

SECTION-14

PROTECTION SYSTEM

14.1 SCOPE OF WORK

Scope of work under this section covers the provision of labour, tools, plants, materials and performance of work necessary for the design, engineering, manufacture, quality assurance, quality control, shop assembly, shop testing, packaging & delivery at site including insurance, unloading, site storage and preservation, in plant transportation at site, erection / installation, testing, supervision, pre commissioning, successful commissioning, performance and acceptance testing, handing over to Employer and warrantee for two years of Protection System as per the specifications hereunder, complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation. The scope of work covered under this section shall be read in conjunction with General Technical specifications, Chapter-1.

14.1.1 Detailed scope of work

The scope of work shall be a comprehensive functional system complete in every respect including but not be limited to following:

14.1.1.1 Main Scope

- I. CT, PT sizing and calculation along with their parameter optimization as per the Main SLD covered in tender drawings under section 35.

II. Unit protection

Four (4) sets of Unit protection panel incorporating numerical relays (IEC 61850 based) with local & remote communication facility, time synchronization facilities, all auxiliaries, tripping functions through I/O cards only and Static relays/electromechanical (to be used on minimal basis) for protection functions of following:

A) **Generator Protection**

B) **Generator Transformer Protection**

C) **Excitation Transformer, Unit Auxiliary Transformer, Station Auxiliary transformer**

D) **400kV XLPE Cable**

III. Line protection

Two (2) sets of Line Protection Panels incorporating numerical relays (IEC 61850

based) with local & remote communication facility, disturbance recorder, time synchronization facilities, all auxiliaries, tripping function through I/O cards only and Static relays/electromechanical (to be used on minimal basis) for protection of 400kV Lines.

IV. Line Reactor Protection

Two (2) sets of Line Reactor Protection Panels incorporating numerical relays (IEC 61850 based) with local & remote communication facility, time synchronization facilities, all auxiliaries, tripping function through I/O cards only and Static relays/electromechanical (to be used on minimal basis) for protection of 63MVAR, 400KV Line Reactor.

V. Bus Reactor Protection

Two (2) sets of Bus Reactor Protection Panels incorporating numerical relays (IEC 61850 based) with local & remote communication facility, time synchronization facilities, all auxiliaries, tripping function through I/O cards only and Static relays/electromechanical (to be used on minimal basis) for protection of 80MVAR, 400KV Bus Reactor.

VI. Bus coupler Protection

One (1) set of Bus coupler Protection Panel incorporating numerical relays (IEC 61850 based) with local & remote communication facility, time synchronization facilities, all auxiliaries, tripping function through I/O cards only and Static relays/electromechanical (to be used on minimal basis) for protection of Bus coupler.

VII. Control Panels

One (1) set of control panel incorporating control switches, semaphore indication, LED indications, metering etc. for each of the following:

- i. Lines (2 No.)
- ii. Line Reactor (2 No.)
- iii. Bus Reactor (2 No.)
- iv. Bus coupler (1 No.)

VIII. Busbar Protection

One(1) set of duplicate/redundant Busbar Protection Panel incorporating numerical relays (IEC 61850 based) with local & remote communication facility, time

synchronization facilities, all auxiliaries, tripping function through I/O cards only and Static relays/electromechanical (to be used on minimal basis) for protection of complete 400kV GIS.

14.1.1.2 Miscellaneous components and auxiliary system

- i. One (1) Lot of cables (LAN, OFC, co-axial etc.), hardware (terminators, cable ties etc.) to be used in Protection System.
- ii. One (1) no. Laptop including interface cable for front port communication with numerical relays during testing, installation & commissioning(programming, parameterization)
- iii. One (1) set of Centralized Information station (CIS) including computer , redundant gateways(for interfacing CMS and Protection), SNTP Server(if required for time synchronization of Protection system) to be used in Central Control room for programming, parameterization, disturbance record, event record, storing & viewing under normal plant operation and information exchange between CMS and Protection.(as per Drg. No. SJVN/ED/ARUN-III/EM-2017-05A)
- iv. One (1) no. A3 size, Colored laser Printer for CIS.
- v. Relay Setting calculation and relay coordination study, testing, implementation and demonstration for complete protection system covered in this specification.
- vi. Relay Setting calculation and relay coordination study, testing, implementation and demonstration for complete protection system of MV & LV system & DG Set covered chapter 20 & Chapter-21, Chapter 27 of the specification.

14.1.1.3 Control, monitoring and related items and services

Coordination and provision of necessary contacts and/or ports for integration with plant SCADA system.

14.1.1.4 Common supplies and services

- i. Drawings, documents and design calculations as per clause 14.6.
- ii. Shop, assembly, inspection & tests as per clause no. 14.7.
- iii. Packaging, handling and site storage as per clause no. 14.8.
- iv. Delivery, installation and commissioning as per clause no. 14.9.
- v. Tools and instruments as per clause no. 14.10.
- vi. Spare parts as per clause no. 14.11
- vii. Field/touch-up painting including all painting materials.

14.1.1.5 Completeness of System

Any other item (s) not mentioned specifically but necessary for the satisfactory

completion of scope of work defined above, as per accepted standard (s)/best international practice.

14.2 STANDARDS & REGULATIONS

The design, manufacture and testing of the various equipment covered under this specification shall comply with the requirements of the latest edition of the relevant IEC/IS/IEEE/ISO standards only. Preference for latest IEC standards for particular equipment / system shall be governed over IEEE/ IS/ ISO standards. Further rules, guide lines and standard laid down by international/ national agency shall be applicable in this specification.

The relevant abstract (in soft / hard copy) of all referred standards shall be provided free of cost during engineering stage for facilitating review/ approval of submitted drawing/documents.

14.3 PROTECTION PARAMETERS & GUARANTEES

14.3.1 Rating

Ratings of various relays and metering instruments used in protection scheme shall be as follows

a) Relay Rating*

Current Rating: 1A/5A as per main SLD

Accuracy: 0.2/0.5/5P15/5P20

Voltage rating: 110/ $\sqrt{3}$ V or 110V as per main SLD

Accuracy: 0.2/3P

Auxiliary Voltage: 220V dc, +10%,-20%

230V ac, ± 10

*All CTs & PTs reflected in SLD shall be supplied under Section -10 & Section 16.

b) Metering Instruments

Auxiliary Voltage: 220V dc, +10%,-20%

Output : 4-20mA

14.3.2 Functional Characteristics

a) Unit Protection Scheme

- Protection System for Unit Protection system shall cover protection of Generator, Generator Transformer, UAT, ET & SAT (for Unit1 & 4). It shall be configured into two independent sets of Protection Group A & Group B as

given below.

- Protection system for generator shall be duplicated as shown in Main SLD.

	Group A	Group B
Generator		
	95% Stator Earth fault	95% Stator Earth fault
	100% Stator Earth fault	100% Stator Earth fault
	Generator differential(87G)	Generator differential(87G)
	Voltage controlled overcurrent(27/51G)	Voltage controlled overcurrent(27/51G)
	Pole Slip(78G)	Pole Slip(78G)
	Backup Impedance(21G)	Backup Impedance(21G)
	Loss of Excitation(40G)	Loss of Excitation(40G)
	Negative Phase sequence(46G)	Negative Phase sequence(46G)
	Stator Overload(49G)	Stator Overload(49G)
	Over voltage (59G)	Over voltage (59G)
	Under/Over frequency(81U/81O)	Under/Over frequency(81U/81O)
	Under Voltage(27G)	Under Voltage(27G)
	Over fluxing(99G)	Over fluxing(99G)
	Dead Machine protection(27/50G)	Inter-turn Protection(87TG)
		Overall differential(87OA)
Generator Transformer		
	Transformer differential(87T)	Over current(51GT)
	Back up Earth fault	Restricted earth fault(64GT)
Excitation Transformer, UAT		
	Inst & IDMT O/C(50/51),	Restricted earth fault(64U),
	Overload(49)	IDMT Overcurrent & Earth fault(51/51N)-(only for UAT)

SAT(for Unit-1&4)		
	Inst & IDMT O/C	Restricted earth fault
	Transformer differential(87ST)	
400kV XLPE Cable		
	Main-I Cable Differential	Main-II Cable Differential

b) Line Protection Scheme

Line Protection Scheme shall cover protection of 400kV line & 63MVAR Line Reactor with following Protection functions:

I. 400kV Line Protection

- 21M-1: Main –I Distance Protection
- 21M-II: Main –II Distance Protection
- Directional IDMT Earth fault(67N)
- Overvoltage Relay Stage-1 (59L1) & Stage-2(59L2)
- Auto Reclosing (single phase)-79

II. 400kV, 63 MVAR Line Reactor Protection

- Reactor Differential(87R)
- Reactor REF(64R)
- Reactor Backup Impedance(21R)
- LBB(50Z)
- NGR REF(64NGR)

c) Bus Reactor Protection Scheme

Bus reactor Scheme shall cover protection of 400kV,80MVAR Bus Reactor with following Protection functions:

- Reactor Differential(87R)
- Reactor REF(64R)
- Reactor Backup Impedance(21R)

- iv. Overvoltage(59R)
- v. Overfluxing (99R)

d) Bus bar Protection Scheme

Bus bar Scheme shall cover protection of 400kV GIS with following Protection functions:

- i. Main –I Busbar Protection with inbuilt LBB
- ii. Main –II Busbar Protection with inbuilt LBB
- The system shall provide a high degree of selectivity and discrimination between faulty and healthy circuits. A microprocessor based modular system associated with a local and remote communication interface shall be provided.
- All devices shall remain inoperative during internal faults and transient phenomena. They shall be insensitive to mechanical shocks, vibration and external magnetic fields.
- All relays shall be suitable for local and remote reset. They shall have self-monitoring facilities and LED status indication
- Service voltage failure and any fault in relays and tripping circuitry shall be indicated.
- CTs shall be shorted automatically, when relevant modules are withdrawn.
- Main and back up protection system shall be separated and shall have individual power supply from different source.

The relays shall be provided with the following information, suitably located:

- Function of relay,
- Phase identification,
- Main characteristics.

14.3.3 Performance Criteria and Guarantee

The equipment / components along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions. It is the responsibility of the Contractor to supply the equipment as per guaranteed technical particulars and shall also guarantee the reliability and performance.

14.4 DESIGN AND CONSTRUCTION

The Contractor shall submit for the Engineer's approval, a design report detailing the protected equipment, design parameters of associated current transformers, details of connections and burden between current transformers and relays, details of the relays circuits and performance calculations.

14.4.1 Special Design and Layout Conditions

- a) Protection shall be provided through relays, which shall be Numeric type protection relays based on IEC 61850 protocol. All integrated numeric protection for Generator shall be provided with 100% redundancy of relays as well as CTs. Generator Protections and Generator Transformer Overall differential protection shall be covered by two completely independent CTs.
- b) A single line diagram of the main electrical equipment of the power plant and its protection scheme is shown in Main SLD. The requirement of number of current transformers shall be examined and reviewed in view of the installation of latest state of art protection relays proposed to be installed. The relays / protection system shall be of latest art of technology on the date of supply.
- c) All auxiliaries, tripping function shall be through I/O cards only and Static relays/electromechanical are to be used on minimal basis.
- d) Tripping signal from protection relays shall be hardwired for shut down of machine and tripping of circuit breaker.
- e) Alarm/Trip signal, analog signal for each protection function of protection scheme shall be through communication gateway between protection panel and SCADA.

14.4.2 Time synchronization

All numerical relays, disturbance recorders, event recorders etc. shall have a time synchronization interface which shall be time synchronized through universal time synchronization system as described and supplied under “Section - 15 Control and Monitoring System. Necessary interfacing works between Protection & SCADA like cabling & termination is under scope of this section.

14.4.3 Numerical relay

The numerical relay shall have at least following features

- The relay used in protection system shall be of the numerical, and plug in type arranged in protection cubicles. All relays shall comply with IEC 60255 Recommendation
- All communications of protection system with the control system shall be based on universally accepted Protocol namely IEC 61850
- The relay shall have preferably front panel back lit display,
- The relay shall have self-monitoring features

14.5 AUXILIARY SYSTEMS AND MISCELLANEOUS COMPONENTS

14.5.1 Centralized Information Station (CIS)

Centralized Information System comprising of a computer and a printer to be placed in central control room shall be provided for parameterization, programming, disturbance & event recording, system viewing, displaying protection & metering functions etc.

The configuration of computer, display screen & printer shall be of latest art of technology at the time of detail engineering/supply subjected to the Employer's approval.

14.5.2 Laptop

One (1) no. laptop for parameterization, programming & front port communication of Protection relays during testing, installation & commissioning shall be provided.

The configuration of laptop shall be of latest art of technology at the time of detail engineering/supply subjected to the Employer's approval.

14.5.3 Auxiliary relays

Auxiliary relays for inputs from the protection sensors and devices such as thermal relays, pressure switches etc. shall be provided as specified in the following sections, and as necessary for the installation.

The relays shall be equipped with a manually reset indicator when applicable.

Each relay shall have self-resetting potential free contacts of suitable rating as needed for connection in the tripping circuits and at least two self-resetting potential free contacts for local and remote alarm and supervision, both wired to terminals.

All relays shall be clearly marked with the corresponding relay function.

14.5.4 Metering Instruments

- a) The bidder shall provide ABT based energy meters of accuracy class 0.2 for the measurement of un-balanced load from the secondary of CTs and VTs. They shall be provided with a separate 3 phase 4 wire TTB for the testing of meters without disturbing the CT and VT secondary connection.
- b) These energy meters shall have provision for the local display as well as serial interface for the measurement of power in various forms to generate the report / trends in the Real Time Energy Management System as specified in Section 15.
- c) Meters shall conform to latest IS/IEC standard. All energy meters shall have accuracy class of 0.2.
- d) Meters shall be compensated for temperature errors and factory calibrated to read the secondary quantities. Number of digits provided shall be adequate to cover at least 1000 hours of operation.

14.5.5 Indicating Instruments

- a) All electrical indicating instruments shall be of digital type.

- b) Instruments shall conform to latest relevant IS and shall have accuracy class of 0.2. Watt/Varmeters shall be able to display IMPORT and EXPORT in response to active/reactive power flow towards or away from the substation bus bars respectively.

14.5.6 Indicating Lamps & Semaphores

- **Indicating Lamps**

As per GTS Clause 1.8.7

- **Position Indicators**

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. Their strips shall be of the same colour as the associated mimic.

Position indicator shall be suitable for either AC or DC operation as specified in here. 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. The rating of the indicator shall not exceed 2.5W. It shall not be possible to displace the position of the indicator disc due to the accidental touch during the cleaning of the panel.

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

14.5.7 Switches

- As per GTS Clause 1.8.7

14.5.8 Mimic Board

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

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

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

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

14.5.9 Power supplies

A reliable power supply shall be provided for circuits. The power supply shall be from two independent DC station battery source, one as primary and other as secondary. Switchover from primary to secondary will follow automatically on failure of primary and return to the primary source automatically following restoration of primary supply.

230V AC supply shall be required for heating & lighting of Protection & control Panels

14.5.10 Control and tripping circuitry

Trip circuit supervision systems shall be provided. They shall preferably supervise the circuits continuously irrespective of circuit breaker position whether it is closed or open. Supervisory systems combined with automatic test facilities will also be considered.

Any fault in a tripping circuit shall be enunciated individually.

If applicable, the relevant alarm and tripping circuits shall be blocked in case of electrical braking of the unit to avoid mal-function/information. Buzzer and bell shall be provided for alarm and trip functions separately.

Each relay or relay assembly shall have a test device, which facilitates checking the correct functioning of the equipment during operation or stand still.

The trip circuits shall not be interrupted during test procedure. Correct working shall be indicated by LED's.

For relay testing and setting by means of a portable, precision test set all required circuits shall be terminated to test plugs/switches, arranged at easily accessible locations. An appropriate test set with all accessories shall be included.

14.6. DRAWINGS, DOCUMENTS AND DESIGN CALCULATIONS

After award of contract, the contractor shall furnish all drawings, documents, design calculations, data, manuals & other necessary literature, pertaining to equipment offered by them & so specified under various clauses, in accordance with requirements stipulated in “clause 1.19 of Section – 1 i.e. General Technical Specification (GTS)”. A comprehensive list of all such drawings/documents planned

to be submitted for reference/approval shall be provided beforehand for approval of the purchaser as already explained in clause no. 1.19.6 of Section – 1 (GTS). The list of drawings & documents to be furnished for approval / reference shall not be limited to the following:-

- i) Drawings, documents, design calculations literatures, manuals etc. as per clause no. 1.19 of Section-1 (GTS)
- ii) Drawings, documents, design calculations, literatures, manuals as listed in Annexure – D of Section -1 (GTS) referred under clause no. 1.19.6
- iii) Detailed quality assurance plan, giving complete specifications of the materials and specifications relating to inspection and testing of materials and finished components.
- iv) All drawings having bearing on civil foundations, equipments foundation details and loads
- v) Arrangement, installation, foundation, plan, section, detailing of main equipment and sub-assemblies including control & instrumentation system.
- vi) All Electrical, Hydraulic & Control Drawings such as Electrical Panels OGA, Cable Block & Termination Diagram, Schematic Diagram, JB/MB/Kiosk Diagram etc. in respect of this section.
- vii) All manufacturing drawings not specifically covered under approval/reference category shall be submitted for record and facilitate inspection of the component in the shop and assembly at site.
- viii) Any other drawings, documents, design calculations, literatures, manuals etc. not covered anywhere in the specification, but required to be furnished for approval / reference of employer for suitability of design to fulfill the scope of work.

14.7 SHOP ASSEMBLY, INSPECTION AND TESTS

14.7.1 Type tests

Type tests shall fall under Category –II(refer clause 1.16 of GTS) and verify that all components of the protection system perform satisfactorily at the rating assigned. All equipment proposed according to this specification shall be type tested at typical units

in accordance with the relevant IEC standards.

The Contractor shall prepare written documents, in a form agreed upon by the Contractor and the Employer, of all test certificates/ results and hand over these documents to the Employer in due time for review and acceptance. The Contractor shall conduct the type test(s) for which certificate(s) are not acceptable at his own cost.

14.7.2 Routine tests

At least following inspections and tests shall be performed on the completely assembled protection systems:

- Visual inspection,
- Wiring test
- Insulation test,
- High voltage test on outgoing circuits,
- Functional tests of all relays,
- Functional tests of protection scheme.
- Manual Injection Testing

A 100% test of the protected system should be carried out by injection test of analogue voltages, currents and time using injection set type. The connection terminals shall enable primary system VT circuits to be interrupted and primary system CT circuits to be short circuited. The above test has to be calculated on the approved relay setting calculation & relay coordination study document.

14.7.3 Field Tests

All field tests including tests during installation, pre-commissioning, commissioning, performance and field acceptance tests shall be conducted by the Contractor, in the presence of representative of the Employer.

Procedure to be adopted for conducting the operational, pre-commissioning, commissioning, performance and field acceptance tests shall be submitted well in advance, at least six (6) months before start of relevant testing.

14.7.4 Tests during installation and pre commissioning & Commissioning

At least following tests shall be performed by the Contractor:

- Correctness of interconnections between CTs, CVTs and PTs as well as CT groups and associated relays,
- Testing, calibration and adjustment of protection relays,
- Check of functional characteristics of each of the electrical protections,
- Check of tripping sequence,

- Check of orders issued by each of the protections with respect to the corresponding tripping sequence,
 - The systematic testing of the operation of each chain forming the protection, the associated tripping sub-assembly, the links to the connected systems and all fault simulations by test kit for which the system is to react,
 - The co-ordination of protection and relay setting,
 - The testing of the protection system behavior during failure of one of its components,
 - The testing of the protection system behavior in the event of failure of one of the connected system to which it is connected,
 - Analysis of information consistency and of alarms supplied by protection system.
 - Manual Injection System
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- The final co-ordination of protection and final relay setting

Checks shall be made after the protection systems have been commissioned to ensure that all connections and test links have been replaced and test leads removed and relay setting has been done, as well as to confirm the integrity of the current transformer circuits. Where necessary, voltage readings shall be taken at the terminals on each relay to ensure that loop connections between the relays are complete.

14.7.5 Performance testing

If nothing unusual has been observed in load run and load rejection tests, the test service period of 72 hours shall follow. During this test service period, the unit must operate continuously at rated condition without any interruption except of those beyond the control of the Contractor. However, such interrupted period shall not be counted for in the test service period. There should be one month reliability run of the complete unit reckoned from the date of taking over by employer. During reliability run, machine shall be operated by employer and any problem observed during this run shall be attended by the contractor including replacement of components and providing requisite manpower.

14.8 PACKAGING, HANDLING AND SITE STORAGE

The Contractor shall pack all the consignment in sea worthy packaging strong enough to withstand rough handling during transit. Machine surface shall be suitably protected against scratches, corrosion, shocks, impact etc. Packages shall be suitably and distinctly identified for type of handling and kind of storage.

Electronic equipment shall be packaged, shipped and stored in anti-static packing. All packages shall be stored indoor. Packages containing electronic equipment shall be stored in humidity controlled environment.

14.9 SITE INSTALLATION AND COMMISSIONING

14.9.1 General

The Contractor has to do all the work related to assembly, erection, testing and commissioning complete in all respects. All necessary tools, plants, labour, materials including consumables for performing installation, testing and pre-commissioning shall be provided by the Contractor.

The Contractor shall submit the necessary data/information, layout and foundation/support drawings well in advance. The Contractor shall provide and install the concrete inserts/embedment; support steels and/or components for foundation/supports purpose as per approved erection drawings and coordinate the activities with civil contractors to keep his activities in synchronism with civil work. All installation for foundation shall be verified and accepted by the Engineer.

The Contractor shall use anchor fasteners for installation of fixtures, mountings, conduits, cabling, panels etc. Chipping of concrete and/or taking support from reinforcement bars shall not be allowed.

The Contractor shall supply sufficient number of erection and commissioning spares based on their experience so that erection, testing and commissioning work progresses smoothly and is not hampered for want of such spares. These spares shall be in addition to the spare parts described under clause “Spare Parts”.

14.9.2 Installation procedure

The Contractor shall submit six copies of all detailed programs and the procedures to be adopted for erection / installation, testing and commissioning, at least six (6) months before start of erection activities/ installation.

14.10 TOOLS AND INSTRUMENTS

14.10.1 Tools for erection and Installation.

The Contractor shall bring his own tools, devices, testing instruments / equipments to site in order to erect and install the complete equipment delivered under this section. These shall remain the property of the Contractor unless otherwise agreed to take over any / all of these at mutually agreed conditions.

14.11 SPARE PARTS

The spare parts mentioned here under are meant for use by the Employer during operation and maintenance stage and shall not be used as erection spares required during installation.

14.11.1 Mandatory Spare Parts

The Contractor shall supply the mandatory spare parts as per Schedule-III.

14.11.2 Recommended Spare Parts

The Contractor shall furnish the list of recommended spare parts at Schedule-IV.