structure from his Contractor's premises/ POWERGRID sites for the purpose of seismic withstand test only.

The seismic level specified shall be applied at the base of the structure. The accelerometers shall be provided at the Terminal Pad of the equipment and any other point as agreed by the Employer. The seismic test shall be carried out in all possible combinations of the equipment. The seismic test procedure shall be furnished for approval of the Employer.

The frequency range for the earthquake spectra shall be as per IEC–6227-300.

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

LIST OF GENERAL STANDARDS AND CODES

CODES	TITLE
--	India Electricity Rules
--	Indian Electricity Act
--	Indian Electricity (Supply) Act
--	Indian Factories Act
IS-5	Colors for Ready Mixed Paints and Enamels
IS-335	New Insulating Oils
IS-617	Aluminium and Aluminium Alloy Ingots and Castings for General Engineering Purposes
IS-1448 (P1 to P 145)	Methods of Test for Petroleum and its Products
IS-2071 (P1 to P3)	Methods of High Voltage Testing
IS-12063	Classification of degrees of protection provided by enclosures of electrical equipment
IS-2165 ; P1:1997, P2:1983	Insulation Coordination
IS-3043	Code of Practice for Earthing
IS-6103	Method of Test for Specific Resistance (Resistivity) of Electrical Insulating Liquids
IS-6104	Method of Test for Interfacial Tension of Oil against Water by the Ring Method
IS-6262	Method of test for Power factor & Dielectric Constant of Electrical Insulating Liquids
IS-6792	Method for determination of electric strength of insulating oils
IS-5578	Guide for marking of insulated conductors
IS-11353	Guide for uniform system of marking & identification of conductors & apparatus terminals.
IS-8263	Methods for Radio Interference Test on High voltage Insulators
IS-9224 (Part 1,2&4)	Low Voltage Fuses
IEC-60060 (Part 1 to P4)	High Voltage Test Techniques
IEC 60068	Environmental Test
IEC-60117	Graphical Symbols
IEC-60156	Method for the Determination of the Electrical Strength of Insulation Oils
IEC-60270	Partial Discharge Measurements
IEC-60376	Specification and Acceptance of New Sulphur Hexafloride
IEC-60437	Radio Interference Test on High Voltage Insulators
IEC-60507	Artificial Pollution Tests on High Voltage Insulators to be used on AC Systems
IEC-62271-1	Common Specification for High Voltage Switchgear & Control gear Standards
IEC-60815	Guide for the Selection of Insulators in respect of Polluted Conditions

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

CODES	TITLE
IEC-60865 (P1 & P2)	Short Circuit Current - Calculation of effects
ANSI-C.1/NFPA.70	National Electrical Code
ANSI-C37.90A	Guide for Surge Withstand Capability (SWC) Tests
ANSI-C63.21, C63.3	Specification for Electromagnetic Noise and Field Strength Instrumentation 10 KHz to 1 GHZ
C36.4ANSI-C68.1	Techniquest for Dielectric Tests
ANSI-C76.1/EEE21	Standard General Requirements and Test Procedure for Outdoor Apparatus Bushings
ANSI-SI-4	Specification for Sound Level Meters
ANSI-Y32-2/C337.2	Drawing Symbols
ANSI-Z55.11	Gray Finishes for Industrial Apparatus and Equipment No. 61 Light Gray
NEMA-107T	Methods of Measurements of RIV of High Voltage Apparatus
NEMA-ICS-II	General Standards for Industrial Control and Systems Part ICSI-109
CISPR-1	Specification for CISPR Radio Interference Measuring Apparatus for the frequency range 0.15 MHz to 30 MHz
CSA-Z299.1-1978h	Quality Assurance Program Requirements
CSA-Z299.2-1979h	Quality Control Program Requirements
CSA-Z299.3-1979h	Quality Verification Program Requirements
CSA-Z299.4-1979h	Inspection Program Requirements
TRANSFORMERS AND REACTORS	
IS:10028 (Part 2 & 3)	Code of practice for selection, installation & maintenance of Transformers (P1:1993), (P2:1991), (P3:1991)
IS-2026 (P1 to P4)	Power Transformers
IS-3347 (part 1 to Part 8)	Dimensions for Porcelain transformer Bushings for use in lightly polluted atmospheres
IS-3639	Fittings and Accessories for Power Transformers
IS-6600	Guide for Loading of oil immersed Transformers
IEC-60076 (Part 1 to 5)	Power Transformers
IEC-60214	On-Load Tap-Changers
IEC-60289	Reactors
IEC- 60354	Loading Guide for Oil - Immersed power transformers
IEC-60076-10	Determination of Transformer and Reactor Sound Levels
ANSI-C571280	General requirements for Distribution, Power and Regulating Transformers
ANSI-C571290	Test Code for Distribution, Power and Regulation Transformers
ANSI-C5716	Terminology & Test Code for Current Limiting Reactors
ANSI-C5721	Requirements, Terminology and Test Code for Shunt Reactors Rated Over 500 KVA
ANSI-C5792	Guide for Loading Oil-Immersed Power Transformers upto and including 100 MVA with 55 deg C or 65 deg C Winding Rise

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

CODES	TITLE
ANSI-CG,1EEE-4	Standard Techniques for High Voltage Testing
IEC 60076	Power transformers
IEC 60076-1	Part 1: General
IEC 60076-2	Part 2: Temperature rise
IEC 60076-3	Part 3: Insulation levels, dielectric tests and external clearances in air
IEC 60076-4	Part 4: Guide to the lightning impulse and switching impulse testing - Power transformers and reactors
IEC 60076-3-1	Part 3-1: Insulation Levels and Dielectric Tests –External Clearances in Air
IEC 60076-5	Part 5: Ability to withstand short circuit
IEC 60076-6	Part 6: Reactors
IEC 60076-7	Part 7: Loading guide for oil-immersed power transformers
IEC 60076-8	Part 8: Application guide
IEC 60076-10	Part 10: Determination of sound levels
IEC 60076-10-1	Part 10-1: Determination of sound levels - Application guide
IEC 60076-11	Part 11: Dry-type transformers
IEC 60076-12	Part 12: Loading guide for dry-type power transformers
IEC 60076-13	Part 13: Self-protected liquid-filled transformers
IEC 60076-14	Part 14: Design and application of liquid-immersed power transformers using high-temperature insulation materials
IEC 60076-15	Part 15: Gas-filled power transformers
IEC 60076-16	Part 16: Transformers for wind turbine applications
IEC 60076-18	Part 18: Measurement of frequency response
IEC 60076-19	Part 19: Rules for the determination of uncertainties in the measurement of losses in power transformers and reactors
IEC 60076-21	Part 21: Standard requirements, terminology, and test code for step-voltage regulators
IEC 60044, BS 3938	Current transformers
IEC 60050	International Electrotechnical Vocabulary
IEC 60050(421)	International Electrotechnical vocabulary- Chapter 421 : Power Transformers and Reactors
IEC 60060	High Voltage test techniques
IEC 60060-1	General definitions and test requirements
IEC 60060-2	Measuring systems
IEC 60071	Insulation co-ordination
IEC 60071-1	Part 1: Definitions, principles and rules
IEC 60071-2	Part 2 : Application guide
IEC 60137	Bushing for alternating voltage above 1000V
IEC 60214	On-Load Tap changers
IEC 255-21-3	Relays vibration

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

CODES	TITLE
IEC 60270	Partial discharge measurements
IEC 60296	Specification for Unused Mineral Oil for Transformers and Switchgear
IEC 60422	Supervision and Maintenance guide for Mineral Insulating Oil in Electrical Equipment
IEC 60475	Method of Sampling Liquid dielectrics
IEC 60529	Classification of Degrees of Protection provided by Enclosures
IEC 60542	Application Guide for On-Load Tap-Changers
IEC 60567	Guide for the Sampling of Gases and of Oil from Oil-filled Electrical Equipment for the Analysis of Free and Dissolved Gases
IEC 60651	Sound Level Meters
IEC 61083	Digital Recorders and Software for High Voltage Impulse testing
IEC 61083-1	Part 1: Requirements for digital recorders in high voltage impulse tests
IEC 61083-2	Part 2: Evaluation of software used for the determination of the parameters of impulse waveforms
CISPR 16	Specification for radio disturbance and immunity measuring apparatus
CISPR 16-1	Radio disturbance and immunity measuring apparatus
CISPR-18	Radio Interference Characteristics of Power Lines and High Voltage Equipment
ISO 9001	Quality system-Model for Quality Assurance in Design /development
Cigre Publication 202	Guidelines for conducting design reviews for transformers 100 MVA and 123 kV and above. August 2002-Cigre Working Group 12.22
WG 12-15	Guide for Customers Specifications for Transformers 100 MVA and 123 kV and above
WG 12 19	Short Circuit Performance of Transformers.
BS-4360	Specification for weldable structural steel
BS-5135	Specification for arc welding of carbon and carbon manganese steels
BS-5500	Specification for unfired fusion welded pressure vessels
IS-3618	Specification for phosphate treatment of iron & steel for protection against corrosion
IS-6005	Code of practice for phosphating of Iron and Steel
ISO-8501	Preparation of steel surface before application of Paints and related product
IEC-60599	Mineral oil impregnated electrical equipment in service – guide to the interpretation of dissolved and free gases analysis
IS-10593	Method of evaluating the analysis of gases in oil filled electrical equipment in service
IS-2099	Bushings for alternating voltages above 1000 volts

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

CODES	TITLE
IS-3347 Part I to 8	Dimension for porcelain transformer bushing
DIN-42530	Bushing up to 1000kV from 250A-5000A for liquid filled Transformer
IS-2026 Part 1 to 5	Power transformer
IS-4691	Degrees of protection provided by enclosure for rotating electrical machinery
IEC-60034-5	Degrees of protection provided by integral design of rotating electrical machines(IP Code) classification
IS:325 / IEC -60034	Performance of cooling fan / oil pump motor
IS-13947 part 1 to 5	Specification for low voltage switchgear and control gear
IS:3400	Methods of test for vulcanised rubber
IS:7016 part 1 to 14	Methods of test for coated and treated fabrics
IS:803	Code of practice for design, fabrication and erection of vertical mild steel cylindrical welded oil storage tanks.
IS:3637	Gas operated Relays
IS:335	New Insulating oils – Specification
IEC-62271-203	Gas insulated metal enclosed switchgear for rated voltage above 52kV
IEC-61639	Direct connection between power transformers and gas-insulated metal enclosed switchgear for rated voltages of 52.5 kV and above.
IS:3400 / BS 903 / IS:7016	Air cell (Flexible Air Separator)
IEC 60529 / IP : 55	Degree of protection for cooler control cabinet , MOLG, Cooling fan , oil pump, Buchholz Relay
IEC 60529 / IP : 56	Degree of protection for Pressure Relief Device
IEC 60529 / IP : 43	Degree of protection for Remote tap Changer cubicle (RTCC)
CIRCUIT BREAKERS	
IEC-62271-100	High-voltage switchgear and control gear - Part 100: Alternating current circuit-breakers
IEC-62271-101	High-voltage switchgear and control gear - Part 101: Synthetic testing
IEC-62155	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1000 V
IEC-62271-110	High-voltage switchgear and control gear - Part 110: Inductive load switching
IEC-62271-109	High-voltage switchgear and control gear - Part 110: Inductive load switching
CURRENT TRANSFORMERS, VOLTAGE TRANSFORMERS AND COUPLING CAPACITOR VOLTAGE TRANSFORMERS	
IS-2705- (P1 to P4)	Current Transformers

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

CODES	TITLE
IS:3156- (P1 to P4)	Voltage Transformers
IS-4379	Identification of the Contents of Industrial Gas Cylinders
IEC-61869 (Part-1)	Instrument transformers - Part 1: General requirements
IEC-61869 (Part-2)	Instrument transformers - Part 2: Additional requirements for current transformers
IEC-61869 (Part-3)	Instrument transformers - Part 3: Additional requirements for inductive voltage transformers
IEC-61869 (Part-4)	Instrument transformers - Part 4: Additional requirements for combined transformers
IEC-61869 (Part-5)	Instrument transformers - Part 5: Additional requirements for capacitor voltage transformers
IEC-61869 (Part-6)	Instrument transformers - Part 6: Additional general requirements for low-power instrument transformers
IEC-61869 (Part-9)	Instrument transformers - Part 9: Digital interface for instrument transformers
IEC-61869 (Part-102)	Instrument transformers - Part 102: Ferroresonance oscillations in substations with inductive voltage transformers
IEC-61869 (Part-103)	Instrument transformers - The use of instrument transformers for power quality measurement
BUSHING	
IS-2099	Bushings for Alternating Voltages above 1000V
IEC-60137	Insulated Bushings for Alternating Voltages above 1000V
SURGE ARRESTERS	
IS-3070 (PART2)	Lightning arresters for alternating current systems : Metal oxide lightning arrestors without gaps
IEC-60099-4	Metal oxide surge arrestors without gaps
IEC-60099-5	Selection and application recommendation
ANSI-C62.1	IEE Standards for S A for AC Power Circuits
NEMA-LA 1	Surge Arresters
CUBICLES AND PANELS & OTHER RELATED EQUIPMENTS	
IS-722, IS-1248	Electrical relays for power system
IS-3231, 3231 (P-3)	Protection
IS:5039	Distributed pillars for Voltages not Exceeding 1000 Volts
IEC-60068.2.2	Basic environmental testing procedures Part 2: Test B: Dry heat
IEC-60529	Degree of Protection provided by enclosures
IEC-60947-4-1	Low voltage switchgear and control gear
IEC-61095	Electromechanical Contactors for household and similar purposes
IEC-60439 (P1 & 2)	Low Voltage Switchgear and control gear assemblies
ANSI-C37.20	Switchgear Assemblies, including metal enclosed bus
ANSI-C37.50	Test Procedures for Low Voltage Alternating Current Power

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

CODES	TITLE
	Circuit Breakers
ANSI-C39	Electric Measuring instrument
ANSI-C83	Components for Electric Equipment
IS: 8623: (Part I to 3)	Specification for Switchgear & Control Assemblies
NEMA-AB	Moulded Case Circuit and Systems
NEMA-CS	Industrial Controls and Systems
NEMA-PB-1	Panel Boards
NEMA-SG-5	Low voltage Power Circuit breakers
NEMA-SG-3	Power Switchgear Assemblies
NEMA-SG-6	Power switching Equipment
NEMA-5E-3	Motor Control Centers
1248 (P1 to P9)	Direct acting indicating analogue electrical measuring instruments & their accessories
Disconnecting switches	
IEC-62271-102	High-voltage switchgear and control gear - Part 102: Alternating current disconnectors and earthing switches
IEC-60265 (Part 1 & 2)	High Voltage switches
ANSI-C37.32	Schedule of preferred Ratings, Manufacturing Specifications and Application Guide for high voltage Air Switches, Bus supports and switch accessories
ANSI-C37.34	Test Code for high voltage air switches
NEMA-SG6	Power switching equipment
PLCC and line traps	
IS-8792	Line traps for AC power system
IS-8793	Methods of tests for line traps
IS-8997	Coupling devices for PLC systems
IS-8998	Methods of test for coupling devices for PLC systems
IEC-60353	Line traps for A.C. power systems
IEC-60481	Coupling Devices for power line carrier systems
IEC-60495	Single sideboard power line carrier terminals
IEC-60683	Planning of (single Side-Band) power line carrier systems
CIGRE	Teleprotection report by Committee 34 & 35
CIGRE	Guide on power line carrier 1979
CCIR	International Radio Consultative Committee
CCITT	International Telegraph & Telephone Consultative Committee
EIA	Electric Industries Association
Protection and control equipment	
IEC-60051: (P1 to P9)	Recommendations for Direct Acting indicating analogue electrical measuring instruments and their accessories
IEC-60255 (Part 1 to 23)	Electrical relays
IEC-60297 (P1 to P4)	Dimensions of mechanical structures of the 482.6mm (19 inches)

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

CODES	TITLE
	series
IEC-60359	Expression of the performance of electrical & electronic measuring equipment
IEC-60387	Symbols for Alternating-Current Electricity meters
IEC-60447	Man machine interface (MMI) - Actuating principles
IEC-60521	Class 0.5, 1 and 2 alternating current watt hour metres
IEC-60547	Modular plug-in Unit and standard 19-inch rack mounting unit based on NIM Standard (for electronic nuclear instruments)
ANSI-81	Screw threads
ANSI-B18	Bolts and Nuts
ANSI-C37.1	Relays, Station Controls etc
ANSI-C37.2	Manual and automatic station control, supervisory and associated telemetering equipment
ANSI-C37.2	Relays and relay systems associated with electric power apparatus
ANSI-C39.1	Requirements for electrical analog indicating instruments
MOTORS	
IS-325	Three phase induction motors
IS-4691	Degree of protection provided by enclosure for rotating electrical machinery
IEC-60034 (P1 to P19:)	Rotating electrical machines
IEC-Document 2	Three phase induction motors
(Central Office) NEMA-MGI	Motors and Generators
Electronic equipment and components	
MIL-21B, MIL-833 & MIL-2750	Environmental testing
EC-60068 (P1 to P5)	Printed boards
IEC-60326 (P1 to P2)	Material and workmanship standards
IS-1363 (P1 to P3)	Hexagon head bolts, screws and nuts of product grade C
IS-1364 (P1 to P5)	Hexagon head bolts, screws and nuts of products grades A and B
IS-3138	Hexagonal Bolts and Nuts (M42 to M150)
ISO-898	Fasteners: Bolts, screws and studs
ASTM	Specification and tests for materials
Clamps & connectors	
IS-5561	Electric power connectors
NEMA-CC1	Electric Power connectors for sub station
NEMA-CC 3	Connectors for Use between aluminium or aluminum-Copper Overhead Conductors
Bus hardware and insulators	
IS: 2121	Fittings for Aluminum and steel cored Al conductors for overhead

CODES	TITLE
	power lines
IS-731	Porcelain insulators for overhead power lines with a nominal voltage greater than 1000 V
IS-2486 (P1 to P4)	Insulator fittings for overhead power lines with a nominal voltage greater than 1000 V
IEC-60120	Dimensions of Ball and Socket Couplings of string insulator units
IEC-60137	Insulated bushings for alternating voltages above 1000 V
IEC-60168	Tests on indoor and outdoor post insulators of ceramic material or glass for Systems with Nominal Voltages Greater than 1000 V
IEC-62155	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V
IEC-60273	Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1000V
IEC-61462	Pressurized and un-pressurized insulator for use in electrical equipment with rated voltage greater than 1000V – Definitions, Test methods, acceptance criteria and design recommendations
IEC-60305	Insulators for overhead lines with nominal voltage above 1000V-ceramic or glass insulator units for ac systems Characteristics of String Insulator Units of the cap and pin type
IEC-60372 (1984)	Locking devices for ball and socket couplings of string insulator units : dimensions and tests
IEC-60383 (P1 and P2)	Insulators for overhead lines with a nominal voltage above 1000 V
IEC-60433	Characteristics of string insulator units of the long rod type
IEC-60471	Dimensions of Clevis and tongue couplings of string insulator units
ANSI-C29	Wet process porcelain insulators
ANSI-C29.1	Test methods for electrical power insulators
ANSI-C92.2	For insulators, wet-process porcelain and toughened glass suspension type
ANSI-C29.8	For wet-process porcelain insulators apparatus, post-type
ANSI-G.8	Iron and steel hardware
CISPR-7B	Recommendations of the CISPR, tolerances of form and of Position, Part 1
ASTM A-153	Zinc Coating (Hot-Dip) on iron and steel hardware
Strain and rigid bus-conductor	
IS-2678	Dimensions & tolerances for Wrought Aluminum and Aluminum Alloys drawn round tube
IS-5082	Wrought Aluminum and Aluminum Alloy Bars. Rods, Tubes and Sections for Electrical purposes
ASTM-B 230-82	Aluminum 1350 H19 Wire for electrical purposes

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

CODES	TITLE
ASTM-B 231-81	Concentric - lay - stranded, aluminum 1350 conductors
ASTM-B 221	Aluminum - Alloy extruded bar, road, wire, shape
ASTM-B 236-83	Aluminum bars for electrical purpose (Bus-bars)
ASTM-B 317-83	Aluminum-Alloy extruded bar, rod, pipe and structural shapes for electrical purposes (Bus Conductors)
Batteries	
IS:1651	Stationary Cells and Batteries, Lead-Acid Type (with Tubular Positive Plates)
IS:1652	Stationary Cells and Batteries, Lead-Acid Type (with Plante Positive Plates)
IS:1146	Rubber and Plastic Containers for Lead-Acid Storage Batteries
IS:6071	Synthetic Separators for Lead-Acid Batteries
IS:266	Specification for Sulphuric Acid
IS:1069	Specification for Water for Storage Batteries
IS:3116	Specification for Sealing Compound for Lead-Acid Batteries
IS:1248	Indicating Instruments
IS:10918	Vented type nickel Cadmium Batteries
IEC:60896-21&22	Lead Acid Batteries Valve Regulated types – Methods of Tests & Requirements
IEC: 60623	Vented type nickel Cadmium Batteries
IEC:60622	Secondary Cells & Batteries – Sealed Ni-Cd rechargeable single cell
IEC:60623	Secondary Cells & Batteries – Vented Ni-Cd rechargeable single cell
IEC:60896-11	Stationary Lead Acid Batteries – Vented Type – General requirements & method of tests
IEEE-485	Recommended practices for sizing of Lead Acid Batteries
IEEE-1115	Sizing of Ni-Cd Batteries
IEEE-1187	Recommended practices for design & installation of VRLA Batteries
IEEE-1188	Recommended practices for design & installation of VRLA Batteries
IEEE-1189	Guide for selection of VRLA Batteries
Battery Charger	
IS:3895	Mono-crystalline Semiconductor Rectifier Cells and Stacks
IS:4540	Mono-crystalline Semiconductor Rectifier Assemblies and Equipment
IS:6619	Safety Code for Semiconductor Rectifier Equipment
IS:2026	Power Transformers
IS:2959	AC Contactors for Voltages not Exceeding 1000 Volts

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

CODES	TITLE
IS:1248	Indicating Instruments
IS:2208	HRC Fuses
IS:13947 (Part-3)	Air break switches, air break disconnectors & fuse combination units for voltage not exceeding 1000V AC or 1200V DC
IS:2147	Degree of protection provided by enclosures for low voltage switchgear and control gear
IS:6005	Code of practice for phosphating of Iron and Steel
IS:3231	Electrical relays for power system protection
IS:3842	Electrical relay for AC Systems
IS:5	Colours for ready mix paint
IEEE-484	Recommended Design for installation design and installation of large lead storage batteries for generating stations and substations
IEEE-485	Sizing large lead storage batteries for generating stations and substations
Wires and cables	
ASTMD-2863	Measuring the minimum oxygen concentration to support candle like combustion of plastics (oxygen index)
IS-694	PVC insulated cables for working voltages upto and including 1100 Volts
IS-1255	Code of practice for installation and maintenance of power cables, upto and including 33 kV rating
IS-1554 (P1 and P2)	PVC insulated (heavy duty) electric cables (part 1) for working voltage upto and including 1100 V Part (2) for working voltage from 3.3 kV upto and including 11kV
IS:1753	Aluminium conductor for insulated cables
IS:2982	Copper Conductor in insulated cables
IS-3961 (P1 to P5)	Recommended current ratings for cables
IS-3975	Mild steel wires, formed wires and tapes for armouring of cables
IS-5831	PVC insulating and sheath of electric cables
IS-6380	Elastometric insulating and sheath of electric cables
IS-7098	Cross linked polyethylene insulated PVC sheathed cables for working voltage upto and including 1100 volts
IS-7098	Cross-linked polyethyle insulated PVC sheathed cables for working voltage from 3.3kV upto and including 33 kV
IS-8130	Conductors for insulated electrical cables and flexible cords
IS-1753	Aluminum Conductors for insulated cables
IS-10418	Specification for drums for electric cables
IEC-60096 (part 0 to p4)	Radio Frequency cables
IEC-60183	Guide to the Selection of High Voltage Cables
IEC-60189 (P1 to P7)	Low frequency cables and wires with PVC insulation and PVC sheath

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

CODES	TITLE
IEC-60227 (P1 to P7)	Polyvinyl Chloride insulated cables of rated voltages up to and including 450/750V
IEC-60228	Conductors of insulated cables
IEC-60230	Impulse tests on cables and their accessories
IEC-60287 (P1 to P3)	Calculation of the continuous current rating of cables (100% load factor)
IEC-60304	Standard colours for insulation for low-frequency cables and wires
IEC-60331	Fire resisting characteristics of Electric cables
IEC-60332 (P1 to P3)	Tests on electric cables under fire conditions
IEC-60502	Extruded solid dielectric insulated power cables for rated voltages from 1 kV upto to 30 kV
IEC-754 (P1 and P2)	Tests on gases evolved during combustion of electric cables
AIR conditioning and ventilation	
IS-659	Safety code for air conditioning
IS-660	Safety code for Mechanical Refrigeration
ARI:520	Standard for Positive Displacement Refrigeration Compressor and Condensing Units
IS:4503	Shell and tube type heat exchanger
ASHRAE-24	Method of testing for rating of liquid coolers
ANSI-B-31.5	Refrigeration Piping
IS:2062	Steel for general structural purposes
IS:655	Specification for Metal Air Dust
IS:277	Specification for Galvanised Steel Sheets
IS-737	Specification for Wrought Aluminium and Aluminium Sheet & Strip
IS-1079	Hot rolled cast steel sheet & strip
IS-3588	Specification for Electrical Axial Flow Fans
IS-2312	Propeller Type AC Ventilation Fans
BS-848	Methods of Performance Test for Fans
BS-6540 Part-I	Air Filters used in Air Conditioning and General Ventilation
BS-3928	Sodium Flame Test for Air Filters (Other than for Air Supply to I.C. Engines and Compressors)
US-PED-2098	Method of cold DOP & hot DOP test
MIL-STD-282	DOP smoke penetration method
ASHRAE-52	Air cleaning device used in general ventilation for removing particle matter
IS:3069	Glossary of Terms, Symbols and Units Relating to Thermal Insulation Materials
IS:4671	Expanded Polystyrene for Thermal Insulation Purposes
IS:8183	Bonded Mineral Wool
IS:3346	Evaluation of Thermal Conductivity properties by means of

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

CODES	TITLE
	guarded hot plate method
ASTM-C-591-69	Standard specification for rigid preformed cellular urethane thermal insulation
IS:4894	Centrifugal Fans
BS:848	Method of Performance Test for Centrifugal Fans
IS:325	Induction motors, three-phase
IS:4722	Rotating electrical machines
IS:1231	Three phase foot mounted Induction motors, dimensions of
IS:2233	Designations of types of construction and mounting arrangements of rotating electrical machines
IS:2254	Vertical shaft motors for pumps, dimensions of
IS:7816	Guide for testing insulation resistance of rotating machines
IS:4029	Guide for testing three phase induction motors
IS: 4729	Rotating electrical machines, vibration of, Measurement and evaluation of
IS:4691	Degree of protection provided by enclosures for rotating electrical machinery
IS:7572	Guide for testing single-phase ac motors
IS:2148	Flame proof enclosure for electrical apparatus
BS:4999(Part-51)	Noise levels
Galvanizing	
IS-209	Zinc Ingot
IS-2629	Recommended Practice for Hot-Dip galvanizing on iron and steel
IS-2633	Methods for testing uniformity of coating of zinc coated articles
ASTM-A-123	Specification for zinc (Hot Galavanizing) Coatings, on products Fabricated from rolled, pressed and forged steel shapes, plates, bars and strips
ASTM-A-121-77	Zinc-coated (Galvanized) steel barbed wire
Painting	
IS-6005	Code of practice for phosphating of iron and steel
ANSI-Z551	Gray finishes for industrial apparatus and equipment
SSPEC	Steel structure painting council
Fire protection system	
--	Fire protection manual issued by tariff advisory committee (TAC) of India
HORIZONTAL CENTRIFUGAL PUMPS	
IS:1520	Horizontal centrifugal pumps for clear, cold and fresh water
IS:9137	Code for acceptance test for centrifugal & axial pumps
IS:5120	Technical requirement – Rotodynamic special purpose pumps
API-610	Centrifugal pumps for general services Hydraulic Institutes Standards

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

CODES	TITLE
BS:599	Methods of testing pumps
PTC-8.2	Power Test Codes - Centrifugal pumps
DIESEL ENGINES	
IS:10000	Methods of tests for internal combustion engines
IS:10002	Specification for performance requirements for constant speed compression ignition engines for general purposes (above 20 kW)
BS:5514	The performance of reciprocating compression ignition (Diesel) engines, utilizing liquid fuel only, for general purposes
ISO:3046	Reciprocating internal combustion engines performance
IS:554	Dimensions for pipe threads where pressure tight joints are required on threads
ASME Power Test Code	Internal combustion engine PTC-17
--	Codes of Diesel Engine Manufacturer's Association, USA
PIPING VALVES & SPECIALITIES	
IS:636	Non percolating flexible fire-fighting delivery hose
IS:638	Sheet rubber jointing and rubber inserting jointing
IS:778	Gun metal gate, globe and check valves for general purpose
IS:780	Sluice valves for water works purposes (50 to 300 mm)
IS:901	Couplings, double male and double female instantaneous pattern for fire fighting
IS:902	Suction hose couplings for fire-fighting purposes
IS:903	Fire hose delivery couplings branch pipe nozzles and nozzle spanner
IS:1538	Cast iron fittings for pressure pipes for water, gas and sewage
IS:1903	Ball valve (horizontal plunger type) including floats for water supply purposes
IS:2062	SP for weldable structural steel
IS:2379	Colour Code for the identification of pipelines
IS:2643	Dimensions of pipe threads for fastening purposes
IS:2685	Code of Practice for selection, installation and maintenance of sluice valves
IS:2906	Sluice valves for water-works purposes (350 to 1200 mm size)
IS:3582	Basket strainers for fire-fighting purposes (cylindrical type)
IS:3589	Electrically welded steel pipes for water, gas and sewage (150 to 2000 mm nominal diameter)
IS:4038	Foot valves for water works purposes
IS:4927	Unlined flax canvas hose for fire fighting
IS:5290	Landing valves (internal hydrant)
IS:5312 (Part-I)	Swing check type reflex (non-return) valves
IS:5306	Code of practice for fire extinguishing installations and equipment on premises

CODES	TITLE
Part-I	Hydrant systems, hose reels and foam inlets
Part-II	Sprinkler systems
BS:5150	Specification for cast iron gate valves
MOTORS & ANNUNCIATION PANELS	
IS:325	Three phase induction motors
IS:900	Code of practice for installation and maintenance of induction motors
IS:996	Single phase small AC and universal electric motors
IS:1231	Dimensions of three phase foot mounted induction motors
IS:2148	Flame proof enclosure of electrical apparatus
IS:2223	Dimensions of flange mounted AC induction motors
IS:2253	Designations for types of construction and mounting arrangements of rotating electrical machines
IS:2254	Dimensions of vertical shaft motors for pumps
IS:3202	Code of practice for climate proofing of electrical equipment
IS:4029	Guide for testing three phase induction motors
IS:4691	Degree of protection provided by enclosure for rotating electrical machinery
IS:4722	Rotating electrical machines
IS:4729	Measurement and evaluation of vibration of rotating electrical machines
IS:5572	Classification of hazardous areas for electrical (Part-I) installations (Areas having gases and vapours)
IS:6362	Designation of methods of cooling for rotating electrical machines
IS:6381	Construction and testing of electrical apparatus with type of protection 'e'
IS:7816	Guide for testing insulation for rotating machine
IS:4064	Air break switches
IEC DOCUMENT 2 (Control Office) 432	Three Phase Induction Motor
VDE 0530 Part I/66	Three Phase Induction Motor
IS:9224 (Part-II)	HRC Fuses
IS:6875	Push Button and Control Switches
IS:694	PVC Insulated cables
IS:1248	Indicating instruments
IS:375	Auxiliary wiring & busbar markings
IS:2147	Degree of protection
IS:5	Colour Relay and timers
IS:2959	Contactors
PG Test Procedures	

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

CODES	TITLE
NFPA-13	Standard for the installation of sprinkler system
NFPA-15	Standard for water spray fixed system for the fire protection
NFPA-12A	Standard for Halong 1301 Fire Extinguishing System
NFPA-72E	Standard on Automatic Fire Detectors
--	Fire Protection Manual by TAC (Latest Edition)
NFPA-12	Standard on Carbon dioxide extinguisher systems
IS:3034	Fire of industrial building
--	Electrical generating and distributing stations code of practice
IS:2878	CO2 (Carbon dioxide) Type Extinguisher
IS:2171	DC (Dry Chemical Powder) type
IS:940	Pressurised Water Type
D.G. SET	
IS:10002	Specification for performance requirements for constant speed compression ignition (diesel engine) for general purposes
IS:10000	Method of tests for internal combustion engines
IS:4722	Rotating electrical machines-specification
IS:12063	Degree of protection provided by enclosures
IS:12065	Permissible limit of noise levels for rotating electrical machines
--	Indian Explosive Act 1932
Steel structures	
IS-228 (1992)	Method of Chemical Analysis of pig iron, cast iron and plain carbon and low alloy steels.
IS-802 (P1 to 3)	Code of practice for use of structural steel in overhead transmission line towers
IS-806	Code of practice for use of steel tubes in general building construction
IS-808	Dimensions for hot rolled steel beam, column channel and angle sections
IS-814	Covered electrodes for manual arc welding of carbon of carbon manganese steel
IS-816	Code of Practice for use of metal arc welding for general construction in Mild steel
IS-817	Code of practice for training and testing of metal arc welders. Part 1 : Manual Metal arc welding
IS-875 (P1 to P4)	Code of practice for design loads (other than earthquake) for buildings and structures
IS-1161	Steel tubes for structural purposes
IS-1182	Recommended practice for radiographic examination of fusion welded butt joints in steel plates
IS-1363 (P1 to P3)	Hexagonal head bolts, screws & nuts of products grade C
IS-1364	Hexagon head bolts, screws and nuts of product grades A and B
IS-1367 (P1 to P18)	Technical supply condition for threaded steel fasteners

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

CODES	TITLE
IS-1599	Methods for bend test
IS-1608	Method for tensile testing of steel products
IS-1893	Criteria for earthquake resistant design of structures
IS-1978	Line Pipe
IS-2062	Steel for general structural purposes
IS-2595	Code of practice for Radiographic testing
IS-3063	Single coil rectangular section spring washers for bolts, nuts and screws
IS-3664	Code of practice for ultrasonic pulse echo testing by contact and immersion methods
IS-7205	Safety code for erection of structural steel work
IS-9595	Recommendations for metal arc welding of carbon and carbon manganese steels
ANSI-B18.2.1	Inch series square and Hexagonal bolts and screws
ANSI-B18.2.2	Square and hexagonal nuts
ANSI-G8.14	Round head bolts
ASTM-A6	Specification for General Requirements for rolled steel plates, shapes, sheet piling and bars of structural use
ASTM-A36	Specifications of structural steel
ASTM-A47	Specification for malleable iron castings
ASTM-A143	Practice for safeguarding against embilement of Hot Galvanized structural steel products and procedure for detaching embrilement
ASTM-A242	Specification for high strength low alloy structural steel
ASTM-A283	Specification for low and intermediate tensile strength carbon steel plates of structural quality
ASTM-A394	Specification for Galvanized steel transmission tower bolts and nuts
ASTM-441	Specification for High strength low alloy structural manganese vanadium steel
ASTM-A572	Specification for High strength low alloy colombium-Vanadium steel of structural quality
AWS D1-0	Code for welding in building construction welding inspection
AWS D1-1	Structural welding code
AISC	American institute of steel construction
NEMA-CG1	Manufactured graphite electrodes
Piping and pressure vessels	
IS-1239 (Part 1 and 2)	Mild steel tubes, tubulars and other wrought steel fittings
IS -3589	Seamless Electrically welded steel pipes for water, gas and sewage
IS-6392	Steel pipe flanges
ASME	Boiler and pressure vessel code

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

CODES	TITLE
ASTM-A120	Specification for pipe steel, black and hot dipped, zinc-coated (Galvanized) welded and seamless steel pipe for ordinary use
ASTM-A53	Specification for pipe, steel, black, and hot-dipped, zinc coated welded and seamless
ASTM-A106	Seamless carbon steel pipe for high temperature service
ASTM-A284	Low and intermediate tensile strength carbon-silicon steel plates for machine parts and general construction
ASTM-A234	Pipe fittings of wrought carbon steel and alloy steel for moderate and elevated temperatures
ASTM-S181	Specification for forgings, carbon steel for general purpose piping
ASTM-A105	Forgings, carbon steel for piping components
ASTM-A307	Carbon steel externally threated standard fasteners
ASTM-A193	Alloy steel and stainless steel bolting materials for high temperature service
ASTM-A345	Flat rolled electrical steel for magnetic applications
ASTM-A197	Cupola malleable iron
ANSI-B2.1	Pipe threads (Except dry seal)
ANSI-B16.1	Cast iron pipe flangesand glanged fitting. Class 25, 125, 250 and 800
ANSI-B16.1	Malleable iron threaded fittings, class 150 and 300
ANSI-B16.5	Pipe flanges and flanged fittings, steel nickel alloy and other special alloys
ANSI-B16.9	Factory-made wrought steel butt welding fittings
ANSI-B16.11	Forged steel fittings, socket-welding and threaded
ANSI-B16.14	Ferrous pipe plug, bushings and locknuts with piple threads
ANSI-B16.25	Butt welding ends
ANSI-B18.1.1	Fire hose couplings screw thread
ANSI-B18.2.1	Inch series square and hexagonal bolts and screws
ANSI-B18.2.2	Square and hexagonal nuts
NSI-B18.21.1	Lock washers
ANSI-B18.21.2	Plain washers
ANSI-B31.1	Power piping
ANSI-B36.10	Welded and seamless wrought steel pipe
ANSI-B36.9	Stainless steel pipe
Other civil works standards	
IS-269	33 grade ordinary portland cement
IS2721	Galvanized steel chain link fence fabric
IS-278	Galvanized steel barbed wire for fencing
IS-383	Coarse and fine aggregates from natural sources for concrete
IS-432 (P1 and P2)	Mild steel and medium tensile steel bars and hard-dawn steel wire for concrete reinforcement

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

CODES	TITLE
IS-456	Code of practice for plain and reinforced concrete
IS-516	Method of test for strength of concrete
IS-800	Code of practice for general construction in steel
IS-806	Steel tubes for structural purposes
IS-1172	Basic requirements for water supply, drainage and sanitation
IS-1199	Methods of sampling and analysis of concrete
IS-1566	Hard-dawn steel wire fabric for concrete reinforcement
IS-1742	Code of Practice for Building drainage
IS-1785	Plain hard-drawn steel wire for pre-stressed concrete
IS-1786	High strength deformed Steel Bars and wires for concrete reinforcement
IS-1811	Methods of sampling Foundry sands
IS-1893	Criteria for earthquake resistant design of structures
IS-2062	Steel for general structural purposes
IS-2064	Selection, installation and maintenance of sanitary appliances-code of practices
IS-2065	Code of practice for water supply in buildings
IS-2090	High tension steel bars used in pre-stressed concrete
IS-2140	Standard Galvanized steel wire for fencing
IS-2470 (P1 & P2)	Code of practice for installation of septic tanks
IS-2514	Concrete vibrating tables
IS-2645	Integral cement waterproofing compounds
IS-3025 (Part 1 to Part 48)	Methods of sampling and test (Physical and chemical) for water and waste water
IS-4091	Code of practice for design and construction of foundations for transmission line towers and poles
IS-4111 (Part 1 to P5)	Code of practice for ancillary structures in sewerage system
IS-4990	Plywood for concrete shuttering work
IS-5600	Sewage and drainage pumps
National building code of India 1970	
USBR E12	Earth Manual by United States Department of the interior Bureau of Reclamation
ASTM-A392-81	Zinc/Coated steel chain link fence fabric
ASTM-D1557-80	test for moisture-density relation of soils using 10-lb (4.5 kg) rame land 18-in. (457 mm) Drop
ASTM-D1586(1967)	Penetration Test and Split-Barrel Sampling of Soils
ASTM-D2049-69	Test Method for Relative Density of Cohesionless Soils
ASTM-D2435	Test method for Unconsolidated, (1982) Undrained Strengths of Cohesive Soils in Triaxial Compression
BS-5075	Specification for accelerating Part I Admixtures, Retarding Admixtures and Water Reducing Admixtures

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

CODES	TITLE
CPWD	Latest CPWD specifications
ACSR MOOSE CONDUCTOR	
IS:6745 BS:443-1969	Methods for Determination of Mass of zinc coating on zinc coated Iron and Steel Articles
IS:8263	Methods for Radio Interference
IEC:437-1973 NEMA:107-1964 CISPR	Test on High Voltage Insulators
IS:209, BS:3436-1961	Zinc Ingot
IS:398 Part - V IEC:209-1966	Aluminum Conductors for Overhead Transmission Purposes
BS:215(Part-II), IEC:209-1966	Aluminium Conductors galvanized steel reinforced extra high voltage (400 kV and above)
IS:1778, BS:1559-1949	Reels and Drums for Bare Conductors
IS:1521, ISO/R89-1959	Method for Tensile Testing of steel wire
IS:2629	Recommended practice for Hot dip Galvanising on Iron and Steel
IS:2633	Method for Testing Uniformity of coating of zinc Coated Articles
IS:4826/ ASTMA-472-729	Hot dip galvanised coatings on round steel wires
GALVANISED STEEL EARTHWIRE	
IS:1521, ISO/R:89-1959	Method for Tensile Testing of Steel Wire
IS:1778	Reels and Drums for Bare Conductors
IS:2629	Recommended practice for Hot Dip Galvanising on Iron and Steel
IS:2633	Methods for testing Uniformity of Coating of Zinc Coated Articles
IS:4826/ ASTM: A 475-72a BS:443-1969	Hot dip Galvanised Coatings on Round Steel Wires
IS:6745/ BS:443-1969	Method for Determination of mass of Zinc Coating on Zinc coated Iron and Steel Articles.
IS:209/ BS:3463-1961	Zinc ingot
IS:398 (Pt. I to P5:1992)/ BS:215 (Part-II	Aluminum Conductors for overhead transmission purposes
Lighting Fixtures and Accessories	
IS:1913	General and safety requirements for electric lighting fittings
IS:3528	Water proof electric lighting fittings
IS:4012	Dust proof electric lighting fittings
IS:4013	Dust tight proof electric lighting fittings
IS:10322	Industrial lighting fittings with metal reflectors
IS:10322	Industrial lighting fittings with plastic reflectors
IS:2206	Well glass lighting fittings for use under ground in mines (non-

CODES	TITLE
	flameproof type)
IS:10322	Specification for flood light
IS:10322	Specification for decorative lighting outfits
IS:10322	Luminaries for street lighting
IS:2418	Tubular fluorescent lamps
IS:9900	High pressure mercury vapour lamps
IS:1258	Specification for Bayonet lamp fluorescent lamp
IS:3323	Bi-pin lamp holder tubular fluorescent lamps
IS:1534	Ballasts for use in fluorescent lighting fittings. (Part-I)
IS:1569	Capacitors for use in fluorescent lighting fittings
IS:2215	Starters for fluorescent lamps
IS:3324	Holders for starters for tubular fluorescent lamps
IS:418	GLS lamps
IS:3553	Water tight electric fittings
IS:2713	Tubular steel poles
IS:280	MS wire for general engg. Purposes
Conduits, Accessories and Junction Boxes	
IS:9537	Rigid steel conduits for electrical wiring
IS:3480	Flexible steel conduits for electrical wiring
IS:2667	Fittings for rigid steel conduits for electrical wiring
IS:3837	Accessories for rigid steel conduits for electrical wiring
IS:4649	Adaptors for flexible steel conduits
IS:5133	Steel and Cast Iron Boxes
IS:2629	Hot dip galvanising of Iron & Steel
Lighting Panels	
IS:13947	LV Switchgear and Control gear(Part 1 to 5)
IS:8828	Circuit breakers for over current protection for house hold and similar installations
IS:5	Ready mix paints
IS:2551	Danger notice plates
IS:2705	Current transformers
IS:9224	HRC Cartridge fuse links for voltage above 650V(Part-2)
IS:5082	Wrought aluminium and Al. alloys, bars, rods, tubes and sections for electrical purposes
IS:8623	Factory built Assemblies of Switchgear and Control Gear for voltages upto and including 1000V AC and 1200V DC
IS:1248	Direct Acting electrical indicating instruments
Electrical Installation	
IS:1293	3 pin plug
IS:371	Two to three ceiling roses

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

CODES	TITLE
IS:3854	Switches for domestic and similar purposes
IS:5216	Guide for safety procedures and practices in electrical work
IS:732	Code of practice for electrical wiring installation (system voltage not exceeding 650 Volts.)
IS:3043	Code of practice for earthing
IS:3646	Code of practice of interior illumination part II & III
IS:1944	Code of practice for lighting of public through fares
IS:5571	Guide for selection of electrical equipment for hazardous areas
IS:800	Code of practice for use of structural steel in general building construction
IS:2633	Methods of Testing uniformity of coating on zinc coated articles
IS:6005	Code of practice for phosphating iron and steel
	INDIAN ELECTRICITY ACT
	INDIAN ELECTRICITY RULES
LT SWITCHGEAR	
IS:8623 (Part-I)	Specification for low voltage switchgear and control gear assemblies
IS:13947 (Part-I)	Specification for low voltage switchgear and control gear, Part 1 General Rules
IS:13947 (part-2)	Specification for low voltage switchgear and control gear, Part 2 circuit breakers
IS:13947 (part-3)	Specification for low voltage switchgear and control gear. Part 3 Switches, Disconnectors, Switch-disconnectors and fuse combination units
IS:13947 (part-4)	Specification for low voltage switchgear and control gear. Part 4 Contactors and motors starters
IS:13947 (part-5)	Specification for low voltage switchgear and control gear. Part 5 Control-circuit devices and switching elements
IS:13947 (part-6)	Specification for low voltage switchgear and control gear. Part 6 Multiple function switching devices
IS:13947 (part-7)	Specification for low voltage switchgear and control gear. Part 7 Ancillary equipments
IS:12063	Degree of protection provided by enclosures
IS:2705	Current Transformers
IS:3156	Voltage Transformers
IS:3231	Electrical relays for power system protection
IS:1248	Electrical indicating instruments
IS:722	AC Electricity meters
IS:5578	Guide for Marking of insulated conductors of apparatus terminals
IS:13703 (part 1)	Low voltage fuses for voltage not exceeding 1000V AC or 1500V DC Part 1 General Requirements
IS:13703 (part 2)	Low voltage fuses for voltage not exceeding 1000V AC or 1500V DC Part 2 Fuses for use of authorized persons

ANNEXURE-C

CODES	TITLE
IS:6005	Code of practice of phosphating iron and steel
IS:5082	Wrought Aluminum and Aluminum alloys for electrical purposes
IS:2633	Hot dip galvanising

ANNEXURE-E

COMPREHENSIVE LIST OF DRAWINGS

SL. NO.	DRAWINGS/DOCUMENTS TITLE	CATEGORY
1.00	**SUBSTATION LAYOUT DRAWINGS**	
1.01	Single Line Diagram of substation	A
1.02	Electrical layout (plan & section) drawing	A
1.03	Overall General Arrangement drawing	A
1.04	Structure loading diagram cum layout drawing	A
1.05	DSLP Layout drawing	A
1.06	Switchyard Foundation layout drawing	A
1.07	Erection Key Diagram (plan & section) & Erection Bill of quantity	A
1.08	Indoor Cable trench layout drawing	A
1.09	Outdoor Cable trench layout drawing	A
1.10	Buried cable trench layout drawing	A
1.11	Lighting Fixture & conduit layout – Control room building	A/R
1.12	Lighting Fixture & conduit layout – FFPH building	A/R
1.13	Lighting Fixture & conduit layout – Transit camp (if applicable)	A/R
1.14	Lighting Fixture & conduit layout – Switchyard/Street	A/R
1.15	Lighting Fixture & conduit layout – Switchyard panel room	A/R
1.15	Earthing layout - Control Room building	A
1.16	Earthmat layout – Outdoor Switchyard area	A
1.17	Layout drawing for gravel and fence	A
1.18	Switchyard Road & drain layout drawing	A
1.19	Layout drawing of Visual Monitoring System	A
1.20	SLD of LT AC/DC systems	A
1.21	LT switchgear room -Panel layout	A
1.22	Fire Fighting Piping layout in the switchyard	A
1.23	Fire protection system (Hydrant system & Extinguishers) for Control room building, GIS Building & FFPH building etc	A
1.24	HVW spray system drawings (plan, elevation, side view, isometric view and pylon support location details)	A
1.25	NIFPS drawings	A
1.26	Fire detection & Alarm system for Control room building, GIS Building & Switchyard panel room	A
1.27	Panel layout in Control room building	A
1.28	Layout drawing for LT station	A
1.29	Switchyard Panel room - Panel layout	A
1.30	Power cable termination schedule	R
1.31	Control cable termination schedule	R
	Applicable for GIS	
1.32	Gas System Line Diagram (GAS SLD) indicating compartment details & Weight	A
1.33	GIS Layout drawing including outdoor GIB (Plan & Section)	A
1.34	Layout drawing of UHF sensors for PD Measurement	A
1.35	GIS building - Layout drawing	A
1.36	GIS Building – Lighting Fixture & conduit layout	A
1.37	GIS Building - Layout drawing of Ventilation System	A

COMPREHENSIVE LIST OF DRAWINGS		
1.38	GIS Building (Panel Room) – Air Conditioning system layout drawing	A
1.39	GIS Building – Indoor cable trench Layout drawing	A
2.00	**DESIGN CALCULATION**	
2.01	DSLP Calculation	A
2.02	Sag Tension & Short Circuit Force Calculation (if applicable)	R
2.03	Lighting system design calculation (if applicable)	R
2.04	Earthing system design calculation (if applicable)	R
2.05	Battery/Charger sizing calculation (if applicable)	R
2.06	Hydraulic calculations for Fire protection system	R
2.07	AC & Ventilation calculation for GIS Building (if applicable)	R
2.08	EOT crane sizing for GIS building	R
3.00	**GAS INSULATED SWITCHGEAR**	
3.01	Design Review document along with all supporting documents	A
3.02	Guaranteed Technical Particular (GTP)	A
3.03	Components GA drawing for CB, DS, ES, GIB, CT, VT, Spacers, Bushings etc.	A
3.04	Schematics for CB, DS,ES, CT, VT etc. (Except for LCC)	A
3.05	Type Test Reports for GIS Equipments	A
3.06	Detailed drawing of Bus Extension Module	
3.07	Foundation plan for GIS (Including Loading Data)	A
3.08	Platform Arrangement	R
3.09	Name Plates	R
3.10	GA & Schematic drawings of Local Control Cabinets (LCC)	A
3.11	GA & Schematic drawings of overhead crane	A
3.12	Earthing layout inside GIS building	R
3.13	Catalogues for	R
a)	SF6 gas leakage detector	
b)	SF6 gas filling & evacuation plant	
c)	SF6 gas Analyser	
d)	On line partial discharge monitoring system	
3.14	List of Mandatory spares	A
3.15	List of Special Tools & Tackles	A
3.16	Instruction Manual including catalogue of sensors	R
4.00	**AUTOTRANSFORMER**	
4.01	Design Review	A
4.02	Guaranteed Technical Particulars	A
4.03	Outline General Arrangement Drawing with Bill of material (OGA parts list)	A
4.04	Foundation Plan	A
4.05	Over Fluxing withstand duration curve	R
4.06	Hysteresis Characteristics & specific loss vs flux density curve of iron core	R
4.07	General Arrangement & Control Schematic of OLTC along with write-up	A
4.08	General Arrangement & Control Schematic of Marshalling Box, Common Marshalling Box and Cooler control cubicle along with write-up	A

COMPREHENSIVE LIST OF DRAWINGS		
4.09	General Arrangement & Control Schematic of Digital RTCC relay and cubicle	A
4.10	Interconnection diagram of Drive Mechanism Box, Marshalling Box, Common Marshalling Box & Digital RTCC.	A
4.11	SCADA communication interface of online monitoring equipment	A
4.12	Transport Drawing	R
4.13	Technical Particulars of Online DGA, Drying system, FO system	A
4.14	Outline and control schematic of NIFPS	A
4.15	GA & GTP of bushings	A
4.16	Earthing Arrangement Drawing (Internal & External)	A
4.17	Drawing of Aircell, Conservator & Radiator	A
4.18	Conservator & Tank Oil filling procedure plate	R
4.19	Magnetizing Characteristics of bushings CT	R
4.20	Rating and Diagram plate	A
4.21	Oil flow Diagram	R
4.22	Valve Schedule plate drawing	A
4.23	GA of Twin-Bi directional roller	A
4.24	Instruction Manual	R
4.25	Type Test Report	A
5.00	**REACTOR**	
5.01	Design Review	A
5.02	Guaranteed Technical Particulars	A
5.03	Outline General Arrangement Drawing with Bill of material (OGA parts list)	A
5.04	Foundation Plan	A
5.05	General Arrangement & Control Schematic of Marshalling Box, Common Marshalling Box along with write-up	A
5.06	SCADA communication interface of online monitoring equipment	A
5.07	Transport Drawing	R
5.08	Technical Particulars of Online DGA, Drying system, FO system	A
5.09	Outline and control schematic of NIFPS	A
5.10	GA & GTP of bushings	A
5.11	Earthing Arrangement Drawing (Internal & External)	A
5.12	Drawing of Aircell, Conservator & Radiator	R
5.13	Conservator & Tank Oil filling procedure plate	R
5.14	Magnetization characteristics of Reactor Core and bushing CTs	R
5.15	Hysteresis Characteristics & specific loss vs flux density curve of iron core	R
5.16	Rating and diagram plate	A
5.17	Voltage Ampere curve for Reactor	R
5.18	Valve Schedule plate drawing	A
5.19	GA of Twin bi-directional roller	A
5.20	Instruction Manual	R
5.21	Type test Report	A
6.00	**NEUTRAL GROUNDING REACTOR (NGR)**	
a)	**AIR CORE TYPE NGR**	

COMPREHENSIVE LIST OF DRAWINGS		
6.01	Design Review Document	A
6.02	General Technical Particulars	A
6.03	General Arrangement Drawing with BOM	A
6.04	Main Coil Lifting Details	R
6.05	Foundation Detail Drawing	R
6.06	Main Coil & Insulator Assembly Drawing	A
6.07	Terminal Detail Drawing	A
6.08	Rating & Diagram Plate	A
6.09	Transport Drawing	R
6.10	NGR Pedestal Drawing	A
b)	**OIL FILLED TYPE NGR**	
6.11	Design Review Document	A
6.12	General Technical Particulars	A
6.13	General Arrangement Drawing with BOM	A
6.14	Foundation Detail Drawing	R
6.15	Combined Foundation of Reactor, NGR and LA	A
6.16	Rating & Diagram Plate	A
6.17	Transport Drawing	R
6.18	Control Schematic	A
7.00	**CIRCUIT BREAKER**	
7.01	GA drawing of SF6 CB	A
7.02	GTP	A
7.03	OGA drawing of control unit	A
7.04	OGA drawing of support insulator, interrupter insulator, PIR chamber insulator, grading capacitor insulator (as applicable)	R
7.05	Support structure & foundation plan drawing	A
7.06	Schematic drawings/Wiring diagrams	A
7.07	Rating and name plate drawing	A
7.08	SF6 gas connection diagram	R
7.09	Schematic diagram of operating mechanism	R
7.10	GA drawing, GTP & Type Test Reports of Controlled Switching Device	A
7.11	Terminal pad and corona rings	R
7.12	Sectional view of interrupter	R
7.13	Type Test Reports	A
7.14	Instruction Manual	R
8.00	**ISOLATOR**	
8.01	GA drawing of Isolator with/without earth switch	A
8.02	GTP	A
8.03	Contact blade assembly (main & earth switch)	R
8.04	Terminal pad & hinge contacts	R
8.05	GA of MOM – main switch	R
8.06	Schematic & wiring drawing for main switch	R
8.07	Name plate - details	A
8.08	GA of terminal pad	A

COMPREHENSIVE LIST OF DRAWINGS		
8.09	GA of post insulator for isolator	R
8.10	Type Test Report	A
8.11	Instruction Manual	R
9.00	**INSTRUMENT TRANSFORMER (CT/CVT/IVT)**	
9.01	General Arrangement	A
9.02	GTP	A
9.03	Sectional view	R
9.04	Sec. terminal box GA	R
9.05	Wiring drawing of JB incl. interpole	R
9.06	Terminal pads	A
9.07	Schematic & rating plate	R
9.08	Porcelain insulator	R
9.09	Corona ring	R
9.10	Type Test Reports	A
9.11	Instruction Manual	R
10.00	**SURGE ARRESTER**	
10.01	GA of Surge Arrester	A
10.02	GTP	A
10.03	Porcelain/ Polymer insulator	R
10.04	Cross sectional view	R
10.05	Arrestor and unit name plate	A
10.06	Corona & Grading rings	R
10.07	Insulating base / surge counter detail	R
10.08	Outline drawing of surge counter	R
10.09	Circuit diagram of surge counter	R
10.10	GA drawing of ZnO element	R
10.11	Line terminal bracket with corona rings	R
10.12	Drawing showing pressure relief arrangement.	R
10.13	Type Test Report	A
10.14	Instruction Manual	R
11.00	**BUS POST INSULATOR**	
11.01	GA drawing & GTP	A
11.02	Type Test Reports	A
12.00	**Marshalling Box, Junction Boxes**	
12.01	GA drawings	A
12.02	Schematic drawings	A
12.03	Type Test Reports	A
13.00	**CONDUCTOR, AL. TUBE & GS EARTH WIRE**	
13.01	Type Test Reports (if applicable)	A

ANNEXURE-E

COMPREHENSIVE LIST OF DRAWINGS		
14.00	**DISC INSULATOR**	
14.01	GA drawing & GTP	A
14.02	Type Test Reports	A
15.00	**LONG ROD POLYMER INSULATOR**	
15.01	GA drawing & GTP	A
15.02	Type Test Reports	A
16.00	**INSULATOR STRING(S) WITH HARDWARE ASSEMBLY**	
16.01	GA drawing & GTP	A
16.02	Component drawings	R
16.03	Type Test Reports	A
17.00	**CLAMPS & CONNECTORS**	
17.01	GA Drawings	A
17.02	Type Test Reports	A
18.00	**HORN GAP FUSE**	
18.01	GA drawing & GTP	A
18.02	Type Test Reports	A
19.00	**BATTERY AND BATTERY CHARGER**	
19.01	GA drawing & GTP of Battery Bank	A
19.02	GA drawing, GTP & Schematic Drawings of Battery Charger	A
19.03	Type Test Reports of Battery & Charger	A
20.00	**ILLUMINATION**	
20.01	GTP/Catalogue of fittings/fixtures	A
20.02	GA drawing of lighting poles/posts	A
20.03	GA drawing of Junction box	A
20.04	GA drawing of street lighting panel/outdoor/indoor lighting panel	A
20.05	GA drawing of Receptacles	A
20.06	Schematic drawing of panel/LDBs to fixtures	R
21.00	**LT SWITCHGEAR**	
21.01	SLD, GA & Schematic drawings of MSB	A
21.02	SLD, GA & Schematic drawings of ACDB	A
21.03	SLD, GA & Schematic drawings of 220V DCDB	A
21.04	SLD, GA & Schematic drawings of 48V DCDB	A
21.05	SLD, GA & Schematic drawings of MLDB	A
21.06	SLD, GA & Schematic drawings of ELDB	A
21.07	Type Test Reports	A
21.08	Instruction Manual	R

COMPREHENSIVE LIST OF DRAWINGS		
22.00	**HT POWER CABLES**	
22.01	GTP & Catalogue	A
22.02	Type Test Reports	A
23.00	**POWER & CONTROL CABLES**	
23.01	Type Test Reports for control cables	A
23.02	Type Test Reports for power cables	A
24.00	**CONTROL AND RELAY PANELS & SUBSTATION AUTOMATION SYSTEM (SAS), VISUAL MONITORING SYSTEM (VMS)**	
24.01	GTP for all protection relays, Travelling Wave Fault Locator, SAS Equipment	A
24.02	Type Test Reports of all protection relays , Travelling Wave Fault Locator & SAS IEDs	A/R
24.03	GA and schematic drgs. for :-	
a)	Relay and protection panels for all type of line(s)	A
b)	Relay and protection panels for all type transformer(s) including tertiary loading	A
c)	Relay and protection panels for bus/line reactor(s) (switchable & non-switchable as applicable)	A
d)	Relay and protection panels for tie bay(s)	A
e)	Relay and protection panels for TBC bay(s)	A
f)	Relay and protection panels for BC bay(s)	A
g)	Relay and protection panels for Bus Sectionaliser bay(s)	A
h)	Busbar protection panel (s)	A
i)	Breaker relay panel(s)	A
j)	Interface panel	A
24.04	SAS Architecture	A
24.05	Relay Settings	A
24.06	GTP/Catalogue of VMS equipment	A/R
24.07	GTP/Catalogue of Camera	A/R
24.08	VMS architecture drawing	A
24.09	Technical Literature and O&M manuals	R
25.00	**PLCC EQUIPMENTS**	
25.01	GTP/Drawings for PLCC Carrier Equipment	A/R
25.02	GTP/Drawings for Wave traps	A
25.03	GTP/Drawings Coupling device	A
25.04	Digital/ Analog Protection coupler	A
25.05	SNR calculation (if applicable)	R
25.06	GTP/Drawing of HF cable	A
25.07	Type Test Reports of PLCC equipment	A
25.08	Testing & maintenance equipments	R
25.09	Frequency Planning	A
25.10	Technical literature and O&M Manuals	R

COMPREHENSIVE LIST OF DRAWINGS		
26.00	**DG SET**	
26.01	GTP	A
26.02	Drawings/manuals	A
27.00	**AIR CONDITIONING & VENTILATION SYSTEM**	
27.01	Drawings/GTP/Catalogues	A
27.02	A/C sizing calculation	A
28.00	**LT TRANSFORMER**	
28.01	GTP	A
28.02	Drawings	A
28.03	Type Test Reports	A
29.00	**FIRE PROTECTION SYSTEM**	
29.01	Fire Fighting Annunciation & control panels	A
29.02	GA and Schematic for LCP for deluge valve operation	A
29.03	Hydraulic calculations for HVW spray network	R
29.04	Drawing for deluge valve housing	A
29.05	GTP & drawings for strainers (Y type & basket strainer)	A
29.06	Drawing of valve pit details	A
29.07	System write-up with various settings	A
29.08	GTP & drawing for gate valve, check valve, solenoid valve, outdoor hydrant valve	A
29.09	GTP & catalogue for deluge valve, spray nozzles & projectors	A
29.10	GTP & catalogue for quatrzoid bulb detector	A
29.11	GTP & drawing for pressure switch, pressure gauge	A
29.12	GTP for G.I. & M.S. pipes & pipe accessories	A
29.13	Any other drawing/document required for completion of work	A/R
30.00	**CONTROL ROOM BUILDING / TRANSIT CAMP /FFPH BUILDING/ SWITCHAYRD PANEL ROOM/INDOOR HT SWITCHGEAR ROOM/TOWNSHIP BUILDINGS (AS applicable)**	A
30.01	Architectural drawing	
a)	Plan, section & elevation	
b)	Doors & windows schedule	
30.02	Building design calculation (if applicable)	
30.03	Civil Construction design/drawings	
31.00	**DRAWING FOR GIS BUILDING (If applicable)**	A
31.01	Architectural drawing	
a)	Plan, section & elevation	
b)	Doors & windows schedule	
31.02	GIS building superstructure drawings & design calculation	
31.03	Civil Construction design/drawings	

COMPREHENSIVE LIST OF DRAWINGS		
31.04	GIS Equipment foundation inside GIS building	
32.00	**Switchyard Civil Construction Drawings (as applicable)**	A
a)	Tower Foundation	
b)	Equipment Foundation	
c)	Transformer foundation	
d)	Reactor foundation	
e)	Road construction including culverts, rail cum road	
f)	Switchyard fencing & Gate	
g)	Cable trench section	
h)	Drain section	
i)	Rain harvesting	
j)	Boundary wall	
k)	DG set foundation	
l)	LT transformer foundation	
m)	Car Parking Shed/Security Room	
n)	Outdoor GIB foundation	
o)	Outdoor Sf6/Air bushing foundation	
p)	BMK/ Lighting pole foundation	
q)	Fire Wall	
r)	Drawing of contour levels	
s)	Drawing of Formation levels	
t)	Soil Investigation Report	
u)	Any other foundation inside switchyard	
33.00	**DESIGN, FABRICATION & PROTO CORRECTED DRAWINGS OF ALL TYPES OF TOWERS & BEAMS**	A/R
34.00	**DESIGN, FABRICATION DRAWINGS FOR EQUIPMENT SUPPORT STRUCTURES**	A/R
35.00	**MISCELLANEOUS CIVIL DRGS**	A/R

LEGEND:- **A – for Approval;** **R- for Record**

NOTES:-

1. **In case any additional drawings/documents are required, the same shall also be submitted during execution of the contract.**

2. **In case, some drawings as mentioned in the above list are not applicable for the scope of work, the same shall not be referred to.**

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

Annexure-G

MQP & INSPECTION LEVEL REQUIREMENT

Sl. No.	Item / Equipment	Requirement of MQP/ITP/FAT	Inspection Level
1 A	Transformer /Reactor	Yes	IV
1 B	Circuit Breakers	Yes	IV
2	Current transformer	Yes	IV
3	Capacitive voltage transformers/Potential transformer	Yes	IV
4	Isolators	Yes	IV
5	Lightening Arrestors	Yes	III
6	Line Trap	Yes	III
7	Control & Relay Panels	Yes	III
8	Power Cables	Yes	III
9	Control Cables	Yes	III
10	LT Switchgear & ACDB/DCDB/MLDB/ELDB/ Lighting Panels	Yes	III
11	Fire protection system		
11-A	Panels, Deluge valve, Hydro pneumatic tank.	No	III
11-B	Strainers, extinguishers, MS/GI pipes, Pumps, motors, air compressor, and other valves, Diesel Engines	No	II
11-C	Others	No	I
12	Insulator (Disc, Long Rod, Solid Core)	Yes	IV
13	Conductor	Yes	IV
14	Clamps & Connecters (including equipment connectors)	Yes	III
15	Junction Box / Lighting Switch Boards / Bay MB/Telecom Equipment Cabinet	No	II
16	Cable lugs	No	I
17	Lighting Fixtures ,Lamps & fans	No	I
18	Switches	No	I
19	Conduits	No	I
20	Lighting Poles	No	II
21	MS/GI /PVC Pipes for cable trenches and lighting	No	I
22	Hume Pipes	No	I
23	Galvanized Cable trays	No	II
24	MS/ GI Flat and earthing material	No	II
25	MS Round for Earthmat (40mm dia)	No	I
26	Lighting Earthwire	No	I
27	Aluminium Tube & Busbar materials	No	II
28	Outdoor Receptacle	No	I
29	Nut / Bolts / Spring Washers (Gr 5.6/5)	No	II
30	LT Transformer	Yes	III
31	Battery	No	II
32	Battery Charger	Yes	III

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

Annexure-G

Sl. No.	Item / Equipment	Requirement of MQP/ITP/FAT	Inspection Level
33	D. G. Set	No	II
34	Split A.C/window A.C.	No	I
35	Substation Automation system	No	III
36	Telephone wires	No	I
37	Telephone sockets	No	I
38	Aluminium ladder	No	I
39	Occupancy sensors for control of lighting	No	I
40	Sub Station Structure (lattice/pipe type)	Yes	III
41	HG fuse	No	II
42	PLCC equipment Viz PLCC Terminal ,Carrier equipment, Protection Coupler , Coupling Device but excluding EPAX / HF Cable/ SDH Equipment	Yes	III
43	HF Cable / GPS Clock	No	I
44	EPAX	No	I
45	Cable Glands / Joints /Clamps/ Termination	No	I
46	Video Monitoring System	No	II
47	Controller for switching	No	IV
48	Solar based street lighting pole including solar panel as per technical specification	No	III
49	Event Logger	No	III
50	Lighting transformers	Yes	II
51	String Hardware	Yes	IV
52	Test Equipment	No	I *
53	GS Earthwire	Yes	IV
54	Oil Storage Tank	Yes	III
55	Insulating Oil	No	III
56	Flow sensitive conservator isolation valve	No	II **
57	On-Line insulating oil drying system	No	II **
58	On line DGA & Moisture Analyzer	No	II **
59	WAMS-(PMU & Accessories)	Yes	III
60	FO Cable	Yes	III
61	Re-rollers of MS/HT Angle Section and galvanized tower parts.	Yes	IV
62	Hardware fittings & Earthwire Accessories	Yes	IV
63	OPGW & H/W	Yes	III
64	Bolts & Nuts Gr up to 5.6/5	Yes	II
65	Bolts & Nuts of Gr 8.8 / 8	Yes	IV
66	D-shackle/ Hanger / Links	Yes	IV
67	Danger Plate /Phase Plate / Number Plate / Circuit plate	No	I
68	Pipe Type & Counter Poise Earthing	No	II
69	Spring Washer	No	II
70	ACD & Barbed wire for ACD/Bird guard	No	II

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

Annexure-G

Sl. No.	Item / Equipment	Requirement of MQP/ITP/FAT	Inspection Level
71	Span Marker & Obstruction Light	No	III
72	GIS including spares	Yes	IV
73	GIS Bus Duct	Yes	IV
74	GIS Bushing	Yes	IV
75	SF6 Gas processing Unit	No	II
76	Partial Discharge Monitoring System	No	II
77	STATCOM including Valve, valve base electronics, DC capacitor, series reactor and all accessories	Yes	IV
78	Mechanically switched Reactor bank (3-ph) including all accessories (MSR Branches)	Yes	IV
80	Mechanically switched Capacitor bank (3-ph) including all accessories (MSC Branches)	Yes	IV
81	Pass Harmonic filters	Yes	IV
82	Valve cooling system	Yes	III
	FODP including pigtail	No	II
	Radio link Telecom	Yes	III
	Hardware Fittings for Fibre Optic approach cable	Yes	III
	SDH Equipments (ADM), PDH, Primary Multiplexer	Yes	IV
	Drop & Insert Multiplexer	Yes	IV
	DACS	Yes	IV
	Main Distribution Frame	No	I
	HDPE Pipe	No	II
	NMS, TMN	Yes	IV
	Synchronization Equipment	No	Level-I
93	HT Capacitor	Yes	IV
94	PLC Capacitor	Yes	III
95	48V DCPS	Yes	III
96	Nitrogen Injection system	Yes	III
97	Foundation/Anchor bolts	Yes	III
98	EOT crane/Lift	No	II
99	Optical Signal Column	No	II
100	Maintenance Platform	No	II
101	Spark Gap	Yes	III
102	Thyristor Valve	Yes	III
103	DC current & voltage measuring device	ITP	III
104	Furniture	No	I

Note:

* **MICC for test and measuring equipment shall be issued only after actual verification/demonstration of satisfactory performance at site.**

** **Though level-2 items, CIP can be issued also on review of TCs and visual inspection of these items.**

ANNEX C1

CORONA AND RADIO INTERFERENCE VOLTAGE (RIV) TEST

1. General

Unless otherwise stipulated, all equipment together with its associated connectors, where applicable, shall be tested for external corona both by observing the voltage level for the extinction of visible corona under falling power frequency voltage and by measurement of radio interference voltage (RIV).

2. Test Levels:

The test voltage levels for measurement of external RIV and for corona extinction voltage are listed under the relevant clauses of the specification.

3. Test Methods for RIV:

3.1 RIV tests shall be made according to measuring circuit as per International Special-Committee on Radio Interference (CISPR) Publication 16-1(1993) Part -1. The measuring circuit shall preferably be tuned to frequency with 10% of 0.5 Mhz but other frequencies in the range of 0.5 MHz to 2 MHz may be used, the measuring frequency being recorded. The results shall be in microvolts.

3.2 Alternatively, RIV tests shall be in accordance with NEMA standard Publication No. 107-1964, except otherwise noted herein.

3.3 In measurement of, RIV, temporary additional external corona shielding may be provided. In measurements of RIV only standard fittings of identical type supplied with the equipment and a simulation of the connections as used in the actual installation will be permitted in the vicinity within 3.5 meters of terminals.

3.4 Ambient noise shall be measured before and after each series of tests to ensure that there is no variation in ambient noise level. If variation is present, the lowest ambient noise level will form basis for the measurements. RIV levels shall be measured at increasing and decreasing voltages of 85%, 100% and 110% of the specified RIV test voltage for all equipment unless otherwise specified. The specified RIV test voltage for 765kV, 400kV, 220kV is listed in the detailed specification together with maximum permissible RIV level in microvolts.

3.5 The metering instruments shall be as per CISPR recommendation or equivalent device so long as it has been used by other testing authorities.

3.6 The RIV measurement may be made with a noise meter. A calibration procedure of the frequency to which noise meter shall be tuned shall establish the ratio of voltage at the high voltage terminal to voltage read by noisel meter.

4. Test Methods for Visible Corona [applicable for 400kV and above]

The purpose of this test is to determine the corona extinction voltage of apparatus, connectors etc. The test shall be carried out in the same manner as RIV test described above with the exception that RIV measurements are not required during test and a search technique shall be used near the onset and extinction voltage, when the test voltage is raised and lowered to determine their precise values. The test voltage shall be raised to 110% of RIV test voltage and maintained there for five minutes. In case corona inception does not take place at 110%, test shall be stopped, otherwise test shall be continued and the voltage will then be decreased slowly until all visible corona disappears. The procedure shall be repeated at least 4 times with corona inception and extinction voltage recorded each time. The corona extinction voltage for purposes of determining compliance with the specification shall be the lowest of the four values at which visible corona (negative or positive polarity) disappears. Photographs with laboratory in complete darkness shall be taken under test conditions, at all voltage steps i.e. 85%, 100%, and 110%. Additional photographs shall be taken at corona inception and extinction voltages. At least two views shall be photographed in each case using Panchromatic film with an ASA daylight rating of 400 with an exposure of two minutes at a lens aperture of f/5.6 or equivalent. The photographic process shall be such that prints are available for inspection and comparison with conditions as determined from direct observation. Photographs shall be taken from above and below the level of connector so as to show corona on bushing, insulators and all parts of energised connectors. The photographs shall be framed such that test object essentially, fills the frame with no cut-off.

In case corona inception does not take place at 110%, voltage shall not be increased further and corona extinction voltage shall be considered adequate.

4.1 The test shall be recorded on each photograph. Additional photograph shall be taken from each camera position with lights on to show the relative position of test object to facilitate precise corona location from the photographic evidence.

4.2 In addition to photographs of the test object preferably four photographs shall be taken of the complete test assembly showing relative positions of all the test equipment and test objects. These four photographs shall be taken from four points equally spaced around the test arrangement to show its features from all sides. Drawings of the laboratory and test set up locations shall be provided to indicate camera positions and angles. The precise location of camera shall be approved by Purchaser‘s inspector, after determining the best camera locations by trial energisation of test object at a voltage which results in corona.

4.3 The test to determine the visible corona extinction voltage need not be carried out simultaneously with test to determine RIV levels.

4.4 However, both test shall be carried out with the same test set up and as little time duration between tests as possible. No modification on treatment of the sample between tests will be allowed. Simultaneous RIV and visible corona extinction voltage testing may be permitted at the discretion of Purchaser‘s inspector if, in his opinion, it will not prejudice other test.

5. Test Records:

In addition to the information previously mentioned and the requirements specified as per CISPR or NEMA 107-1964 the following data shall be included in test report:

a) Background noise before and after test.

b) Detailed procedure of application of test voltage.

c) Measurements of RIV levels expressed in micro volts at each level.

d) Results and observations with regard to location and type of interference sources detected at each step.

e) Test voltage shall be recorded when measured RIV passes through 100 microvolts in each direction.

f) Onset and extinction of visual corona for each of the four tests required shall be recorded.

SECTION -4
TECHNICAL DATA REQUIREMENTS

Control and Relay panels

1 Name & country of Manufacture of panels

2 Manufacturer's type & and designation

3 Type of construction (Simplex / Duplex)

4 Thickness of sheet steel
(I) Front

(ii) Back

(iii) Sides

5 Degree of Protection

6 Name of the manufcaturer of relays

7 DC Voltage of the relays

8 Make and model of static (0.2 accuracy class type) energy meters

9 Confirm whether offered C&R panel manufacturer and protective relays have tested commissioned and they are in successful operation for at least two years in 400kV System

TRANSMISSION LINE PROTECTION

Numerical Distance protection Scheme / Line CURRENT Differential protection.

1 Name & country of Manufacture

2 Manufacturer type & designation

3 Switched or Non switched type (is it with separate measurement for single / three phase faults)

4 Setting range of offset feature

5 Whether relay is having self monitoring feature

SECTION -4
TECHNICAL DATA REQUIREMENTS

6 Whether relay is compatible for PLCC equipment and can be used for permissive/ under reach/over reach/ Blocking scheme

7 Suitable for single & three phase trip

8 Type of shaped characteristic

9 No. of tripping contacts with making capacity of 30 amps for 0.2 seconds

10 In case 16 contacts as per above clause are not available with the distance relay offered, type of tripping relay being offered

11 Maximum operating time for at 50% of the reach setting of 2 ohms and 10/20 ohms (with CVT) including all trip relays, if any (Bidder is required to enclose isochronic curve with CVT on Line)
a) at SIR = 4
b) at SIR=15 (3 Phase faults)
c) at SIR =15 (other faults)

12 IDMT earth fault relay meeting Normal Inverse charcteristics as per IEC 60253 is being offered as built in feature for 400/220 kV Lines

13 If no type of IDMT relay being offered

14 Built in feature offered with the relay (Yes/No)
a) Disturbance Recorder
b) Fault Locator
c) Over voltage (one stage only)
d) Auto reclose relay along with dead line charging and check synchronising

STATIC Distance Protection Scheme

1 Name & country of Manufacture

2 Manufacturer type & designation

3 Switched or Non switched type (is it with separate measurement for single / three phase faults)

4 Setting range of offset feature

5 Whether relay is having self monitoring feature

SECTION -4
TECHNICAL DATA REQUIREMENTS

6 Whether relay is compatible for PLCC equipment and can be used for permissive/ under reach/over reach/ Blocking scheme

7 Suitable for single & three phase trip

8 Type of shaped characteristic

9 No. of tripping contacts with making capacity of 30 amps for 0.2 seconds

10 In case 16 contacts as per above clause are not available with the distance relay offered, type of tripping relay being offered

11 Maximum operating time for at 50% of the reach setting of 2 ohms and 10/20 ohms (with CVT) including all trip relays, if any (Bidder is required to enclose isochronic curve with CVT on Line)
a) at SIR = 4
b) at SIR=15 (3 Phase faults)
c) at SIR =15 (other faults)

12 IDMT earth fault relay meeting Normal Inverse charcteristics as per IEC 60253 is being offered as built in feature for 400/220 kV Lines

13 If no type of IDMT relay being offered

14 Built in feature offered with the relay (Yes/No)
a) Disturbance Recorder
b) Fault Locator
c) Over voltage (one stage only)
d) Auto reclose relay along with check synchronising relay (for 132 kV Lines)

Directional O/C and E/F Relay

1 Name & country of Manufacture

2 Manufacturer type & designation

3 Three over current and one E/F element(s) are whether independent or composite units

4 Type of relay Electromechanical/ static/ Numerical

SECTION -4
TECHNICAL DATA REQUIREMENTS

5 Whether charateristics will confirm to IEC255-3

6 Directional sensitivity

7 Overcurrent unit setting range

a) Inverse time

b) High set inst. Unit

8 Earth fault unit setting range

a) Inverse time

b) High set inst. Unit

9 VT fuse failure relay/ feature included for Alarm

Line Over voltage Protection relay

1 Name & country of Manufacture

2 Manufacturer type & designation

3 Type of Relay (Electromechanical/ Static Numerical)

4 Operating indicator provided

5 Operating time

6 Resetting time

7 Whether monitors all three phases ?

8 Built in feature of Main 1/Main 2 distance relay is offered. If so which stage is offered as built in

Distance to fault locator

1 Name & country of Manufacture

2 Manufacturer type & designation

3 Built in feature of Main 1/Main 2 distance relay is offered

SECTION -4
TECHNICAL DATA REQUIREMENTS

4 Maximum registering time

5 Whether direct display unit provided

6 Whether both phase to phase fault & phase to earth fault measuring units included

7 Whether" On - Line" type

8 Accurcay for typical conditions defined under technical specifications

Disturbance Recorder
a. Acquisition unit

1 Name & country of Manufacture

2 Manufacturer's type & and designation

3 No. of Analogue Channels

4 No. of Digital recording Channels

5 Built in feature of Main 1 / Main 2 distance relay offered

6 Pre Fault memory (milli seconds)

7 Post Fault memory (seconds)

8 Total storage memory in seconds

9 Sampling Frequency

10 Resolution of event channels (msec)

11 Time display present?

12 Data output in COMTRADE is available

b. Evaluation Unit

1 Name & country of Manufacture

2 Manufacturer's type & and designation

SECTION -4
TECHNICAL DATA REQUIREMENTS

3 No. of acquisition unit that can be connnected to one evaluation unit

4 Technical paramters of evaluation unit
a. Processor & Speed
b. RAM & Hard Disk Capacity
c. Additional facilities
d. Details of Printer

5 Details of Power supply arrangement for acquistion unit (including printer)

Auto Reclose Relay

1 Name & country of Manufacture

2 Manufacturer type & designation

3 Electromechanical / Static / Numerical

4 Auto Reclose relay along with dead line charging and check synchronising relay offered as part of distance relay

5 Suitable for single & three phase ?

6 Single phase dead time setting ranges

7 Three phase dead time range earth faults

8 Reclaim time seting range

Auto Reclose Relay (FOR NEW SUBSTATION ONLY)

1 Name & country of Manufacture

2 Manufacturer type & designation

3 Electromechanical / Static / Numerical

4 Auto Reclose relay along with dead line charging and check synchronising relay offered as part of distance relay

5 Suitable for single & three phase ?

SECTION -4
TECHNICAL DATA REQUIREMENTS

6 Single phase dead time setting ranges

7 Three phase dead time range earth faults

8 Reclaim time seting range

TRANSFORMER PROTECTION

Differential relay

1 Name & country of Manufacture

2 Manufacturer type & designation

3 Second harmonic restraint feature provided ?

4 Whether three instantaneous units provided

5 Operating current setting range

6 Bias setting range

7 Operating time at 5x setting current

8 Resetting time

9 How ratio / phase angle corrections are being done (inter posing transformer / internal feature in the relay)

Restricted Earth Fault Relay

1 Name and country of Manufacturer

2 Manufacturer type and designation

3 Operating time at 2 x setting

Overfluxing relays

1 Name & country of Manufacture

2 Manufacturer type & designation

SECTION -4
TECHNICAL DATA REQUIREMENTS

3 Whether inverse time operating charcateristics provided ?

4 Maximum operating time

5 Accuracy operating time

6 Resetting time

Directional O/C and E/F Relay

1 Name & country of Manufacture

2 Manufacturer type & designation

3 Whether charateristics will confirm to IEC255-3

4 Directional sensitivity

5 Overcurrent unit setting range

a) Inverse time

b) High set inst. Unit

6 Earth fault unit setting range

a) Inverse time

b) High set inst. Unit

REACTOR PROTECTION

Differential relay

1 Name & country of Manufacture

2 Manufacturer type & designation

3 Second harmonic restraint feature provided ?

4 Whether three instantaneous units provided

5 Operating current setting range

SECTION -4
TECHNICAL DATA REQUIREMENTS

6 Bias setting range

7 Operating time at 5x setting current

8 Resetting time

9 How ratio / phase angle corrections are being done (inter posing transformer / internal feature in the relay)

Restricted Earth Fault Relay

1 Name and country of Manufacturer

2 Manufacturer type and designation

3 Operating time at 2 x setting

Back up Impedance Protection Relay

1 Name & country of Manufacture

2 Manufacturer type & designation

3 Whether charateristics will confirm to IEC255-3

4 Directional sensitivity

5 Overcurrent unit setting range

a) Inverse time

b) High set inst. Unit

6 Earth fault unit setting range

a) Inverse time

b) High set inst. Unit

SECTION -4
TECHNICAL DATA REQUIREMENTS

GENERAL PROTECTION / MONITORING EQUIPMEMT

Trip circuit supervision relay

1 Name & country of Manufacture

2 Manufacturer type & designation

3 Whether preclosing and post closing supervision provided ?

4 Time delay

High Speed Trip Relays

1 Name & country of Manufacture

2 Manufacturer type & designation

3 Contacts ratings
 a) Make & carry continously

 b) Make & carry for 0.5 sec

 c) Break
  I. Resistive load

  ii. Inductive load (With L/R = 40 msec)

4 Operating time at rated voltage (maximum)

5 Resetting time

6 Whether supervisory relays included

SECTION -4
TECHNICAL DATA REQUIREMENTS

Local Breaker Back - up protection

1 Name & country of Manufacture

2 Manufacturer type & designation

3 Operating time

4 Resetting time

5 Setting range
(I) Current
(ii) Time

Bus bar Protection (APPLICABLE FOR NEW STATION ONLY)

1 Name & country of Manufacture

2 Manufacturer type & designation

3 Type of relay

4 Principle of operation

5 Operating time

6 Resetting time

7 Setting ranges

(I) Current
(ii) Time

8 Whether it will cause tripping for the differential current below the load current of heavily loaded feeder (Bidder shall submit application check for the same)

ANNEXURE-1

COMPLIANCE CERTIFICATE OF TECHNICAL SPECIFICATION

The bidder shall confirm compliance to the following by signing/ stamping this compliance certificate and furnishing same with the offer.

1. The scope of supply, technical details, construction features, design parameters etc. shall be as per technical specification & there are no exclusion/ deviation with regard to same.

2. There are no deviation(s) with respect to specification other than those furnished in the 'schedule of deviations'.

3. Only those technical submittals which are specifically asked for in NIT to be submitted at tender stage shall be considered as part of offer. Any other submission, even if made, shall not be considered as part of offer.

4. Any comments/ clarifications on technical/ inspection requirements furnished as part of bidder's covering letter shall not be considered by BHEL, and bidder's offer shall be construed to be in conformance with the specification.

5. Any changes made by the bidder in the price schedule with respect to the description/ quantities from those given in 'BOQ' of the specification shall not be considered (i.e., technical description & quantities as per the specification shall prevail).

Date: Bidder's Stamp & Signature

ANNEXURE – 2

SCHEDULE OF TECHNICAL DEVIATIONS

Bidder shall list below all technical deviation clause wise w.r.t. tender specifications:

S.No.	Section/ Page No.	Clause No.	Deviation	Reason / Justification

Any deviation not specifically brought out in this section shall not be admissible for any commercial implication at later stage. Except to the technical deviations listed in this schedule, bidder's offer shall be considered in full compliance to the tender specifications irrespective of any such deviation indicated / taken elsewhere in the submitted offer.

Date: Tenderer's Stamp & Signature