



**POWER SYSTEM OPERATION CORPORATION LIMITED**  
**National Load Despatch Centre (NLDC), New Delhi**

Dated: 23<sup>rd</sup> April 2020

To  
All Stakeholders.

**Subject: Draft guidelines on communication Interface Requirement.**

Central Electricity Regulatory Commission (Communication System for inter-State transmission of electricity) Regulations, 2017 have been notified on 15<sup>th</sup> May, 2017.

Under clause 7.4 (i), Role of NLDC, of the regulation following role has been assigned to NLDC:

*"The National Load Despatch Centre (NLDC) shall be responsible for preparation and issuance guidelines with the approval of the Commission on the "Interfacing Requirements" in respect of terminal equipment, RTUs, SCADA, PMUs, Automatic Generation Control (AGC), Automatic Meter Reading (AMR) Advanced Metering Infrastructure (AMI), etc. and for data communication from the User's point to the respective control centre(s) based on technical standards issued by CEA within 60 days of issuance of technical standards. "*

(URL: <http://www.cercind.gov.in/2017/regulation/134.pdf> ).

Technical standards for Communication System in Power Systems Operation has been issued by CEA on 27<sup>th</sup> Feb'20.

([http://www.cea.nic.in/reports/regulation/techstandardcommsystempower\\_2020.pdf](http://www.cea.nic.in/reports/regulation/techstandardcommsystempower_2020.pdf)).

In compliance to the above, the draft guideline on communication requirement and data communication is enclosed and hereby placed on the <https://posoco.in/Draft Guideline on Interface Requirement>.

Suggestions/feedback on the Draft guideline are invited from stakeholders.

The suggestions/feedback may kindly be sent to NLDC through email at [communication@posoco.in](mailto:communication@posoco.in) latest by 21<sup>st</sup> May 2020.

  
(Debasis De)  
Executive Director



# INTERFACE REQUIREMENTS

## 1. Introduction

This document has been prepared in line with the clause 7.4 (i) of Communication Regulation: File No. L-1/210/2016/CERC dated: 15th May 2017 stating that *“The National Load Despatch Centre (NLDC) shall be responsible for preparation and issuance guidelines with the approval of the Commission on the “Interfacing Requirements” in respect of terminal equipment, RTUs, SCADA, PMUs, Automatic Generation Control (AGC), Automatic Meter Reading (AMR) Advanced Metering Infrastructure (AMI), etc. and for data communication from the User's point to the respective control centre(s) based on technical standards issued by CEA within 60 days of issuance of technical standards”* (URL: <http://www.cercind.gov.in/2017/regulation/134.pdf> ).

Technical standards for Communication System in Power Systems Operation issued by CEA on 27<sup>th</sup> Feb'20 ([http://www.cea.nic.in/reports/regulation/techstandardcommsystempower\\_2020.pdf](http://www.cea.nic.in/reports/regulation/techstandardcommsystempower_2020.pdf)).

These guidelines focus on the general data acquisition systems for RTUs, SAS Gateway computers, communications, and AMI metering systems required for reliable and economic operations of the control centre(s).

These guidelines shall be applicable to all Users of the grid connected at National, Regional and Inter-State level. It shall also be applicable to customers embedded within the state, connected with the Intra-State transmission system.

All Users, SLDCs (State Load Despatch Centres), RLDCs (Regional Load Despatch Centres), NLDC (National Load Despatch Centre), CEA (Central Electricity Authority), CTU (Central Transmission Utility), STUs (State Transmission Utilities), RPCs (Regional Power Committees), NHPTL (National High Power Test Laboratory), REMC (Renewable Energy Management Centre), FSP (Forecasting Service Provider), Power Exchanges and ISTS (Inter State Transmission System) licensees etc. shall abide by the guidelines as applicable to them

Requirement mentioned herein under this document shall be applicable to Main and Backup Control Centre (wherever applicable) irrespective it is mentioned or not mentioned separately in subsequent sections.



## 2. Relevant definitions from the Regulations

- 2.1. "Control Centre" means NLDC or RLDC or REMC or SLDC or Area LDC or Sub-LDC or DISCOM LDC including main and backup as applicable.
- 2.2. "Data" means a set of values of analogue or digital signal including a text, voice, video, tele - protection, alarm, control signal, phasor, weather parameter, parameter of a machine or the power system.
- 2.3. "Real Time Data" denotes information relating to current operating state of power system in accordance with system operation and control requirements.
- 2.4. "User" means a person such as a Generating Company including Captive Generating Plant, RE Generator, Transmission Licensee [other than Central Transmission Utility (CTU) and State Transmission Utility (STU)], Distribution Licensee, a Bulk Consumer, whose electrical system is connected to the ISTS or the Intra-State transmission system.
- 2.5. "Wide band Node" means wide bandwidth data transmission data with an ability to simultaneously transport multiple signals and traffic types.
- 2.6. "Supervisory control and data acquisition (SCADA)" means a system of remote control and telemetry used to monitor and control the transmission system;
- 2.7. "Communication Channel" means a dedicated virtual path configured from one users' node to another user's node, either directly or through intermediary node(s) to facilitate voice, video and data communication and tele-protection system
- 2.8. "Communication Network" means an interconnection of communication nodes through a combination of media, either directly or through intermediary node(s);
- 2.9. "Communication System" is a collection of individual communication networks, communication media, relaying stations, tributary stations, terminal equipment usually capable of inter-connection and inter-operation to form an integrated communication backbone for power sector. It also includes existing communication system of Inter State Transmission System, Satellite and Radio Communication System and their auxiliary power supply system, etc. used for regulation of inter- State and intra-State transmission of electricity;
- 2.10. "Node" means connection point on a communication network, at which data is conveyed via communication channels to or from that point to other points on the network;
- 2.11. "Remote Station" means transmission substations/ generating stations operated by the users from which data/real-time data is collected;



### 3. Real time data Telemetry

As per Indian Electricity Grid Code (as amended/revised from time to time) clause 4.6.2, all Users, STUs and CTU shall provide Systems to telemeter power system parameter such as flow, voltage and status of switches/ transformer taps, Sequence of Events (SOE) etc. in line with interface requirements and other guideline made available by NLDC. While many of design details related to control systems are not included in this guidelines, the Users, who are getting connected to the ISTS, shall require to include functionalities and the interfaces compatible with the respective Control Centre data collection systems available and being maintained at NLDC / RLDCs and SLDC/Sub-LDC and other LDC level. Control Centre may request or transmit data periodically or “by exception” (periodically, as the need for information arises) on demand, or interactively.

A list showing the parameters to be telemetered from various sub-stations and generating stations with respect to various equipment is given in **Annexure - I**. This list shows minimum required parameters, however, some other parameters shall be provided as per Control Centre requirement. The analog signal sign convention shall be as per IEEE power flow convention and digital status shall be as per IEC standard. All users shall comply with the requirements as specified and shall share with respective control centre.

The typical layout diagram showing point of interface for real time telemetry is attached at **Annexure - II**.

### 4. Communication Interface

The Users shall support at least the following facilities and plan for communication interfaces accordingly at the time of implementation:

1. Real time data exchange including AGC/Control signal with Control Centre (Main & Backup).
2. Phasor data exchange
3. Meter data exchange
4. Protection signal transmission (SPS, Direct Tripping and Permissive Tripping Carrier Signal etc)
5. Voice communication
6. Video Communication

Other requirements, if any, Users may include while designing the local communication interface requirement.



The required communication interfaces shall be provided for both sending and receiving ends. All the interfaces shall be provided with audio-visual status indication to indicate its normal operation as per relevant standards.

Users shall have functionality to support any of the interfaces given below based on availability of the interface at their respective end.

#### **4.1. Remote Station**

“Interfacing Requirements” in respect of terminal equipment, Remote Terminal Unit (RTUs)/ Substation Automation System (SAS), Supervisory Control and Data Acquisition System (SCADA), Phasor Measurement Unit (PMU) /Phasor Data Concentrators (PDC), Automatic Generation Control (AGC), Station Protection / System Protection Schemes (SPS), Automatic Meter Reading (AMR), Advanced Metering Infrastructure (AMI), etc. and for data communication is decided based on communication protocol used for transfer of data between user and respective control centres through dedicated and redundant communication channel with route diversity.

Remote end equipment like RTUs, PMUs, SAS, Metering Gateways, Meter Data Collection Unit, PLCs for AGC etc. shall report through communication protocol which is supported at the reporting Control Centre.

While designing the interface requirement of the remote locations, all the interfaces required for data (power system parameter, meter data, AGC/Control Signal), voice, video, protection signal shall be considered and shall be compatible with respective control centre as well as intervening Communication System equipment.

A typical General Arrangement drawing for a Remote Station is given as part of **Annexure -III**.

The interfaces shall be designed to operate under single contingency failure condition. The following contingencies shall be considered:

1. Failure of single hardware element, i.e. communication port, card, gateway etc. of the Users shall not lead to failure of data communication to control centre.
2. Failure of single communication interfaces.
3. Redundant Communication interfaces shall support redundant communication channel with physical path redundancy.



4. The interface equipment shall be supplied from emergency power supply having at least 10 hrs backup against normal supply failure.
5. Main and Standby link has to be terminated in two different card in communication equipment to ensure that failure of single card will not affect outage of both main and standby communication links.
6. For RTU based stations LDMS system has to be connected with RTU on dedicated port, so that LDMS system and communication channel for data reporting to Control Centre are completely isolated.
7. For any interfacing Equipment, where multiple number of ports work as redundant port, all ports need to be provided from independent interface card.
8. Unmanaged switches shall not be used as interfacing equipment.

Availability of communication links shall be maintained as per Communication Regulations, 2017. Further, the communication channel provided / configured for the real time data communication shall be made error free and shall not lead to intermittency in real time data at respective Control Center.

#### **4.1.1. Remote Terminal Unit (RTU)/Substation Automation System (SAS)/PLCs**

“Remote Terminal Units” (RTU) / Substation Automation System (SAS) is the device suitable for measuring, recording and storing the consumption of electricity or any other quantity related with electrical system and status of the equipment in real time basis and exchanging such information with the data acquisition system for display and control.

The RTU/SAS System /device shall communicate with Control Centre front end system in either IEC-60870-5-101 or IEC—60870-5-104 protocol.

- i) IEC - 101 works on serial communication between site and control centre and it requires serial interface. Different Physical interface that can be used for 101 communications which are:
  - a) RS-232 / RS 422 / RS 485 / X.21 / X.25 / G.703 / V.35.
- ii) IEC 104 works on TCP/IP based communication and it can use following Physical interface:
  - a) Ethernet (IEEE 802.3 / IEEE 802.3u) or Ethernet VLAN (IEEE 802.1 P/Q)
  - b) Optical communication Port
  - c) IP/MPLS Interface-10/100BaseT(Electrical) or 100BaseFX(Optical) Ethernet Link



iii) Distance between PDH/SDH and RTU/SAS should be designed in such a manner that configuration in IEC-101/104 shall not be restricted by the cable length to be connected between RTU/SAS and PDH/SDH equipment.

The communication interface equipment at the remote (RTU / SAS) location shall support the interfaces as mentioned above and the communication provider shall ensure the proposed data sharing protocol by the stations so that the compatible interface is provided.

#### **4.1.2. Phasor Measurement Unit**

PMU (Phasor Measurement Unit)" provides phasor information (both magnitude and phase angle) for one or more phases of AC voltage or current waveforms including positive sequence phasors-and analog quantities like MW, MVAR, frequency, Rate of Change of Frequency (ROCOF) in real time. Control Centre shall exchange phasor information between their respective Synchrophasor systems via high-speed real-time data acquisition networks, using the protocol specified in latest IEEE C37.118 communication standard.

PMU shall report on C37.118 2011 or higher protocol with configuration Frame 3 or better for data communications. Different Physical Interface for PMU includes:

1. Ethernet (IEEE 802.3 / IEEE 802.3u) or Ethernet VLAN IEEE 802.1 P/Q).
2. Optical Interface (100 BASE-FX Multimode 850 nm/1300nm nm)
3. IP/MPLS Interface-10/100BaseT(Electrical) or 100BaseFX(Optical) Ethernet Link

The minimum bandwidth requirement for individual PMU communication is 2 Mbps.

Synchrophasor data is exchanged between Control Centre Phasor Data Concentrators (PDC) continuously at a rate of 25 Frames per second or higher as per the requirement of Control Centre(s).

All data items, regardless of type, are generally collected and disseminated at a frequency of 25 samples per second (can be higher rate of samples per second in future), and must be sent to Control Centre with the associated data quality codes in compliance with latest IEEE C37.118 communication standards.



#### 4.1.3. Metering gateway

Automatic Meter Reading system uses its front end for transferring meter data from interface meters gateway / Meter Data Collection Unit to control centre. It uses DLMS protocol for data communication. Different types of interface required are:

1. Ethernet (IEEE 802.3 / IEEE 802.3u) or Ethernet VLAN IEEE 802.1 P/Q).
2. IP/MPLS Interface-10/100BaseT(Electrical) or 100BaseFX(Optical) Ethernet Link.

The internal communication with the main meter data gateway and other meters in a particular location may use available communication and interface may be decided based on local available communication protocol.

#### 4.1.4. Tele-protection/Control

Equipment protection, Tele-protection /control interface will be used for transmitting control signal from one end to other, it can be from one sub-station to other sub-station or control centre to sub-station/generating station. Interface requirement for tele-protection devices are given below:

1. V.11 / X.21 / X.24; RS-422 / RS-530 / RS-449, from 32 to 256 Kbit/Sec
2. G.703.1 (64 kbps, co-directional)
3. E1 / T1(2Mbps), G.703 Interface Option for transmission over E1 Link
4. 10/100 Mbps Fast Ethernet
5. IP/MPLS Interface-10/100BaseT (Electrical) or 100BaseFX (Optical) Ethernet Link
6. Optical interface at 256 Kbit/s 1310 nm up to 60 km range and 1550 nm up to 110 km range
7. Optical port (optional SFP: 850 nm MM 0.5 to 1 km or 1310 nm SM 30 to 50 km
8. IEEE C37.94, ITU-T G.703 interface.

#### 4.1.5. Voice communication

Voice communication interface shall have following network interface for voice communication between user location to Control Centre:

- a. 2-wire FXO/2-wire FXS
- b. 4- wire E&M.
- c. VOIP system uses TCP/IP communication and it can use Ethernet (IEEE 802.3 / IEEE 802.3u) or Ethernet VLAN IEEE 802.1 P/Q).





d. EPABX exchange to be interfaced with Wide-band network

There shall be provision for establishing voice communication to main and backup control Centre.

The user end communication equipment shall be compatible with respective Control Centres.

#### **4.1.6. Video Communication**

Video communication interface shall be provided on TCP/IP communication and it can use Ethernet (IEEE 802.3 / IEEE 802.3u) or Ethernet VLAN (IEEE 802.1 P/Q).

#### **4.2. Control Centre**

The communication interfaces to be provided at the control centre end shall support all the interfaces that is required at the remote end. Apart from interface requirements of the remote stations, high bandwidth links are required for inter control centre protocol (ICCP) communication and proprietary protocol like ISD / Multisite for Main & Backup operation. Configurable Ethernet ports supporting up to 1 Gbps shall be provided at the control centre end.

The communication equipment shall also support internal VLAN configuration to optimise the communication with the remote end.

Different types of interface required at Control Centre are:

- a) V.11 / X.21 / X.24; RS-422 / RS-530 / RS-449, from 32 to 256 Kbit/Sec
- b) G.703.1 (64 kbps, co-directional)
- c) E1 / T1(2Mbps), G.703 Interface Option for transmission over E1 Link
- d) 10/100 Mbps Fast Ethernet
- e) IP/MPLS Interface-10/100BaseT(Electrical) or 100BaseFX(Optical) Ethernet Link
- f) Optical interface at 256 Kbit/s 1310 nm up to 60 km range and 1550 nm up to 110 km range
- g) Optical port (optional SFP: 850 nm MM 0.5 to 1 km or 1310 nm SM 30 to 50 km
- h) IEEE C37.94, ITU-T G.703 interface.
- i) Gigabit Ethernet or Gigabit optical interface

#### **5. Cross-Border Power System Connections**

As per Regulation Clause 18 (Data and Communication Facilities) of CERC (Cross Border Trade of Electricity Regulations), File No. 13/2/7/2015-PM/CERC dated: 08<sup>th</sup> March 2019 stating that-



*“communication system must be established from generating station or concerned grid substation(s) to control room of System Operator of a neighbouring country and from there to control room of System Operator of India” & “Cross Border Transmission Link shall necessarily have reliable and efficient voice and data communication systems with the System Operators on both the sides”.*

(URL: <http://www.cercind.gov.in/2019/regulation/CBTE-Regulations2019.pdf> ). At each point of interconnection on the India side; respective transmission licensee should ensure facilitating interface requirement for cross border interconnections and will take necessary measures to strictly adhere with regulation and shall comply with the interface guidelines issued by NLDC in this regard.

## **6. Cyber Security Requirements**

The communication service provider while providing the interfaces for the data exchange between the control centres, between the user station and the Control Centre must comply with CERT-In, NCIIPC (National Critical Information Infrastructure Protection Centre) guidelines for the interface being provided to the end user in accordance with CEA technical standards of communication systems.

Necessary firewall / router shall be provided by the respective users while connecting the remote equipment with the control centre network. Direct connectivity with the operational network be avoided while connecting the remote station and shall be through firewall with necessary VLAN configuration.

A typical diagram is attached at **Annexure – IV** showing the cyber security requirements.

## **7. Maintenance, Validation and Testing**

Users shall facilitate for periodic maintenance and testing of interface equipment owned by them in accordance with procedure for maintenance and testing to be prepared by CTU in accordance with CERC Communication Regulations 2017.

## **8. Document Revision**

The interface requirement is based on current protocols implemented at different control centres and remote end equipment and the available protocols and communication interfaces available based on the available communication technology. The documents shall be revised as and when there is change in technology, and as and when any deficiency is noticed with approval of CERC.

**A list of parameters to be telemetered from various sub-stations and generating stations with respect to various equipment**

**A. SCADA System**

| Sl. No | Description  | Analog Points  | Digital Points  | Protection Signal                                    |
|--------|--|--|---|--|
| 1      | Line   | -MW<br>-MVAR   | - line Isolator Status<br>SOE with Time Stamping  | Main1/Main2 protection, Over Voltage protection, LBB |
| 2      | Bays   |  | - Breaker<br>-Isolator/ Disconnecter (Line Selection in DMT scheme)<br>SOE with Time Stamping |  |
| 3      | Main Buses, Transfer Bus, Bus Coupler, Bus Sectionalizer | -Voltage<br>-Frequency<br>-MW & MVAR flow in case of bus sectionalizer<br>-MW& MVAR flow across Bus Couplers | - Breaker, Isolator,<br>- SOE with Time Stamping  | Main1/Main2 protection                               |
| 4      | Transformer  | -MW/MVAR for HV/LV Side<br>-Tap Position   | -Breaker<br>-Isolator Status<br>SOE with Time Stamping  | Main1/Main2 protection                               |
| 5      | (Hot standby) Transformer                                | -MW/MVAR for HV/LV Side  | -Breaker<br>-Isolator Status  |  |
| 6      | Reactor  | MVAR   | -Breaker<br>-Isolator Status<br>--Bypass isolator status of NGR<br>-SOE with Time Stamping    | Main 1 and 2 Protection                              |
|        | (Hot standby) Spare Reactor                              | MVAR   | -Breaker<br>-Isolator Status  |  |
| 7      | FSC/TCSC   | -% compensation  | -Bypass Breaker<br>-Bypass Isolator<br>-FSC ON/OFF Status                                     | Oscillation Damping Controller                       |



| Sl. No | Description   | Analog Points  | Digital Points   | Protection Signal  |
|--------|---|--|--|--|
|        |   |  | SOE with Time Stamping   | (Operated or not) status   |
| 8      | SVC   | -Slope<br>-Gain<br>-Q-Ref<br>-V-Ref<br>-V min<br>-Vmax<br>-Current for each branch<br>-total MVAR compensation   | -Isolator Status for each branch with SOE<br>-SVC Mode (Automatic/Manual)<br>-Q Control Mode (Enable/Disable)<br>SOE with Time Stamping  | Oscillation Damping Controller (Operated or not) status  |
| 9      | HVDC (Both Type: Line Commutate Converter & Voltage Source Converter) | -DC Voltage<br>-DC Power Flow<br>-DC Current<br>-Individual Filter MVAR<br>-Firing Angle-Alpha<br>-Extinction angle- Gamma, etc.<br>-Power order, set point<br>Compensation settings if applicable | -Individual Filter Status<br>-HVDC Mode (Metallic return / Ground return)<br>-Isolator/CB Status of DC Switchyard<br>-RPC Status<br>-Run back Status<br>-POD Status<br>-SSDC Status<br>- SOE with Time Stamping<br>-DMR -1 status<br>-DMR-2 status<br>-MRTB status<br>-GRTB status<br>-SoE for HVDC auto-restart | DC line Fault Protection, ESOF (emergency Switch Off) and HVDC Pole Block protection, POD Status (operated or not) |
| 10     | Converter Transformer   | -MW/MVAR for HV/LV Side<br>-Tap Position   | -Breaker<br>-Isolator Status   |  |
| 11     | Spare Converter transformer   | -MW/MVAR for HV/LV Side  | -Breaker<br>-Isolator Status   |  |
| 12     | Generator   | -MW (HV/LV)<br>-MVAR (HV/LV)<br>-LV Voltage / Frequency<br>Unit Set point<br>-Unit DeltaP for AGC,   | - RGMO/FGMO ON/OFF Status<br>- LV Breaker Status<br>- AGC Local / Remote status<br>- PSS ON/OFF status   | Class A, B, C protection status  |

| Sl. No | Description           | Analog Points  | Digital Points  | Protection Signal      |
|--------|-----------------------|--|---|------------------------|
|        |                       | -Droop settings Value,<br>-AVR Reference Voltage   | - AVR ON/OFF Status<br>- SOE with Time Stamping   |                        |
| 13     | Generator Transformer | -MW/MVAR for HV/LV Side<br>-Tap Position   | -Breaker<br>-Isolator Status  | Main1/Main2 protection |
| 14     | Synchronous Condenser | -MW (HV/LV)<br>-MVAR (HV/LV)<br>-LV Voltage / Frequency  | -Breaker<br>-Isolator Status  |                        |
| 15     | STATCOM               | Qstat,<br>QMSC, QMSR, VHV, VMV,<br>Q <sub>tra</sub> , P <sub>aux</sub> , Q <sub>aux</sub> ,<br>Tap Position of Coupling transformer<br>Power Oscillation damping setting<br>Inductive slope<br>Capacitive slope<br>Up set reference/ Down set reference<br>Feedback signal voltage<br>MSC/MSR switching in and out setting (voltage, time) | - CB<br>- Isolator<br>STATCOM modes status (Voltage/Reactive/NSC etc)<br>POD status<br>- SOE with Time Stamping   |                        |
| 16     | Phase Shifter         | MW / MVAR<br>Angle of shift  | - CB<br>- Isolator<br>- SoE with time stamping  |                        |
| 17     | Wind                  | - Wind speed at hub height<br>- Wind direction<br>- Blade Angle<br>- Ambient air temperature<br>- Relative Humidity (%)<br>- Air Density<br>-Atmospheric Pressure<br>- Total MW/MVAR<br>- Individual Turbine MW, - MVAR, wind speed<br>- Total number of turbines online<br>- Total Power Capacity.  | WTG CB Status<br><br>CB and Isolator status of pooling station<br><br>Turbine Availability<br>PPC modes status<br><br>(Voltage/PF/Reactive Power)<br><br>Frequency control (FGMO/RGMO) status |                        |

| Sl. No | Description | Analog Points   | Digital Points  | Protection Signal |
|--------|-------------|---|---|-------------------|
|        |             | <ul style="list-style-type: none"> <li>- Available Power Capacity</li> <li>-Available Power (Active and Reactive) at Plant level.</li> <li>-Active Power set point</li> <li>-Reactive Power set point</li> <li>-PPC modes signals:<br/>Reference and actual values of Voltage Control mode, Power Factor Control mode and Reactive Power Control mode)</li> <li>-Droop setting of Voltage Control mode</li> <li>-Active power ramp rate UP and down setting</li> </ul>  | <ul style="list-style-type: none"> <li>LVRT/HVRT status</li> </ul>  |                   |
| 18     | Solar       | <ul style="list-style-type: none"> <li>-Global horizontal irradiance</li> <li>-Global plane of array irradiance</li> <li>- Diffusion Irradiance- Watt per meter square</li> <li>- Direct Irradiance- Watt per meter square</li> <li>- Sunrise and Sunset timings</li> <li>-Tilt angle</li> <li>- Dust fall</li> <li>-Ambient temperature (deg C)</li> <li>-Back of PV module temperature</li> <li>-Battery charge</li> <li>-MW/MVAR</li> <li>-Relative Humidity</li> <li>- Performance Ratio</li> <li>- Cloud Cover (Okta)</li> </ul> | <ul style="list-style-type: none"> <li>- Inverter Status (ON/OFF)</li> <li>-Module Availability</li> <li>-CB/Isolator Status</li> <li>-Rectifier Availability</li> <li>-PPC modes status</li> <li>Voltage/PF/Reactive Power)</li> <li>Frequency control (FGMO/RGMO) status</li> <li>AGC status</li> <li>LVRT/HVRT status</li> </ul> |                   |

| Sl. No | Description             | Analog Points  | Digital Points  | Protection Signal |
|--------|-------------------------|--|---|-------------------|
|        |                         | -Temperature, Wind Speed, Rainfall, Wind Speed, Wind Direction<br>- Inverter MW/MVAR (AC Side & DC Side)<br>-Available Power (Active and Reactive) at Plant level.<br>-Active Power set point<br>-Reactive Power set point<br>-PPC modes signals<br>Reference and actual values of Voltage Control mode, Power Factor Control mode and Reactive Power Control mode)<br>-Droop setting of Voltage Control mode<br>-Active power ramp rate UP and down setting |   |                   |
| 19     | Energy Storage Resource | State of Charge<br><br>MW/MVAR (AC Side & DC Side)<br>Modes (Energy storage, Frequency regulation, etc.)   | CB/Isolator Status<br>Controller status,<br>RGMO/FGMO                                 |                   |
| 20     | SPS Signal              |  | DIGITAL STATUS:<br>Enable/Disable,<br>Operated/No Operated.<br>(Condition/Logic Wise) |                   |
| 21     | Weather Parameter       | -Temperature<br>- Wind Speed<br>-Humidity<br>-Rainfall   |   |                   |
| 22     | AGC                     | -Unit Load Set Point (ULSP)<br>-Actual Generation MW<br>-Unit Capability   | -Circuit Breaker Status on/off<br>-Governor status on/off                             |                   |



| Sl. No | Description                  | Analog Points  | Digital Points   | Protection Signal |
|--------|------------------------------|--|--|-------------------|
|        |                              | <ul style="list-style-type: none"> <li>-RGMO/FGMO/Governor input to governor</li> <li>-DeltaP</li> <li>-Reactive Power</li> <li>-AVR Voltage Set Point</li> <li>-Low Voltage (LV) side Actual Voltage</li> <li>-Generator Transformer (GT) Tap Position</li> <li>-Distribution Factor</li> <li>Additional Analog inputs from Hydro power plants</li> <li>-Minimum load at which unit can stably run after synchronization – Unit wise (P1) (in MW)</li> <li>- Forbidden zones or high cavitation zones - Unit-wise (From MW to MW) - P2 to P3</li> <li>- Maximum loading possible on unit (continuous) (P4)</li> <li>- Declared Energy for the day</li> <li>- Schedule Energy (Cumulative)</li> <li>- Water gross head (m)</li> <li>Additional Analog inputs from Gas power plants</li> <li>- Reference exhaust gas temperature</li> <li>- Actual exhaust gas temperature</li> </ul> | <ul style="list-style-type: none"> <li>- AGC Local/Remote</li> <li>Additional Digital inputs from Hydro power plants</li> <li>- Pumping Status on/off</li> </ul> |                   |
| 23     | Loads (Lift Irrigation etc.) | - MW/MVAR  | -Breaker<br>-Isolator Status   |                   |



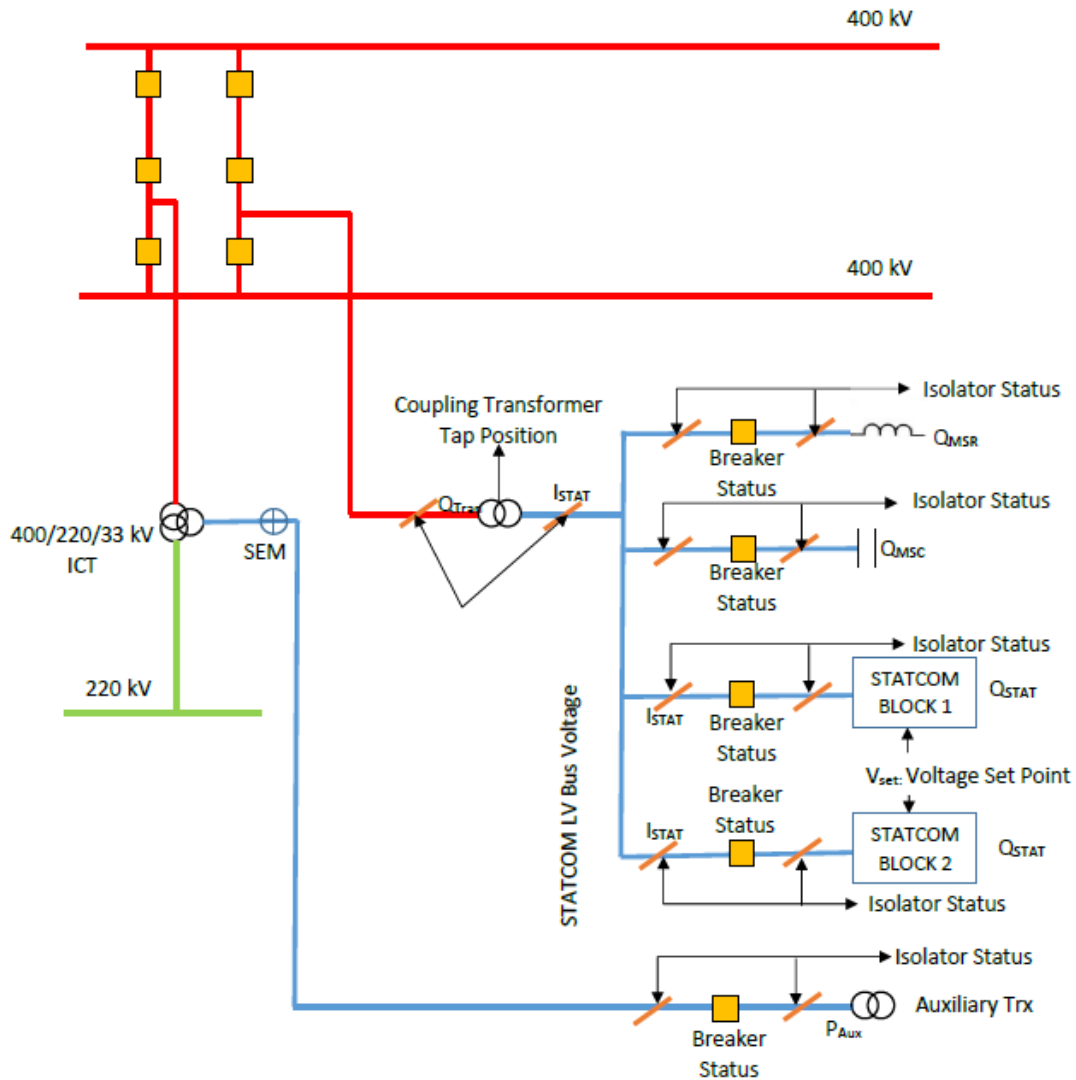
## B. PMU Signal List

| Sl. No | Description  | Analog Points  | Digital Points  | Protection Signal       |
|--------|--|--|---|-------------------------|
| 1      | Line   | <b>VOLTAGE</b> {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA}<br><b>CURRENT</b> {IRM, IYM, IBM, IPM, IRA, IYA, IBA, IPA}<br>MW, MVAR, F , DF/DT          | -Main Breaker status<br>-Tie Breaker status<br>-Isolators | Main1/Main2 protection, |
| 2      | Bays   |  | - Breaker<br>-Isolators                                   |                         |
| 3      | Main Buses, Transfer Buses                             | - <b>VOLTAGE</b> {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA}<br>F, DF/DT  | Bus Sectionalizer,<br>Bus Coupler<br>Breaker              |                         |
| 4      | Transformer/Coupling Transformer/Converter Transformer | - <b>VOLTAGE</b> {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA}<br><b>CURRENT</b> {IRM, IYM, IBM, IPM, IRA, IYA, IBA, IPA}<br>MW/MVAR<br>for HV& LV Side | -Breaker<br>-Isolators                                    | Main1/Main2 protection  |
| 5      | Reactor  | <b>VOLTAGE</b> {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA}<br><b>CURRENT</b> {IRM, IYM, IBM, IPM, IRA, IYA, IBA, IPA}<br>MVAR                         | -Breaker<br>-Isolators                                    |                         |
| 6      | FSC/TCSC   | <b>VOLTAGE</b> {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA}<br><b>CURRENT</b> {IRM, IYM, IBM, IPM, IRA, IYA, IBA, IPA}<br>MVAR                         | -Bypass Breaker<br>-<br>-FSC ON/OFF Status                |                         |

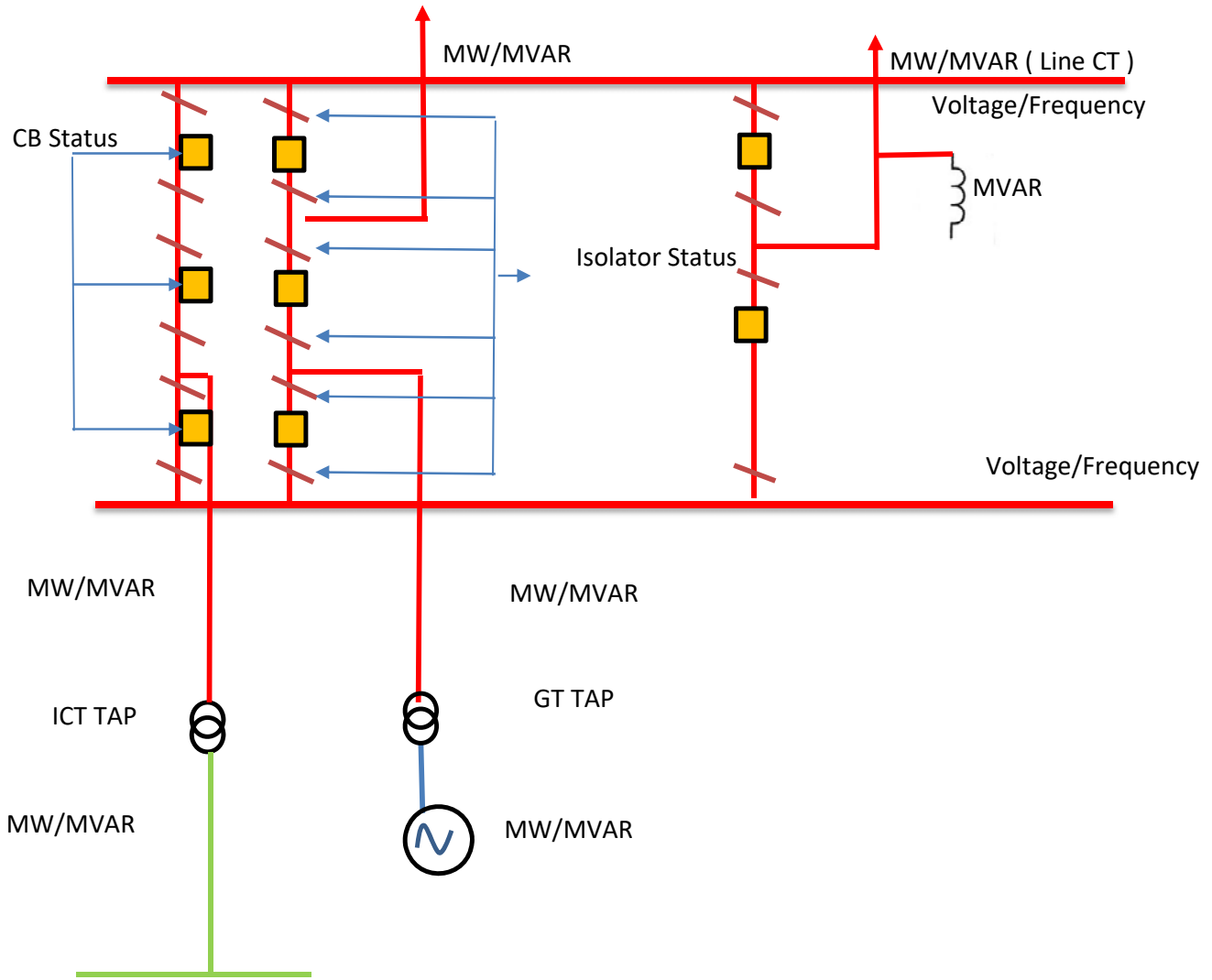
|    |               |  |  |   |
|----|---------------|--|--|---|
| 7  | SVC           | <b>VOLTAGE</b> {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA}<br><b>CURRENT</b> {IRM, IYM, IBM, IPM, IRA, IYA, IBA, IPA}<br>MVAR                               | Breaker  |   |
| 8  | Generator     | <b>VOLTAGE</b> {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA}<br><b>CURRENT</b> {IRM, IYM, IBM, IPM, IRA, IYA, IBA, IPA}<br>MW, MVAR, F, DF/DT for HV& LV Side | -RGMO/FGMO ON/OFF Status<br>Breaker Status<br>-Isolators | V |
| 9  | STATCOM       | <b>VOLTAGE</b> {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA}<br><b>CURRENT</b> {IRM, IYM, IBM, IPM, IRA, IYA, IBA, IPA}<br>MW, MVAR, F, DF/DT                 | - CB OF EACH MODULE<br>MSR, MSC                          |   |
| 10 | Phase Shifter | <b>VOLTAGE</b> {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA}<br><b>CURRENT</b> {IRM, IYM, IBM, IPM, IRA, IYA, IBA, IPA}<br>HV & LV MW / MVAR F, DF/DT         | - CB   |   |

**The layout diagrams showing point of interface for real time telemetry**

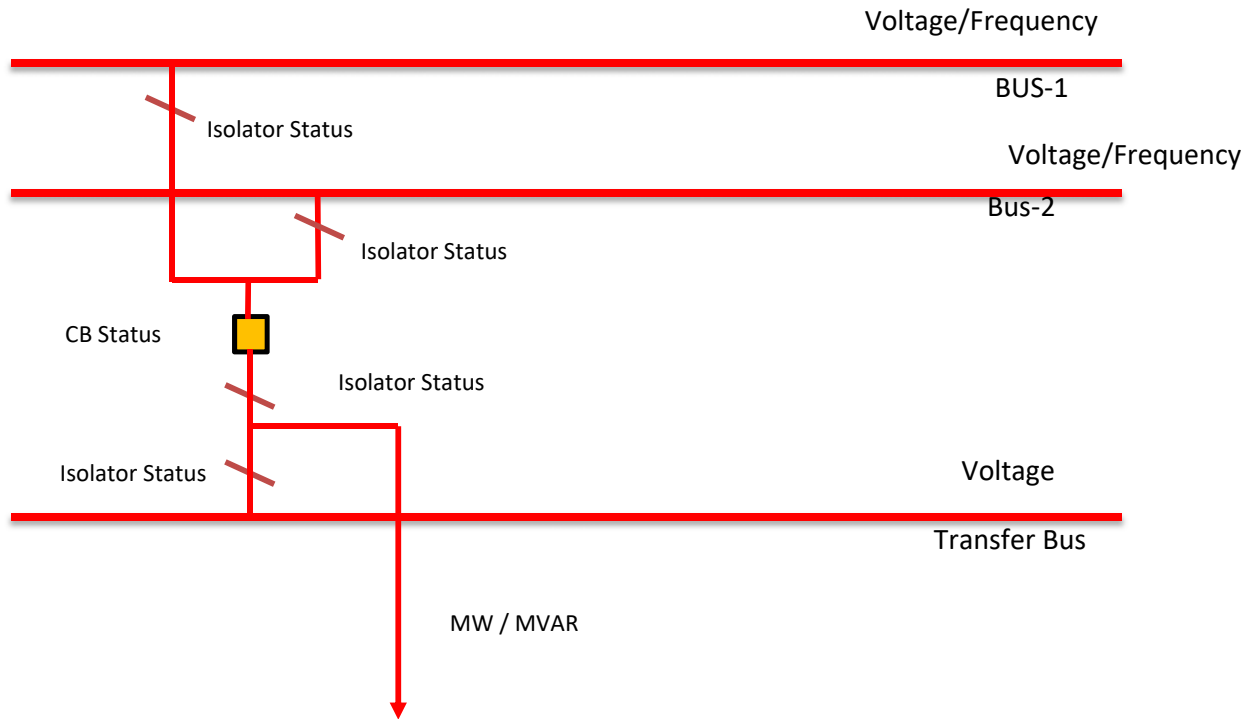
**A. TYPICAL BAYS DIAGRAM: STATCOM**



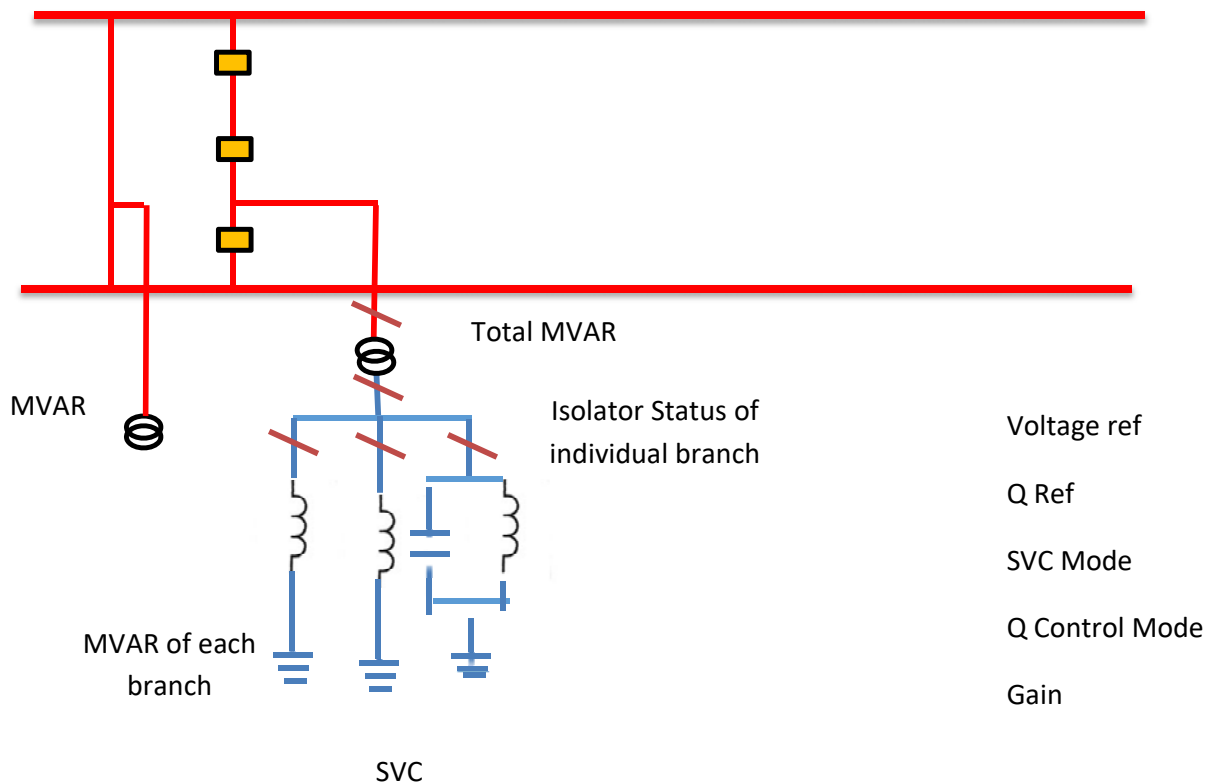
## B. TYPICAL BAYS: *One and a half breaker Scheme*



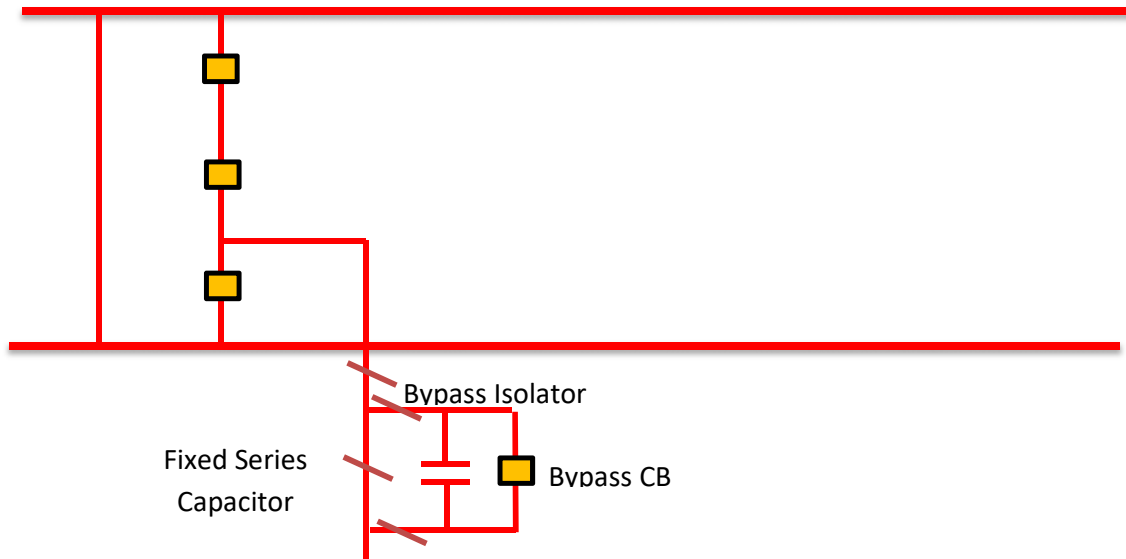
### C. TYPICAL BAYS: *Double Bus and Transfer Scheme*



### D. Static VAR Compensator / Bus Reactor

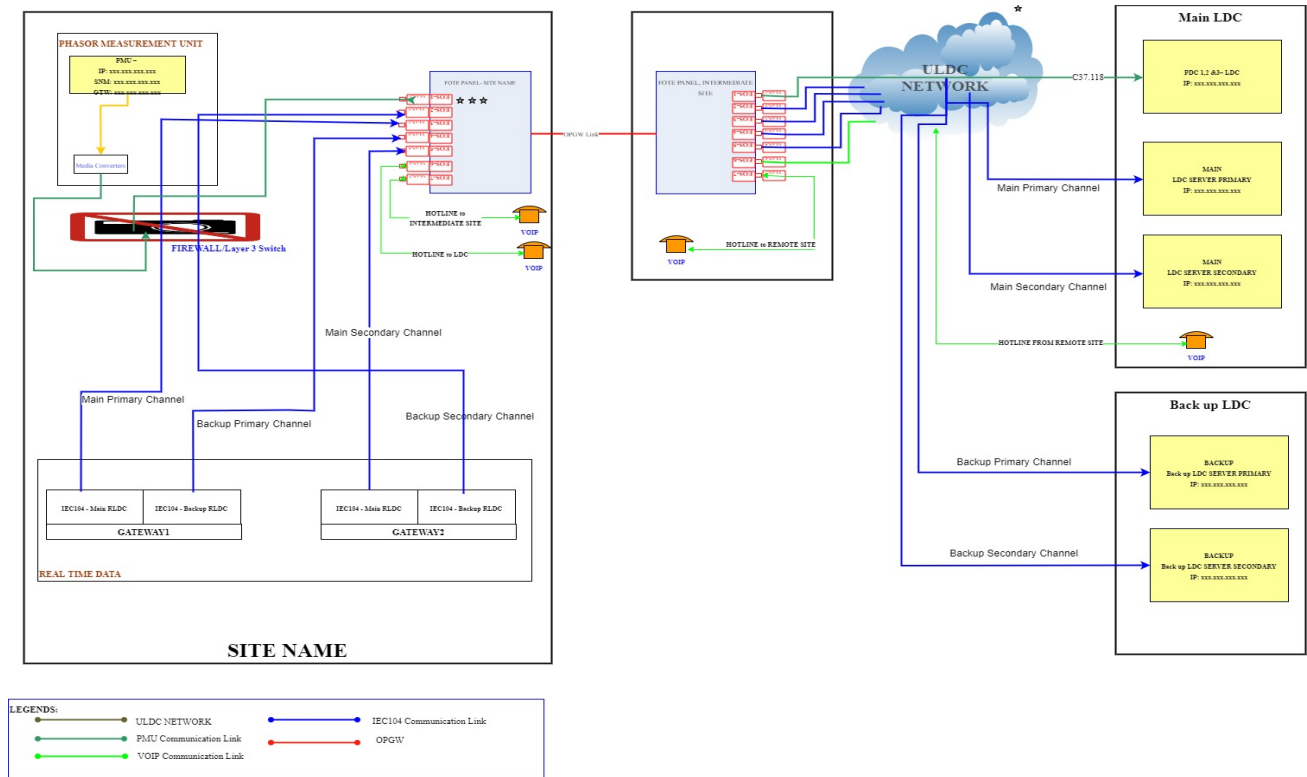


## E. Fixed Series Capacitor



## ANNEXURE-III

### Typical Remote Station General Arrangement Diagram having IEC-104 RTU



Typical Diagram showing Cyber Security Measures in Data Transfer

