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

v. Gas monitoring devices, barriers, pressure switches, support structures etc. as required.

vi. Local Bay Control Cubicle.

vi) GIS Bus Section Bay Module:

SF6 gas-insulated metal enclosed Bus Section Bay module, each set comprising of the following:

i. One (1) number 3-phase, SF6 gas insulated circuit breaker, complete with operating mechanism.

ii. Three (3) numbers 1-phase, 5-core, multi ratio, current transformers.

iii. Two (2) numbers 3-phase, 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. One (1) number 3-phase, SF6 ducts for interconnection of above mentioned elements.

vi. Gas monitoring devices, barriers, pressure switches, support structures etc. as required.

vii. Local Bay Control Cubicle.

vii) GIS Reactor Bay module:

SF6 gas-insulated metal enclosed Reactor Bay module, each set comprising of the following:

i. One (1) number 3-phase, SF6 gas insulated circuit breaker, complete with operating mechanism.

ii. Three (3) numbers 1-phase, 5-core, multi ratio, current transformers.

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

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

v. One (1) number 3-phase SF6 ducts inside GIS hall (upto the outer edge of the wall of GIS Hall).

vi. Gas monitoring devices, barriers, pressure switches, support structures etc. as required.

vii. Local Bay control cubicle.

Gas Insulated Outdoor Bus Duct (GIB):

(i) **765kV & 420kV GIB:**

For making connections with outdoor overhead lines/Transformer/Reactor, Single Phase enclosed SF6 Gas Insulated Bus Duct (including support structure, gas monitoring device, gas barrier, pressure switch, UHF PD Sensor etc.) shall be provided. The GIB shall be measured in running meter as per actual at site and the same shall be paid as per unit rate quoted in Bid Price Schedule. This outdoor bus duct shall be measured from outer wall edge of GIS Building to centerline of SF6 to Air Bushing/SF6 to Oil Bushing (as applicable). SF6 gas duct inside GIS building are part of respective GIS Bay Module.

(ii) **245kV GIB:**

For making connections with outdoor overhead lines/Transformer/Reactor, **Single/Three Phase** enclosed SF6 Gas Insulated Bus Duct (including support structure, gas monitoring device, gas barrier, pressure switch, UHF PD Sensor etc.) shall be provided. The GIB shall be measured in running meter as per actual at site and the same shall be paid as per unit rate quoted in Bid Price Schedule. This outdoor bus duct shall be measured from outer wall edge of GIS Building to centerline of SF6 to Air Bushing/SF6 to Oil Bushing (as applicable). SF6 gas duct inside GIS building are part of respective GIS Bay Module.

(iii) 145kV GIB:

For making connections with overhead lines/Transformer/Reactor, Three Phase enclosed SF6 Gas Insulated Bus Duct (including support structure, gas monitoring device, gas barrier, pressure switch etc.) shall be provided. The GIB shall be measured in running meter as per actual at site and the same shall be paid as per unit rate quoted in Bid Price Schedule. This outdoor bus duct shall be measured from outer wall edge of GIS Building to centerline of SF6 to Air Bushing/ SF6 to Oil Bushing (as applicable). SF6 gas duct inside GIS building are part of respective GIS Bay Module.

The GIB duct length shall be optimized further meeting present & future bay requirements without affecting the switchyard arrangement, bay orientation and any of the specified functional requirements.

Gas Insulated SF6 to Air Termination:

For making connections with overhead lines/Transformer/Reactor, SF6 to Air bushing including accessories shall be as specified below:

(i) **For 765kV/420/245/145kV:** SF6 to air bushings along with terminal connectors & support structure etc. as required for outdoor connections to connect GIS with overhead line/Transformer/Reactor.

Gas Insulated SF6 to Oil Termination:

For making direct connections with Transformer/Reactor, GIS Interface module along with associated active parts to facilitate the direct connection of GIS duct with Transformer/Reactor is under the present scope of subject package which is as specified below:

(i) **For 765kV/420/245/145kV:** 1-phase Gas insulated interface module along with associated active parts to facilitate the direct inter-connection of GIS duct with the Transformer/Reactor.

Supply of SF6 to Oil bushing is in the scope of Transformer/Reactor Manufacturer. The limits of supply of the GIS switchgear manufacturer and transformer manufacturer shall be as per IEC 62271-211. The drawings/details of SF6 to Oil bushing along with other required data of Transformer/Reactor shall be provided during detailed engineering.

Gas Insulated SF6 to Cable Termination:

For making connections of GIS switchgear/duct with XLPE Cable, GIS Interface module along with associated active parts to facilitate the connection of GIS switchgear/duct with XLPE Cable as per IEC-62271-209 is under the present scope of subject package which is as specified below:

(i) **For 245kV:** 1-phase / 3-Phase Gas Insulated SF6 to cable connection module along with associated active parts to interconnect GIS with XLPE Cable. The Support Structure required to support the XLPE cable upto the GIS termination point is also in the present scope of subject package.

(ii) **For 145kV:** 3-Phase Gas Insulated SF6 to cable connection module along with associated active parts to interconnect GIS with XLPE Cable. The Support Structure required to support the XLPE cable upto the GIS termination point is also in the present scope of subject package.

Supply of XLPE Cable along with termination kit is in the scope of Cable Manufacturer. The limits of supply of the GIS switchgear manufacturer and Cable termination shall be as per IEC 62271-209.The drawings/details of XLPE cable along with termination kit shall be provided during detailed engineering.

Gas Insulated Surge Arrester:

(i) **For 765kV/420kV :** 1-phase Gas insulated Surge Arrester along with required accessories (i.e. surge monitor etc.)

(ii) **For 245kV:** 1-phase/3-Phase Gas insulated Surge Arrester along with required accessories (i.e. surge monitor etc.)

(iii) **For 145kV:** 3-phase Gas insulated Surge Arrester along with required accessories (i.e. surge monitor etc.)





Factory Acceptance Test (FAT) Procedures & Formats - Substation Automation System



Power Grid Corporation of India Ltd.
Saudamini, Plot no.2, Sector-29, Gurgaon, Haryana 122 001

DOC: PG/CC/SAS/FAT, Rev04				
Revision	Department	Date	Signature	Signature
01	Engg	-	-	-
02	CC/Engg CC/QAI CC/AM	09.11.2023	Sd/	Sd/
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Sl.No.	Pages	Revision	Remarks
01	All Pages	01	Initial Release
02	All Pages	02	Major revision
03	All Pages	03	Minor revision
04	All Pages	04	Minor revision

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Date:	Date:

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ABOUT THIS DOCUMENT

PURPOSE OF THIS DOCUMENT

This document shall be used as a standard for conducting all tests during the Factory Acceptance Test (FAT) for the typical Substation Automation System (SAS) of every substation as per POWERGRID requirements and specifications.

The 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 the complete control and protection system to be supplied shall be tested for complete functionality and configuration in the factory itself for both green field and brown field projects. The extensive testing shall be carried out during FAT. The purpose of Factory Acceptance Testing is to ensure defect free installation at site. No major change in configuration/setting of system is envisaged at site.

In case of extension/Augmentation 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.

This document details the equipment and functions under test and the corresponding test methods as well as the test documentation.

WHO SHOULD USE THIS DOCUMENT

This document needs to be used by the Vendor representatives (Q&I, Engg, Factory) for Factory acceptance test as per the project requirement. This approved document will be followed by the Vendor Representatives (Q&I, Engg, Testing) and POWERGRID representatives to test and evaluate the complete system.

1. GENERAL

INTRODUCTION

The purpose of this document is to define the Factory Acceptance Test procedures of Substation Automation System (SAS) for supplied by the Vendor to POWERGRID.

The tests are performed by Vendor and each test, or set of tests as appropriate, is covered by an approval stage, which will be signed off upon completion by Vendor and POWERGRID representatives.

Comments are noted in separate Observation and correction reports (snag list) attached as annexure.

2. PRE-FAT – PREREQUISITES

2.1. ENGINEERING DOCUMENTS

Purpose:

This test verifies that the correct manufacturing drawings and documentation for the equipment/system under the test will be used during the Factory Acceptance Test.

Procedure

1. Vendor shall prepare NTAMC signal list and submit the same for approval during detail engineering.
2. Verify that approved drawings (printed and soft copies) of all assembled equipment are present.
3. Verify that the detailed signal list for Local SAS and NTAMC SCADA as per POWERGRID specimen signal list is available with IEC 61850 & IEC 60870-5-104 addresses and display text as per the list.
4. Verify that the detailed GOOSE matrix with publisher and subscriber details is available.
5. Verify all required hardware and software manuals are present.
6. Guaranteed Technical Particulars (GTPs) as approved by POWERGRID are included in Appendix A for reference.
7. A copy of Customer Technical Specification for reference is made available in the FAT room.
8. Availability of the approved Drawing list in the FAT room.

Drawing Verification Log:

Sl No.	Description	Drg No.	Checked
1	Standard Approved MQP		☐
2	Approved FAT Procedure		☐
3	GTP-Guaranteed Technical Particulars		☐
4	Complete SAS Architecture Standard General Technical Particulars for SAS		☐
5	Hardware specification		☐
6	Approved HMI Signal List		☐
7	Approved NTAMC Signal List		☐
8	Approved IP address List as received from POWERGRID		☐
9	Functional Design Specification		☐
10	Exported HMI signal list file in spreadsheet/CSV format.		☐
11	Exported NTAMC signal list file in spreadsheet/CSV format.		☐
12	VLAN Architecture drawing (If applicable)		☐
13	Matrix for GOOSE messages for each feeder (with publisher& subscriber details, Mac id, APP Id, VLAN as required)		☐
14	Matrix for SV (with publisher & subscriber details, SV ID, Destination mac and VLAN details) in case of Process Bus substation		☐
15	Ethernet Network Configuration Document (RSTP details, VLAN details, Port details etc.)		☐
16	IP Addressing as per Submitted Architecture (by Vendor) based on sr.no.9		☐
17	Single SCD File of the entire substation		☐
18	GA & Scheme of Network Panel(HMI/Gateway/Time sync/DR)		☐
19	Aux BCU Panel		☐
20	CRP (Line/Trafo/BR/LR/BB/BC/TBC/TieEtc)		☐
21	Product Manuals (Installation, Configuration, maintenance, Troubleshooting, detailed diagnostics etc.)		☐
22	Control Room Lay-out		☐
23	Switchyard Panel Room layout drawing		☐
24	Bill of Quantity-Spares		☐
25	Operation and Technical Guide for BCU, Gateway, Server, OWS Software		☐
26	Operation and Technical Guide IED configuration softwares		☐
27	Operation and Technical Guide NMS Software		☐

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

Sl No.	Description	Drg No.	Checked
28	Operation and Technical Guide Ethernet Switch		☐
29	Operation and Technical Guide Time synchronizing Equipment		☐
30	Operation and Technical Guide Router Cum Firewall		☐
31	Operation and Technical Guide UPS/Inverter		☐
32	**Other applicable drgs (not listed above)**	**Attach the list as annexure**	☐

Note: A single SCD file shall be there for the entire substation. For extension projects too, the SCD file shall be a single file after integrating the newer IEDs.

2.2. SAS FAT EQUIPMENTS

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	Sys log 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)		

Note: These equipment quantities shall be verified w.r.t. Engg. approved SAS Architecture and BOM.

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Name:	Name:
Date:	Date:

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.	Controlled Switching Device				
17.	Transformer B/U O/C				
18.	RTCC				
19	SAS Spare Equipments				
	Other applicable equipments (not listed above)				

Notes:
1) All Units should be present with loaded configurations

For an overview drawing of the equipment installed for the FAT please refer to the sec. **2.1.1.**

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

3. STATION LEVEL EQUIPMENT

Software and hardware components are checked to ensure required functionalities. Versions are recorded for later support purposes.

3.1. HARDWARE COMPONENT

The following hardware equipment 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			☐

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

S.NO.	Equipment	Hardware Specification (CPU/RAM/HDD)	Serial No.	Checked
3	Operator Workstation-1 with speakers			☐
4	Operator Workstation-2 with speakers			☐
5	Gateway #1			☐
6	Gateway #2			☐
7	Disturbance Recorder PC			☐
8	Sys Log PC			☐
9	Station Ethernet Switch			☐
10	Router Cum Firewall			☐
11	Color Laser JET Printer			☐
12	Dot Matrix printer			☐
13	GPS Receiver Unit			☐
	Other applicable equipments (not listed above)			

Panel Visual Inspections Log:

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.	----				☐
	Other applicable Panels (not listed above)				☐

3.2. SOFTWARE COMPONENTS

The Software to be used will include the following applications/capabilities:

- 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.

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

Configuration files shall be downloaded prior to commencement of tests and shall be the actual configuration files for individual S/S.

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.

Firmware Verification Log.

S.NO.	Equipment	Model	Operating System/Firmware	Checked
1	OWS-1 & 2			☐
2	SERVER 1 & 2			☐
3	Gateway-1&2			☐
4	DR PC			☐
5	Ethernet Switches			☐
6	Firewall Cum Router			☐
7	GPS Receiver			☐
8	Color Laser JET Printer			☐
9	Dot Matrix Printer			☐
10	Voltage Level_BCU_BAY No.			☐
11	Voltage Level IED's (IEC61850 Compliant) for Dia			☐
	Other applicable equipments (not listed above)			

Note: Record all the TCP/IP Devices & IED devices(Protection, BCU, CSD, RTCC,etc) model & Firmware version which are connected in the substation

3.2.2. IP ADDRESS VERIFICATION

SCADA Devices - IP Addresses
IP address has to be kept as per the list provided shared by POWERGRID. This should be checked at each device user interface.

Station level equipment:

Designation	N/W Name	Mac Id	IP Address				Checked
SERVER 1			172	16	55	1	☐
SERVER 2							☐
OWS1							☐
OWS2							☐
EWS/DR PC							☐
SDC1(If Applicable)							☐
SDC2(If Applicable)							☐
GATEWAY1							☐
GATEWAY2							☐
GPS Time Server 1							☐
GPS Time Server 2							☐
Ethernet Switch 1							☐
Ethernet Switch 2….n							☐
Event Printer							☐
Color Laserjet Printer							☐
Router cum Firewall 1							☐
Router cum Firewall 2							☐
Other applicable equipments (not listed above)							☐

Protection & Control IEDs:

RELAY'S NAME	N/W NAME	GOOSE ID	IP Address				Checked
P444_-------Line			172	16	55	1	☐
							☐
							☐
							☐
							☐

Note: Record all the TCP/IP Devices & IED devices (Protection, BCU, CSD, RTCC,etc) model & Firmware version in the substation

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

4. TEST EQUIPMENT PREPARATION

The following equipment is required to conduct the test.

- EWS/DR PC installed with all configuration application of IEDs utilized in the project.
- SAS server-1 &2 installed with required SCADA & other softwares as required.
- Gateway -1&2 installed with required SCADA & other softwares as required.
- NMS software installed in the DR PC
- Ethernet switch configured with Proper VLAN, Bridged priority, Edge port and managed as required and documented properly wherever applicable.
- 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 Analyzer & simulator as applicable (IEC 101/104, Wireshark & etc)

4.1. TEST EQUIPMENT INSPECTION

Purpose

To ensure that the Test Equipment to be used is operational and has 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			☐

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

4.2. 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).

Setup/Program

Perform the steps below to confirm correct operation of all equipment connected to the powersupplies.

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	NA	Gateway-1		☐
7	NA	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		☐

5. 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 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 decentralized I/O devices (bay control units and protection devices) are provided for this test. A complete test of all I/O signals (see SAS signal list) is the objective of this test. All modules are tested by type tests in general and by test routines during manufacturing.

5.1. START-UP BEHAVIOR AND SAS SYSTEM AVAILABILITY

For the 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 the user has to register with the 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.

Note: This test has to be done when all bays along with all signals have been configured and the same are reporting in HMI.

System Start-up	Checked	Start up Time	Comments see log sheet no.
Server-1 (Switch on the relevant MCB Server-1 Workstation boots up and SCADA starts automatically)	☐		
Server-2 (Switch on the relevant MCB Server-2 Workstation boots up and SCADA starts automatically)	☐		
Operator Workstation 1 (Switch on the relevant MCB OWS-1 Workstation boots up and SCADA starts automatically)	☐		
Operator Workstation 2 (Switch on the relevant MCB OWS-2 Workstation boots up and SCADA starts automatically)	☐		
Engineering/DR PC (Switch on the relevant MCB Engineering Workstation boots up and NMS starts automatically)	☐		
Gateway 1 (Switch on the relevant MCB Gateway-1 Workstation boots up and SCADA starts automatically and Data Transmission to RCC/RLDC should resume automatically)	☐		Data Transmission to NTAMC/RCC/RLDC should resume automatically
Gateway 2 (Switch on the relevant MCB	☐		Data Transmission to NTAMC/RCC/RLDC should resume automatically

Gateway-2 Workstation boots up and SCADA starts automatically and Data Transmission to RCC/RLDC should resume automatically)			
Complete system start up	☐		Black Start

Time Synchronization Verification

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	☐

5.2. MONITORING AND CONTROL

5.2.1. 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.
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	☐	

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

BCUs for__kV Level	Checked	Comments see log sheet no.
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	☐	

5.2.2. HMI – USER ADMINISTRATION & ACCESS RIGHTS

Access rights form the basis for safety and security of the overall system with restricted access boundaries for monitoring, control as well as access to specified applications. Access rights are allotted via usernames with password authentication.

Complete flexibility allows for authorization across various screens for viewing access, specific application access, down to individual switching device operation access.

A multi-level login Active directory 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

- Ensure that the HMI Servers are running.
- Ensure that OWS PCs are running.
- Ensure that PCs are connected to the Network.

Procedure

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.

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

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, Engineer, Administrator)
5. Repeat steps 1 to 4 for the other Workstations (OWS-1 &2, Server-1&2, Gateway-1&2)
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	Admin	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	☐	

Automatic Logout

Verify Automatic Logout after 30 min idle time is provided for all access rights.

5.2.3. HMI – DISPLAYS AND HANDLING

Check that the displays are in accordance with POWERGRID requirements. General layout and handling are 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/HMI 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/HMI.
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.

HMI Screen Verification	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 Operations counter for PLCC, CB, LA	☐	
Auxiliary LVAC view & control	☐	
Firefighting system Signals View & control	☐	
Auxiliary DC system view	☐	
Display of Measurement Trends (Real-time and Historical)	☐	
Display of maintenance mode	☐	
Display of safety tagging	☐	
Display of Network/LAN overview	☐	
Display of typical bay communication (Ring)	☐	
Display of event list	☐	

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

HMI Screen Verification	Checked	Comments see log sheet no.
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 witching Device	☐	
Busbar Colouring as per Live condition	☐	
CVT/CT Monitoring	☐	
Transformer Bank with Tap changer Operation	☐	
Bay Authority level to be checked from Local/Remote/Station/RCC	☐	
Busbar Colouring for the dynamic voltage changes	☐	

Note- In case of extension/Augmentation 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 on a laptop. Further after completion of FAT, the verified SCADA configuration shall be used for addition into the existing SCADA at site.

5.2.4. 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/HMI system are configured properly and are in correct operating condition.

Setup

1. Ensure that the HMI Servers are running.
2. Log in HMI/OWS as an “Operator” .

Procedure

1. Verify the layout of each SLD on the OWS/HMI.
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	Checked	Comments see log sheet no.

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

(Naming, SCADA numbers, status indications,measurement items to be checked)		
_____kV LINE FEEDER	☐	
_____kV TRANSFORMER FEEDER	☐	
_____kV BUS REACTOR	☐	
_____kV LINE REACTOR	☐	
------	☐	
--------	☐	
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 SHUNT REACTOR	☐	
_____kV BUS REACTOR	☐	

Note:

1. **Verify Controlling of each equipment and status of changes.**
2. **Verity that SW interlock – Normal/Bypass**
3. **Safety Tagging for each bay checking**
4. **AR ON/OFF command checking**
5. **CSD IN/OUT checking**
6. **86 Reset/Operated checking**
7. **CB 3 Pole & single pole checking**

5.2.5. GIS GAS MONITORING VIEW

Purpose

In this section we will verify that the GIS Gas Monitoring view screen is represented as per requirement and in line with relevant SLDs.

GIS Gas monitoring View verification

Description	Checked
Verify that the “GIS Gas Monitoring view” screen is displayed on the HMI and GSLD in dynamic color in nature.	☐
Verify that the “GIS Gas Monitoring view” is in line with the Gas Compartment scheme.	☐
Simulate SF6 Stage-1 Alarm from BCU & verify it is report as events	☐

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

Description	Checked
Verify that this is detected and is displayed in the view.	☐
Simulate SF6 Stage-2, 3 & 4 Alarm from BCU & verify that this is detected and is displayed in the view and as well as reported as events.	☐
Verify that Gas Pressure is indicated for each compartment (if Applicable)	☐

5.2.6. VALIDATION & VERIFICATION OF SIGNALS ON SCADA HMI/GATEWAY

Purpose

To verify that the signals as per the approved signal list provided by POWERGRID have been correctly configured and are appearing on SCADA HMI/GATEWAY as desired.

Prerequisites for the Validation

1. Approved SCADA Signal list for HMI/Server for Substation level
2. Approved RCC-SCADA Signal list for NTAMC for Gateway
3. Goose signal list (Signals between IED, Mac id, APP id, VLAN) by vendor

HMI/NTAMC SCADA Signal Verification

The Detailed signal list based on which the SCADA configuration has been prepared shall be taken and each signal shall first be validated by simulating “HIGH” and “LOW” states one by one (e.g Naming of each signal, 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.

Typical bays to be created in SCADA configuration for each feeders and any changes in any bays should be reflected in all bays. Signal list for each typical bay must be configured with sufficient spare with each IEDs standard so that changes in any of the Typical should reflect in all the other bays.

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 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 and their naming should be configured in user understandable manner. (**e.g. Auto-reclose status from function RREC wherein the value of AutoRecSt 1 denotes ready so text should be “Auto Reclose Ready”, etc**)

Note:

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

1. **For verifying the HMI/SCADA signals for each bays, the simulation may be done from the respective devices. If the devices are not available due to unavoidable situation, same may be done using the Simulators like Omicron Scout, IEC browser etc.**
2. **For extension/Augmentation projects, The existing project typical has to be taken as reference and configuration has to be done accordingly to reflect the existing projects signal name & appearance.**

GATEWAY DATABASE CONSISTENCY CHECKS

There are three IEC-104 ports on each Gateway for communication with NTAMC, Backup NTAMC & RTAMC Control Centers. Reporting of all signals is required to checked on all six ports through database consistency checks as per the procedure below.

IEC Master Simulation Software is to be connected on each port one by one and data is to be polled through General Interrogation. Output from all six ports consisting of all data points with IEC-104 address and ASDU to be dumped in an excel file and to be checked for count of signals with identical reporting. Mismatch if any between all six ports to be rectified.

After successful completion of this test, no modification of database is allowed.

Description	Checked	Comments see log sheet no.
Gateway Database Consistency Final Database Version_____	☐	

Host firewall of remote gateways shall be enabled and configured as per baseline configuration.

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

Control Authority Transfer Signal Verification:

For Main System:

	STATUS- MAIN CONTROL ON NTAMC	STATUS - MAIN CONTROL ON RTAMC	STATUS - MAIN CONTROL ON BNTAMC	CHECKED	Comments see log sheet no.
COMMAND FROM SCADA FOR MAIN SYSTEM CONTROL AT NTAMC	**SET**	**RESET**	**RESET**	☐	
COMMAND FROM SCADA FOR MAIN SYSTEM CONTROL AT RTAMC	**RESET**	**SET**	**RESET**	☐	
COMMAND FROM SCADA FOR MAIN SYSTEM CONTROL AT BNTAMC	**RESET**	**RESET**	**SET**	☐	
DEFAULT STATUS	**SET**	**RESET**	**RESET**	☐	

For Auxiliary System:

	STATUS- AUX CONTROL ON NTAMC	STATUS -AUX CONTROL ON RTAMC	STATUS -AUX CONTROL ON BNTAMC	CHECKED	Comments see log sheet no.
COMMAND FROM SCADA FOR AUX SYSTEM CONTROL AT NTAMC	**SET**	**RESET**	**RESET**	☐	
COMMAND FROM SCADA FOR AUX SYSTEM CONTROL AT RTAMC	**RESET**	**SET**	**RESET**	☐	
COMMAND FROM SCADA FOR AUX SYSTEM CONTROL AT BNTAMC	**RESET**	**RESET**	**SET**	☐	
DEFAULT STATUS	**SET**	**RESET**	**RESET**	☐	

Buffer Synchronization between Main and Standby Gateway:

Substation Gateways are to be configured in Hot-Hot mode i.e. all six remote communication ports are always ready for transmitting data to the master stations (Main NTAMC, Backup NTAMC, RTAMC). At an instance, each control center polls only one of the gateway independently. During gateway switchover from control center, it is to be checked that the signals which have been reported in real time from previous gateway should not report again as buffer event from second gateway. Buffer signals must be synchronized between both gateways.

	Buffer signals reporting	CHECKED	Comments see log sheet no.
Check Signals reported in real time at SCADA from main gateway and switching over to Standby Gateway (Check for each Master one by one)	Previous event already reported by Main Gateway should not report from Standby Gateway buffer	☐	
Check Signals reported in real time at SCADA from Standby gateway and switching over to Main Gateway (Check for each Master one by one)	Previous events already reported by Standby Gateway should not report from Main Gateway buffer	☐	
Check Signals reporting from buffer after restoration of the link with master station (Check for each master one by one from both gateways)	Previous event should report as buffer as per buffer event capacity	☐	

GOOSE Signal Verification

For all the IEDs subscribing to GOOSE messages from other IEDs (e.g. BCUs, Protection), 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. **(Note: Wherever GOOSE messages configured should be ensured with quality tag configured and failure of the GOOSE signal should reflect in respective subscribed IED as invalid, and alarm appears in SCADA).**

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.

Note:

1. **Each GCB of the IEDs has to be verified for every device for the VLAN, App id, Mac id as per the Goose Signal list documentation. Unused GCB/RCB may be may be removed.**
2. **Wherever available, GOOSE supervision shall be done using LGOS Logical node.**
3. **GOOSE dashboard may be prepared in HMI for easy monitoring of GOOSE reception for process bus/digital substation.**

5.2.7. VALIDATION OF HISTORICAL TREND

Purpose

To verify that the Trend in the OWS/HMI 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/HMI

S.No.	Activity	Checked
1	Verify all Analog signals on trend screen for each feeder configured.	☐
2	Verify that the trend curve on HMI screen for different analog signal has different colors.	☐
3	Verify that the Time Scale for trend curves are user settable.	☐
4	Verify that EHV Lines/ ICT/Reactors/Bus/ LVAC have Predefined trend of current, active and reactive power. Bus have Predefined trend of voltage and frequency.	☐
5	Data archive retrieval is to be checked for proper display of old records	☐

5.2.8. 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.

Historical Event Report

1. Generate some Digital / Analog events in BCU.
2. Click on the Reports button present on the HMI/OWS 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.

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

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 (15min/01 hourly/ 04 hourly/ 08 hourly etc) of analog/ digital values.

The following reports must be covered as a part of the Reports in prescribed format as per POWERGRID.

1. EHV Feeders (Line, Transformer, Reactor, etc)
2. Transformer Feeder & Reactor Temperatures
3. Online Monitoring equipment values
4. LV System – AC switch board values
5. Kiosk Temperatures
6. Battery charger
7. PLCC/DTPC Counter readings
8. Circuit breaker counter recordings
9. LA counter recordings

5.3. SCADA COMMUNICATION

In this chapter the communication to SCADA via IEC101/IEC104/IEC 61850 will be checked. A detailed information test (control authority, commands, and indications) will be done in the chapter following 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 5.17.**

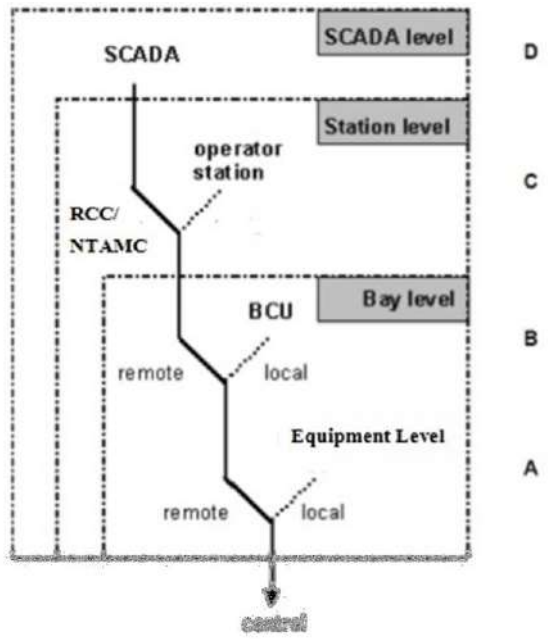
	Checked	Comments see log sheet no.
Communication checks for -spontaneous information -general interrogation	☐	
- time stamping of indications	☐	

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

- **Check response/ refresh time of reporting any data from IED**	☐	

5.4. CONTROL TESTS

Control is possible from Control Panel/LCC 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 the 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 the 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/RCC) button on Software screen raises an event-on-event list. Control from Operator Workstation is only possible if control is switched to local position and local/remote switch on BCU in Remote and mimic board is in	☐	

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

	Checked	Comments see log sheet no.
remote position. In this position no control from SCC/RCC is possible.		
D. Control from SCC/RCC Control from SCC/RCC is only possible if all local/remote switches per bay (on bay- and station level) are in remote position and Local SCADA in Remote position. SCC/RCC interface is simulated with test program IEC Test.	☐	

5.5. CONTROL METHOD

Control of switchgear shall be done from the detailed bay display diagrams in OWS/HMI. 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	☐	
- Bypassing the command for interlocking/Synchorcheck wherever required		
- Source of control appearance in event list	☐	
- Double object control blocking function for control from HMI/ SCADA level	☐	

5.6. CONTROL OF DUMMY CIRCUIT BREAKER

	Checked	Comments see log sheet no.
- Check of dummy circuit breaker function	☐	

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

5.7. CONTROL OF CIRCUIT BREAKER

"CLOSE" and "OPEN" operation of 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). RCC SCADA interface is simulated with test program IEC-Test.

kV Level	Command	Checked typical				Comments see log sheet no.
		701-52	401-52	***-52	***-52	
765kV	Circuit breaker Control/Display BCU Control/Display HMI Control/Display RCC HMI/NTAMC event list	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	
400kV	Circuit breaker Control/Display BCU Control/Display HMI Control/Display RCC HMI/NTAMC event list	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	
-------kV	Circuit breaker Control/Display BCU Control/Display HMI Control/Display RCC HMI/NTAMC event list	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	

5.8. 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.

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

Setup

1. Set up the BCU to check synchronizing ranges as follows:
   - Phase Differences Specification requirement states Phase Difference shall not exceed 30° (1° Hysteresis).
   - Voltage Difference Specification requirement states Voltage Difference shall not exceed 10% (2% Hysteresis).
   - 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
Voltage Difference

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	☐
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		
701		☐
702		☐
---		☐

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

400KV Circuit Breakers		
401		☐
402		☐
---		☐

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.

Synchro-check & Synchronism Check

Purpose

To verify that when the following conditions are met, the Synchro-check logic permits the Immediate closure of the Circuit Breaker.

- **Dead Line-Dead Bus**
- **Dead Line-Live Bus**
- **Live Line-Dead Bus**
- **Live Line- Live 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 (V_{line} V_{busbar}) must be above or below settable thresholds, to permit the circuit breaker closing. The following voltage controls are available:

- ✓ **V_{line}- No Voltage** and **V_{busbar}- No Voltage** – (Dead Line-Dead Bus)
- ✓ **V_{line}- No Voltage** and **V_{busbar}- Healthy Voltage** – (Dead Line-Live Bus)
- ✓ **V_{line}- Healthy Voltage** and **V_{busbar}- No Voltage** – (Live Line-Dead Bus)
- ✓ **V_{line}- Healthy Voltage** and **V_{busbar}- Healthy Voltage** – (Live Line-Live Bus)

With **Healthy V_{line}** and **Healthy V_{busbar} TRUE** if the measured voltage is above the threshold V> (param 1 and param 3), and **No voltage V_{line}** and **No voltage V_{busbar}**

TRUE if the measured voltage is below the threshold V< (param 2 and param 4). These thresholds are given in % of the nominal voltage value, updated at CT/VT 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. **Vline- No Voltage** and **Vbusbar- No Voltage**	Yes	☐
DL-LB	In case of the absence of one of the two voltages i.e. **Vline- No Voltage** and **Vbusbar- Healthy Voltage**	Yes	☐
LL-DB	In case of the absence of one of the two voltages i.e. **Vline- Healthy Voltage** and **Vbusbar- No Voltage**	Yes	☐
LL-LB	In Case of the presence of both voltages i.e. **Vline- Healthy Voltage** and **Vbusbar- Healthy Voltage** Set beyond ranges	No	☐
LL-LB	In Case of the presence of both voltages **Vline- Healthy Voltage** and **Vbusbar- Healthy Voltage** Set within synchronism ranges	Yes	☐

	Checked	Comments see log sheet no.
Displaying and Handling- BCU	☐	
Displaying and Handling- 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)	☐	

5.9. 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 list will also be tested. All bay for each voltage level shall be checked. Furthermore, some faults will be simulated (e.g. control authority, CMD interlocked, CMD monitoring time). NCC/RCC-interface is simulated with test program IEC-Test & event list also recorded.

SCADA-interface is simulated with test program IEC-Test wherever required.

5.10. 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 2.1). 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 OWS/HMI beforehand while operating 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	☐	

5.11. SWITCHING SEQUENCES FOR GIS (IF APPLICABLE)

Switching sequences are initiated and controlled from the Station Controller. The preconditions for switching sequences are parameterized in BCU. The interruption of the switching sequence can occur due to missing 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, a list of negative feedback will be recorded indicating the reason for not executing the command i.e., cause of not executing 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 Isolators &CB		
CHANGE BUSBAR:		

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

closing/opening of Isolators		
CLOSE BUS COUPLER :		
closing of Isolators & CB		
OPEN BUS COUPLER :		
Opening of Isolators & CB		

5.12. 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 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(like WTI,OTI Tempt, Cooler bank events, other configured alarms,etc)	☐	

5.13. EVENT PROCESSING

Events are displayed in chronological order in the 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 and the sorting should be ensured.

Events list should have white background & include all the alarms. . 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 it Should be ensured particularly in CB, Isolator, Earth switch & other events where change of events takes in prescribed time to avoid flooding of information.

Purpose

To verify that the Events Points are configured properly and in correct operating condition.

Setup

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

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 on the Event Screen with proper description and Time Stamp.
4. Time format should be configured as 24hours(hh:mm:ss:000).
5. Acknowledge this alarm.
6. Go to the Event Screen and verify that this alarm is displayed in the list.
7. Verify that the same has been printed on the Dot Matrix Printer.
8. Repeat Steps 1 to 6 for the All the digital Input as per the signal list.

Validation of the Events and Alarm Management on OWS/HMI

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. Persisting alarm shall be distinguishable from acknowledged alarms.	☐

	Checked	Comments see log sheet no.
Event Processing - BCU - HMI	☐ ☐	
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	☐ ☐	

5.14. ALARM PROCESSING

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

Alarms are displayed in chronological order in the 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 – RED , CLEARED- GREEN, AND ACKNOWLEDGED- YELLOW).** Acknowledgement of alarms dependents on permissions level (see 2.4.2.2 "HMI – USER ADMINISTRATION & ACCESS RIGHTS)

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. Time format should be configured as 24hours(hh:mm:ss:000).
5. Acknowledge this alarm.
6. Verify that the same has been printed on the log Printer.
7. Repeat Steps 1 to 6 for the several Digital Input

	Checked	Comments see log sheet no.
Alarm Processing (RED) - BCU - HMI	☐ ☐	
Time tagging - BCU - HMI	☐ ☐	
Filter function- date/time - message group - message text - alarm group	☐ ☐	
Permission of acknowledgement	☐	
Alarm raised: YELLOW FLASHING	☐	
Alarm cleared: GREEN	☐	
Alarm acknowledged: YELLOW	☐	
Alarm list filtering function (Date & Time, Bay No.)	☐	

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

5.15. 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. Current	**Expected measured value**	**Dead band**	**Indicated Value**					
			R		**Y**		**B**	
			BCU	**HMI**	**BCU**	**HMI**	**BCU**	**HMI**
6.35V								
31.75V								
63.5V								
70V								
110V								

POWERGRID Representative	**Manufacturer Representative**
Signature:	**Signature:**
Name:	**Name:**
Date:	**Date:**

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

Power Measurement													
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				☐

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

Winding Temperature LV °C				☐
..... °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)				☐	

Aux system Analogues Values						
Injected		HMI	Measured SUPERVISORY			Comments see log sheet no.
Simulator		Display	Error (%)	Transmitted	Checked	
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				☐	
MSB Incomer-1 Votlage	... V				☐	
MSB Incomer-2 Votlage	... V				☐	

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

Aux system Analogues Values						
Injected		HMI	Measured SUPERVISORY			Comments see log sheet no.
Simulator		Display	Error (%)	Transmitted	Checked	
MSB Bus-1 Votlage	... V				☐	
MSB Bus-2 Votlage	... V				☐	
LVAC Incomer-1 Votlage	... V				☐	
LVAC Incomer-2 Votlage	... V				☐	
LVAC Bus-1 Votlage	... V				☐	
LVAC Bus-2 Votlage	... V				☐	
MSB Incomer-1 Current	....A				☐	
MSB Incomer-2 Current	....A				☐	
LVAC Incomer-1 Current	....A				☐	
LVAC Incomer-2 Current	... V				☐	
LVAC Bus-1 Votlage	... V				☐	
LVAC Bus-2 Votlage	... V				☐	
Diesel Generator Voltage	... V				☐	
Diesel Generator Current	..A				☐	
----------					☐	
Other Aux system measurements if any					☐	

5.16. 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 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	☐	

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

	- alarm dead band	☐	
Current	- 1st upper limit: 1000A for 400&765kV level	☐	
	- 2nd 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	☐	

5.17. REDUNDANCY AND DIAGNOSTIC FUNCTION

The SAS system is designed for a hot/hot configuration. To fulfil this functionality following test will be performed:

5.17.1. 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 functions i.e. open different screens, alarm & trend screen.
2. On OWS-1 (Server1), Close the Server1 Application.
3. Check that the Alarm appears on the client.
4. Observe that Client1 is now connected with the Server2.
5. Start the Server1 application on OWS1, observe that Client1 is 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 OWS2after 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 OWS-1 relate to Server-1.
2. Shutdown Server-1. Observe that OWS-1 is now connected with the Server-2 and receives communications from the remote devices.
3. Startup Server-1 . Observe that there is no interruption to the Bay Level Devices. Restart the Client.
4. Observe that Client is now connected with the Server-1 (Primary Server) and receives communications from the remote devices.
5. Shutdown Server-2. Observe that OWS-2 is still connected with Server-1.
6. Startup Server-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 Server 2* • *Check updating of information event/alarm/analogue appearance on HMI 1 & 2* • *Check execution of command* • *Check appearance of event/alarm* • *Check fault indication of Server 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* • *Check execution of command* • *Check appearance of event/alarm* • *Check fault indication of Server 2*	☐ ☐ ☐ ☐ ☐		

5.17.2. HMI OPERATOR WORKSTATION REDUNDANCY

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

Each HMI operator workstation is independent of the other operator workstation and in case of failure the second workstation remains operational

	Checked	Comments see log sheet no.
HMI 1 faulty Disconnect HMI1 from LAN and generate newinputs (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 newinputs (events and alarms) on BCU. Initiate control of any switching device. • *Check updating of information on HMI 1* • *Check execution of command* • *Check appearance on dot printer* • *Check fault indication of HMI 2*	☐ ☐ ☐ ☐	
HMI 1 and HMI 2 healthy again Check database synchronizing	☐	

5.17.3. ETHERNET SWITCH CONFIGURATION

Purpose

To verify that

- Proper configuration of Ethernet switches at the Station & Process level.
- To enable proper ring formation of the Ethernet switch in station & Process level
- To Document the Ethernet switch configuration considering the proper function of Ring network.

Typical Procedure:

- All IEDs & TCP/IP devices which are connected to non-RSTP ports, such ports should be configured as Edge port.
- Edge port should not be enabled with RSTP or Auto to reduce the ethernet switch processing.
- Only Point to Point port should be enabled with RSTP.
- Other than Edge port, all other unused ports should be disabled.
- Point to Point port & Discarding port need to be properly connected as per the System architecture.
- Ensure Bridging priority, Edge port, RSTP, VLAN configuration in Root & Non-Root Ethernet switches should be as per project requirement & Documented as below given example.

Sr. No	Panel Location	Switch Identification	Switch Port No	Bridge Priority	Edge Port	Switch to Switch Port	Un-used Port	RSTP	VLAN
1.	+R404A	K404	1	8192	No	Yes	No	Yes	As per Network requirement
2.	+R404A	K404	2	8192	No	Yes	No	Yes	As per Network requirement
3.	+R404A	K404	3	8192	No	Yes	No	Yes	As per Network requirement
4.	+R404A	K404	4	8192	No	Yes	No	Yes	As per Network requirement
5.	+R404A	K404	5	8192	Yes	No	No	No	As per GCB Table
6.	+R404A	K404	6	8192	Yes	No	No	No	As per GCB Table
7.	+R404A	K404	7	8192	Yes	No	No	No	As per GCB Table
8.	+R404A	K404	8	8192	Yes	No	No	No	As per GCB Table
9.	+R404A	K404	9	8192	Yes	No	No	No	As per GCB Table
10.	+R404A	K404	10	8192	Yes	No	No	No	As per GCB Table
11.	+R404A	K404	11	8192	Auto	Auto	Disabled	Yes	Default/Not applicable
12.	+R404A	K404	12	8192	Auto	Auto	Disabled	Yes	Default/Not applicable
13.	+R404A	K404	13	8192	Auto	Auto	Disabled	Yes	Default/Not applicable
14.	+R404A	K404	14	8192	Auto	Auto	Disabled	Yes	Default/Not applicable

Note: Control Room Switches has to be Kept as Root Bridge Switch and rest of the switch has to be followed the RSTP Philosophy. SAS Architecture has to be updated with these number if possible for better clarity.

	Checked	Comments see log sheet no.
Document Switch port configuration -IP address of the switch, Bridge numbering, VLAN, IP address, Edge port of as per project requirement considering GCB & considering Ring system	☐	

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

5.17.4. NETWORK REDUNDANCY

The reliability and security of the redundant LAN configuration will be checked.

Purpose

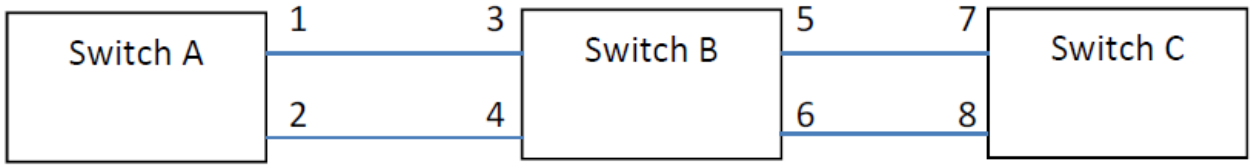
To verify that

- 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 is OFFLINE. When the communications link is restored, the SAS device is automatically back to ON-LINE.

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).



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

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

S.NO.	Panel	Equipment	Communication check	Redundancy check
1	_____KV BCU (Bay01/02/03---)			
2	_____KV BCU (Bay01/02/03---)			
3	Networking Panel			

	Checked	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* • *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.)*	☐ ☐ ☐ ☐ ☐	

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

5.17.5. GATEWAY REDUNDANCY (IEC 101 & IEC104 PORTS)

The redundancy of the IEC 101/104 communication interface from the Gateways will be checked. As the real SCADA system is not available, two no of Laptops with the IEC TEST – Softwares are used to simulate the RCC& RSCC.

5.17.6. 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 checking 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	☐	

5.17.7. 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 - individual bay display	☐	
Check appearance on redundant server/operator	☐	

5.17.8. 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”	☐	

	Checked	Comments see log sheet no.
Check appearance on HMI Display	☐	
Check control blocking	☐	
Check suppression of data transmission	☐	

5.17.9. 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 are 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 event list 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	☐	

5.18. 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 change relay settings	☐ ☐	

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

Information recording in SAS-system - Reset of trip lockout relay - Autoreclosing ON/OFF selection - Reporting of fault location	☐ ☐	
- Hardcopy print (to paper and file)	☐	

5.19. REMOTE DESKTOP

The remote desktop function is a feature of Windows. It is shown as an icon on the desktop of all PCsof this station. Pressing 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 by using both IP & Their PC name	☐	

5.20. 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 must 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 broadcast 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 Timeserver.
7. Power on the GPS receiver.
8. Connect the GPS receiver Antenna. Verify that the GPS receiver is locked with satellite and GPSis updated to satellite time.

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

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	☐	
Reporting of Time synchronization alarm of connected all IEDs in the network	☐	
Bay Control Unit	☐	
Event list printer/ Hardcopy/ Logbook printer	☐	

5.21. VALIDATION OF MEMORY AND DISK UTILIZATION

Purpose

To verify that the OWS/HMI have Memory and Disk Usage and allocation those are within the specification requirements. 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.

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			PASS/FAIL
SERVER-2			PASS/FAIL
OWS-1			PASS/FAIL

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

Computer	Physical Memory	Hard Drive Free Space	PASS/FAIL
OWS-2			PASS/FAIL
DR/EWS PC			PASS/FAIL
GATEWAY-1			PASS/FAIL
GATEWAY-2			PASS/FAIL

5.22. BCU INPUT/OUTPUT/ANALOG DATA RETRIEVAL

Configuration of data reporting at defined interval/cyclic and dead band shall be verified as per approved profile to evade hanging of both SCADA and IED.

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 LHMI, 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 LHMI Digital Inputs Display screen.
3. On the OWS-1 go to the 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) bytoggling the corresponding jig.
3. Verify that the state of this point in the BCU LHMI 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 60870-101/104 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) bytoggling 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.
11. Data reporting shall be verified to evade hanging of both SCADA and IED. Necessary simulation (including analog) shall be done by vendor.

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 the relevant HMI screen.
4. On the OWS-2 go to Alarm/Event list.

Procedure

1. Choose BCU to test. From the HMI workstation initiate digital output requests.
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.

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Signature:	Signature:
Name:	Name:
Date:	Date:

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

Note: Interlock involving GOOSE signal shall also be checked. It shall be ensured that absence of required GOOSE signal does not enable any interlocking condition. Interlock verification page for each control device as per TS based on the available input in the BCU to be prepared in HMI. Spare switching arrangement for Single phase reactor and transformer banks shall be verified by simulation and software interlocks to be verified.

5.23. 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.
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.

Repeat the above procedures for other devices.

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

6. EWS/DR PC

6.1. SETTING AND CONFIGURING OF IEDS

Purpose

To verify that the IEDs configuration with proper tool for each type has been installed and all the IEDs (Protection, BCU, RTCC, CSD, FOTS & other TCP/IP devices) are accessible via the station ethernet ring. The DR PC should be able to change any configuration, settings, IP address & other parameters via TCP/IP should be possible.

Setup

1. Ensure that DR PC is running.

Procedure

(For example, for BCU)

1. Change some parameters in S/W for the BCU to test. Compile the Database for which parameters have been changed. (Wherever applicable)
2. Run S/W on the DR PC and select the compiled Database. Connect the BCU for which the parameters have been changed. (Wherever applicable)
3. Upload the database. (Wherever applicable)
4. Verify that the download is successful and check the DB version on the BCU. (Wherever applicable)

(For example, for Protection IED)

1. Change some parameters in S/W for the Protection IED to test. Compile configuration for which parameters have been changed. (Wherever applicable)
2. Connect the IED for which the parameters have been changed. (Wherever applicable)
3. Download the configuration or setting changed to the respective device. (Wherever applicable)
4. Verify that the download is successful and check the version on the IED. (Wherever applicable)

6.2. NETWORK MONITORING SYSTEM

Purpose

To verify that the Network Monitoring System (NMS) application software can perform the following functions on the LAN devices for both station bus & process bus:

- Configuration Management
- Fault Management
- Performance Monitoring
- Device Monitoring
- Log analysis
- Historical Data storage

Note:

1. **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. If a separate network is available, then the each network has to have NMS separately example like Sample Values network in Process bus substation.**
2. **SNMP V3 may be implemented for the new projects. For extension projects, the existing SNMP version may be used.**

Procedure

1. Verify that NMS software 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 Operator interface(OI) client screens.
3. Verify that it has tools for maintenance of addressed and links.

6.3. AUTO RECLOSE TEST

6.3.1.TEST FOR AUTO-RECLOSE SUCCESSFUL CASE

1. Select the Circuit Breakers of Main & Tie on which Auto reclose must 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 as per the priority logic.
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/Oilpressure/spring discharge). The healthy CB associated with the feeder shall A/R successfully.
9. Repeat steps 4-6 for 3 phase auto reclose and single phase/3 ph. Auto reclose

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Signature:	Signature:
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Date:	Date:

10. In case of single-phase fault for 3ph. Autoreclose selection, the single phase trip shall be connected to 3 ph. trip before autoreclose.

6.3.2.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.

7. DR CONFIGURATION

Check DR is configured as per TS & Latest standardized DR signal list configuration.

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.

7.1. AUTO DR FUNCTIONALITY

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. Ensure the Folders must be created for all Main-1&2, BCU folders based on the substation structure.
3. Observe that the Disturbance File (.cfg/.dat etc.) is automatically created in the DR PC.

4. Open the Disturbance file with DR software.
5. As per the NTAMC AFAS requirement all the details of the IEDs has to be provided along with the location of the Folder created for each Protection IED
6. Verification of auto DR downloading functionality on triggering of waveform in each IED.
7.

8. IEC 60870-5-101/104 DATA RETRIEVAL

Purpose

To perform preliminary verification that the IEC 60870-5-101/104 Communication Ports are functional.

Setup/Program

- Ensure that the test equipment is in the FAT room.
- Use a Protocol Analyzer Test set to simulate an IEC 60870-5-101/104 Master Station polling with General Interrogation and data changes with 2 no of laptop. Use the Protocol Analyzer Test set to Monitor IEC 60870- 5-101/104 Telegram 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 requests 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.
6. Configuration of data reporting at defined interval/cyclic (generally analog without time tag), dead band shall be verified as per approved profile.

8.1. 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.

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

8.2. 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.

9. 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.

The following documents has to be submitted for the clearance of the SAS wherever applicable.

Final FAT submission Verification log:

Sl No.	Description	Drg No.	Checked
1	Standard Approved MQP		☐
2	Approved FAT Procedure		☐
3	GTP-General Technical Parameters		☐
4	Complete SAS Architecture		☐
5	Standard General Technical Particulars for SAS		☐
6	Hardware specification		☐
7	Functional Design Specification		☐
8	VLAN Architecture drawing wherever applicable		☐
9	Matrix for GOOSE messages for each feeder (with publisher& subscriber details, Mac id, APP Id, VLAN as required)		☐
10	Matrix for SV (with publisher & subscriber details, SV ID, Destination mac and VLAN details) in case of Process Bus substation		☐
11	Ethernet Network Configuration Document (RSTP details, VLAN details, Port details etc.)		☐
12	IP Addressing Details		☐
13	Single SCD File of the Entire substation		☐

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

Sl No.	Description	Drg No.	Checked
14	Exported HMI signal list file in spreadsheet/CSV format.		☐
15	Exported NTAMC signal list file in spreadsheet/CSV format.		☐
16	Common BCU/Alarm Panel-01		☐
17	Common BCU/Alarm Panel-02		☐
18	GA & Scheme of Networking Panel		☐
19	CRP (Line/Trafo/BR/LR/Tie/BC/TBC/BS/Etc)		☐
20	Product Manuals(Installation, Configuration, maintenance, Troubleshooting, detailed diagnostics etc.)		☐
21	Control Room Lay-out		☐
22	Switchyard Panel Room layout drawing		☐
23	Bill of Quantity-Spares		☐
24	**Other applicable drgs (not listed above)**	**Attach the list as annexure**	☐

Note: A single SCD file shall be there for the entire substation. For extension projects too, the SCD file shall be a single file after integrating the newer IEDs.

Softcopy of Manuals Log:

Document Title	Doc. No.	Checked
Operation and Technical Guide for BCU, Gateway, Server, OWS Software		☐
Operation and Technical Guide IED configuration softwares		☐
Operation and Technical Guide NMS Software		☐
Operation and Technical Guide Ethernet Switch		☐
Operation and Technical Guide Time synchronizing Equipment		☐
Operation and Technical Guide Router Cum Firewall		☐
Operation and Technical Guide UPS/Inverter		☐
Other applicable equipment Operational & Technical Guide		☐

Softwares/Project Backups/License details Backup:

Software/License	Doc. No.	Checked
Protection Project Configuration- As Manufactured		☐
HMI Project Database – As Manufactured		☐

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

Software/License	Doc. No.	Checked
Gateway Project Database – As Manufactured		☐
Ethernet Configuration – As Manufactured		☐
Any other Configuration(NMS, Syslog, etc)- As Manufactured		☐
HMI associated Software & their license		☐
Gateway associated software & their License		☐
MS office & license		☐
NMS & their license		☐
Protection & Control each type Software & license		☐
CSD, FOTS, RTCC & Other Devices Software & license		☐
Antivirus software & license		☐
Printers software & license		☐
GPS clock software & license		☐
Other applicable equipment Operational & Technical Guide		☐

10. DURATION OF FACTORY ACCEPTANCE TEST

The duration of the Factory Acceptance Testing will be mutually agreed depending upon the size of the substation.

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

11. INDICATION AND CORRECTION REPORT

Any comments should be added in “log sheets”; Along with the Clerance the Indication and Correction report with compliance has to be submitted to the respective Site/RHQ/CC AM.

INDICATION AND CORRECTION REPORT

LOG SHEET:

No.	Reference	Author	Date

Description

12. APPENDIX

GLOSSARY

BCU: Bay Control Unit
DR: Disturbance Recorder
EWS: Engineering Workstation
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: Supervisory Control And Data Acquisition

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

Appendix-III









Factory Acceptance Test (FAT) Procedures & Formats

-Control Protection System

Power Grid Corporation of India Ltd.
Saudamini, Plot no.2, Sector-29, Gurgaon, Haryana 122 001

DOC: PG/CC/CRP/FAT, Rev01				
Revision	**Department**	**Date**	**Signature**	**Signature**
01	CC/Engg CC/QAI CC/AM	09.11.2023	Sd/	Sd/

REVISION HISTORY

Sl.No.	Pages	Revision	Remarks
01	All Pages	01	First Release

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POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

About This Document

Purpose of this document

This document shall be used as a standard for conducting all tests during the Factory Acceptance Test (FAT) for the Control & Protection system of every substation as per POWERGRID requirements and specifications.

The aim of the Factory Acceptance Test (FAT) is to demonstrate equipment functionalities as well as the approval process 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 Control and Protection system to be supplied shall be tested for complete functionality and configuration in the factory itself. The extensive testing shall be carried out during FAT. The purpose of Factory Acceptance Testing is to ensure defect free installation at site. No major change in 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.

Who should use this document

This document to be used by the Vendor representatives (Q&I, Engg, Factory) for Factory acceptance test as per the project requirement. This approved document will be followed by the Vendor Representatives (Q&I, Engg, Testing) and POWERGRID representatives to test and evaluate the complete system.

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

1. GENERAL

1.1. Introduction

The purpose of this document is to define the Factory Acceptance Test procedures of Substation Control & Protection system supplied by the Vendor to POWERGRID.

The tests are performed by Vendor and each test, or set of tests as appropriate, is covered by an approval stage, which will be signed off upon completion by Vendor and POWERGRID representatives.

Comments are noted in separate Incident and correction reports (snag list) attached as annexure.

2. CONTROL & PROTECTION SYSTEM

2.1. FAT test methodology

FAT testing will be performed for Control & relay panels for ensuring the manufacturing as per the approved CAT-I drawings. Pre-FAT test sheets will be used as a reference for the tests to be performed during the FAT.

These test sheets will indicate the specific units that were tested during pre-FAT tests.

2.2. List of Control & Protection Panels

Feeder / Panel	Feeder Specification	Description	Drawing CSD No.	Rev. No.
401	400kV Meerut-Moradabad Line-1	LINE	CPD KZ5J SC43	CAT-I
402	TIE	TIE	CPD KZ5J SC44	CAT-I
403	ICT-500MVA-1	ICT	CPD KZ5J SC45	CAT-I
BB	Busbar Protection panel	BB	CPD KZ5J SC55	CAT-I
---	----------	----------	----------	--
---	----------	----------	----------	--
---	----------	----------	----------	--
---	----------	----------	----------	--
---	----------	----------	----------	--

POWERGRID Representative	Manufacturer Representative
Signature:	**Signature:**
Name:	**Name:**
Date:	**Date:**

2.3. Test report overview

FAT Test	Description	Line	Auto/Power Transf.	Bus/Line Reactor	Busbar	Tie	BC/TBC
FAT001	Visual Inspection	X	X	X	X	X	X
FAT002	Hardware Verification	X	X	X	X	X	X
FAT003	AC Scheme Check	X	X	X	X	X	X
FAT004	DC Scheme Check	X	X	X	X	X	X
FAT005	Auxiliary Report	X	X	X	X	X	X

POWERGRID Representative	Manufacturer Representative
Signature:	**Signature:**
Name:	**Name:**
Date:	**Date:**

2.4. Document verification

2.4.1. Document verification test

Purpose:

This test verifies that the correct manufacturing drawings and documentation for the equipment/system under the 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 all required hardware and software manuals are present.
3. Guaranteed Technical Parameters (GTPs) as approved by POWERGRID.
4. A copy of Customer Technical Specification for reference is made available in the FAT room.
5. Availability of the approved Drawing list in the FAT room.

Document Verification Log:

Sl No.	Description	Drg No.	Checked
1	Approved Standard MQP		☐
2	Standard FAT Procedure		☐
3	Approved GTP-Guaranteed Technical Particulars		☐
4	Approved Hardware specification & BOM		
5	Latest Approved Protection Logic diagram (Line/Transformer/Reactor/BB/etc) (Refer POWERGRID Intranet) *		☐
6	Latest Approved settings/configuration template (pdf) (Refer POWERGRID Intranet)		☐
7	Approved GA & Schematic CRP Drawings (Line/Transformer/Reactor/BB/etc)		☐
8	Product Manuals (Installation, Configuration, maintenance, Troubleshooting, detailed diagnostics etc.)		☐
9	Approved Bill of Quantity spares		☐
10	Operation and Technical Guide of IED configuration softwares.		☐
11	Operation and Technical Guide of Ethernet Switch		
12	**Other applicable drawings (not listed above)**	**Attach the list as annexure**	☐

Note:- *if there is a variation between the approved protection scheme and the latest approved protection logic diagram uploaded on POWEGRID intranet, later shall prevail.

POWERGRID Representative	Manufacturer Representative
Signature:	**Signature:**
Name:	**Name:**
Date:	**Date:**

2.5. Pre-acceptance test

2.5.1. Visual inspection

Purpose: This test will be carried out on the panels before commencing any testing on the panels. This test verifies the cleanliness, physical damages, dimensions, color of the panel and its thickness, mounting arrangements and proper ferruling and labeling etc.

Procedure:

1. Record the name and reference number of the panel to be tested in the test sheet.
2. Verify the check list detailed in the test sheet and ensure that the panel under test is in line with the base document.
3. Record if any comments in the Indication and Correction Report (snag list) attached as to this document.
4. Repeat step 1 to 3 for the other control & protection panels.

Test Document:

Refer Protection FAT Test Sheet in unit 7 (Annexure)

- FAT001: Visual Inspection

Note**:** Copy of this Visual Inspection test sheets will be used for other panels under test

2.5.2. Hardware verification test

Purpose: This test verifies the list, identification data and the quantities of the equipment mounted in each protection panels.

Procedure:

1. Select one of the typical bays.
2. Verify the test sheet selected for the Hardware Verification Test, belongs to the selected typical panel under test.
3. Record the reference number of the selected typical panel to be tested in the test sheet.
4. Verify the list of equipment and its quantities, as specified in the test sheet and it is in line with the base documents.
5. Record if any comments in the Indication and Correction Report (snag list) attached as to this document.
6. Repeat step 3 to 5 for the other panels of the same type.
7. Repeat step 1 to 6 for the other control & protection panels.

Test Documents:

POWERGRID Representative	Manufacturer Representative
Signature:	**Signature:**
Name:	**Name:**
Date:	**Date:**

Refer Protection FAT Test Sheet in unit 7 (Annexure)

- FAT002: Hardware Verification Test

Note: Copy of the respective Hardware Verification test sheets will be used for more than one panel of the same type under test.

2.6. Power scheme verification

2.6.1. AC scheme check

Purpose: This test verifies the AC power circuit of the panel under test. In brief, the test verifies the AC power to the MCBs, heating and lighting circuits and to the power sockets and ensures their operation is correct.

Procedure:

1. Select any of the typical bays.
2. Record the name and reference number of the panel to be tested in the test sheet.
3. Verify the check list detailed in the test sheet and ensure AC circuit is as per the scheme and AC devices are working properly.
4. Record if any comments in the Indication and Correction Report (snag list) attached as to this document.

Test Document:

Refer Protection FAT Test Sheet in unit 7 (Annexure)

- FAT003: AC Power Verification

Note: Copy of the same test sheets will be used for the other Control & protection panels

2.6.2. DC scheme check

Purpose: This test verifies the DC power circuit of the panel under test. In brief, the test verifies the DC1 and DC2 to the MCBs, DC changeovers and DCs to the various equipment in the panel.

Procedure:

1. Record the name and reference number of the panel to be tested in the test sheet.
2. Verify the check list detailed in the test sheet and ensure the DC circuit of the panel works properly.
3. Perform a DC change over and ensure for no power failures in any equipment
4. Record if any comments in the Indication and Correction Report (snag list) attached as to this document.
5. Check complete cubicle wiring as per schematic diagram.

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

6. Repeat step 1 to 6 for the other Control & protection panels.

Test Documents:

Refer Protection FAT Test Sheet in unit 7 (Annexure)

- FAT004: DC Scheme Check

Note: Copy of the same test sheets will be used other protection panels

2.6.3. Auxiliary relay test

Purpose: This test verifies the functionality and properties of Auxiliary Relay under test.

Procedure:

1. Select a Trip Relay/Lockout Relay from any one of the protection panels
2. Record the panel reference in the test sheet
3. Perform the following routine tests which is applicable for this relay
   - Name plate rating details
   - General inspection
   - Resistance check
   - Secondary injection test
     - Pick-Up / Drop-Off test (operating and resetting coil)
4. Record if any comments in the indication and correction report (snag list) attached as to this document.
5. Repeat step 1 to 5 for the same type of relays for the other panels.

Test Documents:

Refer Protection FAT Test Sheet in unit 7 (Annexure)

- FAT005: Routine Test – Auxiliary Relay

Note: Copy of FAT005 test sheet will be used for more than one relay of the same type under test

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

2.7. Relay configuration & setting

The configuration of each IED in the system shall be adopted as per the approved scheme by POWERGRID. This configuration must be verified for each feeder (Line, Transformer, Reactor, Busbar & etc) as per the POWERGRID standard setting/configuration template (in pdf format).

The POWERGRID standard setting/configuration template must be referred to finalise the configuration. For any clarifications or corrections on the configurations changes if required the same has to be recorded in the observation & compliance report.

Note:

1. **However, if the approved setting is not available during FAT, standard setting may be used to complete the FAT.**

2. **The Final setting/configuration project file must be submitted as part of the FAT documentation.**

Following important points must be considered during configuration to ensure the proper Configuration & settings.

1. Defined functionality should be available in the configuration as per POWERGRID TS/Standard drawing.
2. Defining the proper input & output variables as per the approved drawings.
3. Tripping & signal assignment as per the approved Trip matrix.
4. Proper Flow of configuration as per the OEM (Ex. Proper instance of function block to avoid any delay or creating loop)
5. Only inbuilt logical functions should be used until otherwise specified.
6. Proper naming of Each section like Binary input, Protection functions, Binary output, LED, DR, SCADA & etc.
7. Naming of the IED should be proper (Ex SS_Name, Feeder Name).
8. Proper SNTP time setting (DST disabled, NTP ip address, SNTP selected).
9. DR channel configuration shall be done as per POWERGRID standard list.
10. Aesthetic alignment of the configuration in a proper readable format.

2.8. Protection relay - FAT

In addition to the standard routine tests as per the manufacturer OEM recommendations, it's important to verify the functioning and operation of Intelligent Electronic Devices (IEDs) according to specified logic required as per POWERGRID during the Factory Acceptance Testing (FAT) period.

For the demonstration of the following tests, the required simulation tools should be available during FAT.

For each feeder, the FAT reports has to be submitted along with the routine test report of the manufacturer.

POWERGRID Representative	Manufacturer Representative
Signature:	**Signature:**
Name:	**Name:**
Date:	**Date:**

Line Feeder (Distance/Auto-reclose/LBB):

Sl No.	Description	Checked
1	Configuration Check as per the approved drawing & Setting/ Configuration.	☐
2	Correct operation of Tripping relays and associated auxiliary relays.	☐
3	Carrier aided Permissive Scheme in Main-1 & Main-2.	☐
4	Current Reversal & Weak infeed in Main-1 & Main-2.	☐
5	Fault location for each type of faults.	☐
6	AR logic for the One and half breaker system (Both Main & Tie with priority logic) with Main-1 & Main-2 (For Auto reclose logic refer **"Pre-Commissioning Procedures and Formats for Substation Equipment & Protection System, section- Circuit Breaker Panel", DOC ref: D-2-01-03-01-XX**)	☐
7	AR 3 Ph trip logic as per standard setting template	☐
8	DT circuit checking with all possible condition for 1 ½, DM, DMT busbar scheme.	☐
9	DT & Carrier send/receive logic with Carrier switch out & Carrier fail.	☐
10	Single phase initiation to LBB relay.	☐
11	Simulation of Cross-country fault in Distance function.	☐
12	3Ph trip initiation to LBB relay.	☐
13	LBB Retrip assignment & Backup assignment for one and half CB, DM & DMT scheme	☐
14	Ensure the timing for both the LBB Retrip and Backtrip Should start only after the current pickup alongwith LBB Initiation. Resetting the current should also reset the LBB function.	☐
15	Metering function (V, I, P, Q, Hz, PF).	☐
16	DR Standardization as per the POWERGRID Standard. Apart from the DR standardization if the channel available required signals may be configured for better analysis.	☐
17	Red Ferruling in the Tripping circuit	☐

POWERGRID Representative	Manufacturer Representative
Signature:	**Signature:**
Name:	**Name:**
Date:	**Date:**

Line Feeder (Differential/Distance/Autoreclose/LBB):

Sl No.	Description	Checked
1	Configuration Check as per the approved drawing & Setting/ Configuration.	☐
2	Correct operation of Tripping relays and associated auxiliary relays.	☐
3	Communication failure of Differential enabling the Distance Z-1 function.	☐
4	Carrier aided Permissive Scheme in Main-1 & Main-2.	☐
5	Current Reversal & Weak infeed in Main-1 & Main-2.	☐
6	Fault locator & Mutual compensation Fault location (If applicable).	☐
7	AR logic for the One and half breaker system (Both Main & Tie with priority logic) with Main-1 & Main-2 (For Auto reclose logic refer **"Pre-Commissioning Procedures and Formats for Substation Equipment & Protection System, section- Circuit Breaker Panel", DOC ref: D-2-01-03-01-XX)**	☐
8	AR 3 Ph trip logic as per POWERGRID standard protection logic diagram.	☐
9	DT circuit checking with all possible condition for 1 ½, DM, DMT busbar scheme.	☐
10	DT & Carrier send/receive logic with Carrier switch out & Carrier fail.	☐
11	Simulation of Cross-country fault in Distance function.	☐
12	Single phase initiation to LBB relay.	☐
13	3Ph trip initiation to LBB relay.	☐
14	Ensure the timing for both the LBB Retrip and Backtrip Should start only after the current pickup alongwith LBB Initiation. Resetting the current should also reset the LBB function.	☐
15	LBB Retrip assignment & Backup assignment for one and half CB, DM & DMT scheme	☐
16	Metering function (V, I, P, Q, Hz, PF).	☐
17	DR Standardization as per the POWERGRID Standard. Apart from the DR standardization if the channel available required signals may be configured for better analysis	☐
18	Red Ferruling in the Tripping circuit	☐

POWERGRID Representative	Manufacturer Representative
Signature:	**Signature:**
Name:	**Name:**
Date:	**Date:**

Transformer Feeder (Differential/REF/Backup OC&EF/Backup Impedance):

Sl No.	Description	Checked
1	Configuration Check as per the approved drawing & Setting/ Configuration .	☐
2	Correct operation of Tripping relays and associated auxiliary relays.	☐
3	Differential & HV Overflux operation	☐
4	REF & LV Overflux operation	☐
5	HV OC&EF operation.	☐
6	IV/LV OC&EF operation	☐
7	Backup impedance operation	☐
8	Blocking logic for Backup impedance as per the POWERGRID requirement.	☐
9	Configuration check of 33kV Protection to the Utility feeder & Tertiary feeder availability.	☐
10	Mechanical protection logic has to be implemented as per POWERGRID standard protection logic diagram.	☐
11	Mechanical protection operation extended to Master trip operation.	☐
12	Simulation of the VT Selection logic as per the POWERGRID requirement. VT selection output stability should be checked during / after BCU restart and intermediate state of associated BCU binary inputs.	☐
13	3Ph trip initiation to LBB relay.	☐
14	Ensure the timing for both the LBB Retrip and Backtrip Should start only after the current pickup alongwith LBB Initiation. Resetting the current should also reset the LBB function.	☐
15	LBB Retrip assignment & Backup assignment for one and half CB, DM & DMT scheme	☐
16	Metering function (V, I, P, Q, Hz, PF).	☐
17	DR Standardization as per the POWERGRID Standard. Apart from the DR standardization if the channel available required signals may be configured for better analysis.	☐
18	Simulation of Spare selection logic the CT switching & Tripping scheme. Spare selection output stability should be checked during / after BCU restart and intermediate state of associated BCU binary inputs.	☐
19	Red Ferruling in the Tripping circuit	☐

POWERGRID Representative	Manufacturer Representative
Signature:	**Signature:**
Name:	**Name:**
Date:	**Date:**

Bus/Line Reactor Feeder (Differential/REF/Backup Impedance):

Sl No.	Description	Checked
1	Configuration Check as per the approved drawing & Setting/ Configuration.	☐
2	Correct operation of Tripping relays and associated auxiliary relays.	☐
3	Differential operation	☐
4	REF operation	☐
5	Backup impedance operation.	☐
6	Blocking logic for Backup impedance as per the POWERGRID requirement.	☐
7	Mechanical protection logic has to be implemented as per POWERGRID standard protection logic diagram.	☐
8	NGR Bypass operation, NGR equipment alarms such as CB alarms, Closing coil alarms & output configuration as per POWERGRID requirement.	☐
9	Simulation of the VT Selection logic as per the POWERGRID requirement. VT selection output stability should be checked during / after BCU restart and intermediate state of associated BCU binary inputs.	☐
10	3Ph trip initiation to LBB relay.	☐
11	Ensure the timing for both the LBB Retrip and Backtrip Should start only after the current pickup alongwith LBB Initiation. Resetting the current should also reset the LBB function.	☐
12	LBB Retrip assignment & Backup assignment for one and half CB, DM & DMT scheme	☐
13	Metering function (V, I, P, Q, Hz, PF).	☐
14	DR Standardization as per the POWERGRID Standard. Apart from the DR standardization if the channel available required signals may be configured for better analysis.	☐
15	Simulation of Spare selection logic the CT switching & Tripping scheme. Spare selection output stability should be checked during / after BCU restart and intermediate state of associated BCU binary inputs.	☐
16	Red Ferruling in the Tripping circuit	☐

POWERGRID Representative	Manufacturer Representative
Signature:	**Signature:**
Name:	**Name:**
Date:	**Date:**

Centralized busbar differential relay

Sl No.	Description	Checked
1	Configuration Check as per the approved drawing & Setting/ Configuration	☐
2	Correct operation of Tripping relays and associated auxiliary relays.	☐
3	For the status of the switchgear Double point type to be considered	☐
4	**For Centralized Busbar testing refer "Pre-Commissioning Procedures and Formats for Substation Equipment & Protection System,", DOC ref: D-2-01-03-01-XX) and simulate all logic as per the 1 ½, DM, DMT busbar scheme.**	☐
5	The report for the centralized busbar scheme has to be submitted as per the Point no 4.	☐
6	DR Standardization as per the POWERGRID Standard. Apart from the DR standardization if the channel available required signals may be configured for better analysis.	☐
7	Red Ferruling in the Tripping circuit	

De-Centralized busbar differential relay

Sl No.	Description	Checked
1	Configuration Check as per the approved drawing & Setting/ Configuration.	☐
2	Correct operation of Tripping relays and associated auxiliary relays.	☐
3	For the status of the switchgear Double point type considered	☐
4	**For De-centralized Busbar testing refer "Pre-Commissioning Procedures and Formats for Substation Equipment & Protection System, , DOC ref: D-2-01-03-01-XX) and simulate all logic as per the 1 ½, DM, DMT busbar scheme.**	☐
5	The report for the de-centralized busbar scheme has to be submitted as per the Point no 4.	☐
6	DR Standardization as per the POWERGRID Standard. Apart from the DR standardization if the channel available required signals may be configured for better analysis.	☐
7	Red Ferruling in the Tripping circuit	☐

POWERGRID Representative	Manufacturer Representative
Signature:	**Signature:**
Name:	**Name:**
Date:	**Date:**

Bay control Unit(BCU) – Feeders

Sl No.	Description	Checked
1	Interlock for the respective bays.	☐
2	Metering function (V, I, P, Q, Hz, PF).	☐
3	Graphical display of HMI page in BCU as per the SLD & their control	☐
4	Measurement of bay in HMI page as per the SLD (if Menu not available)	☐

Ethernet Switch & DR PC

Note:- If Ethernet Switch & DR PC only supplied as a part of Project without SAS, then SAS FAT procedure (DOC ref: D-2-03-20-05-XX) to be referred for checking the Performance, Document & configuration.

3. STATEMENT OF SYSTEM ACCEPTANCE

Upon successful completion of all applicable tests and the proper disposition of all documented and witnessed discrepancies resulting from tests specified in the procedure, the system, tested and witnessed by the POWERGRID, is accepted.

Note:- The approved corrected copies of the scheme drawings based on the FAT shall be submitted before SAT.

Documents Verification during FAT:

Sl No.	Description	Doc No.	Submitted
1	Visual Inspection report for each feeder		☐
2	Hardware Verification report for each feeder		☐
3	AC Scheme Check Report for each feeder		☐
4	DC Scheme Check Report for each feeder		☐
5	Auxiliary Relay Report for each feeder		☐
6	Typical configuration for each feeder verified (Line, Transformer, Bus reactor, Line reactor, Busbar)		☐
7	Specified Logic Verification-Line Feeder (Distance/Auto-reclose/LBB) Report		☐
8	Specified Logic Verification-Line Feeder (Differential/Distance/Auto reclose/LBB) Report		☐

POWERGRID Representative	Manufacturer Representative
Signature:	**Signature:**
Name:	**Name:**
Date:	**Date:**

Sl No.	Description	Doc No.	Submitted
9	Specified Logic Verification-Transformer Feeder (Differential/REF/Backup OC&EF/Backup Impedance) Report		☐
10	Specified Logic verification-Bus/Line Reactor Feeder (Differential/REF/Backup Impedance) Report		☐
11	Centralised Busbar protection Report		☐
12	De-Centralised Busbar Protection Report		☐
13	Project Backup after complete FAT for all feeder configuration for all Relays involved in the FAT		☐
14	Operation and Technical Guide for Protection IEDs		☐
15	Operation and Technical Guide for BCU & other IEDs supplied		☐
16	Operation and Technical Guide IED configuration softwares		☐
17	Operation and Technical Guide Ethernet Switch		☐
18	**Other applicable equipment Operational & Technical Guide**		☐

Softwares/License details Backup:

Software/License	Doc. No.	Checked
Protection & Control each type Software & license		☐
CSD, FOTS, RTCC & Other Devices Software & license		☐
Antivirus software & license		☐
Other applicable equipment Operational & Technical Guide		☐

POWERGRID Representative	Manufacturer Representative
Signature:	**Signature:**
Name:	**Name:**
Date:	**Date:**

4. OBSERVATION AND COMPLIANCE REPORT

Observations during FAT & its compliance shall be recorded in “log sheets”.

OBSERVATION AND COMPLIANCE REPORT

LOG SHEET:

Sr. No.	Observations	Compliance	Remarks

POWERGRID Representative	Manufacturer Representative
Signature:	**Signature:**
Name:	**Name:**
Date:	**Date:**

5. GLOSSARY

BCU: Bay Control Unit
DR: Disturbance Recorder
EWS: Engineering Workstation
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

POWERGRID Representative	Manufacturer Representative
Signature:	**Signature:**
Name:	**Name:**
Date:	**Date:**

6. ANNEXURE

Annexure -PreFAT Formats

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

पावरग्रिड POWERGRID	Factory Acceptance Test - Protection System Visual Inspection		
Manufacturer:		**Equipment:**	
Contractor:		**Feeder/Circuit:**	

VISUAL INSPECTION

Ref: FAT001

Name of the Panel:

Actions: Verify the check list and ensure that the panel under test is in line with the base document.

Sr.No.	Description	Passed	Failed
1	Ensure all the equipment are free of all foreign materials (dust, solder, droppings, etc)	☐	☐
2	Visually inspect the units and individual modules for cleanliness, healthiness and ensure that they are free from damage	☐	☐
3	Verify that the dimension of the panel as per GA	☐	☐
4	Visually inspect that the equipment are arranged as per the GA drawing of the panel (drawing pocket inside panel is available)	☐	☐
5	Verify the panel outside color and inside color is as per approved drawing	☐	☐
6	Verify the cabinet type is SWING FRAME	☐	☐
7	Verify the locker system of the panel is provided	☐	☐
8	Verify the size of the earthing bar is as per approved drawing	☐	☐
9	Verify the panel name plate and the equipment labels are correct and visible	☐	☐
10	Verify proper labeling is done for all the cables	☐	☐
11	Check for the arrangement of terminal blocks as per the drawing	☐	☐
12	Check the shorting and isolating accessories of CT terminals	☐	☐
13	Verify whether proper ferruling is done or not	☐	☐
14	Check if earth shield connections are provided	☐	☐
15	Check ventilation is provided as per the drawings	☐	☐
16	Check for proper panel door earthing	☐	☐
17	Verify paint thickness as specified in GA drawing	☐	☐
18	Check comprehensiveness of painting against external scratches, rusting, dents/damages etc.	☐	☐
19	Minimum spare TBs should be available as per TS & Truff size should be as accommodate with sufficient space for Field Cable.	☐	☐

POWERGRID Representative	Manufacturer Representative
Signature:	**Signature:**
Name:	**Name:**
Date:	**Date:**

HARDWARE VERIFICATION TEST — Ref: FAT002

Name of the Panel:

Actions: Verify the list of equipment and ensure the identification data, manufacturer and quantities are correct.

Sr.No.	Description	Passed	Failed
1	Verify the list of equipment of the scheme drawing as per GA with the existing cubicle layout & record any non-availability of equipment	☐	☐

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

पावरग्रिड POWERGRID	Factory Acceptance Test - Protection System Hardware verification		
Manufacturer:		**Equipment:**	
Contractor:		**Feeder/Circuit:**	
		Page:	24 of 26

AC POWER VERIFICATION

Ref: FAT003

Name of the Panel:

Actions: Verify the check list and ensure that the AC circuit of the panel is correct and the devices are working properly.

Sr.No.	Description	Passed	Failed
1	Ensure that rated AC supply is given to panel at the incoming terminals	☐	☐
2	Verify the equipment under test are rated for proper AC supply	☐	☐
3	Verify the supply at the 1phase AC supply in OFF condition	☐	☐
4	Switch ON the supply and verify the ON/OFF operation of LAMP of the cubicle by operating the miniature position switch	☐	☐
5	Verify the power supply at the socket DS is correct	☐	☐
6	Verify the power supply at the power socket is correct	☐	☐
7	Switch ON the supply and verify the operation of thermostat, heater and indicator lamp. Adjusting the thermostat settings to 25°C for heater ON and ensure the Heater circuit placement doesn't affect any cable entry.	☐	☐
8	AC circuit wiring checked according to corresponding drawing	☐	☐

POWERGRID Representative	Manufacturer Representative
Signature:	Signature:
Name:	Name:
Date:	Date:

पावरग्रिड POWERGRID	Factory Acceptance Test - Protection System Hardware verification		
Manufacturer:		**Equipment:**	
Contractor:		**Feeder/Circuit:**	
		Page:	25 of 26

DC SCHEME CHECK

Ref: FAT004

Name of the Panel:

Actions: Verify the check list and ensure that the DC circuit of thew panel is correct, and the devices are working properly.

S.No	Description	Passed	Failed
1	Ensure that rated DC supplies DC1 and DC2 are given to panel at the incoming terminals	☐	☐
2	Verify the equipment under test are rated for proper DC supply	☐	☐
3	Check continuity for DC circuit as per the drawing to ensure proper polarity before power ON	☐	☐
4	Check the Proper Co-ordination of the DC Fuse rating from the source -1 & 2 to till downstream circuit Fuse rating	☐	☐
5	Verify DC1 and DC2 at the main supply is in OFF condition. Now switch on DC Source-1. Check DC voltage at Fuse of DC Source-2. No DC voltage should be present. Switch off DC Source-1.	☐	☐
6	Verify DC1 and DC2 at the main supply is in OFF condition. Now switch on DC Source-2. Check DC voltage at Fuse of DC Source-1. No DC voltage should be present. Switch off DC Source-1.	☐	☐
7	Switch ON the DC1 and DC2 main MCBs and verify the supply at all other supply in the OFF condition	☐	☐
8	Switch ON all the supply in the panels and verify that all equipment rated for DC voltage is working properly	☐	☐
9	Perform a DC change over and ensure that no power failure happened in any of the equipment in the panel	☐	☐
10	Ensure that there is no mixing of DC1 and DC2 supply in the panel	☐	☐
11	Cubicle scheme checked according to corresponding drawing	☐	☐

POWERGRID Representative	Manufacturer Representative
Signature:	**Signature:**
Name:	**Name:**
Date:	**Date:**

पावरग्रिड POWERGRID	Factory Acceptance Test - Protection System Hardware verification		
Manufacturer:		**Equipment:**	
Contractor:		**Feeder/Circuit:**	
		Page:	26 of 26

Auxiliary Relay – xxxx Ref: FAT005

Feeder Reference:

1. Name Plate Rating Details of the Equipment

Record the following details of the relay.

Relay Make	
Relay Model	
Order Number	
Serial Number	
Rated Voltage	
Contacts Details	

2. General Inspection of Relay

Sr.No.	Description	Passed	Failed
1	Installation and correct wiring as per drawing	☐	☐
2	Terminal tightness	☐	☐
3	Relay earth connected to local earth bar	☐	☐

3. Secondary Injection Test

Pick-up / Drop-off Test

Inject the relay via the front panel test sockets (if possible) and record the pick-up and drop-off values in the table below.

Operating Coil

Pick-Up		Drop-Off		Result
V	mA	V	mA	

POWERGRID Representative	Manufacturer Representative
Signature:	**Signature:**
Name:	**Name:**
Date:	**Date:**

Cyber Security Requirements

1.IED Cyber Security capability compliance in the IEDs: following requirements shall be met by IED as per IEEE 1686:2013 clause 5.

Clause Number	Sub Category	Checklist
5 IED Cybersecurity features		
5.1	Electronic access control	Check the IED is protected by unique ID and Password Combination. Check it shall not be possible to gain access to the device without a proper ID/password combination that user has generated.
5.1.2	Password defeat mechanism	Check IED does not have undisclosed means whereby user-created ID/password can be defeated. Check Embedded master password technique is implemented? Check whether chip-embedded routines that automatically run in the event of hardware or software failure? Check Hardware bypass of passwords, such as jumpers and switch settings is implemented?
5.1.3	Number of Individual users	Minimum 04 users shall be supported by IED
5.1.4	Password Construction	Check password supported is At least 8 characters and is case-sensitive. When encoding is in plain text, it shall contain: -At least one uppercase and one lowercase - At least one number - One non-alpha numeric character (@,%,&,*) Check the user is notified and prompted to choose another password that conforms if it violates.
5.1.6 IED main security functions		
5.1.6 b)	View configuration settings	Check IED's ability to view configuration settings such as scaling, communication addressing, programmable logic routines(through configuration software), and firmware version
5.1.6 d)	Configuration change	Check IED's ability to **extract & upload configuration files from/to IED** to the unit and /or effect changes to the existing configuration
5.1.6 e)	Firmware change	Firmware change referes to the ability to load new firmware that does not require hardware change.
5.1.6 f)	ID/Password or RBAC management	ID/Password or RBAC management referes to the ability to load new id that does not require hardware management.
5.1.6 g)	Audit trail	Audit trail refers to the ability to view and download the audit trail.
5.1.7	Password Display	Check the vulnerability of password disclosure in local display panel, configuration software (local or remote; offline or online), web browser and terminal access
5.2 Audit trail		
5.2.4 Audit trail event types		
5.2.4 a)	Log In	Log In (locally or remotely) as a user to the device and check the event is created in audit log.
5.2.4 f)	Configuration change	Check new configuration file to the IED or new configuration parameters that causes a change in IED configuration is logged in Audit trail
5.2.4 h)	ID/password creation or modification	Check new ID/password creation/modification is logged in audit log
5.2.4 i)	ID/Password deletion	Check new ID/password deletion is logged in audit log
5.3 Supervisory monitoring and control		

5.3.1	Overview of supervisory monitoring and control	IED shall monitor security related activity and shall make the information available through a real time communication protocol for transmission to the supervisory system.
5.3.3 Alarms: Following shall cause unique alarm occurrence		
5.3.3 b)	Reboot	Rebooting or restarting of IED by means of removing power or through the use of a device resident rebooting mechanism such as reset button, power-up sequence, or access software failure.
5.3.4	Alarm point change detect	Check the momentary change of events and Alarms is detected as individual alarm and event.
5.4 IED cyber Security features		
5.4.2 Specific Cryptographic features		
5.4.2 e)	Network time synchronization	NTP shall be NTP v3/4 or SNTP 3/4
5.5 IED configuration software		
5.5.4.2 change configuration data		
5.5.4.2. a)	Full access	In full access mode, all functions, including ID/password changes and user assignment can be made.
5.6	Communications port access	Check the communication is not possible in disabled communication port and all the unused UDP/TCP ports are disabled

2.Following Security features shall be available in each IED including PMU:

- DOS protection
- NTP/PTP synchronization
- Role Based Access Control compliance as per IEC 62351-8 as per the OEM compliance chart
- Emergency access to device if connection to RBAC Server is lost
- LDAP/AD/Radius support for Authentication and account management

3. Following Security features shall be available in Computers/ workstations/ servers/software for Substation Automation System:

    - All applications(software)/ OS supplied shall be licensed to POWERGRID (if applicable) and any updates shall be supplied during the Warranty period.
    - Computer names shall be as per the standard naming convention of POWERGRID.
    - BIOS Password shall be set/enabled at system boot. Disk encryption policy shall be enabled on mobile devices(laptop/External HDD), if possible.
    - Bluetooth and Wi-Fi driver shall be uninstalled. Corresponding hardware shall be disabled from OS or BIOS, if possible.
    - Wake on LAN feature shall be disabled.
    - System boot from USB or other means shall be disabled.
    - Virtualization feature in CPU shall be disabled, wherever applicable.
    - Standard user (non-administrator) accounts shall be enabled for regular work. Privileges and use of admin privilege shall only be required for specific tasks wherever applicable.
    - Roles such as user, administrator, auditor shall be configured in IEDs and Associated applications.
    - Only whitelisted software shall be installed on systems.
    - Security features such as RBAC, password complexity, syslog, Radius/ AD authentication, enabling of certificates shall be ensured in all installed applications, wherever applicable.
    - Only whitelisted services shall be running on systems.

- External USB storage devices (i.e., pen drive, memory cards, hard disk, mobile phone storage etc.) shall NOT be allowed, only authorized USB storage devices (approved by POWERGRID) shall be allowed on systems based on the roles & requirements of the user.
- Endpoint protection (Antivirus, Anti Malware protection) shall be loaded.
- Host based firewall shall be enabled and only required ports for SAS should be opened in the host-based firewall.
- System level user password policy (password complexity & password expiry) shall also be enabled.
- IP address series will be as allocated by POWERGRID.
- All required services such as Remote Desktop (RDP), SMB, PowerShell, if required for normal operation shall be listed. Any other specific service requirement of POWERGRID will be communicated at the time of execution for listing.
- Offline backups for all systems with encryption/checksum shall be provided at the time of SAT.
- Inventory of all assets shall be carried out as per format laid down in FAT.
- Specific applications (software) used shall be as per Software Development Life Cycle/best practices. (Such as ISO/IEC 42010:2011/IEC 62443-4-1)
- Sensitive database information shall be encrypted.
- All systems shall be enabled for security logs (for OS, Application security logs and shall have the facility to be routed to a standard syslog server in compatible log formats whose IP address will be shared by POWERGRID.
- POWERGRID reserves the right to carry out VA at any point of time and vendor shall support for mitigation during warranty period as per CEA guidelines.

4. Following Security features shall be available in Network switches:
    - Discovery protocol, Web view, Telnet, TFTP shall be disabled,
    - TLSv1.2 or higher access shall be enabled.
    - User Session timeout shall be enabled. Time of logout due to user inactivity shall be configured.
    - ACL on management interfaces shall be enabled to restrict access.
    - Unused ports, proxy ARP, unused protocols shall be disabled.
    - Broadcast suppression, loop protection shall be enabled.
    - Configurable port rate limiting provision shall be provided.
    - Password complexity shall be enabled.
    - SNMPv3 or higher shall be supported.
    - MAC address-based whitelisting shall be available.
    - Availability of IEEE 802.1x based authentication

5. Following Security features shall be available in Network switches, Firewalls and Networking devices:
    - At least two roles should be configured for Network switches as per OEM role recommendation.
    - Default credentials shall be changed/ disabled.
    - Default services (i.e. FTP, HTTP, SMB, Telnet etc.) shall be disabled, if not in use. List of required services shall be verified at the time of FAT.
    - All devices shall be enabled for security logs and shall have the facility to be routed to a standard syslog server in compatible log formats whose IP address will be shared by POWERGRID.
    - Remote administration, if enabled shall be ensured with secure connection (HTTPS/ SSH) only with strong admin credentials.
    - Firmware version along with checksum, product number shall be provided.
    - Time synchronization shall be ensured.

6. Following Security features shall be available in GPS, Fault locators and other network elements:

- Roles should be configured for GPS, Fault locators and other devices .
- Default credentials shall be changed/ disabled.
- Default services (i.e. FTP, HTTP, SMB, Telnet etc.) shall be disabled, if not in use. List of required services shall be verified at the time of FAT.
- All devices shall be enabled for security logs and shall have the facility to be routed to a standard syslog server in compatible log formats whose IP address will be shared by POWERGRID.
- Remote administration, if enabled shall be ensured with secure connection (HTTPS/ SSH) only with strong admin credentials.
- Firmware version along with checksum, product number shall be provided.
- Time synchronization shall be ensured.

7. Training on cyber security should be provided by vendor including following topics but not limited to:
    - Patch management
    - Firmware update procedure
    - Perimeter threat protection
    - Configuration of endpoints
    - Security configuration of supplied devices
    - Device hardening

FAT checklist:

1.IED Cyber Security capability compliance in the IEDs: following requirements shall be met by IED as per IEEE 1686:2013 clause 5.

Clause Number	Sub-Category	Checklist	Comply/ Exception/ Exceed	Remarks
5 IED Cybersecurity features				
5.1	Electronic access control	Check the IED is protected by unique ID and Password Combination. Check it shall not be possible to gain access to the device without a proper ID/password combination that user has generated.		
5.1.2	Password defeat mechanism	Check IED does not have undisclosed means whereby user-created ID/password can be defeated. Check Embedded master password technique is implemented? Check whether chip-embedded routines that automatically run in the event of hardware or software failure? Check Hardware bypass of passwords, such as jumpers and switch settings is implemented?		
5.1.3	Number of Individual users	Minimum 04 users shall be supported by IED		
5.1.4	Password Construction	Check password supported is At least 8 characters and is case-sensitive. When encoding is in plain text, it shall contain: -At least one uppercase and one lowercase - At least one number - One non-alpha numeric character (@,%,&,*) Check the user is notified and prompted to choose another password that conforms if it violates.		
5.1.6 IED main security functions				
5.1.6 b)	View configuration settings	Check IED's ability to view configuration settings such as scaling, communication addressing, programmable logic routines(through configuration software), and firmware version		
5.1.6 d)	Configuration change	Check IED's ability to **extract & upload configuration files from/to IED** to the unit and /or effect changes to the existing configuration		
5.1.6 e)	Firmware change	Firmware change referes to the ability to load new firmware that does not require hardware change.		

5.1.6 f)	ID/Password or RBAC management	ID/Password or RBAC management referes to the ability to load new id that does not require hardware management.		
5.1.6 g)	Audit trail	Audit trail refers to the ability to view and download the audit trail.		
5.1.7	Password Display	Check the vulnerability of password disclosure in local display panel, configuration software (local or remote; offline or online), web browser and terminal access		
5.2 Audit trail				
5.2.4 Audit trail event types				
5.2.4 a)	Log In	Log In (locally or remotely) as a user to the device and check the event is created in audit log.		
5.2.4 f)	Configuration change	Check new configuration file to the IED or new configuration parameters that causes a change in IED configuration is logged in Audit trail		
5.2.4 h)	ID/password creation or modification	Check new ID/password creation/modification is logged in audit log		
5.2.4 i)	ID/Password deletion	Check new ID/password deletion is logged in audit log		
5.3 Supervisory monitoring and control				
5.3.1	Overview of supervisory monitoring and control	IED shall monitor security related activity and shall make the information available through a real time communication protocol for transmission to the supervisory system.		
5.3.3 Alarms: Following shall cause unique alarm occurrence				
5.3.3 b)	Reboot	Rebooting or restarting of IED by means of removing power or through the use of a device resident rebooting mechanism such as reset button, power-up sequence, or access software failure.		
5.3.4	Alarm point change detect	Check the momentary change of events and Alarms is detected as individual alarm and event.		
5.4 IED cyber Security features				
5.4.2 Specific Cryptographic features				
5.4.2 e)	Network time synchronization	NTP shall be NTP v3/4 or SNTP 3/4		
5.5 IED configuration software				
5.5.4.2 change configuration data				
5.5.4.2. a)	Full access	In full access mode, all functions, including ID/password changes and user assignment can be made.		

5.6	Communications port access	Check the communication is not possible in disabled communication port and all the unused UDP/TCP ports are disabled		

Verifed by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

SAT checklist:

1.Configured Security features in each IED including PMU:

Sl.No	IED model	Type of protection/function	Enabled (yes/no)	Remarks
1		DOS protection		
2		NTP/PTP synchronization		
3		Role Based Access Control compliance as per IEC 62351-8 as per the OEM compliance chart (as per table 1.1)		
4		Emergency access to device if connection to RBAC Server is lost		
5		LDAP/AD/Radius support for Authentication and account management		

1.1 RBAC roles as per IEC 62351-8:

Sl.No	IED Model	Type of Role	Created (yes/no)	Remarks
1		Viewer		
2		Operator		
3		Engineer		
4		Administrator		
5		Auditor		
6		RBAC Manager		
7		Super Admin		

2. Following features are to be checked and recorded in Computers/ workstations/ servers/software for Substation Automation System:

S.no	check	Server1	Server2	HMI1	HMI2	Gateway1	Gateway2	DR PC
1.	OS Version							
2.	OS licensed version is used (yes/ no)							
3.	Computer Name							
4.	Windows update date							

5.	BIOS Password enabled (yes/No)							
6.	Check Bluetooth and Wi-Fi Driver are uninstalled.							
7.	Corresponding hardware is disabled from OS or BIOS (yes/no), if possible.							
8.	Wake on LAN feature is disabled (yes/no)							
9.	Check System boot is disabled from USB or any other means (yes/no)							
10.	Check virtualization feature in CPU is disable							
11.	Non-administrator accounts enabled for regular work							
12.	Check changes to setting like a) Boot Sequence b) Boot password c) Wake-on-Lan, d) System time etc. can be made by system admin only (yes/no)							
13.	Roles such as user, administrator, auditor are configured in IEDs and Associated applications.							
14.	Only whitelisted software are installed as per table 2.1							
15.	Security feature enabled as per table 2.2							
16.	Software license details as per table 2.3							

17.	Only whitelisted services running as per table 2.4							
18.	USB drive disabled (yes/No)							
19.	Endpoint protection (Antivirus, Anti Malware protection) loaded Yes/No							
20.	Name of Endpoint protection							
21.	Last signature update date							
22.	Host Based firewall enabled (yes/ no)							
23.	Host Based firewall configured as per whitelisted ports mentioned in 2.5 and 2.6							
24.	Centralized user management provided (yes/ No)							
25.	System level user password policy implemented (yes/ no)							
26.	Offline backups for all systems with encryption/checksum shall be provided at the time of SAT							
27.	Inventory of assets provided as per table 2.7							
28.	Sensitive database information is encrypted (yes/No)							
29.	Security logs enabled (yes/no)							

30.	Facility provided to route logs to syslog server (yes/no)							
31.	Vulnerabilities mitigated as per assessment report (yes/no)							

2.1 List of software to be whitelisted

S.NO	IED/Machine	Name of Whitelisted software

2.2 Configured Security features in software application

Sl.No	Application	feature	Enabled or not
1		RBAC	
2		Password complexity	
3		Syslog	
4		Radius/AD Authentication	
5		Enabling of certificate	

2.3 List of software including the license to POWERGRID and validity of software

S. No.	Name of Third-Party Software	License details	Expiry date of License
1			

2.4 List of Services whitelisted:

S.NO	IED/Machine	Name of Whitelisted Services

2.5 List of services and TCP/UDP port required to be running in IED/ HMI/ Gateway/ Server/ Switch/ other computers

Computer Name	Name of Services	Status (Enabled/Disabled)	By Default, status	Port	Description

2.6 List of Required TCP/UDP Open Ports (for other devices)

IED/Machine	Service	Required TCP Port	Required UDP Port	IP Address

2.7 Inventory of Assets

Specify Name of PC, Name of software, Version, Application software, database, Open-source libraries used in the development of software.

S.No	Name of PC	Software Name	Version	Use of the software	Name of Open-source library used for the development of software	Name of 3rd party library dll used for the development of software
1						

3. Check whether disk encryption policy is enabled on mobile devices (laptop/External HDD), if possible.
4. Network switches, Firewalls, and other networking devices:

	Firewall-1	Firewall-2	GPS	Fault locator 1..	Switch-1	Switch-2	…
Roles configured							
Default credentials changed/ deleted							
Default services (i.e. FTP, HTTP, SMB, Telnet etc.) disabled							
Security logging enabled							
Facility provided to route logs to syslog server (yes/no)							

Remote administration enabled (yes/no) If yes, secure connection (HTTPS/ SSH) is ensured							
Firmware details are provided as per table 4.1							
Time synchronization done (yes/No)							

4.1 Specify Firmware version, Product No and Checksum of all Network switches, Firewalls, and other devices such as GPS, Fault locators, PMU including IEDs

S.No	Name of Device	Firmware Version	Product No	Checksum MD5/SHA/SHA256 of Firm Ware
1 (e.g.)	ABB (REL 670)	1.5.0.35	1.2.3.5	
2				

Note: In some cases, there are two firmware are present in the IED. For e.g. in Siemens IEDs there are two firmware. (EN 100 firmware and other Siprotech firmware).

5. Initialize and test following Cyber Security Logs in Switches

Sl.No	Log name	Availability of log (Yes/No)	Checked log generation OK/Not OK
1.	Login successful		
2.	Logout successful		
3.	Type of login (SSH/VPN/Telnet) successful		
4.	Configuration change successful		
5.	Configuration change failed		
6.	Switch port status changed (Up/Down/disabled/enabled)		
7.	Link status		

8.	Connections denied		
9.	Connections accepted		

6. Initialize and test following Cyber security logs in GPS unit, PMU, Cameras, Applications used for configuring IEDs, BCU, any other device/ application required to generate logs:

S.NO	Description	Checked	Remark
1	Check the Structure of Security Log Entry		Below fields need to be there in the log entry but not limited to this a) Severity b) Date and Time c) IP Address or Port d) Module name & Product Name e) Message
2	Check log is generated when user log in to the system		
3	Check log is generated when user logout from the system		
4	Check log when user enter wrong credentials consecutively three times		
5	Check Log is generated when time out occurs because of inactivity		
6	Check log is generated when a admin user create other user		
7	Check log is generated when user modify the password		
8	Check log is generated when a particular user is deleted from the system		
9	Check log is generated when a control action is performed by user		
10	Check log is generated when a configuration id downloaded		

11	Check log is generated when a configuration is changed		
12	Check log is generated when firmware was changed		
13	Check log is generated when firmware was uploaded		
14	Check log is generated when audit log is viewed/downloaded		
15	Check log is generated when user changed the date and time of a system		
16	Check log is generated when link status is changed on port		
17	Check log is generated when the system restarts automatically		Additional information what triggered the restart
18	Check log is generated when a user initiated the restart		
19	Check log storage capacity of every networking equipment.		

7. Check following features in Network Switches:

Procedure

S.NO.	Description	Checked	Remark
1	Check whether Discovery Protocol is disabled or not		
2	Check whether Web View is disabled or not		
3	Check whether Telnet is disabled or not		
4	Check whether TLS1.2 or hi is enabled or not		
5	Check whether Session timeouts is enabled or not		
6	Check whether ACL on management interfaces to restrict access		
7	Check all unused ports are disabled or not		
8	Check proxy ARP is disable or not		
9	Check Port Configuration	Duplex/Auto/Full	Auto is preferred
10	Check broadcast suppression is enabled or not		
11	Check loop protection algorithm is enabled or not		
12	Check the version of SNMP.		SNMP v3 is recommended

13	Check whether all the Unused protocols are disabled or not		
14	Check for availability of IEEE 802.1x based authentication		

Verifed by:	
POWERGRID Representative	Manufacturer Representative
Signature :	Signature :
Name :	Name :
Date :	Date :

Frequently Asked Questions

A. Package Type: New Substation

1.1. What is the order of precedence of price schedule (BPS/Bid Form), technical specification and other bidding documents?

Reply:- Order of precedence of these documents to address contradictions, if any, in the contents of the bid as followings:

I. Bid Form
II. Attachment -6: deviations
III. Technical Data Sheets
IV. Any other part of the BID

Content of the documents at Sr. No. I above will have overriding precedence over other documents (Sr. no II to IV above). Similarly, content of documents at Sr. No II above will have overriding precedence over other documents (Sr. no III to IV above) and so on.

However, if adequate details are not specified in BPS, then BPS Item shall be read in conjunction with TS.

1.2. Whether Construction Power and Water at Free of cost shall be provided to the successful bidder by Employer?

Reply: - Bidder to refer clause no 14.3 of SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR) which is reproduced below: -

"*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.*

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."

1.3. What is the Minimum specified creepage distance to be considered for insulator string/ longrod insulators/ outdoor bushings & switchyard equipment?

Reply:- Following Standard Creepage distance is to be considered for :

a) Insulator string / longrod insulators/ outdoor bushings (GIS/Transformer/reactors)
   - For both Non-coastal area & Costal area : 31mm/kV

b) All other Switchyard Equipment-:
   - Non-coastal area : 25mm/kV
   - Costal area : 31mm/kV

1.4. Whether RTV coating in all switchyard equipment is required?

Reply:- RTV coating shall be done at site on all porcelain insulators including mandatory spares (i.e. bushings, hollow and solid insulators, disc insulators etc.) for substation(s) in coastal area (if specified in Section project). The cost of RTV coating shall be deemed to be included in the respective equipment/items' erection cost.

1.5. How the variation in the BOQ quantity shall be dealt during post award?

Reply:- Any change in BPS/LOA quantities during detailed engineering shall be dealt in line with provisions of bidding documents/Contracts.

Frequently Asked Questions

1.6. Is Special Tools and Tackles covered under present scope work?

Reply:- Bidder to refer clause no 14.2 of SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR) which is reproduced below: -

"The successful bidder 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."*

1.7. Whether SAS integration/configuration work at remote end (i.e. RLDC/ Backup RLDC /RTAMC/ NTAMC / Backup NTAMC) is envisaged under present scope of bidder.

Reply:- Necessary configuration of data at Gateway for remote operation from NTAMC, Backup NTAMC, RTAMC & supervision from RLDC/ Backup RLDC is included in present scope of bidder.
No work is envisaged at remote end (RLDC/ Backup RLDC /RTAMC/ NTAMC / Backup NTAMC) under the present scope. However successful bidder has to extend all support for successful integration of data at remote end.

1.8. Whether Approach Road is in the scope of Bidder?

Reply:- Bidder to refer clause no 13.0 pf section GTR.
As per site requirement Approach Road, in the vicinity of substation may be constructed based on drawings of internal roads enclosed with the tender drawing & Payment shall be made under unit item rate of associated BPS item for roads.

1.9. What is design temperature for battery capacity calculation as in bidding documents ambient temp is mentioned 0-50 degree?

Reply:- For Battery sizing calculations worst temp combination i.e. Zero degree is to be considered as minimum temperature for sizing calculations.

1.10. As per Scope of work capacity of battery & charger needs to be calculated considering present as well as future bays. Please provide DC load details for future CRP system.

Reply:- Bidders to consider the present bay CRP load requirement of similar feeder i.e. Transformer bay, Line/Bus Reactor Bay, Line bay, Tie bay etc for future bays also for capacity calculation of battery & charger.
If higher capacity/rating are required based on design calculations same shall be provided by contractor without additional cost to employer. However, capacity of battery & battery chargers should not be less than as specified in the BPS.

1.11. For the proposed S/S under TBCB, Kindly provide the following:-

- Coordinates of the identified land.
- Single Line Diagram,
- General Arrangement Drawing.

Reply:- It is responsibility of bidder to develop Single line diagram, General arrangement and all other associated layout considering the present as well as future scope of work for proposed Substation. SLD, Plan & General arrangement Layout of proposed substation shall be finalised during detailed Engineering based on best engineering practices, meeting the requirements of Technical Specifications & orientation of line corridors. Location/coordinates of identified land/Plot plan of proposed new substation shall be shared during detailed engineering to successful bidder.

1.12. Whether encumbrance free land will be provided to successful Bidder?

Reply:- Reasonably Encumbrance free land will be provided to successful Bidder.

1.13. Whether Line side insulator string is not in bidder's scope. Kindly confirm?

Reply:- Transmission line side insulator string along with hardware for line termination is envisaged under present scope of the bidder.

1.14. Whether space shall be provided at site for storage & site office construction at free of cost.

Reply:- It is not binding on employer to provide the space for requisite facilities. However, the same can be at substation site, on the availability of space.

1.15. Kindly provide the spacing of main Earthmat for proposed substation.?

Reply: - For estimation of risers of new substation/switchyard, maximum spacing of Main Earthmat shall be considered as below:-

- 30Mx30M for 765kV S/s
- 24Mx24M for 400kv S/s
- 16Mx16M for 220kV S/s
- 12Mx12M for 132kV switchyard respectively.

For substations with multiple voltage levels, maximum spacing of highest volage level shall be considered for estimation of risers quantities.
Actual spacing for main earthmat shall be finalized during detailed engineering based on soil resistivity data and payment shall be made as per actual executed quantity at site. However, no cost compensation shall be considered in case of actual spacing of main earthmat finalized during detailed engineering is less than that mentioned above.

1.16. Kindly provide seismic ground acceleration value & seismic zone applicable to project?

Reply:- Destination/Location is defined in bidding documents. Please refer IS-1893 Part-1 for selecting, seismic force ground acceleration value & seismic zone applicable to that location.

B. Additional Query for Package Type: Substation Extension Work

1.17. Kindly provide following details of existing Substation for TBCB projects:

- Single line diagram,
- General Arrangement drawing,
- FFPH layout etc

Reply: - Details/document , if not available in bidding documents, shall be shared with successful bidder during detailed engineering.

1.18. We presume that existing LT Switchgear viz. ACDB, DCDB, ELDB & MLDB has sufficient spare feeders to meet the present scope of Extn. bays as defined in section project.

Reply: - The bidders are advised to visit the substation sites and acquaint themselves with the topography, infrastructure and also the design philosophy.

1.19. Kindly provide the make and model no, availability of bay units of existing Bus bar protection scheme for present scope of work.

Reply: - The bidders are advised to visit the substation sites and acquaint themselves with the topography, infrastructure and also the design philosophy.

1.20. Kindly provide the make and model no, availability of licences of existing Substation automation system for present scope of work.

Reply: - The bidders are advised to visit the substation sites and acquaint themselves with the topography, infrastructure and also the design philosophy.
Additional licence for present scope of SAS Augmentation, is not envisaged under present scope.

1.21. Kindly provide the spacing of main Earthmat for proposed substation.?

Reply: - For estimation of riser of substation extn, main earthmat spacing shall be considered same as that in the existing switchyard. The bidders are advised to visit the substation sites and acquaint themselves with the topography, infrastructure and also the design philosophy.

C. Additional Query for Package Type: Transformer/Reactor Package

1.22. What shall be the procedure for long term storage of Transformer and Reactor?

Reply:- Detail procedure for storage of spare transformer unit with and without isolator switching arrangement shall be as per annexure " *Spare Transformer/Reactor Unit Storage & Connection Arrangement*" attached with Section – Transformer & reactors.

1.23. Kindly provide the distance between CMB to control panel/RTCC Panel required to estimate special cable.

Reply:- For estimation purpose CMB to control panel/RTCC Panel distance of 300mtr(approx.) shall be considered.

1.24. The Supply of 4-20mA output for OTI, WTI is in bidder's scope. Please clarify regarding the scope of integration of same in existing SCADA.

Reply:- Integration of OTI, WTI is in not in scope of transformer/Reactor Package.

D. Additional Query for Package Type: GIS

1.25. Whether LCC panels have to be placed in GIS hall or can be placed in Room adjacent to GIS hall?

Reply: - LCC panels shall be located inside the GIS hall itself preferably in front of respective GIS bay. CRP panel (Protection panels) shall be placed in Local Control Relay Room (LCR room) adjacent to GIS hall.

1.26. Kindly confirm the requirement of EOT Crane for 765kV, 400kV, 220kV & 132kV GIS Halls?

Reply:- One EOT Crane(As per BPS) of suitable capacity in line with technical specifications for each 765kV, 400kV, 220kV & 132kV GIS Halls-

1.27 How many Air change per Hour requirement for ventilation of the GIS Hall?

Reply:- The ventilation of the GIS hall shall be of a positive pressure type with minimum 2 air changes per hour. The pressure inside the GIS hall shall be maintained 5 mm of water above the atmospheric pressure.

1.27. What is the minimum clearance requirement between GIB and any building?

Reply:- The horizontal clearance between GIB and GIS building /any other building wall shall be preferably be three (3) meters.

1.28. During extension of GIS Substation, OEM representative of existing GIS, tools & tackles required for extn work & Consumable items for existing GIS is in whose scope?

Reply:- During Extension of existing GIS substation, tools and tackles as well as consumables/gaskets, etc. as required & also OEM representative of existing GIS (for supervising connection of the Interface Module), shall be arranged by the present bidder/contractor without any additional financial implication to Owner/Employer.