BIDDING DOCUMENT

FOR

"Implementation of Islanding Scheme of Guwahati under PSDF"

FUND: "Power System Development Fund"

(E-Tender)

(VOL – II)

BID IDENTIFICATION NO:

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ASSAM ELECTRICITY GRID CORPORATION LIMITED

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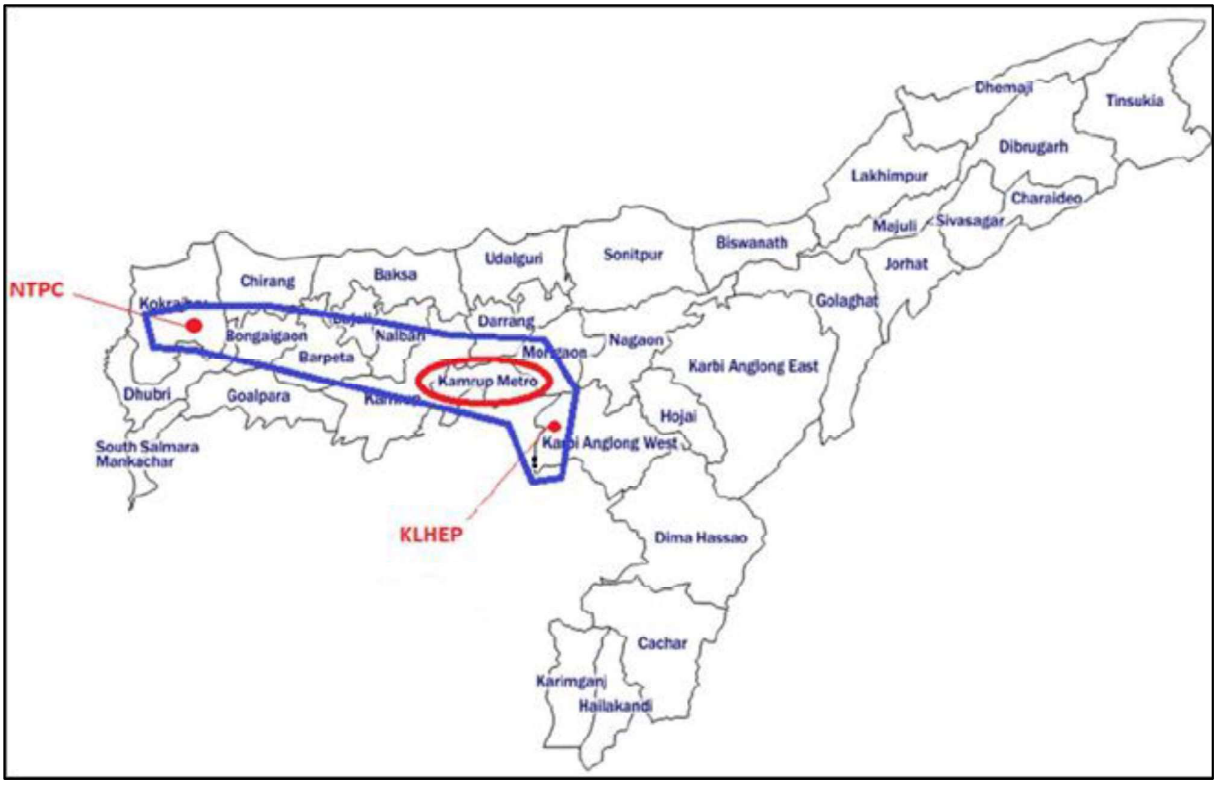

Technical Specifications of Guwahati Islanding Scheme

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1 Introduction

As per Clause 10 of the Central Electricity Authority (Grid Standards), Regulations, 2010: "Islanding Schemes- (1) The Regional Power Committees shall prepare Islanding schemes for separation of systems with a view to save healthy system from total collapse in case of grid disturbance. (2) The Entities shall ensure proper implementation of the Schemes referred to in sub regulation (1)."

The 2012 Grid Disturbance and ensuing National Blackout is recent memory. Further the Oct'2020 Mumbai Blackout has reinforced the requirement of safeguarding the critical Capital loads in the entire country. In this respect, Islanding Scheme for Guwahati has been designed to safeguard the essential and critical loads of Guwahati. Furthermore, in the event of failure of the national grid, the supply of power to the super-critical and critical loads of Guwahati will be ensured via this scheme. Thereafter, the rest of Assam Grid, NER Grid and Indian Grid can be extended power from this Island.

The Island consists of generators connected at 400kV level, ISTS lines and numerous state transmission lines/stations with DISCOM loads. The participants for the commissioning and operation of the Islanding Scheme are as follows:

a) AEGCL - Assam Electricity Grid Corporation Ltd.
b) APDCL – Assam Power Distribution Corporation Ltd.
c) APGCL – Assam Power Generation Corporation Ltd.
d) PGCIL – Power Grid Corporation of India Ltd.
e) NTPC – National Thermal Power Corporation Ltd.

1.1 Brief information of the Island

- Anticipated Load – 658.27 MW
- Anticipated Generation – 863.5 MW
- Ratio between Anticipated Generation and Anticipated Load = 1.29 (=863.5/658.27) i.e. Anticipated Gen is 31.17% more than Anticipated Load.
- As per SOP Design Protocol 1(xxiii) "*Islanded system should preferably have 20% excess generation than load.*" So, considering the maximum load of the island the all three machines of BgTPP (3*250 MW) and *KLHEP of APGCL (2*50 MW+13 MW)* are required in the Island.

***Figure 1**: Formation of Guwahati Island along with generating stations of "NTPC-BgTPP & KLHEP (Including Myntriang)"*

Power from NTPC and KLHEP will be supplied to Guwahati Capital and adjacent areas post island formation through 400kV and 220kV Transmission networks. All other elements in the periphery will be disconnected during Island formation.

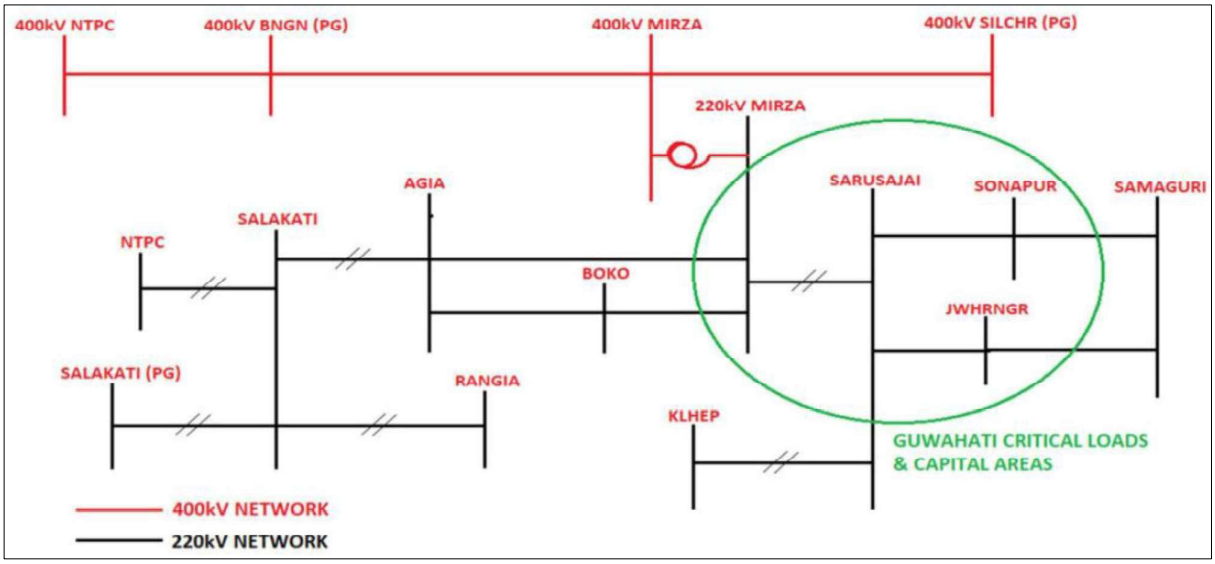

***Figure 2**: 400kV and 220kV Transmission links between NTPC – Guwahati and KLHEP - Guwahati*

1.2 Details of Generating Station Participating in the Guwahati Island:

S. No.	*Description*	*Company*	*No. of Units*	*Total Capacity*
1.	Bongaigaon Thermal Power Plant (BgTPP)	NTPC	3	750 MW
2.	Karbi Langpi HEP (KLHEP) + Myntriang SHEP	APGCL	2+1	100 MW+13.5MW
	TOTAL			**863.5 MW**

Table 1: *Participating Generation in the Island*

1.3 Details of Participating Loads in the Island:

S. No.	Substation	Capacity (MW)	Maximum Anticipated Load (MW)
1	400/220/132/33 kV Mirza	75	45.8
2	220/132/33 kV Sarusajai	113	94.5
3	132/33 kV Kahilipara	191.5	100
4	132/33 kV Sishugram	121.5	89.18
5	132/33 kV Kamakhya	80	33.75
6	220/33 kV Jawaharnagar	100	54.75
7	132/33 kV Narangi	65	55.17
8	132/33 kV Azara	90	32.5
9	220/132/33kV Sonapur	50	24.78
10	132/11kV AIIMS	25	21.57
11	132/33kV Chandrapur	61.5	37.73
12	132/33 kV Dispur	32	13.2
13	132/33 KV Guwahati Medical College & Hospital	100	42.5
14	132/33 KV Paltan Bazar	100	16.92
	TOTAL		**662.35**

Table 2*: Participating Load in the Island*

1.4 Categorization of Loads based on Priority:

Sl. No.	Name of the Stations	ICT	Total Transformation Capacity (MVA)	PRIORITY	Maximum Load Observed (in MW)	Cumulative Load (In MW)
1	132/33 kV Kahilipara	All ICTs (1 to 5)	191.5	PRIORITY - 1	155.34	100
2	132/33 KV Guwahati Medical College & Hospital	All ICTs (1 to 2)	100	PRIORITY - 2	42.5	142.5
3	132/11 kV Dispur (Capital)	ICT-1	16	PRIORITY - 3	6.40	148.9
4	132/11 kV Dispur (Capital)	ICT-2	16	PRIORITY - 4	6.80	155.7
5	132/33 KV PALTAN BAZAR	All ICTs (1 to 2)	100	PRIORITY - 5	16.92	172.62
6	132/33 kV Sonapur	All ICTs (1 to 2)	50	PRIORITY - 6	24.78	197.4
7	132/33 kV Azara	All ICTs (1 to 2)	90	PRIORITY - 7	32.50	229.9
8	132/33 kV Narangi	All ICTs (1 to 2)	65	PRIORITY - 8	55.17	285.07
9	132/33 kV Sishugram	ICT-2	31.5	PRIORITY - 9	22.18	307.25
10	132/33 kV Sishugram	ICT-3	40	PRIORITY - 10	33.70	340.95
11	132/33 kV Sarusajai	All ICTs (1 to 3)	113	PRIORITY - 11	94.50	435.45
12	400/220/132/33 kV Mirza	ICT-1	25	PRIORITY - 12	21.20	456.65
13	220/33 kV Jawharnagar	ICT-1	50	PRIORITY - 13	30.91	487.56
14	132/33 kV AIIMS	ICT-1	25	PRIORITY - 14	21.57	509.13
15	400/220/132/33 kV Mirza	ICT-2	50	PRIORITY - 15	24.60	533.73
16	132/33 kV Chandrapur	All ICTs (1 to 2)	61.5	PRIORITY - 16	37.73	571.46
17	132/33 kV Kamakhya	ICT-1	40	PRIORITY - 17	28.18	599.64
18	132/33 kV Kamakhya	ICT-2	40	PRIORITY - 18	5.57	605.21
19	132/33 kV Sishugram	ICT-1	50	PRIORITY - 19	33.30	638.51
20	220/33 kV Jawharnagar	ICT-2	50	PRIORITY - 20	23.84	662.35
Maximum Load Observed in Guwahati:					**662.35 MW**	

***Table 3**: Priority wise Categorization of Loads*

Due to the dynamic nature of the growth and integration of load at 33kV level which may result in varied criticality of the feeders (super-critical/critical etc.), it is found more prudent to consider

control of connected load at 33kV level by tripping the LV side of the ICTs for maintaining load-generation balance within healthy limits. Priority List (Merit Order) is given in table below:

1.5 Islanding Forming Loads and ICTs

Sl. No.	Name of the Stations	ICT	CAPACITY	33 kV Feeders connected
1	132/33 kV KAHILIPARA	ICT-1	40	33kV Jalukbari
				Fancy Bazar/ Fatasil/fancy bazar
				Nabard
		ICT-2	40	Borbari/ narengi
				33kV Kahilipara
				SLDC+ Capacitor Bank
		ICT-3	30	33kV Ulubari-I
				33kV Medical (Main)
				33kV Jawaharnagar-I
				33kV Shubham
		ICT-4	50	33kV Ulubari-2
				33kV Jawaharnagar-2
				33kV Medical (Alt)
		ICT-5	31.5	33kV paltanbazar (Alt)
				33kV Barsapara
				33kV Ulubari-3
				33kV Dispur/ Capital/ Jatia
2	132/11 KV Dispur (Capital)	ICT-1	16	11kV GAD (Dispur Complex)
				11KV Capital & RP Road (Dispur Complex)
				11KV New South
		ICT-2	16	11KV New Jatia
				11 KV Ganesh Mandir
				11KV New assembly
3	132/33 kV SONAPUR	ICT-1	25	33 kV Sonapur
				33 kV Digaru
				33 kV Khetri
				Two No.(2) numbers of 33 kV Bus Connected with a Sectionliser.
		ICT-2	25	
4	132/33 kV AZARA	ICT-1	40	33kV Mirza
				Bus Coupler Connected

Sl. No.	Name of the Stations	ICT	CAPACITY	33 kV Feeders connected
		ICT-2	50	
				33 KV Godebori-Azara
5	132/33 kV NARANGI	ICT-1	25	33 kV Bamunimaidam Feeder
				33 kV Narangi Industrial Feeder
		ICT-2	40	33 kV Jaica Feeder
				33 kV Uzan-Bazar Feeder
				33 kV Zoo-Road Feeder
6	132/33 kV SISHUGRAM	ICT-2	31.5	33kV Amingaon
				33kV Kamalpur
				33kV North Guwahati
				33kV Topcem
				33kV Changsari (Transformers I & II normally run in parallel
		ICT-3	40	33kV IIT
				33kV Sualkuchi
				33kV Hajo
				33kV BSPL
				33kV Sivsai
				33kV DRDO
7	132/33 kV SARUSAJAI	ICT-1	50	Jawaharnagar
				Garbhanga
				Fatasil
		ICT-2	31.5	33 KV Sarusajai-Mirza
				Paltan Bazar
				Station service
		ICT-3	31.5	Mega Alloy
				Bhetapara
				Garchuk
8	400/220/132/33 kV MIRZA	ICT-1	25	33 KV Kukurmara-NITB (Airport) Feeder
9	220/33 kV JAWHARNAGAR	ICT-1	50	33 KV INDIAN HOTEL FEEDER
				33 KV GARBHANGA FEEDER
				33 KV JAWAHARNAGAR FEEDER
10	132/33 kV AIIMS	ICT-1	25	(i) 33 KV AIIMS Feeder-I (Supplying Power to AIIMS)
				(ii) 33 kV AIIMS Feeder-II

Sl. No.	Name of the Stations	ICT	CAPACITY	33 kV Feeders connected
11	400/220/132/33 kV MIRZA	ICT-2	50	Consortium Feeder
				IIIT G Feeder
12	132/33 kV CHANDRAPUR	ICT-1	31.5	33kV Narengi
				33kV Bamunimaidan
		ICT-2	30	33kV Mayong
				33kV Colony
13	132/33 kV KAMAKHYA	ICT-1	40	33kV KAMAKHYA LOCAL
				33kV FANCY BAZAR
				Station transformer
		ICT-2	40	33kV FATASIL
				33kV GMDA
14	132/33 kV SISHUGRAM	ICT-1	50	33kV EPIP (Transformers I & II normally run in parallel)
15	220/33 kV JAWHARNAGAR	ICT-2	50	33 KV SONAPUR FEEDER
				33 KV 12 MILE FEEDER
16	132/33 KV Guwahati Medical College & Hospital	ICT-1	50	S/S under Construction
		ICT-2	50	
17	132/33 KV PALTAN BAZAR	ICT-1	50	S/S under Construction
		ICT-2	50	

***Table 4**: Island forming Feeders and ICTs*

1.6 Categorization of Loads based on Priority:

Due to the dynamic nature of the growth of the loads at 33kV and the resulting shifts in the criticality of the feeders, it is found to be more prudent to consider control of connected loads at 132kV level. Therefore, for disconnection of loads, disconnection from the HV side of the ICTs catering to the loads had to be considered through use of heavy-duty relays. Thus, a Priority (Merit order) listing of the connected loads has been prepared based on assessment by SLDC.

Sl. No.	Name of the Stations	ICT	Total Transformation Capacity (MVA)	PRIORITY	Maximum Load Observed (in MW)	Cumulative Load (In MW)
1	132/33 kV Kahilipara	All ICTs (1 to 5)	191.5	PRIORITY - 1	100	100
2	132/33 KV Guwahati Medical College & Hospital	All ICTs (1 to 2)	100	PRIORITY - 2	42.5	142.5
3	132/11 kV Dispur (Capital)	ICT-1	16	PRIORITY - 3	6.4	148.9
4	132/11 kV Dispur (Capital)	ICT-2	16	PRIORITY - 4	6.8	155.7
5	132/33 KV PALTAN BAZAR	All ICTs (1 to 2)	100	PRIORITY - 5	16.92	172.62
6	132/33 kV Sonapur	All ICTs (1 to 2)	50	PRIORITY - 6	24.78	197.4
7	132/33 kV Azara	All ICTs (1 to 2)	90	PRIORITY - 7	32.5	229.9
8	132/33 kV Narangi	All ICTs (1 to 2)	65	PRIORITY - 8	55.17	285.07
9	132/33 kV Sishugram	ICT-2	31.5	PRIORITY - 9	22.18	307.25
10	132/33 kV Sishugram	ICT-3	40	PRIORITY - 10	33.7	340.95
11	132/33 kV Sarusajai	All ICTs (1 to 3)	113	PRIORITY - 11	94.5	435.45
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15	400/220/132/33 kV Mirza	ICT-2	50	PRIORITY - 15	24.6	533.73
16	132/33 kV Chandrapur	All ICTs (1 to 2)	61.5	PRIORITY - 16	37.73	571.46

17	132/33 kV Kamakhya	ICT-1	40	PRIORITY - 17	28.18	599.64
18	132/33 kV Kamakhya	ICT-2	40	PRIORITY– 18	5.57	605.21
19	132/33 kV Sishugram	ICT-1	50	PRIORITY - 19	33.3	638.51
20	220/33 kV Jawharnagar	ICT-2	50	PRIORITY - 20	23.84	662.35
Maximum Load Observed in Guwahati:						**662.35 MW**

Table 5: *Priority of loads*

1.7 Locations where UFR will operate

System frequency has been taken as primary indicator of grid stability. In the event of a fall in frequency, primary defence mechanism like ADMS and secondary defence mechanism like AUFLS/UFR shall spring into action. Even after that when the grid frequency falls further then at frequency of **47.9 Hz** the Island shall be formed by operation of **Under Frequency Relays** installed at the strategic locations as below:

Sl. No.	Name of Sub-station	Elements to be opened	Name of the utility	UFR Location
1	400kV/220 kV Bongaigaon	1.Dia 416, 417 & 418 2. Dia 420 & 419 3. Dia 422 & 423 4. Dia 425, 427 & 426 5. Dia 413, 414 & 415 6. Dia 410, 411 & 412 7. Dia 407, 408 & 409 8. Dia 404, 405 & 406 9. Dia 401, 402 & 403	POWERGRID	Bongaigaon
2	BgTPP NTPC	400 kV Bongaigaon Line 2	NTPC	BgTPP
3	400/220 kV Azara	1. 400kV SILCHAR LINE MAIN BAY; 2. 400kV SILCHAR LINE TIE BAY	AEGCL	Azara
4	220kV BTPS	1. 220kV RANGIA LINE I; 2. 220kV RANGIA LINE II; 3. 220kV SALAKTI (PG) LINE I; 4. 220kV SALAKATI (PG) LINE II;	AEGCL	BTPS

Sl. No.	Name of Sub-station	Elements to be opened	Name of the utility	UFR Location
		5. 220/132kV, 160MVA ICT-I; 6. 220/132kV, 160MVA ICT-II 7. 220/132kV, SPARE ICT BAY		
5	220/132/33kV Sarusajai	1. 132kV UMTRU LINE I; 2. 132kV UMTRU LINE II	AEGCL	Sarusajai
6	132/33kV Kahilipara	1. 132kV UMTRU LINE I; 2. 132kV UMTRU LINE II	AEGCL	Kahilipara
7	220/132kV Agia	1. 220/132kV, 100MVA ICT-I; 2. 220/132kV, 160MVA ICT-II; 3. 220/132kV, 160MVA ICT-III	AEGCL	Agia
8	220/132kV Boko	1. 220/132kV, 100MVA ICT-I; 2. 220/132kV, 50MVA ICT-II	AEGCL	Boko
9	132/33kV Kamakhya	1. 132kV TRACTION LINE	AEGCL	Kamakhya
10	220/33kV Jawaharnagar	1. 220kV SAMAGURI LINE	AEGCL	Jawaharnagar
11	220/132/33kV Sonapur	1. 220kV SAMAGURI LINE; 2. 132kV BAGJHAP LINE I; 3. 132kV BAGJHAP LINE II	AEGCL	Sonapur
12	220/132 kV AMINGAON GIS	1. 132kV KAMALPUR LINE I; 2. 132kV KAMALPUR LINE II; 3. 132kV HAJO LINE; 4. 220/132kV, 160MVA ICT-I 5. 220/132kV, 160MVA ICT-II	AEGCL	AMINGAON GIS
13	132/33 kV Chandrapur	1. 132kV BAGJHAP LINE	AEGCL	Chandrapur
14	Karbi Langpi HEP	--	APGCL	Karbi Langpi HEP
Note: Few additional quantities are kept in BoQ to be used in case of any extra element to be added.				

***Table-6**: Elements to be opened for forming the Island*

1.8 Load and Generation Control Points in the island

After island has formed the load and generation of the island will be maintained in a balanced proportion by tripping the loads or generators to bring the frequency at equilibrium. The table mentioned below consist of details of loads and units for maintaining load – generation balance.

Sl. No.	Name of Station	Name of Elements where heavy-duty relay will be installed for LGBR.	Name of Utility
1	BgTPP NTPC	1. Unit-1 2. Unit-2 3. Unit-3 4. 400 kV Bongaigaon (PG) line-1	NTPC
2	400/220 kV Azara	1. 132/33kV, 50MVA ICT-I; 2. 132/33kV, 50MVA ICT-II	AEGCL
3	220/132/33 kV Sarusajai	1. 132/33kV, 31.5MVA ICT-I; 2. 132/33kV, 31.5MVA ICT-II; 3. 132/33kV, 50MVA ICT-III	AEGCL
4	132/33 kV Kahilipara	1. 132/33kV, 40MVA ICT-I; 2. 132/33kV, 40MVA ICT-II; 3. 132/33kV, 50MVA ICT-III 4. 132/33kV, 30MVA ICT-IV 5. 132/33kV, 31.5MVA ICT-V	AEGCL
5	132/33 kV Sisugram	1. 132/33kV, 50MVA ICT-I 2. 132/33kV, 40MVA ICT-II 3. 132/33kV, 50MVA ICT-III	AEGCL
6	132/33 kV Kamakhya	1. 132/33kV, 40MVA ICT-I 2. 132/33kV, 40MVA ICT-II	AEGCL
7	220/33 kV Jawaharnagar	1. 220/33kV, 50MVA ICT-I; 2. 220/33kV, 50MVA ICT-II	AEGCL
8	132/33 kV Narengi	1. 132/33kV, 50MVA ICT-I 2. 132/33kV, 50MVA ICT-II	AEGCL
9	132/33 kV Azara	1. 132/33kV, 40MVA ICT-I 2. 132/33kV, 40MVA ICT-II	AEGCL
10	220/132/33 kV Sonapur	1. 132/33kV, 25MVA ICT-I 2. 132/33kV, 25MVA ICT-II	AEGCL
11	132/33 kV AIIMS	1. 132/33kV, 25MVA ICT-I 2. 132/33kV, 25MVA ICT-II	AEGCL
12	220/132 kV AMINGAON GIS	1. 132/33kV, FUTURE ICT-I; 2. 132/33kV, FUTURE ICT-II	AEGCL
13	132/33 kV Chandrapur	1. 132/33kV, 31.5MVA ICT-I 2. 132/33kV, 30MVA ICT-II	AEGCL

Sl. No.	Name of Station	Name of Elements where heavy-duty relay will be installed for LGBR.	Name of Utility
14	132/33 kV Guwahati Medical College	1. 132/33kV, 50MVA ICT-I 2. 132/33kV, 50MVA ICT-II	AEGCL
15	132/33 kV Paltan Bazar	1. 132/33kV, 50MVA ICT-I 2. 132/33kV, 50MVA ICT-II	AEGCL
16	Karbi Langpi HEP	1. Unit-1 2. Unit-2 3. Myntriang SHEP	APGCL
17	132/33 Dispur	1. 132/11kV, 16MVA ICT-I 2. 132/11kV, 16MVA ICT-II	AEGCL
Note: Few additional quantities are kept in BoQ to be used in case of any extra element to be added.			

Table-7: Name of Elements where heavy-duty relay will be installed for LGBR

1.9 Transmission Network Pre and Post Island Formation

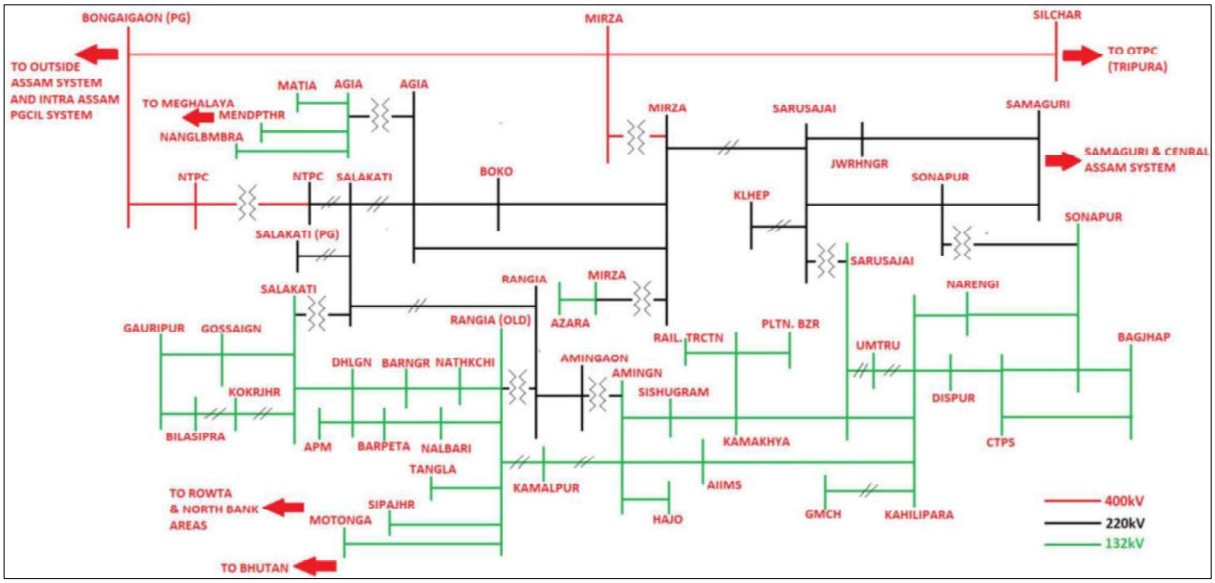

Figure 3*: Transmission network prior to Island formation*

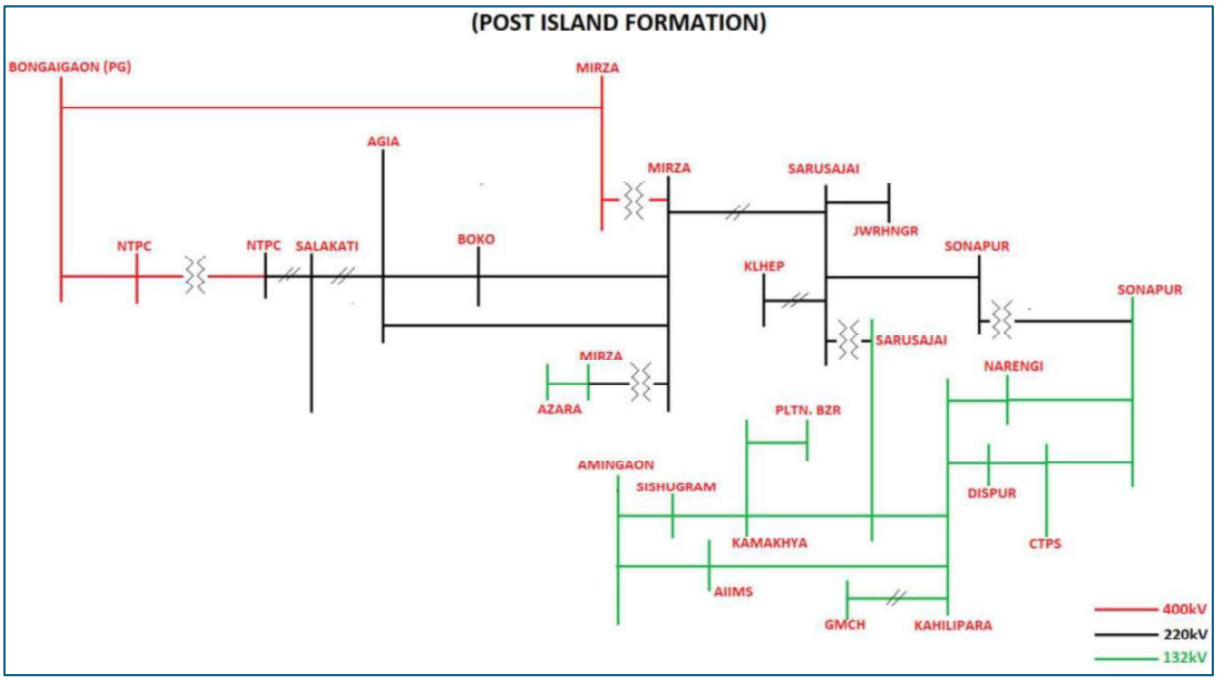

***Figure 4**: Transmission network after Island Formation*

1.10 Initiation of Island Formation (Stage-1):

In the stage -1, the Guwahati Island will be formed by tripping all the tie lines/ICTs connected to the Identified Guwahati Island. The Formation of Island will take place by implemented (Under Frequency Relay) UFR scheme, wherein the UFRs will pick up signal whenever frequency reaches 47.9 Hz.

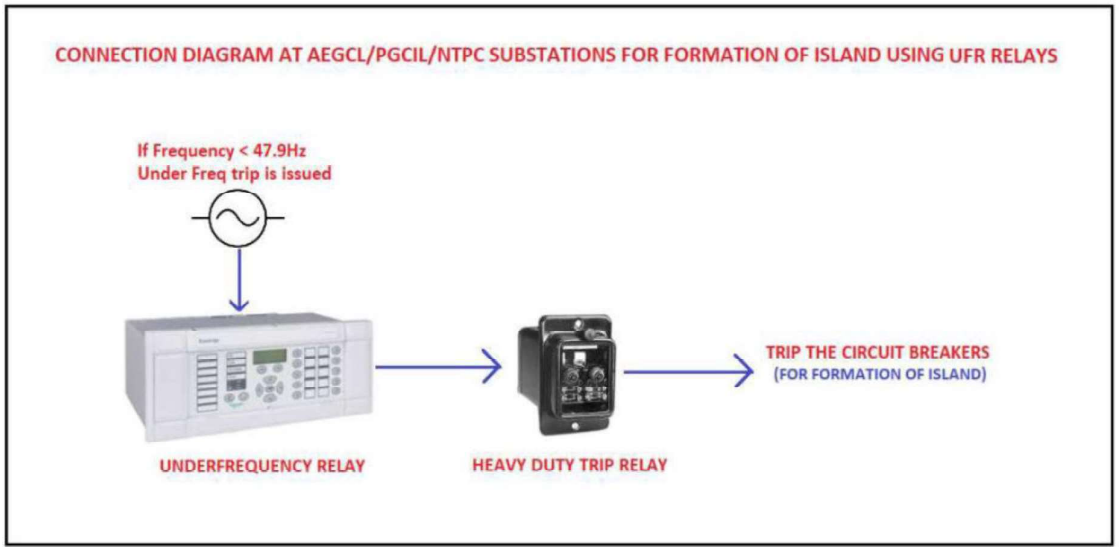

***Figure 5**: Connection diagram for station with two number of UFR is installed*

1.11 Logic of the Scheme for maintain Load generation balance in the Island (Stage-2):

Post Island formation, the monitoring and control software at SLDC/NERLDC will perform the following tasks:

a. Confirmation of Island formation
b. Maintaining Load – Generation Balance by disconnecting Load or Generation
c. Effective monitoring and control of the created Island

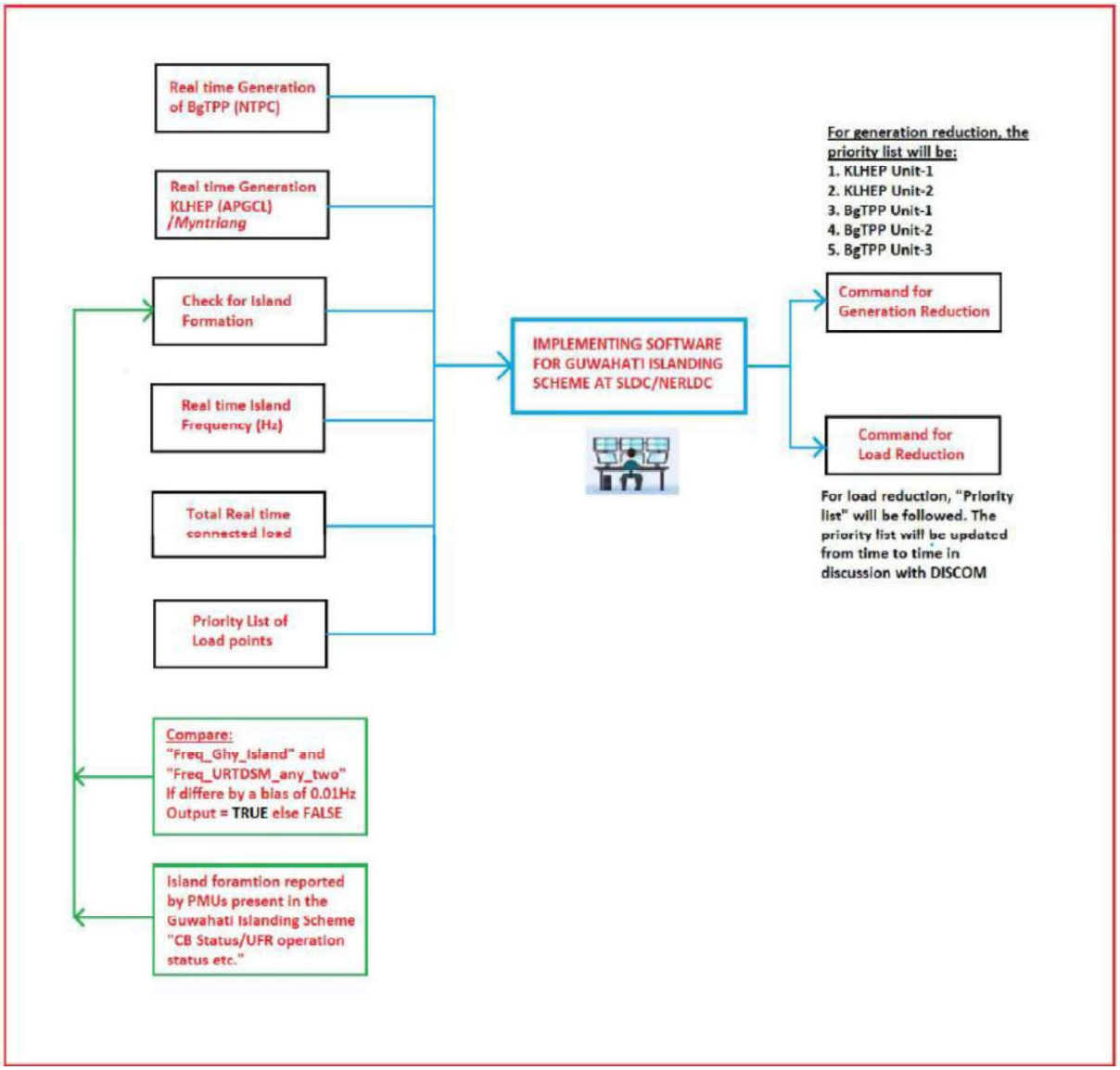

***Figure 6**: Brief of the software to be implemented for Guwahati Island*

Some of the possible Grid Conditions and action required are discussed below:

Assumptions/ Legend (Variables):

Total Generation BGTPP + KLHEP = G

Present Load = L

Possible cases that can occur in island are described below along with the logic:

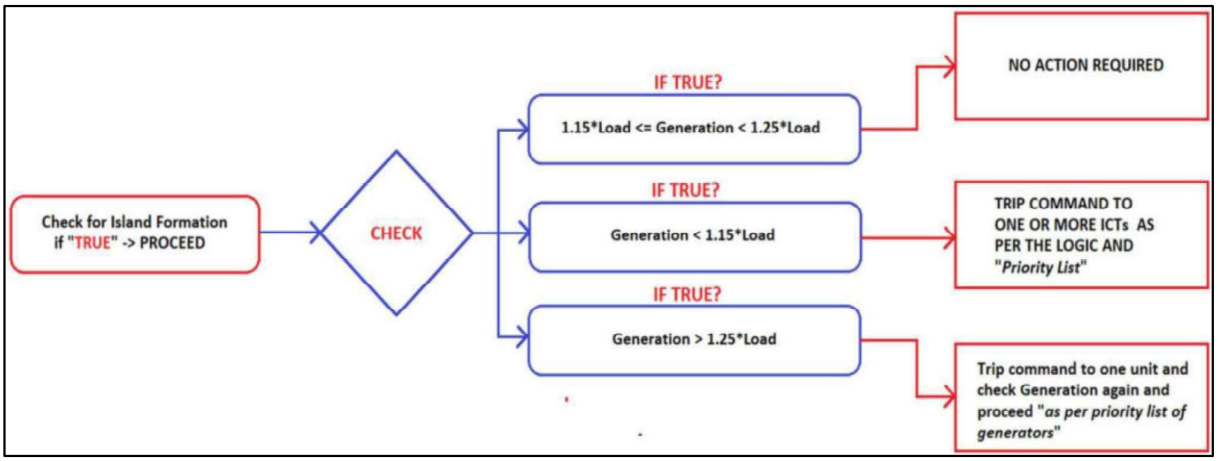

***Figure 7**: Logic of "Load – Generation balance post Island formation"*

1) Case-1: When Total Generation (G) is within prescribed range:

No action is required

Note: In practical scenario, the generation cannot be matched exactly to 1.2 times of load; therefore, for implementation of logic, a range of 1.15L to 1.25L has been considered.

2) Case-2: When Total Generation (G) is less than 1.15 times of the present Load (L):

Trip command to one of more ICTs to disconnect load at 33kV according to Priority/Merit order starting from the least priority

3) Case-3: When Total Generation (G) is more than 1.25 times of the present Load (L)

For optimum operation of generation and for lesser stress on Generators, the lowest unit Generation (KLHEP) may be considered at the starting point

The above load-generation balance will be maintained by the "Internal Logic Decision" by the implemented Software. Software would maintain a list of loads/ICTs and Generators which when disconnected would being the generation within the healthy range of 1.15*L < G < 1.25*L

1.12 Control data flow between SLDC/NERLDC and field end equipment:

Control data flow between SLDC/NERLDC and field end equipment is given below:

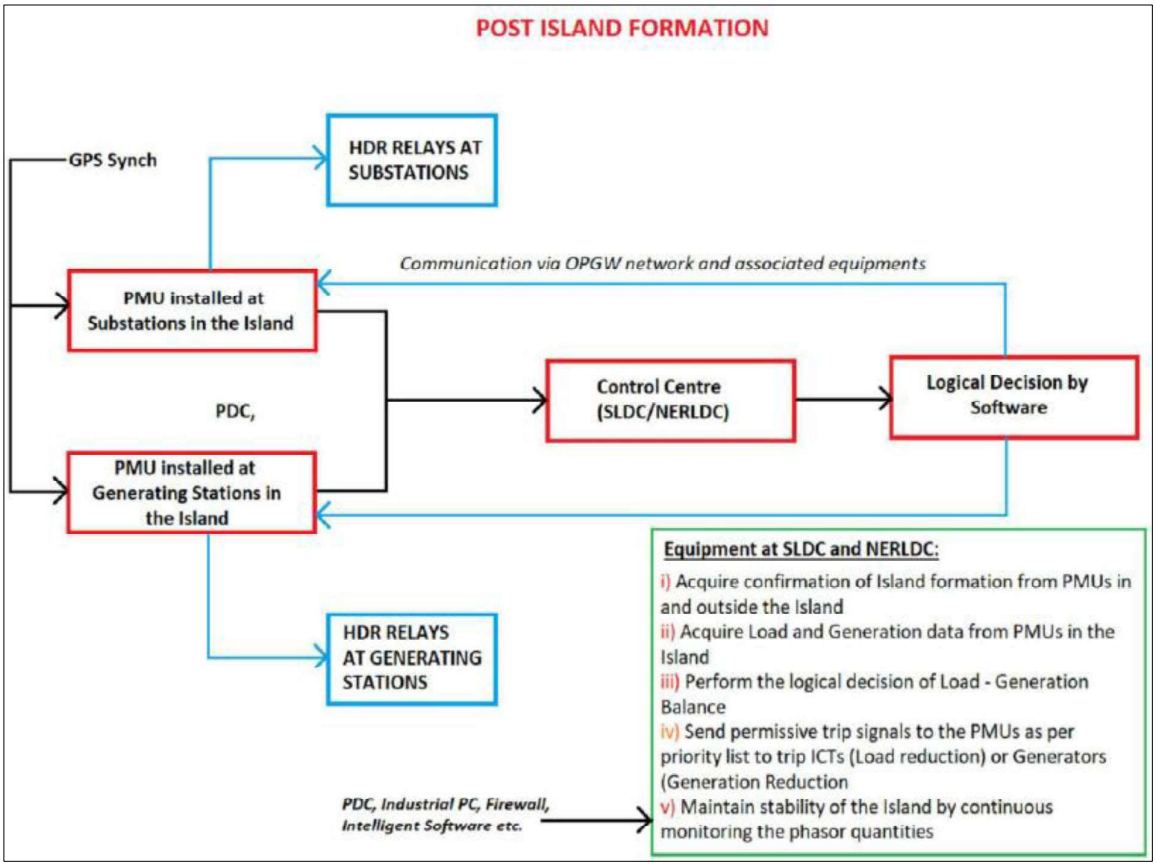

Figure 9: *Control Signal from SLDC/NERLDC to station*

2 Proposed System Architecture and Scope of Work

2.1 Architecture

As per the requirement of the Islanding & Load Shedding System, the following System Architecture is proposed:

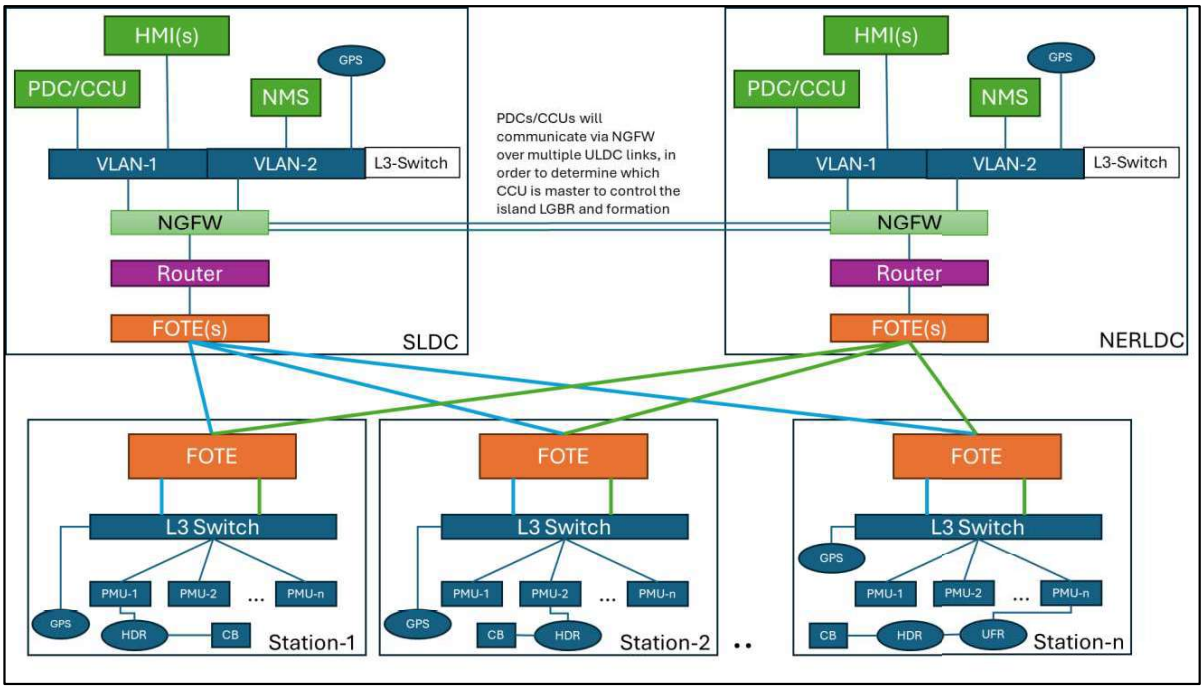

Figure 9: Architecture of Guwahati Island Scheme

As illustrated in the architecture diagram, an Islanding Central Control Unit (CCU)/Phasor Data Concentrator (PDC) along with the Workstation (HMI/EWS system) will be provided at the SLDC and NERLDC control centers. These central controllers will execute the islanding and load-shedding logics from the central level.

At the substations and generating stations participating in the scheme, dedicated Islanding Panels shall be installed. Each panel will house Phasor Measurement Units (PMUs), GNSS Receivers, and Industrial Grade Layer-3 Ethernet Switches. These devices will be interconnected locally and integrated with the wide-area system through Fiber Optical Terminal Equipment (FOTE) over the ULDC fiber optic backbone.

All PMUs installed at the substations will report their synchro-phasor data simultaneously to two PDCs/CCUs:

- One installed at SLDC.
- Another installed at NERLDC

This redundancy ensures high system reliability. The PDCs/CCUs will exchange data and control messages with each other through a secure channel via the Next Generation Firewalls (NGFWs) and Routers. These interconnections enable the two central controllers to coordinate and determine which CCU will act as the master controller at any given time, responsible for:

- Island formation,
- Load–generation balancing within the island,

- Issuing load shedding or generator tripping commands through the communication backbone.

The architecture ensures redundancy, cybersecurity, and real-time coordination across all levels of the system, from substations to the central control centres.

The PMUs will be exchanging the real time data of feeders (analog as well as digital) under monitoring with the PDC/CCU installed at the SLDC/NERLDC through IEEE C37.118 protocol, however PMUs shall also support IEC 61850 or Secure IEC 60870-5-104 protocols in order to receive the tripping command from PDC/CCU.

Using the data collected from the PMUs and combination of the advanced automation applications in PDC/CCU, the PDC/CCU shall send trigger bits/command through Secure IEC 60870-5-104 to the PMUs in the field for the operations of the feeders at the participating substations to achieve the desired generation and load shedding scheme.

Further, all necessary measures to ensure cyber security of Sub Station, Power Station as well as well as Control Centre equipment shall be taken. The PMU based scheme is proposed in view of fast response time of PMUs as well as its capability to implement logical functions.

The contractor shall arrange for conducting the cyber security audit of entire Islanding scheme system (free of cost) through CERT-In empanelled auditor before operational acceptance of the system. The contractor shall submit the signed report of the cyber security audit. Further the contractor shall ensure to close all the vulnerabilities (if any) found in the cyber security audit before initiation of guarantee period. The contractor shall ensure that Security and Testing of Cyber Assets of Islanding Scheme shall be carried out as per the Article 13 of CEA (Cyber Security in Power Sector) Guidelines, 2021.

All the software and hardware provided by the bidder for Guwahati Islanding Scheme shall be loaded with valid license with a validity until the expiration of AMC of Guwahati Islanding Scheme. In case of end-of-life support or expiration of license of any of the software/hardware, the bidder shall ensure upgradation of license/replacement of software or hardware free of cost so as to meet the functionalities of Guwahati Islanding Scheme.

2.2 Scope of Work

1. The Contractor shall supply, install, test, and commission all necessary hardware strictly in accordance with the technical specifications provided in this document. This shall include but not be limited to PMUs, PDC/CCU, GNSS &NaVIC receivers, Layer-3 switches, routers, Next Generation Firewalls, HDR panels, and all related accessories, cabling, and auxiliaries.

2. The Contractor shall supply, install, test, and commission all necessary software as per the specifications. The supplied software shall be fully licensed, updated, and capable of performing all functions required for successful implementation of the Guwahati Islanding Scheme.

3. The Contractor shall implement the islanding and load-shedding logic of the Guwahati Islanding Scheme as described in this specification, or as finalized during detailed engineering in consultation with the Owner.

4. The Contractor shall design and implement the Control Centre systems, integrating all supplied hardware and software into a unified and functional architecture.
5. The Contractor shall design and implement the complete system for both Control Centre and Remote Stations, ensuring seamless integration of field devices with the Control Centre over the ULDC/AEGCL fiber optic network.
6. The Contractor shall provide all drawings, documentation, and configuration records necessary for system implementation, operation, and future maintenance. This includes "As-Built" drawings, configuration manuals, and system inventory.
7. The contractor shall provide all the engineering files, configuration files, configuration manuals, etc. of various devices being deployed in the Guwahati Islanding Scheme. The same will be handed over to owner in view of future modifications.
8. The Contractor shall ensure that all works are executed in compliance with prevailing cyber security, communication, and grid operation standards (IEC, IEEE, CEA, and IEGC provisions, as applicable).
9. Training: Contractor shall provide the training to Manpower of AEGCL as described below in order to grasp the system functionality

Sl. No.	Description of Training	Number of Manday required	Number of Participants	Modules
1.	Control Centre Hardware and Software	7 days	15 (comprising of AEGCL – T&C wing, protection wing, communication wing, SLDC wing + PGCIL representative + NTPC representative (as NTPC and Bongaigaon PG are included in the scheme) + representative from NERLDC + representative from APGCL)	To be finalized by the OEM during project execution. The training should include both theoretical concepts and hands-on software-based programs, along with demonstration and troubleshooting features of the entire network architecture.
2.	Substation Hardware and Software	7 days	15 (comprising of AEGCL – T&C wing, protection wing, communication wing, SLDC wing + PGCIL representative + NTPC representative (as NTPC and Bongaigaon PG are included in the scheme) + representative from NERLDC + representative from APGCL)	To be finalized by the OEM during project execution. The training should include both theoretical concepts and hands-on software-based programs, along with demonstration and troubleshooting features of the entire network architecture.

3 Technical Specifications of various components utilized in Islanding Scheme

3.1 Phasor Measurement Unit

Substations and generating stations are generally equipped with Current Transformers (CTs) for each bay in the switchyard, along with Capacitive Voltage Transformers/Potential Transformers (CVTs/PTs) provided in each transmission line bay and on each bus. Typically, CTs are designed with one metering core and four protection cores, while CVTs are provided with three cores for metering and protection purposes.

The Phasor Measurement Units (PMUs) offered shall be connected to the available CT and CVT cores, and they shall be suitable for measurement from both metering and protection cores. The specific cores to be utilized for PMU connections shall be finalized during the detailed engineering stage.

The Phasor Measurement Units (PMUs) to be supplied under this specification shall be installed at designated Substations and Power Stations. Each PMU shall communicate with the Phasor Data Concentrator (PDC), which is to be supplied by the bidder and installed at the SLDC/NERLDC, in compliance with the IEEE C37.118.1-2011, IEEE C37.118.2-2011, IEEE C37.118.1a-2014, or IEC/IEEE 60255-118-1:2018 standards (including all subsequent amendments). Preference shall be given to PMUs conforming to IEC/IEEE 60255-118-1:2018.

The supplied PMUs shall be mounted within the panels provided by the bidder. All associated hardware, including panels, accessories, and cabling required for proper installation and operation, shall also be provided by the bidder.

The PMUs shall be compatible with secure IEC 60870-5-104 and IEC 61850 communication protocols. The CCU/PDC shall be capable of issuing islanding commands to the PMUs using IEC 61850 R-GOOSE or secure IEC 60870-5-104, and shall also report the required data points to the SLDC/NERLDC SCADA over secure IEC 60870-5-104. The successful demonstration of this functionality shall be carried out by the bidder during Factory Acceptance Testing (FAT) and Site Acceptance Testing (SAT).

The PMUs shall be designed for continuous operation in utility-grade environments and shall comply with the standards, protocols, and performance criteria specified herein.

3.1.1 General Requirements

The offered PMUs shall be supplied as complete systems suitable for installation at substations or power plants. They shall be capable of seamless communication with the CCU/PDC located at the SLDC/NERLDC. All required cables, connectors, and installation hardware shall be provided by the bidder. As a general practice, the PMUs shall be installed near the control and relay panels, with CT/PT and CVT connections extended from these panels.

3.1.2 Communication Interfaces

For integration with the PDC/CCU, each PMU shall be equipped with at least two (02) Ethernet port of 10/100 Base-Tx and two (02) optical fibre port of 100 Mbps. The optical ports should support both single mode and multiple modes. These ports shall support

streaming of data in UDP/IP multicast or unicast and TCP/IP modes in compliance with IEEE C37.118. The Ethernet port shall allow direct connection to the substation communication equipment, and the PMU shall also be capable of reporting data over TCP/IP also.

3.1.3 Data Reporting Capability

The PMU shall be capable of synchro-phasor reporting to a minimum of four (04) clients over TCP and at least four (04) clients over UDP in multicast or unicast mode. The device shall be capable of transmitting data both in multicast and unicast configurations as required by the system operator. The PMU must primarily report data via its proprietary protocol along with the other protocols mentioned in the document.

3.1.4 Power Supply

The PMUs shall be suitable for operation on unearthed DC supplies of 220 V, 110 V, or 48 V with an operating tolerance of +10% and –15%. In addition, the PMUs shall also be capable of operating on an AC auxiliary supply of 230 V, 50 Hz (±10%). The bidder shall ensure that the supplied units can operate reliably with any of the available supply voltages at the substation.

3.1.5 Reporting Rate

The PMUs shall support user-selectable synchro-phasor reporting rates of 50 frames per second, or higher, for a 50 Hz system. PMUs with higher reporting rates shall be given preference. All hardware and software supplied shall be adequately sized to support the maximum reporting rate offered by the device.

3.1.6 Protocol Support

The PMUs shall support multiple protocols to ensure interoperability with CCU and SCADA systems. These shall include:

- Routable GOOSE (R-GOOSE) and IEC 61850-90-5,
- IEEE C37.118.2-2011 (Communication), IEEE C37.118.1-2011 with Amendment IEEE C37.118.1a-2014 (Measurement), or IEC/IEEE 60255-118-1:2018 (preferred),
- IEC 61850 Editions 1 and 2,
- IEC 60870-5-104 Client and Server protocols with secure implementation in compliance with IEC 62351-5 and IEC 62351-3 to ensure authentication, encryption, and integrity of communications.
- IEEE 1588 PTP or SNTP/NTP or IRIG-B for precise time synchronization.

3.1.7 Measurement Capabilities

Each PMU shall be capable of measuring and reporting three (03)-phase voltage phasors (magnitude and angle), three (03)-phase current phasors (magnitude and angle), positive sequence voltage and current (magnitude and angle), breaker status, main protection status, frequency, rate of change of frequency (ROCOF), and analog quantities such as MW and MVAr. Measurement coverage shall be provided for a minimum of three (03) bays per PMU as specified in the Bill of Quantities.

3.1.8 Time Synchronization

The PMU shall be supplied with a GNSS &NaVIC receiver for accurate time synchronization. The internal PMU clock shall be synchronized with the GNSS &NaVIC clock and revert to an internal oscillator with stability of at least 1 ppm upon loss of GNSS &NaVIC signal. The PMU shall generate an alarm in the event of GNSS signal loss, and the alarm shall be transmitted to the PDC. The PMU shall maintain TVE, frequency error, and ROCOF within the limits specified in IEEE C37.118 and its amendments. The PMU shall also time synchronise with control centre's clock over NTP for time synchronization, in case of failure of GNSS &NaVIC.

3.1.9 Protection and Monitoring Functions

The PMU shall include continuous self-monitoring and diagnostic features capable of detecting and reporting internal faults or abnormal conditions. All alarms shall be displayed locally and reported to the PDC, with status indications provided on the PMU front panel.

3.1.10 Configuration and display

The PMU shall support Configuration Frames 2 and 3. A local display, embedded in PMU, shall be provided to display measured voltages, currents, frequency, active, reactive, and apparent power, power factor, primary and secondary phasors, positive, negative, and zero-sequence values, and breaker and protection status. Remote configuration via PDC/CCU over the same communication channel used for reporting shall be supported.
Alternatively portable configuration device for configuring the PMUs can be provided. Testing & configuration accessories such as test switches, connectors, hardware and software shall be also supplied.

3.1.11 Cybersecurity and NMS compatibility

The PMU shall incorporate robust cybersecurity features. Access shall be role-based and password-protected, with logs maintained for all access attempts. Configuration changes shall require authorized access, and all such changes shall be logged and reported to the PDC/CCU. The PMU shall be protected from external threats including malware and spam. Compliance with IEC 62351 or equivalent cybersecurity standards shall be ensured, and secure firmware upgrades shall be supported.
The PMUs shall support network monitoring by the NMS for device availability and health supervision. The PMU shall expose parameters such as device status, communication port status, CPU and memory utilization, and internal alarms via standard protocols including ICMP, SNMP, and Syslog. This information shall be used exclusively for device monitoring in the NMS.

3.1.12 Data Streaming

The PMU shall support multiple independent data streams. Each stream shall be individually configurable with respect to contents, reporting rate, class of service (P or M), communication mode (TCP/UDP), and destination IDCODE.

3.1.13 Performance Classes

The PMUs shall meet the requirements of both P-Class and M-Class performance as specified in IEEE C37.118.1-2011, IEEE C37.118.1a-2014, or IEC/IEEE 60255-118-1:2018. The reporting class shall be user-selectable. Certified test reports demonstrating compliance with both classes shall be submitted by the bidder.

3.1.14 Accuracy and Frequency Range

The PMUs shall measure electrical parameters with specified accuracy in the frequency range of 48 Hz to 52 Hz, in accordance with IEEE C37.118.1 standards. Data shall remain available outside this band, and the PMU shall ensure that the effect of frequency deviations on measurement accuracy remains within the permissible limits of the applicable standards.

3.1.15 Environmental and Reliability Requirements

The PMU shall be suitable for continuous operation in utility environments with an ambient temperature range of –10 °C to +60 °C and relative humidity up to 95% non-condensing. The design shall comply with IEC 60068 standards for temperature, humidity, and vibration testing, as well as IEC 61000 for EMC/EMI compliance. The PMU shall withstand seismic conditions in line with IEEE 693 or equivalent. The design shall target a minimum MTBF of 100,000 hours, and hot-swappable modules or redundant designs shall be preferred.

3.1.16 Redundancy and Latency

The PMU shall support redundant communication paths over Ethernet and fiber. Dual redundant AC/DC power supply inputs shall be provided. End-to-end latency shall not exceed 20 ms for P-Class operation at 50 fps, in compliance with IEEE C37.118.

3.1.17 Interoperability and Testing

The PMUs shall be interoperable with PDCs and SCADA systems of multiple vendors. The bidder shall demonstrate interoperability and compliance with all functional requirements during Factory Acceptance Tests (FAT) and Site Acceptance Tests (SAT). All features specified in this document shall be successfully validated during FAT and SAT.

3.1.18 Documentation

The bidder shall provide comprehensive documentation to establish compliance with IEEE and IEC standards. This shall include details of supported performance classes, measurement functions, certified test results, equipment settings used in testing, and environmental conditions during testing.

3.2 Phasor Data Concentrator (PDC)/ Central Control Unit (CCU)

The delivered system shall provide both the core Phasor Data Concentrator (PDC) functions and the additional Central Control Unit (CCU) features in one integrated package. The PDCs shall be designed to ensure continuous and uninterrupted availability of synchro-phasor data to all users and applications. They shall serve as the backbone for wide-area monitoring of the power system and shall be engineered with due consideration for the reliability, redundancy, and performance requirements of such critical applications. The supplied CCU shall support secure IEC 60870-5-104 as well as IEC 61850 GOOSE and Routable GOOSE

(R-GOOSE) protocols for exchanging control and operational data with PMUs installed in the field, thereby enabling system protection and control functionalities. The system shall also include all required software tools for graphical display, real-time monitoring, report generation, alarm management, and secure storage of synchro-phasor data for offline analysis and post-event diagnostics.

3.2.1 Characteristics of the PDC/CCU

a. The PDC/CCU shall always maintain up-to-date configuration information for all input and output streams. It shall automatically request updated configuration files from PMUs or other PDCs whenever it has been offline for more than one minute, in accordance with IEEE C37.118. PMUs shall indicate in their data frames if their configuration has changed, enabling the PDC to request the new configuration file. The same mechanism shall apply when a PDC is receiving synchro-phasor data from another PDC.
b. The PDC/CCU shall be capable of retrieving the data stream configuration from a PMU or another PDC after an interruption and restoration of incoming data streams. It shall also forward the corresponding updated configuration information to its output destinations.
c. The PDC/CCU shall have the capability to request a device capability file (list of all available signals) from PMUs or PDCs, combine them, and transmit the consolidated list to its output destinations, in accordance with IEEE C37.118.
d. The PDC/CCU shall perform comprehensive sanity checks on received configurations, including verification of CRC, expected vs. received byte counts, and other consistency checks.
e. The PDC/CCU shall detect configuration changes by comparing newly received configuration files with previously stored versions. Upon detecting a change, it shall take action based on user-defined rules to reconfigure its outputs and communicate changes to all affected destinations and applications. In addition, the system shall support secure remote configuration of PMUs or other PDCs from the PDC, with proper authorization and authentication.
f. The PDC/CCU shall comply with the latest revision of IEEE C37.244-2013.
g. The PDC/CCU shall provide a user-friendly graphical user interface (GUI) for configuration, system monitoring, and administration.
h. The PDC/CCU shall include extensive diagnostic features for detecting data format errors, data quality issues, and communication failures, including verification of received configurations, CRC checksum errors, and byte count mismatches.
i. The PDC/CCU shall support auto-configuration of input streams, automatic adaptation to input changes, and automatic reconnection in case of connection losses.
j. The PDC/CCU shall support configurable data sampling rates from 1 to 100 samples per second.
k. The application processing latency of the PDC/CCU shall not exceed 2 ms for up to 100 PMUs and 5 ms for up to 500 PMUs.
l. The PDC/CCU shall support highly configurable data output streams, allowing independent configuration of data format, reporting rate, PMU/channel names, wait times, and other parameters for each output stream.

m. The PDC/CCU shall support secure IEC 60870-5-104 protocol for data distribution to SCADA/EMS systems.
n. The PDC/CCU shall support redundant power supply inputs (DC and/or AC) and redundant communication interfaces to ensure uninterrupted operation in case of hardware or link failures.
o. The PDC/CCU shall support secure role-based access control, with authentication and audit trails for all configuration changes, in compliance with IEC 62351 cybersecurity standards.
p. The PDC/CCU shall provide health monitoring of hardware and software components, with automatic generation of alarms in case of abnormal conditions such as high CPU utilization, memory faults, or disk failures.
q. The PDC/CCU shall support automatic backup of configuration files and logs, with restoration capability in case of hardware or software failures.
r. The PDC/CCU shall support seamless failover between Main and Backup PDC/CCU sites to ensure continuity of service in the event of disaster recovery operations or major downtime of main PDC/CCU.
s. The PDC/CCU shall support time synchronization with GNSS/IRIG-B/PTP and ensure all processed and archived data is time-stamped accurately to Indian Standard Time (IST).
t. The PDC/CCU shall support phasor data scaling, conversions, and ID code changes.
u. The PDC/CCU shall support archiving of data in relational databases and COMTRADE file formats.
v. The PDC/CCU shall support the formation of logic schemes required for successful implementation of islanding schemes.
w. The PDC/CCU shall be capable of generating islanding and load shedding commands to PMUs or field devices through IEC 60870-5-104 protocol.
x. The PDC/CCU shall be capable of issuing islanding commands to PMUs over the same communication channel used for data reception.
y. It shall be possible to modify the islanding logic in the PDC/CCU during the Defect Liability Period (DLP) and Annual Maintenance Contract (AMC) period. The arrangement for making such modifications shall be within the scope of the bidder

3.2.2 Functions of the PDC/CCU

Data Acquisition

a. The PDC/CCU shall collect and aggregate synchro-phasor data received directly from PMUs located at various substations and generating stations in full compliance with IEEE C37.118 standards, at user-selectable phasor data reporting rates.
b. The PDC/CCU shall conform to IEEE C37.118 streaming protocol standards for both input phasor data streams and the combined output stream.
c. The phasor data set shall include, at a minimum, three-phase voltage phasors, three-phase current phasors, eight (08) digital inputs, positive sequence voltage and current,

active and reactive power (MW and MVAr), frequency, and rate of change of frequency (ROCOF) from each monitored feeder and generator.

d. Where active and reactive power values are not measured directly by PMUs, the PDC/CCU shall calculate these parameters internally.

Data Exchange with Other PDCs

a. The PDC/CCU shall be capable of receiving real-time synchro-phasor data streams from PMUs and from other PDCs. It shall support parsing, interpreting, and forwarding of synchro-phasor data in full compliance with IEEE C37.118 protocol.
b. The PDC/CCU shall be able to re-transmit aggregated synchro-phasor data to higher-level PDCs, ensuring scalability of the Wide Area Measurement System (WAMS).
c. The PDC/CCU shall support bi-directional data exchange between any pair of PDCs.

Data Exchange with SCADA/EMS Systems

a. The PDC/CCU shall support seamless data exchange with SLDC/NERLDC SCADA/EMS systems at the Control Centres using either IEC 60870-5-104 or ICCP protocols.

3.2.3 Communication Protocols supported by PDC/CCU

The PDC/CCU shall support both UDP and TCP operating modes for communicating with PMUs and peer CCUs/PDCs. It shall be configurable to use either TCP or UDP for messaging and data exchange with each PMU or PDC/CCU, depending on system requirements.

IEEE C37.118 Protocol

a. The PDC/CCU shall, at a minimum, fully support IEEE C37.118.2-2011 standard communication protocol between PDC/CCU and PMUs for synchro-phasor data reception and messaging.
b. The PDC/CCU shall fully support IEEE C37.118.2-2011 protocol for PDC/CCU-to-PDC/CCU data reception and messaging.
c. The PDC/CCU shall also support extended messaging communication protocols based on IEEE C37.118.2-2011 to enable additional PDC/CCU-to-PDC/CCU messaging functions.
d. For measurement compliance, the system shall support IEEE C37.118.1-2011 with Amendment IEEE C37.118.1a-2014 or IEC/IEEE 60255-118-1:2018, the latter being the preferred standard.

Secure IEC 60870-5-104 Protocol

a. The PDC/CCU shall support IEC 60870-5-104 Client and Server protocols to collect data from slave devices and report data to higher-level hosts or SCADA/EMS systems.

b. IEC 60870-5-104 implementation shall comply with IEC 62351-5 and IEC 62351-3 to ensure authentication, encryption, and integrity of communications (“Secure 104”).

IEC61850Protocol

a. The PDC/CCU shall support IEC 61850 Server functionality, including GOOSE and Routable GOOSE (R-GOOSE) communication, with support for both Edition 1 and Edition 2.
b. The PDC/CCU shall support IEC 61850 Client functionality, also covering both Edition 1 and Edition 2.
c. The PDC/CCU shall support IEC 61850-90-5 for synchro-phasor data transfer over wide-area networks.

IP Multicast Support

a. The PDC/CCU shall be capable of supporting IP multicast when using UDP/IP for synchro-phasor data streaming. It shall support receiving UDP/IP multicast input data from multiple PMUs or PDCs, and transmitting output data as UDP/IP multicast and/or TCP/IP unicast streams. The destination multicast IP address shall be user configurable.

Time Synchronization Messaging

a. The PDC/CCU shall support IEEE 1588 Precision Time Protocol (PTP) and IRIG-B for time synchronization and accurate time-stamped data delivery.

Redundancy and Failover

a. The PDC/CCU shall provide dual redundant communication interfaces (Ethernet and/or fibre) with automatic failover to ensure continuity of data streams without packet loss.

Configuration Characteristics

a. The PDC/CCU shall provide administrative tools for system configuration and management. These shall include, but not be limited to:

    i. Connection management of PMUs.
    ii. Configuration of data output streams.
    iii. User profile and access management.
    iv. Alarm threshold configuration.

3.2.4 PLC Logic

The PDC/CCU shall support IEC 61131-1 compliant logic features, enabling the development of custom logics for automation, protection, and control functions at the control centre. The logic environment shall support all five programming languages defined in IEC 61131-3, namely:

a. Sequential Function Chart (SFC)
b. Function Block Diagram (FBD)
c. Ladder Diagram (LD)
d. Structured Text (ST)
e. Instruction List (IL)

The PDC/CCU shall provide powerful tools for online debugging, simulation, and validation of IEC 61131-3 applications within the system itself. It shall also be possible to define and manage a list of variables, including data-type variables, arrays, and structured data types, for use in logic applications.

The IEC 61131-3 logic functionality shall be used to develop and execute custom control centre applications, including islanding schemes, generator tripping, and load shedding logics, to maintain grid stability and balance system frequency under abnormal operating conditions. The outputs of these logics shall be linked with the command execution functions of the PDC/CCU, enabling the system to issue islanding and load shedding commands to PMUs and field devices through IEC 60870-5-104 and/or IEC 61850 R-GOOSE protocols.

3.2.5 Redundant Data Handling

The PDC/CCU shall be capable of handling redundant data streams provided by alternate devices, either in aggregated or time-aligned PMU outputs. The system shall allow the operator to designate a preferred source for data to be included in an output stream and configure one or more alternate sources to be used if the preferred data fails to arrive. Whenever an alternate data source is used, the PDC/CCU shall clearly indicate this condition in the output stream.

3.2.6 Duplicate Data Handling

The PDC/CCU shall be capable of identifying and managing duplicate data received via alternate communication paths or through both aggregated and time-aligned streams. The system shall use the data that arrives first within the defined waiting period and discard any duplicates received later. The PDC/CCU shall also be capable of validating received data, selecting only error-free inputs for use, and discarding all data streams containing errors.

3.2.7 Performance Monitoring by PDC

The PDC/CCU shall continuously monitor the performance of synchro-phasor data and the overall measurement system. It shall detect errors originating from PMUs, communication networks, or internal PDC functions, and provide both real-time visibility and historical records. Performance monitoring by the PDC shall include, but not be limited to, the following features:

a. **Real-time and historical monitoring –** The PDC shall provide real-time status of its operation, including the state of each input and output stream and recent operating history. It shall also maintain historical records for post-event analysis and assessment.
b. **Source errors (PMU/PDC input side)** – The PDC shall detect and log errors reported by data sources, such as loss of time synchronization, PMU computation errors, invalid data, or data misalignment with local time. Additional source-reported error categories, if available, shall also be captured.
c. **Communication errors** – The PDC shall detect and log network-related issues, including lost TCP connections, buffer overflows, and other communication faults identifiable by the receiving PDC.
d. **Internal PDC errors** – The PDC shall detect and record internal failures, such as system resets, program execution errors, or memory overflows. All such events shall be recorded with precise timestamps.
e. **Overflow protection –** The PDC shall incorporate overflow blocking mechanisms to prevent repeated or recurring errors from filling system buffers or degrading performance.
f. **System events** – The PDC shall monitor and log operational events that are not direct errors but impact the system, including loss and restart of the PDC, power interruptions, and configuration changes.
g. **Data completeness and statistics –** The PDC shall record the number of measurements received versus expected, packet errors, missing data, and related statistics (e.g., minimum, maximum, average, and standard deviation over user-defined periods) to evaluate the overall health of the measurement system.
h. **Alarm generation –** The PDC shall automatically generate alarms when errors, abnormal events, or performance deviations are detected. These alarms shall be displayed locally on the PDC HMI and also reported to the CCU/SCADA operator interface for immediate operator awareness and corrective action.

3.2.8 Performance of Data Validation by PDC

The PDC/CCU shall perform comprehensive data validation and checking on all incoming synchro-phasor data streams. Validation shall not be limited to basic checks, but shall also include advanced sanity checks to identify abnormal or corrupted values. In line with cybersecurity standards, data validation shall be regarded as the first activity toward fulfilling system security and data integrity requirements.

a. The PDC shall perform quality checks on all received phasor data and shall insert the appropriate quality flags or codes into the correlated data stream. These quality codes shall indicate the presence of one or more conditions affecting the validity of a data value.
b. All quality codes applicable to a data value shall be retained and stored in the database along with the corresponding measurement.
c. For data acquired from PMUs, the PDC shall be capable of receiving, interpreting, and maintaining the time quality and message quality codes in accordance with IEEE C37.118 standards.
d. The PDC shall generate operator alarms whenever the proportion of invalid or poor-quality data from a PMU exceeds a configurable threshold or persists for a user-defined duration.

3.2.9 PDC Scalability

The delivered PDC/CCUs shall be fully equipped and activated with the necessary hardware and software to integrate PMUs as per the sizing requirements specified in the Detailed Requirement Schedule (DRS). No additional licensing or hardware shall be required for the declared base capacity.

a. The PDCs shall support an expansion capability of at least 50% beyond the current sizing requirements, to accommodate future PMUs without replacement of the core system.
b. The spare capacity shall be usable for the integration of PMUs from different manufacturers, provided they conform to IEEE C37.118 standards, with the PDC supporting all necessary protocol emulations.
c. The PDC design shall support horizontal scalability, allowing interconnection with additional PDCs to further extend system capacity in future deployments.
d. The PDC shall support firmware and software upgrades to accommodate evolving standards, including IEC/IEEE 60255-118-1, without requiring replacement of major hardware.

3.2.10 Visualization and Report Generation

The PDC/CCU shall be equipped with advanced applications for data analytics, visualization, and report generation to support real-time monitoring, post-event analysis, and operational decision-making. The visualization and reporting system shall include the following features:

a. **Graphical Displays** – The system shall provide a wide range of graphical visualization tools, including geo-spatial maps, bar charts, bar gauges, histograms, statistical summaries, time series charts, tabular views, annotation lists, and schematic diagrams.
b. **Time-Series Database –** The system shall include an integrated time-series database capable of storing synchro-phasor data at the full input frame rate or at user-defined down-sampled rates. The database shall maintain a continuous rolling archive, automatically overwriting the oldest data when the archive becomes full.

c. **Data Retrieval and Analysis –** The system shall provide robust data retrieval and processing capabilities for post-event and disturbance analysis, trend evaluation, statistical reporting, and compliance verification.
d. **Secure Web Dashboards –** Visualization dashboards shall be accessible through a secure, role-based web interface, allowing multiple authorized users to access real-time and historical data concurrently.
e. **Alarm and Event Overlay –** The system shall support overlaying alarms, events, and performance statistics (as defined in Clause 2.2.8) directly on graphical displays, enabling operators to correlate disturbances, system anomalies, and operational events with synchro-phasor measurements in real time.
f. **Report Generation –** The system shall provide automated and user-driven report generation facilities, with customizable templates to suit operational, analytical, and regulatory requirements. Reports shall be exportable in commonly used formats such as CSV, Excel, and PDF.
g. **Customizable Views –** Users shall be able to create, save, and recall personalized dashboards and reports, including selection of data points, time ranges, sample rate of data (varying from 1 sample/seconds to 25/50 samples/seconds depending upon the reporting rate of PMUs) and visualization types.

3.2.11 Design and Sizing Parameters for CCU

The PDC/CCU shall be supplied with adequate hardware and software capacity to support the present and future requirements of synchro-phasor data acquisition and processing. The following minimum design and sizing parameters shall apply:

a. The PDC/CCU shall support a minimum of 65,000 data points, covering phasors, frequency, ROCOF, analog values, and digital statuses.
b. The system shall be configurable to integrate up to 100 PMUs reporting at 50 frames per second (fps) or 50 PMUs reporting at 100 fps using IEEE C37.118 protocol.
c. The PDC/CCU shall support at least four synchro-phasor data outputs, each configurable up to 120 fps using IEEE C37.118 protocol, for onward reporting to other PDC/CCU systems.
d. The hardware shall be provisioned with redundant and hot-swappable components, including dual power supplies, redundant CPUs, RAID-based storage, and dual network interfaces, to ensure continuous operation without single points of failure.
e. The PDC/CCU shall support a minimum of 65,000 data points under base configuration, with provision for at least 50% spare capacity, i.e., scalability up to 97,500 data points, for future expansion without requiring major hardware replacement. The system shall also support horizontal scalability by interconnecting multiple PDC/CCU units for larger deployments. The bidder shall provide detailed computer architecture of the proposed PDC/CCU hardware and software, clearly demonstrating how the system design supports the required scalability (e.g., processor capacity, memory expansion, modular storage, virtualization, or clustering). The design shall allow seamless integration of PMUs from different

vendors conforming to IEEE C37.118, with support for necessary protocol emulations.

f. The PDC/CCU shall support firmware and software upgrades to accommodate evolving standards, including IEC/IEEE 60255-118-1, without requiring major hardware replacement.

3.2.12 Performance Requirements for PDCs

PDC Latency Requirement

The latency of the PDC shall be determined by the data aggregation mode and the output processing time of the device. In time alignment modes, the latency shall be the sum of the user-defined wait time and the output processing time. For **absolute time alignment**, the wait time shall be sufficiently long to accommodate delays introduced by PMUs and communication networks. For **relative time alignment**, the wait time may be shorter, as it only accounts for differences in delays from multiple data sources. In both cases, the PDC latency shall be measured from the receipt of the first data sample until the complete output package is transmitted.

PDC Processing Time

The processing time of the PDC shall be defined as the interval between the receipt of all required data (or expiry of the wait time) and the transmission of the processed output data stream. The maximum processing time per PDC shall be less than **5 milliseconds**, while the average processing time shall not exceed **2 milliseconds** under all conditions when operating in single-input forwarding mode or in relative time alignment mode with zero wait time.

The PDC latency at each Control Center, under the above operating conditions, shall not exceed **2 milliseconds** per output stream, excluding PMU measurement latency (as specified in IEEE C37.118), communication network latency, network element latency (routers/switches), and PDC wait time. For PDCs configured with more than one output stream, the latency requirement for each output stream shall not exceed **5 milliseconds**.

3.2.13 Cybersecurity Requirements

The PDC/CCU shall comply with recognized national and international cybersecurity standards, including **CERT-In, and NCIIPC guidelines**. At a minimum, the system shall incorporate the following security features:

a. **OS and Platform Hardening**

- PDC/CCU servers (Linux or Windows) shall be hardened in accordance with the latest CERT-In, NCIIPC, and other standard recommendations.

- Only essential services and ports shall be enabled; unnecessary services must be disabled.
- For Windows-based systems, antivirus/anti-malware protection and host-based firewalls shall be provided; for Linux-based systems, equivalent hardened configurations shall be implemented.

b. **Secure Protocols and Standards**

- All communication protocols (IEEE C37.118, IEC 60870-5-104, IEC 61850, ICCP, DNP3) shall implement the relevant security extensions as per IEC 62351 for authentication, encryption, and integrity.
- Web dashboards and configuration interfaces shall use HTTPS/TLS with strong ciphers.

c. **User Access Control**

- Role-based access control (RBAC) shall be implemented **locally** within the PDC/CCU without dependency on external Active Directory (AD) or LDAP services.
- The system shall support multiple user levels (Administrator, Operator, Viewer) with unique local credentials.
- All user actions shall be logged with username, timestamp, and activity details.
- Compatibility with external AD/LDAP services shall be supported for future integration, but shall not be a prerequisite for system operation.
- Strong password enforcement and automatic session logging shall be mandatory.

d. **Logging and Monitoring**

- All security-related events (login attempts, configuration changes, service restarts, etc.) shall be logged with precise timestamps.
- Logs shall be exportable in standard formats (Syslog, CEF, JSON) for integration with external monitoring platforms such as SIEM/SOC or NMS.
- The PDC shall generate alarms in case of unauthorized access attempts or other abnormal security events.

e. **Patch and Update Management**

- The vendor shall supply periodic security patches and updates for both operating system and application software during the warranty and AMC period.
- All updates shall be tested and validated to ensure no degradation of PDC/CCU functionality.

f. **Physical and Network Security**

- The PDC/CCU shall be provisioned with dual NICs to separate control/data traffic from management traffic.

- Deployment in a DMZ or secure VLAN shall be supported, in accordance with control centre cybersecurity zoning requirements.
- Secure boot, BIOS/firmware password protection, and hardware-level safeguards shall be provided.

3.2.14 Interoperability and Testing

The PDC/CCU shall be interoperable with PMUs, SCADA/EMS systems, and other PDCs from multiple vendors. The bidder shall demonstrate interoperability and compliance with all functional and performance requirements specified in this document during Factory Acceptance Tests (FAT) and Site Acceptance Tests (SAT). All features and functions specified herein shall be successfully validated during FAT and SAT to the satisfaction of the Employer.

3.2.15 Documentation

The bidder shall provide comprehensive documentation establishing compliance of the PDC/CCU with the relevant IEEE and IEC standards. Documentation shall include, but not be limited to:

a. Details of supported performance classes and measurement functions.
b. Certified test reports from accredited laboratories or certification agencies.
c. Records of equipment settings and configurations used during testing.
d. Environmental conditions under which the testing was carried out.

All such documentation shall be submitted as part of the technical offer and shall also be provided with the delivered equipment for future reference and audit.

3.3 Network Management System (NMS) Including Workstations

The bidder shall supply, install, and configure a Network Management System (NMS) including all required hardware, software, and workstations. The NMS shall provide centralized monitoring, visualization, control, reporting, and inventory management of all network and hardware devices including PMUs deployed under this project.

3.3.1 Device Discovery and Topology

a. The NMS shall automatically discover all devices on the network, including but not limited to routers, switches, firewalls, servers, storage systems, access points, PMUs, GNSS receivers, printers, and other connected devices.
b. Discovery shall be possible through IP range scans (start–end IP), topology learning, and SNMP-based detection.
c. The NMS shall automatically generate Layer-3 network maps of core infrastructure, cloud resources, and other connected systems.
d. The network map shall be interactive and display:

- Status of each device, including field equipment installed at substations (PMUs, GNSS, switches, etc.).
- End-to-end network health.
- Device properties (hardware, software, firmware).
- Detailed performance data.
- Status of communication links.

3.3.2 Network Monitoring

a. The NMS shall continuously monitor availability and performance of all infrastructure components, from routers, switches, and firewalls to servers and storage devices.
b. Monitoring shall cover metrics such as CPU, memory, bandwidth utilization, latency, packet loss, error rates, and device temperature.
c. The NMS shall support access and monitoring of devices using ICMP, SNMP, WMI, and SSH protocols.

3.3.3 Alerts and Notifications

a. The NMS shall provide real-time alerts and notifications via email, SMS, Slack, and system logging.
b. Alerts shall be generated under the following conditions:

- Device or monitor state changes.
- Performance threshold breaches.

c. The NMS shall automatically identify network dependencies and support root cause analysis to isolate faults.
d. The system shall be capable of taking self-healing actions, such as restarting an application service, based on pre-defined rules.

3.3.4 Reporting and Dashboards

a. The NMS shall provide a customizable reporting environment with an easy drag-and-drop dashboard designer.
b. Reports and dashboards shall display real-time statistics for selected monitors and performance parameters.
c. Reports shall be exportable in standard formats, including CSV, Excel, and PDF.
d. The system shall support customizable templates for reports and dashboards, allowing operators to create, save, and reuse standard layouts as per operational or regulatory requirements.
e. Reports shall be schedulable and automatically distributed to designated users.

3.3.5 Inventory Management

a. The NMS shall maintain a complete hardware inventory of all connected devices.

b. Reports on installed software, firmware versions, and applied updates shall be generated.
c. The system shall provide warranty and support status reports for all managed assets.

3.3.6 Security and Access Control

a. The NMS shall support secure communication (HTTPS, SNMPv3, SSH) and comply with IEC 62351 and relevant national cybersecurity guidelines (e.g., NCIIPC).
b. The system shall provide role-based access control (RBAC) with multiple levels of user privileges.
c. All configuration changes and user activities shall be logged with timestamps for audit purposes.
d. For Windows-based systems, antivirus/anti-malware protection and host-based firewalls shall be provided; for Linux-based systems, equivalent hardened configurations shall be implemented.

3.3.7 Redundancy, Scalability, and Integration

a. The NMS shall be designed with redundancy for critical components such as appropriate raid configuration of server hard drive, including dual power supplies, dual ethernet portetc.
b. The system shall be scalable to support future expansion in terms of the number of devices, ports, and data points monitored, with at least 50% spare capacity over current requirements.
c. The NMS shall support integration with other enterprise and grid systems through REST APIs, web services, or SNMP traps. Integration with CCU/PDC monitoring and Security Operations Centres (SOC) shall be possible.
d. All alarms, logs, and events shall be time-stamped using GNSS/NTP/IEEE 1588 to ensure precise correlation with synchro-phasor and SCADA data.

3.3.8 NMS Access and User Interface

a. The NMS shall be accessible to operators and engineers through a secure web-portal interface, providing role-based dashboards and reporting functions. No dedicated client installation shall be required on user workstations.
b. The NMS server shall also be accessible via secure remote desktop services to authorized workstations deployed in the control centre. Access shall incorporate appropriate cybersecurity measures, including encrypted communication (e.g., TLS/SSL), strong authentication, and role-based access control.
c. The web-portal and remote desktop access shall provide full functionality for network monitoring, reporting, configuration, and administrative functions, subject to user privilege levels.

d. The solution shall ensure that multiple concurrent users can securely access the NMS, with activity logging and audit trails maintained for all access sessions.

3.3.9 Documentation

The bidder shall supply complete documentation for the Network Management System. This shall include installation and commissioning manuals, configuration and administration guides, user operation manuals, cybersecurity hardening procedures, and troubleshooting references. Documentation shall also cover customization of dashboards, reporting templates, integration with APIs/protocols, and guidelines for future configuration changes and system expansion.

3.4 NaVIC& GNSS based Time Synchronization Equipment

The PMUs and CCU/PDC require precise time synchronization with Coordinated Universal Time (UTC). For this purpose, GNSS &NaVIC-based time synchronization receivers shall be supplied, installed, and commissioned at control rooms and substations as specified in the BoQ.

3.4.1 General Requirements

The time synchronization receiver shall provide UTC reference signals with sufficient accuracy to ensure that the Total Vector Error (TVE) of associated PMUs remains within the limits specified by applicable standards. The receiver shall clearly indicate synchronization status, including loss of signal, reacquisition progress, and current accuracy. It shall include propagation delay compensation and provide offset correction to local time, thereby achieving an overall time accuracy of at least ±0.2 microseconds with respect to UTC. Following loss of signal and subsequent reacquisition, the receiver shall return to within ±0.2 µs of UTC within one minute. The unit shall also support proper leap-second correction.

3.4.2 Standards Compliance

The time synchronization receiver shall support IRIG-B time profile as defined in IEEE C37.118.1-2011, IEEE C37.118.1a-2014, and IEEE C37.242-2013. It shall comply with IEC/IEEE 60255-118-1:2018 standard for synchro-phasor measurement requirements and shall also be fully compliant with IEEE 1588v2 Precision Time Protocol (PTP). These provisions will ensure interoperability with PMUs, CCUs/PDCs, and other compliant equipment.

The bidder shall submit all relevant certificates demonstrating NaVIC and GNSS functionality testing, accuracy validation, and interoperability compliance with the above standards. In addition, the bidder shall provide documented evidence of compliance with applicable cybersecurity norms, including protection of management interfaces, secure firmware/software design, and adherence to IEC 62351 or equivalent security frameworks.

3.4.3 NaVIC/GNSS Operation

The receiver shall be capable of operating with either NaVIC or GNSS satellite signals. The primary source of synchronization (NaVIC or GNSS) shall be user-selectable and finalized at the time of implementation. In the event of a failure or loss of the selected primary source, the receiver shall provide automatic fallback to the alternate source while maintaining the required time accuracy. The switchover between NaVIC and GNSS shall be seamless and shall not interrupt synchronization of the PMUs.

3.4.4 Interfaces

The receiver shall be provided with multiple interfaces to ensure compatibility with PMUs and CCUs/PDCs. At a minimum, it shall provide one IRIG-B output port, one PPS output port, and one Ethernet port supporting IEEE 1588 PTP. All interfaces shall be capable of supporting synchronization of multiple PMUs and CCU/PDC equipment at the respective substation or control centre.

3.4.5 Hardware and Accessories

The bidder shall supply all hardware and accessories necessary for complete installation and reliable operation. This shall include a GNSS &NaVIC antenna with a suitable mounting kit, low-loss RF coaxial cable of sufficient length to connect the antenna to the receiver (minimum 30 m, extendable as per site requirements), and IRIG-B cables of appropriate length for connecting the receiver to PMUs or CCU/PDC. In addition, PPS distribution cables, connectors, power supply adapters, signal splitters, or converters as required for integration shall also be supplied.

3.4.6 Capacity and Coverage

A single GNSS &NaVIC receiver unit shall be capable of providing synchronized time to all PMUs and associated devices installed at the respective substation or control centre, as specified in the BoQ. The receiver shall be designed for 24×7 continuous operation under utility-grade environmental conditions, ensuring reliability and long-term performance.

3.4.7 Environmental Conditions

The supplied GNSS &NaVIC receivers shall be suitable for continuous operation in substation environments that may not be fully air-conditioned. The equipment shall be designed to operate within a temperature range of –10 °C to +55 °C and a relative humidity range of 5% to 95% non-condensing. The receiver shall be housed in an enclosure providing at least IP-52 protection for indoor installation, while the outdoor antenna shall meet minimum IP-65 protection. The equipment shall comply with IEC 61000 series EMC standards and IEC 60068-2 environmental standards for vibration, shock, and transport. Power supply options shall be compatible with typical substation DC (48/110/220 VDC) and AC (230 VAC ±15%) sources.

3.4.8 Documentation

The bidder shall provide full documentation for the GNSS &NaVIC time synchronization system. Manuals shall include installation instructions, antenna placement guidelines, configuration procedures for UTC, NaVIC, and GNSS modes, interface details for IRIG-B, PPS, and IEEE 1588 PTP, and procedures for handling alarms and loss-of-signal scenarios. Documentation shall also include cybersecurity compliance guidelines, future reconfiguration procedures, and test certificates for NaVIC/GNSS accuracy, leap-second handling, and interoperability with PMUs and PDCs.

3.5 Router – Integrated Services Router

The router to be supplied shall be an Integrated Services Router (ISR) or equivalent designed for reliable performance in substation and control centre environments. The router shall provide advanced routing, security, and connectivity features to support SCADA, PMU, VoIP, and other critical utility applications.

3.5.1 Hardware Specifications

The router shall support embedded hardware-based cryptography acceleration for IPsec and SSL. It shall be equipped with a minimum of 10 onboard 10/100/1000 Mbps ports, with support for Layer 2 and Layer 3 switching and routing. The unit shall provide expansion capability through at least 2 module slots, and shall include a minimum of 1 GB DDR3 DRAM (expandable) and 2 GB internal flash memory. Additionally, the router shall include at least one external USB slot for flash-memory expansion.

3.5.2 Power Specifications

The router shall support **dual redundant AC power supply inputs** for high availability. It shall operate on standard utility AC power within the range of **100–240 VAC, 50/60 Hz**.

3.5.3 Environmental Conditions

The router shall be suitable for substation environments and designed for 24×7 operation. The router shall be suitable for substation environments and shall support an operating temperature range of –10 °C to +60 °C. The relative humidity tolerance shall be 5% to 95%.

3.5.4 Security Features

The router shall include integrated security features including stateful firewall, IPsec VPN, Access Control Lists (ACLs), and secure management access. The device shall support SNMPv3, SSH, HTTPS, RESTCONF/NETCONF, and Syslog for monitoring and configuration in compliance with utility cybersecurity guidelines (e.g., IEC 62351, NCIIPC).

3.5.5 Compliance and Reliability

The router shall comply with international safety and EMC standards, including IEC 60950-1, EN60950-1, UL 60950-1, EN 62311, and EMC standards such as EN55022 Class B, EN 55024, EN61000-4 series, VCCI Class B, 47 CFR Part 15, and EN 300 386 v1.6.1. Radio compliance shall include EN 301 511, EN 301 908-1/2, and 47 CFR Part 22/24 where applicable. The router shall have a Mean Time Between Failures (MTBF) of at least 400,000 hours under Ground Benign operating conditions.

3.5.6 Quality of Service (QoS)

The router shall support **advanced QoS features** to prioritize mission-critical traffic such as SCADA, PMU, and VoIP applications. It shall support DiffServ, Class of Service (CoS), and traffic shaping/policing mechanisms to guarantee latency-sensitive communications.

3.5.7 VPN and Encryption Standards

The router shall support IPsec VPN using **AES-256, SHA-2, and IKEv2**, and SSL VPN for secure remote access. All encryption features shall comply with FIPS 140-2 or higher certification standards for cryptographic modules.

3.5.8 Routing and Protocol Support

The router shall support static routing, RIP, OSPF, BGP, and MPLS as required. It shall support dual-stack IPv4/IPv6 operation and provide full interoperability with future IPv6-only deployments. The router shall also support Virtual Routing and Forwarding (VRF) for logical separation of IT and OT traffic.

3.5.9 Management and Monitoring

The router shall support centralized and secure management through NMS using SNMPv3, NetFlow/IPFIX, Syslog, and RESTCONF/NETCONF APIs. It shall allow secure firmware upgrades using digitally signed images and provide automated backup/restore capabilities for configuration.

3.5.10 Cybersecurity Compliance

The router shall comply with relevant cybersecurity standards, including IEC 62351, NCIIPC guidelines, and CERT-In advisories. The device shall support Role-Based Access Control (RBAC), Multi-Factor Authentication (MFA) for administrator access, and secure, tamper-evident logging of all configuration and management activities.

3.5.11 Licensing and Feature Availability

All features specified in this document, including routing, VPN, security, and management, shall be delivered permanently enabled in the supplied router. No additional licensing, subscriptions, or feature unlocks shall be required for compliance with this specification.

3.5.12 Documentation

The bidder shall provide complete documentation for the supplied routers. This shall include detailed hardware specifications, supported routing and VPN protocols, QoS configuration procedures, and security configuration guides. Manuals shall cover installation, integration with SCADA, PMU, VoIP, and NMS applications, firmware upgrade procedures, and backup/restore methods. The documentation shall also include guidelines for future configuration changes, expansion, and security hardening. All compliance certificates for safety, EMC, and cybersecurity standards shall be submitted along with the manuals.

3.6 Gigabit Ethernet Switch (Layer-3, Industrial Grade)

In substations and power plants, the Layer-3 industrial grade Gigabit Ethernet switch shall provide reliable connectivity between PMUs and the upstream communication equipment. In the control centre, the Layer-3 switch shall be used to interconnect various devices including CCU/PDC, NMS servers, GNSS receivers, routers, , firewalls, and workstations, thereby forming the core of the local area network.

3.6.1 General Requirements General Requirements

The switch shall be an industrial-grade device, designed for continuous operation in substation and control centre environments. It shall provide interfaces for PMUs on one side and communication equipment on the other side in substations, and for multiple servers, routers, VoIP and IT/OT equipment in control centres.

The switch shall support dual power options depending on location:

- Substations: DC supply of 220 V DC, 110 V DC, or 48 V DC (+10%, –15%) or AC supply of 220 V AC, 50 Hz..
- Control centres: AC supply of 220 V AC, 50 Hz.

The bidder shall supply all required accessories, including mounting hardware, cables, connectors, and software licenses, for complete installation and commissioning.

3.6.2 Port Requirements

The number of ports required in each switch shall be worked out by the bidder based on the devices to be integrated at the respective location. Each switch shall include a minimum of **50% spare ports** for future expansion.

However, minimum 08 number of**Gigabit Ethernet (10/100/1000 Mbps auto-sensing)**port and minimum two ports of**fiber (1 Gbps SFP/SFP+)**shall be provided for reliable backbone connectivity.

3.6.3 Hardware and Software Features

The switch shall support the following minimum features:

- Layer-2 and Layer-3 switching capabilities.
- Support for VLANs (IEEE 802.1Q) and inter-VLAN routing.
- Support for IPv4/IPv6 dual stack.
- Support for Spanning Tree Protocol (STP, RSTP, MSTP).
- Link aggregation (IEEE 802.3ad LACP).
- Quality of Service (QoS) with traffic prioritization for SCADA, PMU, and VoIP applications.
- IGMP Snooping for multicast traffic optimization.

Port mirroring for diagnostics.

Redundant power supply support preferred.

3.6.4 Cybersecurity and Management

The switch shall support **secure access and management** using SSH, HTTPS, SNMPv3, and Syslog. Role-Based Access Control (RBAC) shall be provided. The device shall comply with **IEC 62351 cybersecurity guidelines** and shall include protection against unauthorized access.

The switch shall integrate with the Network Management System (NMS) supplied under this project, exposing status, alarms, and performance data. It shall support centralized monitoring of port health, link utilization, and error statistics.

3.6.5 Environmental Conditions

The switch shall be suitable for **substation-hardened operation** and designed for 24×7 use. It shall support an operating temperature range of **–10 °C to +60 °C** and relative

humidity tolerance of **5% to 95%.** The enclosure shall provide a minimum protection rating of **IP-30** or better.

3.6.6 Compliance and Reliability

The switch shall comply with relevant international standards, including:

- IEEE 802.3 (Ethernet standards).
- IEEE 802.1D/802.1Q/802.1s/802.1w (bridging, VLAN, STP, MSTP, RSTP).
- IEC 61850-3 and IEEE 1613 for substation-hardened equipment.
- IEC 61000 series for EMC compliance.

The device shall have a high **Mean Time Between Failures (MTBF)** suitable for critical utility installations.

3.6.7 Documentation

The bidder shall provide comprehensive documentation, including installation manuals, configuration and administration guides, user operation manuals, and troubleshooting references. Manuals shall cover VLAN and QoS configuration, integration with NMS, and procedures for future expansion. Compliance certificates for environmental, EMC, and cybersecurity standards shall be submitted along with the documentation.

3.7 Next Generation Firewall (NGFW)

The Next Generation Firewall (NGFW) shall provide advanced perimeter and internal security for Control Centre networks. The firewall shall protect SCADA, PMU, NMS, GNSS, routers, switches, and other mission-critical applications against cyber threats, while complying with utility-grade cybersecurity standards. The bidder shall be responsible for maintaining the cybersecurity posture of the supplied system, including patching, firmware upgrades, and software updates during the AMC/Guarantee period, at no additional cost to the owner. All software shall be supplied with valid licenses up to the end of the AMC period. Outdated or end-of-life software shall be replaced or upgraded by the bidder free of cost during AMC.

3.7.1 Security and Functional Features

The NGFW shall include, but not be limited to, the following features:

- **Encryption & VPN**: IPSec VPN (AES-128/256 with MD5/SHA1/SHA2), SSL VPN, and client-based VPN for Windows, Linux, and Mac platforms. Must support at least 100 VPN tunnels with redundant operation and minimum throughput of **5 gbps**.
- **Deep Packet Inspection (DPI)** and application control for known and unknown TCP/UDP applications, with configurable allow/block policies.

- **Threat Protection**: The NGFW shall include Intrusion Detection and Prevention (IDS/IPS) capabilities, Anti-Virus, Anti-Spyware, DoS/DDoS prevention, IP/MAC spoofing protection, Man-in-the-Middle (MITM) prevention, and automatic signature updates (online/offline).
- **Zero-Day Protection**: Advanced malware detection/sandboxing for zero-day threats, with automatic updates.
- **Traffic Shaping**: Integrated bandwidth allocation, prioritisation, and QoS enforcement.
- **High Availability**: Active/Passive and Active/Active modes with stateful session failover and load balancing.
- **SSL/TLS Inspection**: Capability to inspect encrypted SSL/TLS traffic, including TLS 1.3.
- **Web & Application Filtering**: Category-based filtering (malware, social media, P2P, etc.) with customizable policies.
- **Logging & Retention**: Storage and export of logs/events for **minimum 180 days**, supporting CSV and SIEM formats. Logs shall be exportable to a centralized log management system (e.g., syslog, SIEM).

3.7.2 Power Supply

The NGFW shall support **dual redundant hot-swappable AC power supplies**, operating on **220 V AC, 50 Hz** input. The design shall ensure uninterrupted firewall operation in case of failure of one power supply module. Power modules shall be replaceable without interrupting traffic (hot-swap capability).

3.7.3 Network and Protocol Support

The NGFW shall support:

- **Utility Protocols**: IEC-60870-5-104, ICCP/TASE.2, PMU (IEEE C37.118), IEC 61850, and Ethernet.
- **IP Support**: Simultaneous operation of IPv4 and IPv6.
- **Segmentation**: Configurable VLANs and VRF for traffic separation.
- **Sessions**: Minimum **500,000 concurrent sessions** and at least **20,000 new sessions per second**.
- **Management**: Secure remote configuration, centralized authentication with RADIUS/LDAP/TACACS+, RBAC, and SNMPv3 with encrypted authentication. The NGFW shall be accessible for secure configuration and management via an **HTTPS web portal**, in addition to CLI (SSH) and APIs (REST/JSON). The web portal shall provide role-based dashboards, real-time monitoring of sessions/traffic, and policy management.
- **Time Synchronisation**: NTP/SNTP support with mandatory sync to official Indian Timekeeping Agency (time.nplindia.org).

3.7.4 Performance Requirements

The firewall shall meet the following minimum benchmarks:

- Firewall throughput (1518-byte packets): ≥ 5 Gbps
- NGFW throughput with IPS/AV/DPI enabled: ≥ 1.5 Gbps
- IPSec VPN throughput: ≥ 500 Mbps
- Concurrent sessions: ≥ 500,000
- New sessions per second: ≥ 20,000
- Minimum interfaces: 8 × GE RJ-45, 2 × SFP (fiber)
- Expansion capability for higher throughput shall be available.

3.7.5 Compliance and Deployment Requirements

- The NGFW shall be rack-mountable in standard 19-inch equipment cabinets.
- The firewall shall support firmware checksum validation before upgrades and provide a documented process for patching and updates.
- All updates, patches, and signature definitions shall be provided free of cost for a minimum of **36 months from shipping**.
- The product shall not be declared End-of-Sale or End-of-Support or End-of-life for at least **5 years** from supply date.
- Must comply with NCIIPC guidelines, CERT-In advisories, and provide a hardening checklist aligned to IEC 62443.
- Integration with centralized SIEM/NMS using syslog, CEF/LEEF, or equivalent format.
- Support for REST/JSON APIs for integration with orchestration platforms.

3.7.6 Documentation

The bidder shall provide comprehensive documentation, including installation manuals, configuration and administration guides, cybersecurity hardening guidelines, and troubleshooting references. Documentation shall cover VPN setup, VLAN/VRF configuration, RBAC, log management, firmware upgrade, and integration with SCADA/PMU/VoIP/NMS environments. Manuals shall also provide procedures for future configuration changes, patch management, and AMC support. Compliance certificates for performance, cybersecurity, and regulatory standards shall be included.

3.8 Workstation (HMI)

3.8.1 General Requirements

The system shall be provided with Human-Machine Interfaces (HMI) for the monitoring, visualization, control, and configuration of islanding operations from the central location. The HMI shall be interfaced with the PDC/ CCU, which integrates data from all PMUs installed at participating substations. The workstation shall be used for real-time monitoring and

control, to edit and view configurations of the PDC/CCU, NMS, PMUs, Ethernet Switches, GNSS, Routers, and Firewall. It shall be supplied with all necessary software licenses, sufficient storage capacity for COMTRADE files, and user interfaces to compose islanding logics and to visualize PMU data through Single Line Diagram (SLD) representations or any other representation as decided during the implementation.

For Windows-based systems, antivirus/anti-malware protection and host-based firewalls shall be provided.

3.8.2 Displayand Control Functions

The HMI shall provide real-time acquisition and display of synchro-phasor s, analog and digital measurements, alarms, and events. It shall also allow visualization of the status of major equipment in Single Line Diagram/Customised format and enable the control of circuit breakers wired to PMUs at different substations. The system shall support the display and storage of both measured and derived values, as well as alarm and event logs. It shall have the capability to generate, store, and retrieve user-configurable Sequence of Event (SOE) reports and shall continuously monitor the communication status of PMUs and Ethernet Switches deployed at substations.

3.8.3 RemoteAccess and User Management

The workstation shall support remote access with at least three web-based monitoring licenses provided. The system shall incorporate Role-Based Access Control (RBAC) with configurable user management, ensuring secure operations. The design shall guarantee that faults or malfunctions in the islanding system will not affect the SCADA system of the SLDC/NERLDC.

3.8.4 DataArchival and Reporting

The PMU/CCU shall automatically archive Disturbance Recorder (DR) files from PMUs in IEEE COMTRADE format, preserving them at full fidelity and at the native sampling rate of each PMU. These files shall be stored on the HMI PC for a minimum of one year, and the storage system shall be appropriately sized to accommodate this requirement. The bidder shall supply all necessary tools for extracting, visualizing, and analyzing these data. The system shall also record all islanding and restoration events at the CCU and provide facilities for generating user-customizable reports. These reports shall include, at a minimum, details of event time, triggering frequency, generation and load before and during the event, breaker and line tripping times, feeder-wise load shedding, feeder prioritization, and bus voltage and frequency.

3.8.5 Power Supply and Installation

The HMI shall be installed in the SLDC/NERLDC control room in the space provided by the SLDC/NERLDC team. The workstation shall be powered by 220 V AC supply provided by SLDC/NERLDC.

3.8.6 Hardware and System Requirements

The workstation shall be of enterprise or industrial grade and meet the following minimum requirements:

- **Processor**: Intel Core i7 (12th Gen or higher) or equivalent, ≥ 8 cores.
- **Memory (RAM)**: ≥ 32 GB DDR4/DDR5 ECC, expandable.
- **Storage**:
  - Minimum 2 × 2 TB SSDs in RAID-1 for OS and applications.
  - Minimum 4 TB HDD/SSD for COMTRADE, PMU Data archiving and reports.
- **Graphics**: Dedicated GPU with ≥ 4 GB VRAM, supporting multi-monitor displays.
- **Networking**: Dual Gigabit Ethernet ports (10/100/1000 Mbps).
- **Power**: Redundant power supply units with hot-swap capability.
- **Display**: Dual 27-inch LED monitors, Full HD or higher.
- **Peripherals**: Industrial-grade keyboard, optical mouse, DVD-RW or equivalent.
- **Operating System**: Windows 11 Pro (64-bit) or equivalent, with OEM license.
- **Software**: Preloaded HMI applications with valid licenses, SQL/time-series database support, and reporting/visualization tools.

3.9 Under Frequency Relay (UFR)

3.9.1 General

The Under Frequency Relay (UFR) shall be numerical, microprocessor-based, and designed for automatic load shedding and controlled islanding to protect the power system from instability during frequency decline. It shall comply with relevant IEC/IEEE standards for protection, communication, and electromagnetic compatibility.

3.9.2 Functional Requirements

The UFR shall provide a minimum of four (4) programmable under-frequency stages, each with definite time characteristics. Each stage shall also support rate-of-change-of-frequency (df/dt) functionality, with programmable start values and operation times. A dual-time delay option shall be available to allow fast tripping as well as delayed action.

The relay shall support **dual VT inputs with automatic selection**. A preferred VT shall be selectable by the user, and failover shall occur when any phase of VT-A drops below a defined threshold or when VT-fuse-failure is detected. The changeover shall include

hysteresis and minimum dwell time (1–5 s configurable) to avoid hunting. Manual re-transfer enable/disable shall also be available.

A recovery function shall be provided with user-selectable deviation and delay time to assist system restoration. The relay shall incorporate undervoltage blocking to avoid maloperation during system undervoltage. External inputs shall allow enabling, blocking, or selective operation of the protection stages.

The relay shall provide trip outputs to control High-Speed Drop Relays (HDRs) for tripping of feeders/generators. It shall also provide operation status and event outputs to Phasor Measurement Units (PMUs) for reporting and monitoring at the Control Centre.

At least four (4) binary outputs and four (4) signalling/alarm contacts shall be available. Configurable logic shall be provided for load-shedding, islanding, and alarm actions.

The UFR shall provide SOE (Sequence of Events) and event recording with a time resolution of 1 ms or better.

3.9.3 Communication and Data Integration

The UFR shall be equipped with modern communication protocols including IEC 61850 (GOOSE/R-GOOSE), IEC 60870-5-104, and IEEE C37.118 for seamless integration with PMUs, PDC/CCU, and SCADA/EMS systems. At least one Ethernet port (10/100 Mbps) and one optical fibre port (100 Mbps) shall be available.

The relay shall support secure remote parameterization, monitoring, firmware upgrade, and event log retrieval.

3.9.4 Power Supply

The UFR shall operate on DC supply voltages available in substations: 220 VDC, 110 VDC, or 48 VDC (+10%, -15%). The Contractor shall confirm compatibility with the supply available at each installation site.

3.9.5 Time Synchronization

The relay shall support time synchronization via IRIG-B, SNTP/NTP, or IEEE 1588 (PTP). The time stamping shall be compatible with PMUs and PDCs for system-wide coordinated event logging.

3.9.6 Environmental Conditions

The relay shall be suitable for substation environment with the following:

- Operating temperature: –10 °C to +55 °C
- Storage temperature: –25 °C to +70 °C
- Relative humidity: 5% to 95% non-condensing

- Vibration/shock withstand: IEC 60255-21/IEC 60068 standards
- EMC compliance: IEC 61000, IEC 60255-26, IEC 61850-3

3.9.7 Documentation

The Contractor shall provide type test certificates, routine test certificates, operation manuals, configuration manuals, wiring diagrams, and application notes for UFR.

3.10 Heavy Duty Relay (HDR)/High Burden Relay

The bidder shall supply Heavy Duty Relays (HDRs) for the operation of circuit breakers at the participating substations. The HDRs shall be of robust construction, suitable for continuous operation in substation environments, and shall conform to the specifications detailed below:

Parameter	Specification
Standard Coil Rating	110/125 VDC or 220/250 VDC. HDR shall operate reliably between 75% – 120% of rated voltage.
No. of Output Contacts	Minimum 12 NO contacts.
Operating Time	Typically, ≤ 25 ms.
Insulation	Shall comply with IS 3231:1965 / IEC 255-5, Series C-2; withstand 2 kV for 1 minute.
Contact Rating (DC)	- Continuous: 1250 W with maximum of 10 A at 660 V. - Short-Time (3 sec): 1250 W with maximum of 30 A at 660 V. - Breaking Capacity: 100 W (resistive) or 50 W (inductive), with maximum of 5 A at 660 V.
Flag Indication	Provided with mechanical flag.
Contact Reset	Self-reset type.
Environmental & Mounting Conditions	Operating temperature: –10 °C to +55 °C. Relative humidity: up to 95% non-condensing. Designed for installation in substation control panels or relay racks with vibration and EMC immunity as per IEC 60255.

3.11 Panels

Minimum one number of panels shall be considered for SLDC, NERLDC and for each substation covered under the scheme. If required, depending upon the number of PMUs to be installed, additional panels shall be considered for substations. The bidder shall supply panels for housing PMUs and GNSS equipment. The panels shall meet the following requirements:

1. Panels shall be free-standing, floor-mounted type, and the overall height shall not exceed 2100 mm.
2. Panels shall provide full maintenance access to all hardware and wiring through lockable, full-height doors.

3. Panels shall be designed with provisions for bottom cable entry.
4. The safety ground shall be isolated from the signal ground. Safety ground shall be connected to the substation ground network through a copper bus bar, while the signal ground shall be connected to the communication equipment signal ground.
5. Each panel shall be supplied with two PDU: 230 V AC, 50 Hz, single-phase switch and a 15/5 A duplex socket arrangement for panel lighting and maintenance.
6. Each panel shall be provided with an internal maintenance lamp, space heaters with thermostat, and suitable gaskets for environmental protection.
7. All panels shall be suitable for indoor installation, dust-proof, rodent-proof, and shall comply with IP41 class of protection.
8. Panel design shall ensure there are no sharp corners or edges; all edges shall be rounded to prevent injury during handling or maintenance.
9. A document holder shall be provided inside each cabinet to store test reports, drawings, maintenance registers, and related documents.
10. All materials used in the enclosure, including cable insulation, sheathing, wire troughs, terminal blocks, and enclosure trims, shall be flame retardant and shall not emit toxic gases under fire conditions.
11. The structural frame of the panels shall be fabricated from cold-rolled sheet steel of thickness not less than 3 mm for all load-bearing members such as base frame, front sheets, and door frames. For other parts such as sides, doors, top, and bottom portions, the sheet thickness shall not be less than 2 mm.
12. All sheet steel work shall be degreased, pickled, and phosphated in accordance with IS:6005. The phosphate coating shall be sealed with two coats of stoving-type zinc chromate primer. Two coats of synthetic enamel paint of RAL7032 shade shall be applied on both the exterior and interior surfaces.

3.12 Earthing Requirements

1. All panels shall be equipped with a dedicated earth bus securely fixed. The location of the earth bus shall be selected to avoid radiation interference under various switching conditions of isolators and breakers.
2. The earth bus shall be made of perforated copper bar of minimum size 25 × 6 sq.mm, with threaded holes at intervals of 50 mm, fitted with bolts and nuts for effective connection of cable armours, mounted equipment, and other metallic parts. Provision shall be made for extending the earth bus bar to adjoining panels on either side.
3. Each panel shall have a dedicated provision for connecting to the substation earthing grid. All necessary clamps, terminals, and connectors for this purpose shall be supplied by the bidder.
4. Each panel shall be connected to the substation control room earth system at a minimum of two separate points. Each panel body shall be bonded to the single earth flat running in the station from at least two independent locations.

5. All metallic cases of PMUs and associated equipment shall be connected to the earth bus using copper wires of size not less than 2 × 2.5 sq.mm. All earthing wires shall be insulated and colour coded green.
6. Looping of earth connections that could result in loss of earthing to other devices in case of a break shall not be permitted. However, parallel or alternative earthing paths may be provided by looping between equipment to ensure redundancy of earthing connections to the main earth bus.
7. The earthing system shall comply with IEC 60364, IEC 60255, IS 3043 and other relevant latest standards.
8. The earth resistance of each panel's connection to the substation earthing grid shall be less than 1 ohm, ensuring effective fault current dissipation and equipment safety.
9. The bidder shall carry out earthing continuity and resistance tests during Factory Acceptance Test (FAT) and Site Acceptance Test (SAT) and submit the corresponding test reports for approval.
10. All earthing connections and terminations shall be made corrosion-resistant. Tinned copper lugs and anti-oxidant compounds shall be used at all termination points to ensure long-term reliability.
11. All earthing conductors shall be properly tagged, labelled, and marked for identification and maintenance purposes.

3.13 Cabling and Interconnections

1. All cabling between component units of the PMU, PMU to GNSS (including antenna), PMU to Layer-3 Switch, PMU to the substation/power station control and relay panels, and Layer-3 Switch to Wide Band Communication Equipment shall be supplied, laid, terminated, and commissioned by the bidder.

2. Interconnections shall be shown in bidder-supplied drawings. Any additional equipment, hardware, or software required for integration shall also be supplied by the bidder. Final requirements shall be confirmed during the site survey.

3. Plug-type connectors with captive fasteners or compression-type connectors shall be used for all internal interconnections. Connectors shall be polarized to prevent incorrect assembly.

4. Each end of every interconnection cable shall be identified with a durable marker showing the cable number, termination number, and location. This information shall match the bidder's approved drawings.

5. Adequate space and hardware shall be provided for routing of field wiring within enclosures. Internal wiring shall be neatly arranged and supported, and shall not be fastened directly to the panel frame.

6. Internal interconnection wiring shall be routed separately from power wiring to avoid interference.

7. All wiring shall use copper conductors with flame-retardant, low-smoke, halogen-free insulation. Conductors in multi-core cables shall be individually colour coded.
8. Non-flammable, self-extinguishing plastic wire troughs may be used. Metal clamps, if used, shall have insulating inserts between clamp and cable.
9. Wiring across moving parts such as door hinges or sliding components shall allow full movement without binding or chafing.
10. All cables shall comply with relevant IS/IEC standards.
11. Power cables shall be copper conductor, XLPE insulated, armoured, flame retardant, and low smoke halogen-free.
12. Control and communication cables shall be copper conductor, multi-core, twisted pair where applicable, shielded, and FRLSH insulated.
13. Ethernet cables shall be Category-6A or higher, shielded (STP/FTP).
14. Fibre optic cables, where required, shall be single-mode, armoured, minimum 12 fibres, conforming to ITU-T G.652D or equivalent.
15. Signal and communication cables shall be individually or overall shielded for EMI/RFI protection. Shields shall be earthed at one end only.
16. Power supply cables shall have a minimum cross-section of 2.5 sq.mm copper for single-phase loads and 4 sq.mm copper for DC supply runs. Voltage drop shall not exceed 3% at rated load.
17. Power, signal, and communication cables shall be segregated by routing in separate trays or conduits, with adequate spacing between high- and low-voltage circuits.
18. Cable identification shall be ensured by printed ferrules on each conductor at both ends. Cable tags of stainless steel or UV-resistant material shall be fixed at regular intervals along the route.
19. At least 20% spare cores shall be provided in each control and communication cable. Spare cores shall be terminated on spare terminals and properly identified.
20. Cables shall be laid on trays, ducts, or conduits with proper clamping and dressing. Minimum bending radius shall not be less than 12 times the overall cable diameter.
21. Entry and exit into panels shall use compression type cable glands with neoprene seals.
22. All terminations shall be made with crimped tinned copper lugs with insulating sleeves.
23. The bidder shall carry out laying, termination, testing, and commissioning of all cables, including interconnections among bidder-supplied equipment and with employer's panels.

24. Testing shall include insulation resistance measurement, continuity check, high voltage withstand test where applicable, and loop resistance measurement. Test results shall be submitted for approval.

25. Any other type of cable or interconnection necessary for proper functioning of the system, as identified during site survey or commissioning, shall be supplied and installed by the bidder.

3.14 Wiring Requirements

Shielded (screened) cables shall be used for external cabling from the PMU/SIC panels. These external cables (except communication cables) shall meet the following requirements:

1. All cables shall have stranded copper conductors complying with IEC 60228.
2. Minimum core cross-section shall be 2.5 sq.mm for PT cables, 4 sq.mm for CT cables, 2.5 sq.mm for power and control outputs, and 1.5 sq.mm for digital status inputs and transducer mA current outputs.
3. Rated voltage shall be Uo/U = 0.6/1.1 kV.
4. Cable insulation and sheathing shall be flame retardant, low smoke, halogen-free (FRLS/FRLSH) type. External sheathing shall have oxygen index not less than 29 and temperature index not less than 250. The sheath shall meet fire resistance requirements as per IS 1554 Part-I / IEC 60332, and smoke density requirements as per IEC 61034.
5. Cables shall have shielded, longitudinally laid with overlap, with an aluminium/polyester tape and tinned copper drain wire of minimum 0.5 sq.mm cross-section.
6. Dielectric withstand capability shall be minimum 2.5 kV at 50 Hz for 5 minutes.
7. Cables shall be marked externally with manufacturer's name, type, number of cores, cross-section, and year of manufacture at regular intervals.
8. Communication cables shall be of shielded twisted pair copper cable of minimum 0.22 sq.mm or fibre optic cable (single mode, armoured, conforming to ITU-T G.652D or equivalent).
9. Shields shall be earthed at one end only, preferably at the panel side, to prevent ground loops.
10. Colour coding of conductors shall conform to relevant IS/IEC standards. Each conductor shall be identified at both ends by printed ferrules, and cables shall be tagged with stainless steel or UV-resistant tags at regular intervals.
11. Power, control, and communication cables shall be segregated and laid in separate trays/conduits with adequate spacing. Minimum bending radius shall not be less than 12 times the overall diameter.

12. At least 20% spare cores shall be provided in control and status cables, terminated on spare terminals and properly identified.
13. The bidder shall conduct routine tests including insulation resistance, continuity, high voltage withstands, and loop resistance tests, and shall submit type test certificates from NABL/ILAC accredited laboratories for each cable type offered.
14. All cables and accessories shall be suitable for operation in ambient temperature range –10 °C to +55 °C, relative humidity up to 95% non-condensing. Outer sheaths for outdoor cables shall be UV-resistant.

4 Inspection and Testing

4.1 Type Tests

Type test reports for PMU, PDC/CCU, Ethernet switches, GNSS &NaVIC receivers, NMS, Firewalls, Routers, and associated equipment covered under this specification shall be submitted for the Owner's approval. The submission shall include a tabulation detailing each type test report with reference to the applicable standard, certificate number, description of the equipment subjected to the type test, place of testing, date of testing, and final results. Type test reports shall not be older than five years and shall be issued by NABL/ILAC accredited laboratories.

4.1.1 Electromagnetic Compatibility (EMC) Tests

Electromagnetic compatibility (EMC) means the ability of equipment or a system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment. EMC qualification requires demonstration of acceptable noise emission limits and immunity to specified electromagnetic disturbances.

4.1.2 Immunity and Emission Tests

The PMU, PDC/CCU, Ethernet Switches, GNSS &NaVIC equipment, NMS servers, Routers, and Firewalls shall comply with the following immunity and emission tests in accordance with IEC 61000-4, IEC 61000-6, IEEE C37.90, and CISPR 22/32:

a. Radiated and conducted emissions
b. Radiated radio frequency electromagnetic field compatibility test
c. Conducted disturbance induced by radio frequency fields
d. Fast transient/burst immunity test
e. 1 MHz oscillatory wave test
f. Surge immunity test
g. Power frequency immunity test
h. Power frequency magnetic field immunity test
i. Electrostatic discharge (ESD) test
j. DC voltage dips, short interruptions, and variations
k. AC ripple on DC supply
l. Ring wave immunity test (IEC 61000-4-12)
m. Voltage fluctuation and flicker test (IEC 61000-3-3)

4.1.3 Environmental **Tests**

The PMU, PDC/CCU, Ethernet Switches, GNSS &NaVIC receivers, NMS, Firewalls, and Routers shall comply with environmental tests in accordance with IEC 60068-2, IEC 60255-21, IEC 61850-3, and equivalent standards:

a. Dry heat test
b. Cold test

c. Cyclic temperature with humidity
d. Vibration test
e. Shock and bump test
f. Seismic qualification test (IEC 60068-3 or IEEE 693)
g. Salt mist corrosion test (IEC 60068-2-52) for GNSS antenna units and other outdoor-exposed equipment

4.1.4 Safety-Related Tests

The PMU, PDC/CCU, Ethernet Switches, GNSS &NaVIC receivers, NMS, Firewalls, and Routers shall comply with safety tests in accordance with IEEE 1613, IEEE C37.90, and IEC 60255:

a. Impulse voltage withstand test
b. AC and DC dielectric voltage withstand test
c. Insulation resistance test
d. Verification of protective earth continuity
e. Fire hazard/flammability compliance for enclosures and insulation (IEC 60332, IEC 60754, IEC 61034)

4.1.5 Performance Class Validation (Applicable to PMU and PDC/CCU)

The PMU and PDC/CCU shall be type tested for synchro-phasor measurement accuracy in compliance with IEEE C37.118.1 (P-class and M-class) and IEC/IEEE 60255-118-1. The tests shall include validation of Total Vector Error (TVE), Frequency Error (FE), and Rate of Change of Frequency (ROCOF).

4.1.6 Cybersecurity and Interoperability Validation

a. The NMS, Firewall, Routers, and PDC/CCU shall undergo penetration testing and vulnerability assessment to confirm compliance with prevailing cybersecurity guidelines (CERT-In, NCIIPC, or IEC 62443 / NIST standards). b) Interoperability tests shall be demonstrated for PMU and PDC/CCU using IEEE C37.118.2, IEC 61850-90-5, and IEC 60870-5-104 protocols to ensure seamless integration with third-party devices.
b. The Firewall and NMS shall also demonstrate compliance with secure SNMPv3 monitoring and secure syslog export capabilities.

The list of tests is also tabulated in the Annexure-1

4.2 Factory Acceptance Tests (FAT)

All routine tests shall be carried out on every equipment as per the latest relevant IEC/IEEE/IS standards in the presence of the Owner or Owner's representatives. The Supplier shall prepare and submit a detailed FAT program for approval prior to commencement of testing. The FAT program shall cover testing of each equipment individually, followed by verification of the integrated system, and shall permit the verification of all performance, functional, and interoperability requirements as specified in this document.

4.2.1 General Requirements

a. FAT shall be performed on PMUs, PDC/CCU, GNSS &NaVIC receivers, Firewalls, Routers, Ethernet Switches, HMI systems, NMS servers, and associated components.
b. FAT shall be conducted strictly in accordance with applicable standards: IEEE C37.118.1/.2, IEC/IEEE 60255-118-1, IEEE C37.244, IEC 61850-3, IEC 62443, CERT-In/NCIIPC guidelines, and other relevant standards.
c. All necessary test instruments, tools, test software, and simulators shall be arranged by the Supplier.
d. Test procedures, results, and compliance reports shall be documented and jointly signed by Supplier and Owner representatives.

4.2.2 Routine Verification Tests

a. Verification of completeness of wiring, connections, and labeling as per approved drawings.
b. Continuity checks for all control, signal, and communication circuits
c. Measurement of insulation resistance (IR) and high-voltage (HV) withstand tests.
d. Verification of proper functioning of PMUs, PDC/CCU, GNSS &NaVIC, Firewalls, Routers, Ethernet Switches, HMI hardware and software, and NMS systems.
e. Verification of redundancy in power supply units, network switches, and firewalls/routers.

4.2.3 Functional and Integration Tests

a. Demonstration of data transfer between PMUs, PDC/CCU, and HMI PC in compliance with IEEE C37.118.2 and IEC 61850-90-5.4.
b. Integration of PMUs with PDC/CCU, including data aggregation, alignment, and forwarding.
c. Demonstration of tripping and load-shedding commands from PDC/CCU to PMUs, with verification of command acknowledgement.
d. Verification of reporting rates (25/50 fps or higher) and compliance with TVE, FE, and ROCOF limits.
e. Demonstration of proper time synchronization via GNSS &NaVIC, IEEE 1588 PTP, and IRIG-B.

4.2.4 System-Level Demonstrations

a. Functional testing of GNSS &NaVIC receiver under the following conditions:
   - With antenna input.
   - Without external synchronizing input (free-running mode).
   - Without antenna input but with external synchronizing input.
b. Demonstration of HMI screens for real-time measurements, events, alarms, SOE reports, and single line diagram (SLD) displays.
c. Verification of COMTRADE file archival at HMI PC and CCU with retrieval functionality.
d. Verification of data logging and archival for minimum 90–180 days as specified.

4.2.5 Cybersecurity and NMS Validation

a. Verification of software/firmware versions, licensing, and updates.
b. Demonstration of Role-Based Access Control (RBAC), password management, and secure remote access (HTTPS, SSH, SNMPv3).
c. Verification of syslog export, secure patch management, and firmware checksum validation.
d. Demonstration of NMS device discovery, topology mapping, device health monitoring, and generation of real-time alerts/notifications.

4.2.6 Redundancy and Failover Tests

a. Simulation of redundant power supply switchover.
b. Demonstration of Active/Passive and/or Active/Active failover for firewalls and routers without session loss between SLDC and NERLDC system.
c. Verification of PDC/CCU auto-reconnect and restoration of communication following link interruptions.

4.2.7 Islanding Scheme Demonstration

a. Simulation of frequency disturbance or ROCOF condition to trigger islanding logic.
b. Verification of tripping and load-shedding commands as per configured islanding scheme.
c. Demonstration of restoration logic and event reporting.

4.3 Site Acceptance Tests (SAT)

The successful bidder shall submit a detailed equipment installation and commissioning procedure for the Owner's approval prior to commencement of site works. Commissioning checks indicated below are minimum requirements; however, the Contractor shall carry out all actual commissioning checks on the supplied equipment as per the manufacturer's recommendations and Owner's instructions. The Original Equipment Manufacturer's (OEM) engineer shall be present during performance of all site tests, and the manufacturer's concurrence shall be obtained before final acceptance.

A detailed SAT procedure and schedule shall be finalized during the engineering stage by the successful bidder in consultation with the Owner, ensuring full coverage of functional, performance, interoperability, and cybersecurity requirements specified in this document.

SAT shall confirm compliance of all equipment and the integrated system with relevant standards, including but not limited to IEEE C37.118.1/.2, IEC/IEEE 60255-118-1, IEEE C37.244, IEC 61850-3, IEC 62443, IEC 61000, and applicable national guidelines (e.g., CERT-In, NCIIPC).

4.3.1 Preliminary Checks

a. Verification of nameplate details of every equipment against approved specifications.

b. Inspection for any physical damage during transport and installation.
c. Checking tightness of all bolts, clamps, and connecting terminals.
d. Verification of panel cleanliness and removal of foreign material.
e. Verification of earthing continuity and connections.
f. Functional check of panel heaters and internal lighting.
g. Verification of completeness of Bill of Materials (BOM) in each panel.

4.3.2 Commissioning Checks

a. Tracing of each wire by continuity tests to ensure correctness of wiring as per drawings; verification of all interconnections between panels and equipment.
b. Measurement of insulation resistance (IR) of all circuits and dielectric withstand checks for modules and panels.
c. Verification of communication status of PMUs, PDC/CCU, Routers, Switches, Firewalls, GNSS, and HMI systems.
d. Validation of electrical parameters, digital inputs (DI), and digital outputs (DO) at each PMU.
e. Verification of data transfer from PMUs to PDC/CCU, including synchro-phasor s, analog values, digital status, and disturbance record (DR) files.
f. Demonstration of end-to-end control from PDC/CCU/HMI to PMUs, including trip and load-shedding commands.
g. Validation of communication from PDC/CCU to SLDC/NERLDC SCADA/EMS over IEC 60870-5-104 and/or ICCP.
h. Verification of integration with the existing PDC at SLDC/NERLDC, ensuring seamless data exchange, time alignment, and redundancy.
i. Functional testing of GNSS &NaVIC receiver system:

- With antenna input.
- Without external synchronizing input (free-running mode).
- Without antenna input but with external time synchronizing input.
- Integrated verification of synchronization across all PMUs, DR units, and relays with simulated signals.

j. Demonstration of correct operation of the Islanding Scheme logic, including tripping, load shedding, and restoration as configured.
k. Validation of firewall policies, security rules, and enforcement of RBAC (Role-Based Access Control).
l. Verification of changes to Islanding Logics and re-testing after modifications.
m. Validation of PMU measurement accuracy and values against reference instruments at field level.
n. Verification of equipment and communication link status monitoring in NMS, including alarms and alerts.
o. Demonstration of COMTRADE file archival, retrieval, and reporting functions at HMI PC.

p. End-to-end redundancy testing: failover of dual firewalls, routers, and communication links to demonstrate uninterrupted operation.
q. Validation of automatic reconnection and data streaming restoration after communication link interruptions.

4.3.3 Documentation and Training

a. Submission of signed commissioning checklists, test results, and as-built drawings to the Owner.
b. Provision of OEM-certified test certificates for all major equipment.
c. Delivery of a commissioning report jointly signed by Owner and Supplier representatives.
d. Training session(s) for SLDC/NERLDC engineers and operators covering HMI navigation, reporting, troubleshooting, cybersecurity practices, and change management for islanding logics.

5 Data Requirement Sheet (DRS)

5.1 Phasor Data Concentrator (PDC/CCU)

Sl. No.	Description of Features	Requirement	Offered by Bidder	Compliance (Yes/No)	Remarks
1	Manufacturer	To be specified			
2	Model No.	To be specified			
3	Country of Origin	To be specified			
4	Operating System	The latest Windows Server LTSC (2025 or newer), or Embedded RTOS (VxWorks/Linux)			
5	RAM Requirement	16 GB or above			
6	Hard Disk Storage	2 TB or above			
7	No. of Processor Cores	8 or above			
8	Processor Speed	2.8 GHz or above			
9	I/O Ports	Minimum 2 × 1 Gbps Ethernet (expandable)			
10	Power Supply	Dual AC supply (redundant)			
11	User Interface	Through ≥ 55” monitor with GUI-based configuration & monitoring			
12	Mounting	Rack-mountable (19”)			
13	Supported Standards	IEEE C37.118.1/.2, IEC/IEEE 60255-118-1, IEEE C37.244, IEC 61850-3			
14	Communication Protocols	IEEE C37.118 synchro-phasor, IEC 60870-5-104 (Server/Client), IEC 61850 Ed1 & Ed2 (GOOSE/R-GOOSE), DNP3.0, SNMPv3, HTTPS/SSH			
15	PDC Sizing	Minimum 65,000 data points; 100 PMUs/1200 phasors @50 fps with 4 outputs; 50 PMUs/700			

		phasors @100 fps with 4 outputs			
16	Reporting Rate	Configurable from 1 to 100 fps			
17	Latency Performance	≤2 ms (100 PMUs), ≤5 ms (500 PMUs)			
18	Data Archiving	Relational DB and COMTRADE format; archival for 90–180 days			
19	Logic Functions	IEC 61131-3 PLC-based logic for islanding/load-shedding			
20	Cybersecurity	RBAC, RADIUS/LDAP/TACACS+, SNMPv3, Syslog export, firmware checksum validation, patch management			
21	Redundancy & Failover	Support for N+1 redundancy, automatic reconnection, Active/Passive or Active/Active failover			
22	Visualization & Reporting	Geo-spatial map, time-series charts, histograms, customizable reports & templates			
23	Documentation	Test certificates, type test reports, O&M manuals, compliance with cyber norms (CERT-In/NCIIPC)			

5.2 Phasor Measurement Unit (PMU)

Sl. No.	Description of Features	Owner's Requirement	Offered by Bidder	Compliance (Yes/No)	Remarks
1	Device	Phasor Measurement Unit (PMU)			
2	Manufacturer	To be specified			
3	Model No.	To be specified			
4	Country of Origin	To be specified			

5	Minimum Analog Channels	PMU shall be able to measure parameters for minimum 5 bays in single PMU			
6	Minimum Digital Inputs	8			
7	Minimum Digital Outputs	8			
8	CT Core	Suitable for Metering & Protection cores			
9	Auxiliary Power Supply	220 V DC, 110 V DC, 48 V DC (+10%, –15%) and 220 V AC			
10	Communication Ports	Two Ethernet port (10/100 Base Tx) and Two optical fiber port (100 Mbps)			
11	Time Synchronization Ports	IRIG-B (demodulated), 1 PPS, IEEE 1588v2 (PTP), Ethernet port (10/100 Base Tx)			
12	Protocols Supported	IEEE C37.118.2 (latest), IEC 61850 Ed.1 & Ed.2, IEC 61850-90-5, R-GOOSE, IEC 60870-5-104, DNP3.0 (serial & TCP/IP), IEEE 1588 PTP, IRIG-B			
13	Minimum Reporting Clients	Minimum 2 TCP clients and/or 2 UDP clients			
14	Performance Class	Both M-class and P-class, user selectable			
15	Reporting Rates	25, 50, or higher fps for 50 Hz system; user selectable; PMU sized for highest supported rate			
16	Compliance Standards	IEC/IEEE 60255-118-1:2018, IEEE C37.118.1-2011, IEEE C37.118.1a-2014			
17	Total Vector Error (TVE)	Less than 1%			

18	Active & Reactive Power	Computation for each feeder			
19	Frequency & ROCOF	Reporting of frequency and Rate of Change of Frequency (df/dt)			
20	Synchrocheck& Protection	Synchrocheck (25), Overfrequency (81O), Underfrequency (81U), ROCOF (81R); if not supported, separate relays shall be supplied			
21	Configuration Frames	Support Configuration Frame 2 & 3			
22	Multiple Data Streams	Support multiple independently configurable data streams (contents, sampling rate, class of service, TCP/UDP, destination IDCODE)			
23	LED display	LED to display real-time values, software version, configuration changes			
24	Remote Configuration	Possible via same channel as reporting to PDC/CCU			
25	Configuration Tool	Yes, with user-friendly interface			
26	Station/Phasor/Analog Names	Fully user configurable			
27	Disturbance Recorder	Minimum 8 analog + 16 digital channels			
28	Event Recorder	Up to 512 event records			
29	Self-Monitoring	Continuous self-diagnostics with alarms locally and to PDC			
30	Cybersecurity Features	RBAC, password protection, log maintenance, firmware validation, malware resistance, event logs forwarded to PDC;			

		compliant with IEEE 1686 / IEC 62443			
31	Test Reports	Bidder to provide measurement compliance test reports for both P and M classes			
32	Documentation	OEM to provide manuals, O&M guides, cyber compliance certificates, installation instructions			
33	Operating Temperature	–10 °C to +60 °C			
34	Humidity	10% to 95% non-condensing			
35	Standards Compliance	IEC 61850-3, IEC 60068-2, IEC 60255-21			

5.3 Network Management System (NMS)

Sl. No.	Description of Features	Minimum Requirement	Offered by Bidder	Compliance (Yes/No)	Remarks
1	Make	To be specified			
2	Model No.	To be specified			
3	Country of Origin	To be specified			
4	Mounting	Xeon-grade hardware, rack-mounted, industrial grade			
5	Processor cores	I8 cores or above			
6	Processor Speed	2.8 GHz or above			
7	RAM	16 GB or above (expandable to 32 GB)			
8	Storage	Minimum 2 TB (RAID-1/RAID-5 supported)			
9	Operating System	Latest Windows Server (2025 or higher) OR Linux-based hardened OS			
10	Network Interfaces	Minimum 2 × 1 Gbps Ethernet ports			

		(expandable), SNMPv3 support			
11	Web Access	Secure HTTPS-based web portal for operators/engineers			
12	Remote Access	Accessible via Remote Desktop Service (with multi-factor authentication and cybersecurity hardening)			
13	Auto Discovery	Auto-discovery of devices (Routers, Switches, Firewalls, PMUs, GNSS, Servers, Printers, etc.) with Layer-2/3 topology maps			
14	Device Monitoring	Continuous monitoring of availability, performance, link health (ICMP, SNMP, WMI, SSH)			
15	Alerts	Configurable threshold alarms via email, SMS, syslog; root-cause analysis			
16	Reporting	Customizable dashboards and templates; real-time and historical reports; export in CSV/PDF			
17	Inventory	Hardware/software inventory; patch/warranty reports			
18	Security	Role-based access control (RBAC); audit logs; compliance with ISO 27001 & CERT-In guidelines			
19	Data Retention	Logs and performance data retention for minimum 180 days (with archiving support)			
20	Documentation	OEM manuals, configuration guides, compliance/test certificates			

5.4 GNSS & NaVIC Time Synchronization Unit

Sl. No.	Description of Features	Owner's Requirement	Offered by Bidder	Compliance (Yes/No)	Remarks
1	Device	GNSS &NaVIC Time Synchronization Unit			
2	Manufacturer	To be specified			
3	Model No.	To be specified			
4	Country of Origin	To be specified			
5	Time stability of internal clock	Minimum 1 ppm			
6	Propagation delay compensation	Yes			
7	Offset for correction to local time	Yes			
8	Reverting to internal time base	Yes, upon loss of signal from GNSS &NaVIC using OCXO or better Oscillator			
9	Resynchronization Delay	≤ 5 minutes			
10	Accuracy of synchronization	≤ 0.2 µs (microseconds) to UTC; <1.5 µs during re-sync			
11	Interfaces	Minimum: 2 Ethernet port, 2 IRIG-B port, 2 PPS port			
12	IEEE 1588v2 (PTP) Compliance	Yes			
13	Time Synchronization Standards	IEEE C37.118.1-2011, IEEE C37.118.1a-2014, IEC/IEEE 60255-118-1:2018, IEEE C37.242-2013			
14	Dual Source Capability	Shall support both GNSS and NaVIC with user-selectable mode and automatic fallback			
15	Loss of Signal Alarm	Unit shall generate alarm on sync loss and revert to internal time base; alarm sent to			

		PDC/CCU using SNMPv3 protocol			
16	Antenna & Cabling	Outdoor GNSS &NaVIC antenna with weatherproofing; required length of coaxial cable, IRIG-B cable, surge arrestor, power cable, and mounting accessories to be supplied			
17	Power Supply	Dual AC (100 to 230 V, 50 Hz) and DC (48/90 to 250 V, ±10% to –15%)			
18	Environmental Conditions	Operating Temp: –10 °C to +55 °C or higher; Storage Temp: –20 °C to +70 °C; Humidity: 10–95% non-condensing			
19	EMC/Surge Compliance	IEC 61850-3, IEC 61000-4 series			
20	Regulation	MTCTE Certification			
21	Cybersecurity	Role-based access, password protection, firmware update validation, compliance with IEC 62443; all logs to be maintained			
22	Performance monitoring and Assurance	The system should support a high accuracy synchronisation monitoring and assurance tool for continuous PTP performance evaluation and alarm generation (e.g MTIE, TIE, etc)			
23	Documentation	OEM to provide manuals, configuration & maintenance guides, cyber compliance			

		certificates, calibration/test certificates for GNSS & NaVIC			

5.5 Layer-3 Switch

Sl. No.	Description of Features	Minimum Requirement	Offered by Bidder	Compliance (Yes/No)	Remarks
1	Device	Layer-3 Industrial Grade Ethernet Switch			
2	Manufacturer	To be specified			
3	Model No.	To be specified			
4	Country of Origin	To be specified			
5	Performance	Minimum 5 Gbps switching capacity			
6	Functions	Data exchange between PMUs, GNSS, Routers, Firewalls, PDC/CCU, and other devices at substation/control centre			
7	Layer-2 & Layer-3 Features	Static routing IPv4/IPv6; RIP (RIPv1/v2, RIPng); OSPFv2/v3; BGPv4 with IPv6; policy-based routing; IPv6-over-IPv4 tunneling			
8	Advanced Protocols & Features	DHCP client/relay/server; Multicast VLAN; Jumbo frames; 32K MAC table; DHCPv6, ICMPv6			
9	Standards & Protocol Support	IEEE 802.3u, 802.3x, 802.1p, 802.1Q (≥32 VLANs); 802.1d/802.1w RSTP (<50 ms); 802.1s MSTP; DiffServ QoS; IEEE 1588v2 (PTP, Power Profile)			
10	Network Management	Console port; CLI/Web/SNMPv3/REST; secure firmware/patch management			

11	Security Features	IPv4/IPv6 ACLs; IEEE 802.1X port-based auth; MAC auth; DHCP snooping; port security & isolation; RBAC & logging			
12	Speed Configurability	WAN ports configurable from 64 kbps to 2 Mbps (where applicable)			
13	Interface Ports	Adequate ports for all PMUs and devices, with 50% spare capacity			
14	Mounting	Rack-mountable, industrial grade			
15	Environmental Compliance	IEC 61850-3, IEEE 1613 (substation hardened); EMI/EMC: IEC 61000, FCC Part 15			
16	Operating Temperature	–10 °C to +75 °C; fanless design			
17	Power Supply	220 V AC at Control Centre; 220/110/48 V DC (+10%, –15%) at Substations			
18	Documentation	OEM manuals, configuration guides, firmware upgrade procedures, compliance certificates			

5.6 Next Generation Firewall (NGFW)

Sl. No.	Description of Features	Minimum Requirement	Offered by Bidder	Compliance (Yes/No)	Remarks
1	Make	To be specified			
2	Model No.	To be specified			
3	Country of Origin	To be specified			
4	GbE RJ45 WAN Ports	Minimum 8			
5	SFP ports	Minimum 2			
7	USB Ports	Minimum 2			
8	Console Ports	1 × RJ45			

9	Mounting	19” Rack or DIN Rail mount			
10	Certifications	CB, CE, UL, FCC, VCCI, ICES, BSMI, RCM; IEC 61850-3, IEEE 1613 (substation hardened)			
11	Power Input	Dual AC 230 V, 50 Hz; Redundant DC 48/110/220 V (+10%, –15%); external adapter support			
12	Operating Temperature	–10 °C to +60 °C (storage)			
13	Humidity	10% to 90%, non-condensing			
14	Log Storage Duration	Minimum 180 days (exportable to centralized syslog/SIEM)			
15	Threat Protection	Intrusion Detection & Prevention (IDS/IPS); DoS/DDoS protection; Deep Packet Inspection (DPI); Malware, Anti-virus, Anti-spyware protection; MITM prevention			
16	VPN & Encryption	Minimum 100 IPSec VPN tunnels; AES-128/256, SHA-1, SHA-2; throughput ≥ 5 Mbps; SSL VPN for clients (Windows/Linux/Mac)			
17	High Availability	Active/Passive and Active/Active with stateful session failover, load balancing			
18	Application & Content Control	Handle unknown applications (TCP/UDP); policy-based filtering (protocols, file types, directions); URL filtering			
19	Logging & Reporting	Logs/events in CSV/standard format; export to SIEM/syslog; searchable dashboard;			

		minimum 90 days onboard, 180 days external			
20	User Management	Centralized authentication (RADIUS, LDAP, TACACS+); RBAC with audit trails			
21	VLAN & Session Capacity	Support sufficient VLANs (≥ 1000) and high concurrent sessions (≥ 1 million)			
22	Network Monitoring	SNMP v3 (encrypted); real-time traffic visualization; policy hit counters			
23	Time Sync	Compatible with NTP/SNTP; synchronized to official Indian Time (time.nplindia.org)			
24	SCADA/OT Protocols	Support SCADA protocols: IEC 60870-5-104, ICCP, IEEE C37.118, IEC 61850 (GOOSE/R-GOOSE)			
25	Management Access	Secure HTTPS Web UI, CLI via SSH, REST API; role-based user access			
26	Cybersecurity Lifecycle	OEM to provide firmware/security patches free during AMC; process for checksum validation before upgrades			
27	Documentation	OEM manuals, cyber compliance certificates, test reports, configuration & upgrade guides			

5.7 Router

Sl. No.	Description of Features	Minimum Requirement	Offered by Bidder	Compliance (Yes/No)	Remarks
1	Make	To be specified			
2	Model No.	To be specified			
3	Country of Origin	To be specified			

4	Interfaces	Minimum 8 × GE LAN ports and 2 × WAN ports (10/100/1000 Mbps)			
5	Routing Features	Support for static routing, OSPFv2/v3, BGPv4 (with IPv6), policy-based routing, MPLS ready			
6	VPN Support	IPSec VPN with AES128/256, SHA1/SHA2; ≥ 100 VPN tunnels; throughput ≥ 300 Mbps			
7	Firewall & Security	Access Control Lists (ACLs), port security, MAC filtering, DHCP snooping; IDS/IPS integration			
8	QoS Features	Bandwidth allocation, prioritization, traffic shaping (per VLAN and per application)			
9	Protocol Support	IPv4/IPv6 dual stack; RIP, OSPF, BGP; DHCP, NAT, NTP/SNTP			
10	Management	Secure HTTPS Web GUI, CLI (SSH), SNMPv3, remote syslog			
11	High Availability	VRRP/HSRP support for redundancy; failover with zero session loss			
12	Power Supply	Dual AC 230 V (50 Hz) supply; redundant DC 48/110/220 V (+10%, –15%)			
13	Operating System	OEM embedded OS (hardened, security patched)			
14	Operating Temperature	–40 °C to +70 °C			
15	Humidity	10% to 85% (operating); 5% to 95% (storage, non-condensing)			

16	Certifications	IEC 61850-3, IEEE 1613 (substation environment); EMI/EMC: IEC 61000			
17	Log Storage	Local logging (≥ 90 days) + export to centralized syslog/SIEM			
18	Mounting	Rack mountable, DIN rail support optional			
19	Documentation	OEM manuals, compliance/test reports, configuration & firmware upgrade guides			

5.8 Workstation (HMI)

Sl. No.	Description of Features	Minimum Requirement	Offered by Bidder	Compliance (Yes/No)	Remarks
1	Processor	64-bit, 8-core, 16-thread, ≥ 2 GHz, ≥ 8 MB cache			
2	Memory	32 GB DDR4 RAM (expandable to 64 GB)			
3	Graphic Processor	Dedicated GPU (2 GB or higher) for visualization			
4	Hard Disk	2 TB HDD + 512 GB SSD (OS + application separation)			
5	Display & Access Tools	≥ 24" dual monitor with HDMI; USB keyboard & mouse			
6	USB Connectors	≥ 4 × USB (2.0 or higher, at least 2 × USB 3.0)			
7	Mounting	Rack-mounted CPU; monitor, keyboard, mouse on operator table			
8	Operating System	Latest Windows 11 Pro			
9	Pre-installed Software	Licensed MS Office (latest), licensed			

		antivirus with 3-year subscription			
10	Network Interface	≥ 4 Ethernet ports, 10/100/1000 Mbps			
11	Power Input	220 V AC ±10%, 50 Hz			
12	HMI Functions	Real-time display of synchro-phasor s, alarms, events; user interface for islanding logic editing; SLD visualization			
13	Event/DR Storage	Auto-archival of COMTRADE DR files from PMUs; minimum 1-year retention			
14	Reporting	Configurable Sequence of Events (SOE) report; disturbance reports; customizable templates			
15	Security	Role-Based Access Control (RBAC), user authentication & audit logs			
16	Remote Access	Minimum 3 web remote monitoring licenses			
17	Documentation	OEM manuals, test certificates, compliance reports, configuration & maintenance guides			

5.9 Heavy Duty Relay/High Burden Relay (HDR)

Sl. No.	Description of Features	Minimum Requirement	Offered by Bidder	Compliance (Yes/No)	Remarks
1	Make	To be specified			
2	Model No.	To be specified			
3	Country of Origin	To be specified			
4	Standard Coil Rating	110/125 VDC or 220/250 VDC; shall operate reliably between 75%–			

		120% of rated voltage			
5	No. of Output Contacts	Minimum 12 NO contacts			
6	Operating Time	≤ 25 ms			
7	Insulation	Shall comply with IS 3231:1965 / IEC 255-5, Series C-2, withstand 2 kV for 1 minute			
8	Contact Rating	DC Current: • Continuous: 1250 W (max 10 A at 660 V) • 3 Sec: 1250 W (max 30 A at 660 V) • Break: 100 W (resistive), 50 W (inductive) with max 5 A at 660 V			
9	Flag	Mechanical flag for operation indication			
10	Contact Reset	Manual reset type			HDR shall have two coils operating & reset coil. Reset Logic to be implemented from UFR/ PMU as per islanding condition
11	Earthing	Metallic body connected to panel earth bus with 2 × 2.5 mm² green copper wire			
12	Mounting	Panel-mounted, dust-proof construction, suitable for			

		substation environment			
13	Compliance	IEC/IS standards for HV substations, EMI/EMC, and environmental suitability			
14	Documentation	OEM catalogues, type test certificates, compliance reports to be submitted			

5.10 Under Frequency Relay

Sl. No	Technical Requirement	Specification	Compliance (Yes/No)	Remarks
1	Type	Numerical, microprocessor-based Under Frequency Relay		
2	Function	Automatic load shedding and islanding relay with under-frequency and df/dt functions		
3	Number of frequency stages	Minimum 4, programmable		
4	df/dt function	Programmable rate-of-change-of-frequency protection for each stage		
5	Tripple VT inputs (3 sets of R,Y,B,N)	Supported, with automatic selection, preferred VT, VT-fuse failure detection, hysteresis & dwell time, manual retransfer		To implement 2 out of 3 UFR Logic for station generation & validation for disabling SPS scheme during islanding
6	Time delay	Definite time, dual time delay for fast/delayed action		

7	Recovery function	Programmable deviation and time delay		
8	Undervoltage blocking	Provided to prevent maloperation		
9	External inputs	Provision for blocking/unblocking/selective operation		
10	Outputs for HDR	Minimum 4 binary outputs for tripping High-Speed Drop Relays (HDRs)		
11	Status reporting to PMU	Operation/event status sent to PMU for central monitoring		
12	Event recording	SOE with timestamp resolution ≤ 1 ms		
13	Communication protocols	IEC 61850 Ed.1/Ed.2 (GOOSE/R-GOOSE), IEC 60870-5-104, IEEE C37.118		
14	Communication ports	Minimum 1 Ethernet (10/100 Mbps), 1 Optical (100 Mbps)		
15	Time synchronization	IRIG-B, SNTP/NTP, IEEE 1588 (PTP)		
16	Power supply	220 VDC / 110 VDC / 48 VDC (+10%, -15%)		
17	Environmental conditions	–10 °C to +55 °C (operation), –25 °C to +70 °C (storage), 5–95% RH		
18	EMC compliance	IEC 61000, IEC 60255-26, IEC 61850-3		
19	Vibration/shock	IEC 60255-21, IEC 60068		
20	Mounting	Panel mounting, indoor, IP41 minimum protection		
21	Documentation	Type test, routine test, O&M manuals, wiring/configuration diagrams		

6 Annual Maintenance Contract (AMC)

6.1 Introduction

The scope of work under maintenance & support services shall include maintenance of all the software, hardware and services of supplied System along with the future integration and support services for meeting the future requirement envisaged under this project on single responsibility basis. The maintenance practices to be followed shall be as per ISO 20000 Standard. The essence of the maintenance and support services is to provide maintenance support for the entire system (hardware and software) supplied by the Contractor, with the goal of meeting the availability as set forth herein. The availability of all the equipment/items supplied under the contract is the essence of the contract. Contractor shall maintain required availability of the system during entire contract period (including extension of contract, if any) as per the terms and conditions and requirements mentioned in document. The maintenance of all the supplied system comprises of all activities required to keep the systems up and running all the time at an optimum level by proactive monitoring, diagnosis and rectification of any failure of all the hardware(s) and software(s). The 24x7x365 support shall be provided by Contractor.

The period of maintenance support shall consist of one-year Warranty (Defect Liability extendable, if defects found) period commencing from Operational Acceptance and four years Maintenance period thereafter. Payment will not be released during defect liability period. The Owner at their own discretion may extend the duration of maintenance period for up to 2 years based on the same rates in the contract and at the same terms and conditions. For any addition during the maintenance period, Contractor shall provide services for maintenance of those systems also without any additional cost. The contractor shall guarantee continuous availability of the system at 99.0% for a period of four years commencing after completion of the warrantee period. The availability figures of 99.0% will be measured and verified for each PMU installed in the system. Further the availability of 99.0% of Islanding System at SLDC/NERLDC including PDC, NMS, Firewall etc. shall also be ensured by the contractor. During this period, the contractor shall take continual actions to ensure the guaranteed availability and shall make available all the necessary resources such as specialist personnel, tools, test devices etc for replacement or repair of all defective parts and shall have prime responsibility for keeping the system operational. For the period, commencing immediately after Operational Acceptance, the actual availability achieve would be calculated jointly by the contractor's representative and AEGCL. In case the actual achieved availability falls short of the guaranteed availability, it would be considered as contractors default. However, before declaring the contractor's default the AEGCL shall negotiate for reaching a mutually acceptable agreement. The contractor shall ensure 99.0% availability of entire system including PMU, PDC & all other items in the BoQ. For all third-party equipment (Hardware & Software), Contractor shall have back-to-back support & warranty with appropriate response time from OEM and these Back-to-Back contracts will be shared with owner before start of defect liability period. Contractor shall be responsible

for coordination with the OEM for all matter related to that equipment and for meeting the overall response times and availability requirements specifiedin the Specification. The spares as mentioned in the Annexure-2 of Particular Conditions shall be provided to SLDC. The system availability shall be computed after ensuring the availability of spares. Contractor shall also be responsible for hardware/software replacement/upgradation without any additional cost in case OEM declares end of life/end of support/ obsolescence for the product.

6.2 Scope of Work under AMC

The maintenance of the System shall comprise of the following category of works which is further elaborated for each of the different subsystems:

a. Preventive Maintenance of Substation PMU/GNSS/Router/Switch & Control Centre (SLDC/NERLDC) equipment like PDC, NMS, Firewall, Router etc.
b. Preventive Maintenance Activity (performance monitoring, system backup, patch management, updates, emergency response and troubleshooting).
c. The integration of new equipment such as PMUs, Workstations, Printers, Switches, Routers, etc., shall fall under the scope of the Contractor. The procurement of such new equipment and necessary cables will be the responsibility of the Owner. Upon successful integration, the newly added equipment shall automatically form part of the Annual Maintenance Contract (AMC) without imposing any additional cost on the Owner.
d. The establishment of connections between HDRs/PMUs and the associated field equipment (CT/CVT/PT or Circuit Breaker) using appropriate cabling, for the purpose of data acquisition and control, shall fall under the scope of the Contractor. Furthermore, the connection of PMUs with the existing Layer-3 (L3) switch shall also be within the Contractor's scope.
e. At control centre, the LAN connection between new equipment and existing system will be under the scope of contractor.
f. Changes in the logics of operation of islanding scheme during the AMC period.
g. OEM Back-to-back Support:
    i. All the supplied system shall be under OEM (Hardware and Software) warranty & support till the completion of entire AMC period (including extension of contract, if any).
    ii. During entire contract period (including extension of contract, if any), if OEM discontinues / declared ends of support to any item supplied (software/hardware/security solution/OS) under the contract, contractor has to replace such hardware, software (or both, depending on software or hardware dependencies on each-other) without any additional cost to Owner. Replacement shall be of either same or higher configuration keeping required performance specified under the contract and it shall be from the same OEMs. OEM can be changed only after the receipt of letter from OEM regarding non-availability of similar or higher configuration of non-supported item(s). If any development,

customizations, testing, etc. needs to be done for the compatibility of Islanding Scheme and other applications, then the same shall be done by the contractor at its own cost. Quarterly payment shall be released after the submission of valid OEM support for all the supplied system.

h. Contractor shall ensure that the supplied system is cyber secure & all kinds of cyber security measures need to be adopted by the contractor during AMC period as per directions of SLDC Assam. Any kind of upgradation in the system for enhancing the cyber security of the system and to comply with the guidelines, shall be done by the contractor free of cost during entire AMC period.

i. Signature updates throughout the contract period including AMC of various software licenses supplied under this project shall be in scope of the contractor.

j. In case of end-of-life, obsolescence and end-of-support of the operating system, Anti-Virus or any other software delivered in the project, the contractor should provide latest version and license of operating system, Anti-Virus or any other software delivered in the project at its own cost. If changes of software and operating system require replacement of hardware's, then, hardware shall also be replaced by the contractor without any cost implication to owner. Replacement shall be of either same or higher configuration keeping required performance specified under the contract and from same OEMs.

k. If any development, customizations, testing, etc. needs to be done for the compatibility of Islanding Scheme and other applications on the new OS platform, Anti-virus and any other software delivered in the project upgradation, then the same shall be done by the contractor at its own cost.

6.3 Deployment of Site Engineer

The Contractor shall provide an engineer at SLDC who has an experience and skill to maintain the PMU & Islanding System including PDC & all other items mentioned in the BoQ to achieve the desired level of availability. The site engineer shall be readily available to move to the substation site or NERLDC for attending any kind of issues occurring in NERLDC equipment, PMU, GNSS, Switches etc. Further the maintenance of Islanding System at control centre (SLDC/NERLDC) including PDC, NMS, Firewall etc (Hardware & Software) shall also be responsibility of the site engineer. The timings for Emergency Support would be 24 hours a day, 7 days a week throughout the year. The onsite support staff should possess capability for supporting the equipment and components proposed, but not limited to undertaking preventive and break-fix maintenance, troubleshooting, resolving problems, tuning etc. The Contractor shall also provision for necessary offsite support to ensure continuity of operations.

The site engineer will attend the office at SLDC as per the working hours/days of the AEGCL.

6.4 Payment of Maintenance Charges

In the event of availability falling below a certain level, the maintenance charges shall be proportionately reduced as follows:

Sr. No.	Availability	Deduction as % of the apportioned price of total AMC applicable for that site
1	> 99%	Nil
2	Less than 99%	Deduction of 2% of the quarterly AMC charges for every 1% (or part thereof) decrease in availability below 99%.

The computation of availability/non-availability shall be rounded up to two decimal places, and any deduction in the maintenance charges shall be calculated strictly on a pro-rata basis as per the above table.

6.5 Terms and Condition of Annual maintenance contact (AMC)

6.5.1 Application software maintenance

6.5.1.1 Corrective Maintenance

Corrective Maintenance shall include, but not be limited to, the following activities:

- **Bug Rectification: I**dentification and rectification of bugs or errors that prevent the software from being available, accessible, or correctly reported by the utility during normal operation of the system. This applies to each software module and deliverable, when used under normal conditions of the hardware for which it was designed.
- **Functionality Restoration:** Troubleshooting and rectification of failures in implemented functionalities to ensure that all features of the system operate as intended.
- **System Stability:** Ensuring that corrective actions taken to not introduce new errors and that the system performance is restored to the agreed specifications and standards.
- **Documentation:** Preparation and submission of a corrective maintenance report detailing the fault, root cause analysis, corrective action taken, and preventive recommendations to avoid recurrence.

6.5.1.2 Preventive Maintenance

Preventive Maintenance shall carried out by the contractor on quarterly basisand include proactive measures aimed at minimizing and eliminating potential defects that may prevent the deployed software from being available and functioning reliably. The scope shall cover the following:

- **Defect Prevention: I**dentification and resolution of potential issues before they can impact system availability, including patch application, version upgrades, and fine-tuning of configurations.
- **System Health Checks:** Periodic inspection of hardware and software components to ensure optimal performance and to detect early signs of degradation.
- **Performance Optimization:** Regular housekeeping, such as clearing unnecessary logs, optimizing databases, and validating backup and recovery procedures.
- **Compliance Assurance:** Ensuring that the system continues to comply with evolving standards, cybersecurity requirements, and interoperability obligations.
- **Reporting:** Preparation of preventive maintenance reports highlighting tasks performed, observed risks, and recommendations for improving system reliability.

6.5.2 Hardware Maintenance

(Applicable for all supplied items by the bidder, i.e., PMU with GNSS, Layer-3 Switches, Control Cables, FO Cables, PDC, NMS, Firewall, Routers, HMI etc.)

6.5.2.1 Corrective Maintenance

Corrective hardware maintenance shall include the following activities:

- **Defect Rectification: I**mmediate rectification of hardware defects that prevent the supported equipment from performing its intended functions or cause downtime of critical applications.
- **Troubleshooting: I**dentification and resolution of failures in implemented hardware functionalities, including replacement or repair of defective components, cards, cables, or modules.
- **Restoration of Service:** Ensuring that hardware performance is restored to original specifications within

6.5.2.2 Preventive Maintenance

The Preventive Maintenance (PM) activity shall be carried out by the Contractor on quarterly basis to ensure that the system continues to run at its optimum level. The scope shall include diagnosis, rectification, and performance optimization of both hardware and software components. Preventive Maintenance shall broadly cover the following activities:

a) **Repair/Replacement of Equipment:** Repair or replacement of defective equipment, including all hardware and consumables required for the various systems. The Contractor shall be fully responsible for ensuring the continued operability of all supplied items.

b) **Configuration and Routine Checking:** Configuration of replaced hardware and periodic routine checks as part of a preventive maintenance program. This shall include verification of functionality of all hardware and software.

c) **Performance Monitoring and Tuning:** Monitoring of the performance of PMUs and the overall system, along with necessary tuning for optimum performance to accommodate changes such as the addition of new components.

d) **Backup Management:** Ensuring automated backup of the system at regular intervals and monitoring of all auto-backup schedules to confirm successful execution.

e) **System Restoration:** Restoration of PMUs and Control Centre systems in the event of failure, ensuring timely recovery of all functionalities at the respective Control Centres.

f) **Physical Maintenance:** Regular physical maintenance of all equipment/modules under the contract scope. This shall include cleaning, dusting, inspection for loose connections, checking for insulation damage, rodent damage, and other environmental factors. A quarterly preventive maintenance report shall be submitted to the Owner.

6.6 Availability and Maintenance Charges Payment Calculation

The overall islanding system availability and maintenance charges payment calculation shall be based on the average availability of the following categories of equipment:

a) **Field Devices:** PMUs, GNSS units, Ethernet Switches, and associated hardware at substations and generating stations.
b) **Control Centre Equipment:** PDCs/CCUs, NMS, Firewalls, Workstations, Routers, and related systems installed at SLDC/NERLDC.

6.6.1 Availability and Maintenance Charges Payment Calculation for Field Devices

The availability of field devices shall be computed separately and factored into the average calculation for system availability. Service response requirements are defined in terms of severity levels, with the primary objective of restoring the availability of PMUs and associated devices to operational state as quickly as possible.

Service Response Requirements

Three severity levels shall apply, and problems may be reported telephonically or via email or customer care web portal provided by the contractor. The Contractor shall provide acall tracking system (preferably web portal) at no additional cost to the Owner for logging, monitoring, and closing of all reported issues. The details are tabulated below:

Category	Definition
Severity–1	Outage of PMU data due to any kind of issue in PMU, GNSS, Switch, etc., including wrong PMU data.
Severity–2	Outage of GNSS/Switch/Router, delay in PMU data, poor GNSS lock, latency.
Severity–3	Problems in cabling, panels, etc., that do not affect PMU data availability.

Severity-4	Request for information, technical configuration assistance, "how to" guidance, and enhancement requests.

Initially, the AEGCL Engineers shall attempt to restore the system at the substation. In case the system does not come up and/or the problem is not resolved, the AEGCL Engineer shall intimate the problem to the contractor. Upon receiving intimation, the representative of the contractor shall immediately attend to the problem. The problem shall be attended by the contractor at the earliest, and it shall arrange all necessary resources and take all steps to restore the data availability and functionality at the earliest.

The non-availability hours for availability calculation will be counted from the end of the allowed Action Resolution time. It is the endeavour of both the contractor and AEGCL to maximize system availability to the extent possible.

Duration of outages over and above the action resolution time, as defined in the below-mentioned table, in each of the Severity levels will be counted for the non-availability computation. The resolution may be accomplished by a workaround, and such solution will mark the end of non-availability.

In the event of multiple failures at a site, due to a common cause, the first FPR (Field Problem Report) logged will be used for availability calculation. However, simultaneous multiple outages due to unrelated causes shall be counted separately, and such multiple outages under each category of Severity level will be considered for availability computation of the system as defined in the section below.

Availability Computation

Availability computation shall be carried out on a quarterly basis for each site. The following formula shall be used for calculating availability of field devices:

$A_f = (THQ - ((S1 \times 1 + S2 \times 0.8 + S3 \times 0.5) * THQ))/THQ \times 100\%$

Where:

- **THQ** = Total Hours in the Quarter
- **S1** = Total non-available hours in Severity Level–1 during the Quarter
- **S2** = Total non-available hours in Severity Level–2 during the Quarter
- **S3** = Total non-available hours in Severity Level–3 during the Quarter

Note: The above methodology for computation of field devices availability is tentative and may be revised/updated, if required, at the time of Order Placement to reflect the final agreed criteria.

Response and Resolution Time for Field Devices

This section describes the target times within which the bidder should respond to support requests. The Initial Response Time is defined as the period from the initial receipt of the support request (through approved communications channels) and the acknowledgment of the bidder subject to the maximum time defined in the table below.

The **Action Resolution Time** is the period from the acknowledgment of support request to the bidder delivering a solution subject to the maximum time defined in the table below. This period includes investigation time and consideration of alternative courses of action to remedy the situation. The Action is defined as a direct solution or a workaround.

Severity	Initial Response Time	Action Resolution Time
1	30 minutes	24 hours
2	2 hours	48 hours
3	1 day	2 days
4	1 Day	5 Days

6.6.2 Availability and Maintenance Charges Payment Calculation for Control Centre

Four severity levels shall apply, and problems may be reported telephonically or via email customer care web portal provided by the contractor. The Contractor shall provide a call tracking system at no additional cost to the Owner for logging, monitoring, and closing of all reported issues. The details are tabulated below:

Category	Definition
Severity-1	Complete system failure, failure of servers, loss or failure of any major subsystem or system component such as to cause a significant adverse impact to system availability, performance, or operational capability.
Severity-2	Degradation of services or expiry of software licenses or critical functions such as to negatively impact system operation. Failure of any redundant system component such that the normal redundancy is lost. Non-availability of manpower at Control Centre, cybersecurity compliance, patch management, non-availability of back-to-back OEM warranty contract for third-party hardware/software/solutions along with its subscription.
Severity-3	Any other system defect, failure, or unexpected operation, patch application as recommended by Owner.
Severity-4	Request for information, technical configuration assistance, “how to” guidance, and enhancement requests.

Severity-1

This support level is required in case of a complete system failure, failure of servers, severe

system instability, or the loss/failure of any major sub-system/system or its components, which significantly impacts the system availability, performance, or operational capability at the Control Centre.The following critical functionalities shall be considered under Severity-1:

a) Loss of critical functionality that causes outage of software/hardware-related functions in the Islanding System.
b) Outage of hardware, networking equipment, or software including PDC/Firewall/NMS, etc.
c) Outage of any critical functions as envisaged in the Technical Specifications.
d) Loss of data exchange with PMU or other integrated systems.

Severity-2

Support services not falling under Severity-1 shall be classified as Severity-2. These include:

a) Inability of the user to create/edit logics, displays, databases, or calculations.
b) Cybersecurity remedial actions/compliance suggested by the Owner within the defined timeframe, including timely patch management.
c) Stoppage of data collection for archiving (where data storage continues in pre-specified buffer).
d) Outage of applications not covered under Severity-1.
e) Non-availability of OEM back-to-back warranty for supplied systems (hardware and software) during AMC period.
f) Non-availability of designated Contractor manpower at the Control Centre (maximum travel time of 24 hours shall be allowed for manpower replacement).
g) Non-compliance of monitoring functions.

Severity-3

This category covers support services where the outage or loss of functionality does not qualify as emergency or priority functions under Severity-1 or Severity-2. Examples include:

- Support at Control Centre for integration of new equipment (PMU, GNSS, Switch, Workstation, Printers, etc.).
- Failure of a workstation or other non-critical devices.

Severity-4

This category includes non-critical support such as:

- Requests for information.
- Technical configuration assistance.
- “How to” guidance.
- Enhancement requests.

Response and Resolution Time for Control Centre

This section defines the target times within which the Contractor must respond to and resolve support requests for each severity level.

- **Initial Response Time**: The period between the initial receipt of the support request (through approved communication channels) and the acknowledgment of the Contractor, subject to maximum time defined in the table.
- **Action Resolution Time**: The period between acknowledgment of the support request and delivery of a solution by the Contractor (direct solution or workaround), subject to maximum time defined in the table. This includes investigation, diagnosis, and implementation of corrective measures.

Severity	Initial Response Time	Action Resolution Time
1	30 Minutes	1 Hour
2	1 Hour	6 Hours
3	12 Hours	1 Day
4	1 Day	5 Days

Availability per Quarter of Control Centre (A_c):

$A_c = (THQ – ((S1 \times 1 + S2 \times 0.8 + S3 \times 0.5) * THQ))/THQ \times 100\%$

Where:

- **THQ** = Total hours in the quarter
- **S1** = Total non-available hours in Severity Level-1 in the quarter
- **S2** = Total non-available hours in Severity Level-2 in the quarter
- **S3** = Total non-available hours in Severity Level-3 in the quarter

Total Availability per Quarter (System Level):

$A_{Total} = (A_f + Ac)/2$

Where:

- **A_f**= Availability per quarter of field devices
- **A_c** = Availability per quarter of control centre

7 Security-Related Aspects for Service Level Agreement

1) It shall be ensured that the procured product complies with the current good practices for cybersecurity of industrial control and energy delivery systems.
2) The Contractor shall ensure that complete documentation of all software and firmware supporting the procured product is provided. This shall include scripts, macros, runtime configuration files and interpreters, databases, tables, and all other software with identified versions, revisions, and patch levels. Documentation shall clearly list all active ports and authorized services required for operation, along with all disabled ports, connectors, and interfaces. The product shall be configured to allow the Owner the ability to re-enable ports or services if they are disabled by software.
3) It shall be the responsibility of the Contractor to manage all identified vulnerabilities prior to delivery of the product. Any vulnerabilities remaining at the time of delivery shall be notified to the Owner. During the life cycle of the product, the Contractor shall ensure timely notification of vulnerabilities. Summary documentation of uncorrected vulnerabilities or breaches shall be provided, including description, potential security impact, root cause, and recommended corrective actions.
4) The Contractor shall notify the Owner without delay of any potential security incidents or risks, including breaches affecting data connections, personnel issues, compromise of information (physical or electronic), or vulnerabilities in the Contractor's environment which may affect the Owner's systems.
5) The Contractor shall be accountable for the cybersecurity of its entire supply chain, including subcontractors and sub-suppliers. All equipment and devices supplied under the scope of this contract shall comply with the same security requirements as the procured product. It shall be ensured that all agreed supply chain security requirements such as product assurance, vulnerability testing, audits, and penetration testing in non-operational or controlled test environments are met.
6) The Contractor shall provide summary documentation of the secure product development life cycle adopted. This documentation shall cover the standards and practices followed, continuous improvement mechanisms, details of the development environment, and application of secure coding practices.
7) The Contractor shall provide a complete inventory of all assets supplied under this contract, identifying critical or operationally important assets wherever possible. System interfaces and dependencies shall also be documented, and any changes or modifications shall be updated in the inventory or formally reported to the Owner.
8) The Contractor shall comply with all security policies and procedures of the Owner relating to information management and any connections to the Owner's systems.
9) It shall be ensured that the procured product incorporates appropriate security, network segregation, and defence-in-depth provisions. The Contractor shall provide guidance on the design and configuration of network security zones. Documentation shall specify all communications required between zones, whether inbound or outbound, and identify each network component initiating communication. It shall also be verified and documented that disconnection points exist between zones, with methods to isolate zones while ensuring limited operations continue.

10) The Contractor shall verify and provide documentation that the procured product does not contain unauthorized logging devices such as key loggers, cameras, or microphones.
11) The Contractor shall provide documentation of all accounts, including generic and default accounts, which must remain active for proper operation of the procured product.
12) It shall be ensured that all default account settings are changed to Owner-specific secure settings relating to password length, complexity, history, and configurations. Where required, the Contractor shall support the Owner in implementing these changes. Credentials shall not be published, and new account information shall be provided to the Owner via secure means only.
13) Prior to delivery, the Contractor shall ensure that all accounts not required for normal or maintenance operations are removed or disabled from the procured product.
14) The Contractor shall configure emergency operation accounts, as specified by the Owner, in highly secure settings and provide documentation of their configuration.
15) The Contractor shall provide a configurable account password management system. This shall include capability to enforce password length and complexity, frequency of password changes, login attempt limits with account lockout, inactive session logout, screen lock functionality, prohibition of repeated or recycled passwords, and validation against forbidden strings.
16) It shall be ensured that all passwords are adequately protected. Passwords shall not be stored in clear text, nor shall they be hardcoded into software or scripts.
17) The Contractor shall ensure that all software, firmware, and security patches are updated regularly. Critical patches shall be deployed within an agreed timeframe, and a quarterly patch compliance report shall be submitted to the Owner.
18) The Contractor shall support periodic security audits of the procured system, at least annually or as directed by the Owner. Audit findings shall be addressed within the agreed timeframe without any additional cost to the Owner.
19) Remote access for diagnostics, configuration, or updates shall only be permitted through secure Owner-approved channels, such as VPN with multi-factor authentication. All remote access activities shall be logged and monitored by the Owner.
20) The Contractor shall provide a tested mechanism for automatic backup and restoration of configurations, logs, and security-related settings. Backup data shall be encrypted and stored securely in compliance with the Owner's policies.
21) The procured product shall comply with recognized cybersecurity standards such as ISO/IEC 27001, IEC 62443, NERC CIP, or equivalent. Certificates or supporting documents shall be provided by the Contractor.
22) The Contractor shall notify the Owner at least twelve (12) months in advance of any supplied product, firmware, or software reaching end-of-support or end-of-life status. A migration or replacement plan shall be submitted to maintain system security and availability.
23) The system shall generate security logs in standard formats (e.g., syslog) and shall support integration with centralized Security Information and Event Management

(SIEM), Security Operations Centre (SOC) systems. Logs shall capture login attempts, configuration changes, patch applications, and all security-related events.

24) The Contractor shall provide documented incident response procedures aligned with the Owner's cyber incident response plan. This shall define escalation levels, timelines, and coordination protocols with Owner personnel during cybersecurity events.

--- End of Document ---

BoQ for Control Centre				
Sl. No.	**Name of the equipment**	**Qty (for NERLDC)**	**Qty (for SLDC)**	**Total**
1	Phasor Data Concentrator (PDC)	1	1	2
2	HMI server PC Advantech	2	2	4
3	SAS Rack panel	1	1	2
4	LaserJet Printer	1	1	2
5	NMS software +Server	1	1	2
6	Firewall	1	1	2
7	Furniture	2	2	4
8	GPS clock including all hardware and accessories	1	1	2
9	2 FE/ 4 GE port Router for connecting SDH with Firewall	1	1	2
10	CAT 6 UTP Ethernet Cable (300 m)	2	2	4

BoQ For stations

Sl. No.	Name of Station	No of PMUs Required	Number of UFRs required	Number of Heavy Duty relay required	42U Rack	Time Synchronisation Equipment complete with GPS clock and all hardware	Gigabit Ethernet switch (16 port)	Cables & Accessories				
								Optical Fibre Patch cords (10 Mts) and 10 nos. in one set	CAT 6 UTP ethernet cable (300 mtr)	Cable & accessories 5CX2.5 sq mm PVC Control Cable	2CX6 sq mm PVC Power Cable	Terminal Blocks (20 positions)
1	400/220 kV Bongaigaon	5	1	25	1	1	1			1	1	
2	BgTPP NTPC	3	1	6	1	1	1			1	1	
3	400/220 kV Mirza	1	1	6	1	1	1			1	1	
4	220kV BTPS	3	1	9	1	1	1			1	1	
5	220/132/33 kV Sarusajai	2	1	7	1	1	1			1	1	
6	132/33 kV Kahilipara	3	1	10	1	1	1			1	1	
7	132/33 kV Sisugram	1	0	4	1	1	1			1	1	
8	220/132 kV Agia	2	1	4	1	1	1			1	1	
9	220/132 kV Boko	2	1	3	1	1	1			1	1	
10	132/33 kV Kamakhya	1	1	5	1	1	1			1	1	
11	220/33 kV Jawaharnagar	1	1	5	1	1	1	6	6	1	1	
12	132/33 kV Narengi	2	0	3	1	1	1			1	1	
13	132/33 kV Azara	2	0	3	1	1	1			1	1	
14	220/132/33 kV Sonapur	1	1	7	1	1	1			1	1	
15	132/33 kV AIIMS	1	0	3	1	1	1			1	1	
16	220/132 kV AMINGAON GIS	2	1	10	1	1	1			1	1	
17	132/33 kV Chandrapur	2	1	5	1	1	1			1	1	
18	Karbi Langpi HEP	2	1	3	1	1	1			1	1	
19	132/33 kV Guwahati Medical College	2	0	3	1	1	1			1	1	
20	132/33 kV Paltan Bazar	2	0	4	1	1	1			1	1	
21	132/33 kV Dispur	2	0	3	1	1	1			1	1	
	Total	**42**	**14**	**128**	**21**	**21**	**21**					

Number of Heavy Duty in the Guwahati Island for LGBR and Island Formation (considering of all 132 kV and above Elements)						
Sl. No.	**Name of Station**	**Number of Heavy-duty relay required (for Island formation)**	**Name of Element where Heavy-duty relay will be installed (for Island formation)**	**Number of Heavy-duty relay required (for LGBR)**	**Name of Elements where heavy duty relay will be installed for LGBR.**	**Total number of Heavy duty relay.**
1	400/220 kV Bongaigaon	25	1.Dia 416, 417 & 418 2. Dia 420 & 419 3. Dia 422 & 423 4. Dia 427 & 426 5. Dia 413, 414 & 415 6. Dia 410, 411 & 412 7. Dia 407, 408 & 409 8. Dia 404, 405 & 406 9. Dia 401, 402 & 403	--	--	25
2	BgTPP NTPC	1	--	5	1. Unit-1 2. Unit-2 3. Unit-3 4. 400 kV Bongaigaon (PG) line-1 5. 400 kV Bongaigaon (PG) line-2	6
3	400/220 kV Azara	3	1. 400kV SILCHAR LINE MAIN BAY; 2. 400kV SILCHAR LINE TIE BAY 3. Spare	3	1. 132/33kV, 50MVA ICT-I; 2. 132/33kV, 50MVA ICT-II 3. Spare	6
4	220kV BTPS	9	1. 220kV RANGIA LINE I; 2. 220kV RANGIA LINE II; 3. 220kV SALAKTI (PG) LINE I; 4. 220kV SALAKATI (PG) LINE II; 5. 220/132kV, 160MVA ICT-I; 6. 220/132kV, 160MVA ICT-II 7. 220/132kV, SPARE ICT BAY 8. Spare	--	--	9

5	220/132/33 kV Sarusajai	3	1. 132kV UMTRU LINE I; 2. 132kV UMTRU LINE II 3. Spare	4	1. 132/33kV, 31.5MVA ICT-I; 2. 132/33kV, 31.5MVA ICT-II; 3. 132/33kV, 50MVA ICT-III 4. Spare	7
6	132/33 kV Kahilipara	3	1. 132kV UMTRU LINE I; 2. 132kV UMTRU LINE II 3. Spare	7	1. 132/33kV, 40MVA ICT-I; 2. 132/33kV, 40MVA ICT-II; 3. 132/33kV, 50MVA ICT-III 4. 132/33kV, 30MVA ICT-IV 5. 132/33kV, 31.5MVA ICT-V 6. Spare 7. Spare	10
7	132/33 kV Sisugram	--	---	4	1. 132/33kV, 50MVA ICT-I 2. 132/33kV, 40MVA ICT-II 3. 132/33kV, 50MVA ICT-III 4. Spare	4
8	220/132 kV Agia	4	1. 220/132kV, 100MVA ICT-I; 2. 220/132kV, 160MVA ICT-II; 3. 220/132kV, 160MVA ICT-III 4. Spare	--	--	4
9	220/132 kV Boko	3	1. 220/132kV, 100MVA ICT-I; 2. 220/132kV, 50MVA ICT-II 3. Spare	--	--	3
10	132/33 kV Kamakhya	2	1. 132kV TRACTION LINE 2. Spare	3	1. 132/33kV, 40MVA ICT-I 2. 132/33kV, 40MVA ICT-II 3. Spare	5
11	220/33 kV Jawaharnagar	2	1. 220kV SAMAGURI LINE 2. Spare	3	1. 220/33kV, 50MVA ICT-I; 2. 220/33kV, 50MVA ICT-II 3. Spare	5
12	132/33 kV Narengi	--	---	3	1. 132/33kV, 50MVA ICT-I 2. 132/33kV, 50MVA ICT-II 3. Spare	3
13	132/33 kV Azara	--	---	3	1. 132/33kV, 40MVA ICT-I 2. 132/33kV, 40MVA ICT-II 3. Spare	3
14	220/132/33 kV Sonapur	4	1. 220kV SAMAGURI LINE; 2. 132kV BAGJHAP LINE I; 3. 132kV BAGJHAP LINE II 4. Spare	3	1. 132/33kV, 25MVA ICT-I 2. 132/33kV, 25MVA ICT-II 3. Spare	7

15	132/33 kV AIIMS	--		3	1. 132/33kV, 25MVA ICT-I 2. 132/33kV, 25MVA ICT-II 3. Spare	3
16	220/132 kV AMINGAON GIS	7	1. 132kV KAMALPUR LINE I; 2. 132kV KAMALPUR LINE II; 3. 132kV HAJO LINE; 4. 220/132kV, 160MVA ICT-I 5. 220/132kV, 160MVA ICT-II 6. Spare 7. Spare	3	1. 132/33kV, FUTURE ICT-I; 2. 132/33kV, FUTURE ICT-II 3. Spare	10
17	132/33 kV Chandrapur	2	1. 132kV BAGJHAP LINE 2. Spare	3	1. 132/33kV, 31.5MVA ICT-I 2. 132/33kV, 30MVA ICT-II 3. Spare	5
18	132/33 kV Guwahati Medical College	--	---	3	1. 132/33kV, 50MVA ICT-I 2. 132/33kV, 50MVA ICT-II	3
19	132/33 kV Paltan Bazar	--	---	3	1. 132/33kV, 50MVA ICT-I 2. 132/33kV, 50MVA ICT-II 3. Spare	3
20	Karbi Langpi HEP	2	1. 220 kV Sarusajai Line 1 2. 220 kV Sarusajai Line 2	2	1. Unit-1 2. Unit-2	4
21	132/33 Dispur	--	--	3	1. 132/11kV, 16MVA ICT-I 2. 132/11kV, 16MVA ICT-II 3. Spare	3
	Total	**70**		**58**		**128**

UFR Details of Stations		
Sl. No.	**Name of Station**	**Number of UFR required.**
1	400/220 kV Bongaigaon	1
2	BgTPP NTPC	1
3	400/220 kV Azara	1
4	220kV BTPS	1
5	220/132/33 kV Sarusajai	1
6	132/33 kV Kahilipara	1
7	132/33 kV Sisugram	0
8	220/132 kV Agia	1
9	220/132 kV Boko	1
10	132/33 kV Kamakhya	1
11	220/33 kV Jawaharnagar	1
12	132/33 kV Narengi	0
13	132/33 kV Azara	0
14	220/132/33 kV Sonapur	1
15	132/33 kV AIIMS	0
16	220/132 kV AMINGAON GIS	1
17	132/33 kV Chandrapur	1
18	132/33 kV Guwahati Medical College	1
19	132/33 kV Paltan Bazar	0
20	Karbi Langpi HEP	0
21	132/33 kV Dispur	0
	Total	**14**

Number of Elements present in the Guwahati Island (considering of island specific elements with voltage level of 132 kV and above)								
Sl. No.	Name of Station	Number of Units present	Number of Feeders present	Number of 400/220 kV ICTs	Number of 220/132 kV ICTs	Number of 220/33 kV ICTs	Number of 132/33 kV ICTs	No of PMUs Required (Considering 3 CT & PT Input in one physical PMU)
1	400/220 kV Bongaigaon	0	12	2	0	0	0	5
2	BgTPP NTPC	3	2	2	0	0	0	3
3	400/220 kV Mirza	0	1	0	0	0	2	1
4	220kV BTPS	0	4	0	2	0	1	3
5	220/132/33 kV Sarusajai	0	2	0	0	0	3	2
6	132/33 kV Kahilipara	0	2	0	0	0	5	3
7	132/33 kV Sisugram	0	0	0	0	0	3	1
8	220/132 kV Agia	0	0	0	2	0	2	2
9	220/132 kV Boko	0	0	0	2	0	2	2
10	132/33 kV Kamakhya	0	1	0	0	0	2	1
11	220/33 kV Jawaharnagar	0	1	0	0	2	0	1
12	132/33 kV Narengi	0	2	0	0	0	2	2
13	132/33 kV Azara	0	2	0	0	0	2	2
14	220/132/33 kV Sonapur	0	1	0	0	0	2	1
15	132/33 kV AIIMS	0	0	0	0	0	1	1
16	220/132 kV AMINGAON GIS	0	3	0	2	0	0	2
17	132/33 kV Chandrapur	0	3	0	0	0	2	2
18	Karbi Langpi HEP	2	2	0	0	0	0	2
19	132/33 kV Guwahati Medical College	0	2	0	0	0	2	2
20	132/33 kV Paltan Bazar	0	1	0	0	0	2	2
21	132/33 kV Dispur	0	2	0	0	0	2	2
	Total	5	43	4	8	2	35	42
	Total number of elements	**97**						
	PMU Required	**42**						

Technical QR for Guwahati Islanding Scheme

1. The Bidder must have successfully implemented at least one number similar type of OT project like SCADA/EMS/ADMS system with Cybersecurity in Indian Power Utility in the last 10 Years for a Control centre of a Load Dispatch Centre.

2. The Bidder shall also have experience of similar type of PMU and PDC based Grid Islanding system (scheme for more than 100MW load) in Indian Power Utility in the last 2 years. If the same is under execution, bidder shall submit documentary evidence like PO of similar work.

3. The Bidder shall have well established Testing & Service Facility in India for FAT purpose of Integrated testing of islanding scheme. Service Facility in India shall have included, but not limited to, well trained India Resident Service Engineers with command over Hindi & English.

4. The Bidder may be a manufacturer or authorised representative of manufacturer of PMU. The bidder will have to substantiate that the manufacturer of offered PMUs is having minimum experience of three years for design, manufacture and supply of PMU (which must have been type tested). In case bidder is authorized representative of manufacturer, then such authorization should be at least of one year on date of tendering. Further, bidder has to submit the proof that at least 10 No. of offered PMU should be in satisfactorily operation for at least two years from date of commissioning, for which performance report is required to be submitted. Performance certificate should be issued by order placing authority and should not be more than five years older from the date of bid opening. In case if certificate is issued by executing authority, then shall be counter signed by order placing authority also.

5. The Bidder (Manufacturer/Installation Agency) should have executed at least 1 contract of value not less than Rs. 5 crore (Five Crore) during last 5 years.

== End of Report ==