

Technical Specifications

INDEX

CLAUSE NO.	TITLE	PAGE NO.
1.0	Introduction	3
1.1	Scope of Work	3
1.2	General requirements	5
1.3	PMU Documentation	6
1.4	PMU Requirements	6
1.5	GPS Based Time facility	10
1.6	Industrial Grade WAN Switch/Router	10
1.7	Cyber Security Component in this project	11
1.8	Cabling and Interconnection	11
1.9	PMU Panel	15
1.10	PMU Testing	21
	Annexure-I GTP	26-31

Phasor Measurement Unit (PMU) Requirements

1.0 Introduction

The intent of this specification is to specify the technical requirements for providing Phasor Measurement Units (PMUs) at the Substations 1) 400kV Dholera and 2) 400KV Babarzar. However, the locations may be changed as per the SLDC's technical requirements which shall be conveyed to successful bidder at the time of Kickoff meeting. The PMUs shall be integrated with the existing Phasor Data Concentrator (PDC) installed at respective SLDC/RLDCs and shall communicate as per the latest version of IEEE C37.118.2 and IS/IEC/IEEE 60255-118-1 Standards with all amendments.

1.1 Scope of Work

The scope of work for PMUs shall include Survey, Planning, Design, Engineering, Documentation, Supply, transportation, Unloading, Insurance, Storing, Handling, placement to final locations, Installation, Termination, Integration, Testing, Demonstration for acceptance, and Commissioning:

- a) PMUs, GPS (Global positioning System) Time Receivers, LAN (Local Area Network) switches, and complete with all necessary accessories, cables etc. at the Substations.
- b) Integration of supplied PMUs with PDCs at respective State Load Dispatch Centre (SLDC)/Regional Load Dispatch Centre (RLDC). The Bidder shall extend technical support at local end for seamless integration of PMU with PDC at SLDC/RLDC.
- c) Any other work which is not identified in the specification but is required for completion of the project within intent of the specification shall also be in the scope of the Bidder.
- d) The Bidder shall be responsible for all cabling and wiring associated with the equipment provided both inside and outside the control room/bay kiosks to interconnect the PMUs with all CT/CVT inputs, Digital inputs, Power Supply and output up to communication equipment in the control room.
- e) The Bidder shall also be responsible for determining the adequacy of the local power source for the equipment and for cabling to it, with adequate circuit protective breakers, if required. Define source power requirements for each cabinet/ rack of equipment provided.
- f) In addition, the Bidder shall be responsible for designing equipment and cabling to eliminate potential interference to or from the equipment and for earthing of all cabinets and shields as required for the system.
- g) Provide a working system that meets or exceeds the functional and performance requirements of this specification without affecting the

operation of the existing systems during installation & commissioning.

- h) Equipment engineering and design specific to each location including review of, and conformance with local environmental and earthing considerations.
- i) Integration of supplied PMUs with upstream PDCs at respective SLDC/RLDCs and. The scope of integration is limited up to necessary coordination at local end for seamless integration of the supplied PMUs with respective SLDC/RLDC PDCs.
- j) The Bidder shall provide a remote configuration utility (software) for installing at SLDC/RLDC for performing remote configuration of the supplied PMUs.
- k) Project management, project scheduling, including periodic project reports documenting progress during the contract period.
- l) Technical assistance during the contract warranty and the period of product life cycle.
- m) Provide all additional Equipment and services necessary to ensure compatibility between new and existing equipment.
- n) Provide All hardware, software, and firmware required to satisfy the requirements of this Specification.
- o) Conduct Factory and site testing of all hardware and software provided.
- p) Provide Type Test report to the Employer as per specification. Type test report shall be valid for all the type tests conducted within the last seven years from the date of LOA. In case valid Type test reports are not available, then conduct Type tests at no cost to the Employer.
- q) Shipment of all equipment to designated locations and/or storing areas.
- r) Storing, maintenance of storing area and security including full responsibility for protection from theft and fire for all the items to be supplied.
- s) Developing and providing All documentation and drawings as specified.
- t) Availability of service, Spares, and expansion parts for the supplied items for minimum 10 years including one year warranty from the operational acceptance of the system of the project as per details in various parts of this specification.
- u) The bidder shall observe all safety measure as per GETCO norms during installation and commissioning activity of project.

The Bidder's responsibilities, in relation to individual items and services offered, are delineated in other sections of this specification also.

1.1.1 Exclusions from Bidders scope

The following are the exclusions from the Bidder's scope

- a) Buildings/Civil work except minor modifications required for laying of cables, installation of equipment or panels.

- b) Air conditioning
- c) Firefighting system
- d) AC or DC input power supply
- e) Availability of Communication network to connect the PMUs at Substations.
- f) Control Cable (AC/DC) required from PMU panel to Control cable

1.2 General requirements

The Bidder is encouraged to offer standard products and designs. However, the Bidder must conform to the requirements and provide any special or additional equipment/s or software necessary to meet the requirements stated in the specification. The Employer/Owner reserves the right of execution of works within the stipulated quantity variation provision other than those indicated in the appendices at the same rates, terms, and conditions.

The Bidder's proposal shall address all functional and performance requirements within this specification and shall include sufficient information and supporting documentation to determine compliance with this specification without further necessity for enquiries. The Bidder's proposal shall clearly identify all features described in the specifications or in any supporting reference material that will not be implemented; otherwise, those features shall become binding as part of the final contract.

All equipment provided shall be designed to interface with existing equipment and shall be capable of supporting all present requirements and spare capacity requirements identified in this specification.

The Bidder shall demonstrate a specified level of performance of the offered items during well-structured factory and field tests.

The successful bidder may do a site survey of the locations, for successful completion of scope of supply and services for the PMUs. In that case, after the site survey the Bidder shall submit a survey report to the Employer/Owner. This report shall include at least the following items:

- a) Layout of panels for PMUs to be installed at each substation as required for final and intermediate positions.
- b) The proposed quantity of PMUs and the other components like Switch, GPS, LIU etc.
- c) Proposed routing of power, earthing, LAN cable and signal cables along with Trench size at Control Center Locations to be supplied under this project.
- d) Availability of Space, Air conditioning and AC/DC Power supply
- e) Identification for new rooms/buildings/ trench/ facility modifications, if existing space is not sufficient, for the installation of new panels for PMUs. The construction is not in the scope of the Bidder.
- f) Identify all additional items required for integration for each site/location.

1.3 PMU Documentation

The Bidder shall submit sets of all the standard and customized PMU documents for review and approval which includes the following:

- a) Function design document
- b) Hardware description document
- c) Test equipment user documents
- d) Type test reports
- e) Operation & Maintenance Manual
- f) Test procedures
- g) Guaranteed Technical Specifications (GTP) of all items
- h) PMU installation and Layout, GA, BOQ, schematics and internal wiring drawings for each PMU site
- i) PMU to C&R panels/Bay Kiosk field device cabling details for each PMU site
- j) Local area network diagram showing connectivity of the various components.

After approval of all the above documents, the Bidder shall submit three sets as final documents. The site-specific drawings as indicated as above shall be submitted in three sets for each site before installation of PMUs. In case some modifications/corrections are carried out at site, the Bidder shall again submit "as- built" site-specific drawings in three sets after incorporating all such corrections as noticed during commissioning of the PMUs.

1.4 PMU Requirements

The offered PMUs shall be complete in all respects so that they can be installed at the substation/power plant and can communicate with Phasor Data Concentrator (PDC) at respective SLDC/RLDCs. The necessary cabling, connector, and installation hardware, as required, shall be supplied by the bidder.

The PMUs shall be installed in Bay kiosks in Substations having Substation Automation System (SAS) or near to the control & relay panels in Conventional Substations. The CT/CVT connections to the PMU shall be extended accordingly from the relevant panels.

The typical PMU architecture at substations is given at **Fig 1.1** & **Fig 1.2** below: The actual no of PMUs required at each site shall be based on number of feeders/elements at a site and type of substation architecture like SAS/conventional C&R/GIS/HVDC etc.

The number of PMUs is only indicative, and the quantity of PMU shall be as per BOQ. The quantity of PMUs and the other components like Switch, GPS, LIU etc. may vary due to site requirements during post-award Engineering approvals.

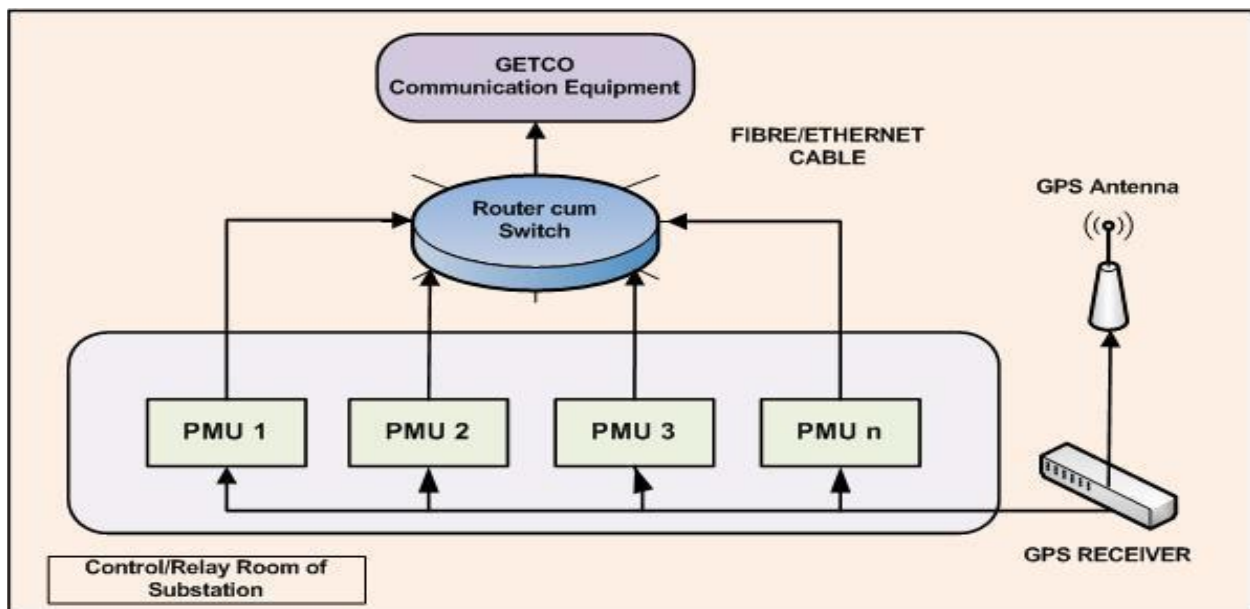


Fig 1.1: Typical PMU Architecture at Substations Control Room

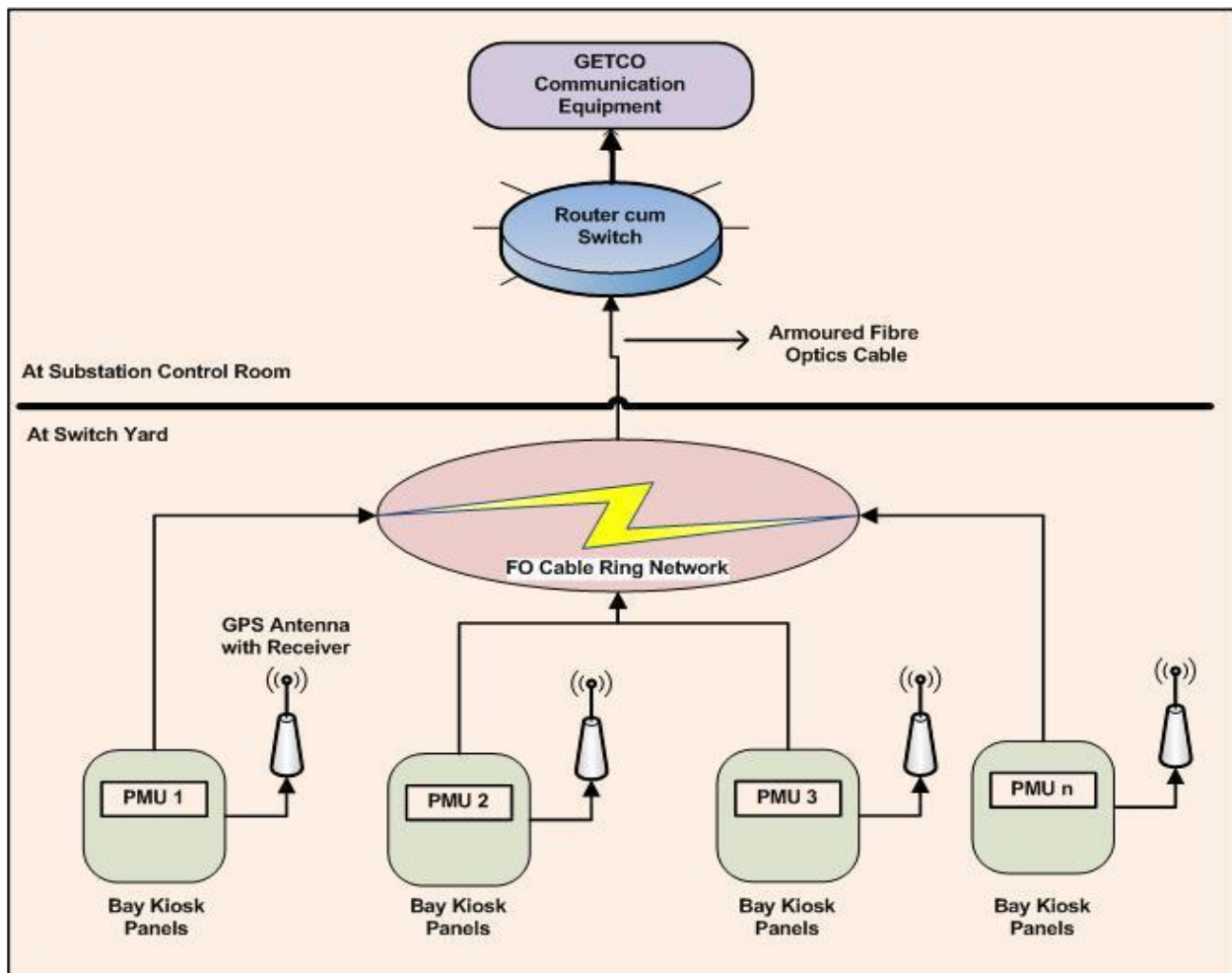


Fig 1.2: Typical PMU Architecture at Substations having Bay Kiosks at switchyard.

Tentative List of Elements to be considered. However, the same may be confirmed during kickoff meeting accordingly: -

Sr.No	400KV DHOLERA	400KV BABARZAR
1	400KV LINE No.1	400KV LINE No.1
2	400KV LINE No.2	400KV LINE No.2
3	400KV LINE No.3	400KV LINE No.3
4	400KV LINE No.4	400KV LINE No.4
5	400/220KV ICT No.1	400/220KV ICT No.1
6	400/220KV ICT No.2	400/220KV ICT No.2
7	400/220KV ICT No.3	400/220KV ICT No.3
8	400KV BUS REACTOR 1	400KV BUS REACTOR 1
9	FUTURE 400KV BUS REACTOR 2	FUTURE 400KV BUS REACTOR 2
10	FUTURE 400/220KV ICT No.4	FUTURE 400/220KV ICT No.4
11	400KV BUS COUPLER	400KV BUS COUPLER
	400KV BUS PT-1	400KV BUS PT-1
	400KV BUS PT-2	400KV BUS PT-2

1.4.1 PMU Functional Requirements:

- a) The PMUs shall communicate with the PDCs at State Load Dispatch Centre/Regional Load Dispatch Center (RLDCs) over the communication link provided by the Employer/ Owner utility.
- b) PMU shall be provided with minimum One Ethernet port of 10/100 Base Tx and minimum one optical fiber port of 100 Mbps for streaming the data in UDP/IP multicast/unicast and TCP/IP in latest version of IEEE C37.118.2 and IS/IEC/IEEE 60255-118-1 standards with all amendments. The Ethernet port shall be used to connect the PMU directly to the LAN switches. The Optical fiber port shall be preferred for connectivity with the switch.
- c) The PMU shall perform synchro-phasor reporting simultaneously for at least 2 clients over TCP and/or 2 UDP clients for multicast or unicast. PMU shall be able to send data in multi-cast and Uni-cast.
- d) The PMUs shall be suitable to operate on unearthed 220V DC or 110V DC or 48V DC power supply with +10%, -15% variation as available in the substation.
- e) The PMUs shall support data 'Reporting Rates of 25 and 50 per second for 50Hz System. The PMUs with higher reporting rates shall be preferred. The actual rate to be used shall be user selectable. All the PMU hardware and software shall be sized considering a reporting rate of 50 frames per second.
- f) The sampling rate of the PMU shall be higher than the reporting rate.

- g) PMU shall be capable of measuring the electrical parameters in the power system frequency band of 48-52Hz with the accuracy as specified in latest versions of IEEE C37.118.2 and IS/IEC/IEEE:60255-118-1 Standards with all amendments, independent of number of Analog Input channels connected to the PMU. The PMU design shall ensure that the impact of frequency fluctuation on accuracy is within permissible limit as per prevailing standards.
- h) The PMUs shall be able to measure/calculate but not limited to following:
- i. 3-phase voltage Phasors (Magnitude and angle),
 - ii. 3-phase current Phasors, (Magnitude and angle),
 - iii. Positive sequence voltage, (Magnitude and angle),
 - iv. Positive sequence current, (Magnitude and angle),
 - v. Breaker Status
 - vi. Protection operated status (Distance protection relay (21-1/21-2), Over Voltage Protection, Main1+Main2 Protection, and any other as per requirement)
 - vii. Frequency
 - viii. Rate of Change of Frequency (ROCOF) $-df/dt$
 - ix. Analog Values (MW & MVAR)
- i) A GPS based time receiver and time synchronization system shall be provided for time synchronization of the PMU. The GPS can be a separate equipment or can be in-built in the PMU.
- j) The PMU shall have an internal clock, which shall be synchronized with the GPS time receiver's UTC time. In case of loss of signal from the GPS based time source, the PMU shall detect a loss-of-time signal and generate an alarm which will be transferred to PDC. Upon loss of signal, the PMU time facility shall revert to an internal time base. The internal clock of PMU shall have minimum stability of 1ppm.
- k) The PMU with supplied time receiver shall keep the total vector error (TVE), the frequency error (FE), and the Rate of Change of Frequency (ROCOF) within the limits as specified in latest versions of IEEE C37.118.2 & and IS/IEC/IEEE:60255-118-1 Standards (with all amendments).
- l) The PMUs shall have continuous self-monitoring, diagnostic features and shall be capable of identifying & communicating problems and shall generate alarm in case of any abnormality which shall be displayed locally as well as shall be transferred to the PDC. The indication shall be available for each module on the front panel of the PMU.
- m) The PMU shall support Configuration frame 2 & Configuration frame 3.
- n) Remote configuration facility shall be supported by the PMUs and the Bidder shall provide the necessary software required for remote configuration of PMUs. The supplied software shall provide remote

configuration of PMUs through the same data channel through which the PMUs are reporting to the PDCs at SLDC/RLDCs.

- o) The PMU shall support multiple data streams, i.e., a PMU can transmit its data in separate data streams (more than one). Each stream shall be configurable independently based on the following: -
 - i. Contents
 - ii. Reporting rate
 - iii. Communication mode (TCP/UDP)
 - iv. Different destinations with separate IDCODE.

1.5 GPS based Time Facility

A GPS based Time Facility shall be provided to synchronize the PMU clock with Coordinated Universal Time (UTC). The GPS based time facility shall be provided separately or as in-built within each PMU. The time receivers shall meet the requirement of the PMU's interfaces and accuracy requirements.

The time receiver shall include propagation delay compensation and shall also include an offset to permit correction to local time to achieve time accuracy of at least ± 1 microsecond (μ s). Within Five minutes of reacquisition of signal, the time shall return to within 1 micro-second of UTC. Proper correction of leap second shall be provided. The signal sent to PMU from the time facility shall be UTC or provide information to the PMU to correct the time to UTC by using the IRIG-B time profile as per IEEE Standard C37.118.

The supplied time system shall have "one IRIG-B port and two Ethernet ports as minimum". Additionally, if the PMU requires time synchronization over IRIG-B AM, then 1PPS port must be provided in the time system.

In some locations, the time facility shall be installed in the switchyard along with the PMU. The time facility must be suitable to work in such Electrical environment.

The time receiver shall detect the loss of signal from the UTC source. A loss-of-signal shall be sent to the PMU and result in an alarm/event in the PMU.

1.6 Industrial Grade WAN Switch/Router (Ethernet/Fibre Switch)

The industrial grade WAN switch shall be used for providing connectivity to the PMU and the connectivity to the communication equipment.

The Ethernet switches shall be of Layer 3 and shall support the features as specified in **PMU and associated items**.

The WAN switch shall be provided for connecting the PMUs to the fault tolerant Ethernet ring and the L3 LAN switch shall be provided for connecting the PMUs to communication equipment.

The quantity of switches shall be as per the BOQ.

The PMUs shall be connected on Fibre /Ethernet port of WAN switch. Detailed Technical specifications of the Industrial grade WAN switches is given at GTP.

1.7 Cyber security component in this package/project.

1.	AV	The solution may support Anti-Virus
2	Diagnostic	The solution shall provide physical diagnostic and test interfaces for hardware troubleshooting
3	DoS	The solution should provide protection to deny of service with specified threshold
4	Environment	The solution shall support operating Temp. ranging from -40 to 75°C
5	Interface	•The solution may support the inspection throughput for at least 200Mbps •The solution shall support dual WAN with combo port type (Fiber optic or copper) •The solution shall support multiple LAN ports (04 ports at least)
6	IPS	•The solution shall have its Intrusion Prevention System (IPS) be used in intranet without Internet access and support customer definition; included full license & real-time signatures update. •The solution shall have its Intrusion Prevention System (IPS) be used in intranet without Internet access and support customer definition; included full license & real-time signatures update.
7	Management	•The solution shall support Simple Network Management Protocol (SNMP) v1/v2/v3. •The solution shall support password strength mechanism of account management.
8	Networking	•The solution shall support DMZ function to specify physical ports as DMZ interface to allow traffic going from WAN interface to LAN interface without NAT enabled. •The solution shall support Link Layer Discovery Protocol (LLDP). •The solution shall support up to 20K concurrent connection at least. •The solution shall be compatible and can be deployed within PRP (Parallel Redundancy Protocol) /HSR (High-availability Seamless Redundancy) network architecture. •The solution shall support multiple account type with different permissions. •The solution shall support ALG (Application Layer Gateway) mechanism.
9	Operation	•The solution shall be able to select which log types to be sent to syslog server.

		• The solution shall NOT require system reboot for network setting change. • The solution shall support dual FW image for user selection. • The solution shall support the firmware downgrade capability. • The solution shall support the selection of operation mode. • The solution shall support Active Query to discover information for hidden OT assets. • The solution shall support up to 32 IP objects for access control use. • The solution shall support up to 32 IPS profiles for customized IPS protection. • The solution shall support packet inspection for traffic crossing all WAN / LAN ports.
10	Policy Enforcement	• The solution shall be able to have whitelisting function to enable packet inspection to allow/block/log incoming traffic based on pre-defined condition (IP address, service type, VLAN ID, protocol type). • The solution will need to have protocol whitelisting function to inspect and allow/block/log insecure or unexpected protocol commands from going through. • The solution shall support the creation of policies to build the baseline for OT traffic control. • The solution needs to support multiple VLAN ID setting for one policy rule. • The solution shall support interface direction selection as one of the policy inspection rules. • The solution shall be able to inspect and to allow/block incoming packets based on pre-defined IP addresses. • The solution shall support to prevent access to specified workstation or system node. • The solution shall support up to 512 Policy Enforcement rules.
11	Power	The solution shall have dual power inputs which can work simultaneously for power redundancy. The solution shall support power input voltage of 110–240 VDC
12	Protocol	The solution shall support industrial control system protocols that are commonly used by industrial systems (Distributed Control Systems, PLC, SCADA, HMI, Open Platform Communications, etc.) • Ethernet IP/CIP (Granular Control Support) • OPC

		• Profinet • Modbus (Granular Control Support) • S7COMM (Granular Control Support) • S7COMM+ (Granular Control Support) • FINS (Factory Interface Network Service) • SeamLess Manage Protocol (Granular Control Support) • SECS/GEM ((Semiconductor Equipment Communication Standard / Generic Equipment Model) • MELSOFT (Granular Control Support) • TOYOPUC (Granular Control Support)
		• The solution shall support SAS communication protocols that are commonly used in Power Substation communication. • TCP/IP • UDP/IP • DNP3 • IEC 60870-5-104 • IEC 61850 • IEEE C37.118 • OSPF • BGP The solution shall support to check the packet for OT protocol format compliance
13	Protocol Filter	• The solution shall support advanced configuration on CIP (Common Industrial Protocol) protocol to allow user selecting specific select Class ID / service code to allow/deny. • The solution shall support advanced configuration on S7 protocol to allow user selecting specific function code to allow/deny. • The solution support SMB (Server Message Block) Granular control and shall be able to analyze SMB exchange and to block or allow frame pass according to data format (SMB v1 / SMB v2/v3) and message type. SMBv1/2/3 granular control filtering options: 1. SMB versions 2. file access permission: read only, write only, read/write. • The solution shall support up to 32 ICS protocol filter rules. • The solution shall support up to 32 profiles for OT protocol filter. • The solution shall support advanced matching criteria configuration on IEC-61850-GOOSE protocol. • The solution shall support advanced matching criteria

		configuration on IEC-61850-MMS protocol.
14	Rule	The solution shall support rule editing function to have IPS profile to list out IPS rules and allow user to enable/disable individual rule with desired actions (allow & log, block & log)
15	Signature	• Vendor shall specify the regular release cycle and process for signature and pattern. • Vendor shall specify the method of updating the latest signature to the solution. • Vendor shall specify how to get the CVE Common Vulnerabilities and Exposures) list for the latest release signature set. • Vendor shall specify how to capture the packets on the device for debugging like Trend other products?
16	Threat	The solution shall support Malware threat attack behaviour detection and prevention • Crypto wall (Ransomware) • MIRAI • Hajime • BADRABBIT • HIDDEN COBRA • VPN Filter • Shamoon • Shadow Hammer • WannaCry (Ransomware) The solution shall have capability to prevent and detect attack attempts and generate detection log The solution shall support continuous threat detection for OT and IT systems (Alerts, CVE monitoring, work flow, etc.) The solution has capacity to detect Windows remote task execution/schedule and do further control. The console part includes: 1. Powershell execution. 2. schtasks/atvc

1.8 Cabling & Interconnections

All cabling and interconnection mentioned below shall be in the scope of the Bidder for Supply and installation. The cabling and interconnection shall be shown in the substation drawings for approval of Employer/Owner.

- PMU to time system along with antenna
- PMU to LAN switch
- PMU to the control and relay panels (located in the substation control

- room)
- iv. PMU to the relay panels in the bay kiosks in switchyard of SAS based substations etc.,

Plug-type connectors with captive fasteners or compression type connectors shall be used for all internal interconnections. The connectors shall be polarized to prevent improper assembly. Each end of interconnection cables shall be identified by a marker which includes the cable number and the identifying number and location of each of the cable's terminations. This information shall match with the Bidder's drawings.

Adequate space and hardware shall be provided for routing of the field wiring within the enclosures. The wiring within enclosures shall be neatly arranged and shall not be directly fastened to the enclosure frame. All internal interconnection wiring and cables shall be routed separately from field wiring to the PMU terminals & power wiring. All wiring shall use copper conductors and have flame retardant insulation and of low smoke. Conductors in multi-conductor cables shall be individually color coded.

The use of non-flammable, self-extinguishing, plastic wire troughs is permissible. Metal clamps, if used, must have insulating inserts between the clamps and the wiring. Wiring between stationary and movable components, such as wiring across door hinges or to components mounted on extension slides, shall allow for full movement of the component without binding or chafing of the wiring.

The bidder shall be responsible for laying and termination of all cables required under the project which includes interconnections among bidder supplied equipment and their interconnection with employer's panels. Testing and commissioning of these interconnections shall also be done by the bidder.

1.9 PMU Panel

1.9.1 SCOPE OF PMU PANEL:

- The PMUs, Router Cum Switch & GPS shall be installed with separate panel in Control room/relay Room/BCU/Unit control room at location decided.
- The design, preparation of schematic and drawings, manufacture, testing at manufacturer's works, mounting and wiring up of all the equipment of F.O.R destination supply thereof, testing and commissioning at site.
- Design and fabrication of PMU panels for mounting the PMU and PMU assemblies along with all necessary accessories like GPS, Router/switches etc. and wiring up of the same to provide self-contained and ready to use as per specification.
- Complete testing at manufacturer's works of the PMUs & complete solution after mounting and fully wiring up in the PMUs panels.
- F.O.R. destination supply of completely assembled PMUs panels. Testing and commissioning of these panels at site.
- Preparation and furnishing of all the required drawings including

schematic, internal external cable connection drawings and wiring schedules. All wires shall be printed ferruled at both ends even on shorting links also and shall be clearly shown in the schematic drawings.

- Preparation and furnishing of erection, commissioning instructions, operation and maintenance manuals all operational features/optional features.
- The successful Bidder have to submit five sets of all types of drawings, schematics and electrical internal circuits, indicating measuring points and measuring values, external cable connection drawings, wiring schedules, erection instructions, operation and maintenance manuals.

1.9.2 SIZE AND GENERAL DIMENSIONS REQUIREMENTS:

400/220/132KV PMU panel: The panels shall be 'Simplex' type. The overall panel dimensions shall be 2312mm H (Height – H) x 750mm (Depth-D) x 900mm W (Width – W).

At Generating station, Substation having BCU unit in switch yard, Bidder can change height of panel as per site requirements. Substation wise minimum one PMU panel shall be provided by bidder & in case of Nos. of PMU is higher in one substation in that case bidder shall provide separate panel for 400 kV feeder & 220 kV feeder in one substation.

Nos. of PMUs in one panel shall be finalized after finalizing PMUs configuration & Site survey of locations.

The panels shall be modular rack mounting type consisting of standard width racks, in accordance with the IEC – 297. The panel have full transparent (Perspex) front door with lockable handle.

1.9.3 GENERAL REQUIREMENT FOR PMU PANEL:

Panels shall be completely metal enclosed and shall be dust, moisture and vermin proof to meet the requirement to IP-54 of IS: 2147.

The panels shall be free standing, floor mounting type and shall comprise rigid, welded structural frame enclosed completely with specially selected, smooth finished cold rolled sheet steel of thickness not less than 3.0 mm for load bearing members (front panel, base frame, door frame) and 2.0 mm for non load bearing members (side panel, cubicle roof, door). There shall be sufficient reinforcement to provide level surfaces, resistance to vibration, and rigidity during transportation and installation. No deviation to this clause is permitted.

All doors and removable covers shall be gasketed all round with neoprene gaskets, ventilating louvers, with screens and filters.

Design, material selection and workmanship shall be such as to result in neat appearance inside and outside with no weld, rivets or bolt heads apparent from outside and with all exterior surface true and smooth.

Cable entries to the panels shall be from the two numbers of screwed type removable gland plates in panel bottom. Each of size 350mm x 200mm with punched hole for suitable size cable glands.

Simplex panel shall consist of vertical front panel with equipment mounted thereon and having wiring access from the rear. It shall have two doors.

1.9.4 LABEL

All front mounted equipment as well as equipment mounted inside the panels shall be provided with individual labels with equipment designation engraved. The labels shall be mounted directly below the respective equipment. Label with large and bold letters engraved with panel designation shall be provided at the top of each panel on front and rear side.

All the front mounted equipment shall also be provided tag numbers corresponding to the ones shown in the panel internal wiring to facilitate each tracing of wiring. These labels shall be mounted directly by the side of the respective equipment and shall not be hidden by the equipment wiring.

Labels shall be made of Aluminium anodized plate P.V. Castings. Labels shall have white letters on black background.

1.9.5 PANEL INTERNAL WIRING:

All wiring shall be carried out with 1100V grade single core multi strand flexible copper conductor wires with HRPVC insulation and shall be flame retardant, vermin and rodent proof. The current carrying capacity of wire shall be adequate for the duty assigned to it considering short circuit condition and shall have sufficient flexibility to facilitate proper termination at any location. Colour coded wires (red, yellow, blue, black) shall be used for CT, VT and CVT secondary connections. The copper conductor used for internal wiring be as follows:

- ☐ **CT circuit - 4.0 Sq. mm per lead.**
- ☐ **VT/CVT circuit - 2.5 Sq. mm per lead.**
- ☐ **AC/DC Supply - 2.5 Sq. mm per lead.**
- ☐ **Digital status - 1.5 Sq. mm per lead.**

The wire numbers shown in the wiring diagram shall be in accordance with IS375/BS152/BS156. Panel wiring shall be securely supported, neatly installed by lacing and tying, readily accessible and connected to equipment terminals and terminal blocks. Flame retardant, plastic wiring channels/troughs with strap on plastic covers shall be used for this purpose. Sufficient space in channel for modification of wiring shall be kept.

The unused space on the front or rear of the panels shall be kept clear of wiring to facilitate addition of devices without rewiring associated portion of the panels.

Wire termination shall be made with solder less crimping type of tinned copper lugs, which firmly grip the conductor. Insulation sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules, marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Printed ferrules shall fit tightly on the wire and shall not fall off when the wire is disconnected from terminal blocks.

The bidder shall be responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.

1.9.6 INTERIOR LIGHTING:

The panel shall be provided with fluorescent LED light with lighting fixture rated for 240V AC supply, controlled by panel door switch and fuse. The number of such lighting fixtures shall be 1 no. per panel.

The panel shall be provided with 240V, 50Hz. 15 A, 3 pin universal socket with switch. The socket with switch shall be mounted inside the panel at convenient location.

1.9.7 EARTHING:

Each panel shall be provided with earth bus tinned copper, having minimum cross section area of 25 x 6 sq mm flat securely fixed along with inside base of panels. Since several control panels are to be mounted adjoining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply. Provision shall be made to extend the earth bus bars to future adjoining panels. Provision shall be on the earth bus of the end panels for connecting owner's earthing grid. Necessary terminal clamps and connectors for this purpose shall be included in the scope of supply, of the Bidder.

All metallic cases of PMUs, GPS, Router/Switches and other mounted equipment shall be connected to earth bus by copper wires of size not less than 2.5 sq. mm. The colour of the earthing wire shall be green.

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

VT, CVT and CT secondary neutral or common lead shall be earthed at one place only. Such earthing shall be made through links, so that earthing may be removed from one group without disturbing continuity of earthing systems for other group.

1.9.9 TERMINAL BLOCKS:

Terminal blocks shall be 1100 V grade, 45 amps rated, one piece moulded, complete with insulated barriers, stud type, melamine housing brass terminals, washers, brass nuts and brass lock nuts and identification strips. Markings on the terminals strips shall correspond to wire number on the wiring

diagrams. Not more than 2 wires shall be connected to any terminals.

Terminal blocks for CT, CVT and VT secondary leads shall be provided with test links and isolating facilities. CT secondary wiring should be such that it can connect additional circuit in series.

At least 20% spare terminals shall be provided in each panel and these spare. Terminals shall be uniformly distributed on all terminal blocks, near each group of connections for feeder/PMUs wise circuits.

All spare contacts and terminals of the panel mounted equipment and devices shall be wired up to terminal blocks with ferrule numbers starting with U.

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

There shall be minimum clearance of 250mm between the first row of terminal blocks and the associated cable gland plate. Also the clearance between two rows of terminal blocks edge shall be minimum of 150mm.

Molding materials shall be self extinguishing or resistant to flame propagation, substantially non hygroscopic and shall not carbonized when tested for tracking. The insulation between any terminal and framework between adjacent terminals shall with stand test of 2 kV rms. For one minute. The molding shall be mechanically robust to withstand handling while making terminations.

Easily removable Protective transparent plastic covers for placing over the live parts of the terminal blocks shall be provided invariably.

1.9.10 PAINTING:

All sheet steel work shall be phosphate in accordance with the following procedures and in accordance with IS: 6005 'Code of Practice for phosphating iron and steel'.

Oil, grease, dirt and swart shall be thoroughly removed by emulsion cleaning.

Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

After phosphating, through rinsing shall be carried out with clean water followed by final rinsing with dilute bi-chromate solution and oven drying.

The phosphate coating shall be sealed by the application of two coats of ready mixed, stoving type zinc chromate primer. The first coat may be 'Flash dried' while the second coat shall be stowed.

After application of the primer, two coats of finishing synthetic enamel paint shall be applied, each coat followed by stowing. The second finishing coat shall be applied after completion of tests. The panel shall have colour confirming to shade 631 of IS-5 for outside. Inside of the panel will be egg shell white.

Each coat of primer and finishing paint shall be of a slightly aesthetically pleasing appearance free from dirt and uneven surface.

Finished painted appearance of panel shall present an aesthetically pleasing appearance free from dirt and uneven surface.

The bottom plate shall be painted with anti-corrosive paint. A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation of the panel. The paint thickness shall be 60- 100 microns for powder coating.

1.9.11 MOUNTING:

All equipment on front of panel shall be mounted flush.

Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent equipment. Equipment mounted inside the panel shall be so located that terminals of adjacent devices are readily accessible without the use of special tools. Terminal markings shall be clearly visible.

Cut-outs and wiring for free issue items. If any, shall be according to corresponding equipment manufacturer's drawings, cut -out, if any provided for future mounting of equipment shall be properly blanked off.

No equipment shall be mounted on the doors without prior approval of the purchaser.

Panels shall be matched with other panels in the control room/Relay room in respect of dimensions, colour, appearance and arrangement of equipment on the front.

1.9.12 D C DISTRIBUTION AND DC SUPERVISION RELAY:

220/110 V DC distribution for the C&R panels shall be such that separate sub – circuits with suitable HRC Fuse is provided for each of the following:

- Main DC Supply
- PMU wise circuits
- GPS
- Router/Ethernet Switch
- Firewall

DC supervision shall be provided to supervise continuously the DC supply for the above circuits. The scheme shall be suitable to work on 220/110 VDC supply from the station battery, and shall have position for visual alarm. One number indicating lamp along with 'accept' push button shall be provided on each control panel for this purpose.

There shall be two DC source. Distribution of circuit should be as per working Source I and Source II, independently.

1.9.13 DC SUPERVISION RELAY:

The Bidder shall provide DC Supervision relay & shall be capable of monitoring the failure of D.C supply to which it is connected. It shall have adequate potential free contacts to meet the scheme requirement. The relay shall have a time 'delay on drop-off' of not less than 100ms. In addition, be provided with operation indicator/flag.

However, Bidder shall supply panel as per GETCO approved technical specifications.

1.10 PMU TESTING

(a) Type Testing

The reports for all type tests as per this technical specification shall be furnished by the Bidder along with equipment / material drawings. However, type test reports of equipment/ material already accepted in GETCO can be accepted for all projects with similar requirement. The type tests conducted earlier should have either been conducted in a NABL accredited laboratory, or accredited based on ISO / IEC Guide 25 / 17025 or EN 45001 by the national accreditation body of the country where laboratory is located or witnessed by GETCO/representative authorized by GETCO/representative of Utility /representative of accredited test lab/ representative of the National Accreditation Board for Certification Bodies (NABCB) certified agency shall also be acceptable.

Unless otherwise specified elsewhere, the type test reports submitted shall be of the tests conducted **within the last Seven (7) years from the date of LOA**. In case the test reports are of the test conducted earlier than seven (7) years from the date of LOA, the Bidder shall repeat these test(s) at no extra cost to the Employer.

The type testing requirements are described below:

The list of Type tests applicable on the PMU is mentioned in **Table-1** and type test requirements are mentioned in **Table-2**. The Bidder may optionally submit type test reports for all the tests conducted at accredited laboratory for review & approval by Employer. However, in the event, the type test reports are not meeting the specification requirement, Employer may ask for the repeat type testing of above tests (EMI/EMC, Environmental & Functional tests) as required. at no additional cost.

The supplied Phasor Measurement Units (PMUs) shall comply with type test requirement as per below mentioned standards:

i) **For Functional Type Tests:** As per the latest versions of IEEE C37.118.2 and IS/IEC/IEEE 60255-118-1 standards with all amendments.

ii) **For EMI/EMC Immunity & Environmental Tests:** As per IS/IEC/61850-3: 2013 (and latest amendments up to the date of LOA), which is identical to IEC 61850-3 and is adopted by Bureau of Indian Standards. Type tests shall be compliant either to the international standards or corresponding Indian standard (as per Degree of equivalence) referred in IS/IEC/61850-3: 2013

standard.

(b) Routine Testing (Factory Acceptance Testing)

Each complete unit shall undergo routine testing as part of factory acceptance testing. The list of Routine tests to be performed in the factory is mentioned in **Table-1**.

(c) Field Tests (Site Acceptance Testing)

The Bidder shall carry out the field-testing (Site Acceptance Testing) of PMUs after installation, commissioning, and integration with upstream PDC. The list of field tests is mentioned in **Table-1**.

Table-1: List of Tests on PMU:

Test Nos.	DESCRIPTION OF THE TEST	Type test	Routine test (FAT)	Field test (SAT)
FUNCTIONAL TESTS FOR PMU				
1.	Check for BOQ, Technical details, Construction & Wiring as per PMU drawings	✓	✓	✓
2.	Check for PMU database & configuration settings	✓	✓	✓
3.	Check the operation of all Analog inputs, Digital and Status input points of PMU	✓	✓	✓
4.	Check operation of all communication ports of PMU	✓	✓	✓
5.	Check for communication between PMU and PDC	✓		✓
6.	Test for PMU time synchronization from GPS	✓		✓
7.	Test Power Supply Voltage Margin, Ripple Levels and Short Circuit Protection	✓		
8.	Test for PMU operation with DC power supply voltage variation	✓		
9.	Check for auto restoration of PMU on DC power recovery after its failure	✓	✓	✓
10.	Test for PMU diagnostic feature	✓		
11.	Accuracy tests as per the latest versions of IEEE C37.118.2 and IS/IEC/IEEE 60255-118-1 standards with all amendments	✓		
12.	Test for PMU internal Clock stability	✓		
13.	End to end test (between PMU&PDC) for all I/O points			✓
14.	Testing and Configuration of PMU from HMI or Portable Configuration tool	✓	✓	✓
EMI/EMC IMMUNITY TESTS FOR PMU				
15.	Surge Immunity Test as per IEC 61000-4-5& IEC 60255-22-5 with Severity Level 3	✓		

16.	Electrical Fast Transient Burst Test as per IEC 61000-4-4 Level-4 or IEC 60255-22-4 with Severity Level 3	✓		
17.	Damped Oscillatory Wave Test as per IEC 61000-4-18 & IEC 60255-22-1 with Severity Level 3	✓		
18.	Electrostatic Discharge test as per IEC 61000-4-2 Level-4 or IEC 60255-22-2 with Severity Level 3	✓		
19.	Radiated Electromagnetic Field Test as per IEC 61000-4-3 or IEC 60255-22-3 Severity Level 3	✓		
20.	Damped Oscillatory magnetic Field Test as per IEC 61000-4-10 with Severity Level 3	✓		
21.	Power Frequency magnetic Field Test as per IEC 61000-4-8 with Severity Level 3	✓		
INSULATION TEST FOR PMU				
22.	Power frequency voltage withstand Test as per IEC 60255-5 for 1kV	✓		
23.	1.2/50 μ s Impulse voltage withstand Test as per IEC 60255-5	✓		
24.	Insulation resistance test	✓		
ENVIRONMENTAL TEST FOR PMU				
25.	Dry heat test as per IEC60068-2-2 / 2-3	✓		
26.	Damp heat test as per IEC60068-2-78	✓		
27.	Cold Test as per IEC60068-2-1	✓		

Note: Test levels for above type tests are elaborated in Table 2

Table-2: PMU Type Test Requirements

Test No.	Test Name	EUT Status	Test Level	Power Supply Points		I/O Points	Passing Criteria
				CM	DM	CM	
1	Surge Immunity Test	ON	Level 3	2 kV	1 kV	2 kV	A
2	Electrical Fast Transient Burst Test as per IEC 61000-4-4, or IEC 60255-22-4	ON	Level 3	2 KV	-	1 kV	A
3	Damped Oscillatory Wave Test	ON	Level 3	2.5 kV	1 kV	2.5 kV	A

4	Electrostatic Discharge Test as per IEC 61000-4-2 or IEC 60255-22-2	ON	Level 3	+/- 6 kV in Contact discharge mode or +/- 8 kV in Air discharge mode	A
5	Radiated Electromagnetic Field Test	ON	Level 3	10 V/m electric field strength	A
6	Damped Oscillatory Magnetic Field Test	ON	Level 3	10 A/m at 1MHz of magnetic field strength	A
7	Power frequency magnetic field	ON	Level 3	30 A/m of magnetic field strength (Continuous duration sine wave)	A
8	Power frequency voltage withstand	OFF	-	1 kV rms for 1 minute	No break down or flashover shall occur
9	1.2/50µs impulse voltage withstand	OFF	-	2 kVp	No break down or flashover shall occur
10	DC Voltage Dips & Interruptions / Variation as per IEC 61000-4-29 or IEC 60255-11	ON	-	-	-
11	Insulation Resistance Test	OFF	-	Measure Insulation resistance using 500 VDC Megger before & after Power Freq& Impulse voltage withstand tests	As per manufacturer standard
12	Dry heat test	ON	-	Continuous operation at 55° C for 16 hrs	0
13	Damp heat test	ON	-	at 95% RH and 40° C for 16 hrs	0
14	Cold test	ON	-	Continuous operation at 0° C for 96 hrs	0

Note: -

1. EUT - Equipment Under Test
2. CM - Common Mode; DM - Differential mode
3. I/O points do not include Communication ports

4. Passing Criteria
 - 0 - no failure: normal performance within the specified limits
 - A: minor failure: temporary degradation or loss of function or performance which is self- recoverable
5. Functional test as per the sl. nos. 1-14 of Table-1 shall also be done during type testing.

Annexure-I: GTP of PMU and associated items

1. Phasor Measurement Unit (PMU) – P and M class

The Phasor Measurement Units (PMUs) shall communicate to the Phasor Data Concentrator (PDC) at respective SLDC/RLDC as per the latest version of IEEE C37.118.2 and IS/IEC/IEEE 60255-118-1 Standards with all amendments.

S.No	Description of the Features	Minimum Quantity of the features	Offer by the Bidder
1.	Device	Phasor Measurement Unit (PMU)	
2.	Manufacturer		
3.	Model No.		
4.	Country of origin		
Inputs			
5.	Minimum Analog Channel	PMU shall measure 4 sets of 3 phase voltage inputs and 4 sets of 3 phase current inputs. (i.e., Current and voltage of feeders/elements)".	
6.	Minimum Digital Channels	32 (i.e., 8 Digital Inputs per feeder)	
7.	CT core	Capable for both Metering & Protection Core	
8.	Auxiliary Power Supply Source	220V DC or 110V DC or 48V DC (+10%, -15%) power supply source	
9.	Communication ports	Minimum One Ethernet port (RJ45) of 10/100 Base Tx and one optical fiber port of 100Mbps	
10.	Interface ports for Time synchronization	Time synchronization shall be done either with the built-in GPS (within the PMU) or with an external GPS based time facility through any of the following protocols: a) IRIG-B interface port for either a standard or high-accuracy demodulated IRIG-B time-synchronization input signal. b) SNTP through Ethernet port c) 1 PPS (only if the offered PMU supports time synchronization over IRIG-B AM)	
11.	Communication Protocols	UDP/IP multicast/unicast & TCP/IP	
Measurement Output			
12.	Performance Class	Both P and M class, User configurable	

13.	Test Compliance as per IEEE 37.118 and IEC/IEEE 60255-118-1 Standards	PMUs shall meet all performance requirements for the given class and reporting rate as per the latest version of IEEE C37.118.2 and IS/IEC/IEEE 60255-118-1 Standards with all amendments. Bidder to fill the values as per test conducted in the lab for each individual values both in steady state and Dynamic State.	
14.	Features	Shall be IEC 61850 Compliant for Edition 1.0 and Edition 2.0	
15.	Environmental Condition	As per TS	
16.	Reporting rates (Frame per second)	25, and 50 frames per second for 50 Hz System. The actual rate to be used shall be user selectable. All the PMU hardware and software shall be sized considering 50 frames per second.	
17	Configuration Frame	PMU shall support Configuration Frame - 2 & Configuration Frame-3	
18	Minimum reporting clients	Minimum 2 clients over TCP and/or 2 UDP clients	
19	Active & Reactive Power	3 Phase active and reactive power measurement/computation for a feeder should be possible in PMU.	
Other features			
21.	HMI facility	Display on PMU for display of real time measured values & buttons to make configuration changes to HMI.	
22.	Remote configuration Change	PMU shall provide remote configuration capability through same data channel from which the PMUS are reporting to PDC at respective SLDC/RLDC from the supplied Configuration software.	
23.	Configuration software	Yes (only software)	

24	PMU integration with PDC	The PMU shall be capable of reporting with its full features to the PDC installed at respective SLDC/RLDC. It is the responsibility of the bidder to coordinate with SLDC/RLDC for successful integration of PMUs with the PDC.	
25	Station Name, Phasor Name, Analog name, Digital Name	These should be user configurable in PMU.	
27	Event Recorder	Up to 1024 event records	
28	Cyber Security	a) Cyber Security compliance as per IEC 62351 b) The PMUs shall support Syslog feature. c) The Access of PMU must be through password and log of same shall be maintained. d) Any configuration change must be through access right and log of the same must be maintained, e) All logs of event shall report to Syslog server.	
29	Self-monitoring, diagnostic features, and alarm to PDC.	a) The PMUs shall have continuous self-monitoring, diagnostic features and shall identify & communicate hardware or software errors/faults. b) It shall generate alarm in case of any abnormality displayed locally and transferred to the PDC. c) The indication shall be available for each module on the front panel of the PMU.	
30	Multiple data streams configurable independently.	PMU shall support multiple data streams i.e., a PMU shall be capable of transmitting its data in separate data streams (more than one). Each stream shall be configurable independently based on the following: - a) Contents b) Reporting rate c) Communication mode (TCP/UDP) d) Different destinations with separate IDCODE.	

	Environmental condition		
31	Temperature	-10 to +55 degrees Celsius	
32	Humidity	10% to 95%	

2. **GPS based time facility**

S.No	Description of the Features	Minimum Quantity of the features	Offered by the Bidder
1.	Manufacturer		
2.	Model No.		
3.	Time stability of internal time base	Minimum 1ppm	
4.	Propagation delay compensation	Yes	
5.	Include an offset to permit correction to local time	Yes	
6.	Reverting to internal time base upon loss of signal from UTC source	Yes	
7.	Resynchronization Delay	Not more than 5 minutes.	
8.	Accuracy of resynchronization	≤ 1 Microsecond	
9.	Interfaces (minimum)	a) Ethernet port Copper — 2 no. (10/100 Mbps) b) IRIG-B port – 1 Additionally, if the PMU requires time synchronization over IRIG-B AM, then 1PPS port must be provided in the time system.	

10.	Environmental Compliance	IEC61850-3 and IEEE1613 (Electric Utility Substation), EMS- IEC61000, EMI: FCC part15 A	
11.	Power Supply (in Watts)		
12.	Heat Load		

3. Industrial grade Router/LAN Switch

S.No	Description of the Features	Minimum Quantity of the features required	Offered by the Bidder
1.	Manufacturer		
2.	Model No.		
3.	Processing Capacity	Minimum 2 Mbps	
4.	Functions	Data Exchange between the PMUs and PDC	
5.	features required	QoS, MPLS, Security, Broadband, Multiservice, Voice, IP to IP Gateway & Hot standby operation with a similar router. Support IEEE 802.3u: Auto-negotiation on TP, IEEE 802.3x, 802.1p: flow control and prioritization, IEEE 802.1Q: VLANs, maximum 32 VLANs, IEEE 802.1d, 802.1w: Spanning Tree, Rapid Spanning Tree including RSTP 2004 extensions providing sub-second hop on rings, IEEE 802.1p: Diff Serv, prioritization for routed IP flows/ports	
6.	Routing Protocol	SNMPv1/v2c/v3, DHCP Server/Client, OSPF, BGP, ARP, IPCP, IP, forwarding, VLAN & MPLS etc.	
7.	Network management	a) Console port for configuration of software features b) Shall be able to manage the switch through Command-line interface, Web browser. c) Support SNMPv3 d) SNTp e) TCP/IP, IPv4, IPv6, OSI, Telnet, UDP, DHCP	

8.	Security	a) Access Control Lists for IPv4 for filtering traffic to prevent unauthorized users from accessing the network. b) Port-based rate limiting, and access control list (ACL) based rate limiting. c) IEEE 802.1x to provide port-based user authentication with multiple 802.1x authentication sessions per port. d) Media access control (MAC) authentication to provide simple authentication based on a user's MAC address. e) Port disabling and port isolation. f) MAC based port security. g) Port based Network Access Control (802.1x) h) SNMP v3 i) SSH/SSL Encryption j) Multi-level user passwords	
9.	Interface ports	Fibre optic ports and Ethernet ports as per Requirement V.35/G.703 Ports as per the system requirement. There shall be 50% spare ports.	
10.	Mounting	Rack mountable 19 inch	
11.	Cable standard	Cat 6 or higher bandwidth cable	
12.	Environmental Compliance	IEC61850-3 (Electric Utility Substation)	
13.	Operating temp	- 20 to 70°C,	
14.	Power supply	220VDC, 110VDC, 48V DC (+10% & -15%) (As per site requirement)	