



ORISSA POWER TRANSMISSION CORPORATION LIMITED
OFFICE OF THE SR. GENERAL MANAGER,
CENTRAL PROCUREMENT CELL,
JANAPATH, BHUBANESWAR – 751022.

TECHNICAL SPECIFICATION

CONTROL AND RELAY PANEL

CONTROL AND RELAY PANELS

protection and control panels

1.0 Panels

General

Simplex and/or duplex panels shall be provided to suite the substations site. Bidder shall be fully responsible for his bids to match the dimensions, colour and fittings with those in the existing control rooms where the extensions are required. In no case any proposal for increase in price at a later date shall be entertained by the Employer. However panels not matching those already installed may be acceptable to the Project Manager. Specific approvals will be required on a case by case basis. Panels shall be free standing mounted on floors fitted with embedded channels, insert plates or foundation bolts. The panels shall be made vibration and shock proof by providing anti vibration strips.

The base frame of all panels shall have a smooth bearing surface such that when fixed on the embedded foundation channels/insert plates it shall be free standing and provide a level surface. The panels shall be completely metal enclosed, dust, moisture and vermin proof. The enclosure shall provide a degree of protection not less than IP-31 in accordance with IS 13947

The design, materials selection and workmanship shall be such that it provides a neat appearance both inside and outside without signs of welds, rivets or bolt heads from outside. The exterior surfaces shall be smooth and sleek.

Relay panels of modern modular construction in 19 inch hinged racks would also be acceptable. Cable entry to the panels shall be from the bottom. The provision of all cable glands and shrouds of the panel shall be part of the scope of supply. Cable gland plate fitted on the bottom of the panel shall be connected to earthing of the panel/station through a flexible braided copper conductor.

1.1 Simplex Panel

Simplex panels shall be provided with equipment mounted on front panel vertically. The wiring access shall be from rear for control panels and either from front or rear for relay panels. Where panel width is more than 800 mm, double leafed doors shall be provided. Doors shall be fitted with either built-in locking facility or with padlock.

1.2 Duplex Panel

Duplex panels shall be walk-in, tunnel type comprising of two vertical front and rear panels connected back to back by formed sheet steel roof as tie members and a central corridor in between. The corridor shall facilitate access to internal wiring and external cable connections. Where a number of duplex panels are located in a row side by side, the central corridor shall be aligned to form a continuous passage. Both ends of the corridor shall be provided with double leaf doors with lift off hinges. Doors shall be fitted with either built-in locking facility or with padlock. Separate bottom cable entries shall be provided for the front and rear panels. The inter-connections between front and back panels shall be established by providing wiring at the top of the panel.

IMP: Only Relay panel front side should be provided with protective front door with PRESPEX cover with flush type handle with locking facility to protect the relays from the external.

1.3 Constructional Features

It is the responsibility of the Contractor to ensure that the equipment specified and such unspecified complementary equipment required for completeness of the protective/control schemes can be properly accommodated in the panels without congestion. Panels shall be free standing, floor mounting type and shall comprise of structural frames completely enclosed with smooth finished, cold rolled sheet steel of thickness not less than 3 mm for all weight bearing members such as base frame, front panel, door frames. All other parts may be provided with 3.0 mm thick steel sheet. There shall be sufficient reinforcement to provide level surfaces, resistance to vibration and rigidity during transportation and installation. All doors, removable covers and panels shall be gasketed all around with neoprene or superior material. Ventilating louvres, where provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh.

1.4 Mounting

All equipment on and in panels shall be mounted and completely wired to the terminal blocks ready for external connections. The equipment on front of panel shall be mounted flush. Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent devices. Equipment shall be readily accessible without use of special tools. Terminal marking on the equipment shall be clearly visible. The Contractor shall carry out cut-out, mounting and wiring of all equipment and items which are to be mounted in his panel. Cut-outs if any, provided for future mounting of equipment shall be properly blanked off with blanking plates. The center lines of switches, push buttons and indicating lamps shall be not less than 750 mm from the bottom of the panel. The center lines of relays, meters and recorders shall be not less than 450 mm from the bottom of the panel. The center lines of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. The top lines of all meters, relays and recorders etc. shall be matched. No equipment shall be mounted on the doors. All the equipment connections and cabling shall be designed and arranged to minimise the risk of fire and damage which may be caused by fire.

1.5 Terminal Blocks

Terminal blocks and boards shall conform to the requirements of the relevant sections of this Specification. De-link type terminal blocks shall be provided in all the circuits and Terminals.

1.6 Supporting steel

All necessary embedded levelling steel, sills, anchor bolts, channels and other parts for supporting and fastenings the panels and vibration damping shall be supplied by the Contractor.

Instruments, Meters, Recorders and Transducers

2.0 General

All instruments, meters, recorders and transducers shall be enclosed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. All indicating instruments and recorders shall be digital type and provided with individual transducers and shall be calibrated along with the transducers to read directly the primary quantities. They shall be accurately adjusted and calibrated at works and shall have a means of calibrations check and adjustment at site. The Contractor shall confirm that the indicating instruments, recorders along with transducers and energy meters offered

by him are suitable for connecting to the instrument transformers having the technical particulars given in reference drawing. Synchronizing Instruments shall also meet the requirements of the relevant clause of this section of the Specification. Digital bus voltage and frequency meters shall be of class 0.5 and shall have digital readouts of five and four digits respectively, with display size, not less than 50 mm (height)

2.1 Metering Instruments

Energy-meters (NOT REQUIRED)

Energy meters shall be provided on all line feeders, transformer feeders, buscoupler and bus transfer bays as per the requirements stated in the schedule of requirement of this specification.

On 400/220/132 kV feeders emanating from various substations, where commercial metering is required redundant energy metering in form of MAIN shall be employed.

All 33 kV feeders emanating from various substations shall be treated as feeders with commercial metering requirements. Only single energy meters shall be employed.

Energy meters shall be solid state trivector type. The energy meters are intended to measure, record and display active energy (kWh/MWh), reactive energy (kVARh/MVARh), apparent energy (kVAh/MVAh), Maximum Demand (MVA/kVA/MW/kW/ etc. They should be of three phase two element type or three element type suitable for measurement of unbalanced loads in three phase, three wire circuits. The meters shall be provided with at least six registers for TOD metering purposes. The meters shall have LCD or cyclometer type registers.

Energy meters shall be of draw out or non-drawout type and suitable for flush mounting with back connected terminals.

Energy meters shall be suitable for operation from the secondary of CT's and VT's. Separate test blocks for the testing of the meters (without disturbing the CT and VT secondary connections) shall be provided.

Energy Meters shall have reverse running stops. Meters shall conform to IEC 687 /IS 13779. All watt-hour meters shall have accuracy class of 0.2. All VARh-hour meters shall have accuracy class of 3.0. The energy meters shall also conform the requirements stipulated in Technical Report of Central Board of Irrigation and Power, India.

Energy Meters shall be compensated for temperature errors and factory calibrated to read the secondary quantities. The number of digits provided shall be adequate to cover at least 1500 hours of operation.

Current coils of the meters shall have continuous overload capacity of at least 200% for both accuracy and thermal limits, and shall withstand at least 20 times of rated current for 0.5 seconds without loss of accuracy.

Energy meters should have facilities for data transfers remote metering with proper security via an optically isolated communication port using serial communication. Where required, output ports shall be provided for summation and time synchronisation.

Energy meters shall be provided with features for monitoring tamper and fraud. The possible cases of tamper and fraud shall be proposed by the Project Manager to Contractor for incorporation in to the metering software.

Energy meters should be provided with adequate software and hardware to store the load survey data from the last reset time. Energy meters shall also be provided with self diagnostic features.

Technical requirement for energy meters

Description	Requirement
Operating voltage	110V Phase to phase, 65.3V Phase to neutral
Operating current	1—5 A
Measurement	Real and reactive energy Maximum demand Bi-directional power flow
Display	Digital type (electronic type). In case of electronic type of display the minimum retention time for non volatile memory shall not be less than 5 years
Communication	Optical Port / E— Port

Table 9.3.2. Technical requirements for energy meters

2.2 Recording instruments

Recording instruments shall have the following characteristics features :

- Static/Digital type voltage and frequency recorders in individual units for the sub-station with time tagged information shall be acceptable. It shall meet the accuracy of +/-:1.0% span and full span response time of less than 2 seconds. It shall also meet the high voltage susceptibility test, impulse voltage withstand test, high frequency disturbance test – class III and fast transient disturbance test level III as per IEC 60255.

2.3 Transducers

General

The transducers used for recording/indicating instruments and telemetry/data communication applications shall in general conform to IEC 688-1.

Transducers shall be suitable for measurement of active power, reactive power, voltage, current and frequency in three phase, four wire system. These could be separate or combined type. Serial port on combined type is also acceptable.

The input to the transducers will be from substation current and potential transformers. The output shall be in milli ampere DC proportional to the input. It shall be possible to feed the output current directly to the telemetry terminals, indicating instruments or recording instruments.

The transducer characteristic shall be linear throughout the measuring range.

The transducer output shall be load independent.

The input and output of the transducers shall be galvanically isolated.

The transducer shall derive its auxiliary supply from the quantity to be measured without need for any external supply.

Each transducer shall be housed in a separate compact case and have suitable terminals for inputs and outputs. Input side terminal connectors (from CT's and PT's) to be suitable for three phase, four wire connection.

The transducers shall be suitably protected against transient high peaks of voltage and current.

The transducer shall withstand indefinitely without damage and work satisfactorily at 120% of the rated voltage and 200% of the rated input current as applicable.

Voltage, frequency and current transducers associated with the ISCS shall have an output to 0-10 mA and the active and reactive power transducers shall have an output of 10-0-10 mA. Voltage, frequency and current transducers associated with conventional systems shall have an output to 4-20 mA and the active and reactive power transducers shall have an output of 10-0-10 mA.

The response time of the transducers associated with ISCS shall be less than 500 milliseconds. Response time for transducers associated with conventional systems shall be less than one second.

The transducers shall have a working temperature range of 0-50C.

The accuracy class of transducers shall be 0.5 or better except for frequency transducer which shall be 0.2.

The transducers shall have an AC ripple on output of less than 1%

The transducers shall be suitable for load resistance of 1000-1500 ohms

The CT and PT ratios and scale ranges for the voltage, current and frequency transducers shall be suitable for the various CT and PT ratios (as applicable) furnished with the specification and compatible with the feeder/transformer voltage levels and ratings.

The transducer shall be provided with terminal connectors for wire of maximum cross section of 4 mm., with dual screws, for rigid connections.

The transducer shall have dual output.

Transducers (recording/indicating instruments and telemetry/data communication application)

The transducers shall in general conform to IEC 688-1 and have the following features:

- Each transducer shall be housed in a separate compact case and have suitable terminals for inputs and outputs.
- The transducers shall have an output of 4-20 mA.
- The response time of the transducers shall be less than one second.
- The accuracy class of transducers shall be 0.5 or better except for frequency transducer which shall be 0.2.
- The PT ratios and scale ranges for the voltage and frequency transducers shall be as follows:

	PT Ratio	Scale range
Voltage transducer :	400kV/110V	0-500kV
	220kV/110V	0-300kV
	132kV/110V	0-200kV
	33kV/110	0-50kV
Frequency transducers :	as above	45-55 Hertz.

All the transducers shall be suitable for CT and PT parameters specified.

- The transducer shall have dual output.

2.4 Annunciation System:

General

The annunciation shall be of visual and audible type. The visual annunciation shall be provided by annunciation facia, mounted flush on the top of the control panels. The audible alarm shall be provided by alarm buzzer or bell. The annunciation facia shall be provided with translucent plastic windows for alarm points with minimum size of 35 mm x 50 mm. The facia plates shall be engraved in black lettering with inscriptions. The list of such inscriptions shall be furnished by the Contractor for the Project Manager's approval. The inscriptions shall be engraved on each window in not more than three lines with letter sizing not less than 5 mm. Where annunciation systems are already provided, the annunciation scheme shall be engineered as an extension to the existing scheme. Each annunciation window shall be provided with two white lamps in parallel to provide safety against lamp failure. Long life lamps shall be used. The lamp circuit shall include series resistor of adequate rating. The cover plate of the facia windows shall be flush with the control panel and shall be capable of easy removal to facilitate replacement of lamps. The cover plate transparency and the lamps wattage in the fascia windows shall be designed to ensure clear visibility of the inscriptions in the control rooms (having an illumination level of 350 lux) from the location of the Operator's desk. **TRIP** and **NONTRIP** facia shall be differentiated. All **TRIP** facia shall have red colour and all **NONTRIP** fascia shall have green colour.

Sequence of operation of the annunciator shall be as given in Table 10.1.

Alarm Condition	Fault Contact Status	Visual Annunciation	Audible Annunciation
Normal	Open	OFF	OFF
Abnormal	Close	Flashing	ON
Accept push button is pressed	(a) Close (b) Open	Steady on Steady on	OFF OFF
Reset push	(a) Close (b) Open	ON ON	OFF OFF
Lamp test push button pressed	Open	Steady on	OFF

Table 10.1. Sequence of annunciator operation

Visual and audible annunciation for the failure of DC supply to the annunciation system shall also be provided and this annunciation shall operate on 240 Volts AC supply with separate fuses. On failure of the power supply to the annunciation system for more than two or three seconds (adjustable setting) a facia shall light up and an audible alarm shall sound. A separate push button shall be provided for the cancellation of this audible alarm alone, however the facia window shall remain steadily lit till the supply to the annunciation system is restored. The sound of the audible alarm (bell) provided for this annunciation shall be different from the audible alarm provided for the annunciation system.

A separate voltage check shall be provided to monitor the failure of supply (240V AC) to the scheme mention above. If the failure of supply exists for more than two to three seconds this relay shall initiate visual and audible annunciation.

The annunciation system shall be capable of catering to at least 20 simultaneous signals at time.

One self resetting push button shall be provided on each panel for testing the facia window lamps. Push buttons for testing flasher and audible alarm circuits of the annunciation system and for testing the annunciation supply failure monitoring circuit shall be provided. These testing circuits shall be so connected that while testing is being done it shall not prevent the registering of any new annunciation that may occur during the test.

One set of the following push buttons shall be provided on each panel as shown in the sample front view drawing attached to this Specification.

- Reset push button for annunciation system.
- Accept push button for annunciation system.

The annunciation shall be repetitive type and shall be capable of registering fleeting signals.

Minimum duration of the fleeting signal registered by the system shall be 15 milliseconds.

Auxiliary relays for the annunciation system shall have adequate auxiliary potential free contacts for use in event logger.

The annunciation shall be suitable for operation with normally open contacts which close on a fault or contacts which open on a fault. It shall be possible at site to change annunciators from “close to fault “ to “ open to fault “ and vice-versa.

In case of a static annunciator scheme, special precautions shall be taken by Contractor to ensure that spurious alarm conditions do not appear due to the influence of external electro magnetic or electrostatic interference on the annunciator wiring, and switching disturbances from the neighbouring circuits within the panels.

Annunciation systems to be supplied for existing substations should be matched with the existing scheme in co-ordination with the Project Manager during detail engineering stage.

2.5 PANEL INTERNAL WIRING

1. Panels shall be supplied complete with interconnecting wiring provided between all electrical devices mounted and wired in the panels and between the devices and terminal blocks for the devices to be connected to equipment outside the panels. When panels are arranged to be located adjacent to each other all inter panel wiring and connections between the panels shall be furnished and the wiring shall be carried out internally

2. All wiring shall be carried out with 1100V grade, single core, stranded copper conductor wires with PVC insulation. The minimum size of the multi-stranded copper conductor used for internal wiring shall be as follows.

3. All circuits except current transformer circuits and voltage transfer circuits meant for energy metering one 2. sq. per lead.

4.1 All current transformer circuits one 4.0 sq. mm lead.

4.2 Voltage transformer circuit (for energy meters): Two 2.5 mm sq per lead.

4.3. All internal wiring shall be securely supported, neatly arranged, readily accessible and connected to equipment terminals and terminal blocks. Wiring gutters & troughs shall be used for this purpose.

4.4. Auxiliary bus wiring for AC and DC supplies, voltage transformer circuits, annunciation circuits and other common services shall be provided near the top of the panels running throughout the entire length of the panels.

4.5. Wire germination shall be made with solder less crimping type and tinned copper lugs, which firmly grip the conductor. Insulated sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wire and shall not fall off when the wire is disconnected from terminal blocks. All wires directly connected to trip circuit breaker or device shall be distinguished by the addition of red coloured unlettered ferrule.

4.6. Longitudinal troughs extending throughout the full length of the panel shall be preferred for inter panel wiring. Inter-connections to adjacent panel shall be brought out to a separate set of terminal blocks located near the slots of holes meant for taking the inter-connecting wires.

4.7. Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipments.

4.8. All wiring shall be switch board type single conductor tinned annealed copper wire insulated with varnished cambric, faulted asbestos, single braided cotton cover painted overall with flame proof moisture resistant paint and suitable for 660 volt service or equivalent polynychloride insulation which has proved its utility in tropical regions against hot and moist climate and vermin (Misc. white ants and cockroaches etc) Rubber insulated wiring will not be accepted.

The sizes of wiring in different circuits shall not be less than those specified below :

Table – I

Circuit	Minimum permissible Size of wire.
Metering and relaying circuits connected to Current Transformers.	4.0 mm sq.
Potential circuits for metering and Relaying,	4.0 mm sq.
Other control, visual and audible alarm signaling circuits etc.	2.5 mm sq

The following colour scheme shall be used for the wiring.

Table – II

Circuit where use.	Colour of wire and ferrule.
Red phase of instrument transformer circuit	Red.
Yellow phase of instrument transformer	Yellow.
Blue phase of instrument transformer circuits	Blue.
Neutral connections earthed or not earthed in the instrument transformer circuit	Green.
A.C. Control wiring circuits using D.C. upply	Grey

All wiring inter-connecting the front cubicles with the rear cubicles of the panel board over the access corridor shall be wired in gutters held against the ceiling of the corridor by means of screws. All potential bus wiring, audible alarm bus wiring, AC and DC control supply bus wiring, wiring for cubicles lighting and such other wiring which runs from cubicle to cubicle within the switch board shall be laid out in gutters and shall be carefully screened. As the front and rear cubicles will be detachable, the inter-connection shall be made through suitable terminal connectors securely fixed on the panel.

Wiring connected to the space heaters in the cubicles shall have porcelain braided insulation over a safe length from the heater terminals.

Each wire shall be continuous from end to end without having any joint within itself. Individual wires shall be connected only at the connection terminals or studs of the terminal blocks, meters, relays, instruments and other switchboard devices.

Terminal ends of all wires shall be provided with numbered ferrules suitable coloured (Ref : Table-II) for phase identification. At point of inter/connection where a change of number is necessary, duplicate ferrules shall be provided with the appropriate numbers on the changing end.

At the terminal connection, washers shall be interposed between terminals, wire terminals and the holding nuts. All holding nuts shall be secured by locking nuts. The connection stud shall project at least 6 mm. from the lock nut surface.

Wire ends shall be so connected at the terminal studs that no wire terminal number ferruled gets masked due to succeeding connections. All wires shall be suitable for bending to meet the terminal stud at rectangles with the stud axis, and they shall not be skewed.

All studs, nuts, bolts, scores, etc. shall be threaded according to the British Standard practice unless Employer's prior approval to any other practice of threading is obtained. Spare quantities of nuts, lock nuts and washers of all varieties used on the panel board shall be supplied to the extent of 10% of the used quantities.

2.6 TERMINAL BLOCKS

All the terminal blocks to be used in the panel shall be provided with 1100V grade stud type terminal block of Polyamide material. (OAT-6 for non-disconnecting type and OAT 6T for disconnecting type of Elmex) / Connectwell (Equivalent). At least 20% spare terminals shall be provided.

- (i) All internal wiring to be connected to external equipment shall terminate on terminal blocks. Disconnecting type Terminal blocks shall be 1100 V grade and have 20 Amps. Continuous rating, molded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts,. Markings on the terminal blocks shall correspond to wire number and terminal numbers on the wiring diagrams. All terminal blocks shall have shrouding with transparent unbreakable material.
- (ii) Disconnecting type terminal blocks for current transformer and voltage transformer secondary leads shall be provided. Also current transformer secondary leads shall be provided with short-circuiting and earthing facilities.
- (iii) At least 20% spare terminals shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks.
- (iv) Unless otherwise specified, terminal blocks shall be suitable for connecting the following conductors of external cable on each side.

- (v) There shall be a minimum clearance of 250mm between the first row of terminal blocks and the associated cable gland plate or panel sidewall. Also the clearance between two rows of terminal blocks edges shall be minimum of 150mm
- (vi) Arrangement of the terminal block assemblies and the wiring channel within the enclosure shall be such that a row of terminal blocks is run in parallels and close proximity along each side of the wiring duct to provide for convenient attachment of internal panel wiring. The side of the terminal block opposite the wiring duct shall be reserved for the owner's external cable connections. All adjacent terminal blocks shall also share this field-wiring corridor. All wiring shall be provided with adequate support inside the panels to hold them firmly and to enable free and flexible termination without causing strain on terminals.
- (vii) The number and sizes of the Owner's multi core incoming external cables will be furnished to the contractor after placement of the order. All necessary cable-terminating accessories such as gland plates, supporting clamps & brackets, wiring troughs and gutters etc. (except glands & lugs) for external cables shall be included the scope of supply

2.7 PAINTING:-

Powder coating type is preferable.

All sheet steel work shall be phosphated in accordance with the IS:6005 Code of practice for phosphating iron and steel.

(1) All unfinished surface of the steel panels and frame work shall be sand blasted to remove rust, scale, foreign, adhering matter of grease.

(2) A suitable rust resisting primer shall be applied on the interior and exterior surfaces of the steel, which shall be followed by application of an under coat suitable to serve as base and binder for the finishing coat. The finishing coat on the exterior of the panels shall be deep gray powder coated. Polished cellulose appearance while on the interior faces the finishing coat shall be of light gray shaded paint sprayed to give a contrasting effect with the cubicle wiring.

A small quantity of finishing paint shall be supplied with each consignment of the panels to enable the Employer's store at site any finish which may get damaged during the transshipment. The panel boards may alternatively be given a plastic durable covering coat for protection of the finish during the transshipment, which shall be capable of being peeled off after installation.

2.8 TERMINAL BLOCK CONNECTION

Terminal Block connectors built from cells of moulded dielectric and brass stud inserts shall be provided for terminating the outgoing ends of the cubicle wiring and the corresponding incoming tail ends of the control cables. All the terminal connectors shall have de-link (disconnecting) facilities.

Provision shall be made on each pillar for holding 20% extra connection (10% incoming + 10% outgoing). All blocks shall be shrouded by easily removable shroud molded of transparent dielectric materials. The terminal blocks shall be suitable for 660 volts service and connection with both aluminum and copper cable.

2.9 SPACE FOR CONTROL CABLES AND CABLE GLANDS

Sufficient space for receiving the control cables inside the board at the bottom of the cubicles and mounting arrangement for the terminal cable glands shall be provided. The specification does not cover supply of control cables and cable glands for which the employer will make separate arrangement.

2.10 SPACE HEATERS

60 W. 240 V. 50 HZ tubular space heaters with thermostat auto suitable for connection to the single phase AC supply complete with on-off switches located at convenient positions shall be provided at the bottom of the switch board cubicle to prevent condensation of moisture. The watt loss per unit surface of heater shall be low enough to keep surface temperature well below sensible heat.

2.11 DISTRIBUTION AND CONTROL OF AUXILIARY POWER CIRCUIT

2.11.1 D.C. CIRCUIT

There shall be separate D.C. incomers for the each control and relay board panel fed from D.C. distribution boards through a suitable fuse switch unit, provided there. M.C.B.s. of required Amps rating shall be provided in the panel as D.C. incomer (source I one number and source II one number). A continuous D.C. bus shall be provided in the control and relay board panel and D.C. supply for control, protection, supervision and indication of circuit breaker and other equipments shall be teed off in each panel from D.C. bus through a set of HRC Fuse (both on +ve and -ve side) D.C. supply to individual panel thus teed off shall be distributed within the panel as below.

2.11.2 SWITCHES & FUSES:

Each panel shall be provided with necessary arrangement for receiving, distributing and isolating of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with fuses. The selection of the main and sub circuit fuses rating shall be such as to ensure selective clearance of sub-circuit faults. Voltage transformer circuits for relaying and metering shall be protected by fuses. All fuses shall be HRC cartridge type conforming to IS: 3703 mounted on plug in type fuse bases. The short time fuse rating of fuses shall be not less than 9 KA. Fuse carrier base shall have imprints of the fuse rating and voltage.

A D.C. operated no-volt, auxiliary relay provided with hand reset reverse flag and two set of self reset N/C contracts with test push button shall be provided in the operating circuit of each control and relay panel to supervise the breaker control supply. One N/C contact shall be used for visual alarm and the other N/C contact shall be used for audible alarm and shall be connected to the alarm bus of the annunciation scheme.

A.D.C. operated no-voltage auxiliary relay provided with hand reset reserve flag indicator and two sets of self reset N/C contacts with test push button shall be provided in the main alarm bus to supervise the alarm but supply. One N/C contact shall be used for visual alarm and the other for audible alarm. The visual and audible alarm of alarm bus fail and those of incoming D.C. bus fail shall be common and shall be operated by 240 V single phase A.C. auxiliary supply as described in the Specification.

(** DC sources supervision relays are to be mounted in the panel)

2.12 A.C. CIRCUIT

240 volts, single phase, A.C. auxiliary supply to the control and relay board will be fed from A.C. distribution board through a suitable fuse switch provided thereof. A continuous A.C. bus shall be provided at the control and relay board where from A.C. supply to each panel shall be teed off through a set of links. One 16 Amp rated M.C.B. shall be provided at the control and relay board for the incoming A.C. supply. A set of fuse and link rated for 6 amps for 3 pin plug circuit, 6 amps for 2 pin ply circuit and 6 amps for heater and illuminating lamp circuits shall also be provided. A hand reset type no-volt auxiliary relay rated for 240 volts A.C. and provided for monitoring the auxiliary A.C. supply from D.C. operated facial annunciation scheme.

2.13 MCB's

The incoming DC supply sources (source I and source II) circuits in the control and relay panels shall be controlled by required Two pole DC MCB's. In each control and relay panel there shall be separate DC MCB as incoming to the panels and the sub circuits shall be controlled by HRC fuses of different circuits having both "+" ve and "-" ve control. The incoming MCB's also followed by HRC fuses for better protection. The ratings of the MCB's are to be designed to take care of the continuous rating and also during short ckt or in the event of faults. For AC incoming circuits and other distributed circuits circuits also to be provided with MCB of proper ratings.

2.14 MIMIC DIAGRAMS

10 mm. wide, 2mm thick colour mimic diagrams and symbols showing the exact representation of the system shall be provided in the front of control panel. The mimic strips shall be made with anodized aluminum materials, which shall be screwed on to the panel and can be easily cleaned. The colour code of such aluminium strips are as given in the following table. Upper bus and lower bus of the mimic shall represent the main bus and transfer bus of the station respectively. Central line of the upper bus mimic shall be at a distance of 695 mm from the top of the panel and center to center distance between the bus mimic shall be 610 mm.

When semaphore indicators are used for equipment position they shall be so mounted in the mimic that the equipment close position shall complete the continuity of the mimic.

Indicating lamp, one for each phase, for each bus shall be provided on the mimic to indicate bus charged condition.

TABLE
COLOUR SCHEME FOR MIMIC DIAGRAMS

Equipment	Colour	I.S. Code No.(IS.5)
400 KV	Orange	
220KV/. 132KV	Signal Red	537
33 KV	Brilliant Green	414
415/250V	Black	221
Earth	White	309
110 V	Canary Yellow	-

Automatic semaphore indicators shall be provided for isolators and earth switch position indication and incorporated in the mimic diagram

2.15 DISCREPANCY TYPE CONTROL SWITCHES.

Control switches for circuit breakers shall be incorporated in the mimic diagram to represent the relevant circuit breakers as also the sequence of the mimic diagram. The switches shall be provided with a built-in two lamp. The switches shall have maintained contact positions for 'ON' and 'OFF' positions respectively and two momentary contact positions for 'ON' and 'OFF' impulse.

2.15.1 The switches shall be provided with a notching mechanism which should accurately limit the angles of actuation. A strong restoring spring is to be provided to return the switch mechanism automatically from the momentary contact position to the maintained contact position. Such control springs shall be strong enough to prevent any inadvertent operation due to light touch or some other different arrangement should be provided to prevent any inadvertent operation. Such springs shall not be used as current carrying parts in these switches. The rating of the switch contacts shall be suitable for the duty imposed by the circuit breaker closing mechanism and shall conform to the recommendations to be given by the circuit breakers manufacturers. The built-in-pilot lamp of the control switch shall give a steady light when the position of the control switch corresponds to the position of the associated circuit breaker. A flickering light shall be given by the same lamp when due to hand operation or due to automatic tripping of the breaker, the position of the control switch does not coincide with that of the corresponding circuit breaker. The arrangement to provide the flickering voltage for the above purpose shall be made. In order to avoid continuous burning of the aforesaid built-in lamps associated with the control switches under steady state condition, the said lamps shall be connected through a switch. The circuit should be such that irrespective of the position of the aforesaid switch, winking of the lamp shall not be affected by change in respective control switch position. The winking of the control switch pilot lamp shall be followed by an alarm annunciation after a preset time adjustable between 0-10 secs. Switches complete with accessories for the above function shall be supplied.

2.16 INDICATING LAMPS

5/7 Watt Indicating cluster LED type Lamps shall be provided on the control panel mounting with rear terminal connections. Lamps shall be provided with series connected resistor preferably built in the lamp assembly. Lamps shall have translucent lamp covers to diffuse lights coloured red,green,amber,clear white or blue as specified as per the following:

Function	Quantity	Colour of lens
1. Circuit Breaker spring charged/normal pressure indication.	1 No.	Blue
2. Circuit Breaker trip circuit	2 Nos.	White

	healthy indication.		
3.	Circuit Breaker Low Air Pressure indication	1 No.(where necessary)	White
4.	Incoming D.C. fail indication.	2 Nos.	White
5.	A. C. fail indication.	1 No.	White
6.	P. T. supply indication.	3 Nos.(where necessary)	Red/Yellow/Blue.
7.	Indication lamps for CB closing ,opening Isolator closing and opening		Red and Green
8.	Auto trip	1 No.	Amber
9.	Protection on Transfer Mode	1 No.	White
10.	CB on Local/Remote	2 Nos	White

All the indicating lamps under (1) and (2) shall be provided with push button control. All the lamps shall be connected to the auxiliary D.C. supply of the sub-station except Sl.No 4 and Sl. No.6 which should be connected to the auxiliary A.C. supply and P.T. secondary supply. The lamps shall be suitable for switch board purpose and shall be of low watt consumption. Lamp and lenses shall be interchangeable and easily replaceable from the front of the panel. Tools if required for replacing the bulbs and lenses shall also be included in the scope of supply. The indicating lamps with resistors shall withstand 120% of rated voltage on a continuous basis. In initial supply, 20% of the lamps actually used on the switch boards and 10% of the lamp covers used shall be supplied in excess to serve as spares.

2.17 TEST BLOCKS

Switchboard type, back connected, test blocks with contacts shall be provided with links or other devices for shorting terminals of C.T. leads before interrupting testing instruments in the circuit without causing open circuit of the C.T. The potential testing studs shall preferably be housed in narrow recesses of the, block molding insulation to prevent accidental short-circuit across the studs. All Test Blocks for meters, relays, etc. shall be placed as close to the respective equipment as possible.

2.18 NAME PLATES & MARKING OF IDENTITY

All equipments, instruments, relays and such other similar electrical devices mounted on the front and rear side as well as mounted inside control and relay panels shall be provided with name plates bearing the manufacturer's name, serial number and the electrical rating data.

All front mounted equipment shall also be provided at the rear with individual name plates engraved with tag numbers corresponding to the one shown in the panel internal wiring to facilitate easy tracing of the wiring.

Each equipment and meter shall be prominently marked with the quantity measured e.g. KV,A,MW,MVAR, etc. All relays and other devices shall be clearly marked with manufacturers name,type,sl No & electrical rating.

Name plates shall be made out of non-rusting metal or 3 ply lamicaid. Name plate shall be black with white engraving lettering.

Each switch shall bear clear inscription identifying its function e.g. "BREAKER" '52A', "SYNCHRONISING" etc. Similar inscription shall also be provided on each device whose

function is not otherwise identified. Switches also have clear inscription for each position indicating e.g. "TRIP-NEUTRAL-CLOSE", "ON-OFF", "R-Y-B-OFF" etc.

All panel shall be provided with name plate mounted inside the panel bearing LOA NO. & Date, Name of the sub-station & Feeder and reference drawing number.

2.19 SAFETY EARTHING FOR THE PANEL

All panels shall be equipped with an earth bus securely fixed. Location of earth bus shall ensure no radiation interference for earth system under various switching conditions of isolators and breakers. The materials and size of the bus shall be at least 25X6 sq.mm perforated copper threaded holes at gap of 50mm with a provision of bolts and nuts for connection with cable armours and mounted equipment etc for effective earthing. When several panels are mounted adjoining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply. Provision shall be made for extending the earth bus bars to future adjoining panels on either side.

Provision shall be made on each bus bar of the end panels for connecting substation earth grid. Necessary clamps and connectors shall be included in the scope of contract.

All metallic case of the relays, instruments and other panel mounted equipment including gland plate shall be connected to the earth bus by copper wires of size not less than 2.5 sq mm. The colour code of earthing shall be green.

Looping of earth connections which would result in loss of earth connections to other devices when loop is broken shall not be permitted. However looping of earth connections between equipment to provide alternative path to earth bus shall be provided.

VT and CT secondary neutral or common lead shall be earthed at one place only at the terminal blocks where they enter the panel. Such earthing shall be made through links so that earthing may be removed from one group without disturbing the continuity of earthing system for other groups.

2.20 PANEL BOARD LIGHTING

The panel interior (both control panel and relay panel) shall be illuminated by 20W, CFL tube light connected to 240 V. single phase A.C. The illumination of the interior shall be free from hand shadows and shall be planned to avoid any strain or fatigue to the fireman likely to be caused due to subnormal or non-uniform illumination. One emergency D.C. light (CFL type) shall also be provided for each relay panel with individual switch, with proper identification mark.

A door operated button switch shall be provided for control of the A.C. lighting for all the control and relay panel interiors.

One 5 amps. two pin socket and one 15 amps. 3 pin power socket outlets together with plugs shall be provided at convenient points in the panel board for A.C. supply.

2.21 ANNUNCIATOR

Each control and relay panel shall be provided with **microprocessor based** annunciator(s) facial on the front of the control panel for projecting mal-operation in the system equipment due to fault. The annunciation board shall be of the switch board type, back connected suitable for semi-flush mounting provided with dust tight cases. The single relays shall be suitable for tropical use. The alarm concealing visual signal resetting and annunciation testing buttons shall be mounted on the front of each control panel at convenient height, preferably under the annunciation board.

- a) One part of the annunciation shall comprise of one electrical D.C. operated bell and one D.C. operated hooter for trip and non-trip alarm mounted inside or on top of the switch board cubicle on vibration absorbent mountings. A suitable hand reset relay device shall be employed in the suitable hand reset relay device shall be employed in the suitable alarm circuit to permit manual cancellation of the audible alarm in token of its acceptance by an operator before rectification of the abnormality. The wiring shall be such that a single set of bell and alarm cancellation relay will be sufficient and serve in commons with all the alarm actuating devices.
- b) The other part of the annunciator shall discriminate and sort out the cause of alarm and project visual alarm signals by tokens of telephone type flush lamps illumined windows on facial plate. There shall be an independent token for each abnormal condition announced and the wiring of all the tokens shall be so done that each token will operate independently of the other without causing any maloperation on the enunciator. A reset device, manually operated by an operator, shall be provided for each column of the visual alarms to enable the operator to cancel each visual alarm at will after removal of the discrepancy or abnormal condition. Suitable testing device shall be provided on each enunciator to be assembled for routine checking of enunciator alarm and indication. The enunciator shall be suitable for operation across the D.C. supply voltage of the sub-station. Momentary closing of fault contacts shall also cause operation of enunciator system as above and shall require canceling and resetting operations by the operator to silence the bell and reset the enunciator window.
- c) Minimum of 4 Nos spare windows each for trip and non trip are to be provided in each annunciator

2.22 INCOMING D.C. FAIL ALARM SCHEME

Control and Relay Board shall have a common “Incoming D.C. Fail” alarm scheme operated by 240 V single phase A.C. auxiliary supply for audible as well as visual alarm in case of failure of D.C. incoming supply to the board.

All auxiliary relays, test relays, canceling, resetting and testing push buttons, alarm bells etc. required to render the annunciation system operative as above shall be considered to be within the scope of the tender.

Separate scheme for each source of DC supply shall be considered.

2.23 INCOMING A.C FAIL ALARM SCHEME

Control and Relay Board shall have a common “Incoming A.C. Fail” alarm scheme operated by 240 V D.C. auxiliary supply for audible as well as visual alarm in case of failure of A.C. incoming supply to the board.

3.0 INDICATING INSTRUMENTS AND METERS

3.1 All electrical indicating instruments shall be of digital Type suitable for flush mounting

3.2 Instruments shall have 4- digit display, display height being not less than 25 mm.

3.3 Instrument shall conform to relevant IS and shall have an accuracy class of 1.0 or better. For energy meters it should be of minimum 0.2. watt and VAR meters shall have an indication of (+) and (-) to indicate EXPORT and INPORT respectively

3.4 Digital voltage and frequency meters shall be of class 0.5 and shall have digital display of 5 and 4 digits respectively, with display size, not less than 25 mm height.

3.5 All instrument shall be switchboard type, back connected suitable for flush mounting and provided with dust tight cases for tropical use with dull black enamel finish.

3.6 All fixing screws, nuts and treated parts shall be designed to Indian Standards.

3.7 All instruments shall have a practicable laboratory means of adjustment of accuracy. The limits of error shall be those permissible for industrial grade instruments of switch board type. The calibration of the instruments shall function satisfactorily when mounted on steel panels or alternatively magnetically shielded instruments shall be used.

3.8 Instruments shall be capable of indicating freely when operated continuously at any temperature from 0 to 50 deg. C.

3.9 All circuits of instruments shall be capable of withstanding the effect of shock vibration and humidity and a dielectric test of 2500 volts r.m.s to ground for one minute as per relevant BSS/ISS

4.0 NON-TARIFF ENERGY METERS

- a) Export/Import KWH and KVARH meters for 33KV , 132 KV , 220 KV & 400 KV KV. Line shall be supplied by the Bidder. Necessary cut-out, wiring and 3 element Test Terminal Block are to be supplied by the bidder as specified in the Schedule of requirement of control panel. Export/Import meters for non-tariff use shall be of the commercial grade accuracy i.e 0.2 Class, and shall be of 3 element type and suitable for 3-phase, 3–wire connection.
- b) One 3 element type KWH meter with M.D.I. for each 33 KV. 132 KV,220 KV. Transformer panel shall also be provided and shall be connected preferably on H.V. side.
- c) One Trivector metre of solid state type with KWH, KVAH, KVARH with MDI is to be provided both for 33 KV. 132 KV,220 KV control panel.

4.1 MW INDICATOR

In all the 33KV, 132 KV,220,400 KV lines and transformer feeders, indicating MW meters with M.D.I. (three) element type shall be mounted on the front side of the control panels to indicate the instantaneous MW flowing. The MW meters shall be connected to the measuring C.T. core. Scale range for line feeders shall be 200-0-200 MW and for transformer feeders 0-150 MW or as suitable for the proposed system.

4.2 MVAR INDICATOR

In all the 400 KV,220KV. 132 KV line feeders indicating MVAR meters shall be mounted on the front side of the control panel to indicate the instantaneous MVAR following through the feeder in either direction. The scale should be center zero. The MVAR meters shall be connected to the measuring C.T. core. The scale shall be 200-0-200 MVAR or as suitable for the proposed system

5.0 Relays

General Requirements

- 5.1 All electro mechanical relays (auxiliary and tripping relays shall conform to the requirements of IS:3231/ICE-60255 and all Main numerical relays shall confirm to ICE-61850 and other applicable standards for future SCADA purpose. Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear.

- 5.2 All protective relays shall be in draw out or plug-in type/modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied loose and shall be included in contractor's scope of supply.
- 5.3 All AC operated relays shall be suitable for operation at 50 Hz AC Voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for 1 Amp CT secondary. All DC operated relays and timers shall be designed for the DC voltage specified, and shall operate satisfactorily between 80% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.
- 5.4 The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of; protective relays and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. also required for the complete protection schemes described in the specification shall be provided. All protective relays shall be provided with at least two pairs of potential free isolated output contacts. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme, contacts shall be silver faced with spring action. Relays case shall have adequate number of terminals for making potential free external connections to the relays coils and contacts, including spare contacts.
- 5.5 All protective relays, auxiliary relays and timers except the lock out relays and interlocking relays specified shall be provided with self-rest type4 contacts. All protective relays and timers shall be provided with externally hand reset positive action operation indicators with inscription. All protective relays which do not have built-in-hand-reset operation indicators shall have additional auxiliary relays with operating indicators (Flag relays) for this purpose. Similarly, separate operating indicator (auxiliary relays) shall also be provided in the trip circuits of protections located outside the board such as Buchholtz relays, oil and winding temperature protection, sudden pressure devices, Oil surge relay and fire protection etc.
- 5.6 Timers shall be of the electromagnetic or solid state type. Pneumatic timers are not acceptable. Short time delays in terms of milliseconds may be obtained by using copper slugs on auxiliary relays. In such case it shall be ensured that the continuous rating of the relay is not affected. Time delays in terms of milliseconds obtained by the external capacitor resistor combination is not preferred and shall be avoided to the extend possible.
- 5.7 No control relays which shall trip the power circuit breaker when the relays is de-energised shall be employed in the circuits.
- 5.8 Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.
- 5.9 Auxiliary seal-in-units provided on the protective relays shall preferably be of shunt reinforcement type. If series relays are used the following shall be strictly ensured.
 - a. The operating time of the series seal-in-unit shall be sufficiently shorter than that of the trip coil or trip relay in series with which it operates to ensure definite operation of the flag indicator of the relay.
 - b. Seal-in-unit shall obtain adequate current for operation when one or more relays operate simultaneously.
 - c. Impedance of the seal-in-unit shall be small enough to permit satisfactory operation of the trip coil on trip relays when the D.C. Supply Voltage is minimum.

- 5.10 All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.
- 5.11 The setting ranges of the relays offered, if different from the ones specified shall also be acceptable if they meet the functional requirements.
- 5.12 Any alternative/additional protections or relays considered necessary for providing complete effective and reliable protection shall also be; offered separately. The acceptance of this alternative/additional equipment shall lie with the OPTCL.
- 5.13 The bidder shall include in his bid a list of installations where the relays quoted have been in satisfactory operation.
- 5.14 All relays and their drawings shall have phase indications as R-Red, Y-yellow, B-blue.
- 5.15 Wherever numerical relays are used, the scope shall include the following:-
- a) Necessary software and hardware to up/down load the data to/from the relay from/to the personal computer installed in the substation. However, the supply of PC is also covered under this clause.
 - b) The relay shall have suitable communication facility for future connectivity to SCADA. The relay shall be capable of supporting IEC 61850 protocol.

6.0 Protection System

Protective system

6.1 Protection discrimination

On the occurrence of a fault on the power system network the high speed discriminating protection systems (main protection) shall rapidly detect the fault and initiate the opening of only those circuit breakers which are necessary to disconnect the faulted electrical element from the network.

Protection equipment associated with adjacent electrical elements may detect the fault, but must be able to discriminate between an external fault and a fault on the electrical element which it is designed to protect. Sequential time delayed tripping is not permitted except in the following specific circumstances:

- Protection for short connections between post current transformer housings and circuit breakers when the technical advantages of complete overlapping of the protection are outweighed by economic considerations, (i.e. short-zone protection)
- Operation of time graded back-up protection takes place as a result of either the complete failure of the communication links associated with the main protection systems, or the fault resistance is substantially greater than a value which can be detected by main protection systems.
- Operation of line back-up protection to disconnect primary system faults in the case of a circuit breaker failing to operate, (i.e. circuit breaker failure protection)

- All back-up protection systems shall be able to discriminate with main protection systems, circuit breaker fail protection and with other back-up protection systems installed elsewhere on the transmission system.

6.2 Protection settings

A list of the settings to be applied to all protection systems together with all associated calculations, shall be provided for review and approval not less than three months prior to the first programmed date for commissioning. The settings for line protection shall be such as to permit correct operation of the protection for earth faults with up to 100 ohms fault resistance. Any limitations imposed on the power system as a result of the settings proposed shall be explicitly stated. In the absence of system data required for calculation purposes, assumptions may be made providing these are clearly identified as such in the relevant calculations.

6.3 Fault clearing time

The protection equipment shall be capable of achieving the following discriminative fault clearing times, inclusive of circuit breaker and signalling times:

- One millisecond for all electrical elements whose boundary connections are defined by circuit breakers located within a given substation.
- For interconnecting tie lines in which the boundary connections of the electrical element being protected are defined by circuit breakers located in adjacent switching stations, an additional 20 ms fault clearance time is allowed at the substation remote from the fault point. This additional fault clearance time is permitted subject to the requirement that the positive sequence impedance of the primary circuit from the switching terminal to the point of fault shall not be less than ten ohms. The Contractor shall supply the Project Manager with details of the operating times under defined conditions of all protection equipment proposed. Any limitation in operating time performance shall be declared by the Contractor, e.g. end of zone faults where distance protection is applied, high resistance faults, faults at high X/R with significant DC component and time constant, faults coincident with communication channel noise. The Contractor shall specify the increase in operating time which could occur under such conditions.

6.4 Signalling equipment operating times:

For design purposes the operating times of signalling equipment to provide a contact signal for use with associated distance protection shall be assumed to be as follows:

- Intertripping (transfer trip) not greater than: 20 milliseconds
- Permissive transfer trip: 15 to 20 milliseconds
- Blocking signal operate time: 10 milliseconds
- Blocking signal reset time: 10 milliseconds

Protection Schemes

6.5 Line protection

General requirement for line protection relays

The line protection relays shall protect the line and clear faults on line in the shortest possible time with reliability, selectivity and full sensitivity to all types of line fault. The general concept for 1) 400kV and 220kV levels is to have primary and back-up protection systems having equal performance requirement especially in respect of time as would be provided by two Main protections called **Main-I** and **Main-II**. It is desirable that Main-I and Main-II protection should work on two different principles of operation and one back up dir O/C & E/F protn is envisaged.

2) For 132 kV level the concept of one main distance protection and one backup directional O/C and E/F protection is envisaged.

3) For 33 kV level, the requirement is that of modular directional O/C and E/F protection.

The protection requirements are summarised below, and illustrated in the single line diagrams in the schedules.

- **400kV and 220kV lines**

- Main I Numerical non switched distance protection meeting performance levels.
- Main II Numerical non switched phase comparison, carrier aided or of numerical distance using a different principle of operation
- Phase segregated teleprotection facility
- Power swing detection blocking and tripping
- Synchronising.
- Line overvoltage (Only for 400kV and 220kV line \geq 200kM long)
- Autoreclosure
- Numerical directional overcurrent and earth fault
- Three phase to ground
- Numerical local breaker back up
- Pole discrepancy protection

6.5.1 Distance Protection Relay (Numerical IEC-61850 Protocol compliance)

The relay shall:

1. Be static and modular in construction
2. Have high speed phase segregated non switched distance relays for three phase systems to clear all type of line faults within the set reach of the relay.
3. Cover at least two line sections with 15% in hand margin.
4. Measure all type of faults without the need to switch the measuring elements to the faulty phase or phases. Zone switching to extend the reach of the measuring elements is not allowed. The reach of each zone shall be independently and individually adjustable and shall have settings in steps of 1%. Memory circuits with defined characteristics shall be provided in all three phases to ensure correct operation during close-up 3 phase faults and other adverse conditions. Independent zero sequence compensation shall be provided for each zone.
5. Have reverse reaching zone operating times as given in Table. The Carrier transmission time has been considered as 20 ms.

6. Have stepped time-distance characteristics and at least two directional and one non-directional independently variable time graded distance protection zones to cover two adjacent line sections.

7. Have a maximum Zone 1 operating time from fault initiation to trip impulse from relay (complete protection time excluding applicable carrier time) under source to line impedance ratios and under all possible combinations of fault with CVT being used on the line (with all filters included) and at 50% of Zone I reach as follows:

- For S.I.R. 0.01 to 4: 30 ms at the nearest end and 50 ms at far end.
- For S.I.R. 4 to 15: 30 ms at the nearest end and 50 ms at far end.

Carrier transmission time is considered as 20 ms. Any reduction in carrier transmission time shall be reflected in the reduction of maximum operating time.

The trip times should not be affected by DC offset and under frequency up to 47Hz.

8. Have a reach for Zones 1,2 and 3 to cover line length as per 3 above. The relay shall have an adjustable characteristic angle setting range of 30 to 75 degree, preferably adjustable dynamically following the load conditions of the power system. It should be ensured that this long coverage is consistent with limitations imposed by heavy loading and sound phase component of fault current. If so characterised by system requirements, it shall be possible to have circular characteristics of offset Mho type & Quadrilateral shaped. If the characteristics of starting relays are such that it cannot pick-up because of very low infeed, under voltage relays may also be used as supplementary relays.

9. Have two independent continuously variable time setting range of 0-3 seconds for Zone 2 and 0-5 seconds for Zone 3.

10. Have a maximum resetting time of less than 35 milliseconds.

11. Have facilities for offset features with adjustment of at least 20% of Zone 3 setting.

12. Have automatic residual compensation capabilities variable from 30-150%.

13. Be such that the setting / reach should not be affected by mutual coupling effect of double circuit line or nearby paralleled circuits. The proof of compensation should be given if provided.

14. Operate instantaneously when circuit breaker is closed to zero volt 3 phase fault.

15. Be suitable for single and three phase tripping.

16. Have a continuous current rating of twice rated current. The voltage circuit shall be capable of continuous operation at 1.2 times rated voltage. The relay shall also be capable of carrying a high short time current of 70 times rated current without damage for a period of one second.

17. Be selective between internal and external faults.

18. Incorporate three separate high speed trip relays for single phase faults and a fourth high speed trip relay for multi phase faults. Each of these shall have adequate contacts to meet the complete scheme requirements. The relay shall conform to the requirements for tripping relays specified in this specification.

19. Include power swing blocking protection which shall:

- be of triple pole type

- have suitable setting range to encircle the distance protection described above.
 - have a continuously adjustable time delay on pick up of setting range 0-2 seconds.
 - block tripping during power swing conditions.
20. Include fuse failure protection which shall:
- monitor all the three fuses of CVT and associated cable against open circuit.
 - inhibit trip circuits on operation and initiate annunciation.
 - have an operating time less than seven milliseconds.
 - remain inoperative for system earth faults.
21. Have integrated two stage over voltage protection facilities.
22. Shall have comprehensive self test feature including diagnostics at power up.
23. Broken conductor detection facility.
24. Distance to fault locator

6.5.2 Distance to fault locator

General

Distance to fault locators shall be the inbuilt features of the distance relay for both Main I and Main II, shall be capable of locating phase to phase and phase to earth faults. They shall also preferably be capable of locating open circuit faults.

1. Have built-in display feature.
2. Display directly in percent of line length or kilometres without the requirement for further calculation.
3. Have an accuracy of 3% or better for all types of faults and fault levels. This level of accuracy should not be impaired under the following conditions:
 - presence of remote end infeed
 - predominant DC component in fault current
 - high fault arc resistance
 - severe CVT transients
4. Have facility for remote data transmission
5. Meet IEC 255 Part IV or other equivalent internationally recognised standard.

1. Have mutual zero sequence compensation unit if fault locator is to be used on double circuit transmission line.

Table 16.3.2 Operating Times for Distance Protection

Operating Time (ms)	SIR = Z_s/Z_L	Fault Position % of Impedance Setting
≤ 20	10	5 to 20
≤ 30	30	10 to 60
≤ 50	60	1 to 95

SIR = System Impedance ratio. Z_s = Source impedance. Z_L = Relay setting impedance

6.5.3 Line over voltage protection relay

The line over voltage protection (59L) relay shall:

1. Monitor all three phases
2. Have two independent (59L1 and 59L2) stages
3. Have an adjustable setting range of 100-170% of rated voltage with an adjustable time delay range of 1 to 60 seconds for the first stage. (59L1)
4. Have an adjustable setting range of 100-170% of rated voltage with an adjustable time having setting range 100-200 seconds for the second stage. (59L2)
5. Be tuned to power frequency
6. Be provided with separate operation indicators (flag target) for each stage relays. (59L1 and 59L2)
7. Have a drop-off to pick-up ratio greater than 95%. Integral of overvoltage feature is also acceptable.

6.5.4 Auto reclosing relay

The auto reclosing relay shall:

1. Have single phase and/or three phase reclosing facilities. (Single /three phase reclosure shall be adapted for 400kV/220kV systems and 3pole trip/ reclosure for 132kV system)
2. Have a continuously variable single phase dead time range of 0.1-2 seconds in steps of 0.1 second.
3. Have a continuously variable three phase, one shot dead time range of 0.1-5 seconds in steps of 0.1 seconds.
4. Have a continuously variable reclaim time range of 5- 50 seconds.
5. Incorporate a four-position selector switch from which single phase/three phase/single and three phase auto reclosure and non-auto reclosure mode can be selected.
6. Have facilities for selecting check synchronising or dead line charging features. It shall be possible at any time to change the required feature by connection of links.
7. Be of single shot type.
8. Include check synchronising relay which shall
 - Have a time setting continuously variable between 0.5-5 seconds.
 - Have a response time within 200 milli seconds with the timer disconnected.
 - Have a phase angle setting not exceeding 35 degree.
 - Have a voltage difference setting not exceeding 10%
9. Include dead line charging Relay which shall
 - Have two sets of relays and each set shall be able to monitor the three phase voltage.
 - Have one set connected to the line CVT's with a fixed setting of 20% of rated voltage.
 - Incorporate necessary auxiliary relays and timers to give comprehensive scheme.

The scheme shall be such as to have Main I and Main II fully segregated such that shutdown and testing on one main protection should not affect the other main protection. The auto reclosure should then be connected to one protection. Integrated auto-reclosure feature as part of both Main I and Main II is also acceptable.

The scheme shall have check synchronous and voltage check interlocks (25, 27). These interlocks are supplementary to all other decision interlocks that may be required or specified in order to ensure correct operation of the scheme.

6.6 Local Breaker Back-up protection relay (50 LBB) for circuit breakers

The local breaker backup protection relay shall:

1. Be of triple pole type
2. Have an operating time of less than 15 milliseconds.
3. Have a resetting time of less than 15 milliseconds.
4. Have three over current elements. Each element shall be arranged to get individual initiation from the corresponding phase of line protection.
5. Be of solid-state type having a setting range of 5-80% of rated current
6. Have a continuous thermal withstand twice the rated current irrespective of the setting.
7. Have three separate timers, one for each phase with continuously adjustable setting range of 0.1-1 seconds.
8. Have necessary auxiliary relays to make a comprehensive scheme.

Protective system

6.7 Unit and backup protection

Power system elements and the network shall be provided with independent high speed discriminative protection systems. Duplicate schemes (Main I and Main II) shall be provided for all 400kV and 220kV systems. For all other systems up to 132kV, the protection equipment shall be divided into 'Main' and 'Backup' systems.

Protection schemes of different philosophy (Main I and Main II or Main and Back-up) shall preferably be fed from different DC supplies when available in the substation. This shall include energisation of trip coil circuits in case of 400 kV and 220 kV breakers. However in case of 132kV system where a duplicate DC source is available, the two trip coils shall be energised from the different sources.

Protection equipment shall not initiate a trip signal following the normal and correct discharge operation of one or more surge arresters.

Measurement functions relays must be achieved through electronic circuits. Auxiliary relays, repeat relays, trip relays and any other simple auxiliary or contact multiplication function may be based on standard attracted armature or other electromechanical techniques.

Relays based on numerical design technique shall constitute all primary protections. The Employers intends to avail the improved benefits in the functionality, design, reliability and cost effectiveness of

integrated substation control systems in future for which relays with numeric design only shall be required. It is the responsibility of the Contractor to demonstrate that all relay equipment offered has a reasonable level of in-service experience. For numerical relays, the following conditions apply :

1. The Bidder must be able to demonstrate that a minimum of 10 relays of each type offered have been in full service without relay failures for a minimum of three years in two different countries, one of which may be the country of manufacture. Experience involving trial installations is not acceptable.
2. The Bidder must include a statement of the number of years of guaranteed manufacturing and parts support which will be provided for the relays offered.
3. The Bidder is be required to state the full firmware version together with the version of relays for which experience records are offered.

For relays which are provided with communication facilities, the communications facility should allow all information which is available locally at the relay front panel to be accessed remotely. It should also be possible to carry out bulk transfer of settings and fault record information using the appropriate PC based software.

6.8 Protection discrimination

On the occurrence of a fault on the power system network the high speed discriminating protection systems (main protection) shall rapidly detect the fault and initiate the opening of only those circuit breakers which are necessary to disconnect the faulted electrical element from the network.

Protection equipment associated with adjacent electrical elements may detect the fault, but must be able to discriminate between an external fault and a fault on the electrical element which it is designed to protect. Sequential time delayed tripping is not permitted except in the following specific circumstances:

- Protection for short connections between post current transformer housings and circuit breakers when the technical advantages of complete overlapping of the protection are outweighed by economic considerations, (i.e. short-zone protection)
- Operation of time graded back-up protection takes place as a result of either the complete failure of the communication links associated with the main protection systems, or the fault resistance is substantially greater than a value which can be detected by main protection systems.
- Operation of line back-up protection to disconnect primary system faults in the case of a circuit breaker failing to operate, (i.e. circuit breaker failure protection)
- All back-up protection systems shall be able to discriminate with main protection systems, circuit breaker fail protection and with other back-up protection systems installed elsewhere on the transmission system.

6.8.1 Codes and Standards

The equipment supplied shall generally comply with the codes and standards indicated in relevant sections of this specification. Additionally the equipment shall also conform the requirements of this specification.

6.8.2 Environmental requirement

The protection, control and metering equipment shall operate satisfactorily under the various atmospheric, mechanical, electrical and environmental conditions as stipulated in the relevant sections of this Specification. The equipment shall conform to EMC Class III.

6.8.3 Future network scada system

At some time in the future the Employer intends to introduce a network SCADA system. All equipment to be installed under this Specification shall be suitable for future remote operation and remote data acquisition.

The limit of responsibility with regard to this contract shall be to provide equipment suitable for future connection to and communication with a SCADA system, either by means of RTU or modem. Neither the RTU nor the modems form part of the scope of this Specification.

The proposed protocol for the SCADA system is IEC 61850 compliance. Equipment necessary to interface the Integrated Substation Control System with the SCADA system are part of the scope of this Specification.

6.8.4 Control and monitoring levels

The substation control and monitoring system shall allow for three levels of man machine interface. The number of levels initially employed will be limited to one i.e. substation levels. Provision shall be made for the future implementation of the second and third level of network control and monitoring from a system control centre via SCADA.

Selection of substation control shall be from the individual equipment basis i.e., from the control panels.

At the station level, control panels should be located in the main control room.

A mimic diagram representing the substation lay-out in single line diagram form should be provided. The mimic board is intended to give operating personnel an overall view of the switchgear state. It shall be made up from the individual circuit control panels mounted side by side. The arrangement should correspond to the primary equipment layout.

Alarm annunciation equipment should be mounted adjacent to the mimic diagram, or form an integral part of the control panel. Operation of an alarm should cause the appropriate window to flash and sound an audible warning. Operation of an accept button will silence the audible warning, steady the flashing window and prepare the annunciation to respond to subsequent initiation. A reset button should be provided to extinguish alarms which have reset.

A lamp test button shall be provided which will initiate steady state illumination of all alarm windows. Trip or protection initiated alarms should have windows distinct from others (e.g. red display instead of white). Control and selector switches should be of approved types complying with accepted standards such as IEC 337. Control switches shall have two independent motions or two handed operation to effect operation. Indicating instruments should be of approved types complying with accepted standards such as IEC 5 1.

6.9 Enclosures

Protection systems shall preferably be accommodated in rack or hinged rack cubicles and be of modular construction with factory assembled and tested wiring. Conventional analogue relays may be mounted on conventional relay panels which must be mounted to allow access to the front and

rear of the panel. Relays mounted on such panels shall be flush mounted. The construction method shall offer the benefits of minimum site construction times and circuit outage requirements. Interconnections shall be identified in accordance with the requirements for dependent local end marking as specified in IEC Publication 391 Sections 3.4.1.a.1 and 5.1.2. The interconnections shall be recorded on an appropriate schedule or diagram.

For modular protection systems, means shall be provided to lock positively each withdrawable module or unit in the “service” position. It shall not be possible to remove any module without first short-circuiting all associated current transformer circuits.

6.10 Operator interface

6.10.1 General

All numerical protection systems shall be provided with an integral local operator interface facility to enable communication with the relay without the use of external equipment. Any facilities provided for connection to an external computer shall be an additional feature to the local operator interface. No exceptions to this requirement shall be accepted.

6.10.2 Identification

Each protection system shall have a unique identifier which is clearly visible. If the protection system is software operated the software reference and issue level shall be identified.

6.10.3 Settings

Each protection system shall provide a means by which the user can easily access the protection system to apply the required settings. This facility shall be secure from inadvertent operation. A display of the selected settings shall be provided on the protection system.

6.10.4 Indications

Each relay or protection scheme shall be provided with an adequate number of indications to ensure that the appropriate faulted phase, zone, etc. can be easily identified after a fault condition. Each indicator shall be visible and capable of being reset without removing the relay cover.

For relays based upon numerical techniques, indication shall be provided for failures detected in the protection relay or communications equipment. The indications provided shall be designed to allow the defective item to be quickly identified. The status of the DC power supplies shall be permanently indicated.

Details of the indication required for specific types of relay are provided in the individual parts of this section of the specification covering particular types of relay.

6.11 Protection system output contacts

All protection systems shall be provided with an adequate number of contacts of suitable rating to carry out the required tripping functions, alarm indications, fault recorder functions and such supplementary signalling functions as may be necessary for initiation of automatic switching control, inter tripping etc. In all cases contacts intended for tripping duty shall be designed such that they cannot inadvertently interrupt trip coil current.

6.12 Testing and isolating facilities

Each functional protection system shall be so arranged that operational and calibration checks can be carried out with the associated primary circuit(s) in service.

Adequate test facilities shall be provided within the protection system to enable the protection and auto-reclosing equipment to be tested from the front of the protection equipment panel with the primary circuit(s) in service. The test points shall be clearly identified and labelled.

Relays based on digital and numerical design techniques shall include supervision facilities which provide a periodic self check of the key elements within the relay and also provide continuous self monitoring of all internal power supplies and microprocessor operation. A defect in any of the self supervision facilities shall not cause maloperation of the protection relay internal self-test facilities and shall give an alarm should an internal fault occur.

Adequate facilities shall be provided, preferably at the front of each protection equipment panel, to isolate all DC and AC incoming and outgoing circuits so that work may be carried out on the equipment with complete safety for personnel and without loss of security in the operation of the switching station. The isolation points shall be clearly identified and labelled. The labels on the isolation points shall either describe the function or be uniquely numbered.

The Contractor shall provide a list of all of the protection and auto-reclose equipment being offered under the contract.

The Contractor shall also provide a list of all of the test and ancillary equipment required for commissioning and routine testing of all protection and auto-reclose equipment.

6.13 Service life and support

The protection systems shall be designed for a service life of at least 15 years, and preferably 20 years, given that normal maintenance in accordance with manufacturers recommendations is carried out during the lifetime of the protection system.

The Contractor shall state the service life of the protection system equipment in relation to that of the main HV plant and apparatus so that Employer can assess the cost of any replacement during the life of the substation.

The Contractor shall state the period for which lifetime support will be provided for the protection system equipment and shall make recommendations for the provision of spare parts.

The Contractor shall supply circuit diagrams for each protection system and the associated tripping system(s). The diagrams shall provide sufficient information to enable fault finding and maintenance to be carried out and shall not consist solely of information used for equipment manufacture.

When the Contractor has been notified of incorrect operation, or failure to operate when required, of any protection system supplied under the contract, the Contractor shall investigate the incident and inform Employer of any such incidents if they result in the necessity to modify the equipment. The Contractor shall also inform Employer of the details of the modifications required to prevent such incidents re-occurring.

The Contractor shall offer a service to enable any faulty item of protection equipment to be rectified or replaced within a stated period of the fault being reported. The Contractor shall state the repair/replacement period.

The Contractor shall, when requested, offer the Employer a maintenance contract for the protection equipment supplied under the contract. The Contractor shall supply details of the cost of the maintenance contract and information on test procedures and test frequencies that would be supplied under the maintenance contract.

The Contractor shall offer training for Employer's personnel in the operation and maintenance of the protection equipment.

6.14 Thermal rating of equipment

Relay equipment intended to perform a current measurement function shall be capable of continuous operation at a current of not less than 2.4 times the nominal rating or twice the setting value, whichever is the more onerous.

Relay equipment intended for use in a normally quiescent mode and having a short time rating - for example, high impedance differential protection - shall be rated in accordance with the intended function and taking account of such inherent protective devices as may be incorporated in the design. The short time rating for all protection relaying schemes shall be 100 times the nominal relay rating for a duration of one second.

Voltage sensitive equipment intended for use on effectively earthed networks shall have a continuous withstand of not less than 1.2 times nominal voltage and a short duration withstand of not less than 1.5 times nominal phase-to-ground voltage for 30 s.

6.15 Insulation

The rated insulation voltage of circuits connected to current transformers of high impedance relays shall be 1000 V. All other circuits shall have an insulation voltage of 2500V.

All open contacts of the protection system shall withstand a voltage of 1000V. The protection system shall comply with the dielectric test requirements of IEC 255-5. The test voltage shall be selected according to the rated insulation voltage of the circuits being tested from Series C of Table 1 of IEC 255-5. The protection system shall comply with the impulse test requirements of IEC 255-5 with test voltage of 5kV.

6.16 Test requirements

6.16.1 General requirements

The Contractor shall supply test results and/or in service operating evidence to confirm compliance with the general and performance requirements as detailed in this Specification.

6.16.2 Pre-commissioning and energisation tests

The Contractor shall submit details of all pre-commissioning and energisation tests to the Project Manager for approval prior to the tests, and shall provide the Project Manager with the opportunity to witness the commissioning tests.

6.16.3 Testing, inspection and test certificates

The Bidder shall enclose with his bid the reports of type and routine tests conducted on similar equipment earlier as a proof of designing and developing similar equipment. Bid documents, furnished without these test reports shall be considered as incomplete and shall be liable for rejection.

All equipment furnished shall conform to the type tests and shall be subject to routine tests in accordance with the requirements stipulated for control and relay panel equipment. The Project Manager reserves the option to call for any or all the type tests to be repeated on the equipment. The Project Manager further reserves the option to intimate the type tests to be carried out on the equipment up to six months after the award of contract. Payments would be made for the type tests actually carried out in accordance with the rates given in the Bid Price Schedule.

The Project Manager will have the right to call for any other tests of reasonable nature to be carried out at the Contractor's premises or at site or in any other place, in addition to the aforesaid type and routine tests, to satisfy that the materials comply with the Specification.

The Contractor shall advise the Project Manager three months in advance of the type tests to be conducted on the finished equipment giving a programme for conducting the tests and shall proceed to test the equipment only after approval of the Project Manager. All type tests shall be performed in presence of Project Manager should he so desire.

The Contractor shall give one months notice of routine tests and inspection to be carried out on the finished equipment. A programme for conducting the tests shall be furnished and the Contractor shall proceed to test the equipment after approval of the Project Manager. The tests shall be witnessed by the Project Manager should he so desire.

All inspections, type tests and routine tests shall be carried out after approval of all the relevant drawings required under the contract.

None of the equipment to be furnished or used in connection with this contract shall be despatched until factory tests are satisfactorily completed. Such factory tests on the equipment shall not however relieve the Contractor from full responsibility for furnishing equipment conforming to the requirements of this contract, nor prejudice any claim right or privilege which the Employer may have because of the use of defective or unsatisfactory equipment. Should the Project Manager waive the rights to inspect and test any equipment, such a waiver shall not relieve the Contractor, in any way, of his obligations under this contract.

Six (6) copies of test reports of successful tests shall be submitted by the Contractor to the Project Manager for approval before shipment of equipment.

For equipment tests for which IEC recommendations or Indian Standards are available, test reports confirming that the equipment has passed the specified type and routine tests shall be furnished for the approval of the Project Manager by the Contractor before shipment of the equipment.

For equipment/tests for which IEC/IS specifications do not exist, the Contractor shall propose a test procedure for the approval of the Project Manager before conducting tests. Test certificates for tests carried out shall be submitted for approval of the Project Manager before shipment of the equipment. Failure of any equipment to meet the requirements of tests carried out at works or at site shall be sufficient cause for rejection of the equipment. Rejection of any equipment will not be held as a valid reason for delay in the completion of the works in accordance with the agreed programme.

The Employer reserves the right to call for field tests on the completely assembled equipment at site. The price for conducting all the type tests in accordance with relevant standards and specifications shall be indicated in Bid Price Schedule and these would be considered for bid evaluation. The break-up price of type tests shall be given in the relevant price schedule for payment purpose only. In case Bidder does not indicate charges for any of the type tests or does not specifically identify any test in the price schedules, it will be assumed that the particular test has been offered free of charge. Further, in case any Bidder indicates that he shall not carry out a particular test, his offer shall be considered incomplete and shall be liable to rejection.

Six (6) copies of all test reports shall be supplied for approval before shipment of equipment. The reports shall indicate clearly the standard values specified for each test, to facilitate checking of the test reports. Fourteen (14) bound copies of test reports shall be submitted along with the equipment after approval of test results.

6.16.4 Soak test

All solid state equipment/system panels shall be subject to the Hot Soak Test as a routine test in accordance with the procedure detailed in the following paragraph.

All solid state equipment shall be burn-in tested for minimum of 120 hours continuously under operational conditions. During the last 48 hours of testing, the ambient temperature of the test chamber shall be 50C. Each panel shall be complete with all associated sub-systems and the same shall be in operation during the above test. During the last 48 hours of the above test, the temperature inside the panel shall be monitored with all the doors closed. The temperature of the panel interior shall not exceed 65C.

6.16.5 Type tests

Impulse voltage withstand test as per Clause 6.1 of IS 8686 (for a test voltage appropriate to Class III as per Clause 3.2 of IS-8686)

High Frequency Disturbance test as per Clause 5.2 of IS 8686 (for a test voltage appropriate to Class III as per Clause 3.2 of IS 8686)

Type tests listed under IEC-Technical Committees recommendation `TEC-57' and functional type tests listed under **CIGRE Study Committee 34** (Protection) Report on simulator, Network analyser or PTL as applicable.

6.16.6 Routine tests

Contact insulation resistance test as per Clause 10.5 of IS-3231.

Insulation withstand capability as per Clause 10.5 of IS-3231 on all AC/DC relays.

7.0 Protection Schemes

7.1 General

The following sections of this specification identify the protection requirements for specific schemes. Drawings showing single line diagrams for each type of circuit are included in this Specification. The arrangements shown on these drawings represent the minimum requirements. Other protection arrangements may be provided but the Bidder must clearly state the reasons for offering supplementary protection schemes.

7.2 Technical requirements

Technical requirements of the protection and auxiliary relays, recorders and meters to be provided as part of the scope are detailed in the following sub clauses.

The setting ranges of the equipment offered, if different from that specified shall be acceptable if they meet the functional requirements. The Bidder shall quote for protection equipment meeting the requirements given in these sub clauses.

The Bidder may also quote alternative or additional protections or relays considered necessary by him for providing an effective and reliable protection scheme. These equipments shall be quoted separately as an alternative or addition to the main offer. The Employer reserves the right to accept or otherwise such equipment.

7.3 400kV Reactor protection

Protection requirement

The 400 kV reactors provided with the lines shall have the following protections.

- Differential protection.
- Restricted earth fault protection.
- Backup impedance protection.

7.3.1 Differential protection relay (87R)

This relay shall :

1. Be triple pole type
2. Have operation time less than 25 milliseconds at five times setting.
3. Be tuned to system frequency.
4. Have three instantaneous high set units to ensure rapid clearance of heavy faults with saturated CT's.
5. Have current setting range of 10 to 40% of 1 Amp.
6. Be Low impedance type.
7. Be stable for all external faults.
8. Be provided with suitable non-linear resistors to limit the peak voltage to 1000 volts.

7.3.2 Restricted earth fault protection relay (64 R)

This relay shall:

1. Be single pole type
2. Be of current/voltage operated high impedance type
3. Have a current setting of 10-40% of 1A and a suitable voltage setting range.
4. Be tuned to system frequency.
5. Be fitted with suitable non-linear resistors to limit the peak voltage to 1000 volts.

7.3.3 Back up impedance protection relay (21 R)

This relay shall:

1. Be triple pole type
 2. Be single step polarised 'mho' distance relay or impedance relay suitable for measuring phase to ground and phase to phase faults.
 3. Have an ohmic setting range of 20-320 ohms and shall be continuously variable.
 4. Have an adjustable characteristic angle of 30 to 80 degree.
 5. Have a definite time delay with a continuously adjustable setting range of 0.2 - 2.0 seconds.
- Shall initiate three phase tripping

7.4 Transformer protection

The following protection shall be provided for all 315MVA 400/220kV and 220/132/33 KV,160 or 100MVA autotransformers(33 kv side is delta winding and is a loaded winding), and 220/33kV and 132/33kV double wound transformers: **All the relay shall be latest numerical version having IEC 61850 protocol compliance**

1. Transformer differential protection (87AT)
2. Over fluxing protection (99AT)
3. Restricted earth fault protection (64AT)
4. Back-up directional over current protection (67/51/50) on HV side
5. Back-up directional earth fault protection (67N/51N/50N) on HV side
6. Back-up directional over current protection (67/51/50) on LV side
7. Back-up directional earth fault protection (67N/51N/50N) on LV side
8. Restricted earth fault protection (64R)
9. Transformer over load protection (51OL)
10. LBB for 400kV, 220kV and 132kV sides.

7.4.1 Transformer differential protection relay (87AT)

This relay shall :

1. Be triple pole type, with faulty phase identification/indication
2. Have an operating time not greater than 30 milliseconds at five times setting.
3. Have three instantaneous high set units to ensure rapid clearance of heavy faults with saturated CT's.
4. Have an adjustable dual slope bias setting range of 10%-50%.
5. Be suitable for rated current of 1A.
6. Have second harmonic and fifth harmonic restraint feature and also be stable under normal over fluxing conditions and inrush of current during charging.
7. Have at least three bias winding per phase.
8. Have an operating current setting adjustable between 10% and 50%
9. Should not require interposing transformers and the relay should correct the vector group difference and CT primary/load current difference.

7.4.2 Over fluxing protection relay (99AT)

This relay shall :

1. Operate on the principle of voltage to frequency ratio and have two settings - for alarm and trip.
2. Have inverse time characteristics, matching with transformer over fluxing withstand capability curve.

3. Provide an independent 'alarm' with the time delay continuously adjustable between 0.1 to 6.0 seconds at values of " v/f " between 100% to 130% of rated values.
4. Have a set of characteristics of various time multiplier settings. The maximum operating time of the relay shall not exceed 3 seconds and 1.5 seconds at " v/f " values of 1.4 and 1.5 times, the rated values, respectively.
5. Have a tripping time governed by " v/f " Vs. time characteristics of the relay.
6. Have an accuracy of operating time better than $\pm 10\%$.
7. Have a resetting ratio of 98% or better.

7.4.3 Restricted earth fault protection relay (64AT)

This relay shall:

1. Be single pole type.
2. Be of current/voltage operated high/low impedance type.
3. Have a current setting range of 10-40% of 1A and a suitable voltage setting range.
4. Be tuned to the system frequency
5. Have suitable non-linear resistor in case required to limit the peak voltage to 1000 Volts.

7.4.4 Transformer overload protection feature

The transformer overload protection shall:

1. Be a single pole type
2. Be a definite time overcurrent type
3. Have two separate sets of overcurrent relay elements, each with continuously adjustable setting range of 50-200% of rated current independently.
4. Have two separately adjustable time delay relays, one for alarm having setting range of 1 to 10.0 seconds, continuously. The second time delay relay should have continuously adjustable setting range of 1.0 to 10.0 minutes for tripping.
5. Have a drop-off/pick-up ratio greater than 95%.

7.4.5 HV /LV side back-up directional over current protection

This relay shall:

1. Be single pole type.
2. Have IDMT characteristics with a definite minimum of three seconds at ten times the setting.
3. Have a variable setting range of 50% to 200% of rated current.
4. Have a characteristic angle of 45 degrees, a directional controlled, low transient over reach, high set instantaneous unit of continuously variable setting range of 500- 2000% of rated current.
5. Provision of highest setting in two stages.

7.4.6 HV/LV side back-up directional earth fault protection

This shall also have identical specification as at clause above excepting that the adjustable setting range shall be 20-80%.

7.5 TEE protection differential relays (87 TT1,87TT2) (applicable for 5 CT scheme)

Where a Tee Protection for a five CT system is provided the following shall be applicable.

7.5.1 First set of differential relays

One set of differential protection relays (87 TT1) shall

1. Be triple pole type.
2. Have an operating time less than 30 milliseconds at five times setting
3. Have three instantaneous high set over current units.
4. Have an adjustable bias setting range of 20% to 50%
5. Be suitable for rated current of 1A.
6. Have three bias windings.
7. Have an operating current setting of 15% or less.

7.5.2 Second set of differential relays.

The second set of Differential relay (87 TT2) shall:

1. Be triple pole type.
2. Have operating time less than 25 milliseconds at five times setting.
3. Be tuned to system frequency
4. Have current setting range of 20 to 80% of 1A.
5. Be voltage operated, high impedance type
6. Be stable for all external faults.
7. Be provided with suitable non linear resistors across the relay to limit the peak voltage to 1000 volts.

7.6 BUS BAR PROTECTION:

Bus bar protection schemes shall be provided for each main and transfer bus of 400 KV and 200 KV provided in the switch yard. This shall constitute main and check features. The overall scheme shall be engineered such that operation of both main and check features connected to the faulty bus shall result in tripping of the same. The scheme shall be provided with necessary expansion capacity and interfaces for adding features when the switch yard is extended in future to its ultimate capacity. The bus bar relay shall be of latest numerical relay having IEC protocol 61850 compliance.

7.6.1 Busbar protection (Latest version numerical having IEC-61850 protocol compliance)

Bus bar protection schemes shall be provided for each main bus of 400kV and 220kV switchyard. The overall scheme shall be engineered so as to ensure that operation of any one out of two schemes connected to main faulty bus shall result in tripping of the same. However in case of transfer bus, where provided, only one busbar protection scheme shall be required.

Each busbar protection scheme shall

1. Be of modular construction and have features of self monitoring facility to ensure maximum availability of scheme. The scheme shall be static/ microprocessor/ Numerical based.
2. Have maximum operating time up to trip impulse to trip relay for all types of faults of 15 milli seconds at 5 times setting value.
3. Operate selectively for each busbar.
4. Give hundred percent security up to 40kA fault level.
5. Incorporate a check feature.
6. Incorporate continuous supervision for CT secondaries against any possible open circuit and if it occurs, shall render the relevant zone of protection inoperative and initiate alarm.
7. Not give false operation during normal load flow in busbars.
8. Incorporate clear zone indication.
9. Be of phase segregated and triple pole type and provide independent zones of protection for each bus (including transfer bus if any). If a bus section is provided then each side of the bus section shall have separate busbar protection scheme.
10. Include individual high speed hand reset tripping relays for each feeder, including future ones.
11. Be of low/medium impedance biased differential type and have operate and restraint characteristics.
12. Be transient free in operation
13. Include continuous DC supplies supervision.
14. Shall include multitap auxiliary CT's for each bay including future bays as per SLD and also include necessary CT switching relays wherever CT switching is involved.
15. Include protection 'in/out' switch for each zone with at least six contacts for each switch.
16. Shall have CT selection incomplete alarm wherever CT switching is involved.
17. Have necessary auxiliary relays to make a comprehensive scheme.

At existing substations busbar scheme with independent zones for each bus will be available. All necessary co-ordination for 'CT' and 'DC' interconnections between existing schemes (panels) and the bays proposed under the scope of this contract shall be fully covered by the bidder. Any auxiliary relays, trip relays, flag relays required to facilitate the operation of bays covered under this contract shall be fully covered in the scope of the bidder.

The Contractor shall offer all equipment to meet the requirements as above to make the scheme full and comprehensive.

7.6.2 Weatherproof relay panels

Where required these panels shall be provided for busbar differential protection. The panels shall include necessary number of electrically reset relays each with at least eight contacts for isolator auxiliary contact multiplication and for changing the CT and DC circuits to relevant zone of protection.

The panel shall be sheet steel enclosed and shall be dust, weather and vermin proof. Sheet steel used shall be at least 3.0 mm thick and properly braced to prevent movement. The enclosures of the panel shall provide a degree of protection of not less than IP55 (as per IS 2147). The constructional requirements shall comply with the relevant section of this Specification.

Two test terminal blocks required for bus coupler bay CT connection shall be supplied and mounted inside the panel of adjacent bay.

The test terminal blocks shall be fully enclosed with removable covers and made of moulded, non-flammable plastic material with boxes and barriers moulded integrally. Such blocks shall have washer and binding screws for external circuit wire connections, a white marking strip for circuit identification and moulded plastic cover. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring. Terminal block shall have shorting, disconnecting and testing facilities for CT circuits.

7.7 Tripping relay (86)

High speed tripping relay shall:

1. Be instantaneous (operating time not to exceed 10 milliseconds).
2. Reset within 20 milliseconds. Not self resetting.
3. Be DC operated
4. Have adequate contacts to meet the requirement of scheme, other functions such as auto-reclose relay, LBB relay as well as cater to associated equipment such as event logger, disturbance recorder, fault locator, etc.
5. Be provided with operation indicators for each element/coil.

7.8 Flag relays

These shall have:

1. Hand reset flag indication
2. Two elements
3. Four contacts (NO or NC or combination as required), for each element/coil.

7.9 Trip circuit supervision relay

The relay shall be capable of monitoring the healthiness of each 'phase' trip coil and associated trip circuit of circuit breaker during 'ON' and 'OFF' conditions. The relay shall have adequate contacts

for providing connections to alarm and event logger. The relay shall have time delay on drop-off of not less than 200 milliseconds and be provided with operation indications for each phase.

7.10 Supply supervision relay

The relay shall be capable of monitoring the DC supply to which it is connected and indicating failure. It shall have adequate potential free contacts to meet the scheme requirement. The relay shall have a `time delay on drop-off` of not less than 100 milliseconds and be provided with operation indicator/flag.

7.11 Bus coupler / transfer bus coupler protection

The protection scheme for the above are to be provided with directional numerical over current and earth fault protection scheme . The relay shall be latest version numerical and IEC 61850 compliant for future SCADA purpose. The details as indicated under unit back up protection relay.

All 220 kV substations shall be of Double Main (DM) or Double Main and Transfer (DMT) busbar configuration and shall be provided with a single bus coupler circuit breaker. In addition 220 kV DMT busbar configurations shall be provided with a transfer bus coupler circuit breaker. The required protection equipment for these breakers comprises overcurrent and earth fault relays. These relays shall comply with the requirements for backup over current and earth fault protection as described elsewhere in this section, except that the relays shall not be directional. The earth fault element shall have a current setting range of at least 20 - 80 per cent in six equal steps.

All 132 and 33 kV substations shall be of Single Main and Transfer (SMT) busbar configuration and a bus section isolator. Overcurrent and earth fault protection, complying with the requirements as given elsewhere in this section but without directional feature, shall be provided.

In DMT/SMT configurations, whenever the main breaker of a feeder or transformer is substituted by the bus coupler or transfer bus coupler breaker, a facility for switching over of the trip function of the feeder or transformer relays from the main breaker to the bus coupler or transfer bus coupler breaker, shall be provided through provision of a lockable protection transfer switch. The provision of a key interlock on the above switch is to be so arranged that at one time only one feeder or transformer can be taken to transfer mode.

7.12 Circuit breaker monitoring auxiliary relays

All circuit breakers shall be provided with several relay contacts for annunciation of circuit breaker conditions such as :

- Low air/hydraulic oil/gas pressure.
- Lockout conditions due to abnormally low air/hydraulic oil/gas pressure.
- Pole discrepancy trip.
- Compressor/hydraulic pump trouble.

The exact requirements for this shall be available in the circuit breaker drawings to be provided by the manufacturer. The programmable Inputs/Outputs of the numeric relays shall be used as much as possible for providing annunciation in the control room for such cases. In case this is found inadequate, suitable auxiliary flag relays may be provided in the relay panels to provide annunciation.

7.13 Disturbance recorder (Required for 400 and 220 KV sub-station)

7.13.1 General

Where required disturbance recorders shall be provided separately. Integrated out put from the relays memory is also acceptable.

Disturbance recorders shall be microprocessor based and shall be used to record the graphic form of instantaneous values of voltage and current in all three phases, open delta voltage and neutral current, open or closed position of relay contacts and breakers during system disturbances. Necessary auxiliary VT's, to generate open delta voltage, shall be supplied by the Bidder. The Bidder shall furnish along with the offer a typical printout for simulated conditions, on original paper.

The disturbance recorder shall be an individual acquisition unit, one for each feeder, and shall have at least 8 analogue and 16 event channels for acquisition of fault data and events. The restitution unit, printer, EGA/VGA screen and key board shall be common for the entire substation. The acquisition unit shall acquire fault data and store either on portable magnetic cassettes or floppy discs, or instantaneously transfer data to the restitution unit for storage in solid state non-volatile memory. The restitution unit shall be capable of reading fault data from the magnetic cassettes or floppy discs or from its own memory, as the case may be, and controlling the printer to give the graphic form whenever desired by the operator. The acquisition units shall be located in the protection panels of the respective feeders and the restitution unit along with the printer shall be located suitably within the substation control room. Only one printer for the entire substation is required for disturbance recording purposes.

The disturbance recorder system shall have non-volatile memory of the last ten faults of at least 1.6 second duration each.

7.13.2 Features of the disturbance recorder.

The disturbance recorder shall incorporate the features as described below:

7.13.3 Software stability

The operation of the equipment shall be based on programme stored in non-volatile solid state memory. The programme shall be stable and no inadvertent change of programme shall occur.

7.13.4 Reliability

Large scale integrated circuits shall be used as far as possible to reduce the number of components and interconnections and the amount of wiring. The components used shall be subjected to strict quality control which shall include screening of components by heat soaking and testing their functioning prior to assembly.

7.13.5 Simplicity of maintenance and repair

The number and type of modules employed shall be minimised. The modules shall be of plug-in type and shall be easily accessible for maintenance and repair wherever required.

7.13.6 Immunity from the effects of hostile environment

The equipment shall be designed to operate satisfactorily even when subject to the effects of severely hostile electrical environment such as interference signals arising from switching transients. The equipment shall be mounted in self contained, free standing cubicles and shall be of dust, vermin and rodent proof construction. Ventilation arrangements shall be provided if warranted by power dissipation level of the equipment.

7.13.7 Interface with PC

The disturbance recorder should have an interface arrangement for the transfer and storage of data to PC through its serial port. Necessary PC, software, special cables etc. shall be part of the disturbance recorder and should be included in the Bid.

PC based user friendly, disturbance recorder evaluation software shall be provided for the analysis and evaluation of the record data made available in the PC under WINDOWS environment. The software features shall include:

- Repositioning of analogue and digital signals
- Selection and amplification of time and amplitude scales of each analogue and digital channel
- Calculation of MAX/MIN frequency and phase difference values
- Recording of MAX/MIN values etc. of analogue channels
- Grouping of signals to be drawn on the same axis etc.,
- Listing and numbering of all analogue and digital channels and current, voltage, frequency and phase difference values at the time of fault/tripping.

7.13.8 Power supply

Disturbance recorder equipment shall be suitable for operation from 220V DC or 110V DC supplies as available at substation. Voltage variation of +10% and -20% can be expected. Any other power supply that may be required for proper functioning of the equipment including the printer shall be derived by the Bidder from his own equipment and shall form an integral part of the disturbance recorder system.

7.13.9 Alarms and indications

All external and internal faults in the disturbance recorder equipment such as power supply fail, printer faulty, paper exhausted, processor/memory fail etc. are required to be indicated by means of light emitting diodes on the front of panels of the equipment if type 2 disturbance recorders are offered, or on the front of panel of the restitution unit if type 1 disturbance recorders are offered.

7.13.10 Scan rate

The frequency response shall be DC on lower side and 250 Hz or better on upper side. The acquisition unit shall have a scan rate of 1000 Hz/channel or better.

The equipment shall have as an inherent part of it, starting sensors based on over voltage, rate of change of current, and rate of change of frequency. These starting sensors, when picked up, shall

start the disturbance recorders to give out the graphic form of analogue and event signals, in the case of type 2 disturbance recorders. If type 1 disturbance recorders are offered the starting sensors, on pick up, shall preserve the fault data acquired during the period of system disturbance, including pre-fault and post fault time, on magnetic cassettes, floppy disks, CD or solid state memory of restitution unit, as the case may be. Preserved fault data shall not be erased other than by the operator. Erasing arrangement shall be provided in the restitution unit.

7.13.11 Starting sensors

The equipment shall have inherent to it starting sensors based on over voltage, rate of change of current and rate of change of frequency. The starting sensors on pick-up shall preserve the fault data acquired during the period of system disturbance including pre-fault and post fault time on magnetic cassettes, CD or floppy diskettes or solid state restitution unit as the case may be.

7.13.12 Pre-fault and post-fault time

Pre-fault time shall not be less than 160 ms and the post fault time adjustable at a minimum of two seconds and a maximum of not less than five seconds. If another system disturbance occurs during one post-fault time, the recorder shall also be able to record the same.

7.13.13 Amplitude and event resolution

Amplitude resolution shall not be less than eight bit. Event resolution shall be 2 ms or better.

7.13.14 Print out

The print out shall contain the following:

1. Feeder identity.
2. Date and time (in hour, minute and second up to 100th of a second).
3. Identity of trigger source.
4. Graphic form of analogue and event signals of all the channels.

The print out shall be clear and legible without the help of looking glass or any such device. Minimum acceptable paper width shall be 8-1/2 inches. (216 mm approx.)

7.13.15 Type and quantity of paper

Printer shall use plain paper. The Bidder shall provide as part of his scope of supply sufficient consumable for 6 months operation. The arrangement of feeding and removing paper rolls shall be quick and simple.

7.13.16 Time generator

Each disturbance recorder shall have its own time generator. The facility shall exist to synchronise the time generator from station time synchronisation equipment having output of following types at 30 min interval

1. Voltage signal - 3 to 50V continuously settable, with 50 ms minimum pulse duration.

2. Potential free contact (Minimum pulse duration of 50 ms.)

3. IRIG-B

4. RS232C

At substations where station time synchronisation equipment is not available, time generator of any one of the disturbance recorders can be taken as master. The facility shall exist to synchronise the time generators of other disturbance recorders and event loggers in that station with respect to it. The recorder shall give annunciation in case of absence of 'Sync'. pulse within a specified time. The clock of the time generator shall be such that, the drift is limited to ± 0.5 seconds per day, if allowed to run without synchronisation. Facility shall exist to display the time in hours, minutes and seconds on the front of panel.

7.13.17 Inputs

The equipment shall be suitable for inputs from current transformers with 1A rated secondary and capacitive voltage transformers with 63.5V (phase to neutral voltage) rated secondary. Any device required for processing of input signals in order to make them compatible to the equipment shall form an integral part of the equipment. However, such processing of input signals shall in no way distort its wave form. The equipment shall be carefully screened, shielded, earthed and protected as may be required for its safe functioning. The input circuits shall withstand the following tests.

- 5kV impulse test in accordance with IEC 225 Part-IV.
- High frequency disturbance test in accordance with IEC 255 Part-IV).

8.0 Event logger ()**

**As per the customers requirement

All 400 and 220 KV sub-station shall have separate Event Logger panel provision.

8.1 General

The event logger shall be used to record the open and close states of switch yard equipment, relays and changes of alarms.

The function of the equipment should be based on programmes stored in it. The stored programmes should permit some degree of flexibility of operation. Facility should be provided to erase the existing programme and reprogram allowing changes to be made very easily.

The number of modules and different types of modules should be minimised. The modules should be of plug-in type and should be easily accessible to simplify maintenance and repair.

The equipment should be designed to operate satisfactorily in severely hostile electrical environment such as in 400kV/220kV switchyard which are prone to various interference signals, typically from large switching transients.

The equipment should be carefully screened, shielded, earthed and protected.

Input/ Output circuits should withstand the following tests:

- Impulse test in accordance with IEC 255, Part-IV.
- High frequency disturbance test in accordance with IEC 255, Part-IV.

Since the equipment will be used in dedicated non-attended situations, programme stability is vitally important. Programme must not be capable of being changed unintentionally during normal operation.

8.2 Construction

The equipment should be constructed in clearly defined plug-in modules. A monitor module should be provided for indicating internal faults such as processor failure, memory failure, other internal hardware failures, and also external plant failures. These failures should be displayed on the LED's mounted on the monitor module. The equipment is used to record changes in digital points, i.e. operations and resetting of alarms and switching of primary equipment within a substation. Approximately 500 points should be accommodated in a single equipment. When such changes occur, a print out on a local teletype writer, which forms a part of this contract, should result.

The date and time should be printed to the nearest 10 ms followed by a message describing the point which has operated. Such messages may be abbreviated or in full English forms. Events occurring whilst a previous event is in process of being printed are to be stored to await printing. Over 100 such events must be stored. Facility shall exist to synchronise the internal clock system which will give a pulse output every half an hour with a pulse duration of at least 50 milliseconds through potential free contacts. However, if master clock system is not available, time generator of any one of the disturbance recorder shall be taken as master and event logger(s) in that station will be synchronised with it. The event logger shall give annunciation in case of absence of synchronising pulse within a specified time window. The internal clock of the event logger shall be such that the drift is limited to ± 0.5 seconds per day, if allowed to run without time synchronisation. The print out of current alarm and plant stages must be available on request by the operator. The operator should also be able to enter the date and time from the key board.

8.3 Technical requirements

The event recorder shall record all changes of alarms and plant states of switchyard equipment, along with the date and time of all alarms and plant state changes to the nearest 10 ms.

Facility shall be provided to commit 50 points of sequential memory or 25% of alarm whichever is the greater. In addition the unit shall be capable of handling up to 40 changes in any one 10 ms interval and 500 alarms and changes of state of switchyard equipment.

On receipt of an alarm the equipment must:

- Print out a message on Printer
- Set off an audible alarm.
- Set off a beacon.

Allow normal inputs of

- Accept
- Alarm demand log
- Plant state demand log
- Date and time

The Bidder shall furnish along with the offer a two copies on original paper typical print out for simulated conditions.

Only plain paper readily available in India shall be used for the printer. The arrangement of feeding and removing paper rolls or stacks shall be quick and simple. The width of paper shall be 216 mm approximately. The Bidder shall provide as part of his scope of supply, consumables for up to six months operation.

Event printout of the shall contain as a minimum the following:

- Station identification.
- Date and time (in hour, minutes, seconds and milliseconds).
- Event number.
- Event description (at least 40 characters).

The auxiliary power supply required for the event logger, VDU and printer shall be either 220V DC or 110V DC (as available in the station) with voltage variation of + 10% to -20%. Any other power supply that may be required for proper functioning of the equipment has to be derived by the Bidder from his own equipment which shall form an integral part of the event logger station.

Bidder shall supply VDU, printer and keyboard arrangement.

At existing substations where an event logger is provided, Bidder shall provide necessary potential free contacts of various relays/equipment for plant and alarm states and shall co-ordinate with existing event logger for proper logging of events.

A combined solution of disturbance recorder and event logger function with a VDU, key board and a printer is also acceptable.

9.0 Synchronising equipment

Where required synchronising equipment shall be provided along with this Contract.

The synchronising instruments shall be mounted on a synchronising trolley. The trolley shall be equipped with double voltmeter, double frequency meter, synchroscope and lamps fully wired. The trolley shall be of mobile type with four rubber padding wheels capable of rotating in 360 degree around the vertical axis. Suitable bumpers with rubber padding shall be provided around the trolley to prevent any accidental damage to any panel in the control room while the trolley is in movement.

The trolley shall have two metre long flexible cord fully wired to the instruments and terminated in a plug in order to facilitate connecting the trolley to any of the panels. The receptacle to accept the plug shall be provided on the panel.

Synchronising check relay with necessary ancillary equipment shall be provided. This shall permit breakers to close after checking the requirements of synchronising of incoming and running supply.

The phase angle setting shall not exceed 35 degree and have voltage difference setting not exceeding 10%. This relay shall have a response time of less than 200 milliseconds when the two system conditions are met within present limits and with the timer disconnected. The relay shall have a frequency difference setting not exceeding 0.45% at rated value and at the minimum time setting. The relay shall have a continuously adjustable time setting range of 0.5-3 seconds. A guard relay shall be provided to prevent a closing attempt by means of synchronising check relay when control switch is kept in closed position before the two systems are in synchronism.

Suitable auxiliary voltage transformers, wherever necessary, shall also be provided for synchronising condition. In case the synchroscope is not continuously rated, a synchroscope cut-off switch shall be provided and an indicating lamp to indicate that the synchroscope is energised, shall also be provided.

Each circuit for which a synchronous closure is required shall be provided with a lockable synchronising selector switch which shall be used to select the voltage signals (incoming and running voltage) appropriate for that circuit. The provision of a key interlock shall ensure that at any one time only one feeder / transformer can be synchronised.

10.0 Time synchronisation equipment for substation

The Bidder shall offer necessary time synchronisation equipment complete in all respects including antenna, all cables, processing equipment etc. required to receive co-ordinated universal time (UTC), transmitted through GEO Positioning Satellite System (GPS).

The time synchronising system should be compatible for synchronisation with event loggers, disturbance recorders, relays, computer systems and all other equipment provided in the protection, control and metering system of the substation wherever required.

Equipment should operate up to an ambient temperature of 50C and 100% humidity. The synchronisation equipment shall have two microsecond accuracy. Equipment should give real time corresponding to IST (taking into consideration all factors such as voltage and temperature variations, propagation and processing delays etc.

Equipment should meet the requirement of IEC 255 for storage and operation. The system should be able to track the satellites to ensure no interruption of synchronisation signal.

The output signal from each port shall be programmable at site for either one hour, half hour, minute or second pulse, as per requirement.

The equipment offered shall have six output ports. Various combinations of output ports shall be selected by the Project Manager, during detailed engineering, from the following:

1. Voltage signal : 0-5V continuously settable, with 50 ms. minimum pulse duration.
2. Potential free contact : minimum pulse duration of 50 ms
3. IRIG-B & SNTP
4. RS232C

The equipment should have a periodic time correction facility of one second periodicity.

Time synchronisation equipment shall be suitable for operation from 220V DC as available at substation with a voltage variation of +10% and -20%. Any other power supply that may be required for proper functioning of the equipment shall be derived by the Bidder from his own equipment which shall form an integral part of the system.

Equipment shall have real time digital display in hour, minute, second (24 hour mode) and have a separate time display unit to be mounted on the top of control panels having display size of approximately 100 mm height.

Bidder shall quote unit rates for each type of output port for the purpose of addition/deletion.

Schedule of Quantities

11.0 General

Protection, control, metering panels and associated equipment to be located in switchyard control rooms at various substations shall be offered as panels/systems/modules of following description. The quantities are given at the end of this section.

Sl. No.	Description of Panels	Control Panel type and designation	Relay Panels type and designation
1	Line protection panel:		
1.1	400kV line-4CT,5CT (1 ½ breaker scheme)	CPF4H	RPF4H
1.2	220kV line-DMT	CPF2D	RPF2D

1.3	132kV line—MT	CPF1M	RPF1M
1.4	33kV line—MT	CPF0M	RPF0M
2	Transformer protection panel:		
2.1	400/220kV Auto-Transformer	CPH4H	RPH4H
		CPL2D	RPL2D
2.2	220/132kV Auto-Transformer	CPH2D	RPH2D
		CPL1M	RPL1M
2.3	220/33kV power Transformer	CPH2D	RPH2D
		CPL0M	RPL0M
2.4	132/33kV power Transformer	CPH1M	RPH1M
		CPL0M	RPL0M
3	Reactor protection panel:		
3.1	Bus reactor	CPR4H	RPR4H
3.2	Line reactor	CPS4H	RPS4H
4.1	Transfer bus coupler		
	220kV line-DMT	CPT2D	RPT2D
	220kV line-T	CPT2T	RPT2T
4.2	Bus coupler		
	220kV line-DMT	CPB2D	RPB2D
	132kV line—MT	CPB1M	RPB1M
	33kV line—MT	CPB0M	RPB0M
4.5	Bus sectionaliser	CPZ2D	RPZ2D

11.1 Type designations for the various panels

The panels are designated by a alpha-numeric code consisting of five characters (AAANA) through out this schedule in this specification to represent their use for various applications. Their representation shall be as here under:

Character position	1	2	3	4	5
Character representation	A	A	A	N	A

H					1½ breaker scheme
D					Double main and transfer switching scheme
M					Main and transfer switching scheme
S					Single bus
T					Two mains bus switching scheme
R					Ring main bus switching scheme
0					33kV
1					132kV
2					220kV
4					400kV
F					Feeder
H					Transformer High Voltage Side
L					Transformer Low Voltage Side
R					Bus reactor
S					Shunt(line) reactor
T					Transfer bus coupler
B					Bus coupler and Bus bar
Z					Bus sectionaliser
C					Capacitor bank protection
V					Bus bar
M					Diameter with Transformer and Feeder
N					Diameter with Feeder and Feeder
O					Diameter with Feeder and Feeder
P					1/2 Diameter with Single Feeder
Q					1/2 Diameter with Single Feeder with Reactor
CP					Control panel
RP					Relay panel
KP					Common panel

11.2 Bill of quantities for individual panels

Each panel described above shall constitute the equipment as detailed here under . The quantities of each type of equipment are minimum. The bidder may include additional devices in the panels depending upon the design and requirements as per stipulations of the specification.

Control panel (CPANA)

Sl. no	List of equipment	CPA4H / CPA2H	CPA2D / CPA1M / CPA2T	CPA1M / CPA0S / CPA0T
		Quantities required for each panel		
		For 400kV / 220kV and 1½ breaker scheme	For 220kV and 132kV	For 33kV
1.	Ammeter (Digital)	3 Nos. for each bay (1 for each	1No. (2 Nos. for Bus	1No.

		bay in case of 220 kV) + 1No. for reactor (as per requirement)	section coupler)	
2 .	Wattmeter (Digital)	1 No. for each bay	1 No. (2 Nos. for Bus section coupler)	1 No.
3 .	VARmeter (Digital)	1 No. for each bay + 1 No. for line reactor (as per requirement)	1 No. (2 Nos. for Bus section coupler)	1 No.
4 .	Voltmeter (Digital)	1 No. for each bay	1 No. for each bay	1 No. (only in bus coupler panel)
5 .	Digital voltmeter with selector switch	1 set for new substation in any one specific control panel	1 set for new substation in bus coupler panel	Not required
6 .	Digital frequency meter	1 set in any one specific control panel	1 set in bus coupler panel	1 set in bus coupler panel
7 .	Solid state trivector type energy meter for recording export, import of MWH, MVA and MVARH with MDI.	NOT REQD	NOT REQD	NOT REQD
8 .	Winding temperature indicator	Not required	Not required	Not required
9 .	Discrepancy control switch for breaker	1No. for each circuit breaker	1No. for each circuit breaker	1 No. for each circuit breaker
10 .	Discrepancy control for isolator	1No. for each isolator	1No. for each isolator	1No. for each isolator
11 .	Discrepancy control for earth switch	one for each earth switch	one for each earth switch	one for each earth switch
12 .	Mimic to represent SLD	one for each panel	one for each panel	one for each panel
13 .	Ammeter selector switch	one for line reactor (as per requirement)	one for each panel	one for each panel

14.	Voltage selector switch	one for each bay	one for each bay	one for each volt meter (only in buscoupler Bay)
15.	DC source selector switch	one for each panel	one for each panel	one for each panel
16.	Indicating lamps			
16.1.	Red indicating lamps for ON	one for each isolator, earth switch and circuit breaker	one for each isolator, earth switch and circuit breaker	one for each isolator, earth switch and circuit breaker
16.2.	Green indicating lamps for OFF	one for each isolator, earth switch and circuit breaker	one for each isolator, earth switch and circuit breaker	one for each isolator, earth switch and circuit breaker
16.3.	White indicating lamp for circuit breaker healthy	one for each circuit breaker	one for each circuit breaker	one for each circuit breaker
16.4.	Indicating bulb for circuit breaker control position (Local/Remote) (If required)	two for each circuit breaker	two for each circuit breaker	two for each circuit breaker
16.5.	Blue indicating lamp (for spring charge)	one for each circuit breaker	one for each circuit breaker	one for each circuit breaker
16.6.	for annutiation D.C. fail	one in any one specific control panel	one in bus coupler pannel	one in buscoupler pannel
16.7.	for Annunciation A.C. fail	one in any one specific control panel	one in buscoupler pannel	one in buscoupler pannel
16.8.	for flasher healthy	one in any one specific control pannel	one in buscoupler pannel	one in buscoupler pannel
16.9.	for Busbar VT secondary healthy	three for each bus in any one specific control panel	three for each bus in buscoupler pannel	three for each bus in buscoupler pannel
17.	Push buttons			

17.1.	for alarm accept	one for each panel	one for each panel	one for each panel
17.2.	for alarm reset	one for each panel	one for each panel	one for each panel
17.3.	for lamp test	one for each panel	one for each panel	one for each panel
17.4.	for audio alarm reset	one in any one specific control panel	one in buscoupler panel	one in buscoupler panel
17.5.	for annunciation D.C. fail accept	one in any one specific control panel	one in buscoupler panel	one in buscoupler panel
17.6.	for annunciation D.C. fail test	one in any one specific control panel	one in buscoupler panel	one in buscoupler panel
17.7.	for annunciation A.C. fail accept	one in any one specific control panel	one in buscoupler panel	one in buscoupler panel
17.8.	for annunciation A.C. fail test	one in any one specific control panel	one in buscoupler panel	one in buscoupler panel
18.	Annunciation windows with necessary annunciation relays	24 for each feeders bay 24 for each treansformer bay 24 for each Tie	24 for each feeders panel 24 for each transformer panel 24 for each Tie and each bus coupler panel	18 for each feeders panel 18 for each transformer panel 18 for each bus coupler panel
19.	Synchronising socket	one for each circuit breaker	one for each circuit breaker	Not required
20.	Bus CVT selector switch (as per requirment)	one for each panel	one for each panel	one for each panel
21.	Protection trip transfer switch (TTS)	not required	one for each panel	one for each panel
22.	Reactor de-interlocking push button	one for each circuit breaker bay (where applicale)	not required	not required
23.	Hooter	one for each new sub-station	one for each new sub-station	one for each new sub-station
24.	Buzzer	one for each	one for each new	one for each

		new sub-station	sub-station	new sub-station
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11.3 Line protection panel (RPLNA)

The line protection panel or panels may be a single panel or more panels to accommodate all the equipments listed below. However, for bay extension, new panels must match the existing panels in all respect.

Sl. No	Equipment	Quantities required			
		400kV RPL3H	220kV RPL2 A	132kV RPL1 A	33kV RPL0A
1	Main-I protection scheme (composite numerical distance protection relay with auto reclosing and check synchronising facility)	1 set	1 set	1 set	Not required
2	Main-II protection scheme(composite numerical distance protection or phase comparison relay with auto reclosing and check synchronising facility)	1 set	1 set	Not required	Not required
3	Composite numerical directional over current and earth fault relay.(selectable Features Dir & Non Dir)	1 set	1 set	1 set	1 set
4	Over voltage/ Under voltage protection scheme (if not available in the main-I protection module)	1 set	1 set	1 set	Not required
5	Selector switch for carrier in/out for main-I and main-II protection scheme	2 Nos.	2 Nos.	1No.	Not required
7	Disturbance recorder (if not available in the distance protection or main protection module)	1 set	1 set	1 set	Not required
8	Distant-to-fault locator for phase and earth faults(if not available in the distance protection or main protection module)	1 set	1 set	1 set	Not required
9	CVT selecting relays or switches (depending on switching scheme)	1 set	1set	1set	Not required
10	Test terminal blocks for Main-I/ Main II/other protection relay	1 set for each module	1 set for each module	1 set for each module	1 set for each module
11	Auxiliary relays for carrier supervision of Main-I and Main II	1 set	1 set	1 set	Not required

	protection relays (depending on its application)				
12	Carrier receive lockout relay (depending on its application)	1 set	1 set	1 set	Not required
13	Breaker failure protection scheme	1 set	1 set	1 set	1 set
14	Trip circuit pre and post supervision relays for trip coil I and II	1 set	1 set	1 set	1 set
15	DC supply supervision relay	1 set	1 set	1 set	1 set
16	Flag relays for circuit breaker trouble shooting	1 set	1 set	1 set	1 set
17	Trip relays single/three phase for group-A	1 set	1 set	1 set	1 set
18	Trip relays single/three phase for group-B	1 set	1 set	1 set	1 set
19	Trip relays single/three phase for LBB	1 set	1 set	1 set	1 set
20	Under Frequency Relay			1 set	1 set

11.4 Transformer protection panel(RPHNA and RPLNA)

The transformer protection panel or panels may be a single panel or more panels to accommodate all the equipments listed below. However, for bay extension, new panels must match the existing panels in all respect.

Sl. No	Equipment	Quantities required		
		For each High Voltage panel of 400/220kV and 220/132kV transformers	For each High Voltage panel of 220/33kV and 132/33kV transformers	For each Low Voltage Panel of transformers
1	Main-I Transformer composite numerical protection comprising of the following: <ul style="list-style-type: none"> Differential protection Restricted earth fault protection Over fluxing protection 	1 set	1 set	Not required
2	Main-II Duplicated numerical protection as Main-I	1 set	Not required	Not required
3	Composite numerical directional over current and earth fault protection relay(selectable Features Dir & Non Dir)	1 set	1 set	1 set

4	Over load protection (if not included in sl.no. 1 and 2 above)	1 set	1 set	1 set
5	Over voltage/ Under voltage protection scheme (if not available in the main protection module)	1 set	1 set	Not required
6	Flag relays for thermal imaging, MOG, WTI, OTI, Bucholz, PRV,OSR and status indication etc.. (1.MOG-AI,2.WTI,BUCH,OTI – AI & Trip,3. PRV,OSR – Trip)	1 set	1 set	Not required
7	Solid state trivector type energy meters for measurement of export/ import of MWH, MVA and MVARH with MDI.	1 set	1 set	1 set
8	CVT/PT selection relays (depending upon the the switching scheme of the system)	1 set	1 set	1 set
9	Breaker failure protection scheme	1 set	1 set	1 set
10	Trip circuit pre and post supervision relays for trip coil I and II.	1 set	1 set	1 set
11	DC supply supervision relay	1 No for each panel	1 set	1 set
12	Flag relays for circuit breaker trouble shooting	1 set	1 set	1 set
13	Trip relays three phase for group-A	1 set	1 set	1 set
14	Trip relays three phase for group-B	1 set	1 set	1 set
15	Test terminal blocks for all protection relays	1 set for each module	1 set for each module	1 set for each module

11.5 Transfer bus coupler (RPT2D) / Bus coupler and Busbar (RPBNA) protection panel

Bus bar protection panel shall be equipped to accommodate all present and future bays.

Sl. No	Equipment	Quantities required			
		RPB4H	RPB2A	RPB1A/ RPB0A	RPT2D
1.	Composite numerical Directional Over current and earth fault protection (selectable Features Dir & Non Dir)	1 set	1 set	1 set	1 set
2.	Test terminal block for all	1 set for	1 set for	1 set for	1 set for

	protection relays	each module	each module	each module	each module
3.	Trip circuit pre and post supervision relays for trip coil I and II	Not required	1 set	1 set	1 set
4.	DC supply supervision relay	Not required	1 set	1 set	1 set
5.	Flag relays for circuit breaker trouble and status indication etc.	Not required	1 set	1 set	1 set
6.	Breaker failure protection scheme	Not required	1 set	1 set	1 set
7.	Trip relays single/three phase for group-A	Not required	1 set	1 set	1 set
8.	Trip relays single/three phase for group-B	Not required	1 set	1 set	1 set
9.	Bus bar differential relay for Bus-I	1 set	1 set	Not required	Not required
10.	Bus bar differential relay for Bus-II	1 set	1 set	Not required	Not required
11.	CT switching/selection relays(if required)	1 set	1 set	Not required	Not required
12.	Bus bar differential relay for Check Zone	1set	1set	Not required	Not required

At existing substations, necessary trip relays and auxiliary relays required shall be included in the offer to accommodate the new bays for existing bus bar protection schemes.

11.6 Common equipment (RPKNA)

Sl. No	Equipment	Quantities required
1.	Bus-I voltage recorder	1 No.
2.	Bus-II voltage recorder	1 No.
3.	Bus-I frequency recorder	1 No.
4.	Bus-II frequency recorder	1 No.
5.	Bus-I & Bus-II Digital Volt meter	1 Set
6.	Bus-I & Bus-II Digital Frequency meter	1 Set
7.	Event logger(Separate panel)	1 No.

11.7 Bus sectionalizer protection panel

Sl. No	Equipment	Quantities required
1.	Composite numerical directional Over current and earth fault protection relay(selectable Features Dir & Non Dir)	2 sets
2.	Test terminal block for all protection relays	1 set
3.	Trip circuit pre and post supervision relay for trip coil I and II	2 No
4.	DC supply supervision relay	1 No
5.	Flag relays for circuit breaker trouble and status indication etc.	2 No
6.	Breaker failure protection scheme	2 set
7.	Trip relays three phase for group-A	2 set
8.	Trip relays three phase for group-B	2 set
9.	Bus bar differential relay for Bus-I (numerical type- IEC -61850)	1 set
10.	Bus bar differential relay for Bus-II (numerical type- IEC -61850)	1 set
11.	CT switching/selection relays	1 set
12.	Bus bar differential relay for Check Zone (numerical type- IEC -61850)	1set

11.8 Synchronising panel

Synchronisation panels are required for new substations and addition of new voltage (132kV and above) to existing substation.

Sl. No	Equipment	Quantities required
1	Double Voltmeter (0-150v range)	1 no for each panel
2	Double Frequency meter (45-55Hz)	1 no for each panel
3	Synchroscope	1 no for each panel
4	Synchronising relay	1 set for each panel

**** ALL THE RELAYS SHALL BE OF NUMERICAL VERSION HAVING IEC 61850 PROTOCOL COMPLIANCE.ALL CARE SHALL BE TAKEN IN DESIGNING THE PROTECTION SYSTEM FOR FUTURE SCADA PROVISION. THERE SHALL BE ADEQUATE NO OF INPUT AND OUT PUT CONTACTS FOR USE. SHALL HAVE SELF**

**SUPERVISING AND INTERNAL FAULT DETECTING/DIAGNOSING FACILITY.
SUFFICIENT FAULT /DISTURBANCE RECORDING FACILITIES.**

12.0 ERECTION AND MAINTENANCE TOOL EQUIPMENT:

All special testing equipment required for the installation and maintenance of the apparatus, instruments devices shall be furnished. The testing plug shall be supplied along with the panels for conducting testing of relays. These testing plug should be suitable for test terminal box provided in the panel.

12.1 TROPICALISATION:

Control room will be normally air-conditioned. All equipments shall however be suitable for installation in a tropical monsoon area having hot, humid climate and dry and dusty seasons with ambient conditions specified in the specification. All control wiring, equipment and accessories shall be protected against fungus growth, condensation, vermin and other harmful effects due to tropical environment.

12.2 RELAY TEST KIT

One relay test kit shall comprise of the following equipment as detailed hereunder.

1. Relay tools kits: 3 Sets
2. Test plugs: 2 Nos
3. Special type test plugs for using with modular type cases(if applicable): 1 No

**13.0 ADDITIONAL INFORMATION ON PROTECTION RELAYS,
SWITCHES ETC.**

13.1 RELAYS:

1. All relays shall conform to the requirements of IS: 3231/IEC-60255 and IEC-61850 protocol compliance. Relay shall be suitable for flush or semi-flush mounting on the front with connections from the rear.
2. Shall be draw out or plug in type/modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied, which is in the scope of this contract.
3. The protective relay shall be suitable for efficient and reliable operation of the protection scheme as indicated in the specification. Necessary auxiliary relays etc for interlocking scheme, for multiplying contacts suiting for the scheme and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme, contacts shall be silver faced with spring action. It shall have adequate numbers of terminals for making potential free external connection to the relay coils and contacts, including spare contacts. All the contacts of the auxiliary relays and timers except lock out type relays shall have self reset type contacts
4. No control relay which shall trip the power circuit breaker when the relay is deenergised shall be employed in the circuit.
5. Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.
6. All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.

7. The bidder shall include in his bid a list of installations where the relays quoted have been in satisfactory operation.

8. The numerical relays shall include the followings:

i) Necessary software and hardware to up/down load the data's to/from the relay from/to the personal computer (supply is in the scope of this contract.).

ii) The relay shall have suitable communication facilities for future connectivity to SCADA. The relay shall be capable of supporting IEC 870-5-103 protocol. Neither the interface hardware nor the software for connectivity to SCADA will form part of the scope of this specification.

iii) In the numerical relays the features like disturbance recorder and event logging function as available in these relays shall be supplied.

13.2 A) Transmission Line protection:

The line protection relays are required to protect the line and clear the faults on line within shortest possible time with reliability, selectivity and full sensitivity to all type of faults on lines.

1. The maximum fault current could be as high as 40 KA and minimum fault current could be as low as 20% of rated current of the CT secondary. The starting and measuring relay characteristics should be satisfactory under these extremely varying conditions.

2. The protective relays shall be suitable for use with capacitor voltage transformer having non-electronic damping and transient response as per IEC.

3. Disturbance recorder, Distance to fault locator, over voltage, auto reclose functions are integral functional part of the relay.

4. The following protection for line protection shall be provided.

13.3 For 400 KV & 220 KV

Main – I Numerical distance protection scheme.

Main – II Numerical distance protection scheme of a make different from that of Main – I.

Back up: Directional Over current and Earth fault protection.

For 132 KV.

Main- Numerical distance protection scheme.

Back up: Directional over current and Earth fault protection.

13.4 MAIN-I & MAIN-II:

1. Shall be numerical type and shall be continuous self monitoring and diagnostic feature.

2. Shall be non-switched type with separate measurements for all phase to Phase & phase to ground faults.

3. Shall have stepped time distance characteristics and a minimum of three independent zones & a zone for reverse reach..

4. Shall have mho & quadrilateral (with site selection facilities) characteristics or other suitable characteristics for the above mentioned zones.

5. Shall have following maximum operating time (including trip relay time, if any) under given set of conditions and with CVT being used on line (with all filters included)

13.4.1	For 400,220 KV	400KV	220KV
Source to Impedance ratio:	4	15	
Relay setting (ohms)	10/20	22	
Fault locations (as % of Relay settings)	50	50	
Fault resistance (ohms)	0	0	
Maximum operating time	40ms	45ms for Phase faults	
	For all faults	60ms for all other faults	

13.4.2 For 132 KV line:

Data's as indicated for 200 KV line

Shall remain same except maximum

Operating time: 5ms relaxation in the above timings

6. Relay shall have independent setting of "R" and "X" and also an adjustable relay characteristic angle having setting range from 30 -75 degree.
7. Shall have independent continuously variable time settings from 0 to 5 seconds.
8. Shall have resetting time of less than 55 milliseconds (including the reset time of the trip relays)
9. Shall have offset features with adjustable 10 – 20% of zone setting.
10. Shall have variable residual compensation.
11. Shall have memory circuits with defined characteristics in all three phases to ensure correct operation during close up 3-phase faults and other adverse conditions and shall operate instantaneously when circuit breaker is closed to zero volts three phase fault.
12. Shall have week end in-feed features.
13. Shall be suitable for single and three phase tripping.
14. Shall have a continuous current rating of two times of rated current. The voltage circuits shall be capable of operation at 1.2 times rated voltage. The relay shall have the capability to carry a short circuit current of 70 times the rated current without damage for 1second.
15. Shall be provided with necessary self reset type trip duty contacts for completion of the scheme.(a minimum number of such contacts shall be 4 per phase). The making capacity of the contacts shall be 30 amps for 0.2 seconds with an inductive load of L/R>10ms.
16. Shall have permissive under reach/over reach/blocking communication mode.
17. Shall have sufficient number of potential free contacts for carrier aided tripping, Auto reclosing, Event logger, Disturbance recorder & Data acquisition system.
18. Shall have power swing blocking protection (i) suitable setting range to encircle the distance protection (ii) block tripping during power swing conditions.

19. Include fuse failure protection (i) monitor all three fuses of CVT and associated cable against open circuit(ii) inhibit trip circuits on operation and initiate annunciation(iii)have an operating time less than 7ms(iv)remain inoperative for system earth faults.
20. Shall have directional back up Inverse Definite minimum Time earth fault relay with normal inverse characteristics as per IEC 60255-3 as a built in feature.
21. Shall have broken wire features having option for tripping/ annunciation.

13.5 BACK UP DIRECTIONAL O/C & E/F PROTECTION SCHEME.

1. Shall have three over current and one earth fault elements.
2. Shall be numerical type.
3. Shall have suitable VT fuse failure for relay alarm purpose.

O/C features:

4. Shall have IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting.
5. Shall have variable setting range up to 200% of rated current.
6. Shall have relay characteristic angle of 30/45 deg lead.
7. LED indications for different type faults.

E/F features:

8. Shall have IDMT characteristics with a definite minimum time of 3.0 seconds at 10 times setting.
9. Shall have variable setting range up to 80% of rated current.
10. Shall have characteristic angle of 45/60 deg lag.
11. LED indications for all type of faults
12. Include necessary separate interposing voltage transformers or have internal features in the relay for open delta voltage to the relay.
13. Shall have continuous self monitoring and diagnostic feature.

13.6 AUTO RECLOSING RELAY:

1. Shall have single phase and three phase reclosing facilities.
2. Shall have continuously variable single phase dead time range of 0.1 – 2 sec
3. Shall have continuously variable reclaim time range 5 – 25 sec.
4. Shall have provision of selection with single phase//three phase//single and three phase auto reclosure and non auto reclosure mode (can be selected through programming).
5. Shall have provision of selecting check synchronizing or dead line charging.
6. Shall be single shot type.
7. Shall have priority circuit to closing of both circuit breakers incase one and half breaker arrangements to allow sequential closing of breakers.
8. Include check synchronizing relay which shall
 - I) Have a time setting variable from 0.5 – 5 sec with a facility of additional 10 sec.
 - II) Have a response time within 200 ms with the timer disconnected.
 - III) Have a phase angle setting not exceeding 35 deg.

- IV) Have voltage difference setting not exceeding 10%
- V) Include dead line charging relay.

13.7 TRANSFORMER PROTECTION:

Transformer differential protection scheme shall be of numerical relay.

1. Shall be triple pole type with faulty phase identification/indication.
2. Shall have an operating time not greater than 30ms at 5 times the rated current.
3. Shall have three instantaneous high set over current units.
4. Shall have an adjustable bias setting range of 10 – 50%.
5. Suitable for rated 1 amp current.
6. Shall have 2nd harmonics or other inrush proof features and also should be stable under normal over fluxing conditions. Magnetising inrush proof features shall not be achieved any intentional time delay.
7. Shall have an operating current setting of 15% or less.
8. Shall have an internal feature of the relays to take care of the angle and ratio correction.
9. Shall have provision of self monitoring and diagnostic feature.
10. Shall have provision of recording features to record graphic from of instantaneous values during faults and disturbances for the pre and post fault period and during running conditions.
11. Current in all the windings in separate analog channels and voltage in one channel. The disturbance recorder shall have the facility to record the following external digital channel signals apart from the digital signals pertaining to differential relay.
 - a) REF protection operated.
 - b) HV breaker status (suitable for 1&1/2 breaker system also)
 - c) IV & LV breaker status.
 - d) Bucholtz /OLTC Bucholtz /PRV alarm/trip.
 - e) WTI/OTI alarm/trip
 - f) MOG alarm

Necessary hardware and software for automatic up-loading the data captured by disturbance recorder to the personal computer.

12. Shall have built in features of definite time over load protection (alarm) relay.
 - a) Shall be single pole type.
 - b) Shall have definite time O/C.
 - c) Shall have one set of O/C relay element, with continuously adjustable setting up to 200%(50% -200%) of rated current.
 - d) Shall have adjustable time delay alarm having setting range of 1 to 10.0 sec continuously.
 - e) Shall have a drop-off/pick-up ratio greater than 95%
13. Shall have feature of REF protection for three winding transformers.
 - a) Shall have current setting (continuously variable) range from 10%- 40% of 1 Amp.
 - b) Shall be tuned to the system frequency.

- c) Shall have provision of for limiting the peak voltage (>1000Volts) during fault condition.
14. Shall be numerical type and shall have continuous self monitoring and diagnostic feature.

13.8 OVER FLUXING PROTECTION:

1. Shall be latest version numerical relay.
2. Shall have the principle of voltage to frequency ratio and shall be phase to phase connected.
3. Shall have inverse time characteristics, matching with transformer over fluxing withstand capability curve.
4. Provide an independent alarm with the time delay continuously adjustable between 0.1 to 6.0 seconds at values of v/f, from 100% to 130% of rated values.
5. Shall have tripping time to be governed by v/f Vs time characteristics of the relay.
6. Shall have a set of characteristics for various time multiplier settings. The maximum operating time of the relay shall not exceed 3 seconds and 1.5 seconds at v/f values of 1.4 and 1.5 times, the rated values, respectively.
7. Shall have resetting ratio of 95% or better.
8. Shall be numerical type and shall have continuous self monitoring and diagnostic feature.
9. Shall have fault recording feature.

13.9 LOCAL BREAKER BACKUP PROTECTION SCHEME:

1. Shall have triple pole type.
2. Shall be of numerical type and shall have continuous self monitoring and diagnostic feature.
3. Shall have an operating time of less than 15ms
4. Shall have resetting time of less than 15ms.
5. Shall have three over current elements.
6. Shall be arranged to get individual initiation from the corresponding phase of main protections of line for each over current element.
7. Shall have setting range of 20-80% of rated current.
8. Shall have continuous thermal withstand two times rated current irrespective of the setting.
9. Shall have a timer with continuously adjustable setting range of 0.1 – 1 sec.
10. Shall have necessary auxiliary relays to make a comprehensive scheme.

13.10 TRIPPING RELAY:

1. High speed tripping relay.
2. Instantaneous operation(time not to exceed 10ms)
3. Reset within 20ms
4. Shall be DC operated.

5. Shall have adequate contacts to meet the requirement of scheme, other functions like auto-reclose relay, LBB relay as well as cater to associated equipment like event logger, disturbance recorder, fault locator etc.
6. Shall have provision of operation indicators for each element/coil.

13.11 TRIP CIRCUIT SUPERVISION RELAY:

1. The relay shall be capable of monitoring the healthiness of each “phase” trip coil and associated circuit of circuit breaker during ON and OFF conditions.
2. Shall have adequate contacts for providing connection to alarm and event logger.
3. Shall have time delay on-drop-off of not less than 200ms and be provided with operation for each phase.

13.12 DC SUPERVISION RELAY:

1. Shall be capable of monitoring the failure of DC supply to which it is connected.
2. Shall have adequate potential free contacts to meet the scheme requirement.
3. Shall have a time delay drop-off of not less than 100ms and be provided with operational indicator/flag.

13.13 SWITCHES:

1. Control and instrument switches shall be rotary operated type with escutcheon plates clearly marked to show operating position and circuit designation plates and suitable for flush mounting with only switch front plate and operating handle projecting out.
2. The selection of operating handles for the different types of switches shall be as follows.

<u>Purpose</u>	<u>Type</u>
Breaker, Isolator control switches	Discrepancy type
Synchronising switches	Oval, Black, keyed handle (having common key for a group of switches)
Synchronising selector switch	Oval or knob, black
Instrument switches	Round, knurled, black
Protection transfer switch	Pistol grip, lockable & black

**** In case the rotary switches are provided for breaker and isolator control Semaphores are also to be provided along with the switches.**

3. The control switch of breaker and isolator shall be of spring return to neutral type. The switch shall have spring return from close and trip position to “after close” and “after trip” position respectively.

4. Instrument selection switches shall be of maintained contact (stay put) type. Ammeter selection switches shall have make before break type contacts so as to prevent open circuiting of CT secondary when changing the position of the switch. Voltmeter transfer switch for AC shall be suitable for reading all line to line and line to neutral voltage for non effectively earthed systems and for reading all line to line voltages for effectively earthed systems.

5. Synchronising switches shall be of maintained contact (stay put) type having a common removable handle for a group of switches. The handle shall be removable only in the off position and it shall be coordinated to fit into all the synchronizing switches. These shall be arranged to connect the synchronizing equipment when turned to the “on” position. One contact of each switch shall be connected in the closing circuit of the respective breaker so that the breaker cannot be closed until the switch is turned to the ON position.

6. Lockable type switches which can be locked in particular position shall be provided when specified. The key locks shall be fitted on the operating handles.

7. The contacts of all the switches shall preferably open and close with snap action to minimizing the arcing. Contacts of switches shall be spring assisted and contact faces shall be with rivets of pure silver or silver alloy Springs shall not be used as current carrying parts.

8. The contact combination and their operation shall be such as to give completeness to the interlock and function of the scheme.

9. The contact rating of the switches shall be as follows.

Description	Contact Rating In Amperes		
	220 V DC	50 V DC	230 V AC
Make & carry continuously	10	10	
Make & carry for 0.5 sec	30	30	30
Break for			
i) Resistive load	3	20	7
ii) Inductive load (L/R=40ms)	0.2	-	-

13.14 INDICATING INSTRUMENTS, RECORDERS & TRANSDUCERS:

All instruments, meters, recorders and transducers shall be enclosed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. All megawatt, megavar, bus voltage and frequency indicating instruments shall be provided with individual transducers and these shall be calibrated along with the transducers to read directly the primary quantities. They shall be accurately adjusted and calibrated at works and shall have means of calibration check and adjustment at site. The supplier shall submit calibration certificates at the time of delivery. However no separate transducers are envisaged for digital bus voltmeters and digital frequency meters and the indicating meters provided in the synchronizing equipment.

13.14.1 Indicating Instruments:

1. All electrical indicating instruments shall be of digital type suitable for flush mounting.

2. Shall have 4 digit display, display height being not less than 25mm.
3. Shall confirm to relevant IS and shall have an accuracy class 1.5 and or better watt and Var meters shall have an indication of (+) and (-) to indicate Export and Import respectively.
4. Digital voltage and frequency meters shall be of 0.5 class and shall have digital display of 5 and 4 digits respectively, with display size not less than 25mm height.

13.14.2 Bus voltage & Frequency recording instruments:

1. Shall be static/digital type frequency and voltage recorder either as individual units or composite unit for total sub-station with time tagged information shall also be applicable if it meets the accuracy of $\pm 1.0\%$ span and full span response time of less than 2 seconds. The static/digital shall also meet the high voltage susceptibility test, impulse voltage with stand test, high frequency disturbance test-class III and fast transient disturbance test level III as per IEC -60255.

13.14.3 Transducers:

1. Transducers shall in general confirm to IEC-688-1
2. Shall be suitable for measurement of active power, reactive power, voltage, current and frequency in three phase four wire unbalanced system.
3. Transducers shall have input from sub-station current and voltage from the instrument transformers. The output shall be in miliampere D.C proportional to the input and shall feed the output current to the indicating instruments /telemetry terminals.
4. Characteristic shall be linier throughout the measuring range.
5. Output shall be load independent.
6. Input and output shall be galvanically isolated.
7. Transducers should work satisfactorily at 120% of rated value continuously.
8. Shall have 4-20mAmp.
9. Response time shall be less than 1 sec.
10. Accuracy class shall be 1 or better voltage/current, 0.5 or better for watt/var and 0.2 or better for frequency transducers.
11. Shall have a low AC ripple on output less than 1%.
12. Shall be suitable for load resistance of 1000 – 1500.
13. Shall have dual output.