

Model Technical Specifications

For

**Switch Gear- Monitoring, Control &
Metering**

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1 Protections, Control & Metering

These specifications cover the scope of switchgear monitoring, control, and metering systems.

1.0.1 System Description

The Switchgear shall be envisaged as a fully integrated system with SCADA for protection, control, measurement, monitoring, and data acquisition of all MV and LV circuit breakers forming part of the Auxiliary Power Supply System of the entire project.

The system shall be equipped with communicable numerical protection relays complying with IEC 61850 on all feeders. These relays shall be networked over Ethernet-based communication and fully integrated with the SCADA system.

The SCADA system shall be based on a distributed architecture, comprising multiple Data Concentrators/Gateways and HMI Workstations, all interconnected through a redundant Station LAN. The system shall be engineered to ensure fast, safe, reliable, and secure control of the Auxiliary Power Supply system, along with comprehensive online monitoring and real-time data acquisition.

The Design Philosophy shall be as follows:

1. 33 kV and LT incomers, bus couplers, bus sections, bus ties, and transformer feeders shall be electrically operated and controlled from the Switchgear SCADA system.
2. The SCADA communication architecture shall be based on dual redundant Ethernet ring networks with fast network recovery features. The system shall incorporate redundant servers, dual communication paths, and dual-port numerical relays to ensure high availability, reliability, and fault tolerance of the SCADA network.

1.0.2 Scope of Work

The contractor's scope of work shall include complete design, engineering, supply, installation, testing and commissioning of the following.

- a) Communicable Numerical Relays (with IEC 61850) in all 33KV Switchgears and 415V LT Switchgear in the bidder's scope.
- b) IEC 61850 Ethernet switches in Switchgear panels – Sufficient quantity of Ethernet switches as per requirement for boards under bidder's scope. At least 2 ports per switch shall be kept as spare ports.
- c) Cat5e Ethernet cable / FO cable for connection of Numerical Relays to Ethernet switches in all Switchgears in the bidder's scope.
- d) Optical Fibre Cable with fire-retardant outer sheath as required for the complete SCADA network.
- e) Optical Fibre Cable termination equipment such as LIU, patch cord, etc. for the complete network including all MV & LV Switchgears.
- f) Integration with Energy Management System (EMS) with SCADA
- g) All other equipment required to meet the intended specification.

1.0.3 System Architecture

- a) The numerical relay network shall include relays on all MV & LV switchgears being supplied under this package.
- b) The network of each Data Concentrator shall consist of two separate rings of Ethernet switches connected through Fibre Optic cable. Each IED, located in individual switchgear panel, shall be connected to two Ethernet switches pertaining to each of the redundant rings mounted in the corresponding MV/LV Switchgear through Cat5e Ethernet cable. Data concentrators shall be distributed functionally and shall be interconnected through Fibre Optic cables forming a Station LAN.

- c) The integration of the complete automation system (including all status, analogue indications, alarms and controls) to enable the operator to monitor the complete auxiliary power supply from the HMI station.
- d) The point-to-point testing of all signals for the Switchgear network at the plant and equipment end and the terminal end (data concentrators/Controller and HMI Workstations) shall be the responsibility of the contractor. The contractor shall provide full details of the offered system Architecture during detailed engineering.
- e) The system shall be a computer-based system that shall integrate independently operating subsystems, such as Data Concentrators, Protection Units, Metering, and Alarm annunciation, into a unified data acquisition, monitoring, protection.
- f) The System architecture shall be flexible to allow future extensions. Each component / module of the system including all the communication links, shall be provided with built-in supervision and self-diagnostic features and any failures shall be alarmed to the operator.
- g) The offered equipment shall be of state of art technology and hardware shall be of proven field track record.
- h) Each of the circuit breakers shall be provided with communicable numerical relay i.e. Intelligent Electronic Device (IED) which shall be connected to two separate Ethernet switches located in the switchgear with Cat5e Ethernet cable /FO cable.
- i) Each of the above Ethernet switches shall be connected with Optical Fibre cable to other Ethernet switches forming two redundant Ethernet ring networks. All the Data concentrator system shall be interconnected through Optical Fibre cables forming a Station LAN.
- j) Data from the Employer's Battery Health Monitoring Systems shall also be integrated in the SCADA system.
- k) The System architecture shall be flexible to allow future extensions. Required application features, spare capacity, spare ports etc shall be provided.

1.0.4 Functional Requirements

The functionalities of the SCADA System shall be distributed amongst the following components / sub-systems.

- (a) Feeder IED: IED located in the individual feeder shall have the complete protection, measurement & monitoring functionalities pertaining to the feeder. Control logics related to closing & tripping of the feeder, viz. upstream breaker interlock, protection (86) interlock of own & other associated feeders, synchronism check, tripping on bus no-volt, etc. shall be built in the feeder IED. The detail logic configurations shall be finalized during detail engineering.
- (b) Data concentrator & HMI: Overall and detailed Dynamic Single Line Diagrams for the entire Auxiliary Power Supply system shall be built in the Data concentrator / HMI. Trip selection for manual changeover and Station level logics shall also be included in the Data concentrator / HMI. Other functionalities of HMI shall include Sequence of Events, Alarms, Trends, Reports, Upload of Disturbance Records (DR), Online monitoring of Ethernet rings, etc.

1.0.5 System Performance Requirements

- (c) Latency: As the Switchgear SCADA system shall be controlling the entire Auxiliary Power Supply system and thereby the entire plant operation, requirement of speed is of utmost importance. The system shall be so designed and implemented as to provide data transfer speeds prescribed by IEC 61850-5. Latency calculations based on system design shall be

submitted for review and approvals. Validation of the calculations shall be done during SCADA FAT and SAT.

- (d) Reliability: All components shall be designed and configured to make the system highly reliable. Failure of any component shall be immediately announced and wherever possible, the system shall be made self-healing. Reliability analysis of the entire system considering the reliability of all individual components shall be carried out and the reliability analysis calculations shall be submitted for review and approval by the Employer.
- (e) Ease of operation: The system shall be user friendly with respect to engineering, configuration, operation & maintenance with built in tools for operator help.
- (f) Diagnostic tools: The system shall have necessary diagnostic tools to continuously monitor the system performance and provide feedback to the operator / engineer. Necessary software tools to track changes in the system shall be provided.

1.1 Numerical Relays

1.1.1 General Requirements

- (a) All Numerical relays shall be of types, proven for the application satisfying requirements specified elsewhere and shall be subject to Employer's approval. Numerical Relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity to the satisfaction of the Employer.
- (b) All numerical relays shall be rated for control supply voltage as mentioned elsewhere under system parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Making, carrying and breaking current ratings of their contacts shall be adequate for the circuits in which they are used. Contacts for breaker / vacuum contactor close and trip commands shall be so rated as to be used directly used in the closing and tripping circuits of breaker / vacuum contactor without the need of any interposing / master trip relays. Threshold voltage for binary inputs shall be suitably selected to ensure avoidance of mal operation due to stray voltages and typically shall be more than 70% of the rated control supply voltage.
- (c) One minute power frequency withstand test voltage for all numerical relays shall at least be 2kV (rms).
- (d) All IEDs shall have freely programmable optically isolated binary inputs (BI) and potential free binary output (BO) contacts.
- (e) The above quantities are only indicative and shall be finalized during detailed engineering. In case the offered IED does not have the required number of I/Os, the same can be achieved through external I/O device of same make complying with the requirement stated elsewhere in this specification.
- (f) Failure of a control supply and de-energization of a relay shall not initiate any circuit breaker.
- (g) Disturbance Record waveforms, event records & alarms shall be stored in Non-volatile memory and failure of control supply shall not result in deletion of any of these data.
- (h) All the numerical relays shall have communications on three ports, local front port communication to laptop and dual ports on IEC 61850 to communicate with the data concentrator through LAN. The dual IEC 61850 ports shall be connected to redundant rings as shown in the architecture.
- (i) All Numerical relays shall have features for electrical measurements including voltage, current, power (active & reactive), frequency, power-factor and energy parameters.
- (j) Relays shall have event recording feature, recording of abnormalities and operating parameters with time stamping.
- (k) Master trip (86) and non-86 trips shall be software configurable to output contacts and no separate master trip relay shall be used.
- (l) All numerical relays shall have provision of both current (CT) and voltage (VT) inputs. Relays shall be suitable for both residually connected neutral CT input as well as CBCT input. Relays shall be suitable for CT secondary current of 1A. Following minimum no. of

CT inputs to be provided in numerical relays used for different type of feeders as mentioned below including phase and neutral CT inputs.

1.	DB(MV transformer feeders without differential)	4CT
2.	DBF(MV transformer feeders with differential)	7CT
3.	DC(MV incomer)	5CT
4.	DD/DE-OG/DE-IC(MV Tie, buscoupler)	4CT
5.	DAET(LT incomer)	4CT
6.	DAE(Bus coupler, Tie)	4CT

- i. All CT terminals on the relays shall be of fixed type suitable for connection of ring-type lugs to avoid any hazard due to loose connection leading to CT open-circuit. In no circumstances Plug In type connectors shall be used for CT / VT connections.
- ii. All numerical relays shall have key pad / keys to allow relay setting from relay front. Pre-programmed or programmable key for Master trip (86) reset shall be provided on the relay front. Relay to be self or hand reset shall be software selectable. Manual resetting shall be possible from remote.
- iii. Relays shall have suitable output contact for circuit breaker failure protection (CBFP).
- iv. Relays shall have self diagnostic feature with continuous self check for power failure, program routines, memory and main CPU failures and a separate output contact for indication of any failure.
- v. Relays shall have at least two sets or groups of two different sets of adaptable settings. Relays shall have multiple IEC / ANSI / user-programmable characteristics.
- vi. Design of the relay must be immune to any kind of electromagnetic interference. Vendor to submit all related type test reports for the offered model along with the offer.
- vii. All cards/ hardware of numerical relays shall be suitable for operation in Harsh Environmental conditions with respect to high temperature, humidity & dust.

1.1.2 Protections: Relay Types & Protections

1.1.2.1 Transformer Feeder Protections (Module Type DB/DBF)

The Transformer protection relay shall be suitable for providing the following protections.

a) **Three Phase Over current and Earth Fault protection (50 & 50N)**

The relay shall have instantaneous as well as time delayed over current and earth fault protections. The over current element should have the minimum setting adjustable between 250-2000% of CT secondary rated current. The short circuit protection shall also have cold load pick up (doubling) / group-changeover feature to allow higher setting during transformer charging (inrush) and lower setting during normal operating condition.

With CBCT the relay shall be suitable for detection of earth fault currents in the range of 10mA secondary.

b) **Restricted Earth Fault protection (64R)**

Restricted earth fault protection (64R) shall be provided with high stability circulating current principle having pick up setting range of 10 to 40 % of CT secondary. Necessary stabilizing resistors shall be provided.

c) **Stand by earth fault protection (51N)**

For transformers of rating 5MVA and above, definite time delayed Stand by earth fault protection shall be provided having a pick up setting range of 10% to 40% with a timer delay of 0.3 sec to 3 sec.

d) Transformer Differential protection (87T)

Differential protection for transformers (87T) of rating 5MVA and above shall be provided with stabilized biased differential relay. The differential protection shall be provided with harmonic restraint during switching and over fluxing condition. No ICT shall be provided either for ratio correction or for transformer primary and secondary correction. The necessary correction shall be programmable at offered numerical relay. Sensitive phase current and phase angle displays should be available to facilitate the commissioning and checking of the measurement circuit connection and vector group matching.

e) Transformer trouble trips

Transformer troubles like Buchholz, Winding temperature, Oil temperature & Pressure Relief Device trips shall be wired to separate binary inputs of the relay and shall be configured to issue trip command to the breaker.

f) Transformer trouble Alarm

Alarm contacts of the above transformer troubles shall be wired to separate binary inputs of the relay for communication to HMI.

1.1.2.2 Protections for Incomers, Bus-couplers and Tie feeders (Module Type DC/DE/DD)

The Incomer, Bus Coupler & Tie feeder protection relay shall be suitable for providing the following protections

a) Three Phase Over current and Earth Fault protection (50 & 50N)

The over current element should have the minimum setting adjustable between 250 to 2000% of CT secondary rated current. The earth fault element should be suitable for residually connected CT input. The relay shall be suitable for detection of earth fault currents in the range of 5% to 10% of the CT rated current.

b) Synchronizing Check (25)

Synchronizing check feature as a part of manual live change over and dead bus closing feature shall be provided.

c) Bus No-volt

Bus no volt signal shall be configured in the relay for use in control logics.

1.1.2.3 Other Protections and Control features

- a) Control of breakers shall be carried out from the HMI station of EMS with SCADA system through the LAN and the numerical relays. Provision of controlling the breaker from Local front port using a laptop shall be envisaged by the bidder.
- b) Trip circuit supervision shall be provided for all feeders to monitor the circuit breaker / contactor trip circuit both in pre-trip and post-trip conditions.
- c) Schematics requiring auxiliary relays / timers for protection function shall be a part of numerical relay. The number of auxiliary relay and timer functions shall be as required for the application. Timer functions shall be configurable for on & off delays as per requirement.
- d) The numerical relay shall be able to provide supervisory functions such as trip circuit monitoring, circuit breaker status monitoring, VT and CT supervision.
- e) The numerical processor shall be capable of measuring and storing values of a wide range of quantities, all events, faults and disturbance recordings with a time stamping using the

internal real time clock. Battery backup for real time clock in the event of power supply failure shall be provided.

- f) At least 200 time tagged events / records shall be stored with time stamping. Details of at least 5 previous faults including the type of protection operated, operating time, all currents & voltages and time of fault.
- g) Diagnostics Automatic testing, power on diagnostics with continuous monitoring to ensure high degree of reliability shall be shall be provided. The results of the self reset functions shall be stored in battery back memory. Test features such as examination of input quantities, status of digital inputs and relay outputs shall be shall be available on the user interface
- h) The alarm / status of each individual protection function and trip operation shall be communicated to the Switchgear SCADA system.
- i) Sequence of events shall have 1ms resolution at device level.
- j) Measurement accuracy shall be 1 % for rated RMS Current and voltage
- k) It shall be possible to carryout open / close operation of breakers from a laptop by interfacing from the relay front port during initial commissioning.
- l) Additional GOOSE Controls shall be configured in the Numerical Relays for following functions. The response time of GOOSE interlocks shall be 10ms. (GOOSE Performance Class P1, Message Type 1A)
 - a. Inter tripping
 - b. Reverse Blocking
 - c. Earthing Interlocks

1.2 Ethernet Switch

- a) Ethernet switches shall be 'substation hardened', and shall comply with IEC61850 for communications and environment requirements. The Ethernet switches shall be of managed type with two (2) No of Fibre Optic cable ports and Sixteen / Eight Copper ports to achieve the LAN configuration indicated in the drawings. The Ethernet switches shall have features to support the dual redundant rings as shown in the architecture drawings. These switches shall be mounted inside the switchgear Panels and shall be suitable for accepting dual redundant power supplies. The FO ports shall be Single-mode 1000Mbps ports. Copper ports shall be 10/100Mbps ports.
- b) Necessary software for configuration and real-time network monitoring shall be provided along with the Ethernet switches. Network monitoring feature shall be integrated with the SCADA software to provide complete network status on the HMI.

1.3 Lan Cable & Connector

LAN CABLE & CONNECTOR Cat5e Ethernet cable shall be used for connecting the numerical relays to Ethernet switches. In case FO ports are proposed on the numerical relays, Ethernet switches shall also have suitable FO ports as per the quantity mentioned above. Further, additional FO patch cords of maximum length (quantity – 10% of total quantity of IEDs) shall be supplied to facilitate maintenance.

1.4 FO cable & Connector

The Fibre Optic cable shall be armoured, Single-mode, graded index OMI (ISO/IEC 11801) of Diameter 125µm core / cladding with max attenuation of 1.52 dB/km at 1310nm wavelength & 1.0 dB/km at 1550nm wavelength. The cable should be suitable for operation at 1310/1550nm. The outer Sheath / Jacket of the FO Cable shall be Fire retardant.

1.5 System Software Requirements and Documentation

- a) The Contractor shall provide all licensed software packages required by the system for meeting the intent, functional and parametric and performance requirements of the specification.
- b) All licenses (except anti-virus) shall be valid for the continuous service life of the plant. All technical manuals, reference manuals, user guide etc., in English required for modification/editing/addition/deletion of features in the software for the Numerical Relays, Ethernet Switches etc. shall be furnished. The Bidder shall furnish a comprehensive list of all such system/application software documentation.
- c) The developed application software dump /backup shall be submitted in Duplicate DVDs. Further Relay Configuration Files as commissioned shall be collated and submitted in a Hard disk drive for backup.
- d) System Security features shall be provided at each level for safeguarding against unauthorized access.
- e) At least two licensed copies of necessary software for numerical relay configuration / setting / disturbance analysis and other utilities shall be supplied.
- f) Numerical relay configuration for all relays being supplied under the package shall be carried out in line with the approved schematics and shall be submitted for Employer's approval.
- g) Setting calculations and relay settings configured in relay software for all relays shall be submitted for Employer's approval. Approved relay configuration / settings files shall be loaded in all the relays prior to dispatch to site.

1.6 Auxiliary Power Supply

The numerical relays & Ethernet switches being installed at switchboard shall be suitable for auxiliary power supply 240V/110V AC with tolerance of 80% to 120 % of rated voltage & shall be finalized during detailed engineering. Ethernet switches shall have provision to receive dual redundant power supplies. However other network components as data concentrator, LAN switches etc. shall be suitable for 240V AC & redundant 240V AC UPS supply for these components shall be provided by the Contractor.

1.7 Input / Output Interface, Filters and Optical Isolation

Relay shall be immune to capacitance effect due to long length of connected control cables. Any external hardware, if required for avoiding mal operation of the relay due to cable capacitance shall be included as a standard feature. All I/Os shall have optical isolation. Analog inputs shall be protected against switching surges, harmonics etc. No separate earth bus shall be required for the relays. It shall be possible to connect the relay earth to the common earth bus in the switchgear panel which shall be connected to the plant earth mat.

1.8 Time Synchronization and GPS

Time clock synchronization equipment provided in EMS shall be used for time synchronization for all the clocks of the numerical relays, LAN system with data concentrator, etc. The resolution of time synchronization shall be +/- 1.0 millisecond or better throughout the entire system.

1.9 Testing

1.9.1 Type Tests and Factory Acceptance Tests

Type test reports for the following tests on the model of the relays, Ethernet switches, LAN equipments shall be submitted for Employer's review.

S. No.	Equipment	Standard
1	Dimensions of structure and visual inspection	IEC 60297-3-101
2	Functional requirements:	Relevant IEC 60255-100 series
	– Steady-state simulation	
	– Dynamic simulation	
3	Product safety requirements (including the dielectric tests and thermal short time rating)	IEC 60255-27
4	EMC requirements:	IEC 60255-26
	– Emission	
	– Immunity	
5	Energizing quantities:	
	– Burden	N/A
	– Change of auxiliary energizing quantity	IEC 60255-11
6	Contact Performance	N/A
7	Communication requirements	Relevant IEC protocol standards
8	Climatic environmental requirements: Cold, Dry Heat, Change of Temperature, Damp heat	IEC 60068-2-14, IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-78, IEC 60068-2-30, IEC 60255-27
9	Mechanical requirements: – Shock, Vibration, Bump, Seismic	IEC 60255-21-1, IEC 60255-21-2, IEC 60255-21-3
10	Enclosure protection	IEC 60529, IEC 60255-27

1.9.2 Factory Acceptance Tests (Fat) & Pre-Fat

- a) Pre-FAT shall be carried out at Contractor/.Employer’s Engineering Office before the system is cleared for FAT. The pre-FAT shall include verification of the complete configuration of the system with respect to all process displays like single line diagrams, trends, alarms, reports, etc.
- b) Full functionality of the relay including protection /metering to be demonstrated using secondary injection procedures.
- c) All equipment furnished under this specification shall be subject to test by authorized quality assurance personnel of the bidder and Employer’s representatives during manufacture, erection and on completion. The approval of the Employer or passing such inspections or tests will not, however, prejudice the right of the Employer to reject the equipment if it does not comply with the specifications when erected or fails to give complete satisfaction in service. Quality assurance system followed by manufacturer should preferably be in line with IEC 61850 Part 10. However, an indicative requirement

of operational and pre-FAT tests as well as FAT test (Integrated Test) is given in this Section.

- d) The FAT shall be mutually agreed upon and approved by Employer during detailed engineering. The Factory Acceptance Tests (FAT) shall include all reasonable exercises which the combination of equipment and software can be expected to perform. These tests shall be divided into, as a minimum, but not limited to the following categories:
 - i. Pre power on checks
 - ii. Power on checks
 - iii. Hardware tests
 - iv. Functional tests
 - v. Parametric tests
 - vi. Specific tests on electronic hardware
 - vii. Power failure auto-restart tests
 - viii. Testing of interlocking
- e) The Bidder shall submit a detailed FAT procedure for Employer's approval during detailed engineering stage based on the above guidelines. The test results obtained shall be properly documented by the Bidder and furnished in the Employer approved format as decided during detailed engineering and submitted in the requisite number of copies with all annex irrespective of the fact that Employer's representative was present during the tests.

1.9.3 Erection, Commissioning & SAT for Relays & its Monitoring & Control

- a) The contractor shall prepare an erection guideline and commissioning Procedure, SAT procedure for the SCADA system and submit to Employer for review and approvals.
- b) Site tests shall include all tests to be carried out at site upon receipt of equipment. It shall include but not be limited to testing calibration, configurations and pre commissioning trials start up tests, trial operation and performance and guarantee tests. The Contractor shall be responsible for all site / commissioning tests.
- c) The Contractor shall maintain all tests, calibration records in Employer approved formats, and these shall be countersigned by authorized quality assurance personnel of the Contractor supervising these works.
- d) The Contractor shall maintain master checklists to ensure that all tests and configurations for all equipment/devices furnished under these specifications are satisfactorily completed under the supervision of the authorized quality assurance personnel of the Contractor.
- e) The site / commissioning tests shall be categorized under following categories:
 - i. Start up tests
 - ii. Calibration and configuration checks
 - iii. Pre-commissioning tests
 - iv. Trial Operation
 - v. Availability Tests
- f) The system will be handed-over to the Employer for commercial operation after the site / commissioning tests have been completed to the satisfaction of the Employer. A hand-over certificate will be issued by the Employer.

1.9.4 Relay Test Equipment

The required relay test equipment shall comprise the following:

- (a) One 3 phase (4 Voltage and 6 current sources) dynamic portable relay test system for allowing dynamic and steady state testing.

(b) Any other auxiliary items required for comprehensive protection testing all types of the protection relays supplied under this contract.

It shall have the capability to replay the Disturbance / Fault records acquired by the numerical relays in IEEE / COMTRADE format or EMTP simulations, to facilitate dynamic testing of all the numerical relays supplied under this contract. The required software for steady state/dynamic testing of all the numerical protection relays along with a laptop PC shall also be supplied. The relay test set shall be suitable for IEC 61850 compliance testing with required no. of RJ45, FO and USB Ports. The test set shall have min 8 nos. (GI) binary inputs and 4 nos. (GI) binary outputs. The associated software for automated relay testing and IEC61850 GOOSE/GSSE Configuration shall also be supplied. All commissioning tests on protection relays, energy meters and transducers shall be carried out with this relay test equipment being supplied under this contract and test reports shall be maintained as per the agreed protocols.

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