Model

Technical Specification

For

Phasor Measurement Unit (PMU)

PHASOR MEASUREMENT UNIT

1. *General*

The Bidders are encouraged to offer their standard products that meet or exceed the specification requirements. Although the bidder is encouraged to use as much standard hardware and software as possible, the proposal will be judged by its conformance to the Specification. The proposal shall clearly identify all deviations from the Specification to help EMPLOYER evaluate the degree of conformance of the Bidder's offering.

The substations /Generating stations normally are provided with CTs on each bay of the switchyard and CVTs in each transmission line bay and on each bus. Generally CTs have one metering core and four protection cores. The CVTs are provided with three cores, one for metering and other two for protection. The PMUs to be supplied shall be connected to either of these CT and CVT cores.

The specification identifies some minimum requirements for each of the major component which are essentially required for measurement of complex quantities and transmitting the same to the PDC (Phasor Data Concentrator) at control center. The delivered system is expected to provide meaningful measurement of the acquired data so that it is useful to the operators in assessing the current state of grid and can also be used for carrying out the post- facto analysis. The offered PMU must be in operation at least for one year as on date of bid opening.

1.1. Intent of Specification

The intent of this Specification is to describe the technical requirements for supply installation, testing, commissioning & integration of PMUs. The PMUs to be supplied under this Specification shall be installed at the Substations/Power stations and shall communicate to the Phasor Data Concentrator (PDC) at the Control Centre on IEEE C37.118 format.

1.2. Scope of Work

The scope of work shall include site survey, planning, design, engineering, testing, supply, integration, transportation & insurance, delivery at site, storage, installation, training, commissioning, demonstration for acceptance and documentation of:

a) Phasor Measurement Units (PMUs) along with GPS

b) All cabling, wiring, terminations and interconnections to the equipment including necessary trench/surface conditioning to interconnect the PMUs to the installed or being installed communication equipment by the Owner.

c) Integration of supplied PMUs to PDC conforming to IEEE C37.118 standard.

d) Cable connection / interfacing with communication equipment.

e) In case of multiple PMU at a substation/power plant the Router with firewall shall be provided which shall interface PMUs on one side and communication equipment on the other side.(

f) Any other work which is not identified in the specification but is required for completion of the work within intent of the specification shall also be in the scope of the Bidder.

g) On-site training of the Employer personnel.

h) Maintenance of the supplied equipment for 4 years after the one year warranty period.

The list of substations/power plants where PMUs are to be installed are indicated at Table-I and BOQ is specified at Table-2. The Data Requirement Sheet (DRS) to be submitted along with the Bid is attached at **Annexure-I**.

The Bidder shall indicate the Communication speed required for single PMU at 25 samples/second in their offer.

1.3. PMU Requirements

The offered PMUs shall be complete in all respect so that they can be installed at the substation/power plant and can communicate with Control centre having Phasor Data Concentrator (PDC). The necessary cable and connector and installation hardware shall also be supplied by the bidder. The PMUs shall normally be installed near to the control & relay panels and CT/CVT connections to the PMU shall be extended from the control & relay panels. The PMUs shall conform to IEEE C37.118 standard and shall be designed to meet the following requirements:

a. The PMUs shall be designed to measure the electrical parameters in the power system frequency band of 45-55 Hz.

b. The supplied PMU will be standalone in the substation control rooms /relay panel room.

c. The auxiliary power supply to PMUs will be provided from the station DC which is used for control and protection of substation devices. Accordingly the PMUs shall be suitable to operate on unearthed 220 V or 110V (+10%, -15%) DC power supply depending upon the station DC supply available.

d. The minimum offered configuration of PMUs shall have at least 9 analog input channel (1 set of 3-phase voltages, two set of 3-phase current) and 8 digital inputs. In case of substations & power plants where all the control & relay panels are installed in a single room, the Bidder may offer higher configuration to meet the requirement of multiple feeders and BOQ may be adjusted accordingly. Typical configuration diagram is shown in **Annexure-II.**

e. The PMUs shall be used to measure the following:

- 3 phase positive sequence voltages as magnitude and angle (polar form) quantities
- 3 phase positive sequence currents magnitude and angle (polar form) quantities

f. All the measurements shall be tagged with UTC (Coordinated Universal Time). The time tagging accuracy shall be at least one micro-second.

g. The PMU output shall be in IEEE C37.118 format and shall communicate with the PDC in the same format. The accuracy of the measurements shall be as per the IEEE C37.118 standard level 1.

h. The PMUs shall be suitable for configuring the data sampling rate of 10, 25, 50 samples per second. Actual rate shall be user selectable.

i. The PMUs shall have continuous self monitoring ,diagnostic feature and capable to identify & communicate problems and shall generate alarm in case of any abnormality which shall be displayed locally as well as shall be transferred to the PDC.

j. The PMU design shall ensure that the impact of frequency fluctuation (45-55 Hz) on accuracy is within permissible limit as per prevailing standards.

k. Testing & configuration accessories such as test switch, connector ,software etc which are not in-built to the PMUs but are required for testing and configuration changes, at least one set of such testing & configuration accessories shall be supplied complete with necessary hardware.

l. The PMUs shall communicate with PDC on Ethernet interface over the communication link provided by the employer. One communication port of 10/100/1000 Base Tx for TCP/IP for streaming data in IEEE C 37.118 format shall be provided in the PMU. Additional optical remote communication ports 10/100/1000 Base Tx for TCP/IP shall also be available for streaming data in IEEE C37.118 format.

m. There shall be provision for HMI (Human Machine Interface) in PMU to perform setting changes. In addition HMI should display the measured quantities for ease during testing. The Operation indications and time tagged events shall be available by the Local HMI. Alternatively Portable configuration device for PMUs at end can be provided for configuring the PMUs.

n. Remote configuration facility shall be provided in PMU and the supplier shall supply the software required for remote configuration of PMU.

o. Remote firmware upgrade feature shall be made available.

p. PMU shall be capable of sending data in Unicast and multicast both.

1.4. GPS based Time Facility

GPS based time facility to synchronize PMU clock with UTC source, shall be provided for each PMU. 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. The time receiver shall detect the loss of signal from the UTC source and a loss-of-signal event shall be sent to the PMU which will be transferred to PDC and shall result in an alarm at PDC. Upon loss of signal, the PMU time facility shall revert to an internal time base. The internal time

base shall have minimum stability of 1pps. Within five minutes of reacquisition of signal, the time shall return to within 1.5 micro-second of UTC. Proper correction of leap second shall be provided.

1.5. Phasor Data Concentrator (PDC) Requirements

The PMU to be supplied shall communicate to the PDC. The PDC is not in the scope of the present specification. However, the PDC to which PMUs to be integrated shall meet atleast the following features.

- Shall support data streaming in IEEE C37.118 format.
- Shall be capable of receiving data in Unicast and Multicast.
- PDC shall be able to receive the loss of signal event of the time receiver from PMU and shall result in an alarm at PDC.
- PDC shall support Remote configuration of PMU.

1.6. Environmental Requirements

The PMU will be installed inside buildings without temperature or humidity control. The PMU shall be capable of operating in ambient temperatures from -10 deg C to +55 deg C and relative humidity up to 10-90% non-condensing.

1.7. PMU Panel Construction

a) The PMUs shall be installed at the substation control room where the space in the existing panels may be available. The supplied PMU may be mounted in the existing panel wherever the space in the panel is available. The stand alone panel shall be provided, if space in the existing panel is not available.

b) Panels shall be free standing surface or flush type and shall comprise structural frames completely enclosed with specially selected smooth finished, cold rolled sheet steel of adequate thickness for weight bearing members of the panels such as base frame, front sheet and door frames, as well as for sides, door, top and bottom portions.

1.8. PMU Panels

The panel enclosures shall meet the following requirements:

a) The enclosures shall be finished inside and out. All cabinet metal shall be thoroughly cleaned and sanded, and welds chipped to obtain a clean, smooth finish. All surfaces shall be treated to resist rust and to form a bond between the metal and the paint. Enclosures (except for server racks) shall confirm to IP-31 degree of protection in accordance with IS-2147. All the louvers shall be provided with suitable wire mesh.

b) Enclosures shall be floor mounted with front and rear access to hardware and Wiring.

c) Moving assemblies within the enclosure, such as swing frames or extension slides, shall be designed such that full movement of the assembly is possible without bending or distortion of the enclosure or the moving assembly. Enclosures shall not require fastening to the floor to preclude tipping of the enclosure when the moving assembly is extended.

d) Cable entry shall be through the bottom. No cables shall be visible, all cables shall be properly clamped, and all entries shall be properly sealed to prevent access by rodents.

e) Cooling air shall be drawn from the conditioned air within the room. Ducted or directed cooling air to the enclosures will not be supplied by Employer.

f) All wiring shall use copper conductors. Conductors in multi core cables shall be individually colour coded.

g) Wiring within the enclosures shall be neatly arranged and securely fastened to the enclosure by non-conductive fasteners. Wiring between all stationary and moveable components, such as wiring across hinges or to components mounted on extension slides, shall allow for full movement of the component without binding or chafing of the wire.

h) All materials used in the enclosures including cable insulation or sheathing, wire troughs, terminal blocks, and enclosure trim shall be made of flame retardant material and shall not produce toxic gasses under fire conditions.

i) All enclosures shall be provided with suitable internal lighting lamp, 230 VAC 15/5A duplex type power socket & switch for maintenance purpose.

j) The finish colours of all enclosures/panels shall be finalized during detailed Engineering.

1.9. Earthing

a) All panels shall be equipped with an earth bus securely fixed. Location of earth bus shall ensure no radiation interference for earth systems under various switching conditions of isolators and breakers. The material and the sizes of the bus bar shall be at least 25 X 6 sq.mm perforated copper with threaded holes at a gap of 50mm with a provision of bolts and nuts for connection with cable armours and mounted equipment etc for effective earthing provision shall be made for extending the earth bus bars to adjoining panels on either side.

b) Provision shall be made on each bus bar of the panels for connecting substation earthing grid. Necessary terminal clamps and connectors for this purpose shall be included in the scope of supply of Bidder.

c) Panels shall be connected to the substation control room earth system at least at two places separately.

d) All metallic cases of PMUs shall be connected to the earth bus by copper wires of size not less than 2X2.5 sq. mm. The Colour code of earthing wires shall be green.

e) 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.

1.10. Interconnections

The bidder shall be responsible for laying and termination of all cables at 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.

The signals cables for communication shall be shielded type to provide suitable protection against noise and electromagnetic interference. All the cables shall be suitably sized to meet the functional requirements. Shielded/Armored cables shall be used for other requirements. These external cables (except communication cables) shall have the following characteristics:

- Minimum core cross-section of 2.5/4 mm^2 (depending upon site requirements) for PT cables and 2x2.5 mm^2 for CT cables, 2.5 mm^2 for Power & Control outputs and 1.5 mm^2 for Digital Status inputs shall be provided.
- Rated voltage of cables shall be Uo/U of 0.6/1.1KV

The Communication cable shall be of shielded, twisted pairs and of minimum 0.22sq mm size as per IS 1554 Part- I.

1.11. Router

In case of multiple PMUs at a substation/power plants all the PMUs shall be connected to the communication equipment through router. The router shall interface PMUs on one side and communication equipment on the other side. Router shall be provided with following features.

S.No	Description of the Features	Minimum Quantity of the features
1.	Functions	High performance Routing for data
2.	Routing Capability	Static & Dynamic routing
3.	Processing capacity	Minimum 2Mpps
4.	IPSec VPN tunnels	Minimum 10
5.	Features to support	QoS, MPLS, Security, Broadband, Multiservice, Voice, IP to IP Gateway
6.	Routing protocols	EIGRP, IGRP, IS-IS, OSPF, BGP, ARP, IPCP, IP forwarding, VLAN & MPLS etc.
7.	Network protocols	TCP/IP, IPv4,IPv6, OSI, Telnet, UDP, DHCP
8.	Network management	Using SNMP Protocol
9.	Minimum inbuilt software firewall features required	a) Data encryption supported DES (56 BITS) 3des (168 bits) and hashing algorithm like MD5 and SHA-1 b) Filtering of packets based on Source address, Destination address, Protocol type, User, Port number, URL c) Filtering of Protocols such as FTP, SMTP,

		HTTP, SNMP, UDP, ICMP, RPC, DNS, DHCP, ARP d) Detailed system logging
10.	Speed configurability at each port	All ports shall be configurable from 64kbps to 2Mbps
11.	Interface ports	a) For connecting to communication equipment on 1Gbps Ethernet port or G.703 Port. b) 1Gbps Ethernet port for each PMU
12.	Mounting	Rack mountable
13.	Minimum no. of concurrent TCP sessions	10

1.12. Training

Training shall be conducted by contractors personal who are experienced instructor. All necessary training material shall be provided by the contractor. Each trainee shall receive individual copies of all technical manuals and all other documents used for training. The training courses, and their duration in each courses are identified in Table-1

Table-1: Training Requirements

S.No	Training Course	Total No. of days	Participation
1	PMU– Technical internals	3	Persons responsible for Installation and commissioning

1.13. Spares

One spare PMU identical to PMU in Main items as a spare shall be supplied by the contractor, under the contract as indicated in **Table-2 (BOQ).**

1.14. Maintenance

Contractor shall be responsible for providing "Maintenance on call" of the system under warranty including supply of spares for ensuring the successful operation of the system. The maintenance period shall be for 4 years after one year of warranty period. The maintenance period shall be extended for a further period of 3 years at the same price in the final offer of the vendor with same terms & conditions. During this period, the contractor shall have prime maintenance responsibility for the system. The response time for the maintenance shall be less than 24 hours excluding the journey period.

1.15. Documentation

Complete documentation is required to support PMU setup, operation and maintenance. The documentation shall include following:

a) Procedures for PMU setup and use with regards to all features.

b) Documentation of procedures regarding routine maintenance including use of system diagnostics.
c) Detailed connection diagrams showing how the PMUs are installed at site.
d) A complete copy of PMUs functional design
e) Details of PMU database.
f) Details of hardware/software and as built system.

All documentation shall be delivered in both electronic format (e.g. PDF, MS WORD, Hypertext, etc.) on CDs/DVDs/USB drive, and in hardcopy format. Sufficient on-line, documentation, such as help screens, user guidance messages, context-sensitive help information links, etc., shall be included with the system to minimize the need for users to consult the hardcopy documentation**.**

1.16. Testing of PMUs

The offered PMUs shall conform to the type tests as per applicable standard and the bidder shall supply type tested PMU. The bidder shall submit PMU type test reports along with the bid for the offered make and model. The type test report shall include at least these tests indicated as follows:

A. Level-1 accuracy test as per IEEE C37.118 standard
B. Electromagnetic compatibility (EMC), Immunity conforming to the requirements of IEC-60255/IEC 61000.
C. Emission test conforming to the requirements of EN 55011
D. Insulation Test per IEC 60255-5
E. Environmental Test as per IEC 60068-2-2

In case the type tests are conducted after placement of order, the Bidder shall get the Type Test procedure approved by the Employer/Owner and then these tests shall be conducted at bidder's own cost in presence of owner representative. The Bidder shall offer the PMUs for inspection & Factory acceptance Tests (FAT). During FAT the supplier shall demonstrate all the functions of PMU. The compatibility to integrate with PDC in accordance to IEEE C37.118 shall also be demonstrated. These functionalities shall also be demonstrated at site at the time of commission of PMUs at site. The procedure for all the testing shall be agreed between the supplier and purchaser before proceeding for the testing.

Locations for Installation of PMU

Table-1

S.No.	Name of Station	Owner Utility	Voltage Level	Communication type
1				
2				
3				
4				
5				

Table-2

Typical BOQ (Bill of Quantity)

S.No	Name of the item	Unit	Qty
1	PMU (complete with all necessary accessories, cables etc. as per specification) with minimum 1 three phase voltage & 2 three phase currents	Nos	--
2	Panel for mounting PMUs and other equipment	Nos	--
3	GPS (complete with all necessary accessories, cables etc. as per specification)	Nos	--
4	Router (In case of multiple PMUs)	Nos	--
	Spares		
5	PMU (complete with all necessary accessories, cables etc. as per specification)	Nos	--
	Services		
6	Installation and commissioning of PMUs and associated items at site along with all interconnections with CT, PT and communication equipment complete in all respect as per technical specification.	Nos	--
F	**Training**	Lot	1
G	**Maintenance**		
1	AMC of the equipment being supplied for 1 year during warranty period	Lot	1
2	AMC of the equipment being supplied for 4 years after warranty period	Lot	1

Annexure –I

Data Requirement Sheet to be submitted by the Bidder along with Bid:

S.No	Item Description	Offering as per Bidder
1.	Make & Model of PMU	
2.	Compliance to IEEE C37.118	Yes / No
3.	No of 3 phase Current input	
4.	No of 3 phase Voltage input	
5.	Accuracy of measurements	
6.	Data Sampling Rates provided	
7.	Power Frequency measuring range	
8.	PMU configuration feature	
9.	DC Supply operating range	
10.	Baud rate required at 25 samples/second for Communicating with PDC	
11.	Make & Model of Router	
12.	Make & Model of GPS	

Annexure –II

Typical Hardware configuration Diagram for Multiple PMUs