Technical Specifications

Ring Main Units for R-APDRP projects

1 Introduction

This document contains the Technical Specifications that apply to **Ring Main Units- RMU**, which covers the supply of Ring Main Units (RMUs).

1.1 Project Background

The objective of the Project is to improve the reliability, efficiency, and loss reduction of the Utility's 11 kV distribution network. This is to be achieved by upgrading and/or replacing existing overhead lines and underground cables, constructing additional feeder segments and Ring Main Units (RMUs). The RMUs should be motorized and suitable to be connected to F-RTU so as to be monitored and controlled through SCADA/DMS.

1.2 Key RMU Configurations:-

Key RMU components/types are listed as follows:

- Right side extensible motorized Ring main unit with with Two (2nos.) load break switches (LBSs) with earthing switches and (1nos.) vacuum / SF6 circuit breakers with earthing switches.
- Right side extensible motorized Ring main unit with Two (2nos.) load break switches (LBSs) with earthing switches and (3Nos.) vacuum / SF6 circuit breakers with earthing switches.
- One (1) to three (3) numerical relays for overcurrent (OC) and earth fault (EF) protection in conjunction with the corresponding circuit breaker(s).
- Two nos. (2) Fault Passage Indicator (FPI) in the RMU's main loop circuit to provide indications that feeder downstream phase or earth faults have occurred.
- Necessary current transformers for protection of the distribution transformer (wherever required).
- Capacitor voltage dividers serving live-line cable indicators.
- Bus connected PT panel on the left hand side for measurement of the power voltage and having auxiliary transformer for supplying power to a battery & battery charger of the RMU for motorized operation

1.3 Scope of Work

The Package scope of work shall include design, manufacture, testing and delivery of new Ring Main Units for protection of the distribution transformers

Where relevant, the RMU scope of work shall be coordinated with the work to be carried out under the project's other construction packages.

Each new RMU shall be equipped with main-line load break switches and a fault passage indicator (FPI). Furthermore, to protect each of its lateral / transformer feeders, it shall be equipped with a corresponding set of circuit breakers and self-powered numerical relays.

1.4 Applicable Standards

- The RMUs shall be manufactured to the highest quality consistent with best practice and workmanship and in full accord with the Supplier's quality assurance plan. The RMUs shall conform to the Indian or IEC international standards that are applicable. These include the standards listed in Table 1-1 below.

Table 1-1: Applicable Standards

Standard	Description
IS 3427	AC metal enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV
IS 12063	Classification of degrees of protection provided by enclosures of electrical equipment
IS 9920 (Parts 1 to 4)	High Voltage Switches
IS 9921 (Parts 1 to 5)	Specification for AC disconnectors and earthing switches for voltages above 1000 V
IS 13118	HV AC Circuit Breakers
IS 10601	Dimensions of terminals of HV Switchgear and Control gear
IS 12729	General requirements of switchgear and control gear for voltages exceeding 1000 V
IEC 1330	High voltage/Low voltage prefabricated substations
IEC 60694	Common clauses for MV switchgear standards
IEC 6081	Monitoring and control
IS 2705	Current Transformers
IS 3156	Voltage transformers
IS 8686	Specification for Static Protective Relays
IEC 62271-200	Standards for high voltage metal clad switchgear up to 52 KV.

1.5 Environmental Conditions

All materials supplied shall be capable of operating under relevant environmental conditions are listed as follows:

- Maximum ambient air temperature: 40 ºC
- Minimum ambient air temperature: 10 ºC
- Maximum relative humidity: 70 %
- Average thunder storm days per annum: 10
- Average rainfall per annum: 400 mm

- Maximum wind speed: 119 km/hr
- Altitude above mean sea level: 1000 m

1.6 Distribution Network Electrical Parameters

The main parameters of the distribution network are as follows:

- Nominal system voltage: 11 kV (rms)
- Highest system voltage: 12 kV (rms)
- Number of phases: 3
- Frequency: 50 Hz
- Variation in frequency: 49.5 Hz to 50.5 Hz
- Type of earthing: Solid
- Power frequency withstand voltage: 28 kV
- Basic impulse withstand voltage: 75 kV

1.7 Testing

- The specified RMUs shall be subject to type tests, routine tests, and acceptance tests. Where applicable, these tests shall be carried out as per the standards stated above. The type test produced by supplier shall be only from reputed testing laboratories such as CRRI & ERDA from India and KEMA, Volta, KERI, CESI etc from remaining part of the globe. Report from any other testing lab mentioned above shall not be accepted. In such a case manufacture has to perform the repeat type test for the RMU.
- Prior to acceptance testing, the supplier shall prepare and submit a detailed auality assurance plane and routine/ inspection test plan for review and approval by the Utility.
- The manufacture must have in house NABL accredited testing lab for carrying out internal inspection and testing in side the factory witness by the utility. All the equipment used must be up to date and calibrated by reputed agency.

2 RMU Design Features

All design features of the proposed RMU, as described in the supplier's bid and in the bid's reference materials, shall be fully supported by the equipment actually delivered. The key design features include those that relate to:

- Maintainability and life span
- Ability to operate in severe outdoor environmental conditions.
- Immunity to electrical stress and disturbance.
- Acceptable insulation properties.

2.1 Maintainability, Expandability, and Life Span

2.1.1 Maintainability

- The Utility intends to be self-reliant for RMU maintenance. To this end, the Supplier shall provide the support, documentation, and training necessary to operate and repair the RMU.

2.1.2 Life Span

- Each RMU shall have a design life of at least 20 years from the date of final acceptance. The Contractor shall make available, at no cost to the Employer, the manufacturing drawings, wiring diagrams, bill of material, foundation detail drawings, unpacking and transportation instructions, operation & maintenance manual, installation and commissioning manual, and other relevant documentation. The specific components of each component /sub-assembly shall be identified and referenced in Supplier-supplied documentation.

2.2 Outdoor Features

2.2.1 General

- The RMUs shall be designed specifically for outdoor installation with ingress protection degree of IP54. They shall also be suitable for conditions in which they will be exposed to heavy industrial pollution, and high levels of airborne dust.

- The Outdoor RMU shall be conformably coated to meet these climatic conditions. In this respect, standards such as IEC 62271-200, covering equipment, systems, operating conditions, and environmental conditions shall apply. In particular, the RMU equipment shall have been type tested for IP54 from a national NABL aggregated laboratory. Failure to conform to this requirement shall constitute grounds for rejection of the proposal

- In addition to the above, materials promoting the growth of fungus or susceptibility to corrosion and heat degradation shall not be used, and steps shall be taken to provide rodent proof-ness.

2.2.2 Corrosion Protection

The main SF6 tank, housing the on-load break switches and the vacuum / SF6 circuit breakers, should be of no other material except 2 mm stainless steel or metalized Cast Resin of 10mm thickness, so as to have high corrosion

resistance and ensure high longevity. This tank containing SF6 to a maximum pressure of 1.55 bars should be hermetically welded or sealed and sealed for life, ensuring a leakage rate not more than 0.1 % per annum. Except for stainless steel, all steel surfaces that are not galvanized shall be treated to protect against corrosion. As a minimum, corrosion treatment shall include the following procedures:

- The surface shall be cleaned to bare material by mechanical or chemical means.
- One or more phosphatizing or priming coats of paint shall be applied to the bare surface using a zinc-based or lead-based primer.
- A finish coat with high scratch resistance or epoxy powder finish paint shall be applied over the primer. The coat thickness shall be of the order of 50 to 70 micrometers. The RMU should be of the final finish-coat as per manufacturer standard.

2.3 Immunity to Electrical Stress and Disturbance

- The electrical and electronic components of the RMU shall conform to relevant standards concerning insulation, isolation, and immunity from electromagnetic interference, radiated disturbance, and electrostatic discharge. The ability to meet these requirements shall be verified by type tests carried out by accredited test laboratories that are independent of the bidder and/or the manufacturer of the RMU components. Certified copies of all available type test certificates and test results shall be included as part of the bidder's proposal.

2.4 Minimum Insulation of Equipment

- The RMUs shall be of SF6 gas-insulated type with a maximum gas operating pressure up to 1.55 BAR.

2.5 Nameplate Information

RMU nameplate information shall be determined in agreement with the Employer. This information may include for example:

- Name of manufacturer and country
- Type, design, and serial number
- Rated voltage and current
- Rated frequency
- Rated symmetrical breaking capacity
- Rated making capacity
- Rated short time current and its duration
- Rated lightning impulse withstand voltage
- Purchase Order number and date
- Month and year of supply

Each RMU shall also exhibit a Danger Board to indicate the presence of high voltage (11,000 V).

2.6 Interconnecting Cables, Wiring, Connectors, and Terminal Blocks

- The Contractor shall provide all interconnecting wires, cables, connectors, terminations and other wiring accessories such as terminal blocks required by the RMU.

2.6.1 Metallic Cables

- All metallic cables and wiring shall be of required cross-section solid or multiple strands of round copper conductors and have flame retardant insulation. All wiring shall be neatly laced and clamped.
- All wire and cable connectors and terminators shall be permanently labeled for identification. All connection points for external cables and wires shall be easily accessible for connection and disconnection and shall be permanently labeled. Conductors in multi-conductor cables shall be individually color-coded.

2.6.2 Connectors

- Plug-type connectors with captive fasteners shall be used for all interconnections. The connectors shall be polarized to prevent improper assembly.

3 RMU Characteristics

- As a minimum, the RMUs shall be equipped with on-load break switches and a fault passage indicator (FPI), circuit breakers, and numerical relays for the protection of transformer feeders, The Load Break Switches and the Circuit Breakers used in the RMU shall be of SF6 insulated and vacuum / SF6 type.

3.1 Parameter Requirements

The RMUs shall be suitable for cable networks of 630 Amps and loop cable networks of 400 Amps. The minimum design parameters to which their major components shall conform or exceed are summarized in the following tables.

Table 3-1: System Parameters

Parameter	Value
Nominal System Voltage	11 kV
Highest System Voltage	12 kV
Rated Voltage	12 kV
System frequency	50 Hz
Number of Phases	3 Phase/3 Wire

Table 3-2: Circuit Breaker Parameters

Parameter	Value

Lightning Impulse Withstand Voltage Phase-to-Phase & Phase-to- Earth:	75 kV (peak)
Power Frequency Withstand Voltage to Earth, Between Poles, & Across Opening Span	28 kV rms for 1 minute
Rated Short Time Withstand/Breaking Current:	20 kA (rms)
Rated Duration of Short Circuit:	3 seconds
Rated Normal Current:	400 / 630 Amps (rms)
Internal arc classification for Tank & RMU cable chambers	20 KA for 1 sec
Rated duration of the ARC	1 sec

Table 3-3: Load Break Switch Parameters

Parameter	Value
Rated Short Circuit Making Capacity	50 kA peak at rated voltage (both LBS & Earthing Switch)
Rated Load Interrupting Current	630 Amps
Rated Cable Charging Interrupting Current	25 Amps

The RMU switchgear shall be capable of withstanding the specified currents without damage in accordance with the latest versions of IEC 60694 (Common Specifications for High-Voltage Switchgear and Control Gear Standards) and IS 3427 (AC Metal Enclosed Switchgear and Control Gear for Rated Voltages above 1 kV and up to and including 52 kV).

3.1.1 Design Details

- The RMU shall be designed to operate at the rated voltage of 12 kV.
- It shall include, within the same metal enclosure, load break switch, circuit breakers and earthing switches for each Load Break Switch/Circuit Breaker.
- Suitable fool-proof interlocks shall be provided to the earthing switches to prevent inadvertent or accidental closing when the circuit is live and the concerned Load Break Switch/Circuit Breaker is in its closed position.
- The degree of protection required against prevailing environmental conditions, including splashing water and dust, shall be not less than IP 54 as per IS 12063.
- The active parts of the switchgear shall be maintenance free. Otherwise, the RMU shall be of low-maintenance type.

- The tank shall be made of minimum 2 mm thickness of stainless steel or 10mm Think metalized Cast Resin.
- The Stainless Steel tank should be completely welded & metalized cast resin tank shall be sealed So as to ensure IP 67 degree of protection and shall be internal arc tested.
- The RMU shall be suitable for mounting on its connecting cable trench.
- For each RMU enclosure, a suitably sized nameplate clearly identifying the enclosure and the electrical characteristics of the enclosed devices shall be provided.
- The access to the cable compartment should be from the front of the switchgear only to have minimum operating & maintenance space at site and the cable chambers shall be tested for 20 KA, 1 sec internal arc test
- The RMU design shall be such that access to live parts shall not be possible without the use of tools.
- The design shall incorporate features that prevent any accidental opening of the earth switch when it is in the closed position. Similarly, accidental closing of a Circuit Breaker or Load Break Switch shall be prevented when the same is in an open position.
- The RMU tank must be equipped with a suitable pressure relief device. The pressure relief must ensure that the escaping gases are dissipated to the rear / top of the switchgear.
- The complete RMU shall be tested in INDIAN or FOREIGN laboratory and designed for an Internal Arc.

3.1.2 Earthing

- There shall be continuity between metallic parts of the RMUs and cables so that there is no dangerous electric field in the surrounding air and the safety of personnel is ensured.
- The RMU frames shall be connected to the main earth bars, and the cables shall be earthed by an Earthing Switch having the specified short circuit making capacity.
- The Earthing Switch shall be operable only when the main switch is open. In this respect, a suitable mechanical fail-proof interlock shall be provided.
- The Earthing Switch shall be provided with a reliable earthing terminal for connection to an earthing conductor having a clamping screw suitable for the specified earth fault conditions. The connection point shall be marked with the earth symbol. The flexible connections between the earthing blade and the frame shall have a cross-section of at least 50 mm^2 copper or equivalent in GI
- The Earthing Switch shall be fitted with its own operating mechanism. In this respect, manual closing shall be driven by a fast acting mechanism independent of the operator's action.

3.1.3 Incomer Load Break Switches

- The Load Break Switches shall be maintenance free. With outdoor canopy doors open, the position of power contacts and earthing contacts shall be clearly visible from the front of the RMU through the Mimic facia.

- The position indicator shall provide positive contact indication in accordance with IS 9920. In addition, the manufacturer shall prove the reliability of indication in accordance with IS 9921. These switches shall have three positions (or states), i.e., Open, Closed, and Earthed, and shall be constructed in such a way that natural interlocking prevents unauthorized operations.

- The switches shall be fully assembled, tested, and inspected in the factory.

- In case of Manual operation, opening and closing shall be driven by a fast-acting mechanism independent of manual operator action.

3.1.4 Circuit Breakers

- The Circuit Breakers shall be maintenance free and, when standing in front of the RMU with outdoor canopy doors open, their positions shall be clearly visible, through the Mimic facia.

- The position indicator shall provide positive contact indication in accordance with IS 9920. The breakers shall have three positions (or states), i.e., Open, Closed, and Earthed, and shall be constructed in such a way that natural interlocking prevents unauthorized operations. They shall be fully assembled, tested, and inspected in the factory.

- An operating mechanism shall be used to manually close the Circuit Breaker and charge the mechanism in a single movement. It shall be fitted with a local system for manual tripping. There shall be no automatic reclosing. The Circuit Breaker shall be capable of closing fully and latching against the rated making current. Mechanical indication of the OPEN, CLOSED, and EARTHED positions of the Circuit Breaker shall be provided.

- Each Circuit Breaker shall operate in conjunction with a suitable protection relay under transformer feeder/ circuit phase and earth fault conditions.

3.1.5 Cable Termination

- Bushings shall be conveniently located for working with the specified cables and shall allow for the termination of these cables in accordance with the prevailing practice and guidelines of cable manufacturers. The dimensions of the terminals shall be in accordance with IS 10601.

- A non Ferro-magnetic cable clamp arrangement shall be provided for each cable to be terminated in the RMU.

- A suitable arrangement for the Circuit Breakers, Earthing Switches, and Load Break Switches shall be provided so that these devices can be padlocked in the "Open" and "Closed" positions.

- A permanent "Live Cable" indication as per IEC 61958 shall be provided for each cable using a capacitor voltage divider.

- It shall be possible to test the core or sheath insulation of the cables without disconnecting the cables in the cable compartment, after accessing the cable compartment.

3.1.6 Safety of Equipment

- With respect to the RMU's SF6-filled equipment, any accidental overpressure inside the sealed chamber shall be limited by the opening of a pressure-limiting device in the enclosure so that the gas will be released away from the operator and to the rear bottom or top of the tank without endangering the operator or anyone else in the vicinity of the RMU.

3.2 Current and Voltage Transformers.

- The RMU shall be provided with current and voltage transformers. These CTs & PTs shall meet the electrical and mechanical ratings as per the relevant standards.

3.2.1 Current Transformers

- 3 nos, ring type, single core CTs shall be provided in each incoming load break switch for metering purposes. A similar arrangement shall be provided in each circuit breaker cable compartment to mount a 3 nos, single-core, ring type CT for protection purposes.

- The CTs shall conform to IS 2705. The design and construction shall be sufficiently robust to withstand thermal and dynamic stresses during short circuits. Secondary terminals of CTs shall be brought out suitably to a terminal block, which will be easily accessible for testing and terminal connections.

- Further characteristics and features distinguishing CTs used for metering from CTs used for protection are listed as follows:

- **CTs for Metering:**

- Material: Epoxy resin cast/ Tape wound

- Burden: 1VA

- Ratio: 200/1 A

- Accuracy Class: 0.5

- **CTs for Protection:**

- Material: Epoxy resin cast/ Tape wound

- Burden: 1.0VA

- Ratio: 200/1 A
- Accuracy Class: 5 P 10
- The RMU's other CTs / sensors, i.e., those used by Fault Passage Indicators (FPIs), shall be supplied by the FPI manufacturer. These CTs/sensors shall be an integral part of the FPI's design to ensure that they properly match the requirements of the FPI.

3.2.2 Voltage Transformers

- A single 3 phase or Three single potential transformers shall be provided. These should be housed in a separate air insulated PT Panel, directly connected to the RMU through main bus. The burden per transformer shall not be more than 50 VA and the voltage ratio shall be 11000/110 or 230 V. The accuracy class shall be 0.5.
- HRC fuses shall be provided on the HV side.
- The PTs shall be of cast epoxy-resin construction, and they shall conform to IS 3156. Their design and construction, in particular, shall be sufficiently robust to withstand the thermal and dynamic stresses during short circuits.

3.3 Fault Passage Indicator

- The FPI shall facilitate quick detection of faulty section of line. The fault indication may be on the basis of monitoring fault current flow through the device. The FPI should be self-powered and should have internal lithium battery for external indication and setting of FPI in the absence of current.

The FPIs shall include:

- Fault detection - Phase to phase and Phase to earth faults.
- One potential-free output contacts for hardwiring to RTUs. On this basis, the SCADA/DMS will be able to monitor phase / earth fault condition.
- Local fault indications - LCD display on FPI front panel along with LED indication on front panel of RMU enclosure.
- Multiple reset option –
- End of time delay (Adjustable from 2 to 16 Hrs)
- Remote reset (Via potential free input contact of FPI)
- Manual reset (Reset button on front panel of FPI)
- Automatic reset on current restoration.

The characteristics of the FPIs shall include:

- Phase fault thresholds configurable from at least 100 to 800 A
- Earth fault thresholds configurable from at least 20 to 200 A
- Multiple number of steps for adjusting phase and earth fault thresholds.
- Fault current duration range configurable from at least 40 ms to 100 ms in 20 ms steps and further 100 ms to 300 ms in 50 ms steps.
- Variations with respect to these characteristics may be acceptable as long as they prove applicable and provide the same or better flexibility.

3.4 Protection Relay

- The RMU shall be equipped with self-powered numerical relays, to trip the RMU circuit breakers.

3.4.1 General

- The Circuit Breaker in the RMU shall be fitted with a communicable-type, self-powered numerical relay, i.e., one for each outgoing circuit breaker. The protection relay's auxiliary contacts shall be hardwired to the RTU. The relay shall also interface with the RTU via an RS 232/485 port in order to send, as a minimum, real-time readings using the MODBUS protocol.
- The numerical relay shall be self-powered and should provide Inverse Definite Minimum Time (IDMT) and Instantaneous protection characteristics. On this basis, the relay as a minimum shall provide:
- Phase Overcurrent Protection (50/51)
- Earth Fault Protection (50N/51N)
- The relay shall be provided with an input for remote tripping, which shall be realized via an electric output pulse even without presence of phase current. A flag indicator shall be installed for signaling the occurrence of trip conditions.

3.4.2 Features and Characteristics

- The numerical relay shall have the following minimal features and characteristics noting that variations may be acceptable as long as they provide similar or better functionality and/or flexibility:
- It shall be housed in a flush mounting case and powered by the RMU power supply unit.
- It shall have three phase overcurrent elements and one earth fault element.
- IDMT trip current settings shall be 50-200% in steps of 1% for phase overcurrent and 10-80% in steps of 1% for earth fault.
- Instantaneous trip current settings shall be 100-3000% in steps of 100% for phase overcurrent and 100-1200% in steps of 100% for earth fault.

- Selectable IDMT curves shall be provided to include, for example, Normal Inverse, Very Inverse, Extreme Inverse, Long Time Inverse, and Definite Time. Separate curve settings for phase overcurrent and earth fault shall be supported.
- For IDMT delay multiplication, the Time Mutiplier Setting (TMS) shall be adjustable from .01 to 0.1 in 0.1 steps.
- The relay shall also be provided with:
  - Alphanumeric Liquid Crystal Display (LCD) for relay setting.
  - Communications via a MODBUS RS232/RS485 port to provide the RTU (and hence the DAS) with phase current measurements. It is also desirable that this same means of communication can be used by the RTU to send setting and control commands to the relay.
  - Parameter change capability that is password protected.

3.5 Power Supply

- Each RMU shall be fitted with a power supply, including batteries and battery charger, suitable for operating the motors of the On-load Isolators and Circuit Breakers. On this basis, the following operational specifications shall apply:
- The power supply unit shall conform to the following requirements:
  - Input: 230 V AC nominal from the RMU's auxiliary power transformer allowing for possible variations from 190 to 300 V AC
  - Output: Stable 24 V DC.
  - Batteries: 24 V DC (2 Nos of 12 V DC each)
- The auxiliary power transformer's inputs shall be equipped with surge protection devices in accordance with IEC 62305.
- The 24 V DC batteries shall have sufficient capacity to supply power to the following devices with a nominal backup of 4 hours:
  - RMU's motors for a minimum of five (5) operations
  - RMU's trip coils, close coils, FPI (in case required).
- The batteries shall be of sealed lead acid VRLA or dry type and shall have a minimum life of five (5) years at 25^{o}C.
- The battery charger shall be fully temperature compensated.
- To prevent deep discharge of the batteries on loss of AC power source, the battery charger shall automatically disconnect all circuitry fed by the batteries following a user-adjustable time period or when the battery voltage falls below a preset value. If the battery voltage falls below the preset value, the time to fully recharge all batteries shall not exceed twenty-four (24) hours.
- An automatic battery checking device shall be provided to check the battery's health and initiate a battery-failed alarm signal in case battery deterioration is detected. Such detection may be based on comparing measurement values with set values (e.g., internal resistance, voltage, etc.).
- The battery charger shall be provided with an alarm displayed at the local control panel and remotely at the DAS to account for any of the following conditions:
  - Low battery voltage
  - High battery voltage

- Battery failed
- Battery charger overvoltage
- Grounded battery/battery-charger
- Others according to manufacturer's design

3.6 Multi-Function Meter

- The RMU main incoming On-load switch circuits shall be equipped with Intelligent Electronic Devices (IEDs) in the form of communicable multi-function meters capable of providing distribution system voltage, current, power factor, power, and energy readings.

3.6.1 Operational Features

- The multi-function meters shall have an accuracy class of 0.5 and shall provide data on an RS 232/485 communications port using the MODBUS protocol.

Each multifunction meter shall have the following minimum features:

- Measurement, display, and communications capability of up to 31 parameters
- THD measurement and power quality data
- True rms measurement
- Digital communications
- Simple menu driven interface
- High quality LED display
- Able to monitor:
  - Voltage: line-to-line and line-to-neutral
  - Current: phase and neutral
  - Frequency
  - Power factor
  - Power (active, apparent, and reactive)
  - Energy (active and reactive)
  - Total harmonic distortion

3.7 Construction

- The RMU shall be sufficiently sturdy to withstand handling during shipment, installation, and start-up without damage. The configuration for shipment shall adequately protect the RMU equipment from scraping, banging, or any other damage.

3.8 Enclosures

- All supplied enclosures shall be sized to provide convenient access to all enclosed components. It shall not be necessary to remove any component to gain access to another component for maintenance purposes or any other reason.

- The enclosures shall also be designed to ensure that the enclosure remains rigid and retains its structural integrity under all operating and service conditions with and without the enclosure door closed.
- The thickness of all enclosure panels shall be at least 2 mm.

The appropriate corrosion treatment and finish requirements shall apply to both inside and outside enclosure surfaces. Other required features are as follows:

- The enclosure is Constructed of mild steel with IP rating 54 or better. Must be powder coated by means of seven tank process, the overall paint layer thickness shall be of the order of 60 to 80 microns.

- Means, such as insulated heat shields and/or air vents, to prevent high temperatures from damaging the RMUs enclosed components. If air vents are installed, these vents shall in no way reduce the effectiveness of the enclosure's protective characteristics.

- A metal pocket attached to the inside of the front door to hold documentation, maintenance log sheets, and other such information.

- Door opening mechanism with built-in key-lock facility suitable for padlocking. An opening mechanism that is less prone to breaking than a projecting door handle is preferred, e.g., a push-button opening mechanism.

- A grounding terminal including grounding bolt and lock washer for connecting a 50 mm^2 galvanized steel grounding conductor. The grounding bolt and lock washer shall be made of stainless steel.

- Means of preventing moisture from condensing on electronic components mounted inside the enclosure proposed for housing the RTU. If necessary, heaters providing adjustable thermostat-control within the range 20 to 60 ºC shall be installed in the enclosure for this purpose.

- Means of protection against rain water, and high levels of airborne dust, should be provided.

- Means of enabling the SCADA to monitor the open/closed status of the enclosure door. A SCADA equipment alarm shall be produced whenever the enclosure door is open.

- The outdoor RMU shall include having a minimum protection class of IP 54. It shall be tested in accordance with the latest IEC 60529 standard.

- The outdoor canopy shall have a hinged front access door with a two-point latch locking system with a latch operating lockable handle. The door shall be fitted with a perimeter flange and gasket (rubber or neoprene) to prevent the entrance of water. In addition, a means of monitoring and indicating that the door is open shall be provided.

3.9 Motors

- The RMU shall be fitted with spring charging motors of high insulation class allowing the circuit breakers and load break switches to be operated without manual intervention.

- In addition to allowing circuit breaker tripping by the RMU's protection relays, the motorized operating mechanism shall be suitable for remote control by the SCADA.

- The motors along with the supplied control card and push buttons shall allow Utility's personnel to electrically operate the circuit breakers and load break switches at site without any modification of the operating mechanism and without de-energizing the RMU.

4 Inspection and Test

- Inspections and tests shall be performed to ensure RMU compliance with these Technical Specifications. Responsibility for conducting the inspections and tests shall rest with the Supplier. The Utility representatives will participate in the RMU inspections and will witness the testing as described in the following sub-clauses.

4.1 Inspections

- Utility's representatives shall be allowed access to supplier's facility where the RMU or its parts are being produced or tested. Such access will be used to verify by inspection that the RMUs are being or have been fabricated and tested in accordance with the Technical Specifications.

- The supplier shall give the utility's representatives 15 days notice in writing concerning the date and place at which the equipment will be ready for inspection or testing. The supplier shall provide all the necessary assistance and facilities to utility's representatives to carry such inspections and test witnessing.

- The supplier shall provide any and all documentation that is necessary to complete the inspections. The representatives shall be allowed to inspect the supplier's quality assurance standards, procedures, and records. Inspections, as a minimum, shall include checks on inventory, general appearance, cabling, drawing conformance, and labeling.

4.2 Test Procedures

- The supplier shall provide test plans and detailed procedures for all required testing. The plans and procedures shall ensure that each test is comprehensive and verifies proper performance of the RMU under test and, in this respect, shall be submitted for review and approval by the Utility.

- The test plans shall include all routine tests and acceptance tests as per relevant BIS/IEC standards and shall describe the overall test process including the responsibilities of the test personnel and how the test results will be documented.

- The test procedures shall describe the individual tests segments and the steps comprising each segment, particularly the methods and processes to be followed.

4.3 Test Reports

- The supplier shall maintain complete records of all test results. The records shall be keyed to the test procedures.

- Upon completion of each test, the supplier shall submit a test report summarizing the tests performed and the results of the tests.

4.4 Factory Acceptance Test

- A formal factory acceptance test shall be conducted to ensure that the RMUs have been designed to meet the utility's functional requirements in all respects. Utility representatives shall witness the test on a representative RMU, and the test shall be carried out in accordance with the supplier's test plan and procedures as approved by the Utility. Should the factory acceptance test prove unsatisfactory in any way, the Utility reserves the right to have further tests conducted and, if applicable, request further improvements in the supplier's RMU design.

TECHNICAL SPECIFICATION FOR 11 kV OUTDOOR POLE-MOUNTED LOAD BREAK SWITCHES / SECTIONALISER

5 Introduction

This document contains the Technical Specifications that apply to **Sectionlisers**, which covers the supply of Sectionliser.

5.1 Project Background

The objective of the R-APDRP Project is to improve the reliability, efficiency, and loss reduction of the Utility's 11 kV distribution network. This is to be achieved by upgrading and/or strengthening existing overhead lines with help of communicable equipments like Sectionliser. The Sectionliser should be suitable to be connected to F-RTU so as to be monitored and controlled through SCADA/DMS.

5.2 Scope of Work

This specification covers requirements for outdoor Pole-mounted sectionaliser / load break switches that have programmable fault detection, sectionaliser features and integrated remote operation capability and that are intended for installation on 11kV Feeders on distribution networks to implement complete overhead network automation. A primary objective of this specification is to foster modularity and a maximum level of interchangeability and integration to a central SCADA system by supporting IEC60870-5-101 & IEC 60870-5-104 communications protocol.

2. APPLICABLE STANDARD

The following standards contain provisions that, through reference in the text, constitute requirements of this specification at the time of publication the revisions indicated were valid. All standards are subject to review and parties to purchasing agreements based on this specification are encouraged to investigate the possibility of applying the most recent revisions of the standards listed below.
IEC 60265-1 *High Voltage Switches*
IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code).*

3. CONSTRUCTION

3.1 General
The sectionaliser / load break switche shall be suitable for use on non-effectively earthed and effectively earthed networks and under the system conditions and service conditions as follows:

3.1 Environmental Conditions

All materials supplied shall be capable of operating under relevant environmental conditions are listed as follows:

a)	Altitude		-	up to 3000 m;
	(For altitudes above 1000m derate in accordance with ANSI C37.60)			
b)	Ambient temperature	minimum	-	-5 °C;
		maximum	-	50 °C;
c)	Maximum daily variation		-	35 °C;

d)	Pollution level	-	medium/heavy;
e)	Lightning activity	-	high.

3.2 Distribution Network Electrical Parameters

The main parameters of the distribution network are as follows:

f)	Nominal system voltage (U) (r.m.s.)	-	11 kV;
g)	Maximum system voltage (Um) (r.m.s.)	-	15.5 kV;
h)	Load current	-	630 A;
i)	Short circuit-breaking capacity	-	12.5 kA;
j)	Lightning Impulse Withstand Voltage (BIL)	-	110 kV
k)	System frequency	-	50 / 60Hz;
l)	Number of phases	-	3;
m)	Interrupting medium	-	SF6
n)	Insulation medium	-	SF6
o)	Minimal number of rated load operations	-	600
p)	Minimal number of no load mechanical operation	-	10000
q)	Operating Mechanism	-	LV motor / Suitable

4 . DEFINITIONS AND ABBREVIATIONS

4.1 Automatic Detection Group Selection (ADGS):

An automated feature to determine and activate a pre-programmed group of detection settings based on the direction of power flow.

4.2 Sectionliser (AR):

A mechanical switching device that, after opening, closes automatically after a predetermined time. Several reclosures could occur before lockout.

4.3 Cold load pick-up (CLP) feature:

A feature that allows modification of the over-current fault detection characteristics in order to prevent false fault detection under conditions of system energisation.

4.4 Dead time:

Also referred to as "Reclosing Interval". This is the time between the instant that the current is interrupted by the AR and the instant the contact of the AR closes as a result of an automatic reclose operation.

4.5 Definite time:

A fault detect event occurs if the current exceeds the fault threshold setting for a time equal to the definite time setting.

4.6 Effectively earthed system:

An earthed system in which the healthy phase power frequency phase-to-earth over voltages associated with earth faults are limited to 80% of the highest phase-to-phase voltage of the system.

4.7 Pickup:

The fault detection elements are monitored and an element “picks up” when the measured current exceeds the preset level of the specific element. Typical detection elements are Phase, Earth and Sensitive Earth Fault (SEF).

4.8 Pole-mounted remote terminal unit (PMRTU):

A remote terminal unit that is designed for pole mounting and that operates specific pole-mounted equipment remotely.

4.9 Sequence reset time:

The time duration after a supply interruption occurred before the sectionalising sequence resets if the sectionaliser does not detect another fault.

4.10 Sectionalising:

The ability of the load break switch to count the operations of an upstream AR and to open during the dead time of the AR after a configurable number of supply interrupts.

4.11 Secure control:

A single mechanically non-latching switch that effects one state of a control function only. An example of which is either a non-latching switch or two separate push buttons that affect one state of a control function only in each position. If a control is activated repeatedly it only effects that state and does not change the state of the control.

4.12 Sensitive earth fault (SEF):

A relay that is sensitive to very low earth fault currents and in which the operating settings are for current magnitude and definite time delay.

4.13 Supervisory:

Remote control and indications of an LBS or a PMRTU by means of a telecommunications link.

4.14 Supply Interruption:

A fault pickup followed by a “no current” and “no voltage” condition is called a Supply Interruption. This condition typically occurs when an upstream recloser trips due to a downstream fault.

4.15 Toggled control:

A single mechanically non-latching switch/push-button that enables a single control function on the first operation of the switch/push-button and disables the function on the second operation of the same switch/push button.

5. Testing

The specified sectionaliser shall be subject to type tests, routine tests, and acceptance tests. Where applicable, these tests shall be carried out as per the standards stated above. Prior to acceptance testing, the supplier shall prepare and submit a detailed test plan.

6. Mounting of Sectionliser

The LBS shall be suitable for single / double pole mounting. Adequately rated lifting eyes shall be provided and they shall be designed to allow the completely assembled LBS. The diameter of the eyes shall be a minimum of 30mm. Suitable mounting brackets for surge arresters shall be provided. The LBS shall be fitted with an external M12 Earthing stud, complete with a nut, lock nut and spring washer. The earth stud shall be welded to the tank for optimal Earthing connection. All support structures and associated bolts and nuts with these parts, shall be hot-dip galvanized.

7. Bushings

The preferred arrangement for termination is an insulated bushing arrangement achieved by using epoxy resin bushings. The material for bushing shall be outdoor aromatic epoxy resin with silicon rubber boots details of the type and Creepage shall be provided.

8. Finish

All interior and exterior ferrous surfaces of the LBS and control cabinets shall be manufactured from marine grade 316 Stainless steel.

9. Control Equipment

9.1 Control cabinet
9.1.1.1 Cabinets that house equipment for detection and control shall be mounted independently of the LBS.
9.1.1.2 Suitable ultraviolet-resistant cable shall be provided to connect the LBS to the control cabinet.
9.1.1.3 It shall be possible to disconnect the cable at the LBS while the LBS is connected to the power system, without causing damage or mal-operation: care shall be taken that CTs are not open circuited.
9.1.1.4 A robust, multipin weather proof connector shall be supplied. Preference will be given to products supplying connectors at both the LBS and the control cabinet.
9.1.1.5 Cabinets shall be adequately sealed and dust protected and shall be internally treated to prevent moisture condensation. The degree of protection shall be suitable for purpose.
9.1.1.6 The control cabinet shall be for all – weather access & vandal resistant.
9.1.1.7 The door of the cabinet shall be fitted with a robust fastening arrangement that is capable of being secured by a padlock that has a two point locking mechanism system.
9.1.1.8 The cabinet shall be fitted with an external Earthing stud with a nut, lock nut and a serrated washer.
9.1.1.9 The control cabinet shall house Control and detection enclosure, which shall incorporate all the electronic modules. These electronic circuits shall fulfill the functions ,detection ; Network measurement; Communications; Switch control; Operator interface; and Uninterruptible power supply.
9.1.1.10 All the components shall be assembled in a die cast aluminum enclosure to protect the electronics against electromagnetic, electrostatic and environmental influences.
9.1.1.11 The controller shall provide following integrated features:-
- Local human machine interface (HMI) shall be menu driven via 6 menu display groups.
- Trip & close circuit isolation shall be through switches.
- Front mounted isolated RS 232 data port for local communication at site.
- It shall be with automatic and manual battery health monitoring.

10. Detection, Measurement & Power Quality characteristics.

10.1 Detection features:-
The Following detection element shall be provided with at least 4 independent detection group.
-Phase Instantaneous Over-current
- Earth Instantaneous Over-current
- Phase Time Over-current.
- Earth Time Over-current.
- Sensitive Earth fault (SEF).
- Earth fault.
- Sensitive Earth Fault Instantaneous Over-current.
- Cold load pickup control.

10.1.1 Each of the detection elements is monitored with independent definite time settings and fault threshold.
10.1.2 The ratio of drop-off current to pick-up current shall be at least 90 % for all detection functions.
10.1.3 The O/C pick-up setting shall be selectable from 10 A to 400 A in steps.
10.1.4 A cold load pick-up feature shall be provided that allows user selectable modification of detection element characteristics under condition of system power restoration.

10.1.5 The SEF functions shall be equipped with harmonic filtering to prevent operation when harmonics are present in the primary residual earth currents
10.1.6 SEF a primary earth fault current of 4A to 20A in steps not exceeding 1A shall be detectable.
10.1.7 The LBS and Control element shall support multiple detection groups and this shall meet the requirements specified below:
- The LBS shall have minimum 2 independent detection groups. The Detection Groups shall have clear indication and shall be marked as "I, II or "A, B"
- Each detection group shall have the facility to configure O/C, E/F and SEF fault detection current and definite time.
- Changes to any of the detection parameter to any of the not active detection group shall not affect the detection functionality of the active detection group.
- Information about activation of any of the detection group shall be recorded in history and shall be easily assessable. Information about fault detection shall clearly indicate the detection group, active at the time of fault.

11. Sectionalizing function

11.1 The number of detected faults to trip shall be selectable to be either 1, 2.
11.2 Reset times shall ideally be separately selectable from 5s to 120s in 1s steps.

12. Statistical measurement functions

The Measurement shall be done with one of the following methods i.e. three-phase-3-wire method; and or the three-phase-4-wire method and made available at HMI and remote location.

12.1 Quantities to be measured/calculated with specified accuracy are:

- Live/Dead indication
- Voltage
- Current
- Frequency
- Power (kW, kVA, kVAR)
- Power Factor
- Supply Outage Monitoring

13. Local Engineering

14.1 The LBS controller shall contain a real time clock (with leap year support) that can be set both locally and remotely.

14. Event Recording

15.1 The controller shall provide , Non-volatile memory storage shall be sized to store at least 5000 logs as :
- All operating, detection and communications parameters.
- An event record containing at least 5000 events.
- All setting change logging.
- The interval can be configured from 1 to 1440 min.

15. TELE CONTROL REQUIREMENTS

16.1 The LBS controller shall detect and report disconnection of the control cable between the controller and LBS.
16.2 It shall be possible to operate LBS change the active detection group, turn sectionaliser functionally ON/OFF and turn E/F and SEF ON/OFF remotely using the protocol specified.

16. Communication

17.1 - As a minimum, one independent RS-232,
17.2- A USB port shall be provided to upload the non-volatile data to and from a personal computer..
17.3- To interface to remote communications equipment (modems, GSM/GPRS)

17.4 **- Provision shall be made for mounting radios and modems**

17.7**- The protocol to be supported by the AR controller for remote communications shall be one of the following:**

- IEC 60870-5-101

17. POWER SUPPLIES

18.1 The LBS system shall provide power for the electronics, operation of the LBS and operation of the RTU being provided separately. The control transformer so used shall be capable of supplying at least 45VA for the external RTU plus the VA required for self operation of LBS.
18.2 Primary supply: Preference will be given to the ability to obtain primary power directly from the HV power system requiring no additional primary supply connection.
18.3 Test supply: The LBS shall accept an external AC 230 V 50 Hz supply. Optional supply: the LBS shall accept an external DC 110 V supply.
18.4 Auxiliary supply: An auxiliary supply with the following minimum characteristics shall be provided
18.5 One battery and constant voltage charger with current limiting shall be part of the LBS. Battery standby time shall not be less than 24 h, allowing for ten LBS operations and a Transmit:
Receive: Standby duty cycle of 5:5:90 from a 5 W output radio. The battery shall recharge to 80
% of its capacity in a maximum of 15 h. The total number of LBS operations under the above
communications scenario shall be at least 10.
18.6 Batteries shall be disconnected at the manufacturer's specified minimum voltage.
18.7 Battery Low' indication shall be available locally and remotely and shall include a battery test. The indication of "Battery Low" status shall allow for a further ten LBS operations.
18.8 The minimum battery life expectancy shall be 2 years. Details of the guaranteed life expectancy of the battery shall be stated in the tender documentation.

18. MAINTENANACE AND COMMISSIONING

19.1 All the communications equipment shall be easily accessible in the control cabinet. Wiring of "communications links in the control cabinet shall permit the connection of a temporary protocol- Monitor. It shall be possible to perform secondary injection testing while the LBS is communicating with the center.
19.2 It shall be Possible to disconnect the LBS circuit breaker and connect a simulated breaker to the control cabinet for testing purposes.
19.3 The LBS shall not malfunction while the radio is transmitting via an antenna in close proximity and the control cabinet door is open.
19.4 Provision shall be made in the control cabinet for individually isolating the power supply to/from the following:

- Battery;
- Battery charger;
- Radio; and
- Primary supply to the control cabinet electronics.

19. RATING PLATE

Each LBS shall bear a rating plate of an intrinsically corrosion-resistant material, indelibly marked with the sea-level rating for which the equipment has been type tested. The rating plate shall be indelibly marked with:
- The manufacturer's name;
-The equipment type designation and serial number of the LBS;
- The mass, in kilograms;
- The date of manufacture;
- The voltage transformer ratio, class and burden.
- Auxiliary supply voltage (if applicable).

20. ADDITIONAL INFORMATION

The following shall be submitted with the tender.
21.1 Load Break switch details
- Manufacturer;
- Type designation;
- Place of manufacture;
- Fault make capacity; 3s 1s
- Critical current (maximum instantaneous peak).

21.2 A schematic-wiring diagram of the LBS offered.
21.3 A general-arrangement drawing of the LBS offered.
21.4 Details of the maintenance and operating equipment and procedures needed and a detailed parts List of the various components.
21.5 A description of the LBS operation, with instruction and maintenance manuals, including
maintenance schedules, detection characteristics, communications facilities, the method of applying settings to relays and controls, together with any software required and the cost thereof. The software requirements shall be stated in the tender documentation.
21.6 Details and the cost of any available portable calibration and diagnostic test set that may be used to perform the functionality described.
21.7 A list of recommended spares and tools, quoting the prices of each item and its availability.
21.8 If detection setting changes are accomplished by resistors, electronic cards or modules or computer programs, the price and range of such items. The method of changing detection settings shall be stated in the tender documentation.
21.9 Details of technical back-up facilities available. These details shall be stated in the tender
documentation.
21.10 Details of the class, ratio(s) and burden of the detection current transformer and voltage
transformer, if supplied, shall be stated in the tender documentation.
21.11 The supplier shall include the following details of measurement current transformers (not internal to the LBS) that can be supplied with the LBS. The following details shall be provided:
- Available ratio(s) and accuracy class;
- Method of fitting; and
- Effect on Creepage distance and BIL

21.12 Details of LBS service history:
- How many in service, where and for what period;

- Contact names and numbers.

21.13 Details of LV trip/close motor if available as an option

21.14 Power requirements for a close operation

21.15 The maximum achievable separation between the control unit and the circuit breaker.

21.16 Full details of the protocol implementation and the complete point database.

21. TEST

22.1 The LBS / Sectionaliser shall have been type tested in accordance with, and found to comply with, the requirements of either IS or ANSI/IEEE C37.63-2005 for the following, and the appropriate. Values shall be stated.

- Operating duty.
- Making current.
- Insulation (dielectric tests).
- Radio interference voltage.
- Temperature rise.
- Mechanical operations.
- Control equipment surge withstand capability.
- The control cabinet and associated electronics shall have been type tested in accordance with IEEE C37.63-2005 & IS 7567 Year 1993 , UNIPEDE NORM (SPEC)13 (1995): Automation and Control Apparatus for Generating Stations and Substations: Electromagnetic Compatibility Immunity Requirements. The environment shall be considered as failing in the HV substation category, according to NORM (SPEC)13.
- Test records (on identical equipment) in the form of validated copies of test certificates issued by a recognized testing authority shall be submitted with the tender documentation.

22.2 Routine tests

- Routine tests, as required in the relevant standards, shall be carried out as a normal requirement of the contract and, unless otherwise agreed upon, shall be witnessed by the purchaser or by his appointed representative. No additional charge shall be levied for such tests or for the production or presentation of documentation related to routine tests.
- Duplicate copies of routine test certificates shall be supplied together with the equipment when the latter is delivered to the final destination stated in the order.

22. PACKING/DOCUMENTATION

23.1 Packing

All equipment shall be carefully packed to prevent damage or deterioration during normal transportation, handling and storage. Each container shall bear the following information on the outside of the container:

- The address of the destination
- The gross mass, in kilograms
- The name of the manufacturer
- The purchaser's order number and port of destination

23.2 Documentation

Each LBS shall be supplied complete with the documentation specified in Items, together with the routine test certificates specified above.

24. Prequalification criteria

- The Bidder / Manufacturer shall have previous experience in Manufacture, Supply of 11KV and above SECTIONLISER's of at least 300 nos. in the past Five years as on the date of tender opening which should have been supplied to power utilities / SEB's / Power distribution companies in India.

- The 11KV and above SECTIONLISER's of at least 100 nos. supplied by the bidder to any of the power utilities/ SEB's / Power distribution companies in India should have been in satisfactory continuous service for at least one complete year during the last three years as on the date of tender opening.

- Annual turnover of the bidder / Manufacturer shall be minimum 500 crores during any one of the last three years.

- Bidder / manufacturer shall have manufacturing capacity of 2000 nos. SECTIONLISER per annum.

5.2.1

5.2.2

5.2.3

1 General Specification for Faults Remote Monitoring System for Overhead MV Network

Those requirements defines :

- Fault passage indicator specifications
- Concentrator specifications
- Communication with the control centre
- Environmental specifications

5.2.4 Table of contents:

5.3 1. General

5.3.1 1.1 Scope

This specification applies to a system allowing to remotely monitor appearance of faults on an Overhead Medium Voltage network so that to localise faulty sections and send patrols for reconfiguration of the network accordingly.
The system shall be made of:
- Fault detection systems with wireless communication to be installed on Medium Voltage Overhead Electric networks, as specified in this document,
- An application software to be installed on a PC in the control centre so that to display the information from these Fault passage indicators. This shall be referred to as a Fault Monitoring software. Please see Remote control software specs attached seperately

5.3.2 1.2 Quality Insurance

The Bidder shall supply documentary proof that the manufacturer possesses ISO 9001 and ISO 14001 Quality insurance certification, from an independent internationally recognized body, for the design, manufacture and testing of Fault Indicators and remote monitoring and control equipment for medium voltage lines

5.4 2. Wireless communication Fault detection systems

5.4.1 2.1 General information

2.1.1 System parameters
The Fault detection systems shall be designed to operate on a Medium Voltage overhead network with the following characteristics:
- Nominal Operation Voltage 7 to 69 kV
- Frequency 50 Hz
- Type of MV neutral earthing : through a resistor or solidly grounded
- Conductor diameter 5 to 25 mm

One single product shall be proposed to cover the whole range of above characteristics: Particularly, the same product should be installed on any network from 7 to 69 kV. Offers requiring to have in stock 2 or more different product references depending on the Line Voltage or on the conductor diameter shall not be considered.
2.1.2 Service conditions
The Fault detection system shall be designed to operate in the following environmental conditions:

Symmetrical Fault Current	12.5 kA/1s and 25KA/170ms (maximum phase current that the system shall withstand)
Shocks & vibrations	120 minutes of sine vibrations and 2000 negative and 2000 positive shocks, in OX, OY and OZ axes
Lightning surge	125kV shocks
Maximum Ambient Temperature	70° C
Maximum annual average temperature	25° C
Humidity	At least 95% during at least 2 24 hours cycles with

	temperature up to +70°C according to IEC 68 2 30

2.1.3 Purpose of equipment

The main functions of the equipment are:

-To detect phase-to-phase and phase-to-earth fault currents on the MV network.
-To detect voltage presence interruptions.
-To time stamp faults and Voltage dips and store them in memory
-To transmit information to the control centre spontaneously via the GSM/GPRS network.
-To provide a local light indication of fault.
-To measure load current on the line.
-To provide operators with all useful information for fault finding and preventive maintenance.
-To be self-supplied at all times, including during outages.

2.1.4 Constitution

5.4.2 2.1.4.1 Components

The equipment shall be made of the following parts:

-Fault Passage Indicators clipped on the overhead lines. One such device shall be clipped on each phase so that to measure current and Voltage presence in this phase and compute fault detection algorithm accordingly. A short-range radio interface shall be embedded in this Fault Passage Indicator so that to allow it communicate with the Data Concentrator interface mentioned below.
-A Data Concentrator interface, pole-mounted, acting as a communication gateway between Fault Passage Indicators using short-range radio and the remote control centre using GPRS communication.
-A solar supply kit, made of a solar panel and a rechargeable battery or a suitable tray mounted VT having primary of 33 or 11 KV and suitable secondary for charging battery, mounted on the same pole, appropriately dimensioned to continuously supply the GPRS communication interface considering the average sun radiation in India.

5.4.3 2.1.4.2 Data Concentrator Unit

The Data Concentrator interface shall be designed to be mounted on a wooden, concrete or metallic pole. It shall be able to interface up to 9 Fault Passage Indicators installed in a 100m maximum range at least, corresponding to up to 3 overhead lines.
Solutions using a Data Concentrator allowing to interface only 3 or 6 Fault Passage Indicators, i.e. 1 or 2 MV lines, or within a maximum range less than 100m shall NOT be considered.
This box shall include the following functions:

- Short range radio Interface to up to 9 Fault Passage Indicators in a 100m range.
- Embeded GPRS Modem or GPRS Modem/Router connected to Serial port of the Data concentrator
- Communication protocol to the control center shall be Modbus over TCP/IP or IEC 870-5-101 or IEC 870-5-104
- Configuration of the Data Concentrator (GPRS communication, definition of alarms…) and Fault Passage Indicators (Fault detection thresholds…) by connection of a laptop running the configuration software to an RS232 interface on the communication interface. The same software shall also include full diagnostic capabilities, It should be possible to configure these parameters from remote control center over the GPRS network..

It shall be supplied by the solar panel + battery block installed above it on the same same pole. Connection cables between Data Concentrator interface and solar panel + battery block shall be provided.

5.4.4 2.1.4.3 Fault Passage Indicator

The Fault Passage Indicators shall be designed to be clipped on the Overhead MV line. 3 Fault Passage Indicators shall be clipped on one line, one on each phase. It shall include the following functions:
- Measurement of current running in the phase it is clipped on
- Detection of Voltage absence/presence on the phase it is clipped on
- From the 2 previous functions, detection of phase-to-phase and phase-to-earth faults
- Short-range radio communication with a Data Concentrator interface at a maximum distance of 100m at least.

It shall be self-supplied from a non-rechargeable battery of a minimum life time 8 years, in the temperature conditions specified above, including at least 1 short range radio communication with the Data Concentrator interface every hour and 300 hours flashing for fault indication all over these 8 years.

The Fault Passage Indicators shall be suitable for outdoor use in the tropical climate condition stipulated in the relevant paragraph. The components used in the Fault Passage Indicators shall be suitably protected from direct sunlight to prevent malfunctioning due to solar radiation. The maximum operating temperature shall not be less than 70° C. The Fault Passage Indicators shall be suitable for mounting on live line conductors of a diameter ranging between 5 and 25 mm, thanks to clamps designed so that the Fault Passage Indicator can withstand winds of 150km/h without falling from the line. The Fault Passage Indicator shall be fully self-contained type without any external connection, indicator or sensors. The Fault Passage Indicators shall be suitable for use on multiple lines supported by the same pole.

5.4.5 2.1.4.4 Solar panel supply kit/Aux supply

This kit shall be composed of a solar panel and rechargeable battery or a suitable tray mounted VT having primary of 33 or 11 KV and suitable secondary for charging battery. It shall be provided with a cable of minimum length 3m for connection to the Data Concentrator interface installed on the same pole.

5.4.6 2.2 Operational specifications

2.2.1 Fault detection

Fault detection shall be performed by the Fault Passage Indicator described above. Fault sensing shall be made from current measurement and Voltage presence detection, based on detection of the electromagnetic field and its variations.

The Fault Passage Indicator shall be of the programmable type, suitable for sensing:
- Short-circuit faults up to 12.5 kA for 1s and 25 kA for 170ms.
- Low earth leakage faults (referred to as “unbalance”) down to 6A.

The Fault Passage Indicators shall detect faults based on 2 simultaneous tripping criterias:
- In order to detect strong fault currents (typically phase-to-phase faults), it shall trip when the phase current exceeds an absolute threshold for a fixed duration of about 20 to 30 ms. This absolute threshold must be configurable to at least 8 different values between 100 and 800A.
- In order to detect low fault currents (typically resistant phase-to-earth faults), it shall trip when it detects the phase current increase within a fixed duration (about 20 to 30ms) exceeds a relative threshold. This threshold must be configurable to at least 6 different values between 6 and 80A.

It shall be possible to disable this second tripping criteria.

When a fault occurs on the network, the upstream protection will trip within 70s maximum (inverse time protection). Therefore, in order to prevent tripping due to a load increase, on detection of one of the above criterias, the Fault Passage Indicators shall confirm the fault by checking if the voltage disappears within the next 70s. and start to indicate the fault only under this condition.

In case of faults, the Fault Passage Indicators which are detecting the variation of the electromagnetic field due to fault current (Fault Passage Indicators installed between the circuit breaker and fault

point) shall provide a fault indication, while Fault Passage Indicators downstream the fault or on non-faulty branches shall not provide any indication.
The fault indication shall be provided:
- by the means of a flashing light system offering a good contrast against sunshine (red color is prefered) and an MTBF of the light emitting system at least 45 000 Hours (LEDs for instance). It shall provide a light of an intensity of 40 Lumen minimum and give a 360° visibility from at least 50m in sunny day conditions, and at least 300m at night.
- By an alarm sent to the Data Concentrator which shall itself forward the alarm to the control center according to its configuration.
The Fault indication shall remain until:
- a time-out, configurable to at least 4 possible values between 2 and 16 hours, has expired,
- the medium voltage is back,
- the Fault Passage Indicator is reset manually,
- whatever condition comes first.
Caution: since the load current might be very low upon MV return, load current reset is not acceptable.
The Fault indication reset shall consist in:
- stopping the local light indication flashing
- sending an alarm to the Data Concentrator which shall itself forward this alarm to the control center according to its configuration.
The Fault Passage Indicator shall include some self-test possibility usable when it is on the line (powered or not).
The Fault Passage Indicator shall be selective in action as indicated below
- It shall not respond to any sudden variation (increases/decrease) in load current
- It shall not respond to a overcurrent not due to a fault
- It shall not respond to high magnetising inrush currents, created upon line energising.

2.2.2 Detection of voltage presence and absence
The Fault Passage Indicator shall send a message to the Data Concentrator as soon as it detects disappearance or appearance of Voltage on the MV conductor. The Data Concentratorshall then memorise the information as a time-stamped event and send an alarm to the control centre according to its configuration.

2.2.3 Digital inputs
The Data Concentrator shall allow connection of information from sensors available in the immediate vicinity to potential-free inputs. At least 6 potential-free digital inputs shall be included in the Data Concentrator

2.2.4 Measurements
The Fault Passage Indicator shall continuously measure the current running in the conductor on which it is clipped and periodically send the minimum, maximum and average values measured. The Data Concentrator shall then store this information to allow reading it locally by connecting a PC or remotely from the control centre. The sending period shall not be more than 1 hour.

2.2.5 Event time-stamping
Any change of state of information shall generate a time-stamped event stored in the Data Concentrator memory. The event storage capacity shall be at least 100 events.

2.2.6 Short-range radio
Short range radio shall use license-free radio in the frequency bandwidth 902-928 MHz. It shall be designed so that to allow a maximum distance between Data Concentratorand the Fault Passage Indicators equal to 100m or more.
Indicators of short range radio transmission quality shall be available and displayed by connection of a PC to the GSM/GPRS interface.

Antennas for short-range radio communication shall be embedded in or fixed on the products (Data Concentratorand Fault Passage Indicator) so that no specific installation is required.

2.2.7 Communication with the control centre
Communication between the Data Concentrator and the control centre shall be through GPRS network, dual-band 900 MHz – 1800 MHz, and using any standard protocol.
It shall allow communication in 2 ways:
- At any time, based on configured periodic calls or on operator action, the Data Concentrator shall be ready to receive a call from the control centre
- Whenever a monitored information declared as alarming in the Data Concentrator configuration changes status, the Data Concentrator shall make a call to the control centre and send it an alarm.

Monitored information configurable as "alarming" shall include at least the following, consisting both of MV network diagnostic information and monitoring equipment internal faults for self-diagnostic purpose:
- Fault detection appearance with indication of Fault Passage Indicator reporting the fault and tripping criteria tripped.
- Fault detection disappearance with indication of Fault Passage Indicator reporting the fault and tripping criteria tripped.
- Voltage absence
- Voltage presence
- Change of state of a digital input
- Fault Passage Indicator absent (failure of the Data concentrator interface to communicate with it through short range radio)
- Fault Passage Indicator battery low

2.2.8 Configuration and maintenance
Equipment configuration and diagnostic shall be performed by connection of a laptop PC to the Data Concentrator using the PC RS232 interface.

Configuration shall include:
2.2.8.1 Scanning of all Fault Passage Indicators in the short range radio range (at least 100m) and assigning of an identification (typically number) to each of them, so that to allow identification of line (when Data Concentrator is monitoring 6 or 9 Fault Passage Indicators) and phase on the line on which each Fault Passage Indicator is clipped-on, in order to allow identification by the control centre of line and phase where faults or voltage absence are detected.
2.2.8.2 Configuration of fault detection thresholds and other characteristics.
2.2.8.3 Configuration of communication: PIN code, telephone numbers (control centre and mobile for sending SMS messages), transmission speed, etc…
2.2.8.4 Configuration of alarms, as explained above
Diagnostic shall include at least display of the current value of all information monitored (Fault Passage indicators list and status, Fault indications (phase-to-phase and phase-to-earth) from Fault Passage indicators, digital inputs, measurements….) and an embedded protocol analyser showing frames received and sent.

5.4.7 2.3 Additional requirements

2.3.1 Marking
Each Fault Passage Indicator shall carry a weather and corrosion proof plate indicating the following particulars.
- Manufacturer's identification.
- Model or type number (as per catalogue)
- Year of manufacture in characters big enough to allow reading from the ground so that to provide indication of battery age.

2.3.2 Environmental specifications
2.3.2.1 Mechanical resistance to vibration and shocks
2.3.2.2 The equipment shall have vibration resistance in accordance with
2.3.2.3 IEC 60068.2.6: 10 to 500 Hz; 0.7 mm peak to peak from 10 to 59Hz and 5g from 59 to 500 Hz.
2.3.2.4 IEC 60068.2.27: 40g / 6 ms / 2000 positive and 2000 negative shocks in each direction, in the three directions.

Dielectric withstand
IEC 61010 Insulation (50 Hz/1 min.): 2 kV
EN 60-950 Impulse wave (1.2/50 µs): 5 kV

Electromagnetic compatibility
Electrostatic discharge IEC 1000-4-2 Level 3
Radiated fields IEC 1000-4-3 Level 3
Radio frequency IEC 1000-4-6 Level 3
Magnetic immunity, 50 Hz, IEC 1000-4-8 Level 4
Emissions EN 55011 Class A

2.3.3 Environment
Operating temperature: -25°C to +70°C
Storage temperature: -40°C to +85°C
Humidity: 95% at 40°C

2.3.4 Documentation
Each device shall be supplied with a user manual for installation and commissioning on site.