

TD-201 Rev No. 00	Form No.	 	PRODUCT STANDARD PROJECT ENGINEERING & SYSTEMS DIVISION, HYDERABAD	ANNEXURE-2B to PY55294
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COPYRIGHT AND CONFIDENTIAL The information on this document is the property of BHARAT HEAVY ELECTRICALS LIMITED, It must not be used directly or indirectly in any way detrimental to the interest of the company. ANNEXURE-2B TO PY55294 ELECTRICAL CONTROL PHILOSOPHY PROJECT 75MW VISAKH REFINERY MODERNIZATION PROJECT (VRMP) CUSTOMER M/S HINDUSTAN PETROLEUM CORPORATION LIMITED,VIZAG,A.P CONSULTANT ENGINEERS INDIA LIMITED				

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COPYRIGHT AND CONFIDENTIAL The information on this document is the property of BHARAT HEAVY ELECTRICALS LIMITED, It must not be used directly or indirectly in any way detrimental to the interest of the company.	ELECTRICAL CONTROL AND OPERATION PHILOSOPHY			
	Project :	VIZAG REFINERY MODERNIZATION PROJECT(VRM P) (CAPTIVE POWER PLANT PACKAGE)		
	Customer :	M / s. HINDUSTAN PETROLEUM CORPORATION LIMITED (HPCL), VISAKHAPATNAM		
	Consultant :	M / s. ENGINEERS INDIA LIMITED (EIL), NEW DELHI EIL JOB NO : B016		

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LEGENDS:

CPP	:	Captive Power Plant
SCAP	:	Synchronizing control and annunciation panel
GIS	:	Gas Insulated Substation
GRP	:	Generator Relay Panel
GTG	:	Gas Turbine Generator
SAS	:	Substation Automation System
ECS	:	Electrical control systems
STG	:	Steam Turbine Generator

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1.0 **OBJECTIVE**

The document provides guidelines for operation and control philosophy of plant electrical systems. It also covers annunciation, metering, control and indication of plant electrical systems.

2.0 **REFERENCE DOCUMENTS**

- EIL Job specification (Electrical), Section C-4, Subsection C-4.5, B016-606-16-50-SP-0001, Rev B
- EIL Engineering Design Basis (Electrical), (A753-999-16-50-EDB-1001, Rev 0)
- Job specification for ECS (Electrical): Part C section C-4 Subsection C-4.5 B016-606-16-50-SP-0002 Rev A
- Typical ECS I/O list for different type of feeders ECS systems: B016-606-16-50-DS-1038, RevA1.
- EIL's Single Line diagram of CPP (B016-606-16-50-00001-Rev B)
- System architecture-SS automation of SPG Package (B016-606-16-50-SK-4504)
- BHEL's Key Single Line Diagram PY-DL-0-M104-1101-01

3.0 **GENERAL**

To meet the power requirement of the entire complex post VRMP, new CPP consisting of STG, GTG in parallel with 220kV Grid and existing generators is envisaged. Total power of the complex will be fed from existing 4 nos GTGs, new STG, new GTG and import from 220kV grid.

During normal operation, 220kV Grid shall run in parallel with existing generators and new generators. Grid shall feed part of the total load. 220kV grid power will be connected to existing complex loads through 220/33kV transformer & new 33kV GIS and the new units under VRMP through 220/66kV transformers & 66kV GIS.

Emergency power of the new VRMP units including CPP package shall be provided through 2nos 11kV DG sets (each rated 50% of the total rating). Normal power supply to various VRMP units is fed from 66kV GIS and 11kV utility switchboard. Emergency power supply to various VRMP units is fed from 11kV emergency switchboard in CPP. 220kV, 66 kV, 33kV and 415 V system neutrals shall be solidly earthed, whereas, 11 kV system neutral shall be resistance earthed.

For various MV loads of ISBL, normal PCCs fed from normal power supply and Emergency PMCC fed from emergency supply feeders has been envisaged. Adequate no's of MCCs shall be considered for feeding loads as per design basis. Auxiliary service board and lighting distribution boards shall be provided to distribute miscellaneous load and lighting loads respectively. UPS systems and DC systems shall be provided to supply respective loads.



4.0 PHILOSOPHY FOR CONTROLS, MONITORING & AUDIO VISUAL FUNCTIONS OF GENERATORS (GTG & STG), GCB, 220kV GIS, 66kV GIS AND 33KV GIS

As applicable, Control, monitoring and annunciation functions for the above mentioned equipment is envisaged from the following equipment.

- | | | |
|---------------------|---|-----------------------------|
| • SCAP | - | BHEL Scope of supply |
| • 66kV GIS LCC/BCU | - | BHEL Scope of supply |
| • 33kV GIS LCC/BCU | - | BHEL Scope of supply |
| • Mark-VI | - | BHEL Scope of supply |
| • 220kV GIS LCC/BCU | - | Not in BHEL Scope of supply |
| • ECS | - | Not in BHEL Scope of supply |

4.1 CONTROL FUNCTIONS

4.1.1 CONTROL FUNCTIONS OF GENERATORS (GTG AND STG):

- All controls, as required for control and operation of generators, namely, field Voltage and frequency breaker control, etc., shall be from respective control systems of GTG and STG, SCAP and ECS (customer scope).
- Temperature scanners shall be located on either generator relay panels or turbine control panel with alarm on SCAP.

4.1.2 CONTROL AND OPERATION PHILOSOPHY OF 220KV BREAKERS:

- Control from SCAP- Not envisaged
- Control from 220kV GIS: Shall be as per respective package design (Customer scope)

4.1.3 CONTROL AND OPERATION PHILOSOPHY OF 66KV BREAKERS:

- 66kV GIS have Common LOCAL/REMOTE selector switch.

a) Local control operation - From 66kV GIS::

When LOCAL/REMOTE selector switch of GIS is in local mode, following operation is possible from GIS.

- Close of incomer, buscoupler and bussectionalizer breakers in feeder/bus earthing mode only.
- Close of outgoing breakers in service & feeder earthing mode.
- Open of all breakers.
- Close and Open of isolators & earth switches of incomers, buscouplers, bussectionalizers and outgoing feeders.

b) Remote control operation- From SCAP::

When LOCAL/REMOTE selector switch of GIS is in remote mode, controls are possible from remote equipment i.e., SCAP or ECS.

SCAP shall have following switches.

- | | | |
|------|---|--|
| SW-1 | : | SCAP/ OFF/ ECS |
| SW-2 | : | OFF/ Deadbus/ ManualSynch/ AutoSynch |
| | | For 66kV GIS incomer/ buscoupler/ bussectionalizers breakers |
| SW-3 | : | OFF/ GTG/ STG/ ALL |



When SW-1(SCAP/OFF/ECS) selector switch is in SCAP mode, controls are retained with SCAP and following operations are possible from SCAP.

- Deadbus close of incomer, buscoupler and bussectionalizer breakers in service position.
- Auto/Manual synchronizing and close of incomer, buscoupler and bussectionalizer breakers in service position through check synchronizing & auto synchronizer. Synchronization trolley shall be provided for manual and auto synchronization. Selector switch SW-2 shall be kept on AutoSynch or ManualSynch accordingly for this operation.
- Close of outgoing breakers in service mode.
- Open of all breakers.
- Synchronization for GCB of GTG at 11kV level is also envisaged from SCAP.

c) **Remote control operation From ECS:**

When SW-1(SCAP/OFF/ECS) selector switch at SCAP is in ECS mode, controls are transferred to ECS and control operations are possible from ECS as per ECS control and operation philosophy. (Customer scope)

d) **Remote control operation From Mark-VI (for GTG incomer breaker of GIS and GCB) ::**

In addition to synchronizing from SCAP/ ECS, the GTG shall be synchronized from Mark-VI . If synchronization from Mark-VI is selected then all other selections made either at SCAP and ECS shall be defeated. In other words, selection from Mark-VI is master mode. Synchronization shall be possible from Mark VI of generator manually as well as automatically. To achieve Auto/Manual synchronizing, the following shall be provided as a minimum on Mark-VI but not be limited to it:

- Auto/Manual selection
- Synchro check relay for manual synchronizing
- Auto synchronizer for auto synchronizing (standard feature)

66kV GTG incomer breaker and GCB shall be synchronized from Mark VI.

4.1.4 **CONTROL AND OPERATION PHILOSOPHY OF 33KV BREAKERS:**

- 33kV GIS have Common LOCAL/REMOTE selector switch.
- Incomer and buscoupler breakers are in NC.

a) **Local control operation- From 33kV GIS:**

When LOCAL/REMOTE selector switch of GIS is in local mode, following operation is possible from GIS

- Close of incomers and buscouplers breakers in feeder/bus earthing mode only.
- Close of outgoing breakers in service & feeder earthing mode.
- Open of all breakers.
- Close and Open of isolators & earth switches of incomers, buscouplers and outgoing feeders.

b) **Remote control operation-From SCAP::**

When LOCAL/ REMOTE selector switch of GIS is in remote mode, controls are possible from remote equipment i.e., SCAP or ECS.

SCAP shall have following switches.



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SW-1 : SCAP/ OFF/ ECS
SW-4 : Deadbus/ OFF/ Manual

SW-4 (Deadbus/ OFF/ Manual) mode selector switch for closing of incomer and buscoupler breakers in respective mode shall be provided on SCAP. The contacts of the selector switch are extended to 33kV GIS. All necessary logics required for Deadbus & Manual close shall be developed in 33kV GIS Numerical relays.

When SW-1(SCAP/ OFF/ ECS) selector switch is in SCAP mode, controls are retained with SCAP and following operations are possible from SCAP.

- Deadbus/ Manual close of incomer and buscoupler breakers in service position. Selector switch SW-4 shall be positioned accordingly in Deadbus or Manual.
- Close of outgoing breakers in service position
- Open of all breakers.

c) Remote control operation-From ECS::

When SW-1(SCAP/ OFF/ ECS) selector switch at SCAP is in ECS mode, controls are transferred to ECS and control operations are possible from ECS as per ECS control and operation philosophy. (Customer scope)

4.2 MONITORING FUNCTIONS

4.2.1 SCAP:

- Voltage of incomers and buses of 220kV GIS, 66kV GIS, 33kV GIS.
- Current of each phase of 220kV GIS incomers & outgoing feeders, 66 KV GIS incomers, bus couplers / section breakers and outgoing feeders, 33 KV GIS incomers, buscouplers / section breakers and outgoing feeders.
- Line and field voltage of generator.
- Field current of Generator.
- Frequency of Generator.
- Power factor of Generator incomer.
- MW, MVAR & MVA of Generator incomer and outgoing feeders of 66kV GIS, 33KV GIS.
- MWH, MVARH of Generator incomers.
- Voltage and frequency recorder for each bus. Recorders shall be paperless.
- Null voltmeter of Generator.
- ON/OFF/TRIP indications through LED / semaphore indicators of breakers, isolators and earth switches of 220kV GIS, 66 kV GIS, 33kV GIS.

4.3 AUDIO-VISUAL ANNUNCIATION FUNCTIONS

4.3.1 SCAP:

- Annunciation of Fault status of incomers, buscouplers and outgoing feeders of 66kV GIS, 33kV GIS.
- Operating and fault status of all protective relays and trip alarm of Turbine, Generators etc.
- Annunciation of all protective relays and trip alarms of new GTG & STG.
- Hooter and clock.

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5.0 **PHILOSOPHY FOR CONTROLS, MONITORING & AUDIO VISUAL FUNCTIONS OF 220/66KV & 220/33KV GRID TRANSFORMERS / GTG TRANSFORMER / STG TRANSFORMER and 66/11.5KV CPP AUXILIARY TRANSFORMERS.**

As applicable, Control, monitoring and annunciation functions for the above mentioned transformers is envisaged from the following equipment.

- | | | |
|--|---|-----------------------------|
| • SCAP | - | BHEL Scope of supply |
| • OLTC/ RTCC of 220/33 KV Grid transformers | - | BHEL Scope of supply |
| • GTG/ STG Transformers (OCTC controlled) | - | BHEL Scope of supply |
| • OLTC/ RTCC of 66/11.5KV CPP Auxiliary Transformers | - | BHEL Scope of supply |
| • ECS | - | Not in BHEL Scope of supply |
| • OLTC/ RTCC of 220/66KV Grid transformers | - | Not in BHEL Scope of supply |

5.1. **CONTROL FUNCTIONS**

5.1.1 **TAP CHANGING CONTROL OF 220/66KV & 220/33KV GRID TRANSFORMERS:**

LOCAL/ REMOTE selector switch is available on OLTC.

When the LOCAL is selected, tap changing control is possible from OLTC. When the REMOTE is selected, tap changing control is transferred to RTCC.

RTCC/ SCAP/ ECS/ OFF selector switch is available on RTCC.

Based on further switch selection at RTCC, the controls are possible from either RTCC or SCAP or ECS.

5.1.2 **TAP CHANGING CONTROL OF 66/11.5KV CPP AUXILIARY TRANSFORMERS:**

LOCAL/ REMOTE selector switch is available on OLTC.

When the LOCAL is selected, tap changing control is possible from OLTC. When the REMOTE is selected, tap changing control is transferred to RTCC.

RTCC/ ECS/ OFF selector switch is available on RTCC.

Based on further switch selection at RTCC, the controls are possible from either RTCC or ECS.

5.2. **MONITORING FUNCTIONS**

5.2.1 **SCAP:**

- Tap position indication of 220/66kV and 220/33kV Grid transformers.

5.3. **AUDIO-VISUAL ANNUNCIATION FUNCTIONS**

5.3.1 **SCAP:**

- Complete trip and non-trip alarm annunciation including alarm of OLTC for all transformers i.e., GTG transformer, STG transformer, 220/66KV & 220/33KV Grid transformers, 66/11.5kV CPP auxiliary transformers.



6.0 PHILOSOPHY FOR CONTROLS, MONITORING & AUDIO VISUAL FUNCTIONS OF 11KV SWITCHBOARD UTILITY SWITCHBOARD(HT-9422), CPP AUX SWITCHBOARD(HT-9421) AND EMERGENCY SWITCHBOARD(HT-9423)

As applicable, Control, monitoring and annunciation functions for the above mentioned equipment is envisaged from the following equipment.

- | | | |
|---------------------------------------|---|-----------------------------|
| • SCAP | - | BHEL Scope of supply |
| • 11kV UTILITY SWITCHBOARD(HT-9422) | - | BHEL Scope of supply |
| • 11kV CPP AUX SWITCHBOARD(HT-9421) | - | BHEL Scope of supply |
| • 11kV EMERGENCY SWITCHBOARD(HT-9423) | - | BHEL Scope of supply |
| • ECS | - | Not in BHEL Scope of supply |

6.1 CONTROL FUNCTIONS

6.1.1 CONTROL AND OPERATION PHILOSOPHY OF 11KV BREAKERS:

- *11KV UTILITY SWITCHBOARD (HT-9422)* Incomers breakers are NC, Buscoupler2 (between bus B and C) breaker is NC and Buscoupler1 (between A and B) breaker is NO.
- *11KV CPP AUX SWITCHBOARD (HT-9421)* Incomers breakers are NC, Buscoupler (between A and B) breaker is NO.
- *11KV EMERGENCY SWITCHBOARD (HT-9423)* normal Incomers breakers are NC, Buscouplers breakers are NO and DG incomer breakers are NO.
- Auto/Independent/Manual Selector Switch is provided on the switchboard & normally kept in Auto Position for Auto Changeover.
- Each 11kV Switchgear have one LOCAL/REMOTE selector switch.

a) Local control operation-From 11kV Switchgear:

When LOCAL/REMOTE selector switch of 11kV Switchgear is in local mode, following operation is possible from 11kV Switchgear.

- Close of incomers, buscoupler and outgoing breakers in test position.
- Close of Incomer breakers on Deadbus/Manual mode in service position.
- Close of buscoupler breaker on Auto/Independent/Manual mode in service position.
- Close of outgoing breakers in test and service position.
- Open of all breakers.
- For control operation of DG incomers of 11KV EMERGENCY SWITCHBOARD (HT-9423),

Refer section 7.0.

b) Remote control operation-From SCAP::

When LOCAL/REMOTE selector switch of 11kV Switchboard is in remote mode, controls are possible from remote equipment i.e., SCAP or ECS.

SCAP shall have following switches.

SW-1 :SCAP/OFF/ECS

When SW-1(SCAP/OFF/ECS) selector switch is in SCAP mode, controls are retained with SCAP and following operations are possible from SCAP.

- Deadbus closing of selected Incomer and buscoupler breakers in service position.
- Opening of incomer and buscoupler breakers.

**c) Remote control operation-From ECS::**

When SW-1(SCAP/OFF/ECS) selector switch at SCAP is in ECS mode, controls are transferred to ECS and control operations are possible from ECS as per ECS control and operation philosophy. (Customer scope)

6.2 MONITORING FUNCTIONS**6.2.1 SCAP:**

- Voltage of incomers and buses of 11kV switchboard.
- Current of each phase of 11kV incomers and buscouplers.
- ON/OFF/TRIP indications through LED of breakers of 11kV Switchgear.

6.3 AUDIO-VISUAL ANNUNCIATION FUNCTIONS**6.3.1 SCAP:**

- Annunciation of Fault status of incomers, buscouplers of 11kV switchboard.

6.4 OPERATION MODES AT 11KV SWITCHGEAR**AUTO CHANGEOVER:**

- Auto changeover between the two incomers and one buscoupler shall be in such a way those two incomer breakers are 'ON' at a time and buscoupler breaker is normally open.
- Buscoupler breaker is made 'ON' automatically in case the incoming supply at incomer breaker no. 1 or 2 fails and the respective breaker trips on under voltage.
- Blocking of auto transfer (i.e., closing of bus-coupler) if any incomer breaker trips due to a fault. Trip due to 64R shall allow the transfer.
- Tripping of incomer on under voltage shall be blocked, if both the incomers simultaneously experience an under voltage.

INDEPENDENT OPERATION

- In independent mode either of incomer 1 or incomer2 or buscoupler can be closed in dead bus condition after ensuring relevant bus under voltage.

MANUAL CHANGEOVER:

- Incomer no. 1 and 2 breakers are 'ON'. Bus-coupler breaker is 'OFF' Manual closing of bus-coupler with momentary paralleling (interlocked with check synchronizing relay) of the incoming supplies to facilitate taking out any of the incomer breakers for maintenance.
- Trip incomer 1 or 2 (pre-selected) after closing of coupler to avoid continuous paralleling of incomers.

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7.0 PHILOSOPHY FOR CONTROLS, MONITORING & AUDIO VISUAL FUNCTIONS OF DIESEL GENERATOR, DG ISOLATING BREAKERS, DG INCOMER BREAKERS OF 11KV EMERGENCY SWITCHBOARD (HT-9423)

As applicable, Control, monitoring and annunciation functions for the above mentioned equipment is envisaged from the following equipment.

- SCAP - BHEL Scope of supply
- DG AM F PANEL - BHEL Scope of supply

7.1 CONTROL FUNCTIONS

7.1.1 Local control operation-From DG AM F Panel:

- DG ON, OFF, Voltage and frequency control of DG.
- Automatic/Manual synchronization of DGs.
- Deadbus close of 11kV EMERGENCY SWITCHBOARD (HT-9423) DG incomers and DG isolating breakers.
- Auto/Manual synchronization and close of DG incomers and Normal incomer breakers facility for parallel operation during testing and load restoration.
- Opening of incomer and DG isolating breakers.

7.1.2 Remote control operation-From SCAP:

- Open/Close of DG isolating breakers.
- Deadbus close of 11kV EMERGENCY SWITCHBOARD (HT-9423) normal incomer, buscoupler, and DG isolating breakers.
- Control of 11kV EMERGENCY SWITCHBOARD (HT-9423) DG incomer breakers is not envisaged from SCAP.

8.0 PHILOSOPHY FOR CONTROLS, MONITORING & AUDIO VISUAL FUNCTIONS OF 415V PM CC SWITCHBOARD

As applicable, Control, monitoring and annunciation functions for the above mentioned equipment is envisaged from the following equipment.

- 415V PM CC - BHEL Scope of supply
- ECS - Not in BHEL Scope of supply

8.1 CONTROL AND OPERATION PHILOSOPHY OF 415V PM CC:

- 415V PM CC have Common LOCAL/ REMOTE selector switch.
- Incomers breakers are NC and Buscoupler breakers are NO.
- Auto/Independent/Manual Selector Switch is provided on the switchboard & normally kept in Auto Position for Auto Changeover.

a) Local control operation-From 415V Switchgear:

When LOCAL/ REMOTE selector switch of 415V PM CC is in local mode, following operation is possible from 415V PM CC.

- Close of all incomers and Buscoupler in test position.
- Close of Incomer/Buscoupler breaker Deadbus/Manual mode in service position.
- Close of buscoupler breaker on Auto/Deadbus/Manual mode in service & test position.
- Close of all outgoing breakers in test and service position.

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- Open of all breakers.

b) Remote control operation- From SCAP::

Not envisaged

c) Remote control operation-From ECS::

When LOCAL/REMOTE of 415V PMCC selector switch in remote mode, controls are possible from remote equipment i.e., ECS

When SW-1(SCAP/OFF/ECS) selector switch at SCAP is in ECS mode, controls are transferred to ECS and control operations are possible from ECS as per ECS control and operation philosophy. (Customer scope)

8.2 OPERATION MODES AT 415V SWITCHGEAR

AUTO CHANGEOVER:

- Auto changeover between the two incomers and one bus-coupler shall be in such a way those two-incomer breakers are 'ON' at a time and bus-coupler breaker is normally open.
- Bus-coupler breaker is made 'ON' automatically in case the incoming supply at incomer breaker no. 1 or 2 fails and the respective breaker trips on under voltage.
- Blocking of auto transfer (i.e., closing of bus-coupler) if any incomer breaker trips due to a fault. Trip due to 64R shall allow the transfer.
- Tripping of incomer on under voltage shall be blocked, if both the incomers simultaneously experience an under voltage.

INDEPENDENT OPERATION

- In independent mode either of incomer 1 or incomer2 or buscoupler can be closed in dead bus condition after ensuring relevant bus under voltage.

MANUAL CHANGEOVER:

- Incomer no. 1 and 2 breakers are 'ON'. Bus-coupler breaker is 'OFF' Manual closing of bus-coupler with momentary paralleling (interlocked with check synchronizing relay) of the incoming supplies to facilitate taking out any of the incomer breakers for maintenance.
- Trip incomer 1 or 2 (pre-selected) after closing of coupler to avoid continuous paralleling of incomers.

9.0 PHILOSOPHY FOR CONTROLS, MONITORING & AUDIO VISUAL FUNCTIONS OF 415V MCC AND DBs

As applicable, Control, monitoring and annunciation functions for the above mentioned equipment is envisaged from the following equipment.

- 415V MCC and DB - BHEL Scope of supply

Control is envisaged at local switchgear level only.

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10.0 **OPERATING PHILOSOPHY IN VARIOUS CONDITIONS**

NORMAL OPERATION:

During normal operation, all the generators (STG & GTG's) shall operate in parallel among themselves and with grid. In case of outage of any GTG or STG, power drawn from grid shall increase to meet the generation short fall.

EMERGENCY CONDITION

2nos DG sets each rated 50% at 11kV to meet the requirements of emergency loads of the refinery loads like

- Owner's Emergency load.
- Emergency shutdown loads of GTG's, STG's.
- Emergency CPP loads like DC, UPS, AC emergency lighting.

When there is a blackout of CPP due to outage of all generators and grid, DG sets shall start automatically..

Required scheme for automatic start of 1 or 2 DGs based on the loading and parallel operation of DGs along with active & reactive power sharing scheme shall be developed.

11.0 **SUBSTATION AUTOMATION SYSTEM**

A common data concentrator is placed in Electrical control room of SS-93 Building. Networking of SAS shall be in line with the System architecture-SS automation of SPG Package (B016-606-16-50-SK-4504). Metering & status shall be monitored through OWS of SAS. No controls from SAS are envisaged.

12.0 **ELECTRICAL CONTROL SYSTEMS**

ECS design is by customer. BHEL supplied equipment shall provide necessary interface signal on respective package as per the following tender documents.

- ***Job specification for ECS (Electrical): Part C section C-4 Subsection C-4.5 B016-606-16-50-SP-0002 Rev A***
- ***Typical ECS I/O list for different type of feeders ECS systems: B016-606-16-50-DS-1038, RevA1.***

13.0 **ATTACHMENTS:**

Annexure-1: Control and monitoring facilities provided for each electrical system on various panels viz. SCAP, AMF and Switchgear in tabular form is indicated in this annexure.

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Equipment	Breaker	Application	SCAP	SWITCHGEAR	ECS	M ARK VI FOR GTG/ AM F FOR DG /
GTG	-	Synchronization	Auto/ Manual Synch facilities are provided on SCAP. Synchronization is done at GCB and Incomer CB of 66kV GIS.	-	#	Auto/ Manual Synch facilities are provided on Mark VI. Synchronization is done at GCB and Incomer CB of 66kV GIS.
		Control	Voltage control, Speed control, Excitor breaker control, PF & MVAR Regulation	-	#	Voltage and speed control
		Metering	Generator V, A, F, PF, MW, MVA, MVAR Excitor V, A Null voltmeter Trivector meter	-	#	-
		Annunciation	Fault status of trips & alarms of generator, Alarms for generator temperatures	-	#	-
		Indication	PF/MVAR ON/OFF, AVR CH-1/2 in service, AVR in local/ Remote, Exciter CB ON,OFF	-	#	-
		Protection	-	-	#	-
		Remarks				
GCB of GTG	-	Synchronization	Auto & Manual synchronization envisaged	-	#	Auto & Manual synchronization envisaged
		Control	AutoSynch/ ManualSynch/ Deadbus CB Close in service position and CB open	-	#	AutoSynch/ ManualSynch CB Close in service position
		Metering		-	#	-
		Annunciation	Covered in fault status of trips & alarms of generator above	-	#	-
		Indication	CB ON, OFF, RTC	-	#	-
		Protection	-	-	#	-
		Remarks				
STG	-	Synchronization	Auto/ Manual Synch facilities are provided on SCAP. Synchronization is done at Incomer CB of 66kV GIS.	-	#	-
		Control	Voltage control, Speed control, Excitor breaker control, PF & MVAR Regulation	-	#	-
		Metering	Generator V, A, F, PF, MW, MVA,MVAR Excitor V, A Null voltmeter Trivector meter	-	#	-
		Annunciation	Fault status of trips & alarms of generator, Alarms for generator temperatures	-	#	-
		Indication	PF/MVAR ON/OFF, AVR CH-1/2 in service, AVR in local/ Remote, Exciter CB ON,OFF	-	#	-
		Protection	-	-	#	-
		Remarks				
220kV GIS	I/ C	Synchronization	-	#	#	-
		Control	-	#	#	-
		Metering	V, A	#	#	-
		Annunciation	-	#	#	-
		Indication	CB ON, OFF and Isolator/ Earth switch ON & OFF	#	#	-
		Protection	-	#	#	-
		Remarks				
	B/ C	Synchronization	-	#	#	-
		Control	-	#	#	-
		Metering	-	#	#	-
		Annunciation	-	#	#	-
		Indication	CB ON, OFF and Isolator/ Earth switch ON & OFF	#	#	-
		Protection	-	#	#	-
		Remarks				
	OG	Synchronization	-	#	#	-
		Control	-	#	#	-
		Metering	A	#	#	-
		Annunciation	-	#	#	-
		Indication	CB ON, OFF and Isolator/ Earth switch ON & OFF	#	#	-
		Protection	-	#	#	-
		Remarks				
	BUS	Synchronization	-	#	#	-
		Control	-	#	#	-
		Metering	Voltage & Frequency recorder, V	#	#	-
		Annunciation	-	#	#	-
		Indication	-	#	#	-
		Protection	-	#	#	-
		Remarks				
GTG I/ C		Synchronization	Auto & Manual synchronization enivsaged	-	#	Auto & Manual synchronization envisaged
		Control	AutoSynch/ ManualSynch/ Deadbus CB Close in service position and CB open	CB Close in feeder earthing position and CB open	#	AutoSynch/ ManualSynch CB Close in service position
		Metering	V, A	As per SLD	#	-
		Annunciation	CB Tripped on fault, Line PT Sec MCB off, Trip circuit unhealthy	-	#	-
		Indication	CB ON, OFF, RTC and Isolator/ Earth switch ON & OFF	As per SLD	#	-
		Protection	-	As per SLD	#	-
		Remarks				

Equipment	Breaker	Application	SCAP	SWITCHGEAR	ECS	M ARK VI FOR GTG/ AM F FOR DG /
66kV GIS	STG I/ C	Synchronization	Auto & Manual synchronization enivrsaged	-	#	-
		Control	AutoSynch/ ManualSynch/ Deadbus CB Close in service position and CB open	CB Close in feeder earthing position and CB open	#	-
		Metering	V, A	As per SLD	#	-
		Annunciation	CB Tripped on fault, Line PT Sec MCB off, Trip circuit unhealthy	-	#	-
		Indication	CB ON, OFF, RTC and Isolator/ Earth switch ON & OFF	As per SLD	#	-
		Protection	-	As per SLD	#	-
		Remarks				
	GRID I/ C	Synchronization	Auto & Manual synchronization enivrsaged	-	#	-
		Control	AutoSynch/ ManualSynch/ Deadbus CB Close in service position and CB open	CB Close in feeder earthing position and CB open	#	-
		Metering	V, A	As per SLD	#	-
		Annunciation	CB Tripped on fault, Line PT Sec MCB off, Trip circuit unhealthy	-	#	-
		Indication	CB ON, OFF, RTC and Isolator/ Earth switch ON & OFF	As per SLD	#	-
		Protection	-	As per SLD	#	-
		Remarks				
	B/ C & B/ S	Synchronization	Auto & Manual synchronization enivrsaged	-	#	-
		Control	AutoSynch/ ManualSynch/ Deadbus CB Close in service position and CB open	CB Close in bus earthing position and CB open	#	-
		Metering	A	As per SLD	#	-
		Annunciation	CB Tripped on fault,Trip circuit unhealthy	-	#	-
		Indication	CB ON, OFF, RTC and Isolator/ Earth switch ON & OFF	As per SLD	#	-
		Protection	-	As per SLD	#	-
		Remarks				
	OG	Synchronization	-	-	#	-
		Control	CB Close in service position and CB open	CB Close in feeder earthing and service position, CB open	#	-
		Metering	A, MW, MVARand MVA	As per SLD	#	-
		Annunciation	CB Tripped on fault,Trip circuit unhealthy	-	#	-
		Indication	CB ON, OFF, RTC and Isolator/ Earth switch ON & OFF	As per SLD	#	-
		Protection	-	As per SLD	#	-
		Remarks				
	BUS	Synchronization	-	-	#	-
		Control	-	-	#	-
		Metering	Voltage & Frequency recorder, V	As per SLD	#	-
		Annunciation	Bus PT MCB off	-	#	-
		Indication	-	-	#	-
		Protection	-	As per SLD	#	-
		Remarks				
33kV GIS	GRID I/ C	Synchronization	-	-	#	-
		Control	Deadbus/ Manual CB Close in service position and CB open	CB Close in feeder earthing position and CB open	#	-
		Metering	V, A	As per SLD	#	-
		Annunciation	CB Tripped on fault, Line PT Sec MCB off, Trip circuit unhealthy	-	#	-
		Indication	CB ON, OFF, RTC and Isolator/ Earth switch ON & OFF	As per SLD	#	-
		Protection	-	As per SLD	#	-
		Remarks				
	B/ C	Synchronization	-	-	#	-
		Control	Deadbus/ Manual CB Close in service position and CB open	CB Close in bus earthing position and CB open	#	-
		Metering	A	As per SLD	#	-
		Annunciation	CB Tripped on fault,Trip circuit unhealthy	-	#	-
		Indication	CB ON, OFF, RTC and Isolator/ Earth switch ON & OFF	As per SLD	#	-
		Protection	-	As per SLD	#	-
		Remarks				
	OG	Synchronization	-	-	#	-
		Control	CB Close in service position and CB open	CB Close in feeders earthing and service position, CB open	#	-
		Metering	A, MW, MVARand MVA	As per SLD	#	-
		Annunciation	CB Tripped on fault,Trip circuit unhealthy	-	#	-
		Indication	CB ON, OFF, RTC and Isolator/ Earth switch ON & OFF	As per SLD	#	-
		Protection	-	As per SLD	#	-
		Remarks				
	BUS	Synchronization	-	-	#	-
		Control	-	-	#	-
		Metering	Voltage & Frequency recorder, V	As per SLD	#	-
		Annunciation	Bus PT MCB off	-	#	-
		Indication	-	-	#	-
		Protection	-	As per SLD	#	-
		Remarks				
	I/ C	Synchronization	-	-	#	-
		Control	Deadbus CB Close in service position, CB open.	Manual/ Deadbus CB Close in service position, CB Close in test position and CB open	#	-
		Metering	V, A	As per SLD	#	-
		Annunciation	CB Tripped on fault, Line PT Sec MCB off, Trip circuit unhealthy	-	#	-
		Indication	CB ON, OFF, RTC	Open, Close, Trip, Trip Circuit healthy, Spring charged	#	-
		Protection	-	As per SLD	#	-
		Remarks				

Equipment	Breaker	Application	SCAP	SWITCHGEAR	ECS	M ARK VI FOR GTG/ AM F FOR DG /
CPP and Utility 11kV Switchgear	B/ C	Synchronization	-	-	#	-
		Control	Deadbus CB Close in service position, CB open.	Auto/ Manual/ Deadbus CB Close in service position, CB Close in test position and CB open	#	-
		Metering	A	As per SLD	#	-
		Annunciation	CB Tripped on fault,Trip circuit unhealthy	-	#	-
		Indication	CB ON, OFF, RTC	Open, Close, Trip, Trip Circuit healthy, DC Fail, Spring charged	#	-
		Protection	-	As per SLD	#	-
		Remarks				
	OG	Synchronization	-	-	#	-
		Control	-	CB Close in service position, CB Close in test position and CB open	#	-
		Metering	-	As per SLD	#	-
		Annunciation	-	-	#	-
		Indication	-	Open, Close, Trip, Trip Circuit healthy, Spring charged	#	-
		Protection	-	As per SLD	#	-
		Remarks				
	BUS	Synchronization	-	-	#	-
		Control	-	-	#	-
		Metering	Voltage & Frequency recorder, V	As per SLD	#	-
		Annunciation	Bus PT MCB off	-	#	-
		Indication	-	-	#	-
		Protection	-	As per SLD	#	-
		Remarks				
Emergency 11kV Switchgear	Normal I/ C	Synchronization	-	-	#	Auto & Manual synchronization enivsaged from DG AMF panel
		Control	Deadbus CB Close in service position, CB open.	Manual/ Deadbus CB Close in service position, CB Close in test position and CB open	#	AutoSynch/ ManualSynch CB Close in service position.
		Metering	V, A	As per SLD	#	-
		Annunciation	CB Tripped on fault, Line PT Sec MCB off, Trip circuit unhealthy	-	#	-
		Indication	CB ON, OFF, RTC	Open, Close, Trip, Trip Circuit healthy, Spring charged	#	-
		Protection	-	As per SLD	#	-
		Remarks				
	DG I/ C	Synchronization	-	-	#	Auto & Manual synchronization enivsaged from DG AMF panel
		Control	-	Deadbus CB Close in service position, CB Close in test position and CB open	#	Deadbus/ AutoSynch/ ManualSynch CB Close in service position.
		Metering	V, A	As per SLD	#	-
		Annunciation	CB Tripped on fault, Line PT Sec MCB off, Trip circuit unhealthy	-	#	-
		Indication	CB ON, OFF	Open, Close, Trip, Trip Circuit healthy, Spring charged	#	-
		Protection	-	As per SLD	#	-
		Remarks				
	B/ C	Synchronization	-	-	#	-
		Control	Deadbus CB Close in service position, CB open.	Auto/ Manual/ Deadbus CB Close in service position, CB Close in test position and CB open	#	-
		Metering	A	As per SLD	#	-
		Annunciation	CB Tripped on fault,Trip circuit unhealthy	-	#	-
		Indication	CB ON, OFF, RTC	Open, Close, Trip, Trip Circuit healthy, DC Fail, Spring charged	#	-
		Protection	-	As per SLD	#	-
		Remarks				
	OG	Synchronization	-	-	#	-
		Control	-	CB Close in service position, CB Close in test position and CB open	#	-
		Metering	-	As per SLD	#	-
		Annunciation	-	-	#	-
		Indication	-	Open, Close, Trip, Trip Circuit healthy, Spring charged	#	-
		Protection	-	As per SLD	#	-
		Remarks				
	BUS	Synchronization	-	-	#	-
		Control	-	-	#	-
		Metering	Voltage & Frequency recorder, V	As per SLD	#	-
		Annunciation	Bus PT MCB off	-	#	-
		Indication	-	-	#	-
		Protection	-	As per SLD	#	-
		Remarks				
415V PMCCs & MCC	I/ C	Synchronization	-	-	#	-
		Control	-	Manual/ Deadbus CB Close in service position, CB Close in test position and CB open	#	-
		Metering	-	As per SLD	#	-
		Annunciation	-	-	#	-
		Indication	-	Open, Close, Trip, Trip Circuit healthy, Spring charged	#	-
		Protection	-	As per SLD	#	-
		Remarks				
	B/ C	Synchronization	-	-	#	-
		Control	-	Auto/ Manual/ Deadbus CB Close in service position, CB Close in test position and CB open	#	-
		Metering	-	As per SLD	#	-
		Annunciation	-	-	#	-
		Indication	-	Open, Close, Trip, Trip Circuit healthy, DC Fail, Spring charged	#	-
		Protection	-	As per SLD	#	-
		Remarks				

Equipment	Breaker	Application	SCAP	SWITCHGEAR	ECS	M ARK VI FOR GTG/ AM F FOR DG /
	OG	Synchronization	-	-	#	-
		Control	-	CB Close in service position, CB Close in test position and CB open	#	-
		Metering	-	As per SLD	#	-
		Annunciation	-	-	#	-
		Indication	-	Open, Close, Trip, Trip Circuit healthy, Spring charged	#	-
		Protection	-	As per SLD	#	-
		Remarks				
	BUS	Synchronization	-	-	#	-
		Control	-	-	#	-
		Metering	-	As per SLD	#	-
		Annunciation	-	-	#	-
		Indication	-	-	#	-
		Protection	-	As per SLD	#	-
		Remarks				
220/66kV & 33kV GRID Transformers	-	Synchronization	-	-	#	-
		Control	Tap Raise/Lower	-	#	-
		Metering	Tap position indicator	-	#	-
		Annunciation	Trip and Non trip alarm	-	#	-
		Indication	-	-	#	-
		Protection	-	-	#	-
		Remarks				
Generator transformers of GTG and STG	-	Synchronization	-	-	#	-
		Control	-	-	#	-
		Metering	-	-	#	-
		Annunciation	Trip and Non trip alarm	-	#	-
		Indication	-	-	#	-
		Protection	-	-	#	-
		Remarks				
66/ 11.5kV CPP Auxiliary transformers	-	Synchronization	-	-	#	-
		Control	-	-	#	-
		Metering	-	-	#	-
		Annunciation	Trip and Non trip alarm	-	#	-
		Indication	-	-	#	-
		Protection	-	-	#	-
		Remarks				
Emergency DG set	-	Synchronization	-	-	#	Auto/Manual Synch facilities are provided on AMF panel Synchronization is done at Incomer CB of 11V DG Incomer.
		Control	-	-	#	Voltage control, Speed control, DG start and DG stop
		Metering	-	-	#	V, A,F,PF,M W,M VA,M VAR
		Annunciation	-	-	#	Alarm/ Trip fault status of DG
		Indication	-	-	#	DG ON/ OFF
		Protection	-	-	#	-
		Remarks				
DG isolating breakers	-	Synchronization		-	#	-
		Control	CB Close in service position. CB open.	-	#	CB Close in service position. CB open.
		Metering	-	-	#	-
		Annunciation	-	-	#	-
		Indication	CB ON, OFF, RTC	-	#	DG ON,OFF,RTC
		Protection	-	-	#	-
		Remarks				

NOTES

- 1
- For Auto/ Manual Synchronisation of GTG, STG from SCAP. Auto Synchroniser, Dual voltmeter, Dual Frequencymeter, Synchroscope, Synchroscope on/off switch, Checksync. relay, Gaurd relay, SS, Socket, Cable (3meters) etc. are provided on Synchronising trolley.
- 2
- Open, Close, Trip, Trip Circuit healthy, DC Fail(buscoupler), Spring charged LED type indicating lamps provided on switchboard.
- 3
- Only Breaker feeders are covered.
- 4
- TNC Switch is discrepency type.
- 5
- Electrical signals (except for drives) are not envisaged at DCS.
- 6
- Numerical relays shall be hooked upto data concentrator. Further hook-up from data Concentrator to ECS RTU shall be on IEC 61850 RTU Protocol.
- 7
- The Data Concentrator is also connected to its HMI for data logging, NR Parameterisation, Breaker status, monitoring and disturbance record.
- 8
- BHEL supplied equipment shall ensure all the interface I/ Os required for ECS as per typical ECS I/O list for different type of feeders ECS systems: B016-606-16-50-DS-1038, RevA1.

LEGEND:

" - " Not applicable/Not envisaged
" # " By customer
A - AM METER
V - VOLTMETER
MW - MEGAWATT METER
MWH - ENERGY METER
MVA - MEGAVOLTAMP METER
MVAR - MEGAVAR METER
F - FREQUENCY METER
PF - POWER FACTOR METER
TPI - TAP POSITION INDICATOR

TYPICAL ECS I/O LIST FOR FOR DIFFERENT TYPE OF FEEDERS ECS SYSTEM

CAPTIVE POWER PLANT (CPP) PACKAGE TENDER NO. B016-606-02-43-PG-T-7810

PROJECT : VISAKH REFINERY MODERNISATION PROJECT

UNIT : 606

OWNER : HPCL VISAKHAPATNAM

PMC : EIL

JOB NO. : B016

A	18.05.2017	ISSUED WITH TENDER	GK	AS	PG
Rev. No	Date	Purpose	Prepared by	Checked by	Approved by

Generator Transformer, SCAP, GTG/STG

Type	Pt type	Signal description	Set condition description	Reset condition description	Remarks
SCAP / ECS Selector Switch					
DI	S	Control from	SCAP	Not_SCAP	Hardwired
DI	S	Control from	ECS	Not_ECS	Hardwired
Generator Synchronisation Selector Switch					
DI	S	Control from	Local (TCP)	Not_Local	Hardwired
DI	S	Control from	Remote (SCAP / ECS)	Not_Remote	Hardwired
Load shed Command Signals from ECS					
DI	S	Load Shed Block-1	Operated	Reset	Hardwired
DI	S	Load Shed Block-2	Operated	Reset	Hardwired
DI	S	Load Shed Block-n	Operated	Reset	Hardwired
Generator Transformers					
DI	S	Trafo OCTC Tap at each tap position			Hardwired signal for each tap position
AI	T	Oil temperature (4-20 mA) (see note 7)			From Trafo, Hardwired
AI	T	Winding temperature (4-20 mA) (see note 7)			From Trafo, Hardwired
Generators (STG/GTG)					
AI	T	Ambient Temperature of ST Skid (4-20 mA signal)			Hardwired
DI	D	STG/GTG/GTG Winding Temp	Alarm	Normal	Hardwired
DI	D	STG/GTG Bearing Temp	Alarm	Normal	Hardwired
DI	S	STG/GTG running mode	Isochronous	Not_Isochronous	Hardwired
DI	S	STG/GTG running mode	Constant MW	Not_Constant MW	Hardwired
DI	S	STG/GTG running mode	Droop	Not_Droop	Hardwired
DI	S	Field CB in service &	Closed	Not closed	Hardwired
DI	S	Field CB in service &	Open	Not open	Hardwired
DI	D	STG/GTG Exciter	Trip	Normal	Hardwired
DI	D	STG/GTG Generator	Trip	Normal	Hardwired
DI	D	STG/GTG Unit	Trip	Normal	Hardwired
DI	D	STG/GTG Rotor Earth Fault	Operated	Normal	Hardwired
DI	D	STG/GTG Relay 80	Operated	Normal	Hardwired
DI	D	STG/GTG Relay 59G	Operated	Normal	Hardwired
DI	D	STG/GTG Relay 27G	Operated	Normal	Hardwired
DI	D	STG/GTG Relay 32 Alarm	Operated	Normal	Hardwired
DI	D	STG/GTG Relay 81 1 st setting	Operated	Normal	Hardwired
DI	D	STG/GTG Relay 81 2nd setting	Operated	Normal	Hardwired
DI	D	STG/GTG Excitation Failure Relay	Operated	Normal	Hardwired
DI	D	STG/GTG Overfluxing Relay	Operated	Normal	Hardwired
DI	D	STG/GTG Numerical relay	Unhealthy	Healthy	
DI	S	STG/GTG connected to grid	True	False	Hardwired
DO	C	STG/GTG Voltage RAISE	Activated	Reset	Hardwired, for Synch
DO	C	STG/GTG Voltage LOWER	Activated	Reset	Hardwired, for Synch

Type	Pt type	Signal description	Set condition description	Reset condition description	Remarks
DO	C	STG/GTG Freq RAISE	Activated	Reset	Hardwired, for Synch
DO	C	STG/GTG Freq LOWER	Activated	Reset	Hardwired, for Synch
DO	C	Set STG/GTG Run mode to Droop	Activated	Reset	Hardwired
DO	C	Set STG/GTG Run mode to Isochronous	Activated	Reset	Hardwired
DO	C	Set STG/GTG Run mode to Constant MW	Activated	Reset	Hardwired

Following list is **applicable** for 66 kV, 33kV, 11 kV switchgear and 415 PCC/PMCC/EPMCC in CONTRACTOR's scope.

66kV GIS & 33kV GIS

Incomers I/O signals					
AI	A	R phase current			Hardwired
					Hardwired
AI	A	Y phase current			Hardwired
AI	A	B phase current			Hardwired
AI	W	3-phase real power			Hardwired
AI	R	3-phase reactive power			Hardwired
DI	S	CB in service &	Closed	Not closed	Hardwired
DI	S	CB in service &	Open	Not open	Hardwired
DI	D	Relay 86	Operated	Reset	Hardwired
DI	D	Relay 95	Operated	Reset	Hardwired
DI	D	Feeder Trip on Undervoltage	Operated	Reset	Hardwired
DI	D	Unit Transformer, if any, Alarm	Operated	Reset	Hardwired
DI	D	Numerical relay	Unhealthy	Healthy	
DI	D	Bus 1 Isolator	closed	open	Hardwired
DI	D	Bus 2 Isolator	closed	open	Hardwired
DO	C	Bus 1 isolator closed command	Activated	Reset	Hardwired
DO	C	Bus 1 isolator open command	Activated	Reset	Hardwired
DO	C	Bus 2 isolator closed command	Activated	Reset	Hardwired
DO	C	Bus 2 isolator open command	Activated	Reset	Hardwired
DO	C	Dead Bus Close from ECS	Activated	Reset	Hardwired
DO	C	Synch Close from ECS	Activated	Reset	Hardwired
DO	C	Trip From ECS	Activated	Reset	Hardwired
Line VT					
AI	V	R – Y Line Voltage			Hardwired
AI	V	Y – B Line Voltage			Hardwired
AI	V	B – R Line Voltage			Hardwired
AI	F	Line Frequency			Hardwired
DI	D	Line VT MCB	Tripped	Closed	Hardwired
DI	D	Line	Dead	Not_Dead	Hardwired
Bus VT					
AI	V	R – Y Bus Voltage			Hardwired
AI	V	Y – B Bus Voltage			Hardwired
AI	V	B – R Bus Voltage			Hardwired
AI	F	Bus Frequency			Hardwired
DI	D	Bus VT MCB	Tripped	Closed	Hardwired

DI	D	Bus	Dead	Not_Dead	Hardwired
DI	D	Under Frequency Relay	Operated	Reset	Hardwired
DI	D	df/dt Relay	Operated	Reset	Hardwired
DI	D	Control Supply	Failed	Healthy	Hardwired
Bus Coupler/ bus Sectionalizer					
AI	A	R phase current			Hardwired
AI	A	Y phase current			Hardwired
AI	A	B phase current			Hardwired
AI	W	3-phase real power			Hardwired
AI	R	3-phase reactive power			Hardwired
DI	S	CB in service &	Closed	Not closed	Hardwired for ECS
DI	S	CB in service &	Open	Not open	Hardwired for ECS
DI	D	Relay 86 (Differential)	Operated	Reset	Hardwired for ECS
DI	D	Relay 86	Operated	Reset	Hardwired for ECS
DI	D	Relay 95	Operated	Reset	Hardwired for ECS
DI	D	Numerical relay	Unhealthy	Healthy	
DO	C	Dead Bus Close from ECS	Activated	Reset	Hardwired
DO	C	Synch Close from ECS	Activated	Reset	Hardwired
DO	C	Trip From ECS	Activated	Reset	Hardwired
DI	S	L-E selector switch (see note 2)	Local	Not on local	Hardwired
DI	S	L-E selector switch (see note 2)	ECS	Not on ECS	Hardwired
Outgoing Feeder					
AI	A	R phase current			Hardwired
AI	A	Y phase current			Hardwired
AI	A	B phase current			Hardwired
AI	W	3-phase real power			Hardwired
AI	R	3-phase reactive power			Hardwired
DI	S	CB in service &	Closed	Not closed	Hardwired for ECS
DI	S	CB in service &	Open	Not open	Hardwired for ECS
DI	D	Relay 86	Operated	Reset	Hardwired for ECS
DI	D	Relay 95	Operated	Reset	Hardwired for ECS
DI	D	Numerical relay	Unhealthy	Healthy	
DO	C	Close from ECS	Activated	Reset	Hardwired
DO	C	Trip From ECS	Activated	Reset	Hardwired

HV & MV switchboards

Type	Pt type	Signal description	Set condition description	Reset condition description	Remarks
Isolating breaker I/O signals – If Applicable					
DI	S	CB in service &	Closed	Not closed	Hardwired
DI	S	CB in service &	Open	Not open	Hardwired
DO	C	Trip from ECS	Activated	Reset	Hardwired
HV incomer I/O signals					
AI	A	R phase current			These signals are required over numerical relay and metering LAN
AI	A	Y phase current			
AI	A	B phase current			
AI	W	3-phase real power			
AI	R	3-phase reactive power			
AI	H	Frequency			
AI	T	Oil temp (4-20 mA)			From Trafo, Hardwired
AI	T	Winding temp (4-20 mA)			From Trafo, Hardwired

Type	Pt type	Signal description	Set condition description	Reset condition description	Remarks
DI	S	CB in service &	Closed	Not closed	Hardwired
DI	S	CB in service &	Open	Not open	Hardwired (for SOE)
DI	D	Relay 86	Operated	Reset	These signals are required over numerical relay and metering LAN
DI	D	Relay 95	Operated	Reset	
DI	D	Transformer Trouble	Operated	Reset	
DI	D	Trip on undervoltage	Activated	Reset	
DI	D	Numerical Relay	Unhealthy	Healthy	
DO	C	Trip from ECS	Activated	Reset	Hardwired
DO	C	Breaker inhibited from closing due to load shedding	Operated	Reset	Hardwired
DI	S	OLTC L/R Sel Switch	Local	Not_Local	Hardwired
DI	S	OLTC L/R Sel Switch	Remote	No_Remote	Hardwired
DI	S	OLTC C/R Sel Switch	RTCC	Not_RTCC	Hardwired
DI	S	OLTC C/R Sel Switch	ECS	Not_ECS	Hardwired
DI	S	OLTC I/A Sel Switch	Independent	Not_Independen nt	Hardwired
DI	S	OLTC I/A Sel Switch	Auto	Not_Auto	Hardwired
DI	S	OLTC Tap on position 17	Set	Reset	Hardwired
DI	S	OLTC Tap on position 16	Set	Reset	Hardwired
DI	S	OLTC Tap on position 15	Set	Reset	Hardwired
DI	S	OLTC Tap on position 14	Set	Reset	Hardwired
DI	S	OLTC Tap on position 13	Set	Reset	Hardwired
DI	S	OLTC Tap on position 12	Set	Reset	Hardwired
DI	S	OLTC Tap on position 11	Set	Reset	Hardwired
DI	S	OLTC Tap on position 10	Set	Reset	Hardwired
DI	S	OLTC Tap on position 9	Set	Reset	Hardwired
DI	S	OLTC Tap on position 8	Set	Reset	Hardwired
DI	S	OLTC Tap on position 7	Set	Reset	Hardwired
DI	S	OLTC Tap on position 6	Set	Reset	Hardwired
DI	S	OLTC Tap on position 5	Set	Reset	Hardwired
DI	S	OLTC Tap on position 4	Set	Reset	Hardwired
DI	S	OLTC Tap on position 3	Set	Reset	Hardwired
DI	S	OLTC Tap on position 2	Set	Reset	Hardwired
DI	S	OLTC Tap on position 1	Set	Reset	Hardwired
DI	D	Tap Change	In Progress	Completed	Hardwired
DI	D	Tap Changer	Stuck	Normal	Hardwired
DO	C	Tap Raise	Activated	Reset	Hardwired
DO	C	Tap Lower	Activated	Reset	Hardwired
HV line PT I/O signals					
AI	V	R-Y line voltage			These signals are required over numerical relay and metering LAN
AI	V	Y-B line voltage			
AI	V	B-R line voltage			
DI	D	Line PT MCB	Open	Closed	
HV bus coupler I/O signals					
AI	A	R phase current			These signals are required over numerical relay and metering LAN
AI	A	Y phase current			
AI	A	B phase current			
AI	W	3-phase Real power			

Type	Pt type	Signal description	Set condition description	Reset condition description	Remarks
AI	R	3-phase Reactive power			
DI	S	CB in service &	Closed	Not closed	Hardwired
DI	S	CB in service &	Open	Not open	Hardwired (for SOE)
DI	D	Relay 86	Operated	Reset	These signals are required over numerical relay and metering LAN
DI	D	Relay 95	Operated	Reset	
DI	D	Auto-changeover	Blocked	Not blocked	
DI	D	Numerical Relay	Unhealthy	Healthy	
DI	S	Switchboard (A-I-M selector switch)	In auto mode	Not in auto mode	Hardwired
DI	S	Switchboard (A-I-M selector switch)	In indep mode	Not in indep mode	Hardwired
DI	S	Switchboard (A-I-M selector switch)	In manual mode	Not in manual mode	Hardwired
DI	D	AC control supply #1	Failed	Healthy	Hardwired
DI	D	AC control supply #2	Failed	Healthy	Hardwired
DI	D	DC control supply #1	Failed	Healthy	Hardwired
DI	D	DC control supply #2	Failed	Healthy	Hardwired
DI	D	AC space heater supply #1	Failed	Healthy	Hardwired
DI	D	AC space heater supply #2	Failed	Healthy	Hardwired
DO	C	Trip from ECS	Activated	Reset	Hardwired
DO	C	Breaker inhibited from closing due to load shedding	Operated	Reset	Hardwired
HV bus PT I/O signals					
AI	V	R-Y bus voltage			These signals are required over numerical relay and metering LAN
AI	V	Y-B bus voltage			
AI	V	B-R bus voltage			
DI	D	Bus PT MCB	Open	Closed	
HV plant feeder I/O signals					
AI	A	R phase current			These signals are required over numerical relay and metering LAN
AI	A	Y phase current			
AI	A	B phase current			
AI	W	Real power			
AI	R	Reactive Power			
DI	S	CB in service &	Closed	Not closed	Hardwired
DI	S	CB in service &	Open	Not open	Hardwired (for SOE)
DI	D	Relay 86	Operated	Reset	These signals are required over numerical relay and metering LAN
DI	D	Relay 95	Operated	Reset	
DI	D	Numerical Relay	Unhealthy	Healthy	
DO	C	Trip from ECS	Activated	Reset	
DO	C	Breaker inhibited from closing due to load shedding	Operated	Reset	Hardwired
Outgoing transformer feeder I/O signals					
AI	A	R phase current			These signals are required over numerical relay and metering LAN
AI	A	Y phase current			
AI	A	B phase current			
AI	W	Real power			
AI	R	Reactive power			
DI	S	CB in service &	Closed	Not closed	Hardwired
DI	S	CB in service &	Open	Not open	Hardwired (for SOE)
DI	D	Relay 86	Operated	Reset	These signals are required over numerical relay and metering LAN
DI	D	Relay 95	Operated	Reset	
DI	D	Transformer trouble	Operated	Reset	
DI	D	Numerical Relay	Unhealthy	Healthy	

Type	Pt type	Signal description	Set condition description	Reset condition description	Remarks
DO	C	Trip from ECS	Activated	Reset	Hardwired
DO	C	Breaker inhibited from closing due to load shedding	Operated	Reset	Hardwired
HV motor feeder I/O signals					
AI	A	R phase current			These signals are required over numerical relay and metering LAN
AI	A	Y phase current			
AI	A	B phase current			
AI	W	Real power			
AI	R	Reactive power			
DI	S	CB in service &	Closed	Not closed	Hardwired
DI	S	CB in service &	Open	Not open	Hardwired (for SOE)
DI	D	Relay 86	Operated	Reset	These signals are required over numerical relay and metering LAN
DI	D	Relay 86 (Process trip)	Operated	Reset	
DI	D	Relay 95	Operated	Reset	
DI	D	Trip on undervoltage	Activated	Reset	
DI	D	Motor Trip from Process	Activated	Reset	
DI	D	Numerical Relay	Unhealthy	Healthy	
DO	C	Trip from ECS	Activated	Reset	Hardwired
DO	C	Breaker inhibited from closing due to load shedding	Operated	Reset	Hardwired
HV synchronous motor feeder I/O signals					
AI	A	R phase current			These signals are required over numerical relay and metering LAN
AI	A	Y phase current			
AI	A	B phase current			
AI	W	Real power			
AI	R	Reactive power			
DI	S	CB in service &	Closed	Not closed	Hardwired
DI	S	CB in service &	Open	Not open	Hardwired (for SOE)
DI	D	Relay 86	Operated	Reset	These signals are required over numerical relay and metering LAN
DI	D	Relay 86 (Process trip)	Operated	Reset	
DI	D	Relay 95	Operated	Reset	
DI	D	Trip on undervoltage	Activated	Reset	
DI	D	Motor Trip from Process	Activated	Reset	
DI	D	Numerical Relay	Unhealthy	Healthy	
DO	C	Trip from ECS	Activated	Reset	Hardwired
DO	C	Breaker inhibited from closing due to load shedding	Operated	Reset	Hardwired
DI	S	Excitation control in constant PF mode	Set	Reset	Hardwired
DI	S	Excitation control in constant VAR mode	Set	Reset	Hardwired
DI	S	Excitation control in VAR control mode	Set	Reset	Hardwired
DI	S	L-E selector switch (see note 3)	Local	Not on local	Hardwired
DI	S	L-E selector switch (see note 3)	ECS	Not on ECS	Hardwired
DO	C	Set Excitation in Constant PF mode	Activated	Not_Activated	Hardwired
DO	C	Set Excitation in Constant VAR mode	Activated	Not_Activated	Hardwired
DO	C	Set Excitation in VAR control mode	Activated	Not_Activated	Hardwired
DO	C	Excitation raise	Activated	Not_Activated	Hardwired
DO	C	Excitation lower	Activated	Not_Activated	Hardwired

Type	Pt type	Signal description	Set condition description	Reset condition description	Remarks
AO	C	Excitation set point			4-20mA signal from ECS, Hardwired
HV capacitor feeder I/O signals					
AI	A	R phase current			These signals are required over numerical relay and metering LAN
AI	A	Y phase current			
AI	A	B phase current			
AI	R	Reactive power			
DI	S	CB in service &	Closed	Not closed	Hardwired
DI	S	CB in service &	Open	Not open	Hardwired (for SOE)
DI	D	Relay 86	Operated	Reset	These signals are required over numerical relay and metering LAN
DI	D	Relay 95	Operated	Reset	
DI	D	Numerical relay	Unhealthy	Healthy	
DI	S	L-E selector switch (see note 2)	Local	Not on local	Hardwired
DI	S	L-E selector switch (see note 2)	ECS	Not on ECS	Hardwired
DO	C	Close from ECS	Activated	Reset	Hardwired
DO	C	Trip from ECS	Activated	Reset	Hardwired
MV PMCC incomer I/O signals					
AI	A	R phase current			These signals are required over numerical relay and metering LAN
AI	A	Y phase current			
AI	A	B phase current			
DI	W	Real power			
DI	R	Reactive power			
DI	S	CB in service &	Closed	Not closed	Hardwired
DI	S	CB in service &	Open	Not open	Hardwired (for SOE)
DI	D	Relay 86	Operated	Reset	These signals are required over numerical relay and metering LAN
DI	D	Relay 95	Operated	Reset	
DI	D	Trip on U/V	Activated	Reset	
DI	D	Numerical Relay	Unhealthy	Healthy	
DO	C	Trip from ECS	Activated	Reset	Hardwired
DO	C	Breaker inhibited from closing due to load shedding	Operated	Reset	Hardwired
MV PMCC line PT I/O signals					
AI	V	R-Y line voltage			These signals are required over numerical relay and metering LAN
AI	V	Y-B line voltage			
AI	V	B-R line voltage			
DI	D	Line PT MCB	Open	Closed	
MV PMCC bus PT I/O signals					
AI	V	R-Y bus voltage			These signals are required over numerical relay and metering LAN
AI	V	Y-B bus voltage			
AI	V	B-R bus voltage			
DI	D	Bus PT MCB	Closed	Open	
MV PMCC bus coupler I/O signals					
DI	S	CB in service &	Closed	Not closed	Hardwired
DI	S	CB in service &	Open	Not open	Hardwired (for SOE)
DI	D	Relay 86	Operated	Reset	These signals are required over numerical relay and metering LAN
DI	D	Relay 95	Operated	Reset	
DI	D	Auto-changeover	Blocked	Not blocked	
DI	D	Numerical Relay	Unhealthy	Healthy	
DI	S	Switchboard (A-I-M selector switch)	In auto mode	Not in auto mode	Hardwired
DI	S	Switchboard (A-I-M selector switch)	In indep mode	Not in indep mode	Hardwired
DI	S	Switchboard (A-I-M selector switch)	In manual mode	Not in manual mode	Hardwired

Type	Pt type	Signal description	Set condition description	Reset condition description	Remarks
DI	D	AC control supply #1	Failed	Healthy	Hardwired
DI	D	AC control supply #2	Failed	Healthy	Hardwired
DI	D	DC control supply #1	Failed	Healthy	Hardwired
DI	D	DC control supply #2	Failed	Healthy	Hardwired
DI	D	AC space heater supply #1	Failed	Healthy	Hardwired
DI	D	AC space heater supply #2	Failed	Healthy	Hardwired
DO	C	Trip from ECS	Activated	Reset	Hardwired
DO	C	Breaker inhibited from closing due to load shedding	Operated	Reset	Hardwired
MV PMCC outgoing feeder I/O signals					
AI	A	R phase current			These signals are required over numerical relay and metering LAN
AI	A	Y phase current			
AI	A	B phase current			
AI	W	Real power			
AI	R	Reactive Power			
DI	S	CB in service &	Closed	Not closed	Hardwired
DI	S	CB in service &	Open	Not open	Hardwired (for SOE)
DI	D	Relay 86	Operated	Reset	These signals are required over numerical relay and metering LAN
DI	D	Relay 95	Operated	Reset	
DI	D	Numerical Relay	Unhealthy	Healthy	
DO	C	Trip from ECS	Activated	Reset	Hardwired
DO	C	Breaker inhibited from closing due to load shedding	Operated	Reset	Hardwired
Miscellaneous I/O signals					
DO	C	Lighting feeder ' ON'	Activated	Reset	Hardwired
DO	C	Lighting feeder ' OFF'	Activated	Reset	Hardwired
DI	D	UPS Charger	Failure	Normal	Hardwired
DI	D	UPS Inverter	Failure	Normal	Hardwired
DI	D	UPS Battery	Discharged	Normal	Hardwired
DI	D	UPS Battery	Isolated	Normal	Hardwired
DI	S	UPS load on	Inverter	Bypass Trafo	Hardwired
DI	D	DC supply Charger - I	Failure	Normal	Hardwired
DI	D	DC supply Charger - II	Failure	Normal	Hardwired
DO	C	Load Shedding	Operated	Reset	Hardwired

Notes:

1. It is assumed that HV boards and MV PCCs & MCCs have numerical relays. All signals of I/O list that are to be acquired on the relay LAN have been indicated as such. All other I/Os shall be acquired hardwired. In case any of these data can not be acquired over the relay LAN, these signals have to be provided as hardwired.
2. There shall be one Local-ECS selector switch in each HV capacitor feeder in HV switchboard. When this switch is in Local mode, CB closing from local shall be permitted and CB closing from ECS shall be blocked. When the switch is in ECS mode, CB closing shall be permitted from ECS but blocked from local. Simultaneous monitoring and CB tripping are permitted both from ECS and local. Motor feeders are not to be closed from ECS.
3. There shall be one Local-ECS selector switch in each HV synchronous motor feeder in HV switchboard. When this switch is in Local mode, the excitation control of the motor shall be from local. When the switch is in ECS mode, the excitation control of the motor shall be from ECS but blocked from local. The excitation control from ECS may be hardwired raise/lower contacts, or in the form of 4-20 mA signal. Provision has to be kept in ECS for both. Simultaneous monitoring and CB tripping are permitted both from ECS and local.

4. There shall be one lighting feeder ON/OFF DO pair (non-latched) per sub-station. These contacts are to be multiplied on 110 V DC control supply voltage, by CPP CONTRACTOR and used for centralised lighting control in his area.
5. ECS shall also be used for load-shedding purposes and will trip some of the breakers to which ECS monitoring is extended, on load shedding. The reset command for breakers tripped on load shedding shall also be generated from the ECS so that a load tripped on load shedding is not allowed to be restored until the exigency leading to load shed has been attended to. Hence a latched changeover type contact DO shall be provided for each breaker feeder, which shall inhibit closing of the circuit breaker tripped on load shedding. CPP CONTRACTOR shall keep suitable provisions in the switchboard control schemes to implement the same.
6. This I/O list is indicative only. Any other I/O required to meet the contract requirements shall be identified and provided by CPP CONTRACTOR.
7. For the purpose of ECS, "MV", "LV" or "LT" stands for voltage rating ≤ 415 V. "HV" or "HT" stands for voltage rating ≥ 3.3 kV.

Guidelines for ECS I/O Interface Design:

Analogue Input Signals

All measurements for I, V, MW, MVAR, Hz, obtained through signal transducers shall have an accuracy limit of $\pm 0.2\%$ within the nominal range of measurement i.e. 0-120%.

For all measurements for I, V, MW, MVAR, Hz, obtained on the relay and metering LAN, maximum possible accuracy shall be ensured.

Digital Input Signals

Alarm (D)

Alarm is a signal which requires operator to be alerted such as VT circuit MCB (closed, open), relays 86 & 95 (operated, reset), auto-changeover (blocked, not blocked), DC control supply (healthy, failed), line voltage (unhealthy, healthy), bus voltage (unhealthy, healthy), motor trip from process, under-voltage trip. This shall be hardwired / on relay LAN as specified.

For hardwired signal, potential free contacts of rating 2 A, 110 V DC or 240 V AC, make to alarm (NO) preferred. CONTRACTOR shall specifically indicate if NC contact is being provided in place of NO contact.

Generally a hardwired alarm point is put under "sequence of event" monitoring.

Status (S)

For hardwired signal, potential free contacts of rating 2 A, 110 V DC or 240 V AC, make to alarm (NO) required.

Digital Output Signals

Command (C)

Hardwired through potential free changeover type contact of interposing relay, contact rating 5 A, 240 V AC and/or 6 A, 110 V DC.