

Section: Technical Specifications

DAS Ring Main Units

1 Introduction

This document contains the Technical Specifications that apply to DAS Ring Main Units of 3-Way, 4-Way and 5-Way configurations, which covers the supply of Ring Main Units (RMUs) within the BESCOM.

1.1 Key RMU Components

Key RMU components are listed as follows:

- Two (2) load break switches (LBSs) with earthing switches, also known as Operating Devices (ODs), connecting the RMU to incoming and outgoing main loop, 11 kV, 630 Amp capacity capable to connect XLPE cables of size 240/400 mm² cross section.
- One (1) to three (3) circuit breakers (CBs) with earthing switches, also known as Vertical Lines (VLs), connecting the RMU to distribution loop, 11 kV, 400 Amp capacity capable to connect XLPE cables of size 95/240 mm² cross section.
- One (1) to three (3) numerical relays for overcurrent (OC) and earth fault (EF) protection in conjunction with the corresponding circuit breaker(s).
- One (1) Fault Passage Indicator (FPI) in the RMU's main loop circuit to provide indications that feeder downstream phase or earth faults have occurred.
- All necessary voltage and current sensors for metering and protection.
- All necessary dry (potential-free) contacts for indications relevant to RMU monitoring and control.
- Two (2) multifunction meters serving as Intelligent Electronic Devices (IEDs) to provide voltage, current, power, energy and power factor readings that correspond to the RMU's main-line circuits.
- A power supply unit, including auxiliary power transformer and battery backup, to provide stable 24 V DC and 12 V DC sources of power for a separately supplied RTU and radio respectively as well as necessary sources of power for the RMU's spring-charge motors, FPI, relays, and multifunction meters. The power supply shall also provide for RMU enclosure lighting fixtures and power-plug receptacles for maintenance/test equipment.
- Capacitor voltage dividers serving live-line cable indicators.

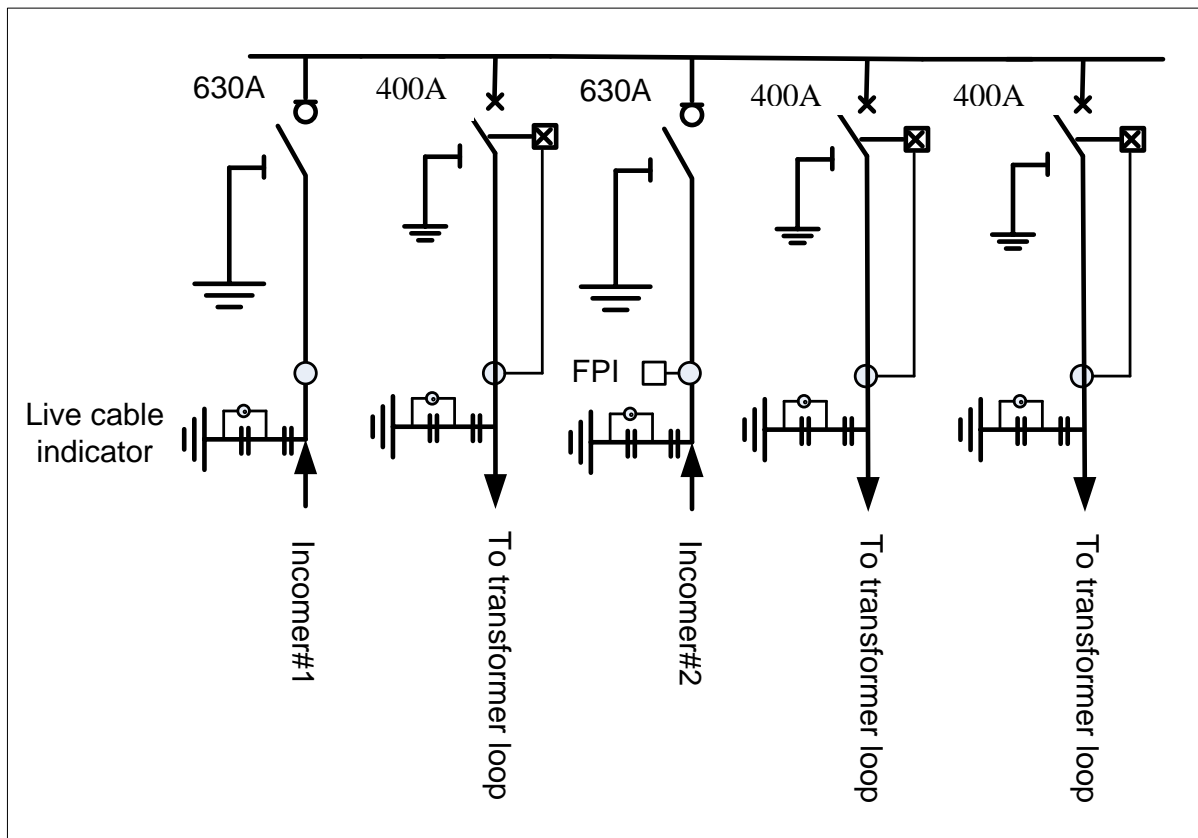
A typical five-way RMU configuration is illustrated in Figure 1-1. In this case, the RMU has six enclosures, one for each of the two load break switches, one for each of the three circuit breakers or VLs, and one for the RMU's auxiliary power supply unit and the necessary SCADA monitoring and

control equipment. The SCADA monitoring and control equipment includes the RTU and radio as supplied by others and referenced elsewhere in these specifications.

1.2 Ring Main Units

Each RMU shall include its own power supply unit (including auxiliary power transformer, batteries, and battery charger), which shall provide a stable power source for not only the RMU, but also the RTU and radio that the RMU must be capable of housing.

Figure 1-1: Typical RMU Configuration



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 circuits, it shall be equipped with a corresponding set of circuit breakers and numerical relays. The RMU interrupters of reputed make shall be enclosed in an SF₆ or vacuum medium and the RMU will include all necessary voltage and current sensors and potential-free contacts so that, as a minimum, the DAS via its RMU remote interface can:

- Monitor and control the open/closed status of the RMU circuit breakers and load break switches.
- Monitor the local/remote position of RMU manually-operated switches that can be used to enable and disable remote monitoring and control of individual ODs and VLs.

- Monitor the health of the power supply, which will include battery failure and low voltage indications.
- Monitor the open/closed status of RMU earthing switches.
- Monitor the open/closed status of RMU enclosure doors.
- Monitor for low SF₆ gas pressure readings.
- Monitor circuit breaker and load break switch spring charge (switch readiness) status.
- Monitor for circuit breaker relay operations.
- Monitor for main-circuit fault currents detected by the RMU's FPI.
- Monitor the number of operations of the RMU's circuit breakers and load break switches.
- Monitor voltage, current, power, energy, and power factor values corresponding to the RMU's main circuits and the phase currents corresponding to the RMU's lateral circuits.

1.3 Specification Organization

These Technical Specifications for DAS RMUs are organized as follows:

- **Clause 1: RMU Design Features.** This clause includes design features related to RMU availability, maintainability, expandability, life span and relevant physical and electrical properties.
- **Clause 2: RMU Characteristics.** This clause describes the main characteristics that relate to the functional and design aspects of RMU components such as line sensors, FPIs, protection relays, multi-function meters, motors, auxiliary transformers, power supply equipment, and enclosures.
- **Clause 3: Inspection and Test.** This clause includes requirements related to inspections, test procedures, test records, factory acceptance tests, site acceptance tests, and commissioning.

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 Contractor's quality assurance plan. The RMUs and the work associated with their installation shall also conform to the Indian and equivalent international standards that are applicable. These include the standards listed in Table 1-1 below.

The Contractor shall provide an English language copy of the applicable Indian and equivalent international standards met by the proposed RMU.

1.5 Environmental Conditions

All materials supplied shall be capable of operating without fault in a tropical climate, which exhibits a high level of ultra-violet radiation and severe thunderstorms. Relevant environmental conditions are listed as follows:

- Maximum ambient air temperature: 45 °C
- Minimum ambient air temperature: 10 °C
- Maximum relative humidity: 90 %
- Average thunder storm days per annum: 50
- Average rainfall per annum: 900 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 BMAZ 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 Hz to 50.5 Hz
- Type of earthing: Solid
- Power frequency withstand voltage: 28 kV
- Basic impulse withstand voltage: 75 kV

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



Standard	Description
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.

1.7 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. Prior to testing, the Contractor shall prepare and submit a detailed test plan for review and approval by the Employer.

2 RMU Design Features

All design features of the proposed DAS RMU, shall be fully supported by the equipment actually delivered. The key design features include those that relate to:

- Availability, maintainability, expandability, and life span
- Ability to operate in severe outdoor environmental conditions
- Immunity to electrical stress and disturbance
- Acceptable insulation properties
- Acceptable surge suppression characteristics
- Convenient RTU interconnection features

In these and all other specified respects, the RMU shall meet or exceed the cited standards or, where appropriate, other equivalent industry standards.

2.1 Availability, Maintainability, Expandability, and Life Span

2.1.1 Availability

The RMU shall be designed to have a fully enclosed metal housing combined with the single-phase insulation of all primary live parts to reduce the risk of internal faults to an absolute minimum and to provide a high degree of safety as well as availability. Nevertheless, manufacturer standard designs shall be used to the fullest extent possible.

Each RMU shall exhibit an availability of greater than 99.5%. To ensure this high degree of availability, the RMUs shall be fabricated, assembled, and finished with workmanship of the highest production quality and shall conform to all applicable quality control standards. All materials comprising the RMU shall be new, unused, and of the best industrial grade, and the RMU shall incorporate all recent improvements in both design and materials. All components shall be of current production from reliable component manufacturers.

2.1.2 Maintainability

The Employer intends to be self-reliant for RMU maintenance. To this end, the Contractor shall provide the support, documentation, and training necessary to operate and repair the RMU. This shall include, but shall not be limited to the maintenance manuals and repair kits applicable to the Contractor's RMU design. Details of the proposed repair kits shall be provided with the bid documents.

The Employer prefers RMU designs that do not require periodic preventive maintenance and inspections.

To facilitate expansion and maintenance, modularity shall be employed in the design of the equipment. All major subassemblies shall carry permanent labels providing a cross-reference to the Contractor's corresponding documentation.

2.1.3 Expandability

The RMUs shall be designed such that, in the future, they can be expanded to accommodate additional enclosures containing circuit breakers and associated equipment that will allow the RMU to supply power to additional distribution circuits. In this respect, for example, the 3-way RMU shall be expandable in the field to a 5-way RMU.

2.1.4 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 designs, drawings, and the rights to manufacture any subassemblies that the manufacturer will not support or discontinues to support during this life span. The specific components of each sub-assembly shall be identified and referenced in Contractor-supplied documentation.

2.2 Outdoor Features

2.2.1 General

The RMUs shall be designed specifically for outdoor installation and, in this respect, shall be suitable for continuous operation in a tropical climate that includes exposure to severe frequently occurring thunderstorms. They shall also be suitable for conditions in which they will be exposed to heavy industrial pollution, salt-spray, and high levels of airborne dust.

The equipment in the proposed outdoor RMU shall be conformably coated to meet these climatic conditions. In this respect, standards such as IEC 60870-2-2 covering equipment, systems, operating conditions, and environmental conditions shall apply along with IEC 60721, which covers the classification of such conditions. In particular, the RMU equipment shall have been type tested for continuous operation under the environmental conditions.

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 installations.**

2.2.2 Corrosion Protection

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 Employer shall approve the finish-coat color. The RAL-code will be agreed upon with the Contractor during the early design phases of project implementation.

2.2.3 Galvanizing

Except for stainless steel, and unless otherwise stated, all structural steel and all exterior and interior steel surfaces of the RMUs, as well as nuts and bolts associated with galvanized parts, shall be hot-dipped galvanized in accordance with IS 802 or an equivalent international standard.

2.3 Immunity to Electrical Stress and Disturbance

The electrical and electronic components of the DAS 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. Failure to conform to this requirement shall constitute grounds for rejection of the proposal.

2.4 Minimum Insulation of Equipment

The RMUs shall be of SF₆ gas-insulated type. Otherwise, from an insulation perspective, the DAS RMU shall be designed so as to minimize exposure to electrically live terminals when visual inspection or maintenance of the internal components is being conducted.

2.5 Surge Voltage Suppression

The DAS RMU equipment shall be designed to operate on input power containing voltage spikes. Equipment shall be protected against part failure or malfunction such as intermittent firing of triggering devices due to surge voltage spikes occurring randomly over the instantaneous supply voltage.

2.6 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 DAS RMU shall also exhibit a Danger Board to indicate the presence of high voltage (11000V).

2.7 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.

2.7.1 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.

2.7.2 Connectors

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

2.7.3 RMU-RTU Connectors

For ease of installation and maintenance, the interconnection between the RMU and the RTU, i.e., the RTU to be installed by others in a separate RMU enclosure, shall be supported by having a multi-pin connector installed in each and every DAS RMU enclosure.

To accommodate all of the DAS RMU equipment points to be monitored and controlled, the connector installed in the enclosure (the Control Cabinet) containing the RTU shall in all cases be sized to accommodate a 5-way RMU, e.g., whether the RMU is 3-way or 5-way, the connector for interconnecting the RMU and RTU shall consist of six (6) multi-pin connectors as illustrated in Figure 2-1.

The following concepts shall apply:

- The Control Cabinet's fixed connector shall consist of 6 individual multi-pin connectors having 24 female inserts and contacts capable of being wired to the RTU and to single multi-pin connectors of female type fixed within the other RMU enclosures via separate hooded plugs having 24 male inserts and contacts attached to cables of suitable length. The RTU male connector and its cable will be provided by the RTU contractor.
- All cabling for the RMU's analog and status input points, control output points, and auxiliary contacts shall be brought out to the single multi-pin connectors in the RMU enclosures. Modbus communication cable shall be adequate size (Minimum 1.5 sqmm) with outer sheath screen cable
- Wiring between the single female connectors in the OD and VL enclosures and the female connectors in the Control Cabinet shall take the form of Contractor-provided cables having at both ends a corresponding male connector.

- The female multi-pin connectors shall contain a locking lever so that, in combination with the male connectors, they shall act as a mechanical locking device between male and female connector pairs. The lever shall only be fully locked if the two connectors are mated correctly.

2.7.4 Terminal Blocks

Apart from the connectors described above Clause, heavy-duty terminal blocks with screw type terminals for 5 mm minimum machine screws shall be provided by the Contractor for other necessary metallic cable terminations. Terminals for auxiliary relays shall equal or exceed the relay wiring requirements. In using a terminal block, no more than two cables or wires shall be connected to any of its individual terminals.

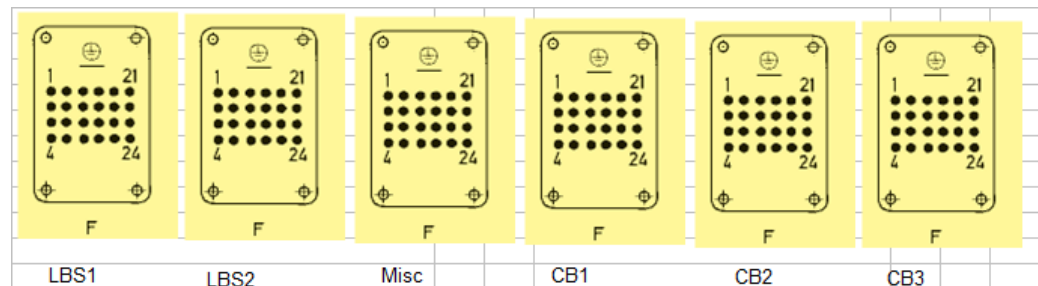
Self-extinguishing fireproof vinyl marking strips shall be used to identify all external connection blocks. Marking tags shall be read horizontally. All terminals to which battery or other high voltages are connected shall be provided with fireproof covers.

All individual status input, AC voltage input, and control output points shall be isolatable without the need to remove wiring by means of individual terminal blocks of the removable link type. In order to avoid open circuits on the secondary side of CTs, termination blocks with by-pass bridges shall be provided for all AC current inputs.

Terminal blocks shall comply with IEC 60947-7-1 (2009): Low-voltage Switchgear and Control Gear, Part 7-1: Ancillary Equipment, Terminal Blocks for Copper Conductors.

Figure 2-1: RMU/RTU Connector Pin-Out

Pin nrs	LBS 1	Pin nrs	LBS 2	Pin nrs	Miscellaneous	Pin nrs	CB1	Pin nrs	CB2	Pin nrs	CB3
1 2	LBS 1: closed	1 2	LBS 2: closed	1 2	SF ₆ Pressure: low	1 2	CB 1: closed	1 2	CB 2: closed	1 2	CB 3: closed
3 4	LBS 1: open	3 4	LBS 2: open	3 4	Charger AC: fail	3 4	CB 1: open	3 4	CB 2: open	3 4	CB 3: open
5 6	Spring 1: charged	5 6	Spring 2: charged	5 6	Voltage DC: low	5 6	Spring 1: charged	5 6	Spring 2: charged	5 6	Spring 3: charged
7 8	Earth switch 1: closed	7 8	Earth switch 2: closed	7 8	Battery alarms: Battery-failed, etc.	7 8	Earth switch 1: closed	7 8	Earth switch 2: closed	7 8	Earth switch 3: closed
9 10	Earth switch 1: open	9 10	Earth switch 2: open	9 10	Spare	9 10	Earth switch 1: open	9 10	Earth switch 2: open	9 10	Earth switch 3: open
11 12	Spare	11 12	FPI: overcurrent operated	11 12	Spare	11 12	Overcurrent relay 1: operated	11 12	Overcurrent relay 2: operated	11 12	Overcurrent relay 3: operated
13 14	Spare	13 14	FPI: earth fault operated	13 14	Spare	13 14	Earth fault relay 1: operated	13 14	Earth fault relay 2: operated	13 14	Earth fault relay 3: operated
15 16	LBS1: Local/Remote Status	15 16	LBS2: Local/Remote Status	15 16	Spare	15 16	CB1: Local/Remote Status	15 16	CB2: Local/Remote Status	15 16	CB3: Local/Remote Status
17 18	LBS 1 control: close	17 18	LBS 2 control: close	17 18	Spare	17 18	CB 1 control: close	17 18	CB 2 control: close	17 18	CB 3 control: close
19 20	LBS 1 control open	19 20	LBS 2 control open	19 20	Spare	19 20	CB 1 control: open	19 20	CB 2 control: open	19 20	CB 3 control: open
21 22	Door: open	21 22	Door: open	21 22	Spare	21 22	Door: open	21 22	Door: open	21 22	Door: open
23 24	Spare	23 24	FPI: reset	23 24	Spare	23 24	Spare	23 24	Spare	23 24	Spare



3 RMU Characteristics

As a minimum, the RMUs shall be equipped with main-line load break switches and a fault passage indicator (FPI), circuit breakers, and numerical relays for the protection of laterals, and multifunction meters providing voltage, current, power, energy, and power factor readings. The Load Break Switches and the Circuit Breakers used in the RMU shall be of SF₆ insulated and vacuum interrupter type.

In addition, each RMU shall be equipped with all necessary connectors, terminal blocks, and other accessories that will allow the RTU it will house to send required RMU/distribution network indications and measurements to the DAS via the communications system.

3.1 General Requirements

Each RMU shall include its own power supply, including battery and battery charger, and provisions for supplying a stable source of power for the RTU and radio to be housed by the RMU. Thus, the RMU shall also provide the necessary space for housing the RTU and radio. In addition, space must be provided for the RMU's auxiliary power transformer, which shall serve as the power supply's 230 V AC input, along with all other RMU devices such as the PTs and CTs for deriving voltage and current signals.

Within this context, the general requirements of the RMU shall include, but shall not be limited to provision of the following monitoring and control features:

- Positions of local/remote switches as used to control local and remote access to circuit breakers and load break switches
- Power supply indications including battery failure and voltage alarms
- Open/closed position of load break switches, circuit breakers, and earthing switches
- Enclosure door-open indications
- SF₆ gas-pressure low alarm
- Circuit breaker and load break switch spring charge (switch readiness) indications
- Circuit breaker relay indications
- Indications of fault current in the RMU's main feeder circuit as detected by the FPI
- Measurement of 11 kV voltage, current, power, energy, and power factor values
- Load break switch and circuit breaker open/close control
- FPI reset control
- Relay settings control

Commissioning of the RMUs shall not be complete until they have been demonstrated on a point-to-point basis to be fully interoperable with the DAS.

3.2 Parameter Requirements

The RMUs shall be suitable for main 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: Across Isolating Distance:	75 kV (peak) 85 kV (peak)
Power Frequency Withstand Voltage to Earth, Between Poles, & Across Opening Span Across Isolating Distance	28 kV rms for 1 minute 32 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 Amps (rms)

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).

3.2.1 Design Details

- The RMU shall be designed to operate at the rated voltage of 12 kV. It shall consist of two (2) numbers of 630 Amp SF₆ insulated Load Break Switches as incomers and up to three (3) numbers of 400 Amp SF₆ insulated Circuit Breakers.

- It shall include, within the same metal enclosure, earthing switches for each Load Break Switch and 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.
- Cast-resin enclosures filled with gas at suitable pressure to ensure adequate insulation and safe operation shall be used. The assembly shall not require further gas processing during its expected operational life of 30 years as per Clause GG 2.3 and 3.3 of IS 3427.
- 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 an adequate thickness of stainless steel or metallised cast resin and shall be internally 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 positions of the different devices shall be clearly visible to an operator when standing in front of each enclosure with its door open. Device operations shall be clearly visible.
- The RMU design shall be such that access to live parts shall not be possible without the use of Constructor-supplied 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. This includes protection against accidental closing resulting from the release of any latch or spring in tension due to vibrations caused externally or internally.

3.2.2 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 mm² copper or equivalent in aluminum.
- 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.

3.2.3 Incomer Load Break Switches

- The Load Break Switches shall be maintenance free. With enclosure doors open, the position of power contacts and earthing contacts shall be clearly visible from the front of the RMU.
- 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.
- Manual opening and closing shall be driven by a fast-acting mechanism independent of manual operator action.
- The Load Break Switches shall be provided with a motorized operating mechanism suitable for SCADA control.
- A facility shall be provided with an electrical operating mechanism allowing an operator at the RMU site to operate the Load Break Switches without any modification of the operating mechanism and without de-energizing the RMU.
- The switch and earthing switch mechanisms shall have a mechanical endurance of at least 5,000 operations. Otherwise, these mechanisms shall conform to IS 9920 (High Voltage Switches Part 1: High Voltage Switches for Rated Voltages above 1 kV and less than 52 kV).

3.2.4 Circuit Breakers

The Circuit Breakers shall be maintenance free and, when standing in front of the RMU with enclosure doors open, their positions shall be clearly visible. 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: Alternating Current Disconnectors (Isolators) and Earthing Switches for Voltages above 1,000 V.

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.

When the Circuit Breaker closing mechanism is of the spring operated type, it shall not be possible for the Circuit Breaker to close until the spring is fully charged and the associated charging mechanism is fully ready for closing. Wherever an external spring charging handle is required to charge the spring, it shall be ensured that the same is not allowed to move during release of the spring energy. Alternatively, it shall not be possible to release the spring energy until the charging handle is completely disengaged from the mechanism. A visual mechanical indicating device shall be provided to indicate the status of the spring, i.e., SPRING CHARGED or SPRING FREE. It shall be possible to charge the spring when the Circuit Breaker is closed and, if the spring is released, the Circuit Breaker shall not open. Nor shall this operation result in any mechanical damage to the component of the Circuit Breaker or its operating mechanism. Alternatively, a fast acting reflex mechanism for Circuit Breakers is also acceptable.

Each Circuit Breaker shall operate in conjunction with a suitable protection relay under lateral circuit phase and earth fault conditions. In addition, the Circuit Breaker shall be provided with a motorized operating mechanism that can be remotely controlled by the DAS.

3.2.5 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. Special clamps to avoid mechanical load of the terminated cable on the bushing.

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 (High-Voltage Prefabricated Switchgear and Control Gear Assemblies - Voltage Presence Indicating Systems) 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 de-energizing the remaining section of the RMU, accessing the cable compartment, or disconnecting the cable.

3.2.6 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 without endangering the operator or anyone else in the vicinity of the RMU.

All manual operations shall be carried out from the front of the RMU. The effort required to be exerted on the lever as used by the operator shall not exceed 250 N.

3.2.7 Front Plate

The front plate shall include a clear mimic diagram indicating RMU functionality. The position indicators shall correctly depict the position of the main contacts and shall be clearly visible to the operator. The lever operating direction shall be clearly indicated.

3.3 Line sensors

The RMU shall be provided with current sensors and voltage sensors. These sensors shall meet the electrical and mechanical ratings as per the relevant standards referenced in Table 1-1.

3.3.1 Current Sensors

A panel shall be provided in each load break switch enclosure to mount a three-phase, single-core, CT for metering purposes. A similar panel shall be provided in each circuit breaker enclosure to mount a three-phase, single-core, CT for protection purposes. CT access for maintenance or any other purpose shall be from the front, back, or top of these panels.

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
- Burden: 2.5VA
- Ratio: 400-200/1 A
- Accuracy Class: 0.5

CTs for Protection:

- Material: Epoxy resin cast

- Burden: 2.5VA
- Ratio: 200-100/1 A
- Accuracy Class: 5 P 10

The RMU's other CTs, i.e., those used by Fault Passage Indicators (FPIs), shall be supplied by the FPI manufacturer. These CTs shall be an integral part of the FPI's design to ensure that they properly match the requirements of the FPI.

3.3.2 Voltage Sensors

Three (3) potential transformers shall be provided. The burden per transformer shall be no more than 50 VA and the voltage ratio shall be 11000/110 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.

3.4 Fault Passage Indicator

Each RMU shall be outfitted with one non-communicable FPI. The FPI shall be mounted in the nominal outgoing OD (Load Break Switch) enclosure along with its integral CT for phase and earth fault monitoring.

The FPIs shall include:

- Fault indicator units for feeder phase and earth faults.
- Potential-free output contacts for hardwiring to RTUs. On this basis, the DAS will be able to monitor fault passage indications. Two such output contacts per FPI are desirable, one for phase and one for earth fault monitoring.
- Potential-free input contacts for hardwiring to RTUs to allow the DAS to reset FPI's following their detection of phase or earth faults.
- Configuration ports for configuring the equipment in the field. Such ports are desirable, but not mandatory.

Local fault indications shall be provided in addition to remote indications through the RTU. The local indications shall use LEDs on the front panel of the RMU enclosure.

The characteristics of the FPIs shall include:

- Phase fault thresholds configurable from at least 100 to 600 A
- Earth fault thresholds configurable from at least 20 to 100 A
- Number of steps for adjusting phase and earth fault thresholds at least four
- Fault current duration range configurable from at least 40 ms to 500 ms

- Protection Relay

The RMU shall be equipped with numerical relays as used to trip the RMU circuit breakers.

3.4.1 General

The Circuit Breaker enclosures in the RMU shall be outfitted with a communicable-type numerical (feeder protection) 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 phase current readings using the MODBUS protocol.

The numerical relay shall be powered by the RMU's power supply unit and be provided with 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 feeder protection 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.
- The Relays shall be of 24V DC auxiliary type.
- It shall have three phase overcurrent elements and one earth fault element.
- IDMT trip current settings shall be 20-200% 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 Multiplier Setting (TMS) shall be adjustable from 0.01 to 0.1 in 0.1 steps.
- The relay shall have local independent LED indications for Healthy, Trip, I>, I>>, IN>, and IN>>> conditions.
- The relay shall also be provided with:

- Alphanumeric Liquid Crystal Display (LCD) for measurement and 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.
- Front USB port for local communications with a laptop PC.
- Parameter change capability that is password protected.
- Capability to record up to 5 of the latest fault records duly time stamped and stored in non-volatile memory for subsequent reading via the above referenced USB port.

3.5 Power Supply

Each RMU shall be outfitted with a power supply, including batteries and battery charger, suitable for operation of a 5-way RMU even if the RMU, for example, is only 3-way. This is to allow for the possible addition of future automated VLs. 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 and 12 V DC
 - Batteries: 24 V DC and 12 V DC
 - Receptacles: 2 x 230 V AC (for test equipment)
 - Lighting Fixtures: One for each enclosure
- 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 spring-charge motors for a minimum of six (6) operations
 - RMU's trip coils, close coils, FPI, multifunction meters, and relays
 - RTU as supplied by others
- The 12 V DC batteries shall have sufficient capacity to supply power to the radio (as supplied by others) with a nominal backup of 8 hours.
- The batteries shall be of sealed lead acid VRLA or dry type and shall have a minimum life of five (5) years at 25°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 and outgoing OD 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:

- It shall be housed in a flush mounting case & powered by the RMU DC power supply unit.
- Measurement, display, and communications capability of up to 31 parameters
- THD measurement and power quality data
- True rms measurement
- Digital communications
- Fully programmable PT and CT ratios
- 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

3.6.2 Specifications

The following table summarizes the specifications applicable to the multi-function meter.

Table 3-4: Multi-Function Meter Specifications

Parameter	Value
Input Voltage: Nominal input voltage (AC rms) Max continuous input voltage	57.7 – 277 V L-N, 100 - 480 V L-L 120% of nominal value
Input Current: Nominal input current System CT primary values Max continuous input current	1 or 5A AC rms (programmable on site) Standard values up to 4 kA (1 or 5 A) 120% of rated value
Overload Withstand: Voltage Current	2 x rated for 1 sec, repeated 10 times at 10 sec intervals 20 x rated for 1 sec, repeated 5 times at 5 minutes
Operating Measuring Ranges	5 to 120% of rated value
Current	5 to 120% of rated value
Frequency	40 to 70 Hz
Power Factor	0.5 lag to 0.8 lead
Accuracy Reference Conditions: Reference temperature Input waveform Input frequency Auxiliary supply voltage Auxiliary supply frequency Power Factor	23°C ± 2°C Sinusoidal (distortion factor 0.005) 50 or 60 Hz ±2% Rated Value ±1% Rated Value ±1% 0.866 lag to 0.866 lead
Accuracy: Voltage Current Frequency Active Power Re-Active Power Apparent Power Active Energy (kWh) Reactive Energy (kVArh) Apparent Energy (kVAh) Phase Angle and Power Factor	±0.5% over 50 to 100% of rated value ±0.5% over 10 to 100% of rated value 0.15% at mid frequency ±0.5% over 10 to 100% of rated value ±0.5% over 10 to 100% of rated value ±0.5% over 10 to 100% of rated value 1% (IEC 62053-21) from 0.866 lag to 0.866 lead 1% (IEC 62053-21) from 0.866 lag to 0.866 lead 1% 1 %
Applicable Standards: EMC Immunity Safety IP for water and dust	IEC 61326 IEC 61000-4-3 (10V/m minimum, Level 3) IEC 61010-1-2001 (permanently connected use) IEC 60529
Environmental: Operating temperature Relative humidity	-10 to +55°C 0 to 90% non-condensing

3.7 Distribution Automation System Interface

The RMU shall be equipped so that it can be monitored and controlled via the DAS. In this respect, it shall interoperate with the RTU that will be housed in the RMU Control Cabinet. The RTU in turn will interoperate with the DAS via the remote radio and the communications system to which the radio is linked.

The RMU shall have provisions for opening and closing its switches using output from the RTU. The RMU shall also supply analog and status signals to the RTU for monitoring the condition of the RMU's distribution network circuits as well as the components of the RMU. A list of input/output points required for 3-way and 5-way RMU configurations is presented in Table 3-5 below.

Table 3-5: Data Points per RMU Configuration

3-Way RMU

DIGITAL INPUT	CONTROL OUTPUT	IED DATA
<u>LBS 1</u> <ul style="list-style-type: none"> ▪ LBS 1: closed ▪ LBS 1: open ▪ Spring 1: charged ▪ Earth switch 1: closed ▪ Earth switch 1: open ▪ LBS 1: local/remote status ▪ Door: open <u>LBS 2</u> <ul style="list-style-type: none"> ▪ LBS 2: closed ▪ LBS 2: open ▪ Spring 2: charged ▪ Earth switch 2: closed ▪ Earth switch 2: open ▪ LBS 2: local/remote status ▪ Door: open <u>FPI</u> (assuming 2 contacts) <ul style="list-style-type: none"> ▪ Overcurrent operated ▪ Earth fault operated <u>CB1</u> <ul style="list-style-type: none"> ▪ CB 1: closed ▪ CB 1: open ▪ Spring 1: charged ▪ Earth switch 1: closed ▪ Earth switch 1: open ▪ Overcurrent relay 1: operated ▪ Earth fault relay 1: operated ▪ CB 1: local/remote status ▪ Door: open <u>Miscellaneous</u> <ul style="list-style-type: none"> ▪ SF₆ Pressure: Low ▪ Charger AC: Fail ▪ Voltage DC: Low ▪ Battery alarms: Battery-failed, etc. Total (with spare): 40	<u>LBS 1</u> <ul style="list-style-type: none"> ▪ LBS 1: close ▪ LBS 1: open <u>LBS 2</u> <ul style="list-style-type: none"> ▪ LBS 2: close ▪ LBS 2: open <u>CB 1</u> <ul style="list-style-type: none"> ▪ CB 1: close ▪ CB 1: open <u>FPI</u> <ul style="list-style-type: none"> ▪ Reset Total (with spare): 8	<u>Multifunction Meter</u> Communication on MODBUS through RS-232/485 ports (2 meters) <u>No. of Measurements:</u> <ul style="list-style-type: none"> ▪ Voltage: 6 ▪ Current: 6 ▪ Active power: 6 ▪ Reactive power: 6 ▪ Power factor: 2 ▪ Active Energy: 2 ▪ Reactive Energy: 2 Total Measurements: 30 <u>Feeder Protection Relay</u> Communication on MODBUS through RS-232/485 ports (One protection relay). <u>Minimum No. of Points:</u> <ul style="list-style-type: none"> ▪ 3 points per relay Total Points: 3



4-Way RMU

DIGITAL INPUT	CONTROL OUTPUT	IED DATA
<p><u>LBS 1</u></p> <ul style="list-style-type: none"> ▪ LBS 1: closed ▪ LBS 1: open ▪ Spring 1: charged ▪ Earth switch 1: closed ▪ Earth switch 1: open ▪ LBS 1: local/remote status ▪ Door: open <p><u>LBS 2</u></p> <ul style="list-style-type: none"> ▪ LBS 2: closed ▪ LBS 2: open ▪ Spring 2: charged ▪ Earth switch 2: closed ▪ Earth switch 2: open ▪ LBS 2: local/remote status ▪ Door: open <p><u>FPI</u> (assuming 2 contacts)</p> <ul style="list-style-type: none"> ▪ Overcurrent operated ▪ Earth fault operated <p><u>CB1</u></p> <ul style="list-style-type: none"> ▪ CB 1: closed ▪ CB 1: open ▪ Spring 1: charged ▪ Earth switch 1: closed ▪ Earth switch 1: open ▪ Overcurrent relay 1: operated ▪ Earth fault relay 1: operated ▪ CB 1: local/remote status ▪ Door: open <p><u>CB2</u></p> <ul style="list-style-type: none"> ▪ CB 2: closed ▪ CB 2: open ▪ Spring 2: charged ▪ Earth switch 2: closed ▪ Earth switch 2: open ▪ Overcurrent relay 2: operated ▪ Earth fault relay 2: operated ▪ CB 2: local/remote status ▪ Door: open <p><u>Miscellaneous</u></p> <ul style="list-style-type: none"> ▪ SF₆ Pressure: Low ▪ Charger AC: Fail ▪ Voltage DC: Low ▪ Battery alarms: Battery-failed, etc. <p>Total (with spare): 47</p>	<p><u>LBS 1</u></p> <ul style="list-style-type: none"> ▪ LBS 1: close ▪ LBS 1: open <p><u>LBS 2</u></p> <ul style="list-style-type: none"> ▪ LBS 2: close ▪ LBS 2: open <p><u>CB 1</u></p> <ul style="list-style-type: none"> ▪ CB 1: close ▪ CB 1: open <p><u>CB 2</u></p> <ul style="list-style-type: none"> ▪ CB 2: close ▪ CB 2: open <p><u>CB 3</u></p> <ul style="list-style-type: none"> ▪ CB 3: close ▪ CB 3: open <p><u>FPI</u></p> <ul style="list-style-type: none"> ▪ Reset <p>Total (with spare): 16</p>	<p><u>Multifunction Meter</u> Communication on MODBUS through RS-232/485 ports (2 meters)</p> <p><u>No. of Measurements:</u></p> <ul style="list-style-type: none"> ▪ Voltage: 6 ▪ Current: 6 ▪ Active power: 6 ▪ Reactive power: 6 ▪ Power factor: 2 ▪ Active Energy: 2 ▪ Reactive Energy: 2 <p>Total Measurements: 30</p> <p><u>Feeder Protection Relay</u> Communication on MODBUS through RS-232/485 ports (3 protection relays).</p> <p><u>Minimum No. of Points:</u></p> <ul style="list-style-type: none"> ▪ 3 points per relay <p>Total Points: 9</p>



5-Way RMU

DIGITAL INPUT	CONTROL OUTPUT	IED DATA
<u>LBS 1</u> <ul style="list-style-type: none"> ▪ LBS 1: closed ▪ LBS 1: open ▪ Spring 1: charged ▪ Earth switch 1: closed ▪ Earth switch 1: open ▪ LBS 1: local/remote status ▪ Door: open <u>LBS 2</u> <ul style="list-style-type: none"> ▪ LBS 2: closed ▪ LBS 2: open ▪ Spring 2: charged ▪ Earth switch 2: closed ▪ Earth switch 2: open ▪ LBS 2: local/remote status ▪ Door: open <u>FPI</u> (assuming 2 contacts) <ul style="list-style-type: none"> ▪ Overcurrent operated ▪ Earth fault operated <u>CB1</u> <ul style="list-style-type: none"> ▪ CB 1: closed ▪ CB 1: open ▪ Spring 1: charged ▪ Earth switch 1: closed ▪ Earth switch 1: open ▪ Overcurrent relay 1: operated ▪ Earth fault relay 1: operated ▪ CB 1: local/remote status ▪ Door: open <u>CB2</u> <ul style="list-style-type: none"> ▪ CB 2: closed ▪ CB 2: open ▪ Spring 2: charged ▪ Earth switch 2: closed ▪ Earth switch 2: open ▪ Overcurrent relay 2: operated ▪ Earth fault relay 2: operated ▪ CB 2: local/remote status ▪ Door: open <u>CB3</u> <ul style="list-style-type: none"> ▪ CB 3: closed ▪ CB 3: open ▪ Spring 3: charged ▪ Earth switch 3: closed ▪ Earth switch 3: open ▪ Overcurrent relay 3: operated ▪ Earth fault relay 3: operated ▪ CB 3: local/remote status ▪ Door: open <u>Miscellaneous</u> <ul style="list-style-type: none"> ▪ SF₆ Pressure: Low ▪ Charger AC: Fail ▪ Voltage DC: Low ▪ Battery alarms: Battery-failed, etc. Total (with spare): 56	<u>LBS 1</u> <ul style="list-style-type: none"> ▪ LBS 1: close ▪ LBS 1: open <u>LBS 2</u> <ul style="list-style-type: none"> ▪ LBS 2: close ▪ LBS 2: open <u>CB 1</u> <ul style="list-style-type: none"> ▪ CB 1: close ▪ CB 1: open <u>CB 2</u> <ul style="list-style-type: none"> ▪ CB 2: close ▪ CB 2: open <u>CB 3</u> <ul style="list-style-type: none"> ▪ CB 3: close ▪ CB 3: open <u>FPI</u> <ul style="list-style-type: none"> ▪ Reset Total (with spare): 16	<u>Multifunction Meter</u> Communication on MODBUS through RS-232/485 ports (2 meters) <u>No. of Measurements:</u> <ul style="list-style-type: none"> ▪ Voltage: 6 ▪ Current: 6 ▪ Active power: 6 ▪ Reactive power: 6 ▪ Power factor: 2 ▪ Active Energy: 2 ▪ Reactive Energy: 2 Total Measurements: 30 <u>Feeder Protection Relay</u> Communication on MODBUS through RS-232/485 ports (3 protection relays). <u>Minimum No. of Points:</u> <ul style="list-style-type: none"> ▪ 3 points per relay Total Points: 9

3.7.1 Multi-Function Meter Interface with RTU

The Contractor is required to furnish the RMU meter information that pertains to interfacing the meter with the RTU through an RS 232/485 serial communications link. The protocol details along with the MODBUS mapping data as implemented in each meter shall be provided. In this respect, the Contractor in cooperation and coordination with the RTU contractor shall share the responsibility of ensuring effective communications is attained between the meter and RTU, i.e., all parameters read by the meters shall also be immediately available to the RTU.

3.7.2 Numerical Relay Interface with RTU

The Contractor is required to furnish the numerical relay information that pertains to interfacing the relay with the RTU through an RS 232/485 serial communications link. The protocol details along with the MODBUS mapping data as implemented in each relay shall be provided. In this respect, the Contractor in cooperation and coordination with the RTU contractor shall share the responsibility of ensuring effective communications is attained between the relay and RTU, i.e., all parameters read by the relay shall also be immediately available to the RTU.

3.8 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. The Contractor shall assume responsibility for correction of all such damage prior to final acceptance of the equipment.

3.9 Enclosures

All Contractor-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.

If made from stainless steel (304L or 316L), the thickness of the enclosure panels shall be at least 1.5 mm. Otherwise the thickness of all enclosure panels shall be at least 2 mm.

The appropriate corrosion treatment and finish requirements of Clause 2.2.2 shall apply to both inside and outside enclosure surfaces. Other required features are as follows:

- Constructed of stainless steel (304L or 316L) according to IEC 60529 with IP rating 54 or better. Alternatively, the RMU metal parts shall be made of high thickness high tensile steel which must be grit/shot blasted, thermally sprayed with Zinc alloy, phosphate, and subsequently painted with polyurethane based powder paint, the overall paint layer thickness including Zinc spraying shall be of the order of 100 to 130 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 mm² 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 °C shall be installed in the enclosure for this purpose.
- Means of protection against rain water, corrosive salt formations, and high levels of airborne dust.
- Means of enabling the DAS to monitor the open/closed status of the enclosure door. A DAS equipment alarm shall be produced whenever the enclosure door is open.

3.10 Control Cabinet

The RMU shall be outfitted with a separate enclosure, referred to herein as the Control Cabinet, to house the following equipment as a minimum:

- Auxiliary transformer
- SCADA terminal blocks
- Power Supply Unit including Charger and Batteries
- RTU (supplied and installed by others)
- Radio (supplied and installed by others)
- Multi-pin connector consisting of plug and socket fittings and angled terminal block
- Other equipment according to manufacturer's design

The Control Cabinet shall be similar in style and finish as the other RMU enclosures. This shall include having a minimum protection class of IP 54. It shall be tested in accordance with the latest IEC 60529 standard.

The cabinet shall have a hinged front access door with a three-point latch locking system and 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.

A metal screen with holes shall be provided on the top and bottom of the control cabinet to provide ventilation aimed at avoiding condensation inside. Venting however shall in no way reduce the effectiveness of the control cabinet's water-tight, dust-tight, and corrosion-resistant characteristics. To augment the cabinet's effectiveness in preventing the ingress of dust, insects, vermin, and small objects, all electronic parts within the control cabinet shall be enclosed in modules. Such parts and modules shall be separated from the power supply modules as also installed in the cabinet.

The Control Cabinet shall include a weather-sealed hole with a double compression cable gland, approximately 30 mm in diameter, on the top of the cabinet for routing an antenna cable that will be supplied and installed by BESCOM. This will enable the cable to connect the radio housed in the cabinet to its externally mounted antenna. To house the radio, and the RTU to be supplied and installed by BESCOM, the Control Cabinet shall include a minimum contiguous space of 600 mm (W) x 500mm (D) x 600 mm (H).

If made from stainless steel (304L or 316L), the thickness of the enclosure panels shall be at least 1.5 mm. Otherwise the thickness of all enclosure panels shall be at least 2 mm.

The control cabinet shall also be provided with:

- Weatherproof fittings for control cables.
- **Provision for handle and padlock. In addition to this, a Metal number lock of adequate size shall be provided.**
- Grounding terminal, with solderless clamp type connector suitable for steel stranded conductor of suitable diameter and complete with lock washer of stainless steel or better.
- Provision for separately grounding the RMU's electronic items.
- Thermally controlled small fan for circulating air when necessary to maintain temperatures within the Control Cabinet to acceptable levels.
- Circuit diagram of control unit for maintenance purpose affixed permanently.
- Others according to manufacturer's design.

3.11 Auxiliary Transformer

The RMU shall be outfitted with a single-phase auxiliary power transformer with a turns ratio of 11000/sqrt (3) to 230, i.e., it shall be connected line-to-neutral to the RMU 11 kV bus and used to provide the required 230 V AC input to the RMU's power supply. The auxiliary power transformer shall have a capacity of at least 1,000 VA. During project implementation, however, the Contractor shall assess this requirement by taking into account the actual load corresponding to the RTU and radio (supplied by others) as well as the load represented by the RMU motors, etc. In this respect, with a suitable margin approved by the Employer, the auxiliary transformer must be capable of

supporting the power supply requirements that correspond to a 5-way RMU. HRC fuses shall be provided on both the HV and LV sides of the transformer.

3.12 Motors

The RMU shall be retro-fitted with spring charge motors of insulation Class E or better allowing the circuit breakers and load break switches to be operated without manual intervention. Motor speed shall ensure springs can be charged within 1 to 2 seconds. Independently of DAS control, the mechanism shall ensure that the motors start up immediately once the spring becomes discharged, so that the breaker becomes ready for the next operation.

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 DAS.

The motors along with a Contractor supplied control panel shall allow Employer 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.

The motors shall be of a reputable make in the form of a universal 24 V DC type. They shall be enclosed and completely dust proof and sized with a suitable margin to meet the torque requirement of the spring charge mechanism.

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 Contractor. The Employer will participate in the RMU inspections and will witness the testing as described in the following sub-clauses.

4.1 Inspections

Employer representatives shall be allowed access to any Contractor or other 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 Contractor shall give the Employer 15 days notice in writing concerning the date and place at which the equipment will be ready for inspection or testing. The Contractor shall provide all the necessary assistance and facilities to Employer representatives to carry such inspections and test witnessing.

The Employer representatives will also visit Employer sites where the RMUs have been delivered and are being or have been installed and tested to ensure the installations and testing are proceeding or have been completed in the manner intended.

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

Where applicable, the Employer's inspections will be performed in conjunction with witnessing the RMU tests. The Contractor shall take all necessary steps to address and resolve any concerns that Employer representatives may raise as a result of these activities in a timely fashion.

This may result in further inspections and tests until the representatives are fully satisfied that the inspections and tests have been completed successfully.

4.2 Test Procedures

The Contractor 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 Employer.

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

Upon completion of each test, the Contractor shall submit a test report summarizing the tests performed and the results of the tests. The test report shall include the following information:

- Test Log - A chronological record of all events related to execution of the tests.
- Test Incident Report – A detailed description of any event during the testing process that required investigation.
- Test Summary Report – A presentation of results pertaining to the designated test activities and a summary of all relevant recommendations and conclusions based on these results.
- Variance Report – A summary of the problems detected during testing and the corresponding resolutions.
- Official Certification – A formal declaration that the required testing was performed and, if applicable, was completed successfully.
- Signatures – As designated representatives of the Contractor and/or Employer, the signatures of witnesses for each completed test, whether successful or not successful, along with relevant dates. Witness names and contact information shall also be provided.

4.4 Type Tests

These tests shall be conducted on RMUs representative of the actual RMUs to be supplied and installed in the BMAZ distribution network such as an existing product capable of meeting the Employer's requirements or a proto-type product designed and developed during project implementation with the express intent of meeting these requirements.

The tests shall take place prior to full-scale manufacture of the deliverable RMUs and shall be performed at an accredited third-party test laboratory selected by the Contractor. The selected test laboratory shall require approval by the Employer. The type tests may not need to be carried out if the Contractor furnishes, along with the bid, type test certificates corresponding to relevant testing within the last five years from the date of bid submission. Failure to conform to this requirement shall constitute grounds for rejection of the bidder's proposal.

4.5 Factory Acceptance Test

A formal factory acceptance test shall be conducted to ensure that the RMUs have been designed to meet the Employer's functional requirements in all respects. Employer representatives shall witness the test on a representative RMU, and the test shall be carried out in accordance with the Contractor's test plan and procedures as approved by the Employer. Should the factory acceptance test prove

unsatisfactory in any way, the Employer reserves the right to have further tests conducted and, if applicable, request further improvements in the Contactor's RMU design.

To the extent possible, the test shall demonstrate the capability of the RMU to interoperate with the RTU to be supplied by BESCOM. It is also the intent of the Employer that the test shall make use of the Data Acquisition (DAC) Simulator to be supplied by BESCOM. The DAC Simulator (representing the DAS) together with the RTU will reduce the risk of discovering interoperability problems subsequent to RMU installation at site. Thus, in preparation for the factory acceptance test, the Contractor shall make every effort to cooperate and coordinate all such activities with these other contractors.

4.6 Routine Factory Tests

These tests shall be carried out during RMU manufacture as a quality control measure, i.e., to ensure each RMU to be delivered meets the Employer's minimum requirements including all relevant standards. Recording and reporting the routine test results shall be the responsibility of the Contractor.

At the Employer's discretion, Employer representatives will witness such testing. This may include requesting the Contractor to perform tests on RMUs selected at random from each batch of RMUs that the Contractor deems ready to be delivered to site. Should any such test prove unsatisfactory, the Employer reserves the right to have further tests conducted and for delivery not to take place until a mutually agreed course of action has been reached.

4.7 Field Performance Tests

4.7.1 Unit Test

Each and every RMU shall be tested at site. This shall include unit testing by the Contractor at the time of installation of each RMU to ensure all components can be powered up and are in good working order.

4.7.2 Site Acceptance Test

Each RMU shall undergo a Site Acceptance Test (SAT) to demonstrate to the Employer that the RMU is fully operational with respect to its functional capabilities and intended use at its specifically assigned site. In this respect, site acceptance testing shall be carried out in such a way as to verify that the RTU can be used to monitor and control the site's associated distribution network devices.

Such testing shall be conducted in a way that will minimize power interruptions. Any need for power interruptions in order to conduct the testing shall be arranged in full and timely coordination with the Employer's system operations staff. Otherwise, the functional capabilities shall be exercised using non-outage techniques such as simulating analog and status inputs and checking for control output signals at points of connection that may need to be temporarily isolated from the distribution network.

During SAT, it shall be demonstrated that the RMU and RTU can interoperate successfully in all respects. To this end, the intent is to make use further use of the DAC Simulator to be provided by the

DAS supplier. Thus SAT shall verify that the RMU interface is fully operational and capable of meeting or supporting all applicable DAS functional performance requirements.

4.7.3 RMU Commissioning

The end-to-end tests for RMU operations and communicability features of the relay and meter shall serve as a means of commissioning the RMU. The Contractor, therefore, shall support end-to-end testing by having adequate Contractor personnel on hand to witness these tests in consultation with DAS.

Prior to starting the warranty period, the Contractor shall submit a report clearly identifying the results of all end-to-end tests from the perspective of the RMUs. This shall include a summary of the variances detected and whether or not these variances were successfully corrected. Where necessary, for Employer consideration, the report shall include the Contractor's plan for resolving any and all variances not yet corrected.

No RMU installation shall be accepted as complete until the Employer is satisfied that all variances associated with an individual site have been corrected and that the RMU is SCADA ready, i.e., can be considered fully integrated with the DAS.

Documentation

It is the intent of the Employer to become self sufficient in all aspects of the field device. In order to assure that the Employer has the opportunity to become self sufficient in a timely and orderly manner, it is necessary that the Contractor provide high quality documentation.

4.7.4 Equipment Manuals

Equipment manuals shall contain the following:

- Description of the function of the equipment
- Installation, setup, and operating instructions
- Block diagram showing logical and physical interconnections among major components
- Expansion and upgrade capabilities and instructions
- Preventive maintenance instructions
- Detailed functional, logical, electrical, and mechanical characteristics of all equipment including protocol descriptions
- Troubleshooting and repair guides, including descriptions and instructions for the diagnostics furnished

4.8 Operating Manuals

The Contractor shall submit, for review and approval, operating manuals for all RMU components including items such as FPI, Relay, and MFM. These manuals shall be in English. They shall include

the RMU operating instructions. Context sensitivity shall be used to go directly to the appropriate place in the manual.

The manuals shall be organized for quick access to each detailed description of the operator procedures that are required to interact with the RMU functions. This shall include the procedures to define, build, edit, and expand all data points provided with the RMU.

The manuals shall present in a clear and concise manner all information that operators, including maintenance personnel, need to know to understand and operate RMUs satisfactorily. The manuals shall make abundant use of diagrams and/or photographs to illustrate the various procedures involved.

4.9 As-Built Documents and Drawings

The Contractor shall submit as built documents including applicable drawings for review and approval. All deliverable documents and drawings shall be revised by the Contractor to reflect the as-built RMU components including all the FPI, Relay, and MFM devices. Any errors in or modifications to an RMU resulting from its factory and/or site acceptance test shall be incorporated. Within this same context, all previously submitted documents that are changed because of engineering changes, contract changes, errors, or omissions shall be resubmitted for review and approval.

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