ODISHA POWER TRANSMISSION CORPORATION LIMITED

TECHNICAL SPECIFICATION

FOR

POWER LINE CARRIER COMMUNICATION

(THE INDOOR PLCC PANELS WILL BE SUPPLIED BY OPTCL AS A OWNER SUPPLY ITEMS BUT OTHER MATERIALS AS REQUIRED ARE IN THE SCOPE OF SUPPLY BY BIDDER)

1. GENERAL

Power Line Carrier Communication equipment shall be supplied with all associated equipment complete with all material and accessories, and installed at various substations as indicated in relevant schedules. The Contractor shall also include all equipment and accessories including modifications for remote end substations of the PLCC link even though the names of the substations do not appear in the Schedule.

The Contractor shall be responsible for the provision of training engineers of the Employer responsible for maintenance of the above equipment. The Contractor shall also be responsible for maintenance till the equipment is handed over to the Employer.

Panels shall be supplied complete with all accessories, meters, switches, indicating lamps, annunciation, and other devices completely wired and assembled as per approval of the Project Manager. The contractor shall also mount and completely wire the equipment to be supplied by others if any for installation on these panels.

2. LIST OF ABBREVIATIONS

The following abbreviations have been used in this document.

AC	Alternating Current
AIS	Alarm Indication Signal
BER	Bit Error Rate
CCIR	Consultative Committee International Radio
CCITT	International Telegraph and Telephone Consultative Committee
CPU	Central Processing Unit
CVT	Capacitive Voltage Transformer
dB	Decibel
DC	Direct Current
DTMF	Dual Tone Multi-Frequency
EEPROM	Electrically Erasable Programmable Read Only Memory
EMI	Electromagnetic Interfaces
Ghz	Gigahertz
HF	High Frequency
ic	Integrated Circuit
IDC	Insulation Displacement Connector
IEC	International Electrotechnical Commission
IEC	International Electrotechnical Commission
IP	Ingress Protection
kA	Kilo Amperes
kb/s	Kilobits per second
kV	Kilo Volts
LED	Light Emitting Diode
LED	Light Emitting Diode
Mb/S	Megabits Per Second
msec	Millisecond
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
nm	Nanometers (meters X 10^{-9})
PAX	Private Automatic (Telephone) Exchange

PCM	Pulse Code Modulation
PLC	Power Line Carrier
PSK	Phase Shift Keying
PSTN	Public Switched Telephone Network
PSU	Power Supply Unit
QA	Quality Assurance
RF	Radio Frequency
RFI	Radio Frequency Interference
RFI	Radio Frequency Interference
RLDC	Regional Load Despatch Centre
SDH	Synchronous Digital Hierarchy
SLDC	State Load Despatch Centre
SPC	Stored Programme Control
sub-LDC	Sub-Load Despatch Centre
VF	Voice Frequency
VSWR	Voltage Standing Wave Radio

3. PLCC SYSTEM

The PLCC system shall be used to carry speech, protection and control signals, SCADA and computer data traffic. Interface connections shall be made directly with telephone equipment and equipment handling digital data.

The PLCC system shall be suitably designed to work over the high voltage overhead power transmission lines and shall comply with IEC 495. The system shall operate satisfactorily under all power system switching and weather conditions that may be encountered at any time. It shall be capable of operating properly during its period of service.

The mean time between failures shall be stated and proof in the form of calculations or actual in-service failure rates shall be provided.

A panel or enclosure shall be provided for paralleling the HF outputs for connection to the coaxial cable between the PLC and the Line Matching Unit. Suitable coaxial cable shall be used between the PLC and this panel. The HF cables from the PLC shall be terminated on the panel with plug-in connectors to allow each PLC to be interchanged between lines.

The PLCC system shall essentially consist of the following:

- Coupling Device, phase to phase or phase to ground.
- HF cable
- Carrier terminal (Owner supply item)
- Protection coupler(owner supply item)
- Telephone instruments
- Line traps

4. STANDARDS

All the PLCC equipment covered under the specification shall conform to the requirements of the latest edition of the relevant IEC/IS Specifications or equivalent National Standards, except to the extent modified by this specification.

The IEC/IS Specifications relevant to the equipment covered under this specification shall include but not be limited to standards indicated in relevant schedules of this specification.

5. DRAWINGS

5.1 Reference Drawings

The drawings attached to this specification shall be the reference drawings.

The Contractor shall evolve and furnish a comprehensive protection, control, interlocking and signalling scheme meeting all the requirements of the technical specifications based on these reference drawings.

The Contractor while preparing the drawings for control and relay panels shall co-ordinate with various other equipment suppliers for actual details of equipment to be directly or indirectly associated with the control and relay panels

The current and voltage transformer parameters are given in the relevant sections of this specification. The contractor shall ensure the supply of CVT to meet the needs of relays and meters being supplied by him.

Attached to Specification is a schedule indicating the existing features of PLCC system at the particular site along with details of remote end equipment.

5.2 Contractors Drawings

Contractor shall furnish the complete scheme, system, and supply drawings as called for in this Specification.

Contractor shall provide a list of drawings and a programme for submission in accordance with the requirements of this Specification.

All drawing submitted by the bidder including those submitted at the time of bid shall be in sufficient detail to indicate the type, size, arrangement, material description, bill of material, weight of each component, break-up for packing and shipment, external connection, fixing arrangement required, dimensions required for installation, interconnection with other equipment and components, clearance and space required for installation, interconnection between various points of equipment and any other information as called for in this Specifications.

6. FREQUENCY PLANNING AND SURVEY

6.1 General

A frequency planning study shall be carried out by the Owner / Contractor such that the SNR for various channels shall be as per IEC. For transposed lines the signal attenuation considered for frequency planning shall be justified through study reports.

The frequency and output power of the PLCC system for protection shall be planned such that the protection signal is received with full reliability even when one phase is earthed or is open circuit on the line side causing an additional minimum loss of 6 dB.

The frequency plan will be referred to Wireless Adviser/DOP Department for clearance. In case any changes to the Contractor's recommendations for carrier frequency and power output are

proposed by these Authorities, the Contractor shall modify his proposal accordingly. Changes of power output shall not, however, involve repeater stations.

The frequency planning exercise shall also include the items outlined in the following sub-clause 6.2, 6.3 and 6.4.

The Contractor's study report shall includes the followings

6.2 Proposed Arrangement

Facilities shall be provided for immediate opening of local breaker under direct tripping command from remote end. The tripping of local/remote end breakers is to be achieved by exchange of commands on PLC system between the two ends of the line in direct tripping mode.

For security reasons each transmission line shall be protected by Main-I and Main-II protections as given below :

- Main-I Distance protection type with permissive inter- tripping.
- Main-II Distance protection of different design/ philosophy/manufacture to the relay under Main I.

6.3 Carrier requirements

6.3.1 For 400kV Lines

a) Two protection channels for Main-I and two for Main-II distance protection schemes**.**

b) Two main and two back-up protection channels for direct circuit breaker inter-tripping.

c) One speech channel with facility for superimposed telex and data signals.

d) The arrangement shall be as per plate 7.1.

6.3.2 For 220 kV Lines

a) One protection channel for Main-I and another for Main-II distance protection schemes.

b) One main and one back-up protection channel for direct circuit breaker inter-tripping.

c) One speech channel with facility for superimposed telex and data Signals.

d) The arrangement shall be as per plate 7.2.

6.3.3 For 132 kV lines

a) One protection channel for Main-I protection scheme**.**

b) One speech channel with facility for superimposed telex and data signals.

c) The arrangement shall be as per plate 7.3.

6.3.4 For 33 kV lines

No PLCC Equipment is envisaged on 33 kV lines.

6.3.5 General

The equipment for protection signals shall have high degree of reliability and speed. It shall be guaranteed to function reliably in the presence of noise impulse caused by isolator or breaker operation. The equipment shall be suitable for direct tripping of remote end breaker for fault in unswitched 400 kV shunt reactors. It shall also be possible to effect direct tripping of breaker at

one end when the other end breaker is opened either manually or by protection relays such as Bus fault relay etc.

The time intervals between receipt of a trip command on the transmit side, its transmission over the carrier link, reception at the far end and giving command to the trip relays at the distant end shall not exceed 20 milliseconds for permissive inter-tripping and 30 milliseconds for direct inter-tripping. The above timings are inclusive of operating time for auxiliary relays and interposing relays, if any, included in the PLCC equipment.

The requirement of protection signalling channel is such that security against incorrect signals being received shall be at least two to three orders higher than reliability against a signal not being received.

Requirement under speech and telex communication is elaborated elsewhere in this section.

The planning of frequencies for the PLCC terminals shall be done considering the existing PLCC Network as well as full communication channel requirement detailed above so that there is no problem of frequency allocation at a later date when the subsequent section communication requirements come up.

For reasons of security and reliability, phase to phase/inter-circuit coupling shall be employed. Double differential coupling shall also be considered for double circuit lines. Bidders shall furnish details of methods of coupling and recommend suitable coupling mode for double circuit lines along with the bids. The coupling mode shall, however, be fully confirmed by Contractor after conducting detailed computer studies, taking into account the transpositions of 400 kV lines, for optimum coupling mode over these line sections. The coupling arrangement shall be fully optimised by the Contractor after conducting detailed studies of every line section individually, taking into account temperature variations, transpositions, earth resistivity, conductor configuration, carrier channels requirements, security and reliability criteria and other relevant details. The line attenuation shall be calculated for complete range of frequencies. Earth resistivity data, existing frequency networks and other relevant details of each line will be furnished to the Contractor for carrying out computer studies and frequency planning. The Contractor shall complete the computer studies wherever required and submit the frequency plan and optimum coupling details within a period of one month from the date of receipt of above data. The cost of doing the computer studies wherever required shall be included in the lump sum bid price and details of computer study charges shall be indicated in the relevant schedule. Bidder must indicate the links on which computer study is required.

The 400 kV transmission lines may be transposed as shown in the relevant specification drawing. There are two transpositions in each line section at distances shown in the drawing. The third transposition is for achieving proper phase sequence at substation.

Transmission tower configuration and conductor details shall be made available to the successful bidder to enable the bidder to make his own computer study assessment of the carrier path based on wave propagation over transposed lines with each transposition point acting as "Modal Converter".

The parameters of the equipment quoted shall be such that the mode of wave propagation on 400 kV /220 kV/132 kV power lines (with transpositions indicated) shall not impose any limitation on the efficient and reliable performance of the information link.

The Contractor shall be required to check and prove, through the results of his computer studies, that attenuation due to transpositions in the EHV lines is within limits and the offered equipment will perform satisfactorily.

The Contractor shall submit curves illustrating `incorrect tripping' and "failure to trip" probability plotted against corona noise level, in the presence of impulse noise due to switching of isolators and circuit breakers etc. Details of field tests and laboratory tests for successful operation of his equipment, under such adverse conditions shall be furnished by the Bidder. These are to be related to end-to-end signalling and shall take into account the type of communication link e.g. account shall be taken of transpositions in the phase to phase coupled HT. line. Details of field tests and laboratory tests for successful operation of the equipment under the above circumstances shall be submitted by the Bidder illustrating the above parameters.

7. LINE TRAP (TO BE SUPPLIED BY THE CONTRACTOR)

7.1 Technical Requirements

Line traps shall be inserted into extra high voltage transmissions line to prevent undue loss of carrier signal for all power system conditions. Their impedance shall be negligible at power frequency (50 Hz) so as not to disturb power transmission but shall be relatively high over the frequency band appropriate to carrier transmission.

Line traps shall consist of a main coil designed to carry continuously the rated current without exceeding the limit of temperature rise. It shall be supplemented with a protective device and tuning device.

Line traps shall be broad band tuned for its entire carrier frequency range. Resistive component of impedance of the line trap within its carrier frequency blocking range shall not be less than 450 ohms for 400kV and 570 ohms for 220kV systems.

Line traps shall be provided with a protective device in the form of a lightning arrestor. The protective device shall be designed and arranged such that neither significant alteration in protective function nor physical damage shall result from either temperature rise or the magnetic field of the main coil at continuous rated current or rated short time current. The protective device shall neither enter into operation nor remain in operation, following transient actuation by the power frequency voltage developed across the line trap by the rated short time current. The protective device shall be shunt connected to the main coil and tuning device.

The lightning arrestor shall be station class current limiting active gap type. Its rated discharge current shall be 10 kA. Co-ordination, however, shall be done by taking 20 kA at 8/20 micro-sec. discharge current into account. Bidder has to furnish full justification in case the use of gap-less metal oxide arrestor is recommended by them.

The lightning arrestor provided with the line trap of each rating shall fully comply with the requirements of IS 3070-Part I (1974)/IEC 99-I (1970) Part I. It shall conform to type tests as applicable and type test certificates shall be submitted by the Bidder.

The lightning arrestor provided with the line trap shall be subject to routine and acceptance tests as per IEC 99-1 (1970) (Part-I).

The line trap on 400kV/220kV/132KV lines shall show no visual corona discharge at a voltage of 320kV/187kV/105kV rms power frequency falling voltage. Suitable corona rings shall be incorporated in the line trap.

Line trap shall be equipped with bird barriers.

Line trap shall be spray painted with light grey paint (shade 631 of IS 5).

7.2 Rating plates

The line trap shall be provided with a rating plate of weatherproof material, fitted so that it is readily visible. The inscriptions shall be indelibly marked. The rating plate shall give the following data:

- Manufacturer's name
- Type and serial number
- Rated inductance in mH
- Rated continuous current in amps
- Rated short time current in kA
- Rated frequency in Hz
- Temperature category
- Insulation level
- Diagram showing the terminal marking
- Year of manufacture
- Total mass in kg

Each tuning unit shall also be provided with a rating plate giving the following information:

- Manufacturers name
- Type and serial number
- Frequency band in kHz
- Rated impulse protective level of tuning unit

7.3 Technical parameters

Line traps shall conform to IEC 353 and the parameters given in Table. 8.3.

Parameter	**400Kv**	**220kV**	**132kV**
Rated power frequency (Hz)	50	50	50
Rated system voltage (kV)	400	220	132
Highest system voltage (kV)	420	245	145
Rated continuous current at 50C (A)	2000	1600	800
Rated short time current for 1 sec. (kA)	40	40	40
Nominal discharge current of protective device at 8/20 micro sec. wave (kA)	10	10	10
Type of tuning	Broad band		
Rated blocking bandwidth	90-150 & 150-500 (to be approved during detail Engineering)		

Minimum resistive component of impedance within rated blocking bandwidth (Ohms).	450	450	450
Rated inductance of main coil (mH)	1.0	1.0	0.5
Corona extinction voltage (kV)	≥320	≥187	≥105
Radio interference voltage (micro volts at 1.1. times Ur/√3, where Ur = maximum system voltage)	500		

Table 8.3. Parameters for line traps

The exact quantities and rating of required line traps shall be decided by the Project Manager based on frequency planning and recommendations of the Contractor.

The Contractor shall indicate continuous current rating of the line trap at 65C ambient.

7.4 Welding or brazing on line trap during manufacture

All the welding included in the manufacture of line traps shall be performed in accordance with the relevant section of this Specification.

7.5 Line trap mounting (to be supplied by the contractor)

Line traps shall be suitable for outdoor pedestal mounting and shall be mechanically strong enough to withstand the stresses due to maximum wind speed specified in the schedules. The contractor shall recommend the mounting of line traps and prepare the lay out of the substation for the Project Managers approval.

Where pedestal mounting is recommended, each line trap shall be mounted on a structure fitted with insulators to provide mechanical stability and structural rigidity. The Contractor shall submit the design calculations to establish the adequacy of his recommendations. All the accessories and hardware, mounting stool, including bolts for fixing the line trap on insulators, shall be of non-magnetic material.

The Bidder shall submit along with his bid, typical drawings clearly indicating the above mentioned features of the line traps, line trap mounting arrangement and terminal connectors. Each transmission line fitted with line traps shall be charged in the presence of the Contractor's representatives.

8. COUPLING DEVICE (TO BE SUPPLIED BY THE CONTRACTOR)

The coupling devices shall be interposed between the capacitor voltage transformer and coaxial line to the PLC transmitter/receiver. The coupling device, in conjunction with the capacitor voltage transformer, shall ensure efficient transmission of carrier frequency signals between the carrier frequency connection and the power line. In addition safety of personnel and protection of the low voltage parts and installation, against the effects of power frequency voltage and transient over voltages shall be ensured.

The coupling device in conjunction with the CVT shall form an electric filter of band pass type and have the following characteristics:

1. It shall match characteristic impedance of HT line to impedance of the carrier frequency connection. Impedance matching between power line and the carrier frequency connection may be done by a transformer or an auto-transformer. The phase to earth characteristic impedance of

the HT line may be assumed to be 320 ohms for 400 kV lines and 400 ohms for 220 kV lines. The design details must be submitted along with the Bids.

2. Galvanic isolation between primary and secondary terminals of the coupling device shall be performed by the above mentioned transformer.

3. Power frequency currents derived by the CVT may be drained to the earth by a separate inductance termed drain coil of suitable rating.

4. Voltage surges coming from the power line at the terminals of the coupling device shall be limited by a non-linear surge arrestor of suitable rating in the primary side. Requirement of a gas type voltage arrestor in secondary side of the coupling device shall have to be fully justified, but in any case the input circuit of PLC equipment shall have protective devices in the form of zener diodes and surge suppressors. The surge arrestor shall have power frequency spark over voltage co-ordinated with the equipment ahead of it.

5. For direct and efficient earthing of its primary terminals, the coupling device shall be equipped with an earthing switch. The coupling device shall be designed such that it shall not be possible to remove the cover before the earthing switch is operated to the `earthed' position. Further the earth switch shall be available for earthing of CVT-HT terminals, when the coupling filter units are removed from circuit for maintenance and replacement. The design shall take due regard of requirements for safety in accordance with the Indian Electricity Rules.

Two phase to earth type coupling filters shall be used to achieve secure phase to phase inter-circuit coupling in case of double circuit lines. Connection between secondary of the two phase to earth type coupling devices shall be through a balancing transformer/hybrid such that reliable communication shall be ensured even when one of the coupled phase is earthed or open circuited on the line side.

Coupling devices shall conform to IEC 481 and have the following carrier frequency characteristics as applicable to a phase to earth type coupling device :

• Nominal line side impedance	320 ohms for 400 kV line 400 ohms for 220 kV lines
• Nominal equipment side impedance	75 ohms (unbalanced)
• Composite loss	Not more than 2 dB
• Return loss	Not less than 12 dB
• Bandwidth	Shall suit the frequency plan between 36 and 500 kHz
• Nominal peak envelope	Not less than 650 Watt power (for inter modulation product 80 dB down)

The coupling device shall be suitable for outdoor mounting. Temperature of metallic equipment mounted outdoor is expected to rise up to 65C during the maximum ambient temperature of 50C specified. The equipment offered by the Bidder shall operate satisfactorily under these conditions.

All the elements of coupling device shall be fitted on a base plate and enclosed in a pad lockable metal box with inspection glass on front. The general arrangement and dimensional details of the metal box shall be similar to that shown in the specification drawings. The Contractor shall submit detailed drawing indicating a general arrangement, interconnection and all other details for approval of the Project Manager during detail engineering.

The HT terminal of coupling device shall be connected to HF terminal of the CVT by means of $6mm^2$ copper wire with suitable lugs and taped with 11 kV insulation by the Contractor.

The coupling device shall have at least two terminals for carrier equipment connection. Bidder shall confirm that such a parallel connection to coupling device directly will not result in any additional attenuation.

9. HIGH FREQUENCY CABLE (TO BE SUPPLIED BY THE CONTRACTOR)

High frequency cable shall connect the coupling device installed in the switchyard to the PLC terminal installed indoors. The high frequency cables supplied by the Contractor shall be suitable for laying directly in trenches or in ducts.

The cable shall be steel armoured and its outer covering shall be protected against attack by termites. Bidder shall offer his comments on method employed by him for earthing of screen and submit full justification for the same with due regard to safety requirements.

Bidder shall enclose in his bid a detailed construction drawing of the cable being offered, with mechanical and electrical parameters.

Impedance of the cable shall be such as to match the impedance of the PLC terminal on one side and the coupling device on the other side, over the entire carrier frequency range of 40-500 kHz.

Loop resistance of cable shall not exceed 30 ohm per km at 20C.

The cable shall be designed to withstand a test voltage of 4 kV between conductor and outer sheath for one minute.

Bidder shall specify attenuation per km of cable at various carrier frequencies in the range of 40 to 500 kHz. The typical attenuation figures for HF cable shall be in the range of 1 to 5 dB/km in the frequency range of 40-500 kHz.

The HF cable shall conform to type tests and be subjected to routine tests as per IEC 96-2/ BS 2316/ IS 5802.

The Bidder shall submit along with the bid, copies of type tests and performance reports of the cable being offered.

All HF cables within the scope of this specification shall be supplied, laid and terminated by the Contractor.

Cables shall be supplied wound on drums containing lengths not less than 500 metres each.

10. POWER LINE CARRIER TERMINAL (OWNER SUPPLY ITEMS -OPTCL)

10.1 General

As already indicated the information link shall be provided for speech, protection, fax and data services. PLC terminals shall be fully co-ordinated to match with the specific requirements. Because of strict requirement of high speed of operation, security, reliability and efficient operation of protection channel along with the carrier terminals, Bidder shall ensure the complete and fool-proof co-ordination of the PLC and protection equipment. It shall therefore be necessary to have these combinations as one unit without any mismatch or necessity of any intermediate co-ordination unit.

PLC terminal shall use amplitude modulation and shall have single side band transmission mode. These shall be equipped for fixed frequency duplex working and shall be fully solid state.

Characteristic input and output parameters of the PLC terminals shall be as per IEC 495 unless otherwise specified.

10.2 Features of PLC terminals

Each PLCC channel shall be capable of carrying any of the following:

1. One speech channel plus telephone signalling channel, nominally 300 Hz to 3.4 kHz for speech. This is also required to carry facsimile transmission and computer data.

2. One restricted speech channel 300 Hz - 2 kHz plus a band of 2 kHz - 4 kHz for the transmission of data and a telephone signalling channel. Data signalling rates of 50, 200,300, 600 baud shall be possible.

3. Two 600 baud channels or one 1200 baud channel. It shall be stated if higher data rates up to 9600 bit/s can be transmitted.

4. One channel for the transmission of speech and tele-protection signals.

5. One channel for the transmission of speech, tele-protection signals and data.

The equipment shall preferably be capable of operation in all the above modes without the provision of additional modules and components. The telephone signalling channel shall be nominally 3.8 kHz out-of-band.

Subject to frequency allocation considerations, PLC equipment may be required to be expanded by the addition of channels to a link (i.e. upgrade to 2 or 4 channels as appropriate). The PLC equipment shall be modular in construction and shall permit such upgrading to be carried out.

The equipment shall be suitable for use with E and M signalling between telephone exchanges at both ends of the lines. Signalling shall be on the pilot tone using a 50 baud channel. If DTMF signalling is available as an alternative this should be stated.

10.3 Transmitter/receiver

The equipment shall use single channel amplitude modulated single sideband suppressed carrier transmission. The Bidder shall quote for terminals which have an output power of 20, 40 and 80 watts.

PLC equipment shall be designed to operate over a frequency band of 50 kHz to 500 kHz.

For each PLC link, the Bidder shall indicate the required frequency spacing between the transmitters and receivers. Spaced band and contiguous band operation should be possible. In twin channel versions, it shall be possible to operate both transmitters and both receivers in adjacent bands. The Bidder shall state the full range of carrier frequencies over which the equipment may be operated.

The carrier frequency output impedance shall be 75Ω or 125Ω unbalanced. Any alternative shall be stated in the tender. The return loss within the nominal carrier frequency band in the transmit direction shall be not less than 12 dB.

The maximum permitted level of spurious emissions shall meet the requirements of IEC 495 Section 8.3.2. Spurious emissions shall be measured as described in Clause 6.2.3 of the recommendations.

The receiver shall have high selectivity and the attenuation of out of band signals shall be as follows:

Frequency out of band (kHz)	**Attenuation(dB)**

0.3	70
0.3 - 4.0	70 - 90
4.0	90

The generation of carrier frequencies shall be fully synthesised. It shall be possible to select any carrier frequency within the whole carrier frequency range in discreet steps of 4kHz. The frequency synthesis shall be highly accurate such that the actual carrier frequency shall not differ from the nominal by more than 20 Hz.

10.4 Speech and signal levels

The voice frequency input impedance shall be 600Ω balanced. The return loss within the effectively transmitted frequency bands shall be not less than 14 dB.

The minimum send level shall be not more than -14 dBm. The maximum receive level shall be at least +4 dBm. Attenuators to facilitate interfacing and matching should be provided.

The absolute input and output levels for signal channels shall be chosen in accordance with the relevant ITU-T Recommendations.

In a pair of PLC terminals, the frequency difference between a voice frequency signal applied to the transmit end and that received at the receive end shall not exceed 2 Hz.

The linearity as a function of the voice frequency input level, shall be such that the overall loss of the speech circuit, of a pair of PLC terminals without compandors and limiters, does not differ by more than ±0.8 dB from the overall loss at 0 dBm for any input level between -10 dBm and 0 dBm. The measurements shall be made at 800 Hz.

Automatic Gain Control: In the case of a 30 dB change in carrier frequency signal level within the regulation range, the change in voice frequency receive levels of both speech and signals shall be less than 1 dB.

Graphs showing frequency/attenuation response of the line filters shall be included with the tender.

The use of companders shall be optional and the final arrangement shall be agreed with the Project Manager.

10.5 Maintenance facilities

Set up and maintenance facilities shall be provided, preferably through the use of a portable PC. The facility shall enable the variable parameters of the equipment to be modifiable.

Details of test equipment required for the set-up and maintenance of the equipment shall be given.

Provision shall be made on each point to point PLC link for emergency and maintenance telephone communications together with audible and visible calling annunciators.

10.6 Alarm facilities

The failure of a module, fuses or loss of power or any other condition affecting the correct operation of individual components of the PLC system shall be automatically detected. Provision shall be made for the indication of these alarms on the affected equipment, and on the substation alarm annunciator panels or alarm monitoring system via potential free contacts.

10.7 Technical parameters

10.7.1 General

1. Carrier frequency range, programmable.	40 - 500 kHz
2. Mode of transmission	Amplitude modulation single side band with suppressed carrier or reduced carrier.
3. Frequency difference	Between VF signal at the PLC terminal transmitting and receiving ends will not exceed 2 Hz with suppressed carrier. With reduced carrier frequency difference shall be zero. This shall include permissible ambient temperature variation and supply frequency and voltage variation of (+) 15% and (-) 10%.
4. RF output power (PEP) at coaxial cable	20W, 40W, 80W as required.
5. Nominal RF impedances	75-125ohm unbalanced 150ohm balanced, optional.
6. Life expectancy	15 Years
7. Carrier frequency output return loss	12 dB minimum
8. Out of band selectivity	90 at 4 kHz
9. Method of generating carrier	Synthesised
10. Accuracy of carrier frequency generation	+/- 20 Hz
11. Minimum VF send level	-14 dBm
12. Maximum VF receive level	+4 dBm
13. VF linearity	+/- 0.8 dBm
14. Module/Card type	Plug In
15. Operating Temperature Range	0-50C
16. Number of AF channels	1 - 4
17. Effective AF bandwidth	300 - 3600 Hz
18. Alarms for	loss of transmit signal loss of receive signal inadequate S/N ratio
19. Power supply, mains	230VAC, +15%, - 15%
20. Power supply, battery	48VDC, +20%,-15% + ve earthed
21. Ambient conditions according to	IEC 495 (revised)

22.	Automatic gain	For 40 dB change in control carrier frequency signal level within the regulation range, change in VF receive levels of both speech and other signals shall be less than 1 dB.

10.7.2 User interfaces

1.	Telephone interface, 4-wire	600 ohm

10.7.3

1.	Number of separate audio 1/0 per channel	1
2.	Number of commands with plugged-in Protection Coupler	4

10.7.4 Other system components

1.	plug-in protection signalling module	plug-in AF modem programmable

10.8 General requirement for PLC terminal

All the PLC terminals shall be of multi-purpose type. The Bidder shall confirm that the total transmission time for teleprotection shall not exceed 20 ms for permissive and 30 ms for direct tripping signals. Speech and teleprotection channels shall independently fulfil the SNR requirements out of the power allocated to its channel from the total power of the PLC terminals.

Detailed calculation for SNR requirement and power allocation over different channels should be furnished along with the bid.

Multiplexing equipment, VFT's and measurand and converters etc. for data are not included in the scope of present specification and shall be procured separately. The successful Bidder shall, however, be required to co-ordinate his carrier equipment with these equipments for successful operation of the system.

The final selection of the output power shall be based on the frequency planning and computer studies conducted by the Contractor. The evaluation of bids shall, however, be done on the basis of prices for carrier sets with power output as stated in this Specification.

In the input circuit of the PLC terminal protective devices shall be provided in the form of zener diodes or surge suppressers in order to eliminate any surge transfer through the coupling device or induced in the connecting path of HF cable.

To improve voice transmission characteristics for the system, compressors and expanders (companders) shall be provided. The companders shall have at least 2:1 compression ratio with a corresponding expansion ratio of 1:2. The operating range of compander shall be compatible with the audio power levels specified for four wire operation. The improvement gained by companders shall however not be taken into account for power allocation and shall be in-hand reserve.

Sudden changes in input level to the receiver shall not cause false tripping. The Bidder shall clearly indicate in his offer the methods adopted to ensure above phenomenon. The receiver design shall also provide protection against false tripping from random noise.

Fail safe devices shall be provided, so that a malfunction in one unit or sub-assembly cannot cause damage elsewhere in the system. All plug in equipment shall be fitted with features to prevent improper insertion. The electrical cables shall not be routed across sharp edges or near sources of high temperature. The adjustments, which are susceptible to misadjustment from accidental contact/vibration, shall be equipped with suitable locking devices.

The PLC set shall be designed to give guaranteed performance from 0C to 50C ambient temperature. The thermal capability of the equipment shall be so designed that the equipment remains operational successfully up to 60C ambient temperature. Any ventilation fans provided for circulation of air inside the cabinets shall conform to relevant Standards.

Terminals shall be provided with a built-in indicating instrument to facilitate checking of important voltage and current values and signal levels in different parts of the PLC Terminals. Protection fuses shall be provided in all important circuits, and fuses shall be so mounted as allow their easy inspection and replacement. All test points shall be easily accessible.

The carrier set shall be provided with suitable supervision and alarm facilities. Individual parts of the carrier set should be accessible from front, making it possible to place the carrier cabinets side-by-side. All components and parts of the carrier set shall be suitably tropicalised.

PLC terminals shall be housed in floor mounting sheet metal cabinets, suitable for mounting on concrete plinth as well as channel frame by means of nuts and bolts or welding. The cabinets shall be properly cleaned and spray painted with two coats of synthetic enamel paint. Exterior of the cabinets shall be painted with smoke-glossy finish. Interior of the cabinets shall be painted with white enamel paint with glossy finish. All the panels shall be properly earthed to the Employer's earthing grid by the Contractor. Contractor shall submit detailed drawings for earthing connections.

All panels shall be protected against moisture ingress and corrosion during storage. Panels shall be properly dried before they are installed and energised. Bidder shall indicate measures adopted to prevent ingress of moisture during operation.

All cabinets having PLC terminals shall be provided with lamps of sufficient wattage for interior illumination with switch.

A name plate shall be provided on the front door of each cabinet indicating channel function, transmitter frequency and direction etc.

10.9 PLC Terminal Speech Communication

PLC equipment offered shall provide telephone communication between the stations where the transmission lines specified in the schedules are terminating.

It shall be possible for a subscriber at any of the stations to contact the subscriber at all other stations connected in the system by dialling his call number. To achieve this an EPAX with four wire interface and remote subscriber units shall be provided at different stations.

The equipment shall contain all normal facilities such as ring back tone, dial tone, engage tone and priority tone, and suitable pulses to establish and disconnect communication between subscribers.

The equipment shall be provided with necessary alarm circuits and fuses etc.

The equipment shall be of 4 kHz bandwidth on either direction and be suitable for providing superimposed data and teleprinter facilities at a later date without major modifications and high cost. The Bidder shall clearly indicate in his bid the provision made in his proposal for future development and the extent to which such additional facilities can be added at a later date.

The system shall be completely automatic with a definite number allocated for each telephone. The numbering scheme for telephones, exchange and tie lines shall be developed by the Bidder and indicated in the bid. Final numbering scheme shall be fully co-ordinated with the existing and proposed future systems by the Contractor.

Arrangement for over-riding facilities shall be provided by means of priority keys wherever specified. The over-riding facility shall enable cutting-in on ongoing calls with the priority key to ask the concerned parties to finish their conversation. The wanted number should then be automatically connected without having to redial the number.

All carrier telephone conversations shall be secret and it should not be possible for anybody to over hear a conversation going on between any two parties excepting those provided with over-riding facilities.

The necessary cables for connecting all the telephone instruments ordered for each substation (including wiring and terminations) shall be provided by the Contractor. These telephone instruments shall be located within the control room building at the respective substation.

All relays etc. used in the equipment shall be of sufficiently robust design to cope with the duty imposed on them. Electronic components used in the equipment shall be of long life type and as few types as possible shall be used.

The cabinets housing the equipment for EPAX, four wire E/M interface and remote subscriber units (four wire) shall have mounting arrangements similar to those for PLC terminals as elsewhere in this section of this Specification.

All the terminals for speech shall be supplied fully wired for addition of VFTs and transit filters in future.

Equipment for speech communication must be fully compatible with Employer's existing equipment. Any interfaces required for proper matching and connection with the Employer’s existing equipment shall be provided by the Contractor.

Terminals for protection shall be suitable for operation between the two ends of each transmission line or on tandem operation basis with back to back connection at the intermediate stations.

Each PLC terminal for speech as well as protection purposes shall be provided with a plug-in type service telephone and buzzer. Further, four wire remote telephone instruments (parallel to service telephone) shall also be provided on one PLC terminal for protection for each link. These instruments shall be located in the respective switchyard control rooms to enable the operator to make emergency calls on point-to-point basis. Each such instrument shall be equipped with a buzzer and `press-to-call' key and shall not require any additional power supply units.

There is also a requirement for express telephone links between substations and Area and State Load Dispatch Centres. A call from the substation shall be initiated by lifting the handset. This would cause a lamp to light on the communications console (to be provided under another contract) at the control centre.

11. ELECTRONIC PRIVATE AUTOMATIC EXCHANGE (EPAX) (TO BE SUPPLIED BY THE CONTRACTOR)

11.1 General requirements

Private automatic telephone exchanges (PAX) are required at substations as stated in the detailed description of work and Bill of Quantities.

The equipment shall be capable of providing proper performance throughout its fifteen year life expectancy.

All equipment shall be designed for ease of maintenance and shall include a variety of built-in alarms associated with vital operating parameters.

All equipment supplied under this specification shall conform with the latest IEC Specifications and CCITT Recommendations.

The topographical, meteorological and system operating conditions shall be as stated elsewhere in this Specification

Each interface shall be protected so that neither a short circuit nor open circuit on the telephone line shall cause permanent damage to the exchange equipment. The application of a 500 volt, 50 Hz, signal to either or both legs of the line, shall not cause permanent damage to, or malfunctioning of the exchange equipment.

The exchange equipment shall be protected from electrostatic discharges transmitted to, or occurring at the line interface units.

Each interface shall have an insulation resistance of greater than 10 Mohms at 500V DC between line terminals and earth.

Each interface shall be capable of withstanding longitudinal 2kV, 10/1000 microsecond voltage surges.

The equipment shall operate from a 48 V DC positive earthed battery supply.

Switching equipment shall provide for the following:

- Interconnection of calling and called extension.
- Interconnection of PAX's via circuits conforming to CCITT Rec. G703 and G705 and PLC channels conforming, to IEC 495.
- Interconnection with a central PAX telephone console at the State Load Dispatch Office and Area Load Dispatch Office.
- A traffic monitoring and reporting system.

11.2 PAX interfaces

11.2.1 General

The PAX requires both analogue and digital interfaces. It shall be capable of interfacing to existing and future GRIDCO telecommunications equipment, and to the public telephone system at selected sites. It shall be capable of interfacing with power line carrier, pilot cable, digital multiplexer, and the PSTN.

The PAX shall be capable of handling analogue and digital trunks, tie lines and extensions, and shall be able to provide the following interfaces:

- 2 wire loop extensions

- 2 wire loop tie lines
- 2 wire E and M tie lines
- 4 wire E and M tie lines
- 2 wire loop PSTN lines

The analogue interfaces shall be two and four wire interfaces, with and without E and M signalling and busy/test signalling, to suit telephone, PLC and pilot cable equipment.

The digital interfaces shall be 64 kbit/sec and 2048 kbits/sec with and without common channel signalling, to suit digital data links and inter-exchange trunks.

11.2.2 Two wire analogue telephone interface requirements

The interface shall be suitable for both standard telephone instruments and telephone consoles for control centre, generating station and substation operators, using DTMF signalling. The interfaces shall provide BORSCHT functions, i.e. **B**attery supply, **O**vervoltage protection, **R**ing current supply, **S**upervision, **C**ode, **H**ybrid and **T**esting functions, for each line connection.

The line feed shall be sufficient to ensure the satisfactory performance of two telephones in parallel on a balanced line of between 0 and 1500 metres in length. The range of loop resistance over which the interface will operate will be 0 to 500 ohms, with a similar limit for the Transmission Equivalent Resistance (TER).

The two wire port impedance shall be 600 ohms, nominal, balanced and suited to the telephone instruments during ringing, signalling and voice transmission conditions.

11.2.3 Analogue power line carrier (PLC) interfaces

The interfaces shall operate as four wire plus E and M interconnections, with the facility for equipment busy signalling wire and test signalling wire, for use with existing transmission equipment interfaces, i.e. PLC and pilot cable interfaces.

The electrical interface requirements are as follows:

- Transmit and receive pairs impedance 600 ohms balanced; return loss better than 20 dB; levels - 3.5 dBm;
- E wire 50 volt battery and relay coil;
- M wire voltage free relay contact to earth;
- Test/busy wires voltage free relay contact to earth;

11.2.4 PAX to PAX interfaces operating over digital trunk circuits

The interfaces shall operate as analogue and digital trunk/tie line interfaces to enable existing changes to be interconnected with the digital PAX and multiplex equipment.

64 kbit/sec interfaces shall be in accordance with requirements of CCIIT Recommendation G 70J, and shall be complete with channel associated signalling.

The Contractor shall be responsible for ensuring that these 64 kbit/sec interfaces enable the full range of network facilities to be available for the PAX extensions.

11.2.5 Pilot cable interface

The interface shall provide facilities to interconnect telephone and other terminals to multiplex and exchanges sites via existing pilot cable systems. These interfaces generally conform to those of the PLC system, and are suitable for extending four wire analogue telephone interfaces beyond the 500 ohm limit.

64 kbit/s interfaces shall be in accordance with CCITT recommendation G703, and shall be complete with channel associated signalling,

The PAX shall have facilities for handling DTMF, decadic, feature and digital phones. It shall be possible to connect remote extensions directly to the PAX over four wire E and M circuits.

11.3 Exchange equipment

The PAX shall be a full digital stored programme controlled type, suitable for the transmission of 64 kbit/s and 2 Mbit/s digital signals and for interfacing with PSTN and other public ISDN exchanges.

The PAX shall be capable of being connected via analogue PLC and pilot cable voice circuits utilising MF and E and M signalling to other PAXs installed in the GRIDCO PAX network.

The PAX shall be capable of automatically searching for alternative routes if the first choice route is unavailable.

The equipment shall be expandable to at least the specified maximum switching capacity without impairment of reliability or performance, and without the need for replacement of installed major software and equipment.

11.4 Extension features

The PAX shall provide for the interconnection of any two extensions connected to the exchange without the participation of a telephone operator, on the basis of keyed or dialled numbers.

The PAX shall provide for:

- Normal inter extension communication.
- Automatic call-back on "Busy" or "No Reply". The calling extension shall have to enter a prefixed code for this facility to be operable
- Conference call, both three way established by an extension, or a multiple conference up to 20 extensions .
- Call transfer to transfer a calling party to another extension.
- Call transfer/follow me to reroute all incoming calls to another extension.
- Call transfer to allow a called extension to be answered at another extension by dialling a code at the other extension.
- Last number redial to allow a redial by using a code.
- Abbreviated dialling to allow codes or a telephone button to dial previously stored numbers.
- Call waiting indication.
- Extension group hunting to allow a number of extensions to be grouped on a common extension number, with incoming calls being assigned in cyclic order to free extensions.

- The facility to hold a call while making a second call.

The features shall be available on an assigned basis.

The exchange transmission performance shall conform with CCITT Recommendations G712, Q507 and Q517 for combined transit/local exchanges and related recommendations in regard to measurement techniques, interface characteristics, and definitions.

11.5 Software

The preferred programming language is CHILL, as described in CCITT Recommendation Z200, Red Book. However other high level languages may be offered which can provide the reliability and maintainability required, and which conform to the basic structural requirements.

The software used on the system shall be of' tried and tested modular construction. The Bidder shall state if software upgrades have been implemented and which version of software is being offered. The procedure for upgrading the system software shall be stated. Details of software licensing arrangements shall be provided.

11.6 Maintenance

The exchange shall provide automatic monitoring and reporting functions to verify the proper execution of call handling and exchange software or hardware malfunctions, and report on the condition of interfaces and exchange resources, e.g. memory occupation, call queue levels, CPU utilisation, traffic levels.

Printed and visual display reports shall be date and time stamped and shall identify exchange and software version codes.

The exchange shall be equipped with the following alarm facilities:

- Urgent alarms indicating a major malfunction
- Non-urgent alarms resulting from transient conditions or self clearing (automatic partial restart) conditions

Local urgent and non-urgent alarm indications shall also be provided.

11.7 Hardware

To meet functionality, reliability and performance requirements, the hardware for the exchange shall use:

- Duplicated call handling processors
- Duplicated memory and memory control
- Duplicated buses for common data, memory and control
- High speed RAM backed by non-volatile, e.g. EPROM, memory and duplicated hard disk storage (storage to have 50% spare capacity)
- Duplicated ringing/tone signalling
- Bulk software loading facilities, preferably of the floppy disc or hard cassette disc type
- System control and display panel

11.8 Numbering plan

The PAX shall have facilities to transpose telephone numbers for routing to and from extensions on remote exchanges.

A closed numbering plan is being used for all extensions on new and existing SPC exchanges. There will be four numbering zones. It shall be possible to restrict interconnection between each numbering zone. However it shall be possible to give any extension interzone access.

11.9 Cables and cabling

Supply, storage, and laying of all necessary telephone cables, special cables and other associated cables in order to render the exchanges fully functional and connected with the requisite number of telephones as detailed in the relevant sections of this Specification shall be within the scope of the Bidder.

11.10 Telephone operators console

An operators console may be required for some PAXs. It shall be equipped with visual display unit, keyboard, handset, headset and exchange function controls, and be designed for stress free operation. Bidders shall include a cost for this optional item.

11.10.1 Voice message recording system

The exchange shall be capable of incorporating a facility for recording of voice messages on a store and forward basis. Telephones connected to the system shall be able to send a voice message to the PAX, together with the called extension number. A message waiting indication shall be available to telephone stations to advise that a message has been stored when a prefix code is keyed. The system shall be capable of 30 hours message storage, with an indefinite retention period, message repeat and message erase codes.

11.10.2 Telephone signalling

Line, information, tone and ring signalling shall be provided to suit analogue and digital telephone extension equipment.

Analogue telephone extension signalling, shall provide the line, information, tone and ringing facilities as follows:

- The extension line control signalling shall use line loop signalling to initiate and terminate extension calling and answer activities, in accordance with BORSCHT exchange and multiplex interface requirements.

- Information signalling will be DTMF in accordance with CCITT Recommendations Q23, Q16 and associated recommendations.

- Tone signalling will conform to the suppliers standard equipment and appropriate CCITT Recommendations.

- Ringing current shall be to manufacturers standard.

11.11 Remote end four wire E/M interface and subscriber unit

The Remote end four wire E/M interface unit, wherever specified, shall be electronic type and be suitable for working on fixed frequency power line carrier systems with E/M signalling. This equipment shall be housed in the carrier set and be fully wired to the carrier terminal equipment.

This unit shall receive and register various signals on PLCC channels from remote end exchanges or other remote end subscriber units and associated four wire interface units.

The unit shall be equipped for routing transit calls and shall be supplied prewired to handle calls from a minimum of eight directions, in a form suitable for transmission over PLCC. The bidder shall indicate the total trunk line capacity for the unit.

The unit shall be suitable for connecting to two wire telephone sets. The associated telephone cables for connecting to the telephones within the control room shall be within the scope of supply.

12. 0 NETWORK PROTECTION EQUIPMENT (PROTECTION COUPLER)(OWNER SUPPLY ITEM – OPTCL)

12.1 General

The Bidder shall offer voice frequency transmission equipment which shall work on frequency shift or coded signal principle for transmission/reception of protection signals as single purpose channel. The equipment shall be suitable for connection to the power line carrier terminal mentioned in Clause above.

The voice frequency transmission equipment shall not only be insensitive to corona noise but shall also remain unaffected by impulse type noise which is generated by electrical discharge and by the opening and closing of circuit breakers, isolators, earthing switches etc. The equipment shall also be made immune to a field strength of 10V/m expected to be caused by portable radio transmitters in the range of 20-1000 MHz. In his offer, the Bidder shall clearly explain what measures have been taken to make the equipment insensitive to corona noise, white noise and to impulse noise of an amplitude larger than the wanted signal, and submit full field test and laboratory test reports. The guarantee on design data shall not be acceptable.

The equipment shall be unaffected by spurious tripping signals. The Bidder shall submit evidence to show how this is achieved satisfactorily.

The equipment shall be designed in accordance with IEC 834-1. All works shall conform with the Indian Electricity Rule, 1956, unless modified by this specification. All materials and equipment offered shall comply with the relevant Standards. These standards shall be stated by the Bidder.

Voice frequency transmission equipment is required for line protection signalling. The equipment shall be used in conjunction with distance protection systems and power line carrier. It shall operate in a duplex mode. It shall be housed in the power line carrier cabinet.

When a line fault occurs, the carrier channel to which the equipment is connected shall be switched over to the teleprotection unit. This shall simultaneously disconnect speech and other signals. This interruption will continue for the short period of the teleprotection command, after which the normal operation of the carrier equipment will be restored. During the transmission of teleprotection signals or when a fault has been detected by the protective relays, the entire output power of the carrier will be made available for transmission of the teleprotection signals. The transmission time of the teleprotection signal, from receipt of command from the transmit end of the channel to the output of the trip command at the receive end of the channel, shall not be more than 20 milliseconds.

The equipment shall allow speech and superimposed data to be transmitted by the carrier along with the teleprotection guard signal. The tripping signal shall be a tone in the speech band which shall be capable of boosting above the guard signal level. Its frequency shall be stable within ±4 Hz.

The operating frequencies of the teleprotection shall be so chosen that under no circumstances shall a spurious tripping signal be transmitted. The equipment shall not issue false commands due to transient phenomena. It shall be insensitive to corona noise and noise generated by the operation of circuit breakers, disconnects and switches, and to electrical surges. It shall be insensitive to harmonics of speech signals.

The teleprotection equipment is to be used together with the PLC equipment. It shall comprise modules, which are directly plugged into reserved slots of the PLC equipment.

The Protection Coupler shall use microprocessor techniques with digital signal processing, to meet the stringent requirements for command transmission over PLC links even under adverse channel conditions.

Full duplex transmission of up to two non-coded permissive or blocking commands plus two coded prioritised direct tripping commands shall be possible for the protection of single and double lines including breaker failure protection.

12.2 Test Facilities

The equipment shall be constructed such that in permissive line protection system, operational reliability of the protection channels may be checked over the carrier link by means of a Local and End To End loop test. It shall be possible to carry out the above test from either end of the carrier link. During healthy condition of the transmission line, the loop test shall not initiate a tripping command. In the event of a system fault, while loop test is in progress, protection signal shall over-ride the test signal.

It shall be possible to test the protection link from either end. This test procedure must not initiate a tripping command.

Facilities shall be provided for displaying and extending alarms (including the tone generator), trip and test conditions and for monitoring and measuring levels. The following operating conditions shall be visually indicated:

- Protection in service
- Protection out of service
- Equipment under test

A cyclic and a manual loop test procedure shall allow in-service testing of the teleprotection channel. Internal self-tests shall continuously supervise the equipment's operating ability.

A hand-held terminal shall be supplied and shall be connectable to a diagnosis interface to display service and operating information.

12.3 Channel Requirements

The equipment shall be suitable for transmission of direct and permissive trip signal as well as blocking signals for protective gear of power system. The equipment shall be operated in the audio frequency range in speech band or above speech band as superimposed channel in 4 kHz band of SSB carrier. The equipment shall operate with full duplex frequency shift mode of operation. The protection signalling equipment shall be of solid state design, modular in construction and have a proven operating record in similar application over EHV systems. Details regarding application of the equipment over 400kV/220kV systems shall be submitted along with the bid.

In its minimum configuration, the Protection Coupler shall convey four independent commands. The four commands are grouped into two non-coded permissive and two coded direct tripping commands, the latter having priority. The first and second main protection schemes with redundancy features are shown in the relevant drawings in the schedules.

The arrangement shown in the drawings is for guidance only and actual arrangement shall be developed by the Contractor in co-ordination with protective relay supplier. The parallel wiring should however retain the concept of two protection channels of each type of protection with each backing up the other 100% during normal operation and also permit testing without affecting the other. The Contractor shall submit drawings showing inter-connection between PLCC and protection panels for approval by the Owner.

The protection coupler shall be designed for transferring commands in blocking, permissive and direct transfer tripping schemes. An unblocking output to be used in deblocking schemes with overreaching first zones and without starters shall be available on the unit.

The command interfaces to the protection relays and alarms shall be free and ***d.c. isolated*** from ground and all other circuits. Each of the tripping outputs shall have associated auxiliary signal output. The standard relay interface modules are to be fitted with tripping signal counters.

The protection coupler shall use the pilot signal of the PLC as a guard signal. The guard signal is to be continuously evaluated on the receive side. In case of insufficient signal quality (signal-to-noise ratio or signal level) the protection coupler shall initiate an alarm.

In the command state, the protection coupler shall cut the guard signal (pilot) and transmit the command signal within the PLC speech frequency band. It shall be possible to boost the command signal to the maximum available transmitter power. The speech and data signals on the same channel are to be interrupted during the short time of command transmission.

As soon as the receiver recognises the missing guard signal and simultaneously detects a valid command signal, the corresponding command output relay is to be operated. Simultaneous loss of a command signal and the guard tone shall lead to an alarm.

A number of frequencies corresponding to the individual commands or command combinations are to be provided in the PLC speech frequency band. Depending on the application (permissive or direct tripping) these frequencies are to be assigned to the actual command. Setting up of the equipment and adapting to field requirements is to be done by means of programming switches on the modules.

It shall be ensured that under no circumstances should the protection channel share the power. Each protection channel shall be able to transmit the power for which the system is designed. For example, a 40 W PLC terminal shall transmit 40 Watt (max) for protection channel alone in the event of fault. Speech and super-imposed data channels, in the same protection terminal must be disconnected momentarily during the operation of protection channels.

The equipment shall be complete with built in counters for counting the number of trip commands sent and number of trip commands received.

The Contractor shall develop drawings showing interconnection between protection panels and PLCC panels and submit the drawings for Project Manager's approval. Supply, laying and terminating of control cables for interconnection between protection panels and PLCC panels at each substation, for the transmission lines covered under this specification, shall be included in the Contractor's scope of work.

12.4 Operating time

The equipment shall be designed for remote tripping/ blocking on permissive basis and direct tripping for reactor fault and others. The overall time of PLC, VFT and transmission path for permissive trip/blocking shall be 20 milliseconds or less.

Operating time lower than that specified above may be offered provided the equipment meets the following requirements of security and reliability:

- False - trip probability (noise burst of any amplitude): 10^{-5}
- Fail to trip probability (for S/N 6dB in 3.1kHz band - white noise measurement): 10^{-2}

The specified time mentioned above comprises the following :

a) Back-to-back signal delay in frequency shift or coded signals protection equipment.

b) Back-to-back delay in PLC terminal.

c) Delay in transmission line.

d) Operation time of interposing relay, if any, in frequency shift or coding equipment.

Reference is invited in this regard to the guide lines expressed in CIGRE Publication "Teleprotection" report by Committee 34 and 35.

12.5 Input/Output criteria

12.5.1 Transmit side

One potential free NO (normally open) contact of protective relays shall be provided for each of the following functions:

- Each Permissive trip command
- Direct trip command
- Contact Rating:
  - Maximum voltage: 660V
  - Maximum current rating: 5A
  - Maximum power rating: 1250 W / VA

12.5.2 Receive Side

Voice frequency transmission equipment for network protection shall be provided with one potential free NO (normally open) contact for each of the following functions:

- Permissive trip command
- Direct trip command
- Contact Rating:
  - Rated voltage: 250 Volts DC
  - Rated current: 0.1 A DC
  - Other parameters: As per IEC-255-0-20

12.5.3 Alarm

In addition, the voice frequency protection terminal shall provide at least one potential free changeover contact for alarm purposes.

- Rated voltage: 250V DC

- Rated current: 0.1A DC
- Other parameters: As per IEC 255-0-20

13. MODEMS (OWNER SUPPLY ITEMS – OPTCL)

13.1 General

The PLCC System shall be equipped with modems for data communication to the LDC SCADA over the bearer circuits.

The signalling data rate of the modems shall be adjustable between 200 - 2400 Baud. The modulation method shall be Frequency Shift Keying (FSK) and modem frequencies and audio bandwidth shall be in accordance with ITU recommendations.

Where necessary, modem audio connections to the site cables shall be protected by barrier transformers and surge arresters, and shall provide 15 kV of isolation.

The modems shall have front panel indications for Carrier Detection and Rx /Tx Data.

The transmit output level should be adjustable between 0dbm and -25dbm with the typical output level being set at 13dbm.

13.2 Channel parameters

Channel parameters are given in Table. 14.3. below.

CCITT channel	Transmission rate (Baud)	Frequency deviation (Hz)	Channel spacing bandwidth (Hz)	Channel mean frequency adjustable in steps of 120 Hz	
				Lowest	Highest
R35	50/75	±30	120	420	3900
R37	100/150	±60	240	480	3840
R38B	200/225	±90	360	540	3780
R38A	200/200	±120	480	600	3840
R38A	300/300	±120	480	600	3840
	600	±240	960	840	3600
V23	1200	±400	2400	1700	
	1200 + speech	±400	1640	2860	
	2400	±800	3200	1800/2000	

Table. 14.3. Channel parameters

13.3 Fax equipment (To be supplied by the contractor)

The FAX equipment to be supplied shall be compatible to CCITT Group 3 and shall be of plain paper type . The equipment shall be suitable for operation with PLCC equipment as well as with

PSTN telephone network. The equipment shall be suitable for operation with 230V single phase supply.

13.4 AC/DC distribution board (To be supplied by the contractor)

13.4.1 General

The Contractor shall provide and install power distribution boards for the PLCC equipment defined in the previous sections. The distribution boards shall distribute power to the equipment and protect against failures on feeder circuits supplying the equipment. The scope of supply shall include distribution boards, installation, cabling, conduit and all associated hardware and accessories required to provide power from the station auxiliary power supplies to the PLC equipment loads.

13.4.2 AC distribution boards

One AC distribution board shall he supplied at each control room/PLCC room for power distribution to the PLC loads. Each panel shall include a minimum of twenty (20) load distribution moulded case circuit breakers. Contractor shall co-ordinate breaker sizing and protection with the PLCC equipment.

13.4.3 DC distribution boards

Separate DC distribution boards shall be provided at each control Room/PLCC room. The DC distribution boards shall provide 48 volt DC power supplies to communication equipment.

DC distribution board shall be fitted with a main MCCB of bi polar type rated for 3,000A at 48V DC and a minimum of 20 manually operated, single pole, feeder circuit. The Contractor shall co-ordinate feeder breaker sizing and protection with the communication equipment. All breakers shall he fitted with magneto thermal tripping and shall comply with IEC 157-1.

14. TESTING AND MAINTENANCE EQUIPMENT (OWNER SUPPLY ITEMS – OPTCL)

Besides the stipulations made elsewhere in this Specification the testing and maintenance equipment shall conform to following technical particulars. Each set of these equipment shall consist of one of the following items.

1. 200HZ to 620kHz Selective Level Meter (SLM) including impedance and return loss measuring attachments compatible with level generator (item 2 below).

2. Level Generator with a range of 50Hz to 620kHz including facility for synchronisation with SLM.

3. Eight digit time interval and frequency counter with a frequency range of 1Hz to 10MHz and timer range of one microsecond to one second in decade steps.

4. Dual trace 15MHz oscilloscope with a display screen 8 x 10 cm and input impedance of 1 Mohm/25 pF with a deflection co-efficient of 5mV/div to 20V/div.

5. Four and a half digit LCD Multimeter with an input impedance of 10 Mohm and a range of 0.1 mV to 1000V DC, 0.1 mV to 600V AC, 0-10A DC and 0-10A AC (40Hz to 10kHz) and 0 - 20 Mohm with built-in power-supply.

6. Print test kits for PLC terminal, E/M interface, and subscriber unit, protection coupler, EPAX etc..

15.

15.1 General

15.2 Factory tests to be performed on line traps

The following type tests in accordance with IEC 353 shall be performed on each type of line trap in presence of the Project Manager. Test reports shall be subject to the approval of the Project Manager before shipment of the equipment. The cost of doing each of these tests shall be indicated in the relevant Schedule of the Bidding Document.

a) Measurement of inductance of the main coil

b) Measurement of temperature rise

c) Insulation tests

d) Short time current tests

The following additional type tests shall be conducted on line traps along with other type tests mentioned in IEC 353.

a) Corona extinction voltage test

b) Radio interference voltage measurement

Procedure for these tests shall be mutually agreed. Prices for these type tests shall be quoted in relevant Schedule of the Bidding Document.

The line traps shall be subject to routine tests as per IEC 353.

The Bidder shall furnish along with his Bid the reports of type and routine tests conducted on similar equipment earlier as per IEC 353.

15.3 Factory test requirements for coupling device

The coupling device including the drainage coil, surge arrester and earthing switch shall conform to type tests and shall be subject to routine tests as per IEC 481/IS 8998.

Routine tests shall include but not be limited to the following :

- Composite loss and return loss tests on coupling device.
- Turns ratio test and insulation tests on the balancing transformer.
- Milli volt drop test, power frequency voltage test and mechanical operation test on earthing switch.
- Power frequency spark over test for lightning arrester as per relevant IS/IEC.

Bidder shall furnish along with his Bid copies of all type and routine test conducted earlier on similar coupling devices in accordance with relevant standards.

15.4 Factory test requirements for HF coaxial cables

The HF cable shall conform to type tests and be subjected to routine tests in accordance with IEC 96-2/BS 2316/IS 5802.

15.5 Factory tests on EPAX

The PAX shall be tested in accordance with the relevant CCITT Recommendations and IEC specifications. In addition, all the functions and features specified shall be tested.

15.6 List of commissioning tests on complete system

The following tests shall be carried out on complete system/subsystem during commissioning:

1. Composite loss and return loss on coupling device using dummy load.

2. Composite loss (attenuation) for HF cable coupling device.

3. End to end attenuation measurement for verification of optimum coupling mode. Test shall be done for all combinations.

4. End to end return loss for optimum coupling mode with.

- open behind line trap.
- grounded behind line trap**.**

5. If end to end return loss for optimum coupling mode is not satisfactory, same shall be measured for other coupling modes also.

6. Adjustment of Tx/Rx levels on PLC equipment as per test schedule.

7. AF frequency response (end to end) for the entire 4kHz bandwidth for speech and operation channels.

8. Measurement of noise in 2kHZ bandwidth with and without line energised.

9. SNR (test-one) with line energised noting down weather conditions.

10. Transmission time for teleprotection and other data channels.

11. Observation of Tx/Rx levels (test-tone) for each channel at both ends by sequential switching on/off parallel channels using dummy load and also with the transmission line.

12. Observation of end to end and trunk dialling performance.

13. Observation of end-to-end protection signalling (command sent and received) in conjunction with protective relays, noting down transmission/receipt of unwanted commands under switching operations in the switchyard during protective relay testing.

15.7 Notes on testing

All measurements for link attenuation, composite loss and return loss shall be carried out for the entire range of carrier frequencies with specific attention to the frequencies as follows:

- Frequencies within coupling device bandwidth.
- Frequencies within line trap bandwidth
- Operating frequencies.

The following tests shall be carried out independently at each end:

- Composite loss and return loss for coupling device.
- Attenuation test for HF cable + coupling device.

- Levels and other local adjustments (on dummy load). Final adjustment shall be on end to end basis.

- Test for loading by parallel channels with dummy line load. This test can be done along with tests for coupling device.

- Protection signalling under local loop-test (dummy load).

All end to end tests shall require availability of healthy complete line for a duration of approximately 5 days.

Necessary test instruments required for all the above tests shall be brought by commissioning engineers of the contractor.

16. NOTES ON COMMUNICATIONS RELATED ASPECTS

16.1 General

The OPTCL have proposed a unified telecommunications and control scheme. Under this scheme the State Load Despatch Centre at Bhubaneswar will be improved and four Sub-Load Despatch Centres will be established. An Interim Augmented Scheme has already been implemented to provide a limited capacity master station and a relatively small number of RTU outstations. A further interim development phase known as the Enhanced Interim Augmented Scheme (EIAS) is currently under examination.

Overall telecommunications planning has to be considered in relation to the complete transmission network. Services required between locations have to be decided as does the bandwidth they require. Transmission media and routing are then to be planned. Services at some stations require links not alone to the adjacent station but also tandem through other stations in the network, for instance SCADA or express speech to the SLDC. Some of the projects under PMU's scope are included in the EIAS project. The EIAS project has already specified services required to specific locations in respect of :

- Conduction of condition survey in respect of existing PLC equipment, both outdoor and indoor removal of old equipment and addition of new equipment including reallocation of equipment wherever necessary/possible.

- Administrative telephone and fax network requirement and advanced PAX systems

- Express telephone requirement to SLDC/Sub-LDC

- Requisite SCADA data channel network (main/standby)

- Provision of settlement metering data channels only

- Provision of high capacity communication network

EIAS project however does not cover the following :

- Provision of protection couplers for lines under this package for 220 KV and 400 KV lines.

- Provision of EPAX for the sub-station:

    - ***As indicated in the BPS sheet.***

The scope of work under this contract and the facilities required in the network shall be broadly classified under the following heads.

1) Supply,erection,testing and commissioning of the equipments and materials at remote and new end of the sub-station(except indoor PLC panels, which is owner supply items).

2) The erection, testing,commissioning works at both new sub-station and remote end are to be taken care.

16.2 The administrative telephone network

The purpose of this network is to provide a means of non-urgent operational and/or administrative telephone speech or fax communication throughout the whole OPTCL. This scope includes supply and installation of equipment to sites which require the same.

This will comprise of a mesh of mainly PLC based telephone circuits between adjacent substations, each of which will require a EPAX to cater for telephones at that site, and the switching of incoming and outgoing calls.

It is required that these switches are configured so as to provide a "closed" numbering system, i.e. one in which each station and each telephone has a unique telephone number which can be accessed from anywhere else on the network by simply dialling its unique number, routing then being carried out automatically by the system. This numbering system is to be compatible with the national numbering scheme being developed by POWERGRID.

In order to support FAX traffic it is necessary that the full available bandwidth of the communications circuits is usable and therefore the Administrative telephone network cannot also support data, teleprinter or protection over its constituent circuits. It is planned that the teleprinter system wherever existing be allowed to run down, and that FAX facilities be used instead.

The administrative telephone network, being composed of short lines between adjacent substations, is to be completely supported on PLC circuits and has to be configured with a certain degree of interconnection so as to allow simultaneous calls to be set up over parallel routes in some cases, and to give some resilience against outages. Whenever possible existing PLC's using modern equipment already in place shall be specified for this network. It shall be possible to extend the network detailed by the addition of extra lines and EPAX's as necessary. Where optical fibre trunk routes have been specified for administrative speech channels, two or more such channels have been allowed.

At the outer edges of this network there are some less important substations which already have PLC circuits from an adjacent more important site. In these cases a single telephone is to be installed, configured as a 'long-line' extension from the EPAX at the larger site.

Where the remote site is also defined as providing metering data and only has a single channel existing PLC circuit then, rather than installing a separate PLC simply for infrequent use of metering data transfer, the ability to relay FAX traffic has been sacrificed and the data channel superimposed on the existing PLC with consequently reduced bandwidth for only speech.

The plan of the proposed administrative speech and fax network is shown in the sketches with this Specification. The existing /proposed PAX installation list is given in the relevant schedule.

16.3 The express speech to SLDC network(Owners supply)

In order to impose effective control, the SLDC will require rapid call set-up to its constituent substations and power stations. For this reason direct speech lines have been planned from the SLDC to each such site, but instead of each terminating on a separate telephone in the SLDC (as in the present SLDC) they will be presented on a communications console with key and lamp control.

The bandwidth of these circuits need not be as wide as that for the administrative network and hence the use of cut-off filters will allow the upper frequencies to be used for data transmission and/or teleprotection as necessary.

16.4 Data to the SLDC (owners supply)

The upper bandwidth of the express speech to the SLDC circuits will be used to carry the associated data from the RTU's. By cutting off the speech band at 2.0 kHz a 200 baud data path can also be carried, as well as up to two 50 baud metering data channels and teleprotection as needed.

Where required for critical substations, it shall have two such 200 baud data channels to the SLDC and the all other substations have only one data channel. Whenever possible the routes of the main and standby data channels shall be different in order to maximise reliability and resilience.

The plan of the main and standby RTU data networks are shown in the schedules as is a list of the RTU's giving their facilities and recommended sizes.

16.5 Settlement metering data (owners supply)

The OPTCL distribution system is to be divided into ten distribution 'circles' formed into four distribution 'groups'.

Settlement metering data will be required from the power stations, 400 kV supply points and the inter-state connectors as well as the distribution bulk supply points.

The groups, and the bulk supply points (BSPs) in each group have been decided but the geographic boundaries between the groups are not consistent with the boundaries between the future generation and transmission sub-LDC areas.

Settlement metering data comprising half hourly data on MW, MWhr, MVAR and MVArh is required, initially to be gathered at the SLDC but with facilities to allow the derived data to be available to the future distribution companies.

A metering data network operating at 50 baud will therefore be required. This is shown in the schedules.

This network is to be provided under this Contract. This will allow all distribution metering data to be available at the SLDC, and in due course when the distribution companies are in existence, data links from their respective offices to the SLDC will allow selected distribution metering data to be supplied to them as required.

16.6 Teleprotection (owners supply)

Teleprotection equipment already exists in OPTCL for the protection of most 400 KV AND 220 kV lines and some 132 kV lines.

The protection coupler requirements for 400kV , 220kV, and 132 kV levels have been shown in the schedules.

It is proposed that the same philosophy be adopted. Therefore all 400 KV and 220 kV lines will have teleprotection as well as the important 132 kV links.

16.7 Trunk networks (owners supply)

The requirements of the Load Despatch Communications network in the scope of EIAS cannot be met by PLC equipment alone. Therefore there will be an additional trunk network which will

interconnect the proposed sub-LDCs and the SLDC. In addition a number of key power stations and substations have been included.

Scope of EIAS already covers the required communications between the SLDC and the future sub-LDC's. There will be a full network of high capacity optical fibre links/microwave between these sites. These are shown in schedules. While designing the PLC network under the present scope of work these high capacity communication networks shall be kept in view and shall be utilised wherever possible.

ODISHA POWER TRANSMISSION CORPORATION LIMITED

TECHNICAL SPECIFICATION

FOR

DISTRUBUTION BOARDS

1) ACDB
2) DCDB
3) OTHER CONSOLES INCLUDING BMK

1) TECHNICAL SPECIFICATION FOR DISTRIBUTION BOARDS

General

Requirements of AC and DC systems

The electrical auxiliary systems shall be of a quality commensurate with the performance, reliability and availability requirements of the substation.

The electrical station services shall be in accordance with all the relevant standards, shall satisfy the requirements specified herein and shall be designed to operate in the environmental conditions specified in the relevant sections of this Specification.
The electrical station systems shall be required to provide the voltage classes indicated in Table 1.1. for operation of various plant equipment operating mechanisms, plants, control and communication systems

Nominal Voltage V	Tolerance	Frequency Hz or DC	Phases	Wires	Neutral Connection
430	±10%	50±5%	3	4	Solidly earthed
240	±10%	50±5%	1	2	Solidly earthed
220	187V to 242V	DC	DC	2	Isolated 2 wires
50	±10%	DC	DC	2	+ve earthed

Table 1.1. Voltage classes

The auxiliaries shall be capable of withstanding all over frequency and undervoltage conditions without loss of supply to the power circuits or shutdown of any auxiliary system meeting the essential loads of the substation plant and equipment.

Configuration
The basic design of the substation electrical auxiliary services shall be as shown in the schematic drawing. This drawing is for guidance only and the Contractor may propose an alternative keeping in view the design philosophy stipulated in this section of the Specification. The design philosophy for auxiliary supply systems shall be as follows:

a) The AC supply for station auxiliary systems shall generally be obtained from a single source from the local distribution network having a track record of good power availability. For 400/220kV substations two separate sources shall be used.

b) Where 11kV or 33kV busbars are available at the substation site station auxiliary transformers shall be installed to provide reliable auxiliary power supplies. At least two auxiliary transformers of a rating sufficient to feed the substation load shall be installed. Where specified, in order to meet the station essential loads a back-up supply from a standby diesel generator set shall be provided. The requirement of diesel generator sets have been indicated in the bill of quantity of relevant schedules.

c) The Contractor shall estimate loads of the substation and determine the required capacity of station auxiliary transformers and diesel generator set and submit same for the approval of the Project Manager. The contractor shall classify the loads based on the principles defined in the following clauses.

Load Classes

Essential loads

These are loads whose failure will affect the capability of the station and station plant and equipment. These loads shall include cooling and other auxiliaries of transformers and reactors, non-interruptible power units, auxiliaries of reactive power compensator, and station services of the relays in the substation.

Emergency loads

These are loads that must remain in service during complete loss of the ac power supply. These loads shall include the station battery chargers, disconnecting switch and circuit breaker operating mechanisms, control room air-conditioning and the emergency lighting of the switchyard and control building. Some emergency loads operate on ac voltage and the others on dc voltage.

Normal loads

These loads, whose failure does not affect capability, shall include but not be limited to control building and switchyard lighting, control building air-conditioning except in control room, air compressors, normal and fire-fighting water pumps, oil treatment loads, etc.

Basic design criteria

The failure or the disconnection for maintenance of any motor, feeder, motor control centre, or 415V power centre or auxiliary transformer shall not affect the power transmission capability of the substation.

To achieve the above criteria, the following facilities shall be incorporated, by the Contractor, in the design of the auxiliary systems :

1. Highly reliable duplicate primary supply sources, with automatic change-over facilities.

2. Duplicate essential loads (e.g. cooling pumps, fans, heat exchangers, etc.). Duplicated loads shall be supplied from two different 430VAC distribution boards (ACDB). Essential loads which are not duplicated shall have duplicated supply circuits with the source having auto change over facility.

3. Provision of a diesel generator set for the essential loads. The generator shall start up automatically, in case of loss of all normal and stand by supplies, to feed the essential loads and emergency loads.

4. In order to limit fault currents, to prevent back feed into the AC bus, and to ensure independence of supply sources, parallel operation between station service transformers shall not be permitted at any voltage level. Also parallel operation shall not be permitted between transformers and diesel generator.

5. System shall be clear and simple to operate to minimise the risk of loss of supply due to human error.

6. The Contractor shall design the LV distribution system to ensure that the voltage supply limits are maintained at all times and that the switchboards and cabling are never overloaded. On larger stations it may be necessary to supply more than one main LVAC switchboard.

415V AC distribution system

General

The 430V secondary distribution system shall comprise 430V power centres serving the different classes of loads either directly or through motor control centres.

Each power centre shall consist of two sections, supplied through two station service transformers of adequate capacity. Each transformer and each section of the 430V power centre shall be designed to carry the total load of both sections. The two sections shall be interconnected through normally open bus tie breakers and normally closed fuse disconnects.

An automatic transfer scheme shall be incorporated within each power centre. This transfer scheme shall automatically disconnect the voltage deficient bus and then re-energise it from the healthy bus.

Restoration of normal supply conditions shall automatically return the power centre to the normal operating mode. The 430V power centres shall be of the metal enclosed switchgear type according to the relevant IEC or Indian Standards.

AC distribution board.

The ACDB’s shall be in accordance with the relevant IEC or Indian Standards and shall also comply with the following requirements:

- The MCC shall be located near the supplied loads or inside the control room at a suitable place.

- The circuit breakers of the MCC shall be individually interlocked to prevent paralleling of two different power centre buses.
- The 240V loads shall be supplied by 240V panels located in the MCC or outside the MCC where it is required.

Supply of essential loads

Essential loads shall be fed from ACDB-1 and ACDB-2 respectively. A diesel generator set shall be connected as indicated in schematic drawing so as to meet the complete requirement of the essential loads of the substations. ACDB's shall be independently fed from two different sections of the main distribution board.

Supply of emergency loads

The emergency loads shall also be supplied from essential bus ACDB-1, ACDB-2, 220V DCDB-1 and 220V DCDB-2, and 50V DCDB-1 and DCDB-2 as shown in the schematic drawing.. These loads shall be supplied from the two different buses under duplicate supply philosophy. Switchyard bay kiosks shall be fed from the two different buses alternatively and interconnected locally with auto changeover switches. Power supply to equipment operating Mechanisms shall be fed from the respective bay kiosks.

Supply of normal loads

Normal loads shall be fed through motor control centres connected with two cables to two different sections of the 415V power distribution centres. A manual change-over switch shall be installed in each MCC, so that the supply is not lost in case of maintenance of one section of the 415V power centre or for a fault. These MCC shall also supply the lighting and small single-phase loads through 240V lighting or distribution panels, located in the MCC and all over the substation.

Some loads, such as switchyard lighting and air-conditioning of the control buildings, normal and fire-fighting water pumps, shall be supplied by duplicate feeders so as not to interrupt working in case of maintenance of one of the sections of the power centre.

For oil treatment and welding, special service outlets shall be provided in local 415V motor control or distribution centres.

2.0 LVAC supplies and equipment

General

Switchboards shall be of the free standing design, suitable for mounting directly above the cable trenches laid inside the control room. Cable trench walls shall be flush with the control room floor. Switchboards shall be suitable for terminating all incoming and outgoing cables and will normally be of the bottom rear entry type, generally in accordance with IEC 947 and 439 and of metal clad design arranged for drawout isolation. Switchboards shall be equipped with circuit breakers and moulded case or miniature circuit breakers. The use of fuse switches will not be permitted.

LVAC scheme

General requirement

The 415V incoming supplies shall be derived from the station auxiliary transformers or in the case of a loss of supplies, from the standby diesel generator where ever applicable. The two incoming supplies shall be interlocked to ensure that only one of the two circuit breakers can be closed at any one time. Where a bus section circuit breaker is provided it shall also be suitably interlocked to prevent the station auxiliary transformer from being backfed.

Main distribution board

The two sections of the main distribution board shall be supplied from separate station auxiliary transformers. The two sections shall have automatic change over facilities in the event of failure of supply from one source. Each section of the board shall feed the following panels:

- Main lighting distribution board
- Fire fighting pump house.
- AC and ventilation plant
- Maintenance equipment and oil treatment plant supplies.

AC distribution board

This shall comprise two sections each of which shall be supplied through different cables from both sections of the main distribution board. Each sections shall be equipped with a back up feed from the standby diesel generator set with automatic change-over facility to generator in the event of loss of supply from the main distribution board.
The AC distribution board shall supply the following loads:

- Control room supply for panels, computers, etc..
- One section of the 220V battery charger / rectifier.
- One section of the 50V battery charger / rectifier .
- 50% of switchyard bay marshalling kiosks.
- Emergency AC lighting system.
- Transformers and reactors (cooling devices and OLTC panels)
- Fire water and civic water pumps
- Spare feeders for future use.

Main lighting distribution board

The main lighting distribution board shall receive incoming supplies from the two sections of the main distribution board as well as a supply from the diesel generator set. This board shall be further connected to lighting panels through a lighting sub-distribution panel. The panel supplying emergency lighting load and the income from the diesel generator shall be equipped to switch on in the event of failure of supply from the primary source.

3.0 Construction

Panels

For indoor applications the switchboards shall be of the cubicle pattern, each circuit being self contained within its own cubicle (compartmentalised type). An access door shall be provided for each cubicle such that access can only be obtained to individual circuits. Circuits shall be segregated one from the other by earthed metal. For outdoor installation they shall be of multi-box construction.
Sheet steel for fabrication of the panels shall be a minimum of 2 mm thick cold rolled grain oriented sheet steel or 2.5 mm hot rolled sheet steel.
All panel edges and cover/door edges shall be reinforced against distortion by rolling, bending or by the addition of welded reinforcement members.

Switchboard

Switchboards shall be vermin proof and suitable for use in a tropical climate. All ventilating louvers shall be covered with a fine mesh from inside.

All switchboards shall be provided with a degree of protection of IP 52 as per IEC 947 or equivalent Indian standard. Provision shall be made in all compartments for providing IP 52 degree of protection, when circuit breaker or module trolley, has been removed.
Switchboards shall be of uniform height and shall not exceeding 2450 mm.
Switchboards shall be easily extendible on both sides, by the addition of the vertical sections after removing the end covers.
All switchboards shall be divided into distinct vertical sections, each comprising:

1. A completely enclosed busbar compartment for horizontal and vertical busbars. Busbar chamber shall be completely enclosed with metallic partitions. Bolted covers shall be provided for access to horizontal and vertical busbars and all joints for repair and maintenance. Access shall be possible without disturbing feeder compartment.

2. Completely enclosed switchgear compartment(s), one for each circuit for housing circuit breaker or motor starter.

3. A compartment or alley for power and control cables. Cable alley door shall preferably be hinged. Cable alley shall have no exposed live parts, and shall have no communication with busbar chamber.

4. A compartment for relays and other control devices associated with a circuit breaker.

All access doors shall be provided with facilities for locking in the closed position. It shall be possible to move each circuit breaker or MCCB to the disconnected position without the need to open the cubicle access door. Attempted disconnection of a circuit breaker or MCCB when in the closed position shall not result in tripping of the particular equipment.

4.0 Cubicle

Cubicles may be arranged vertically in tiers, the number being limited only by the need to ensure that circuits are thermally independent.
It shall be possible to work within each cubicle with the equipment withdrawn whilst the incoming contacts are energised. The minimum requirements for protection shall be:

- Insulating barriers installed between phases within the cubicle.

- An insulating cover to be affixed over the protruding feeder and busbar connections when the equipment is withdrawn.

Where this is not available, protection shall be provided by automatically operated shutters. It shall be possible to open the shutters intentionally, against spring pressure for testing purpose.
Each phase of the down dropper connections from the busbars to the equipment isolating contacts shall be separated from the incoming or outgoing connections and from the other phases by barriers.
Cubicles shall be suitable for terminating all necessary cabling whether of copper or aluminium conductor design. It shall be possible to terminate any cable whilst adjacent circuits are energised.

5.0 Busbar and other equipment housing

All incoming connections, busbars and feeder connections up to the particular MCCB shall be capable of the short time current rating specified, but connections beyond the MCCB need only be matched to the MCCB characteristic.
The overall height of each tier of cubicles shall be such that the operating handles of all equipment are within the reach of a person standing at ground level. Control switches as specified shall be fitted and suitably labelled to indicate their function.
The equipment shall be complete with cable boxes and glands suitable for XLPE or PVC insulated cables.
The switchboard shall be provided with 240V single phase ac illumination and anti-condensation space heaters and each heater shall be provided with an ON/OFF switch.

Sheet steel barriers shall be provided between two adjacent vertical panels running to the full height of the switchboard, except for the horizontal busbar compartment. Each shipping section shall have full metal sheets at both ends for transport and storage.
All equipment associated with a single circuit shall be housed in a separate compartment of the vertical section. The compartment shall be sheet steel enclosed on all sides with the with-drawable units in position or removed. The front of the compartment shall be provided with a hinged single leaf door complete with locking facilities. The main switch shall be operable from outside and will be interlocked with the compartment door such that the latter can be opened only when the switch is off. However, it shall be possible to defeat this interlock and open and close the door with the switch ON. The main switch shall have the facility of being pad-locked in both ON and OFF positions. The switch handle shall clearly indicate the position of main switch.
After isolation of power and control circuit connections it shall be possible to safely carry out maintenance in a compartment with the busbar and adjacent circuit live. Necessary shrouding arrangement shall be provided for this purpose over the cable termination located in cable alley.
The temperature rise of horizontal and vertical busbars when carrying rated current along its full run shall in no case exceed 55C, with silver plated joints and 40C with all other type of joints over an outside ambient temperature of 50C.
All single front switchboards shall be provided with removable bolted covers at the rear. The covers shall be provided with danger labels.
All identical circuit breakers and module chassis of same test size shall be fully interchangeable without having to carry out modifications.
All 415V switchgear cubicles shall be of single front type, with fully withdrawable circuit breakers, which can be drawn out without having to unscrew any connections. The circuit breakers shall be mounted on rollers and guides for smooth movement between **SERVICE, TEST** and **ISOLATED** positions and for withdrawal from the switchboard. Testing of the breaker shall be possible in the **TEST** position.
Wherever two breaker compartments are provided in the same vertical section, insulating barriers and shrouds shall be provided in the rear cable compartment to prevent accidental contact with the live parts of one circuit when working on the other circuit.
All disconnecting contacts for power circuits shall be of robust design and fully self aligning.
Fixed and moving contacts of the power drawout contact system shall be silver plated. Both fixed and moving contacts shall be replaceable.
All modules shall be fixed type except circuit breaker and motor feeder modules, which shall be drawout type.
The connections from busbars to the main switch shall be fully insulated/shrouded, and securely bolted. The partition between the feeder compartment and cable alley may be non-metallic and shall be of such construction as to allow cable cores with lugs to be easily inserted in the feeder compartment for termination.
All equipment and components shall be neatly arranged and shall be easily accessible for operation and maintenance. The internal layout of all modules shall be subject to approval of the Project Manager.
All sheet metalwork shall be painted in accordance with the painting clause specified elsewhere in this Specification. The shade of the paint shall be 692 as per IS 5 (smoke grey).

Earthing

It shall be possible to earth all incoming supplies to the switchboard by means of a fully rated earthing device, either by using the circuit breaker with earthing attachments, a separate earthing truck, or a fixed fully rated earth switch.
Busbars and dead end feeders may be earthed by means of a voltage checking device and hand applied portable earth switches. These shall normally be applied from the front of the switchboard.
Earthing of current free metallic parts on the body of the switchboard shall be done with soft drawn bare copper bus. Tail connections shall have a minimum cross sectional area of 16 mm^2

and the main earth bar for the switchboard shall be brought out to two terminals for connection to the station earth grid.
Earthing connections shall be carried out with green wire and the earthing studs shall be identified as such by an earthing symbol.

Clearances and insulation level
Clearances and creepage distances in air shall be those stated in IEC 158 and 947 and be such that the equipment can withstand the dielectric tests specified.

Thermal performance of switchboard and equipment
The complete switchboard shall be capable of carrying rated load current without the temperature rise of any portion exceeding a level of 65C. Parts that may be touched by operating personnel shall not exceed a level of 35C. In determining the load current performance of tiered cubicles it shall be assumed that all circuits are carrying rated current. The cross sectional area of the busbars may be graded according to the current rating, but shall remain capable of the short time current rating stated in the Schedules.

Protection co-ordination
It shall be the responsibility of the Contractor to fully co-ordinate the overload and short circuit tripping of the circuit breakers with the upstream and down stream circuit breakers/fuses/motor starters, to provide satisfactory discrimination.

6.0 EQUIPMENT TO BE FURNISHED

General
The Contractor shall supply all equipment in accordance with this Specification in each of the modules as specified in the following sub clauses.

Type Designation /Description of Modules
Each 415V switchgear and distribution board shall comprise of a number of different type of modules as detailed in the following clauses. The Contractor shall obtain the approval of the Project Manager for the details of the modules to be provided in each of the Boards. The Employer has classified and type designated the modules to be used in the various Boards.

Module type	Application
AE	Electrically controlled circuit breaker for incomer and bus coupler
M1	Circuit breaker controlled motor feeder
M2	MCCB controlled motor feeder
E	
G1	VT module with undervoltage relay
G2	
H and H(BC)	Isolating switch controlled incoming circuit
S	DC metering and protection module
X	
DC	Incomer from battery and charger
DG1	Electrically controlled circuit breaker for incomer from DG set
H1	
EL	
K2	Non reversible motors having star stop control at MCC
AN	Annunciator module

Table 4.2. 430V switchgear modules and applications

Composition of the Modules
The following are the preferred composition of various modules along with their Bill of Materials. However the Contractor may suggest alternatives keeping in view the requirement of the specification. Such changes shall be subject to approval of the Project Manager. In addition

to the items listed all other items required to provide the necessary functionality as specified in this Specification, shall be deemed to be included in the scope of supply for the module.

7.0 (A) Module type AE

1.	Triple pole air circuit breaker (Device No. 52) complete with all accessories and power operated mechanism as specified.	1
2.	Neutral link.	2
3.	Circuit breaker control switch with spring return to normal.	1
4.	Current transformer for metering.	3
5.	Ammeter	1
6.	Ammeter selector switch.	3
7.	Current transformer for relaying.	3
8.	Triple pole instantaneous over-current relay having the setting range of 200-800% or 500-2000% of CT secondary and adjustable definite minimum time. Alternatively suitable overcurrent releases capable of proper discrimination with all down-stream protection are also acceptable.	1
9.	HRC control fuse.	8
10.	Auxiliary relays	4
11.	Indicating lamps with series resistors and selector lenses (e.g. red, blue, green, white and amber	5
12.	Instantaneous earth fault relay having an adjustable setting range of 10-40% or 20 - 88% of CT secondary current. The earth fault relay shall be provided with a stabilising resistor.	1

7.0 (B) Module type M1

1.	Triple pole air circuit breaker complete with accessories, and power operated mechanism as specified.	1
2.	Circuit breaker control switch with spring return to normal.	1
3.	Three position 6 pole selector switch SWITCHGEAR / NORMAL / TRIAL.	1
4.	Current transformer for metering.	3
5.	Ammeter	1
6.	Ammeter selector switch.	1
7.	Current transformer for relaying.	3
8.	Triple pole instantaneous over-current relay for providing positive sequence current protection in all the three phases. The relay setting range shall be continuously adjustable between 200-800% or 400-1600% of CT secondary rated current as require	1
9.	Double pole inverse definite minimum time overcurrent relays connected in R and B phases for over current protection of motor rated 110 kW - 200 kW. The relay shall have an adjustable setting range of 50% - 200% of CT secondary current and time setting range of 0-30 seconds. The relay shall be CDGM-22 (GEC Alsthom) or equivalent.	1
10.	Single pole adjustable definite time delay relay for motor overload alarm connected in Y-phase only. The relay shall have resetting ratio of not less than 90%. The relay shall have continuously adjustable time delay range of 2.5 to 25 seconds.	1

11.	Instantaneous earth fault relay having an adjustable setting range of 10-40% or 20-80% of CT secondary current. The earth fault relay shall be provided with a stabilising resistor.	1
12.	Auxiliary relays	4
13.	Indicating lamps with resistors and coloured lenses suitable for 220V DC. -	5
14.	HRC control fuses.	8

7.0 (C) Module type M2

1.	415V, 250A, P2 duty 20 kA, 50 Hz MCCB having 4 NO and 4 NC Aux. contacts.	1
2.	Auxiliary relays	1
3.	Indicating lamps with resistors and coloured lenses suitable for 240V AC.	3

7.1 Module type E

1.	Triple pole load break isolating switch	1
2.	Neutral link	1
3.	HRC fuses	3

7.2 Module type G1

1.	(415/√3)/ (110/√3) volts single phase voltage transformer star/star connected with star point solidly earthed mounted on common draw out chassis. Accuracy Class 0.5 for protection and metering with 50VA burden.	3
2.	HRC Fuses mounted on the above chassis.	6
3.	Four position voltmeter selector switch.	1
4.	Voltmeter (0-500V)	1
5.	Double pole instantaneous undervoltage relays with continuous variable setting range of 40-80% of 110 Volts.	1
6.	Time delay pick up relay having a time setting range of 0.5 to 3 seconds. With 3 NO self reset contacts, suitable for 220V DC.	1
7.	Auxiliary relay 220V DC with 2 NO. self reset contacts.	1
8.	Indicating lamps with series resistor and colour lenses (Red, blue and yellow).	3

7.3 Module type G2

1.	HRC Fuse	3
2.	Voltmeter (0-500V)	1
3.	Voltmeter selector switch four position (R-Y, Y-B, B-R OFF).	1
4.	Indication lamps (Red, blue and yellow)	3

7.4 Module type H and H (BC)

1.	Triple pole load break isolating switch with padlocking facility in OFF position and arrangement to defeat door interlocking	1
2.	Neutral link.	1
3.	Red indicating lamp to indicate isolating switch closed position.	1

7.5 Module type S

1.	Voltmeter 0-300V DC for 220V DC DB	1
2.	Voltmeter 0-75V DC for 50V DCDB.	1

3.	Three (3) position voltmeter selector switch	1
4.	Instantaneous under voltage relay with 95% of 220V DC. The resetting ratio of relay of relay should not be more than 1.25. The relay shall be provided with a series resistor and a push button across if for resetting (pick up) the relay at about 105% of the drop out voltage.	1
5.	Instantaneous over voltage relay with setting range of 110% of 220V DC. The resetting ratio of relay should not be less than 0.8. The relay shall have a push button in series capable of resetting the relay at about 95% of the operating voltage.	1
6.	Earth leakage relay only for 220V DC system having adjustable pick up range between 3 to 7 milliamps the relay shall be suitable for 220V DC/240V AC Auxiliary supply.	1
7.	Indicating lamp each for fault annunciation and for 220V DC with earth leakage relay mentioned above.	2
8.	HRC control fuses.	2

7.6 Module type X

1.	Double pole single throw 250V DC air break isolating switch.	1
2.	HRC fuses	2

7.7 Module type DC (Incomer from battery and chargers)

1.	HRC fuses for incomer from battery.	2
2.	DC ammeter with shunt and range of 40-0-50 Amps. For 220V DC DB and 60-0-150 Amp for 50V DC DB.	1
3.	Double pole single throw 250V DC air break switch.	2
4.	HRC fuses for incomer from charger.	2
5.	Double pole single throw 250V DC air break switch connecting battery and charger sections to DCDB	1

7.8 Module type DG1

1.	Triple pole circuit breaker complete with all accessories and power operated mechanism as per the relevant sections of this Specification.	1
2.	Frequency meter.	1
3.	Voltmeter with selector switch.	1
4.	Remote/Local selector switch.	1
5.	Circuit breaker control switch with spring return to normal.	1
6.	Current transformer for metering.	3
7.	Current transformers for differential protection (out of this 3 Nos. will be supplied loose for mounting in DG set panel).	6
8.	Current transformer for relaying.	3
9.	HRC Control fuses	8
10.	Ammeter selector switch.	1
11.	Ammeter	1
12.	Wattmeter of range 0-300 kW.	1
13.	Three pole voltage controlled definite time delay relay having current setting range of 50-200% of CT secondary current and adjustable time delay 0.3 to 3 seconds.	1

14.	Watt hour meter with six (6) digits and minimum count of one (1) kWh.	1
15.	Single pole definite time over current relay having a continuous setting range of 50-200% of CT secondary current and a time delay of 2.5-25 seconds connected in CT of Y phase for overload alarm. The relay shall have a setting ratio of not less than 90%.	1
16.	Three pole differential protection relay having an operating current setting range of 10-40% of generator full load current. The relay shall be of high impedance type, with necessary stabilising resistors.	1
17.	Indicating lamps with resistors and enclosed lenses.	5
18.	Push buttons for remote starting and stopping of diesel generator set (Red and green).	2

7.9 Module type H1

1.	Double pole DC switch with pad locking facility in off position.	1

7.10 Module type EL

1.	Triple pole and neutral switch	1
2.	HRC fuses	3
3.	Contactor	1
4.	Electronic timer suitable for continuous operation.	2
5.	Control Switch.	2

7.11 Module type K1

1.	Triple pole load break isolating switch (device identifier - SW) with neutral link.	1
2.	HRC fuses (device FU) and one control fuse.	3
3.	Triple pole contactor 240V AC rated (device No. 42) with hand reset thermal overload relay (device No. 49) for thermal overload relay for more than 30 kW feeder, connection through suitable current transformers may be taken.	1
4.	Auxiliary relay (device No. 42 X) 240V AC rated with 3 NO and 3 NC self reset contacts.	1
5.	Indicating lamp 240V AC rated red coloured to give motor ON indication.	1
6.	Indication lamp 240V AC rated, green coloured to give motor OFF indication	1
7.	Push button labelled (STOP).	1
8.	Push button labelled `START'	1
9.	Switch fuse unit for space heater supply for motors rated 30 kW and above.	1
10.	Current transformer and an ammeter for all motors rated 50 kW and above.	1

7.12 Module type K2 (mounted at motor)

1.	Triple pole load break isolating switch with neutral link.	1
2.	HRC fuses and one (1) Control fuse	3

3.	Triple pole contactor rated for 240V AC	1
4.	Indicating lamp 240V AC rated red/green coloured to give ON/OFF indication.	2
5.	Push button labelled STOP	1
6.	Push button labelled START	1

7.13 Module type DG- (mounted at generator)

1.	Indicating lamps	9
2.	Push buttons	7
3.	DC Ammeter (0-40A)	1
4.	DC Voltmeter (0-30V)	1
5.	Voltmeter selector switch	1
6.	AC ammeter	1
7.	AC voltmeter	1
8.	Timers (24V DC)	3
9.	Auto/Manual selector switch	2
10.	Auto/test/Manual selector switch	2
11.	CT's for metering	3
12.	PS class CT's for differential protection of diesel generator set	3
13.	Auxiliary contactors suitable for 24V DC	11
14.	Motorised potentiometer for voltage adjustment	1
15.	Battery charger as per clause no **Error! Reference source not found.** of this section	1
16.	HRC control fuses	12
17.	Set of phase and neutral busbars.	1

Module type AN (Annunciation module)

Where an integrated PC based system is not provided at the substation a central alarm annunciator shall be provided for the auxiliary power systems. The annunciation system shall consist of 30 annunciator units each having an engraved translucent plastic window of 35 mm x 50 mm (minimum) size. Engraving shall be black letters and indicate the alarm function. Annunciators shall be suitable for operation on 220V DC and shall have a single common audible alarm.

Push buttons with appropriate nameplates shall be provided for audible alarm acknowledge, alarm reset and lamp test. The push buttons shall be common to all alarm points. Annunciators shall be suitable for operation with both normally open and normally closed alarm contacts. Annunciation system shall be solid state type of reputed make.

On receiving any alarm pulse, including fleeting pulses, the appropriate alarm relay shall pick up energising the corresponding visible and audible alarm units. It shall be possible for the operator to reset the audible alarm even if the alarm condition persists. However, visible alarm shall not reset unless the alarm condition has disappeared and the reset push button is operated. Annunciator shall provide sealed in lamp indication and audible alarm shall be ready to operate for any new alarm condition immediately after the alarm is reset push button. Annunciator shall operate satisfactorily between 80% and 110% of rated supply voltage.

Module equipment and instrumentation.

Circuit breakers, MCCB's, MCB's, selector switches, instrumentation, relays and protection equipment for LV supplies etc. shall generally conform to the requirement of the stipulated under relevant sections of this Specification.

7.14 TECHNICAL SPECIFICATION FOR INDOOR TYPE 415/240 V.A.C POWER DISTRIBUTION SWITCH BOARDS.

7.14.1 SCOPE

The specification covers manufacture, assembly and testing at manufacturer's Works, supply and delivery at site of Indoor and out door type 415/240 volts A.C. power distribution switch-boards, A.C consoles, Bay Marshalling Kiosk ,Receptacle panels complete in all respects as per system requirement for S/S and switchyards 20% spare feeders shall be provided in each Distribution Boards.

7.14.2 STANDARDS

The equipment covered by this specification shall unless otherwise specified be built to conform to Indian Electricity Rule 2956 wherever applicable and shall satisfy the requirements of the latest Indian Standard. Permissible temperature rise shall be as per relevant ISS.

7.14.3 SWITCH BOARD DESIGN

The switch board shall be self supporting, steel cubicle, compartmentalized, fully enclosed with doors for access to the interior. The switch boards shall comprise a non/draw out type panels placed side by side to form a continuous unit with access door for each panel at the rear 3 mm sheet shall be used for fabrication of the panels. Modular type construction for inter-changeability will be preferred.

The complete panels shall not be more than 2450 mm. high with the channel base and 500 mm. depth measured form rear to front faces and of suitable with. The working height shall be limited to maximum 2200 mm. The design shall be such as to permit extension at site on either end. The bottom of the switch board frame shall be suitable for erecting flush on concrete floor by securing it by means of evenly spaced grouting bolts projecting through the base channels. The panels shall be designed to facilitate cable entry from the bottom and removable plates shall be supplied along with the panels for this purpose which will be drilled at site to fit the cable glands.

The switchboard shall be vermin proof and suitable for use in tropical climate. All ventilating louvers and holes shall be covered with fine wire mesh from inside (for indoor use). All control and power cables will be laid in open distribution trenches running under the A.C. switchboards. The cable will enter the cubicles through entry holes of removable plates provided at the bottom of the cubicles. The cable entry holes required and the position of the foundation bolts.

The switchboards shall be supplied complete with channel base, removable bottom plates grouting bolts, lock nuts, washer, etc. and cable glands as specified hereafter. All unfinished surfaces of the steel panels and frame work shall be free from adhesive matter or greases. A suitable rust resisting primer paint shall be applied on the interior and exterior surface of the steel housing allowed by application of an undercoat to serve as base and binder for the finishing coat. The finishing coat on the exterior of the switchboards shall be polished cellulose enamel or dark batter ship grey, evenly sprayed to present a fine appearance while the interior faces shall be sprayed with a finishing coat of light grey paint to provide contrasting background for the wiring inside the cubicle.The internal illumination for working should be of adequate intensity CFL lamps.

A small quantity of finishing paint shall be supplied with the consignment of the Switchboards to enable the employer to restore at site any surface finish which may get damaged during transit.

7.14.4 BUS BARS

The bus bars shall be of E.G. copper/aluminum alloy, liberally sized for the specific current ratings (both short circuit and continuous currents). The size of the bus bars shall be such that the current density is not more than 1A/1.75 A per sq.mm. for aluminum alloy and copper respectively at rated capacity. Necessary precaution shall be taken to avoid bimetallic action where copper conductors shall be connected to the aluminum bus. Means shall be provided for identifying various phases of bus bars. Bus support shall be of arc resistant, non-tracking, low absorption type insulators of high impact strength and high creepage surface. Buses shall be spaced with adequate clearance between phases and phases to ground.

The bus and connections shall be so supported as to be capable of safety withstanding stresses due to maximum short circuit current and also take care of any thermal expansion.

The droppers/riser from or to the bus bars should not be twisted but reasonable bend or joint may be allowed. The bidder shall sbsrish necessary calculations about the adequacy of sleeted bus suyyrot insulator cantilever sireugth w.r to short cicess forces.

7.14.5 AIR CIRCUIT BREAKER FOR INCOMER

A.C. air circuit breaker shall be triple pole, non-draw out type, suitable for 1100 volts grade/650 volts grade service, having continuous current carrying capacity of 400 Amps with breaking capacity of 20 KA at 415 volts. The breaker shall be provided with trip free manually operated mechanism and a push butter to trip the breaker electrically.

The breaker shall be provided with mechanical OFF/ON indicators.

The breaker shall be provided with sets of auxiliary contacts for OFF/On indicating lamps, trip circuit and inter-locking circuit along with two sets of spare contacts. The door of the circuit breaker compartment shall be so interlocked that :

i) The door cannot be opened whist the breaker is in closed opposition (i.e. 'ON')

ii) When the door is opened, the breaker shall be locked so that it can not be closed (i.e. it cannot be made 'ON'). The circuit breaker shall comply with the relevant I.S.S.

The breaker shall be complete with cable glands suitable for entry of 3 x 400 sq.mm. 1100 V/650 V grade aluminum cables.

One number 195 sq.mm. aluminum cable of same voltage grade as above shall be used for neutral, and cable gland suitable for entry of this cable shall also be provided in the switchboard. Thermal overload relay range shall be 100 Amps to 200 Amps calibrated at 55%, 75%, 100% of the height setting and suitable time settings.

Drop out and pick up voltage of the under-voltage release shall be 60% and 80% respectively of the rated voltage.

For incoming circuit 1 no. ACB(as per requirement, it differs from sub-station to sub-station) of suitable capacity according to the system should be design and furnished provided in the panel.The details of main ACDB is as below.

1) Station Transformer capacity: 33/0.433 KV, 250 KVA . Each substation there will be two nos station transformer, hence in Main ACDB there will be two incomer i.e., as source I and source II. There will be a bus coupler in main ACDB for extending the supply as and when required.

All outgoing feeders shall be provided with MCCB & SFU of suitable capacity according to the systems are to be provided.

7.14.6 INDICATING LAMPS

Indicating lamps shall be LED type provided with suitable safety resistor, and coloured dust-tight lens. Lamps shall be of very low wattage consumption and heat generated due to continuous burning shall not deteriorate lamp cover. The lamp holders shall preferably be screwed type.

7.14.7 SPACE HEATERS

The A.C. switchboards shall be provided with space heaters rated for 240 volts single phase A.C. Each heater shall be provided with ON/OFF switch. The wattage of the heater shall be such as to keep 10 deg. C. above the ambient temperature during rainy season but the temperature shall not damage the wiring.

7.14.8 CABLE TERMINATION

Switchboards shall be designed to facilitate PVC cable entry from the bottom of the switchboards. Removal plates shall be supplied for this purpose which will be drilled at site to fit the cable glands.

Sufficient space shall be provided to avoid sharp bending and for easy connection.

Cables shall be PVC insulated, armored and PVC sheathed with 7/0.029" copper conductor for control and Aluminum for cables feeder up to 15 Amp. Rating. Rest of the power cable shall be of aluminum conductor of suitable size as per feeder rating.

Multiway terminal blocks of sturdy construction complete with terminating the internal wiring and outgoing cables.

Power terminals shall be complete with lugs and control terminals shall be clamp type. Screw type terminals with screw directly impinging on conductor shall not be supplied.

Each terminal for 15 Amps. Feeders shall be capable for connection of 2 Nos. 7/0.029" copper wires at one end without any damage to the connector or any looseness of connection.

The terminal shall be properly tagged and ferruled in compliance with approved drawings. The terminal blocks shall be readily accessible and those shall be rust proof and of best quality. Terminal block connector built from cells of moulded dielectric and brass-stud inserts shall be provided. The connection stud shall project at least 6 mm. from the lock nut surface. All blocks shall be shrouded of easily removable shrouds moulded of transparent dielectric material of non-breakable type.

7.14.9 WIRING

The wiring shall be complete in all respect so as to ensure proper functioning of control, protection and inter-locking schemes.

All wiring shall be complete up to the terminal blocks at the factory.

Control wiring shall be carried out with flexible, heat resistant, switchboard wires. PVC insulated with 2.5 sq.mm. stranded copper conductors. Each wire shall be identified at both ends with wire destinations numbered ferrules in accordance with bidder's wiring diagram. Wires shall not be spliced or tapped between terminal points. Each wire shall be continuous and there shall not be any joint within itself. Individual wire shall be connected only at the connection terminal, blocks, meters, relays, instruments, and other devices used in the switchboards. Red, Yellow, Blue and Black ferrules shall be used for Red. Yellow, Blue phases and Neutral respectively.

Wires shall be neatly bunched and adequately supported so as to prevent sagging and strain on termination.

All spare contacts of the equipment shall be wired up to the terminal block. The wiring shall be cf 1.1 KV grade. At least 20% spare terminals shall be provided.

7.14.91 Terminal connection shall be such that the conductors. LM10 may be connected by means of screw or other equivalent means so as to ensure that the necessary contact pressure is maintained permanently.

7.14.9.2 Terminal shall be such that they cannot turn or be LM10 displaced when the connecting screws are tightened and such that the conductor can also not become displaced.

7.14.9.3 Terminals should be so mounted that the appropriate wire may be connected without impairing the normal performance of the unit.

7.14.10SAFETY EARTHING

Earthing of current free metallic parts of metallic bodies of the equipment on the switchboard shall be done with soft drawn bare copper bus. Tail connections shall have minimum area of 16 sq. mm. and the main earth connection for earth switchboard shall be brought out of two terminals for connection with the station earthing system.

7.14.10.1 Earthing terminals should be identified by means of the sign marked on a legible and indelible manner on or adjacent to the terminals.

Earthing lugs shall be provided an all earthing connections shall be carried out with green wires.

7.14.10 SWITCHBOARD LIGHTING

The switchboard illumination by providing CFL lamps and space heating arrangement to be provided.

7.14.11 INDICATING INSTRUMENT & ENERGY METERS

All instruments shall be switchboard type, back-connected, suitable for flush mounting. The construction shall conform to appropriate Indian Standard Specifications. The instruments shall be capable of indicating freely without error when operated continuously at any ambient temperature from 0 deg. to 50 deg. C. They shall withstand the effects of shock, vibration and humidity. All circuits of instruments shall be capable of withstanding 20% overload for a period of at least 8 hours. All instruments shall be provided with suitable means of adjusting the accuracy in a laboratory. KWH meters specified shall be of commercial grade accuracy. Ammeter and voltmeter shall be with accuracy of +/- 1% of full scale value.

7.14.12 RELAYS

The relays shall be suitable for operation within a temperature range of 0 deg. c to 50 deg. C. The contacts of the relays shall be silvered. When open, the contacts shall withstand a voltage of 110% of the normal circuit voltage of the contacts. The relays shall not deteriorate in performance due to ageing of any constituent material.

The relays shall generally comply with the requirements of I.S.S. 3842.

7.14.13 A.C. DISTRIBUTION BOARD SCHEME

Power will be fed to A.C. distribution board through 2 Nos. incoming breakers separately from one no. 250 KVA station service transformer. Normally two feeders will feed power to two sections of A.C.D.B. coupled through a bus coupler breaker. Normally this coupler breaker will be kept upon when both the incomers are kept on. In case of failure of any one of the incomer, this bus-coupler will be made ON. These two incomers breakers and the bus coupler will be interlocked through castle interlock so that any two of the three breakers can be kept on at a time, Suitable scheme for electrical interlock and automatic switching on of the bus-coupler in the event of tripping of any of the healthy incomer is to be taken up by the bidder. Suitable annunciation for failure of A.C supply and for any of the incomer is to be provided.

A 415 V single line diagram accommodating the above facilities and to suit the system is to be design and submitted to the Employer for approval. However, exact requirement layout is to be taken up by the contractor depending on the layout, rating and type of equipment for preparation of drawing.

7.14.14 PROTECTION SCHEME FOR INCOMING CIRCUIT BREAKER

Each incoming circuit to the L.T. switchboard shall be preceded by thermal overload relays, short circuit release and over current and earth fault relays.

The breaker shall also be provided with under-voltage release of tripping out in case of supply failure.

220/240 volts D.C. operated audible as well as visible alarm with cancellation device shall be provided for the auto trip of the breakers.

7.14.15 CURRENT TRANSFORMERS

The current transformer to be provided with the incoming/outgoing circuit for metering shall be air-cooled of class 'CM' accuracy. The VA burden should be such as to suit the requirements. C.Ts shall be bar primary type moulded/cast resin type. The current transformer shall be manufactured and tested according to relevant I.S.S.

7.14.16 INSULATION LEVEL

The insulation at any point of the wiring in switchboards shall be suitable for 1100/660 volts grade service.

TEST – TYPE TEST REPORT shall be furnished.

7.15 DC supply equipment

General scheme

At 400kV and 220kV substations, each DC supply system (50V and 220V dc) shall comprise duplicate batteries and battery chargers**,** a dc distribution board and control gear. The system shall be arranged such that only one of the station batteries and one of the battery chargers shall be in service at any one time, but should either item of equipment fail or need to be taken out of service for maintenance, then the duplicate item of equipment can be brought into service without disruption of supplies. Battery chargers shall be provided with an automatic change-over facility that will operate should one of the charger units fail.

At 132kV substations, each DC supply system shall be provided with one battery and one battery charger, dc distribution board and control gear for 220V DC. However the 50V DC system shall be duplicated as in case of 400/220kV substation.

Each battery shall be either of the lead acid or alkaline type and comprise a sufficient number of cells to provide the required rating. The battery charger shall be capable of float charging the battery, from the AC supply voltage specified. A facility shall be provided for boost charging individual battery cells in situ, by means of wander leads.

The batteries shall be located in a battery room and connected to the distribution boards and battery charger located in an adjacent room via a fuse box located in the battery room.

Where the battery size is less than 200 Ah, and the cells are of the totally enclosed type, consideration will be given to housing the battery in a sheet steel cubicle mounted alongside the charger and distribution board so as to form a complete suite of panels.

The 220V DC power supplies system will operate with both battery terminals free of earth whilst that for communications equipment (the 50V DC power supply) will operate with the positive pole permanently earthed. A suitable earth fault detection scheme shall be provided.

The battery rated output shall be that available at the outgoing terminals, after making due allowance for the resistance of inter cell connections.

The battery size selected by the Contractor shall be proved by calculation which shall be subject to the approval of the Project Manager. Allowance shall be made for ageing of the battery during its service life.

Earthing of current free metallic parts on the body of the distribution boards shall be done with soft drawn bare copper bus. Tail connections shall have a minimum cross sectional area of 16 mm^2 and the main earth bar for the distribution shall be brought out to two terminals for connection to the station earth grid.

Earthing connections shall be carried out with green wire and the earthing studs shall be identified as such by an earthing symbol.

The distribution board shall be provided with 240V single phase ac illumination and anti-condensation space heaters and each heater shall be provided with an ON/OFF switch.

7.15.1 TECHNICAL SPECIFICATION FOR INDOOR TYPE 220 VOLT D.C. SYSTEM POWER DISTRIBUTION SWITCH BOARDS

7.15.2 SCOPE

This specification covers manufacture, assembly and testing at manufacturer's works, supply and delivery of Indoor Type 230 volts D.C. Power Distribution on Switchboards complete in all respects as per system requirement for 220/132/33 KV substation and switchyards. 20% spare feeders shall be provided in each DCDB.

7.15.3 STANDARDS

The equipment covered by this specification shall unless otherwise specified, be built to conform to Indian Electricity Rules 1956 wherever applicable. Permissible temperature rise shall be as per relevant ISS.

Switchboard Design

The switchboards shall be self supporting steel cubicle compartmentalized fully enclosed with doors for access to the interior. The switchboards shall comprise of non/draw out type panels placed side by side to form a continuous unit with access door for each panel at the rear. 12 SWG sheet shall be used for fabrication of the panels. Modular type construction for interchangeability will be preferred.

The complete panels shall not be more than 2250 mm. high with me channel base and 600 mm. depth measured from rear to front faces and of suitable width.

The working height shall be limited to maximum of 2000 mm. The design shall be such as to permit extension at site on either end. The bottom of the switchboard frame shall be suitable for erecting flush on concrete floor by securing it by means of evenly spaced grouting bolts projecting through the base channels. The panels shall be designed to facilitate cable entry from the bottom and removable plants shall be supplied along with the panels for this purpose which will be drilled at site to fit the cable glands.

The switchboards shall be vermin proof and suitable for use in tropical climate. All ventilating louvers and oleos shall be covered with fine wire-mesh from inside or inbuilt type. All control and power cables will be paid in open distribution trenches running under the D.C. Switchboards. The cable will enter the cubicles through entry holes of removable plates provided at the bottom of the cubicles. The successful bidder shall furnish foundation drawings for the switchboards showing the cable entry holes required and the position of the foundation bolts.

The switchboards shall be supplied complete with channel base, removable bottom plates, grounding bolts, lock nuts, washers, etc. and cable glands as specified hereafter. All unfinished surfaces of the steel panels and frame work shall be free from adhering matter or grease. A suitable rust resisting primer paint shall be applied on the interior and exterior surface of the steel housing followed by application of an undercoat to serve as base and binder. The finishing coat on the exterior of the switchboards shall be polished cellulose enamel, or dark battleship grey, evenly sparyed to present a fine appearance, while the interior faces shall be approved with a finishing coat of light grey paint to provide a contrasting background for the wiring inside the cubicle.

A small quantity of finishing paint shall be supplied with each consignment or the switchboards to enable the Employer to restore at site any surface finish which may get damaged during transit.

7.15.4 BUS BARS

The bus bar shall be of E.G. copper/aluminum alloy, liberally sized for the specified current rating (both short circuit and continuous currents). The size of bus bars shall be such that the current density is not more than (1A/1.75A) per sq. mm. for aluminum alloy and copper respectively at rated capacity. Necessary precaution shall be taken to avoid bimetallic action where copper conductors shall be connected to the aluminum bus. Means shall be provided for identifying the positive and negative bus bars. Bus supports shall be of arc resistant, non-tracking, low absorption type insulators of high impact strength and high creep age surface.

The bus and connections shall be so supported as to be capable of safety withstanding stresses due to maximum short circuit current and also take care of any thermal expansion.

The droppers/risers from or to the bus bars should not be twisted but reasonable bend or joint may be allowed.

7.15.5 MCCB/MCB

All incomer feeders will be provided with DC MCCB and all outgoing feeders with DC MCB conforming to latest IS : standards as per system requirements.

7.15.6 FUSE

Fuses shall be HRC link type of renowned make conforming to latest issue of ISS 2208. Rewirable fuses shall not be supplied.

Fuse shall be complete with fuse bases and fittings of such design as to permit easy replacement of the fuse elements.

Link shall also be easily replaceable. Visible indication shall be provides on blowing of the fuse.

7.15.7 INDICATING LAMPS

Indicating lamps shall be LED type provided with suitable safety resistor and coloured dust-tight lens. Lamps shall be of very low wattage consumption and heat generated due to continuous burning shall not deteriorate lamp cover.

7.15.8 CABLE TERMINATION

Switch boards shall be designed to facilitate PVC cable entry from the bottom of the switchboard. Removable places shall be supplied for this purpose which will be drilled at site to fit the cable glands.

Sufficient space shall be provided to avoid sharp bending and for easy connection

Cables shall be PVC insulated, armored and PVC sheathed with 7/0.029" copper conductor for control and for feeders up to 15 Amps. Rating. Rest of the power cable shall be of aluminum conductor of suitable size as per feeder rating.

Multiway terminal blocks of sturdy construction complete with screws, nuts. Washers and marking strips shall be furnished for terminating the internal wiring and outgoing cables.

Power terminal shall be complete with lugs and control terminals shall be clamp type. Scew type terminals with screw directly impinging on conductor shall not be supplied. Connectors built from cells of moulded dielectric and brass stud inserts shall be provided for terminating the internal wiring and outgoing cables.

Each terminal for 25 Amps. Feeders shall be capable for connection of 2 Nos. 7/0.029" copper wires at one end without any damage to the connector or any looseness of connection. The terminals shall be properly tagged and ferruled in compliance with approved drawings. The terminal blocks shall be readily accessible and those shall be rust proof and of best quality.

7.15.9 WIRING

The wiring shall be complete in all respect so as to ensure proper functioning of control, protection and interlocking scheme.

All wiring shall be complete up to the terminal blocks at the factory. The insulation grade of wire to be used for internal wiring if the switch board shall be 1100 volts grade. Wiring shall be carried out with flexible heat resistant, switchboard wires PVC insulated with 2.5 sq.mm. stranded copper conductors.

Earth wire shall be identified at both ends with ferrules showing wire designations in accordance with bidder's wiring diagram. Wires shall not be spliced or tapped between terminal points.

Each wire shall be continuous and there shall not be any joint within itself. Individual wire shall be connected only at the connection terminals, blocks, meters, relays, instruments and other devices used in the switchboards. Red ferrules with positive marking shall be used for positive terminals and white ferrule with negative marking shall be used for negative terminals for D.C. wiring.

Wires shall be beatly bunched and adequately supported so as to prevent sagging and strain on termination. All spare contacts of the equipment shall be wired up to the terminal block.

7.15.10 SAFETY EARTHING

Earthing of current free metallic parts of metallic bodies of the equipment on the switchboards shall be done with soft drawn bare copper bus Tail connections shall have minimum area of 26 sq. mm. and the main earth connection for each switchboards shall be brought out to two terminals for connection with the station earthing system.

Earth terminals should be identified by means of the sign marked in a legible and indelible manner on or adjacent to the terminals. Earth lugs shall be provided and all earthing connections shall be carried out with green wires.

7.15.11 SWITCH BOARD LIGHTING

The interior of each panel switchboard shall be illuminated by CFL lamps connected to 230 volts. Single phase A.C. supply and shall be controlled by a door-operated swich. All A.C. wiring shall be carried out with black wires. The incoming A.C. supply to the D.C. boards shall be provided with H.R.C. fuse and link of proper rating.

7.14.17 INDICATING INSTRUMENTS

All instruments shall be of switchboard type, back-connected suitable for flush mounting. The construction shall conform to the appropriate Indian Standard Specifications. The instruments shall be capable of indicating freely without error when operated continuously at any ambient temperature from 0 deg. C to 50 deg. C. Those shall withstand the effects of shock, vibration and humidity. All circuits of instruments shall be capable of withstanding 20% overload for a period of at least 8 hours.

7.15.13 COMPLETENESS OF SUPPLY

The switchboards offered by the bidder shall be complete in all respects. Any materials necessary which may not have been specifically mentioned but which is usual or necessary for satisfactory and trouble-free operation and maintenance of the switchboards shall be supplied without any extra charge to the employer.

7.15.14**SPARES**

The item wise price for the spares recommended for three years operation and maintenance of each switchboard shall be quoted.

7.15.15**INTER CHANGEABILITY**

All similar materials and removable parts shall be interchangeable with each other.

All switches, contactors, etc. shall be easily removable as a complete unit from the switchboards and shall be capable of being put in similar position in other switchboards for performing identical functions.

The spares called for in respective sections shall be identical with like parts provided in the main equipments in all respects and shall be capable of replacing the main equipments wherever required to carry out identical functions.

7.15.16**ACCEPTABILITY OF DIFFERENT EQUIPMENTS & AUXILIARIES**

All equipments, cables, wires and accessories offered shall be of best quality and of renowned make for successful and trouble free operation of the switchboards.

Equipments/accessories of substandard quality shall not be accepted by the Employer.

7.15.17**TESTS**

The following tests are to be carried out.

i) Checking continuity of the wiring.

ii) Insulation resistance of all wiring circuit with all equipments mounted on the board, before and after application of H.V.

iii) One minute power frequency voltage withstand test. All equipments and wiring shall withstand a power frequency voltage of 2 KV applied between any circuit and earth.

iv) Routine test of all equipments, switches and devices according to relevant I.S.S.

v) Type test reports shall be furnished.

7.15.18**CLEARANCE**

The apparatus forming part of the panel shall have requisite clearances and these shall be maintained during normal service conditions. When arranging the apparatus within the panels, the clearances for them shall be complied with taking into account the relevant service condition. In addition, abnormal conditions such as in short circuit shall not permanently reduce the distances between bus bars.

7.15.19**NAME PLATE OF D.C. SWITCHBOARDS**

Each panel shall be provided with name plates, marked in a durable manner and located in a place such that they are visible and legible when the panel is installed. The following information should be given on the name plate.

a) The manufacturer's name and /or 'trade mark' & identification number.

b) Rated operational voltage.

c) Purchase order number and date.

d) Weight.

7.15.20**D.C. SYSTEM**

The 220 volts .D.C. supply will be available from the lead acid station storage battery banks associated with battery charging equipment.

In the 220 KV system the D.C. supply will be available from two sources. So the system should be designed with provision for a bus coupler.

The battery shall normally float under trickle charge conditions with the charger which continuously supplies the D.C. load to the load bus in D.C. switchboard and trickle charging current to the battery. The charger will be connected to the bus through double pole switch fuse unit. These two double pole switch unit should be mechanically interlocked so that only one switch can be closed at a time. An emergency D.C. lighting system would be provided in each sub-station to operate a separate lighting system with D.C. power in case of total failure of A.C. supply. The D.C. lighting system would be completely independent from the normal A.C. lighting system. For this purpose, provision shall be made in the panel for main failure contactors with contacts rated for 32 Amps. And a switch on emergency lighting circuit across the D.C. but in the vent of main failure. The two switch fuse units required for D.C. lighting feeders shall be taken from the D.C. panel Board. D.C. fail alarm both audible and visual shall be provided in case of total failure of D.C. supply at the load bus as per drawing. 220 volts D.C. system single line diagram (No.SWG/570) is enclosed in Section-8 for guidance and understanding of D.C. system. As the entire D.C. system is to be designed by the contractor depending on the rating and type of equipment being supplied, the necessary modification in the schematic diagram has to be taken up by the contractor and got approved from the Engineer.

8. BAY MARSHALLING KIOSK:

8.1: Same as ACDB but out door type. The purposes of these boards are to be installed in the switch yard at different locations. There shall be two incomer as source I and source II. There shall be adequate AC out lets both 3 phase with neutral and single phase, which will be taken to all the equipments and equipment marshalling boxes. At lest 20% extra outlets are to be provided besides the requirement to meet during exigencies. All the inlet and out lets shall be provided with MCB's. The board shall have two doors one at front and the other at the rear end. Since these boards are to be installed out side in the switch yard sufficient care as per the relevant standards are to be taken care fomr weathering effect. At the front end all AC inlets and out lets are to be provided and at the rear end terminal blocks are to be provided in column wise for DC control /AC control purpose. The minimum quantity of terminal blocks of rating 20 Amps shall be 300 nos with duly marked the number of terminals. At the front side also

adequate capacity (current rating) as per the rating of MCB terminal blocks to be provided for inlet and out let points of AC supply.

8.2 Proper engineering to be made and to be submitted for approval to OPTCL before manufacturing and supply. The components and wirings to be used shall be of as per IS standard and of reputed make.

9. AC CONSOLES:

9.1: Same as ACDB but out door type suitable for use in switchyard illumination control. Adequate nos of MCB,s for incoming and outlets are to be provided in the console to take care of the switch yard illumination system. No of such boards will be as per requirement. Care should be taken as these boards are of outdoor type. 20 % extra outlets should be provided to meet the exigencies.

10. RECEPTACLE AC SUPPLY PANEL:

10.1: Receptacle panels both indoor and out door types are to be provided to meet the emergency requirement of AC supply. For example welding purpose, testing purpose etc. Both three phase and single phase out lets should be provided. One no receptacle panels outdoor type shall be provided near the transformer for oil filtration purpose. The rating of the inlet and out let MCCB, s shall be 250 Amp.

(A) DETAILS OF DISTRIBUTION BOARDS: (FOR 400/220 KV & 220/132 KV SUB-STATION)

1) MAIN ACDB:

a) Incomer - 1: 800 Amp/1600 Amp, 50KA, draw out type, Microprocessor Control, ACB. It shall contain 3 O/C & E/F relays with high setting provision, UV relay, Electrical Close/Open facility for ACB,ON/OFF lamp indication, Auto trip indication, TC healthy indication with P.B, Spring charge indication, R,Y,B healthy indication, Ammeter & voltmeter with selector switch, Annunciation facia with Acc, Reset and Test P.B.

b) One Bus-coupler: Same as Incomer 1 above.

c) Incomer – 2: Same as Incomer – 1 above.

d) Out going Feeders: (For Incomer – 1) ,1)250 Amp MCCB: 4 Nos,
2) 100 Amp MCCB: 4 Nos, 3) Spare compartment: 2 Nos.

e) Out going Feeders: (For Incomer – 2) , 1)250 Amp MCCB: 4 Nos,
2) 100 Amp MCCB: 4 Nos,3) Spare compartment:2 Nos

2) ACDB: R,Y,B Healthy Indication, Ammeter and voltmeter with selector switch.

a) Incomer -1: 250 Amp MCCB and 250 Amp MCCB for DG incomer.(with interlocking facility.

b) Out going feeder(for inc 1): 1) 63 Amp MCCB : 16 Nos 2) 32 A MCCB: 8 Nos

c) Bus coupler: 250 Amp MCCB

d) Incomer -2: 250 Amp MCCB and 250 Amp MCCB for DG incomer. (With interlocking facility.

e) Out going feeder (for Inc 2): 1) 63 Amp MCCB: 16 Nos 2) 32 A MCCB: 8 Nos

3) MAIN LIGHTING DB: R, Y, B Healthy Indication, Ammeter and voltmeter with selector switch.

a) Incomer -1: 250 Amp MCCB.

b) Out going feeder (for inc 1): 1) 63 Amp MCCB: 4 Nos 2) 32 A MCCB: 2 Nos

c) Bus coupler: 250 Amp MCCB

d) Incomer -2: 250 Amp MCCB

e) Out going feeder (for Inc 2): 1) 63 Amp MCCB: 4 Nos 2) 32 A MCCB: 2 Nos

4) INDOOR RECEPTACLE DB: R,Y,B Healthy indication.

a) Incomer: 63 Amp MCB

b) Out going: 32 Amp ,3 Phase,MCB: 2

c) Out going: 32 Amp ,1 Phase,MCB: 4

5) EMERGENCY LIGHTING DB:

a) Incomer: 100 Amp MCCB

b) Out going: 63 Amp ,3 Phase,MCB: 2

c) Out going: 32 Amp ,1 Phase,MCB: 4

d) Out going: 16 Amp ,1 Phase,MCB: 8

6) 220 V DC Indoor Ltg. DB:
a) Incomer : 32 Amp DC MCB from DCDB with auto changeover facility having delay timer with auto/manual selection switch.
b) Outgoing feeder: 16 Amp DC MCB: 5 Nos

7) 220 V DCDB (SET):

7.1) 220 V DC DB:1: Having Earth fault relay (Earth leakage), Under and over voltage, DC Ammeter and Voltmeter. Annunciation scheme.
a) Incomer: 100 Amp DC MCCB:
b) Out going: 100 Amp DC MCCB : To couple the other DCDB
c) Out going feeder: 32 Amp DC MCB: 20 Nos.

7.2) 220 V DC DB:2: Having Earth fault relay (Earth leakage), Under and over voltage, DC Ammeter and Voltmeter. Annunciation scheme.
a) Incomer: 100 Amp DC MCCB:
b) Out going: 100 Amp DC MCCB : To couple the other DCDB
c) Out going feeder: 32 Amp DC MCB: 20 Nos.
(* 220 V DCDB-1 & 220 V DCDB-2 combined shall be treated as 220 V DCDB).

8) 48 V DCDB (SET):

8.1) 50 V DC DB:1: Having Earth fault relay (Earth leakage), Under and over voltage, DC Ammeter and Voltmeter. Annunciation scheme.
a) Incomer: 100 Amp/250 Amp DC MCCB:
b) Out going: 100 Amp/250 Amp DC MCCB: To couple the other DCDB
c) Out going feeder: 32 Amp DC MCB: 20 Nos.

8.2) 50 V DC DB:2: Having Earth fault relay (Earth leakage), Under and over voltage, DC Ammeter and Voltmeter. Annunciation scheme.
a) Incomer: 100 Amp/250 Amp DC MCCB:
b) Out going: 100 Amp/ 250 Amp DC MCCB: To couple the other DCDB
c) Out going feeder: 32 Amp DC MCB: 20 Nos.
(* 50 V DCDB-1 & 50 V DCDB-2 combined shall be treated as 50 V DCDB)

9) BMK (Suitable for Outdoor type) (Provision of telephone jack points)
a) Incomer : 63 Amp TP MCB : 1 for source - 1 and 1 for source -2 (with timer,for auto changeover, contactors (two nos each rated 70 Amp) suitable to take care of changeover automatically.)
b) Out going feeder: 16 Amp TP MCB : 10 Nos , 10 Amp DP MCB: 8 Nos (at Front side)
c) 300 Nos of Terminal Block of Elmex/ any renowned make suitable for 35 Amp rated.

10) OUTDOOR RECEPTACLE DB: (Transformer filtration purpose)
a) Near Transformer: Incomer 250 Amp MCCB: 1 No., Outgoing: 250 Amp MCCB : 1 No., Having provision of R,Y,B indication. (For transformer oil filteration)
b) Inside switch yard at Different location: Incomer: 63 Amp TPN MCB, Out going feeder: 2 Nos 32 Amp TP MCB and 2 Nos 16 Amp DP MCB.

All outdoor kiosk top cover shall be of Aluminum alloy having 3mm thickness & proper sloping shall be maintained for easy drainage of water.

(B) DETAILS OF DISTRIBUTION BOARDS: (FOR 132/33 KV SUB-STATION)

1) MAIN ACDB:

a) Incomer - 1: 800 Amp Amp, 50KA, draw out type, Microprocessor Control, ACB. It shall contain 3 O/C & E/F relays with high setting provision, UV relay, Electrical Close/Open facility for ACB,ON/OFF lamp indication, Auto trip indication, TC healthy indication with P.B, Spring charge indication, R,Y,B healthy indication, Ammeter & voltmeter with selector switch, Annunciation facia with Acc, Reset and Test P.B.

b) One Bus-coupler: Same as Incomer 1 above.

c) Incomer – 2: Same as Incomer – 1 above.

INCOMER -1:

(a) 250 Amp TPN MCCB: 2 Nos. and (2) 250 Amp TPN MCCB for DG incomer.(with interlocking facility.

b) Out going feeder : 1) 63 Amp TP MCCB : 16 Nos (3 phase). 2) 32 A TP MCB: 8 Nos (3 phase)

c) Out going feeder: (1) 100 Amp TP MCCB: 02 Nos.(3 phase)

d) Out going feeder: 32 Amp DP MCB (1 phase)

INCOMER -2:

(a) 250 Amp TPN MCCB: 2 Nos. and (2) 250 Amp TPN MCCB for DG incomer.(with interlocking facility.

b) Out going feeder : 1) 63 Amp TP MCCB : 16 Nos (3 phase). 2) 32 A TP MCB: 8 Nos (3 phase)

c) Out going feeder: (1) 100 Amp TP MCCB: 02 Nos.(3 phase)

d) Out going feeder: 32 Amp DP MCB (1 phase)

2) MAIN LIGHTING DB: R, Y, B Healthy Indication, Ammeter and voltmeter with selector switch.

a) Incomer -1: 250 Amp MCCB.

b) Out going feeder (for inc 1): 1) 63 Amp MCCB: 4 Nos 2) 32 A MCCB: 2 Nos

c) Bus coupler: 250 Amp MCCB

d) Incomer -2: 250 Amp MCCB

e) Out going feeder (for Inc 2): 1) 63 Amp MCCB: 4 Nos 2) 32 A MCCB: 2 Nos

3) INDOOR RECEPTACLE DB: R,Y,B Healthy indication.

a) Incomer: 63 Amp MCB

b) Out going: 32 Amp ,3 Phase,MCB: 2

c) Out going: 32 Amp ,1 Phase,MCB: 4

4) EMERGENCY LIGHTING DB:

a) Incomer: 100 Amp MCCB

b) Out going: 63 Amp ,3 Phase,MCB: 2

c) Out going: 32 Amp ,1 Phase,MCB: 4

d) Out going: 16 Amp ,1 Phase,MCB: 8

5) 220 V DC Indoor Ltg. DB:

a) Incomer : 32 Amp DC MCB from DCDB with auto changeover facility having delay timer with auto/manual selection switch.

b) Outgoing feeder: 16 Amp DC MCB: 5 Nos

6) 220 V DCDB (SET):

6.1) 220 V DC DB:1: Having Earth fault relay (Earth leakage), Under and over voltage, DC Ammeter and Voltmeter. Annunciation scheme.

a) Incomer: 100 Amp DC MCCB:

b) Out going: 100 Amp DC MCCB : To couple the other DCDB

c) Out going feeder: 32 Amp DC MCB: 20 Nos.

6.2) 220 V DC DB:2: Having Earth fault relay (Earth leakage), Under and over voltage, DC Ammeter and Voltmeter. Annunciation scheme.

a) Incomer: 100 Amp DC MCCB:

b) Out going: 100 Amp DC MCCB : To couple the other DCDB

c) Out going feeder: 32 Amp DC MCB: 20 Nos.

(* 220 V DCDB-1 & 220 V DCDB-2 combined shall be treated as 220 V DCDB).

7) 48 V DCDB (SET):

7.1) 50 V DC DB:1: Having Earth fault relay (Earth leakage), Under and over voltage, DC Ammeter and Voltmeter. Annunciation scheme.

a) Incomer: 100 Amp/250 Amp DC MCCB:

b) Out going: 100 Amp/250 Amp DC MCCB: To couple the other DCDB

c) Out going feeder: 32 Amp DC MCB: 20 Nos.

7.2) 50 V DC DB:2: Having Earth fault relay (Earth leakage), Under and over voltage, DC Ammeter and Voltmeter. Annunciation scheme.

a) Incomer: 100 Amp/250 Amp DC MCCB:

b) Out going: 100 Amp/ 250 Amp DC MCCB: To couple the other DCDB

c) Out going feeder: 32 Amp DC MCB: 20 Nos.

(* 50 V DCDB-1 & 50 V DCDB-2 combined shall be treated as 50 V DCDB)

8) BMK (Suitable for Outdoor type) (Provision of telephone jack points)

a) Incomer : 63 Amp TP MCB : 1 for source - 1 and 1 for source -2 (with timer,for auto changeover, contactors (two nos each rated 70 Amp) suitable to take care of changeover automatically.)

b) Out going feeder: 16 Amp TP MCB : 10 Nos , 10 Amp DP MCB: 8 Nos (at Front side)

c) 300 Nos of Terminal Block of Elmex/ any renowned make suitable for 35 Amp rated.

9) OUTDOOR RECEPTACLE DB: (Transformer filtration purpose)

a) Near Transformer: Incomer 250 Amp MCCB: 1 No., Outgoing: 250 Amp MCCB : 1 No., Having provision of R,Y,B indication. (For transformer oil filteration)

b) Inside switch yard at Different location: Incomer: 63 Amp TPN MCB, Out going feeder: 2 Nos 32 Amp TP MCB and 2 Nos 16 Amp DP MCB.

All outdoor kiosk top cover shall be of Aluminum alloy having 3mm thickness & proper sloping shall be maintained for easy drainage of water.

ODISHA POWER TRANSMISSION CORPORATION LIMITED

TECHNICAL SPECIFICATION

FOR

CONDUCTOR, AL TUBE G.I GROUND WIRE,

INSULATORS, HARDWARE, CLAMPS & CONNECTORS

SECTION-I

CONDUCTORS

S E C T I O N - I

TECHNICAL SPECIFICATION OF ACSR "MOOSE","ZEBRA", AND " PANTHER" CONDUCTORS

1. **SCOPE :-**

1.1. This specification provides for the manufacture, testing, supply and delivery at destination of the steel cored aluminum conductors as per Appendix-I attached.

2. **STANDARDS :-**

2.1 The conductors shall comply in all respects to the clauses of this specification as indicated below & with the Indian Standard Specification, International standards with latest amendments. Some of the standards are :-

i) IS 398 - Specification for Aluminium Conductors for overhead transmission purposes,

IS 398, Part-II-Aluminium conductors for overhead Transmission purpose - Specification

ii) IS 1521, 1972 - Method of tensile testing of steel

iii) IS 1778 -1989 – Reel & drums for bare conductors.

iv) IEC - 1098

3. **MATERIALS :-**

3.1 The material offered shall be of best quality and workmanship. The steel Cored Aluminum conductor strands will consist of hard-drawn aluminum wire manufactured from 99.5% pure electrolytic aluminum rods of E.C. Grade. The steel wire shall be made from materials produced either by the acid or basic open hearth process or by electric process. No steel wire drawn from pressmen process shall be used. The steel wire shall not contain sulphur or phosphorus exceeding 0.05 percent, and the total of sulphur and phosphorus shall not exceed 0.085 percent.

3.2 The steel wires shall be evenly and uniformly coated with zinc complying with Indian Standard 4826-1979 specification for galvanized coatings on round steel wires. The uniformity of zinc coating and the weight of coating shall be in accordance with Appendix-II. The coating on the galvanized steel wires may be applied by the hot process or the electrolytic process.

4. **SIZES :-**

4.1 The size of steel-cored Aluminum Conductors shall be as given in Appendix-I. The resistance and weights shall be in accordance with the values given in the same appendix.

5. **TOLERANCES :-**

5.1 The following tolerances shall be permitted on standard diameter of aluminum wires.

Tolerance on standard diameter of aluminum wire $\pm$ 1 percent. wires.

Note : - The cross-section of any wire shall not depart from circularity by more than an amount corresponding to a tolerance of 2 percent on the standard diameter.

5.2 A tolerance of + 2 percent shall be permitted on the standard diameter of the galvanized steel wires. The variation from the approximate weights shall not be more than plus or minus 5 percent.

6. **MECHANICAL PROPERTIES : -**

6.1 The value of the final modules of elasticity for steel cored aluminum conductor in the average of values obtained from actual stress strain tests. The co-efficient of linear expansion for steel Cored Aluminum Conductors has been calculated on the basis of co-efficient of linear expansion of 23.0 x 10-6 per degree centigrade of aluminum and 11.5 x 10-6 per degree centigrade for steel and represent only the average values. These values shall however, be given by the bidder under the guaranteed technical particulars.

7. **SURFACE CONDITIONS :-**

7.1 The wires shall be smooth and free from inequalities, spills and splits. The surface conductor shall be free from points, sharp-edges, abrasions or other departures from smoothness or uniformity of surface contour that would increase radio interference and corona losses. When subjected to tension up to 50% of the ultimate strength of the conductor, the surface shall not depart from its cylindrical form nor any part of the component, parts or strands, move relative to each other in such a way as to get out of place and disturb the longitudinal smoothness of the conductor.

8. **JOINTS IN WIRES : -**

8.1 Aluminium wires : No joints shall be permitted in the aluminium wires in the outermost layer of the ACSR conductor. Joints in the inner layers are permitted, in addition to those made in the base rod or wire before final drawing, but no two such joints shall be less than 15 meter. apart in the complete stranded conductor. Such joints shall be made by cold pressure butt-welding.

Joints are not permitted in the outermost layer of the conductor in order to ensure a smooth conductor finish and reduce radio interference levels and corona losses on the extra high voltage lines.

8.2 Galvanized steel wires : - There shall be no joints except those in the base rod or wire before final drawing, in steel wires forming the core of the steel-reinforced aluminum conductor.

Joints have not been permitted in the steel wires after final drawing in order to avoid reduction in the breaking strength of the conductor that may occur as a result of failure of the joints.

9. **STRANDING :-**

9.1 The wires used in construction of a stranded conductor shall before stranding, satisfy all requirements of IS-398/ (part-II)1976 with latest amendments. For steel-cored aluminum conductors the lay ratio of the different layers shall be within the limits given under Appendix-I.

9.2 For all, constructions, each alternate layer shall be stranded in opposite directions. The wires in each layer shall be evenly and closely stranded round the under laying wire or wires. The final layer of wires shall have a right hand lay.

10. **PACKING AND MARKING : -**

10.1 The conductor shall be wound in non-returnable reels or drums conforming to Indian Standard 1978-1961 specification for Reels and Drums for Bare Wire, or any other authoritative standard and marked with the following : -

a)	Trade name, if any	b)	Contract/Award letter Number
c)	Name of manufacturer	d)	Name & Address of Consignee
e)	Drum Number	f)	Length of conductor
g)	Size of conductor	h)	Gross Weight of drum with conductor
i)	Weight of empty drum **with lagging.**	j)	Net and gross of conductor.
k)	Arrow marking of un-winding		

10.2 The reel shall be of such construction as to assure delivery of conductor in the field from displacement and damage and should be able to withstand all stresses due to handling and the stringing operations so that conductor surface is not dented, scratched or damaged in any way during manufacture, transport and erection. The conductor shall be properly lagged on the drums and the method of lagging to be employed may be clearly stated in the tender. It should be stocked to suit the reel and held in place by steel strapping. Lagging shall not be nailed or bolted in place.

10.3 The conductor drum should be suitable for wheel mounting. Before reeling, the card-board or other suitable material shall be secured to the drum and inside flanges of the drums. After reeling the conductor, the exposed surfaces should be wrapped with suitable soft material to prevent the conductor from dirt and grit. Any space between the drum lagging and conductor should be suitably filled with soft filler material compactly packed. The conductor drum shall be made as per the relevant IS.

11. **LENGTHS : -**

11.1 The conductor shall be supplied in the standard lengths **as below** with a permitted variation of 5%. Not less than 90% of the total quantity of the conductor shall be supplied in the standard lengths. Thus the quantity of the conductor in lengths shorter than standard ones shall not exceed 10% of the total quantity to be supplied. Further no single conductor lengths in respect of such 10% (Maximum supply) in random lengths, shall be shorter than 50% of the standard lengths.

Type of conductor	Length per drum.
MOOSE ACSR	1.1 K.M
ZEBRA ACSR	1.1 K.M.
PANTHOR ACSR	2.2 K.M.

12. TESTS AND TEST CERTIFICATES :-

The following type tests ,(& any other tests if purchaser decides to do), shall be conducted on the conductor at any Govt. approved laboratory or CPRI, in presence of the representatives of OPTCL, on the samples collected and sealed by the representative of OPTCL from the manufactured & offered

drums of conductor at random at free of cost to OPTCL or firm may quote their test charges which will be taken in to account during bid price evaluation. If test charges will not be quoted by the firm, it will be treated as nil during bid price evaluation & firm have to do the type tests at free of cost to OPTCL. **Also the tenderer shall furnish valid type test reports, the tests are as per the IS 398 (part-2) conducted in any govt. approved laboratory or CPRI within last 5 years, from the date of opening of the bid (Techno-commercial) document, without which their bids will not be considered for evaluation.**

12.1 Individual wire and finished steel cored Aluminum Conductor shall be subjected to before dispatch from the works, to the tests as per the provision of the Indian standard Specification 398 (Part-II-1976) with the latest amendments & as per the tests indicated in this specification below.

12.2 Samples for individual wires for test shall be taken before stranding form not less than 10 percent of the spiels in the case of aluminum wire and ten percent of the wire coils in the case of steel wires. If samples are taken after stranding, they shall be obtained by cutting 5 meters from the outer end of the finished conductor from not more than 10 percent of the finished reels.

12.3 The mechanical tests shall be carried out on single wires only.

12.4 The Tensile test shall apply to wires of all diameters forming part of steel cored aluminum conductors. If it is not possible to test the component wires before stranding the test may be made on wires taken from stranded conductors. The tensile strength of any of the wires shall not be less than the minimum values given in Appendix-II.

12.5 A suitable tensile testing machine shall be used the accuracy of which can easily be checked and the machine adjusted if necessary. The test sample before being placed in the machine, shall be straightened, if necessary in such a way as to cause the minimum alteration in its physical properties.

The load shall be applied gradually and rate of separation of the Jaws of the testing machine shall not be greater than 10cm/min. and less than 2.5cm/min.

TYPE TESTS

12.6 **Wrapping Test : -**

12.6.1 Samples of aluminium wires shall be wrapped round a wire of its own diameter to form a close helix of eight turns. Six turns shall then be unwrapped and again clearly wrapped in the same direction as before. The wire shall not break.

12.6.2 Samples of steel wires shall be closely wrapped eight times round a mandrel of diameter equal to four times the wire diameter. Six turns

shall then be unwrapped and again closely wrapped in the same direction as before. The wire shall not break.

12.7 **Galvanizing Test : -**

12.7.1 The uniformity of zinc coating and the weight of coating shall be as given in Appendix-II and shall be determined according to Indian Standard Specification 4826-1979. with latest amendments.

12.7.2 This test shall be made whenever practicable, on wires before stranding and before the specimen has been bent, straightened or tested in any other way.

12.8 **Ductility Test : -**

This test shall be made on galvanized steel wires only by any of the proceedings given in 12.8.1 and 12.8.2.

12.8.1 **Torsion Test : -** One specimen cut from each of the sample shall be gripped at its ends in two vices, one of which shall be free to move longitudinally during the test. A small tensile bond not exceeding 2% of the breaking load of the wire, shall be applied to the sample during testing. The specimen shall be twisted by consisting one of the vices to revolve until fracture occurs and the number of twists shall be indicated by a counter or other suitable device. The rate of twisting shall not exceed 60 rev/min.

When tested before stranding, the number of complete twists before fracture occurs shall not be less than 18 on a length equal to 100 times the diameter of the wire. The fracture shall show a smooth surface at right angles, to the axis of the wire.

When tested after stranding, the number of complete twists before fracture occurs shall be not less than 16 on a length equal to 100 times the diameter of the wire. The fracture shall show a smooth surface at right angles to the axis of the wire.

12.8.2 **Elongation Test : -** The elongation of one specimen cut from each of the samples shall be determined. The specimen shall be straightened by hand and on original gauge length of 200 mm shall be marked on the wire. A tensile load shall be applied as described in 12.5 and the elongation shall be measured after the fractured ends fitted together. If the fracture occurs outside the gauge marks, or within 25mm of either mark and the required elogation is not obtained, the test shall be disregarded and another test made. When tested before stranding, the elongation shall be not less than 4 percent. When tested after stranding, the elongation shall be not less than 3.5 percent.

12.9 Surface Condition Test

A sample of the finished conductor having a minimum recommended length of 5 meters with compression type dead end clamps compressed on both ends in such a manner as to permit the conductor to take its normal straight line shape, shall be subject to a tension of 50% of the UTS of the conductor. The surface shall not depart from its cylindrical shape nor shall the strands move relative to each other so as to get out of place of disturb the longitudinal smoothness of conductor. The measured diameter at any place shall be not less than the sum of the minimum specified diameters of the individual aluminum and steel strands.

12.10 **Ultimate Strength (UTS) Test on Stranded Conductor**

Circles perpendicular to the axis of the conductor shall be marked at two places on a sample of conductor of minimum 5 m length suitably compressed with dead end clamps at either end. The load shall be increased at a steady rate up to specified 50% of UTS and held for one minute. The circles drawn shall not be distorted due to Relative movement of strands. Thereafter the load shall be increased at a steady rate to the minimum UTS specified in Appendix-I and held for one minute. The applied load shall then be increased until the failing load is reached and the value recorded.

12.11 **Corona Extinction Voltage Test**

One sample of conductor of 5m length shall be strung. In case of twin conductor, two samples shall be arranged with the actual sub-conductor spacing between them. This sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than 320 KV (rms) for 400 KV and 176 KV (rms) for 220 KV system line to ground under dry condition. There shall be no evidence of corona on any part of sample when all possible sources of corona are photographed in a darkened room. The test shall be conducted without corona control rings. The voltage shall be corrected for standard atmospheric conditions.

12.12 **Radio Interference Voltage Test**

Under the conditions as specified in 12.11 above, the conductor samples shall have a radio interference voltage level below 1500 microvolts at one MHZ when subjected to 50HZ AC voltage of 1.1 times maximum line to ground voltage under dry condition. This test may be carried out with corona control rings and arcing horns.

12.13 **D.C. Resistance Test on Stranded Conductor**

On a conductor sample of minimum 5 m length two contact clamps shall be fixed with a pre-determined bolt torque. The resistance shall be measured by a Kelvin double bridge by placing the clamps initially zero meter and subsequently one meter apart. The test shall be repeated at least five times and the average value recorded. The value obtained shall be corrected to the value at 20 degree centigrade as per clause No.12.8 of IS : 398 (part V). The resistance corrected at 20 degree centigrade shall conform to the requirements of this specification.

12.14 **Stress-Strain Test**

12.14 (i)This test is contemplated only to collect the creep data of the conductor from the supplier. A sample of conductor of minimum 10 metres length shall be suitably compressed with dead end clamps.

12.14 (ii)**Test Set-up**

12.14 (ii) (a) The test sample shall be supported in a trough over its full length and the trough adjusted so that the conductor will not be lifted by more than 10 mm under tension. This shall be ascertained by actual measurement.

12.14 (ii) (b) The distance between the clamp and the sleeve mouth shall be monitored with callipers during the test to ensure that, after the test, it does not change by more than 1 mm +/-0.1mm from the value before the test.

12.14 (iii) (c) The conductor strain shall be evaluated from the measured displacements at the two ends of the gauge length of the sample. The gauge reference targets shall be attached to the clamps which lock the steel and aluminum wires together. Target plates may be used with dial gauges or displacement transducers and care shall be taken to position the plates perpendicular to the conductor. Twisting the conductor, lifting it and moving it from side-to-side by the maximum amounts expected during the test should introduce no more than 0.3mm error in the reading.

12.14 (iii)Test Loads for Complete Conductor

The loading conditions for repeated stress-strain tests for complete conductor shall be as follows :

12.14 (iii) (a) 1 KN load shall be applied initially to straighten the conductor. The load shall be removed after straightening and then the strain gauges are to be set at zero at zero tension.

12.14 (iii) (b) For non-continuous stress-strain data, the strain reading at 1 KN intervals at lower tensions and 5KN intervals above 30% of UTS shall be recorded.

12.14 (iii) (c) The sample shall be reloaded to 50% of UTS and held for 1 hour. Readings are to be noted after 5, 10, 15, 30, 45 and 60 minutes during the hold period. The load shall be released after the hold period.

12.14 (iii) (d) Reloading up to 70% of UTS shall be done and held for 1 hour. Readings are to be noted after 5, 10, 15, 30, 45, and 60 minutes and then the load shall be released.

12.14 (iii) (e) Reloading up to 85% of UTS shall be done and hold for 1 hour. Readings are to be noted after 5, 10, 15, 30, 45 and 60 minutes and then the load shall be released.

12.14 (iii) (f) Tension shall be applied again and shall be increased uniformly until the actual breaking strength is reached. Simultaneous readings of tension and elongation shall be recorded up to 90 % of UTS at the intervals described under Clause 12.14 (iii) (e).

12.14 (iv)**Test Loads for Steel core Only.**

The loading conditions for repeated stress-strain tests for the steel core of ACSR shall be as follows :

12.14 (iv) (a) The test shall consist of successive application of load applied in a manner similar to that for the complete conductor at 30%, 50%, 70% and 85% of UTS.

12.14 (iv) (b) The steel core shall be loaded until the elongation at the beginning of each hold period corresponds to that obtained on the complete conductor at 30%, 50%, 70% and 85% of UTS respectively.

12.14 (v)Stress Strain Curves

The design stress-strain curve shall be obtained by drawing a smooth curve through the 0.5 and 1 hour points at 30%, 50%, and 70% of UTS loadings. The presence of any aluminum slack that can be related to any observed extrusion entering the span from the compression dead ends shall be removed from the lower ends of the design curves. Both the laboratory and design stress-strain curves shall be submitted to the purchaser along with test results. The stress-strain data obtained during the test shall be corrected to the standard temperature i.e. 20 degree centigrade.

12.15 Chemical Analysis of Zinc

Samples taken from the Zinc ingots shall be chemically/ spectrographically analyzed. The same shall be in conformity to the requirements stated in this specification.

12.16 Chemical Analysis of Aluminum and Steel

Samples taken from the Aluminum ingots/ coils/ strands shall be chemically/ spectrographically analyzed. The same shall be in conformity to the requirements stated in this specification.

ROUTINE/ACCEPTANCE TESTS

12.17 Visual and Dimensional Check on Drums

The drums shall be visually and dimensionally checked to ensure that they conform to the requirements of this specification. Drum dimensions should confirm to **IS: 1778**.The flange diameter, traverse width, barrel diameter and flange thickness are to be as per relevant standard.

12.18 Visual Check for Joints, Scratches etc.

Conductor drums shall be rewound in the presence of the inspector. The inspector shall visually check for scratches, joints, etc. and that the conductor generally conforms to the requirements of this specification.

12.19 Dimensional Check of Steel and Aluminum Strands

The individual strands shall be dimensionally checked to ensure that they conform to the requirements of this specification.

12.20 Check for Lay-ratios of various Layers

The lay-ratios of various layers shall be checked to ensure that they conform to the requirements of this specification.

12.21 Breaking load test on welded Aluminum strand & Individual wires

Two Aluminum wires shall be welded as per the approved quality plan and shall be subjected to tensile load. The welded point of the wire shall be able to withstand the minimum breaking load of the individual strand guaranteed by the supplier.

12.22 Ductility Test

12.23 wrapping test

12.24 Resistance test

12.25 Galvanising Test

13. RETEST AND REJECTION : -

13.1 Each coil or spool selected for testing shall be tested for compliance with the requirements of Indian Standard Specification 398 (part-II) 1976 with latest amendment if any selected coil or spool not fulfill any of the test requirements, that

particular coil or spool shall be withdrawn. In respect of each failure, two test pieces shall be selected from two different coils in the lot and subjected to the test under which the failure occurred. If either of the two retest pieces fails to pass that test, the lot concerned shall be rejected.

If samples are taken for test after stranding and if any selected reel fails in the retest, the manufacturer may test each and every reel and submit them for further inspection. All rejected materials shall be suitably marked and segregated.

14. **GUARANTEED TECHNICAL PARTICULARS : -**

The bidder shall fill in the guaranteed technical particulars in the Performa at Appendix-IV and submit the same with his tender, without which bid will not be considered.

15. **SAG TENSION CHARTS AND SAG TEMPLATES : -**

The contractor shall supply each six copies of sag tension charts and sag templates in respect of each type of the steel core aluminum conductor. The Contractor shall also supply sag template in celluloid which shall be subject to the approval by the purchaser and without involving any extra charges. The design data of the lines on which these conductors will be used are given in **Appendix-III.**

A P P E N D I X - I

ACSR CONDUCTOR:		MOOSE	ZEBRA
1.	Size of conductor: mm	54/7/3.53 mm	54/7/3.18
2.	Stranding and wire diameter		
	Aluminum	54/3.53 mm	54/3.18 mm
	Steel	7/3.53 mm	7/3.18 mm
3.	Sectional area of Aluminum (in $mm^{2)}$	528.50	428.90
4.	Approximate total mass (in Kgs/KM)	2004	1622
5.	Calculated resistance at 20°C Max.: (in Ohms/Km.)	0.05552	0.06868

6.	Calculated breaking load of: composite conductor (in KN) (U.T.S.) (Min)	161.20 KN	130.32 KN.
7.	Lay Rating :-		
	Steel core	Max – 18 Min - 16	Max- 28 Min-13
	Aluminium Layers		
	12 Wire Layer	Max – 14	Max-17
	(Innermost Layer)	Min – 12	Min - 10
	18 Wire Layer	Max -13	Max - 16
	(Lay immediately beneath outside Layer)	Min – 11	Min - 10
	24 wire layer (outside layer)	Max -12 Min -10	Max - 14 Min - 10
8.	Modulus of elasticity (in Kg / mm^2):	6860	8158
			0.7036×10^6 Kg x CM^2 (69 GN per Sq. meter)
9.	Co-efficient of linear expansion of conductor per degree centigrade.	----------19.3×10^{-6} ----------	
10.	Standard area of Cross Section in mm^2 Sq. mm of conductor.	597.0 mm^2	484.5
11.	Diameter of complete conductor in	31.77 mm	28.62 mm

A P P E N D I X - II

Solid Steel and Aluminum Wires used in Steel cored Aluminum Conductors

		ZEBRA		MOOSE	
1.	Diameter	Steel	Aluminum	Steel	Aluminium
	Standard (in mm)	3.18	3.18	3.53	3.53
	Maximum (in mm)	3.24	3.21	3.60	3.55
	Minimum (in mm)	3.12	3.15	3.46	3.51
2.	Cross Sectional Area of nominal Diameter Wire (in mm^2)	7.942	7.942	9.791	9.791
3.	Weight (in Kg/KM)	61.95	21.47		
4.	Minimum tensile strength:	As per relevant ISS			
5.	Minimum breaking load before stranding (in KN)	10.43	1.29	12.86	1.57
6.	Minimum breaking load: after stranding (in KN)	9.91	1.23	12.22	1.49
7.	Zinc coating of steel strands				
	Number and duration: of dips	3 (1 Min. dip)		3 dips of 1min	
	Minimum Weight of : Coating (in gm/ $m^{2)}$ (A s per IS-4826 –1979)	260		260	
8.	Maximum resistance at: 20°C of Aluminum strands (in Ohms / KM)	3.626	2.974	2.921	
9.	Minim Purity of aluminum rod:	----------99.5 %----------			

A P P E N D I X – III

	ACSR CONDUCTOR:	ZEBRA	MOOSE
1.	Conductor	---------Steel cored Aluminum-----	
	(a) Copper equivalent: mm^2		
	(b) Stranding (in mm)	54/7/3.18	54/7/3.53
2.	Normal Span.	320 Meters	
	Wind Span.	320 Meters	
	Weight Span.		
	(a) Max.	500 Meters	
	(b) Min.	50 Meters	
3.	Wind Pressure on full project area.	52 Kgf per M^2	
4.	Temperature		
	(a) Minimum	5 ° C	
	(b) Maximum	67 ° C	
	(c) Every day	32°C	
5.	Factors of safety : Minimum		
	(i) Every day temperature and no wind.	4.00	
	(ii) Minimum temperature and 2/3 maximum wind :	2.00	
	(iii) Every day Temperature and full wind	2.00	
	This is as per Indian Electricity Rules, 1956.		
6.	Relative Humidity.		
	Maximum.	100 Percent	
	Minimum.	60 Percent	
7.	Isoceramic level.	100/Years	
8.	Number of rainy days per year.	100 days	
9.	Average rainfall per year	1150 mm. approx.	
10.	Altitude.	Less than 350 Metres.	

Technical parameters

Sl. No.	Description	ACSR MOOSE	
1	Stranding and wire diameter	54Al /3.53 mm+7 Steel/3.53 mm	
2	Number of Strands		
	Steel centre	1	
	1st Steel Layer	6	
	1st Aluminium Layer	12	
	2nd Aluminium Layer	18	
	3rd Aluminium Layer	24	
3	Sectional area of aluminium	528.5 mm^2	

4	Total sectional area	597.00 mm^2	
5	Overall diameter	31.77 mm	
6	Approximate weight	2004 kg/km	
7	Calculated DC resistance at 20 °C	0.05596 Ω/km	
8	Minimum UTS	161.2 kN	
9	The details of aluminium strand are as follows:		
	Minimum breaking load of strand before stranding	1.57 kN	
	Minimum breaking load of strand after stranding	1.49 kN	
	Maximum DC resistance of strand at 20 °C	2.921Ω/km	
10	The details of steel strand are as follows		
	Minimum breaking load of strand before stranding	12.86 kN	
	Minimum breaking load of strand after stranding	12.22 kN	
11	Minimum number of twist to be with stood in torsion test when tested on a gauge length of 100 times diameter of wire	18 - before stranding 16 - after stranding	
12	Tolerances		
12a	Diameter of aluminium strands Standard	3.53 mm	
	Maximum	3.55 mm	
	Minimum	3.51 mm	
	Diameter of steel strands Standard	3.53 mm	
	Maximum	3.60 mm	
	Minimum	3.46 mm	
13	Lay ratio of Conductor		
13a	Steel - 6 wire layer Maximum	18	
	Minimum	16	
13b	Aluminium - 12 wire layer Maximum	14	
	Minimum	12	
13c	Aluminium - 18 wire layer Maximum	13	
	Minimum	11	
13d	Aluminium - 24 wire layer Maximum	12	
	Minimum	11	
14	Materials composition		
14a	Aluminium	99.5% with copper content less than 0.4%	
14b	Steel Carbon	0.50 to 0.85 %	
	Manganese	0.50 to 1.10 %	
	Phosphorous	not more than 0.035 %	
	Sulphur	not more than 0.045 %	
	Silicon	0.10 to 0.35 %	
14c	Zinc for galvanising	electrolytic high grade zinc of 99.95% purity conforming to IS 209-1979.	

A P P E N D I X – **PANTHER**

1.	Size of conductor	30/7/3.00 mm
2.	Stranding and wire diameter	
	Aluminum	30/3.00 mm
	Steel	7/3.00 mm
3.	Sectional Area of Aluminum	212.10 mm^2
4.	Approximate total mass	974 Kgs/KM
5.	Calculated resistance at 20° C Max.	0.139 Ohm/KM
6.	Calculated breaking load of composite conductor (U.T.S) (Min)	89.67 KN
7.	Lay Ratio :-	
	Steel Core	Max - 28
		Min - 13
	Aluminum Layers	
	12 Wire layer (Layer below outside layer)	Max - 16
		Min - 10
	18 Wire layer (Outside Layer)	Max - 14
		Min - 10
8.	Modulus of elasticity	0.815 x 10^6Kg/CM^2 (80GN/M^2)
9.	Co-efficient of Linear expansion of conductor.	17.8 x 10^{-6} / °C
10.	Standard area of cross Section in sq. mm of conductor	261.50 Sq. mm
11.	Diameter of complete conductor in mm	21 mm

A P P E N D I X - II

PANTHER

Solid Steel and Aluminium Wires used in Steel cored Aluminium Conductors

1.	Diameter	Steel	Aluminum
	Standard	3.00 mm	3.00 mm
	Maximum	3.06 mm	3.03 mm
	Minimum	2.94 mm	2.97 mm
2.	Cross Sectional Area of nominal Diameter Wire	7.069 mm^2	7.069 mm^2
3.	Weight	55.13 Kg/KM	19.11Kg/Km
4.	Minimum tensile strength	134Kg/mm^2	16.87Kg/mm^2
5.	Minimum breaking load before stranding	9.29 KN	1.17 KN
6.	Minimum breaking load after stranding	8.83 KN	1.11 KN
7.	Zinc coating of steel strands		
	No and duration of dips	3 (1 Min. dip)	
	Minimum Weight of coating	As per IS 4826-1979	
8.	Maximum resistance at 20°C of Aluminum strands		4.079 Ohms/KM
9.	Purity of aluminum rod		99.5%

A P P E N D I X - III

PANTHER

1.	Conductor	Steel cored Aluminum
	(a) Copper equivalent	130 mm^2
	(b) Stranding	30/7/3.00 mm
2.	Normal Span.	320 Meters
	Wind Span.	320 Meters
	Weight Span.	
	(a) Max.	500 Meters
	(b) Min.	50 Meters
3.	Wind Pressure on full projected area.	52 Kgf per M^2
4.	Temperature	
	(a) Minimum	5 °C
	(b) Maximum	67°C
	(c) Every day	32°C
5.	Factors of safety : Minimum	
	(i) Every day temperature and no wind.	4.00
	(ii) Minimum temperature and 2/3 maximum wind :	2.00
	(iii) Every day Temperature and full wind	2.00
	This is as per Indian Electricity Rules, 1956.	
6.	Relative Humidity.	
	Maximum.	100 Percent
	Minimum.	60 Percent
7.	Isoceramic level	100/years
8.	Number of rainy days per year.	100 days
9.	Average rainfall per year	1150 mm. approx.
10.	Altitude.	Less than 350 Meters

G.I EARTH WIRE

SECTION – II

TECHNICAL SPECIFICATION FOR G.I. GROUND WIRE.**(7/3.15 mm and 7/3.66mm)**

1. **SCOPE** :

1.1 This specification provides for the manufacture, testing before despatch, supply and delivery of Ground wire for the purpose of earthing and protection of power transmission line, as per the particulars given in Appendix-I attached. The ground wire shall consist of standard galvanized steel wire.

2. **STANDARDS** :

2.1 The ground wire shall comply in all respect with the Indian Standard (IS) 2141-1979

3. **MATERIALS** :

3.1 The material offered shall be of best quality and workmanship. The steel wires (Strands) shall be manufactured from steel produced by any suitable process. The steel wire shall not contain sulphur and phosphorous exceeding 0.040 percent each as per IS : 2141-1971.

3.2 The steel wires shall be evenly and uniformity quoted with zinc complying with IS: 209-1965 specification for zinc (Retired). Only virgin zinc shall be used and reclaimed zinc is not permitted. The virgin zinc shall be of zn 99.95 percent quality.

3.3 The content of carbon shall not be more than 0.55 percent, manganese and silicon contents shall be 0.40 to 0.90 and 0.15 to 0.35 respectively.

4. **SIZE AND CONSTRUCTION** :

4.1 The size of ground wire shall be as given in Appendix-I. The physical properties have been given in the same Appendix. The lay of the strands shall be of lengths as given in the Appendices. The wires shall be so stranded together that when any evenly distributed pulls applied at the end of the completed strands each wire will take on equal share of the pull.

5. **LENGTH OF JOINING**:

5.1 The ground wire may be supplied in the standard length as per manufacturers standard practice and such length will be specifically indicated in the tender. However random length of ground wire upto a maximum of 10 (Ten) percent may be allowed.

5.2 The length of strand which may be supplied without joints in the individual wires comprising it depends on the length of wire which may be carried by the bobbin in a normal stranding machine. The normal lengths of strand which shall be supplied without joints in individual wires, excluding welds made in the rod before drawing shall be as given in Appendix – I.

5.3 Each coil shall be warranted to contain no weld joints or splice ether than in the rod before it is drawn and those permitted in 5.3 above. The wire shall be circular and shall be free from scale or irregularities, imperfections, flow spite and other defects. The zinc coating shall be smooth even and bright.

6. **TESTS AND TEST CERTIFICATES**:

6.1 Ground wire shall be subjected to the tests as specified in the IS:2141-1979 before despatch.

6.2 Al the coils of the galvanized strand shall be of the same grade, diameter and construction manufactured under similar condition shall be grounded to constitute one lot.

6.3 Samples from each lot shall be tested for ascertaining the conformity to the requirements of the ground wire specified herein. The coils selected shall be tested for length of the lay and joints. The lot shall be declared conforming to the requirements of these characteristics if all the coils are found satisfactory. One test specimen from each wire of the strand shall be drawn, from every selected coil and subjected to tensil tests, ductility test and coating test. One specimen of the completed strand from each coil shall be subjected to tensil strength. The lot shall be declared conforming to the requirements of these characteristics if the entire best specimen satisfy the relevant requirements.

6.4 **Chemical Analysis** : One sample shall be drawn from the lot for chemical analysis. Unless otherwise agreed to between the purchase and supplier the chemical analysis shall be carried out.

6.5 **Tensile Test** : The wire when tested in accordance with IS : 1521-1960 shall have minimum tensile strength specified in the Appendix – I. The tensile strength of the finished strand shall not be less than 95% of the aggregate of the single wires.

6.6 **Ductility test** : The wire shall be subjected to wrapping test in accordance with IS : 1755-1961. When wrapped eight times round its own diameter and on being subsequently straightened the wire shall not break or split.

6.7 **Coating test** : The uniformity of zinc coating shall be tested as per IS: 2633-1964. The wire shall withstand the number of dips specified in Appendix – I.

6.8 Three copies of manufacturers test certificate shall be submitted by the contractor to the purchaser for approval immediately after such tests have been conducted on the strands and the wire.

6.9 The purchaser reserves the right to inspect the material at Manufacturer's works before despatch.

7. **PACKING AND MARKING** :

7.1 The ground wire shall be supplied in non-returnable reals or drums of non-perishable or treated wood conforming to IS: 1778-1991 specification for Reals and Drums for Bare wire. Each coil shall be provided with a level fixed firmly on the inner part of the coil, bearing the following information.

(a) Trade name, if any.
(b) Name of manufacturer
(c) Type of wire, size and length of wire.
(d) Not weight of the wire.
(e) Total weight, and
(f) Number of lengths on the real or drum unless otherwise agreed to between the purchaser and the supplier, the stranded wire shall be supplied in 50 Kg. coil.

8. **SAG AND TENSION CHARTS AND SAG TEMPLATE** :

8.1 The successful tenderer shall be required to submit six copies of sag templates and strings charts for different temperatures and spans, One set of charts shall be ink on tracing cloth. The design date of the lines on which the ground wire will be used are given in Appendix – II

A P P E N D I X – I

TECHNICAL SPECIFICATION OF GROUND WIRE

(i)	Material	:	Steel
(ii)	Purity of material	:	Sulphur and phosphorous contents not exceeding 0.040 percent each. Carbon content not exceeding 0.55 percent. Total silicon contents shall be 0.15 to 0.35 and Manganese contents shall be 0.40 to 0.90 respectively.
(iii)	Standing and wire diameter	:	7/3.15 mm
(iv)	Weight	:	428 Kg / Km.
(v)	Single wire before stranding		
	Diameter of wire	:	3.15 mm
	Tolerance	:	+ 0.060 mm - 0.030 mm
	Minimum elongation in 100 mm.	:	4 mm.
	Minimum breaking strength	:	857 kg.
	Minimum tensile strength	:	85.7 kgf / mm2
(vi)	**Stranded wire length of lay**		
	Maximum	:	175 mm
	Minimum	:	145 mm
	Minimum breaking load	:	5810 kg
	Over all diameter	:	9.45 mm
	Modulus of elasticity	:	1.938 x 106 Kg/Cm2
	Co-efficient of linear expansion	:	11.50 x 10^{-6} per deg. C.
	D.C. resistance at 20^0C	:	3.375 Ohms/Km.
(vii)	**Zinc coating** :		
	Number of one minute dips	:	Three
	Number of half-minute dips	:	One
	Quality of zinc	:	Zn 98 IS:209/1966
	Weight of coating on wire process of galvanising	:	275 g/m^2
	Process of galvanising	:	Hot-dip.
(viii)	Joints	:	There shall be no joint in any of the wires constituting the ground wire.
(ix)	**Lengths** -		
	Standard length	:	1500 metres.
	Tolerance on standard length	:	$\pm$ 5 percent
	Random lengths	:	Not more than 5 percent of the lengths ordered.
(x)	**Tests** : -	:	A sample of the finished ground wire when tested in tensile testing machine shall not fail at a stress
	Type tests Ultimate tensile strength test.		

			less than 100% of UTS value of the ground wire. The length of the test sample shall be not less than 5 meters.
	Electrical Tests	:	As per BS : 182/1972 and BS : 3229/1960
	Routine Tests	:	As per clause No. 6 of IS: 2141 1968. In addition to these tests, the weight and adherence of Zinc coating tests shall be conducted as per clause 4 and 5 of IS : 4826/1968.
(xi)	Test Reports	:	Three copies of manufacturer test certificates shall be submitted by the Contracts to the purchaser for approve immediately after such test have been conducted on the galvanised steel strand and the wire.

9. Overhead earth conductors

General(7/3.66mm)

Where earth conductors are erected to provide the specified degree of lightning protection, they shall consist of stranded galvanised steel and shall comply with IEC 888 and IEC 1089 in so far as it applies to steel wires.
Galvanising shall comply with the requirements of IS 2141.
The arrangement of earth conductors shall be such that failure of a single conductor cannot predictably result in a fall across both bus bars in a duplicate bus bar substation.

Technical parameters

SI No.	Parameter		Value
1	Stranding and wire diameter		7/3.66mm
2	Number of strands		1/6
3	Total sectional area		73.65 mm^2
4	Overall diameter		10.98mm
5	Approximate weight		583 kg/km
6	Calculated DC resistance at 20C		2.5 ohms/m
7	Minimum ultimate tensile strength		68.4kN
8	Direction of outer lay		Right hand
9	Tolerances		
9a	Diameter	standard	3.66mm
		maximum	3.75mm
		minimum	3.57mm
9b	Lay length	standard	181mm
		maximum	198mm
		minimum	165mm
10	Steel composition	Carbon	≤ 0.55%
		Manganese	0.4 to 0.9%
		Phosphorous	≤ 0.04%
		Sulphur	≤ 0.04%
		Silicon	0.1 to 0.35%
11	Zinc for galvanising		Electrolytic high grade zinc of 99.95% purity to *209 1979*

Table for Technical parameters for earth wires

INSULATORS
SECTION-III

S.NO. DESCRIPTION PAGE NO.

INSULATORS

TECHNICAL SPECIFICATION FOR DISC INSULATORS FOR SUBSTATION AND TRANSMISSION LINE WORK

1.0 SCOPE.

1.1 This specification provides for design, manufacture, engineering, inspection and testing before despatch packing and delivery FOR (destination) for Indian manufacturers of disc. Insulators as per technical requirements furnished in this specification.

These insulators are to be used in suspension and tension insulators strings for the suspension and anchoring of the conductors on EHV transmission line towers.

1.2 Following is the list of documents constituting this package.
(i) Technical specification.
(ii) Technical data sheet.
(iii) Drawings of insulators
(ii)
1.3 All the above volumes along with amendments there of shall be read and interpreted together. However, in case of a contradiction between the "Technical Specification" and any other volume, the provisions of this volume will prevail.

1.4 The insulators shall conform in all respects to high standards of engineering, design workmanship and latest revisions of relevant standards at the time of offer and purchaser shall have the power to reject any work or material which in his judgment, is not in full accordance therewith.

2.0 **STANDARDS**:
2.1 Except as modified in this specification, the disc insulators shall conform to the following Indian Standards, which shall mean latest revisions and amendments. Equivalent International and Internally recognized standards to which some of these standards generally correspond are also listed below.

Sl. No.	Indian Standard	Title.	International Standard.
1.	IS: 206	Method for Chemical Analysis of Slab Zinc.	
2.	IS: 209	Specification for Zinc.	BS: 3436
3.	IS: 731	Porcelain insulators for overhead power lines with a normal voltage greater than 1000V	BS: 137(I&II); IEC 274 IEC 383
4.	IS: 2071 Part-(I) Part-(II) Part-(III)	Method of High Voltage Testing.	
5.	IS: 2121 (Part-I)	Specification of Conductors and Earth wire Accessories for Overhead Power lines. Armour Rods, Binding wires and tapes for conductor.	
6.	IS: 2486	Specification for Insulator fittings for overhead power lines with a nominal voltage greater than 1000V.	
	Part – I	General Requirement and Tests.	BS: 3288
	Part – II	Dimensional Requirements.	IEC: 120
	Part – III	Locking devices.	IEC: 372
7.	IS: 2629	Recommended practice for Hot Dip Galvanisation for iron	

		and steel.	
8.	IS: 2633	Testing for Uniformity of Coating of Zinc coated articles.	
9.	IS: 3138	Hexagonal Bolts & Nuts.	ISO/R 947 & ISO/R 272
10.	IS: 3188	Dimensions for Disc Insulators.	IEC: 305
11.	IS: 4218	Metric Screw Threads	ISO/R 68-1969 R 26-1963, R 262-1969 & R965-1969
12.	IS: 6745	Determination of weight of zinc coating on zinc coated iron and steel articles.	
13.	IS: 8263	Methods of RIV Test of HV insulators.	IEC 437 NEMA Publication No.107/1964 CISPR
14.	IS: 8269	Methods for switching impulse test on HV insulators.	IEC: 506
15.		Thermal mechanical performance test and mechanical performance test on string insulator units.	IEC: 575
16	IEC	Long Rod Insulators	IEC-433

2.2 The standards mentioned above are available from:

Reference.	Abbreviation.	Name & Address:
BS		British Standards, British Standards Institution, 101, Pentonvile Road, N-19 ND,U
IEC / CISPR		International Electro technical commission Electro Technique International. 1, Rue de verembe Geneva SWITZERLAND.
IS		Bureau of Indian Standards, Manak Bhavan, 9 Bahadurshah Zafar Marg, New Delhi-110001, ORISSA
ISO		International Organisation for Standardization. Danish Board of Standardization Dansk Standardizing Sraat Aurehoegvej-12 DK-2900 Helleprup DENMARK.
NEMA		National Electric Manufacturers Association 1`55, East 44th. Street New York, NY 10017 USA

3.0 **PRINCIPAL PARAMETERS.**

3.1 DETAILS OF DISC INSULATORS:

3.1.1 The Insulator strings shall consist of standard discs for use in three phases. 50 Hz effectively earthed 33/132/220 KV transmission system of OPTCL in a moderately polluted atmosphere. The discs shall be cap and pin, ball and socket type, radio interference and have characteristics as shown in Table-I and all ferrous parts shall be hot dip galvanized as per the latest edition of IS 2629. The zinc to be used for making sleeves shall be 99.95 % pure.

3.1.2 The size of disc insulator, minimum creepage distance the number to be used in different type of strings, their electromechanical strength and mechanical strength

3.1.3 of insulator string along with hardware shall be as follows:

PRINCIPAL PARAMETERS OF THE DISC INSULATORS:-

Sl. No.	Type of String.	Size of disc. Insulator (mm)	Minimum creepage distance of each disc (mm),	No. of standard discs 132 KV /220/400 KV	Electro-mechanical strength of insulator string fittings (KN)
1.	Single suspension	255 x 145	320	1x9/1x14	70 KN/90 KN Normal Disc Insulator
2.	Double suspension.	-do-	-do-	2x9/2x14	70 KN/90 KN Normal Disc Insulator
3	Single suspension	255 x 145	430	1x9/1x14	70 KN/90 KN Antifog Insulator
4	Double suspension.	-do-	-do-	2x9/2x14	70 KN/90 KN Antifog Disc Insulator
5	Single Tension	280x145	430	1x10/1x15	120 KN Antifog Disc Insulator
6	Double Tension	-do-	-do-	2x10/2x15	120 KN Antifog Disc Insulator
7	Single Tension	305x170	475	1x10/1x15/1 x25	160 KN Antifog Disc Insulator
8	Double Tension	-do-	-do-	2x10/2x15/2 x25	160 KN Antifog Disc Insulator
5	Single Suspension	280x145	430	1x10/1x15/1 X25	120 KN Antifog Disc Insulator
6	Double Suspension	-do-	-do-	2x10/2x15/2 X25	120 KN Antifog Disc Insulator

3.2 **<u>SPECIFICATION DRAWINGS</u>**:

3.2.1 The specification in respect of the disc insulators are described.These specification for information and guidance of the Bidder only. The drawings to be furnished by the supplier shall be as per his own design and manufacture and in line with the specification.

4.0 GENERAL TECHNICAL REQUIREMENTS:

4.1 Porcelain:

The porcelain used in the manufacture of the shells shall be ivory white nonporous of high dielectric, mechanical and thermal strength, free from internal stresses blisters, laminations, voids, forgone matter imperfections or other defects which might render it in any way unusable for insulator shells. Porcelain shall remain unaffected by climatic conditions ozone, acid, alkalis, zinc or dust. The manufacturing shall be by the wet process and impervious character obtained by through vetrification.

The insulator shall be made of highest grade, dense, homogeneous, wet-process porcelain, completely and uniformly vitrified throughout to produce uniform mechanical and electrical strength and long life service. The porcelain shall be free from warping, roughness, cracks, blisters, laminations, projecting points foreign particles and other defects, except those within the limits of standard accepted practice. Surfaces and grooves shall be shaped for easy cleaning. Shells shall be substantially symmetrical.

4.1.1 Porcelain glaze:

Surface to come in contact with cement shall be made rough by stand glazing. All other exposed surfaces shall be glazed with ceramic materials having the same temperature coefficient of expansion as that of the insulator shell. The thickness of the glaze shall be uniform throughout and the colour of the glaze shall be down. The Glaze shall have a visible luster and smooth on surface and be capable of satisfactory performance under extreme tropical climatic weather conditions and prevent ageing of the porcelain. The glaze shall remain under compression on the porcelain body through out the working temperature range.

4.2 METAL PARTS:

4.2.1 **Cap and Ball Pins**:

Ball pins shall be made with drop forged steel caps with malleable cast iron. They shall be in one single piece and duly hot dip galvanized. They shall not contain parts or pieces joined together welded, shrink fitted or by any other process from more than one piece of materials. The pins shall be of high tensile steel, drop forged and heat-treated. The caps shall be cast with good quality black heart malleable cast iron and annealed. Galvanizing shall be by the hot dip process with a heavy coating of zinc of very high purity. The bidder shall specify the grade composition and mechanical properties of steel used for caps and pins. The cap and pin shall be of such design that it will not yield or distort under the specified mechanical load in such a manner as to change the relative spacing of the insulators or add other stresses to the shells. The insulator caps shall be of the socket type provided with nonferrous metal or stainless steel cotter pins and shall provide positive locking of the coupling.

4.2.2 **Security Clips**:

The security cops shall be made of phosphor bronze or of stainless steel.

4.3 **FILTER MATERIAL**:

Cement to be used, as a filler material be quick setting, fast curing Portland cement. It shall not cause fracture by expansion or loosening by contraction. Cement shall not react chemically with metal parts in contact with it and its thickness shall be as small and as uniform as possible.

4.4 **MATERIALS DESIGN AND WORKMANSHIP**:

4.4.1 **GENERAL**:

(II) All raw materials to be used in the manufacture of these insulators shall be subject to strict raw material quality control and to stage testing/ quality control during manufacturing stage to ensure the quality of the final end product. Manufacturing shall conform to the best engineering practices adopted in the field of extra high voltage transmission. Bidders shall therefore offer insulators as are guaranteed by them for satisfactory performance on Transmission lines.

(III) The design, manufacturing process and material control at various stages be such as to give maximum working load, highest mobility, best resistance to corrosion, good finish elimination of sharp edges and corners to limit corona and radio interference voltages.

4.4.2 **INSULATOR SHELL:**

The design of the insulator shells shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration. Shells with cracks shall be eliminated by temperature cycle test followed by mallet test. Shells shall be dried under controlled conditions of humidity and temperature.

4.4.3 METAL PARTS:

i) The pin and cap shall be designed to transmit the mechanical stress to the shell by compression and develop uniform mechanical strength in the insulator. The cap shall be circular with the inner and outer surfaces concentric and of such design that it will not yield or distort under loaded conditions. The head portion of the pinball shall be suitably designed so that when the insulator is under tension the stresses are uniformly distributed over the pinhole portion of the shell. The pinball shall move freely in the cap socket either during assembly of a string or during erection of a string or when a string is placed in position.

ii) Metal caps shall be free from cracks, seams, shrinks, air holes, blowholes and rough edges. All metal surfaces shall be perfectly smooth with no projecting part or irregularities, which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stress uniformly. Pins shall not show any microscopically visible cracks, inclusions and voids.

4.4.4 **GALVANIZING**:

All ferrous parts, shall be hot dip galvanized in accordance with IS: 2629. The zinc to be used for galvanizing shall conform to grade Zn 99.5 as per IS: 209. The zinc coating shall be uniform, smoothly adherent, reasonably light, continuous and free from impurities such as flux, ash, rust stains, bulky white deposits and blisters. Before ball fittings are galvanized, all die flashing on the shank and on the bearing surface of the ball shall be carefully removed without reducing the designed dimensional requirements.

4.4.5 **CEMENTING**:

The insulator design shall. Be such that the insulating medium shall not directly engaged with hard metal. The surface of porcelain and coated with resilient paint to offset the effect of difference in thermal expansions of these materials. High quality Portland cement shall be used for cementing the porcelain to the cap & pin.

4.4.6 **SECURITY CLIPS (LOCKING DEVICES**)

The security clips to be used as locking device for ball and socket coupling shall be 'R' shaped hump type to provide for positive locking of the coupling as per IS: 2486 (Part-IV). The legs of the security clips shall allow for spreading after installation to prevent complete withdrawal from the socket. The locking device shall resilient corrosion resistant and of sufficient mechanical strength. There shall be no possibility of the locking device to be displaced or be capable of rotation, which placed in position, and under no circumstances shall it allow separation of insulator units and fittings. 'W' type security clips are also acceptable. The hole for the security clip shall be counter sunk and the clip shall be of such design that the eye of the clip may be engaged by a hot line clip puller to provide for disengagement under energized conditions. The force required for pulling the clip into its unlocked positions shall not be less than 50 N (5 kg.) or more than 500 N (50 kgs.).

4.4.7 MARKING:

Each insulator shall have the rated combined mechanical and electrical strength marked clearly on the porcelain surface. Each insulator shall also bear symbols identifying the manufacturer, month, and year of manufacture. Marking on porcelain shall be printed, not impressed, and shall be applied before firing.

4.5 **BALL AND SOCKET DESIGNATION**:

The dimensions of the ball and sockets for 70 and 90 KN discs shall be of 16 mm and for 120 KN and 160 KN discs shall be of 20 mm designation in accordance with the standard dimensions stated in IS: 2486 (Part-II).

4.6 **DIMENSIONAL TOLERANCE OF INSULATOR DISCS**:

It shall be ensured that the dimensions of the disc insulators are within the limits specified below:

4.6 DIMENSIONAL TOLERANCE OF INSULATOR DISCS:

It shall be ensured that the dimensions of the disc insulators are within the limits specified below:

(a)

Sl. No.	Diameter of Disc (mm)	Standard in mm	Maximum	Minimum
1.	70 KN/90 KN & 120 KN	255/255 & 280	As per IS	As per IS
2.	160 KN	305	As per IS	As per IS

(b)

Sl. No.	Ball to Ball spacing Between Discs (mm)	Standard in mm	Maximum	Minimum
1.	70 KN/90 KN/120 KN	145	As per IS	As per IS
2.	160 KN	170	As per IS	As per IS

(C) GUARANTEED TECHNICAL PARTICULARS
FOR ANTIFOG DISC INSULATORS

Sl. No.	DESCRIPTION	70 KN	90 KN	120KN	160 KN
1.	Manufacture's name &address				
2	Type of Insulator	Ball & socket	Ball & socket	Ball & socket	Ball & socket
3	Size of ball & socket	16B	16B	20	20
4	Dimensions				
(a)	Disc diameter	255	255	280	305
(b)	Unit spacing	145	145	145	170
(c)	Creepage distance of the single insulator-mm	430	430	430	475
5	Electro-mechanical strength of single inslator-kN	70	90	120	160
6	Materials of shell	Porcelain	Porcelain	Porcela in	Porcelain
	Electrical value				
7.					
7.1	Power frequency Withstand voltage disc (a) Dry-kV (rms) (b) Wet-kV (rms)	 80 45	 80 45	 85 50	 90 50
7.2	Power frequency flash over voltage single-disc (a) Dry-kV (rms) (b) Wet-kV (rms)	 85 50	 85 50	 90 55	 95 55
7.3	Impulse withstand voltage 1.2/50 micro second 1.Positive –kV(peak) 2.Negative –kV (peak)	 125 125	 125 125	 130 130	 135 135

7.4	Impulse Flashover voltage 1.2/50 micro second				
	1.Positive –kV(peak)	135	135	140	145
	2.Negative –kV (peak)	130	130	135	140

*** Tolerance as per relevant IS (Latest edition).**

4.7 **INTERCHANGEABILITY:**

The insulators inclusive of the ball and socket fittings shall be of standard design suitable for use with hardware fittings of any make conforming to relevant Indian Standards.

4.8 **CORONA AND RIV PERFORMANCE**:

All surfaces shall be even, smooth, without cuts, abrasions or projections. No part shall be subject to excessive localized pressure. The metal parts and porcelain shall not produce any noise-generating corona under all operating conditions.

4.9 **SUITABILITY FOR LIVE LINE MAINTENANCE**:

The insulator shall be compatible for use with hot line or live line maintenance techniques so that usual hot line operation can be carried out with easy speed and safety.

4.10 **FREEDOM FROM DEFECTS**:

Insulators shall have none of the following defects:

1) Ball pin shake.

2) Cementing defects near the pin like small blow holes, small hair cracks lumps etc.

3) Sand fall defects on the surface of the insulator.

4.11 INSULATOR STRINGS:

4.11.1 TYPE AND RATING:

The insulator strings shall be formed with standard discs described in this specification for use on 3 phases 132/22 KV 50 Hz effectively earthed systems in an atmosphere with pollution level as indicated in project synopsis. Suspension insulator strings for use with suspension/tangent towers are to be fitted with discs 70/90 KN EMS rating while tension insulator strings for use with Anchor/ Tension towers are to be fitted with discs of 120 KN / 160 KN EMS level rating.

4.11.2 STRING SIZE:

The sizes of the disc insulator, the number to be used in different types of strings, their electro-mechanical strength and minimum nominal creep age distance shall be as given in clause 3.12

4.12 STRING CHARACTERISTICS:

4.12.1 The characteristics of the complete string shall be as follows:

Sl. No.	Description.	Suspension.		Tension.	
		132KV	220kV	132KV	220KV

I	Switching surge withstand voltage (dry & wet) KV peak.	-	-	-	-
Ii	Lighting impulse withstand voltage (dry) KV Peak.	650	1050	650	1050
Iii	Power frequency without voltage (wet) KV r.m.s.	275	460	275	460
Iv.	Corona extinction voltage level KV rms	-	176	-	176
v.	Max. RIV for comp. Etc. strong including corona rings at 156 KV (rms). … hours clamps etc. at 1.1. times maximum knee to ground voltage (micro volts).	-	500	-	500
vi.	Mechanical failing load for each sting (kgf)	6500	11500	11500	15500
Vii.	No deformation load for each string (kgf)	-	7705	-	10385
Viii.	Max. voltage across any disc.	13%	13%	13%	13%

4.12.2 Insulator units after assembly shall be concentric and coaxial within limits as permitted by Indian Standards.

4.12.3 The strings design shall be such that when units are coupled together there shall be contact between the shell of one unit and metal of the adjacent unit.

5.0 DETAILS OF SOLID CORE LONG ROD INSULATORS:

5.1 The insulator shall consist of standard-discs for a three-phase 50 Hz effectively earthed 132 KV transmission system heavily polluted atmosphere. The insulator shall be ball and socket type.

5.2 The size of long rod insulator, minimum creepage distance, the number to be used in different type of strings, their electromechanical strength and mechanical strength of insulator string along with hardware shall be as follows:

Sl. No.	Type of string.	Size of long rod insulator (mm)/(Unit) 132/220 KV	Minimum creepage distance (mm) 132/220 KV	No.of unit 132/220 KV)	Electromechanical strength of insulator (KN) 132/220 KV)
1.	Single suspension	200X 1305 /210X2030	4000 / 6125	'1/2	90 KN
2.	Double suspension	-do-	-do-	'2/4	90 KN
3.	Single tension.	205 X 1450 / 215X2550	4300/7130	'1/2	120 KN/160 KN
4.	Double	-do-	-do-	'2/4	120 KN/160 KN

	Tension.				

6.0 **SPECIFICATION DRAWINGS**:

6.1 The specification in respect of the long rod insulators indicated above is given at Annexure-II. These specification is for information and guidance of the bidder only. The drawings to be furnished by the supplier shall be as per his own design and manufacture and shall be in line with the specification.

7.0 **GENERAL TECHNICAL REQUIREMENT**:

7.1 **PORCELAIN**:

The porcelain used in the manufacture of the shell shall be ivory white, nonporous of high dielectric, mechanical and thermal strength free from internal stress blisters and thermal strength from internal stresses blisters, laminations, voids, foreign matter. Imperfections or other defects, which might render it in any way unsuitable for insulator shells. Porcelain shall remain unaffected by climatic conditions, ozone, acid alkalis, and zinc of dust. The manufacturing shall be by the wet process and impervious character obtained by through vetrification.

7.2 **PORCELAIN GLAZE**:

Surfaces to come in contact with cement shall be made rough by stand glazing. All other exposed surfaces shall be glazed with ceramic materials having the same temperature coefficient of expansion as that of the insulator shell. The thickness of the glaze shall be uniform throughout and the colour of the glaze shall be brown. The glaze shall have a visible luster and smooth on surface and be capable of satisfactory performance under extreme tropical climatic weather conditions and prevent ageing of the porcelain. The glaze shall remain under compression on the porcelain body throughout the working temperature range.

7.3 METAL PARTS:

7.3.1 Cap and Ball pins:

Twin Ball pins shall be made with drop forged steel and caps with malleable cast iron. They shall be in one single piece and duly hot dip g galvanized. They shall not contain parts or pieces joined together, welded, shrink fitted or by any other process from more than one piece of material. The pins shall be of high tensile steel, drop forged and heat malleable cast iron and annealed. Galvanizing shall be by the hot dip process with a heavy coating of zinc of very high purity with minimum of 6 dips. The bidder shall specify the grade, composition and mechanical properties of steel used for caps and pins.

7.3.2 **SECURITY CLIPS**:

The security clips shall be made of phosphor bronze or of stainless steel.

7.4 **FILLER MATERIAL**:

Cement to be used as a filler material shall be quick setting, for curing Portland cement. It shall not cause fracture by expansion or loosening by contraction. Cement shall not react chemically with metal parts in contract with it and its thickness shall be as small and as uniform as possible.

8.0 **MATERIAL DESIGN AND WORKMANSHIP**:

8.1 **GENERAL**:

i) All raw materials to be used in the manufacture of these insulators shall be subject to strict raw materials quality control and to stage testing quality control during manufacturing stage to ensure the quality of the final end product. Manufacturing shall conform to the best engineering practices adopted in the field of extra high voltage transmission. Bidders shall therefore offer insulators as are guaranteed by them for satisfactory performance on Transmission lines.

ii) The design, manufacturing process and material control at various stages be such as to give maximum working load, highest mobility, best resistance to corrosion good finish, elimination of sharp edges and corners to limit corona and radio interference voltage

8.2 **INSULATOR SHELL**:

The design of the insulator shell shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration. Shells with cracks shall be eliminated by temperature cycle test followed by temperature cycle test followed by mallet test. Shells shall be dried under controlled conditions of humidity and temperature.

8.3 **METAL PARTS**:

i) The twin ball pin and cap shall be designed to transmit the mechanical stresses to the shell by compression and develop uniform mechanical strength in the insulator. The cap shall be circular with the inner and outer surfaces concentric and of such design that it will not yield or distort under loaded conditions. The head portion of the insulator or is under tension the stresses are uniformly distributed over the pinhole portion of the shell. The pinball shall move freely in the cap socket either during assembly of a string or during erection of a string or when a string is placed in position.

ii) Metal caps shall be free from cracks, seams, shrinks, air holes, blowholes and rough edges. All metal surfaces shall be perfectly smooth with no projecting parts or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly. Pins shall not show any macroscopically visible cracks, insulations and voids.

8.4 **GALVANIZING**:

All ferrous parts shall be hot dip galvanized six times in accordance with IS: 2629. The zinc to be used for galvanizing shall conform to grade Zn 99.5 as per IS: 209. The zinc coating shall be uniform, smoothly adherent, reasonably light, continuous and free from

impurities such as flux ash, rust stains, bulky white deposits and blisters. Before ball fittings are galvanized, all die flashing on the shank and on the bearing surface of the ball shall be carefully removed without reducing the designed dimensional requirements.

8.4.1 **CEMENTING**:

The insulator design shall be such that the insulating medium shall not directly engage with hard metal. The surfaces of porcelain and coated with resilient paint to offset the effect of difference in thermal expansions of these materials.

8.5 SECURITY CLIPS (LOCKING DEVICES

The security clips to be used as locking device for ball and socket coupling shall be 'R' shaped hump type to provide for positive locking of the coupling as per IS: 2486 (Part-IV). The legs of the security clips shall allow for sore adding after installation to prevent complete withdrawal from the socket. The locking device shall be resilient corrosion resistant and of sufficient mechanical strength. There shall be no possibility of the locking device to be displaced or be capable of rotation when placed in position and under no circumstances shall it allow separation of insulator units and fitting 'W' type security clips are also acceptable. The hole for the security clip shall be countersunk and the clip shall be of such design that the eye of the clip may be engaged by a hot line clip puller to provide for disengagement under energized conditions. The force required for pulling the clip into its unlocked position shall not be less than 50 N (5 Kgs.) or more than 500N (50 Kgs.)

8.6 **BALL AND SOCKET DESIGNATION**:

The dimensions of the balls and sockets for 80 KN long rod insulators shall be of 16mm and for 120 KN shall be of 20mm designation in accordance with the standard dimensions stated in IS: 2486 (Part-III).

8.7 DIMENSIONAL TOLERANCE OF INSULATORS DISCS

It shall be ensured that the dimensions of the long rod insulators are within the limits as per relevant IEC/ISS.

9.0 **TESTS (FOR DISC INSULATORS**) :

9,1 The following tests shall be carried out on the insulator string and disc insulators.

9.2 **TYPE TEST**:

This shall mean those tests, which are to be carried out to prove the design, process of manufacture and general conformity of the material and product with the intents of this specification. These tests shall be conducted on a representative number of samples prior to commencement of commercial production. The Bidder shall indicate his schedule for carrying out these tests.

9.3 **ACCEPTANCE**:

This shall mean these tests, which are to be carried out on samples taken from each lot offered for pre-despatch inspection for the purpose of acceptance of the lot.

9.4 **ROUTINE TESTS**:

This shall mean those tests, which are to be carried out on each insulator to check the requirements, which are likely to vary during production.

9.5 **TESTS DURING MANUFACTURE**:

Stage tests during manufacture shall mean those tests, which are to be carried out during the process of manufacture to ensure quality control such that the end product is of the designed quality conforming to the intent of this specification.

9.6 **TEST VALUE**:

For all type and acceptance tests the acceptance values shall be the value guaranteed by the bidder in the guaranteed technical particulars of the acceptance value specified in this specification of the relevant standard whichever is more stringent for that particular test.

9.7 **TEST PROCEDURE AND SAMPLING NORMS**:

The norms and procedure of sampling for the above tests shall be as per the relevant Indian Standard or the Internationally accepted standards. This will be discussed and mutually agreed to between the supplier and purchaser before placement of order. The standards and normal according to which these tests are to be carried out are listed against each test. Where a particular test is a specific requirement of this specification, the norms land procedure for the same shall be as specified in Annexure-IV attached hereto as mutually agreed to between the supplier and the purchaser in the quality assurance programme.

9.8 **TYPE TESTS**:

The following type test shall be conducted on a suitable number of individual unit components, materials or complete strings.

9.8.1 On the complete insulator string with hardware fittings.

a)	Power frequency voltage withstand test with corona control rings and under wet condition.	: BS:137(Part-I)
b)	Switching surge voltage withstand test under wet condition (400 only)	:
c)	Impulse voltage withstand test under dry condition.	: IEC: 383
d)	Impulse voltage flashover test under dry condition.	:
e)	Voltage distribution test.	:
f)	Corona & RIV test under dry condition.	: As per this specification.
g)	Mechanical strength test.	: As per this

		specification.
h)	Vibration.	:
9.8.2	On Insulators:	
a)	Verification of dimensions.	: IS: 731
b)	Thermal mechanical performance test:	: IEC:575
c)	Power frequency voltage withstand and flashover (I) dry (ii) wet.	: BS: 173
d)	Impulse voltage withstand flashover test (dry)	: IEC: 383
e)	Visible discharge test (dry)	: IS:731
f)	RIV test (dry)	: IS:8263
9.8.3	All the type tests given under clause No.6.8.1 above shall be conducted on single suspension and Double Tension insulator string alongwith hardware fittings.	
9.9	ACCEPTANCE TESTS:	
9.9.1	For insulator:	
	a) Visual examination	: IS:731
	b) Verification of dimensions.	: IS:731
	c) Temperature cycle test.	: IS:731
	d) Galvanizing test.	: IS:731
	e) Mechanical performance test.	: IEC:575
	f) Test on locking device for ball and socket coupling.	: IEC:372
	g) Eccentricity test.	: As per this specification.
	h) Electro-mechanical strength test.	:
	i) Puncture test.	: IS:731
	j) Porosity test.	: IS:731
9.10	ROUTINE TESTS:	
9.10.1	For insulators:	
	a) Visual inspection.	: IS:731
	b) Mechanical routine test.	:
	c) Electrical routine test.	: IEC:383
9.11	TEST DURING MANUFACTURE: On all components as applicable.	
	a) Chemical analysis of zinc used for galvanizing.	:
	b) Chemical analysis, mechanical and metallographic test and magnetic particle inspection for malleable castings.	:
	c) Chemical analysis, hardness test and magnetic particle inspection for forgings.	: As per this specification.
	d) Hydraulic Internal Pressure tests on shell.	:
	e) Crack detection test for metal parts.	:

9.12 **ADDITIONAL TEST**:

The purchaser reserves the right for carrying out any other tests of a reasonable nature at the works of the supplier/ laboratory or at any other recognized laboratory/ research institute in addition to the above mentioned type, acceptance and routine tests at the cost of the purchaser to satisfy that the material complies with the intent of this specification.

9.13 **CO-ORDINATION FOR TESTING**:

For insulator strings, the supplier shall arrange to conduct testing of their disc insulators with the hardware fittings to be supplied to the purchaser by other suppliers. The supplier is also required to guarantee overall satisfactory performance of the disc insulator with the hardware fittings.

NOTE:

In respect of electrical tests on a complete string consisting of insulators and hardware guarantee of values of responsibility of testing shall be with hardware manufacturer of RIV corona and voltage distribution test and with insulator manufacturer for all other tests.

9.14 **TEST CHARGES AND TEST SCHEDULE**:

9.14.1 **TYPE TEST**:

The insulator offered shall be fully type tested as per this specification. In case the equipment of the type and design offered, has already been type tested in an independent test laboratory. The bidder shall furnish four sets of type test reports alongwith the offer. These tests must not have been conducted earlier than five years. The purchaser reserves the right to demand repetition of some or all type tests in the presence of purchasers' carrying representative. For this purpose the bidder may quote unit rates for carrying out each type test. These prices shall be taken into consideration for bid evaluation. For any change in the design/type already type tested and the design/type offered against this specification, purchaser reserves the right to demand repetition of tests without any extra cost.

9.14.2 **ACCEPTANCE AND ROUTINE TEST**:

All acceptance and routine tests as stipulated herein shall be carried out by the supplier in the presence of purchaser's representative.

9.14.3 Immediately after finalisation of the programme of type/ acceptance/ routine testing, the supplier shall give sufficient advance intimation to the purchaser to enable him to depute his representative for witnessing the tests.

9.14.4 For type tests involving tests on a complete insulator string with hardware fittings, the purchaser will advice the supplier of the hardware fittings to provide the necessary fittings to the place of the test.

9.14.5 In case of failure of the complete string in any type tests, the supplier whose product has failed in the tests, shall get the tests repeated at his cost.

In case of any dispute, assessment of the purchaser as to the items that has caused the failure in any of the type tests shall be final and binding.

10. **INSPECTION**:

10.1 i. Purchaser and its representative shall at all times be entitled to have access to the works and to all places of manufacturer where insulators are manufactured and the supplier shall afford all facilities to them for unrestricted inspection of the works, inspection of materials, inspection of manufacturing process of insulators and for conducting necessary tests as specified herein.

ii. The supplier shall keep the purchaser informed in advance of the time of starting and of progress of manufacture of insulators in its various stages so that arrangements could be made for inspection.

iii. No material shall be dispatched from its point of manufacture unless the materials has been satisfactorily inspected and tested.

iv. The acceptance of any quantity of insulators shall in no way relieve the supplier of his responsibility for meeting all the requirement of this specification and shall not prevent subsequent rejection, if such insulators are later found to be defective.

10.2 **IDENTIFICATION MARKING**:

10.2.1 Each unit of insulator shall be legibly and indelibly marked with the trade mark of the supplier, the year of manufacture, the guaranteed combined mechanical and electrical strength in kilo-newtons abbreviated by 'KN' to facilitate easy identification and proper use.

10.2.2 The marking shall be on porcelain for porcelain insulators. The marking shall be printed and not impressed and the same shall be applied before firing.

11. **QUALITY ASSURANCE PLAN**:

11.1 The bidder hereunder shall invariably furnish following information alongwith his offer, failing which the offer shall be liable for rejection.

i. Statement giving list of important raw materials, names of sub-suppliers for the raw materials, list of standards according to which the raw material are tested, list of tests normally carried out on raw materials in presence of bidder's representative, copies of test certificates.

ii. Informations and copies of test certificates as in (i) above in respect of bought out materials.

iii. List of manufacturing facilities available.

iv. Level of automation achieved and lists of area where manual processing exists.

v. List of areas in manufacturing process, where stage inspections are normally carried out in quality control and details of such tests and inspection.
vi. Special features provided in the equipment to make it maintenance free.
vii. List of testing equipping available with the bidder for final testing of equipment specified and test plant limitation, if any, vis-à-vis the type, special, acceptance and routine tests specified in the relevant standards. These limitations shall be very clearly brought out in schedule of deviations from specified test requirements.

11.2 The supplier shall within 30 days of placement of order submit the following information to the owner.
i) List of raw material and the names of sub-suppliers selected from those furnished alongwith the offer.

POST INSULATORS.
Post insulator shall conform in general to IS 2544, IEC 168 and IEC 815.

3.1 constructional features

Post type insulators shall consist of a porcelain part permanently secured in a metal base to be mounted on the supporting structures. They shall be capable of being mounted upright and be designed to with stand any shocks to which they may bed subjected to by the operation of the associated equipment. Only solid core insulators will be acceptable.

Porcelain used shall be homogeneous, free from lamination, cavities and other flaws or imperfections that might after the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

Glazing of the porcelain shall be of uniform brown in colour, free from blisters, burrs and other similar defects.

The insulator shall have alternate long and short sheds with aerodynamic profile. The shed profile shall also meet the requirements of IEC 815 for the specified pollution level.

When operated at normal rated voltage there shall be no electric discharge between conductor and insulators which would cause corrosion or injury to conductors or insulators by the formation of substance produced by chemical action.

The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.

All ferrous parts shall be hot dip galvanized in accordance with the latest edition of IS 2633, and IS 4579. The zinc used for galvanizing shall be grade Zn 99.95 as per IS 209. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux ash, rust stains, bulky while deposits and blisters. The metal parts shall not produce any noise generating corona under the operating conditions. Flat washer shall be circular of a

diameter 2.5 times that of bolt and of suitable thickness. Where bolt heads/nuts bear upon the beveled surfaces they shall be provided with square tapered washers of suitable thickness to afford a seating square with the axis of the bolt.

Bidder shall make available data on all the essential features of design including the method of assembly of shells and metals parts, number of shells per insulator, the manner in which mechanical stresses are transmitted through shells to adjacent parts, provision for meeting expansion stresses, results of corona and thermal shock tests, recommended working strength and any special design or arrangement employed to increase life under service conditions.

12. TEST DETAILS.

1. **VOLTAGE DISTRIBUTION TEST**:

The voltage across each insulator unit shall be measured by sphere gap method. The result obtained shall be converted into percentage and proportionate correction be applied as to give a total of 100% distribution. The voltage across any disc. Not exceed the values given in clause 4-12.1

2. **CORONA EXTINCTION VOLTAGE TEST (DRY)**:

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than the value specified at clause 4.12.1 (iv) under dry condition. There shall be no evidence of corona on any part of the sample when all possible sources of corona are photographed in a darkened room.

3. **RIV TEST (DRY):**

Under the conditions as specified in (2) above, the insulator string along with complete hardware fittings shall have a radio interference voltage level below 500 micro volts at one MHz when subjected to 50 Hz AC voltage of 1.1 times maximum time to ground voltage under dry condition. The test procedure shall be in accordance with IS: 8263.

4. The complete insulator string along with its hardware fitting excluding arcing horn corona controlling/grading ring and suspension assembly/dead end assembly shall be subject to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased already rate to 68% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to disassemble them by hand,. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing loads reached and the value recorded.

5. **VIBRATION TEST:**

The suspension string shall be tested in suspension mode, and tension string in tension mode itself in laboratory span of minimum 30 meters. In the case of suspensions string a load equal to 600 Kg. shall be applied along with the axis of the suspensions string by means of turn buckle. The insulators string along with hardware fittings and two sub conductors throughout the duration of the test vibration dampers shall not be used on the test span. Both the sub-conductors shall be vertically vibrated simultaneously at one of the resonance frequencies of the insulator string (more than 10Hz) by means of vibration inducing equipment. The amplitude of vibration at the antipode point nearest to the string shall be measured and the same shall not be less than 120.4 being the frequency of vibration. The insulator strings shall be vibrated for five million cycles then rotated by 90 deg and again vibrated for 5 million cycles without any failure, after the test, the disc insulators shall be examined for looseness of pins and cap or any crack in the cement. The hardware fittings shall be examined to fatigue fatter and mechanical strength test. There shall be no deterioration of properties of hardware components and disc insulators after the vibration test. The disc insulators shall be subjected to the following tests as per relevant standards.

	Test.	Percentage of disc To be tested.
a)	Temperature cycle test followed by	60
	Mechanical performance test.	40
b)	Puncture test (for porcelain insulator only)	

6. **CHEMICAL ANALYSIS OF ZINC USED FOR GALVANIZING**.

Samples taken from the zinc ingot shall be chemically analysed as per IS: 209. The purity of zinc shall not be less than 99.95%.

7. **TEST FOR FORGINGS**:

The chemical analysis hardness tests and magnetic particle inspection for forgings will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the supplier and purchaser in quality assurance programme.

1. **TEST ON CASTING**:

The chemical analysis mechanical and metallographic tests and magnetic particle inspection for castings will be as per the internationally recognized procedures for these tests. The samplings will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the supplier and purchaser in quality assurance programme.

2. **HYDRAULIC INTERNAL PRESSURE TEST ON SHELLS**:

The test shall be earned out on 100% shells before assembly. The details regarding test will be as discussed and mutually agreed to by the suppliers and purchaser in Quality Assurance Programme.

3. **THERMAL MECHANICAL PERFORMANCE TEST**:

The thermal mechanical performance test shall be carried out on minimum 15 number of disc insulators units as per the procedure given in IEC 575. The performance of the insulator unit shall be determined by the same standard.

4. **ECCENTRICITY TEST**:

The insulator shall be vertically mounted on a future using dummy pin and socket. A vertical scale with horizontal slider shall be used for the axial run out. The pointer shall be positioned in contact with the bottom of the outermost petticoat of the disc. The disc insulators shall be rotated with reference to the fixture and the slider shall be allowed to move up and down on the scale but always maintaining contact with the bottom of the outer most petticoats. After one full rotation of the disc the maximum and minimum position the slider has reached on the scale can be found out. Difference between the above two readings shall satisfy the guaranteed value for axial run out.

Similarly using a horizontal scale with veridical slider the radial run out shall be measured. The slider shall be positioned on the scale to establish contact with the circumstance of the disc insulator and disc insulator rotated on its future always maintaining the contact. After one full rotation of the disc the maximum and minimum position the slider has reached on the scale can be found out. Difference between the above two readings shall satisfy the guaranteed value for axial run out.

5. **CRACK DETECTION TEST**:

Crack detection test shall be carried out on each ball and pin before assembly of disc unit. The supplier shall maintain complete record of having conducted such tests on each and every piece of ball pin The bidder shall furnish full details of the equipment available with him for crack test and also indicate the test procedure in detail.

6. Tubular bus conductors:

General

Aluminium used shall be grade 63401 WP conforming to IS 5082. The tube shall be seamless and shall be manufactured by either of the following processes:

- Hot extrusion process through die and mandrel (Hollow billet process). Heat treatment shall be carried out after hot extrusion of tube.
- Bridge extrusion process and then cold drawn. Heat treatment shall be carried out after cold drawing of tube.

Constructional features

For outside diameter (OD) and thickness of the tube there shall be no minus tolerance, other requirements being as per IS 2678 and IS 2673.

The aluminium tube shall be supplied in suitable cut length to minimise wastage.

Technical parameters

Sl No.	Size	4" IPS (EH type)	3"IPS (EH type)	4.5"IPS (EH type)
1	Outer diameter (mm)	114.20	88..9	120.0
2	Thickness (mm) :	8.51	7.62	12.0
3	Cross-sectional area (sq.mm) :	2825.61	2373.63	4071.5
4	Weight (kg/m) :	7.7	6.44	10.993
5	Chemical composition			
	i) Cu	0.05 max	0.05 max	0.05 max
	ii) Mg	0.4 to 0.9	0.4 to 0.9	0.4 to 0.9
	iii) Si	0.3 to 0.7	0.3 to 0.7	0.3 to 0.7
	iv) Fe	0.5 max	0.5 max	0.5 max
	v) Mn	0.03 max	0.03 max	0.03 max
	vi) Al	Remainder	Remainder	Remainder
6	Minimum ultimate Tensile strength Kg/Sq mm	20.5	20.5	20.5
7	Temp co-eff of resistance		0.00364 per Deg C	
8	Minimum electrical conductivity at 20 deg C		55% of IACS	
9	Modulus of Elasticity		6700 Kg/sq mm	

7. Post insulators:

Post insulators shall conform in general to IS 2544, IEC 168 and IEC 815.

Constructional features

Post type insulators shall consist of a porcelain part permanently secured in a metal base to be mounted on the supporting structures. They shall be capable of being mounted upright and be designed to withstand any shocks to which they may be subjected to by the operation of the associated equipment. Only solid core insulators will be acceptable.

Porcelain used shall be homogeneous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

Glazing of the porcelain shall be of uniform brown in colour, free from blisters, burrs and other similar defects.

The insulator shall have alternate long and short sheds with aerodynamic profile. The shed profile shall also meet the requirements of IEC 815 for the specified pollution level.

When operating at normal rated voltage there shall be no electric discharge between conductor and insulators, which would cause corrosion or injury to conductors, or insulators by the formation of substance produced by chemical action.

The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.

All ferrous parts shall be hot dip galvanised in accordance with the latest edition of IS 2633, and IS 4579. The zinc used for galvanising shall be grade Zn 99.95 as per IS 209. The zinc coating shall be uniform, adherent, smooth, reasonably bright,

continuous and free from imperfections such as flux ash, rust stains, bulky white deposits and blisters. The metal parts shall not produce any noise generating corona under the operating conditions.
Flat washer shall be circular of a diameter 2.5 times that of bolt and of suitable thickness. Where bolt heads/nuts bear upon the bevelled surfaces they shall be provided with square tapered washers of suitable thickness to afford a seating square with the axis of the bolt.
Bidder shall make available data on all the essential features of design including the method of assembly of shells and metals parts, number of shells per insulator, the manner in which mechanical stresses are transmitted through shells to adjacent parts, provision for meeting expansion stresses, results of corona and thermal shock tests, recommended working strength and any special design or arrangement employed to increase life under service conditions.

Services to be performed by the equipment being furnished

The equipment shall be able to withstand forces due to wind load on the equipment and approach conductor and due to short circuit, all forces considered together.
The Contractor shall submit detailed calculations proving the satisfactory performance of the equipment under short circuit conditions to meet the layout requirements.

Technical Parameters

SI No.	Parameter	400kV	245kV	132kV	33klV
1	Type	Confirming to IEC 273 (solid core)			
2	Voltage class (kV)	420	245	145	36
3	Dry and wet one minute withstand voltage (kVrms)	630	460	235	70
4	Dry lightning impulse withstand voltage (kVp)	± 1550	± 1050	± 650	± 250
5	Wet switching surge withstand voltage (kVp)	± 1175	NA	NA	NA
6	Max. RIV at corona extinction voltage (microvolts)	500	500	500	NA
7	Corona extinction voltage (kVrms)	320 (min)	156 (min)	105	
9	Total minimum cantilever strength (kg)	not< 800	not< 800	not< 600	not< 600
10	Minimum torsional moment	As per IEC 273			
11	Total height of insulator (mm)	3650	2300	1100	325
12	PCD (mm) top/bottom	127/300	127/254	127/254	76/76
13	No. of bolts top/bottom	4/8	4/8	4/8	4/8
14	Diameter of bolt holes (mm) top/bottom	M16/18	M16/18	M16/18	M16/18
15	Pollution level as per IEC 815	Heavy	Heavy	Heavy	Heavy
16	Minimum total creepage distance (mm)	10500	6125	3625	900

If corona extinction voltage is to be achieved with the help of corona ring or any other similar device, the same shall be deemed to be included in the scope of the Supplier.

8. Spacers

General

Spacers shall conform to IS 10162. Spacers are to be located at a suitable spacing to limit the short circuit forces and also to avoid snapping of sub conductors during short circuit conditions.

Constructional features

No magnetic material shall be used in the fabrication of spacers except for GI bolts and nuts.

Spacer design shall be made to take care of fixing and removing during installation and maintenance.

The design of the spacers shall be such that the conductor does not come in contact with any sharp edge.

SECTION-IV HARDWARES

S.NO. DESCRIPTION PAGE NO.

TECHNICAL SPECIFICATION FOR HARDWARE FITTINGS.

SUITABLE FOR GALVANISED STEEL STRANDED GROUNDWIRE (7/3.15mm and 7/3.66 mm) ACCESSORIES

AND POWER CONDUCTOR ACSR PANTHER ,ACSR ZEBRA AND MOOSE.

1.0 SCOPE

This Specification covers design (if required), manufacture, testing at manufacturer's Works, supply and delivery of GSS), power conductor and ground wire accessories, insulator and hardware fittings for string insulators suitable for use in 220 and 132 KV Over-head transmission lines and sub-stations of OPTCL. The hard wares to be supplied shall be as per approved drawings of OPTCL. Any change there of shall be with due permission of Sr. G.M (CPC).The firm shall submit his drawings for approval of OPTCL and only after which the manufacturing shall be started.

The materials/equipment offered, shall be complete with all components, which are necessary or usual for the efficient performance and satisfactory maintenance. Such part shall be deemed to be within the scope of contract.

2.0 STANDARDS

The materials covered under this Specification shall comply with the requirement of the latest version of the following standards as amended upto date, except where specified otherwise.

i)	IS;2486 Part-II & III	: Insulator fitting for overhead power lines with a nominal voltage greater than 1,000 volts.
ii)	IS:2121 Part I & II	Conductor & earth wire accessories for overhead power lines.
iii)	IS:9708	Stock Bridge Vibration Dampers on overhead power lines.
iv)	IS:2633	Method of testing of uniformity of coating on zinc coated articles
v)	IS:209	Specification for Zinc.
vi)	BS:916	Specification for Hexagonal bolts and nuts.

3.0 MATERIALS AND DESIGN

Aluminium and aluminium alloys, malleable iron and forget steel, having required mechanical strength, corrosion resistance and mach inability depending on the types of application for which accessories / fittings are needed, shall be employed.

In manufacturer of the accessories / fittings, the composition of the aluminium alloys used shall be made available to Employer if required for verification.

The materials offered shall be of first class quality, workmanship, well finished and approved design. All castings shall be free from blow-holes, flaws, cracks of other defects and shall be smooth, close grained and true forms and dimensions. All machined surfaces should be free, smooth and well finished.

Metal fittings of specified material for conductor and earth wire accessories and string insulator fittings are required to have excellent mechanical properties such as strength, toughness and high resistance against corrosion. All current carrying parts shall be so designed and manufactured that contact resistance is reduced to the minimum.

All bolts, nuts, bolt-heads shall be the white worth's standard thread. Bolt heads and nuts shall be hexagonal. Nuts shall be locked in an approved manner. The treads in

nuts and tapped holes shall be cut after galvanising an shall be well fabricated and greased. All other treads shall be cut before galvanising. The bolt treads shall be undercut to take care of increase in diameter due to galvanising.
All nuts shall be made of materials to Clause 4.8 of IS:1367 (latest edition) with regard to its mechanical properties.
The general design conductor and earthe wire accessories and insulator fittings shall be such as to ensure uniformity, high strength, free from corona formation and high resistance against corrosion even in case of high level of atmosphere pollution.
All hooks, eyes, pins, bolts, suspension clamps and other fittings for attaching to the tower or to the line conductor or to the earthwire shall be so designed that the effects of vibration, both on the conductor and the fittings itself, are minimized.
Special attention must be given to ensure smooth finished surface throughout. Adequate bearing area between fittings shall be provided and point or line contacts shall be avoided.
All accessories and hardwares shall be free from cracks, shrinks, slender air holes, burrs or rough edges.
The design of he accessories and hardwares shall be such as to avoid local corona formation or discharge likely to cause interference to tele-transmission signals of any kind.

4.0 GALVANISING :

All ferrous parts of conductor and ground wire accessories and insulator hardwares shall be galvanised in accordance with IS:2629-Recommended Practice for hot dip galvanising of iron and steel or any other equivalent authoritive standards. The weight of zinc coating shall be determined as per method stipulated in IS:2633 for testing weights, thickness and uniformity of coating of hot dip galvanished articles or as per any other equivalent authoritative standards. The zinc used or galvanisation shall conform to grade zn 98 of IS:209. The galvanised parts shall withstand four (4) dips of 1 minute each time while testing uniformity of zinc coating as per IS:2633.

Spring washers shall be elctro galvanised.

5.0 ACCESSORIES FOR CONDUCTOR AND GROUND WIRE, MID SPAN COMPRESSION JOINTS:FOR ACSR- PANTHER ,ZEBRA, MOOSE AND GROUNDWIRE OF 7/3.15 and 7/3.66 mm.

The Mid-Span Joints for conductor and earthwire shall be of compression type. The conductor mid-span joints shall comprise of outer aluminium sleeve of extruded aluminium (99.5% purity) and inner sleeve HDG Steel. All filler plug shall also be provided. The ground wire mid-span joints shall be of HDG steel. The sleeves shall be of circular shape suitable for compression into hexagonal shape.

The compression type mid-span straight joints shall be suitable for making joints in the ACSR “PANTHER,ZEBRA & MOOSE” conductor or in the galvanised steel stranded ground wire.

The joints shall be so designed that when installed no air space is left within the finished joints. The joints shall have the conductivity as specified in relevant Clause.

The joints shall conform to IS:2121 (latest edition) unless specified otherwise. The details of the joints both suitable for ACSR- Panther,Zebra & Moose and ground wire are given in the technical particulars.

The inner and outer diameters and lengths of the offered joints before and after compression shall be clearly shown in the drawings.

6.0 VIBRATION DAMPER FOR ACSR PANTHER,ZEBRA MOOSE AND GROUND WIRE(7/3.15 and 7/3.66 mm)

Vibration Damper having 4 resonance frequency characteristic commonly called 4R Damper shall be offered. The Damper shall eliminate fatigue on the conductor due to vibration and damp out the vibration effectively so that no damage due to vibration is caused to conductor / ground wire / string.

The dampers are proposed to be used at all tension locations and also at suspension locations. One or more dampers are proposed to be used on tension/suspension locations depending upon the span.

Bidder shall also recommend the number of damper required to effectively damp out conductor or ground wire vibration for different values of span lengths and the distance of fixation.

Vibration dampers shall be of approved design. The clamps of the vibration dampers shall be made of aluminium alloy, so designed as to prevent any damage while fixing on the conductor during erection or in continued operation. The fastening bolts should be approved by the Employer. The spring washers should be elctro galvanised and of minimum 2 mm thickness.

The messenger cable shall be made from high tensile strength steel strands in order to prevent subsequent drop of weight in service.

Clamping bolts shall be provided with self locking nuts as designed to prevent corrosion of the threads. All ferrous parts including the messenger cable shalal be bot dip galvanised. The end of the messenger cable shall be effectively sealed to prevent corrosion.

The vibration dampers and its attachment shall have smooth surface so that no corona occurs on them.

The clamps of the stock bridge vibration dampers shall be so designed that in case of loosening of the bolt or changing free parts of the clamp, it does not allow the damper to disengage from the conductor.

7.0 REPAIR SLEEVE FOR ACSR PANTHER,ZEBRA,MOOSE AND GROUNDWIRE :

Compression type repair sleeves shall be offered to provide reinforcement for conductor with broken or damaged aluminium strands/galvanished steel ground wire broken in damaged steel strands. The repair sleeve shall be designed to make good a conductor of which not more than one-sixth ($1/6^{th}$) of the strands in the outermost layer and damaged or severed. The repair sleeves after compression should present a smooth surface.

8.0 SUSPENSION CLAMPS : FOR GROUND WIRE

Suspension clamps of suitable size are require for holding the galvanised steel stranded ground wire at suspension points. The suspension clamps shall be suspended from the lower hanger or 'D' belt of 16 mm. dia. And should, therefore, be supplied with a suitable attached that would allow the clamps to swing freely both in the transverse and longitudinal direction. The clamps shall be so designed that the effect of vibration both on the groundwire and the fittings itself is minimum.

The clamps shall be manufactured and finished so as to avoid sharp radia of curvature, ridges which might lead to localized pressure and damage the ground wire in service.

The clamps shall be made of heat treat malleable iron one Eye hook made of forced steel. The entire assembly shall be hot dip galvanised.

The clamping surface shall be smooth and formed to support the groundwire on long easy curves to take care or required steel vertical and horizontal angles.

The clamps shall permit the groundwire to slip before the failure of the latter occurs. The leg of U-bolt holding the keeper piece of the clamps shall be kept sufficient long and shall be provided with threads, nuts and locking nuts for fixing the flexible earthing hond between the suspension clamps and tower structures.

9.0 TENSION CLAMPS (DEAD AND ASSEMBLY) FOR GROUND WIRE.

Compression type dead end assembly of G.S.S. ground wire shall be required for use on the tension towers. The dead end assembly shall be supplied with complete jumper terminals, nuts and bolts suitable link pieces between the steel clevis and tower strain plates so as to provide sufficient flexibility not less than that of G.S.S. ground wire and the tensile strength not less than 90% that of the G.S.S. ground wire.

The assemblies shall comprise of compression type dead end clamps and one anchor shackle made of forget steel. The entire assembly shall be hot dip galvanised.

One of bolt holding joint per terminal of dead end assemblies shall be kept sufficiently long and threaded and shall be provided with nuts, washers and locking nuts for fixing the flexible earthing bond between the dead-end clamp and tower structures.

10.0 BONDING PIECES (FLEXIBLE COPPER EARTHING BOND FOR EARTHWIRE 7/3.15 and 7/3.66 mm)

The tenderer shall offer flexible copper earthing bonding pieces for connecting the ground wire suspension and tension clamps and tower legs suitable for earthing.

Each bond piece shall have suitable compression type galvanises steel lug or thimble on either and for making connections to clamp and tower legs. The size, strength, etc. of the bonding piece is given in this Specification.

11.0 INSULATOR HARDWARES

The insulator disc hardwares and string assemblies to be offered by the tenderer shall be suitable to meet the requirement given in the specific technical particulars as detailed hereinafter.

Hardwares for suspension and tension insulator shall be suitable for insulator with normal pin shank diameter of 20 mm. in case of tension string unit and 16mm. for suspension string unit.

Each insulator string shall generally include the following hardware components.

Single Suspension Set.	Double Suspension Set.
a) Ball Hook	**a) Ball Hook.**
b) tower side arcing horn	**b) Socket clevis with R-Type security clip-3 Nos.**
c) Socket Eye with R-Type security clip.	**c) Yoke Plate-2 Nos.**
d) Line side arcing horn.	**d) Tower side arcing horns-2Nos.**
e) Armour grip suspension clamps	**e) Ball clevis – 2 Nos.**
	f) Line side arcing homs-2 Nos.
	g) Clevis Eye.
	h) Armour Grip Suspension Clamp.
Single Tension Set :	Double Tension Set :
a) Anchor Shackle.	**a) Anchor Shackle.**
b) Ball Eye.	**b) Chain Link**
c) Tower side arcing horn.	**c) Yoke Plate – 2 Nos.**
d) Socket Clevis with R-Type security clip.	**d) Tower side arching horn.**
e) Line side arcing horn	**e) Ball Clevis – 2 Nos.**
f) Compression type dead end clamp.	**f) Socket Clevis with R-Type security clip – 2 Nos.**
	g) Line side arcing horns.
	h) Compression type dead end clamps.

12.0 CLAMP

12.1 ARMOUR GRIP SUSPENSION CLAMPS

Armour Grip Suspension Clamp shall consist of 2 neoprene insert, one set of armour rods made of aluminium alloy, two aluminium housing having inner profile matching with the profile of the armour rods page and supporting strap made of aluminium alloy. The A.G. type suspension clamp shall be designed, manufactured and finished as to have a suitable shape without sharp edges at the end and to hold the respective conductor properly. It should, however, have sufficient contact surface to minimise damagedue to fault current. The clamp shall be or Armour Grip Type.

The A.G. type suspension clamp shall permit the conductor to slip before the occurrence of failure of the conductor and shall have sufficient slip strength to resist the conductor tension under broken wire conditions. The clamp shall have slip strength of not less than 15 % of respective conductors.

12.2 TENSION CLAMPS

The Tension Clamps shall be made out of aluminium alloy and of compression type suitable for PANTHER,ZEBRA & MOOSE conductor. The tension clamps shall not permit slipping or damage to failure of the complete conductor or any part thereof at a load less than 90% of the ultimate strength of conductor. The mechanical

efficiency of tension / clamps shall not be affected by method of erection involving come / along or similar clamps or tension stringing operation during or after assembly and erection of tension clamp itself. The tension clamp shall be of a design that will ensure unrestricted flow of current without use of parallel groove clamps.
The clamps shall be as light as possible.

12.3 ARCING HORNS

Each hardware assembly shall have provision for attaching arcing horns of both adjustable and non/adjustable type across the suspension and tension strings or tower side. However each hardware assembly shall be provided with arching horn of fixed type on line side only.

12.4 UNIVERSAL JOINTING COMPOUND

BENDEX-HV' Universal jointing compound which is a chemically inert compound to be used as filler for the compression joints and dead end clamps to be supplied.

13.0 TESTS, TEST CERTIFICATE AND PERFORMANCE REPORTS

The fittings and accessories for the power conductor and G.S.S. ground wire, insulator and hardwares shall be tested in accordance with IS:2121, IS:2486, IS:9708 (For V Dampers), BS:916 for hexagonal bolts and nuts or any other authoritative equivalent standards. Six sets of type and routine test certificates and performance reports are to be submitted by the bidder.
The Employer however, reserves the right to get all the tests performed in accordance with the relevant I.S. Specification as Acceptance Test in presence of Employer-s representatives.
The tenderer shall clearly state the testing facilities available in the laboratory at his Works and his ability to carry out the tests in accordance with this Specification. All the specified tests shall be carried out without any extra cost.

Acceptance Test for power conductor and G.S.S. ground wire accessories.

a) Visual examination
b) Dimensional verification
c) Failing load test
d) Slip strength test (for clamps)
e) Electrical resistance test
f) Resonance frequency test (for vibration dampers)
g) Fatigue test (for vibration dampers)
h) Mass pull off test (for vibration dampers)
i) Galvanising test**.**

13.1 ACCEPTANCE TEST FOR HARDWARES

a) Dimensional verification.
b) Ultimate tensile test.
c) Slip strength test.
d) Electrical resistance test.
e) Heating cycle test
f) Breaking strength of full string assembly.

g) Galvanising test.

13.2 SPECIFIC TECHNICAL REQUIREMENTS FOR CONDUCTOR ACCESSORIES AND INSULATOR HARDWARES

Conductor	Panther/zebra/Moose	GSS ground wire
a) Type	ACSR Panther/zebra/Moose	Ground wire.
b) Material	Aluminium conductor steel reinforced.	Galvanised stranded steel wire.
c) Strand & Wire diameter.	Panther/Zebra/Moose Aluminium 30/3mm Steel 7/3mm,/all.54/3.18mm steel-7/3.18mm,/ all.54/3.53mm steel-7/3.53mm resp.	7/3.15 mm. and 7/3.66 mm
d) Weight per Km.	974/1622 /2004Kg/Km.	426 Kg/Km.and 583Kg/Km
e) Overall diameter	21/28.62/31.7 mm	9.4mm. and 10.98 mm
f) D.C. Resistance at 20 deg. C when corrected to standard weight.	0.13750/0.06915/0.05552 Ohms/KM.	3.375 Ohms/KM
g) Minimum Breaking load/Ultimate tensile strength.	144/13289/16120 Kg	5710 Kg.and 10580 Kg
h) Maximum working tension at minimum temperature & 2/3 full wind.	3806/4325 Kg.	1393 Kg.
i) Maximum Sag at maximum temperature & no wind.	6120/9240 mm.	5150mm.

DISC Insulator (for suspension & tension Insulator strings) (132 ,220 and 400 KV)

Disc Insulators	Suspension	Tension
a) Type	**Ball & Socket**	**Ball & Socket.**
b) Ball size	**16mm. Alt. B**	**20mm. Alt.**
c) Diameter	**(IS:2486 Pt.II)**	**B/20mm**
d) Spacing	**254/255 mm.**	**(IS:2486 Pt.II)**
e) E.M. strength	**146/145 mm.** **90/120 KN,.**	**255/280 mm** **145/170mm.** **120/160 KN.**

	Single Suspension	Single Tension	Double Suspension	Double Tension
132 KV / 220 KV /400 KV **String Arrangements :**				
a) No. of insulator discs.	**10/14/25**	**10/14/25**	**2x10/2X14 /2X25**	**2x10/2 X14/ 2X25**
b) Length of string assembly (mm)	**1672/2340**	**1851/3003**	**1837/2243**	**2132/30 82**

GENERAL REQUIREMENT FOR POWER CONDUCTOR & GROUND WIRE:

I) ACCESSORIES.

GENERAL REQUIREMENTS
POWER CONDUCTOR AND GROUND WIRE ACCESSORIES

A) MID-SPAN COMPRESSION JOINTS

	Suitable for ACSR "Panther'/zebra/Moose	Suitable for G.S.S. groundwire 7/3.15 and 7/3.66 mm.
i) Type	**Compression**	**Compression**
ii) Material		
a) Outer sleeve	**Extruded Aluminium**	**Extruded aluminium.**
b) Inner sleeve	**Steel (galvanised)**	**Steel (Galvanised)**

	Before Compress-ion	After Compre-ssion	Before Compression	After Compr ession
iii) Dimension of Compression joint	**Outer dia:38mm**	**Adjacent Size 32**		

for Aluminium part.	**Inner Dia:23mm. Minimum length : 610mm. Minimum weight 1.2 kg. (approx)**	**mm. Diagonal Size : 37nn.**		
iv) Dimension of compression joint for Steel Part	**Outer dia:18mm Inner dia. 9.3 mm Adjacent Size : 15.1mm Minimum Length : 203mm. Minimum weight : 0.28Kg (app.)**	**Adjacent size : 15.1mm. 10mm. Minimum**	**Outer dia.18mm. Inner dia : size : 17.4mm Length 203mm.**	**Adjacent Size : Diagonal**
v) Minimum failing load.	**95% of ultimate tensile strength of conductor**	**95% of ultimate tensile strength of groundwire**		
vi) Electrical resistance 20 Deg. C	**75% of measured resistance of the equivalent length of conductor.**			
vii) Galvanising :				
a) Ferrous Parts.	**Hot-dip galvanised (HDG)**	**Hot dip galvanised.**		
b) No.of dips 4	**4 dips**			

dips for minute withstand.	**1**	**4 dips**
viii) Minimum Corona formation voltage	**110% of maximum line to ground voltage**	

B) VIBRATION DAMPERS:

(SUITABLE FOR ACSR CONDUCTOR: PANTHER/ZEBRA /MOOSE AND G.S.S. GROUND WIRE 7/3.15 and 7/3.66 mm.

i) Type : 4R Stock Bridge Type
ii) Distance between conductor : 74.5 mm. & axis of the Vibration Damper.
iii) Messenger Cable : 130 Kg/mm sq. quality (19 strands)
iv) Bolt size : 16 mm. (dia.)
v) Slip strength of messenger Cable : 500 Kgs.
vi) Mass pull-of : As per I.S.S.

C) REPAIR SLEEVES:

SUITABLE FOR ACSR PANTHER/ZEBRA/MOOSE CONDUCTOR AND G.S.S. GROUND WIRE.

		Suitable for ACSR panther/Zebra/Moose.	**Suitable for G.S.S. Ground wire.**
i)	**Type**	**Compression**	**Compression.**
ii)	**Material**	**Extruded aluminium.**	**Steel**
iii)	**Min. failing load**	**95% of UTS of conductor.**	**95% of UTS of ground wire.**
iv)	**Length**	**241/279 mm.**	**200 mm (150 mm. min.)**
v)	**Dimension :**		

a) After compression (i) Adjacent side	**21mm**	**11.5 mm**
(b) Before Compression :		
(i)Outerdiameter 38/48mm.	**21mm.**	
(ii)Innerdiameter 23/40mm	**11.5mm.**	
vii) Electrical Resistance at 20 deg. C	**Not more than 75% of the resistance of equivalent length of conductor.**	
vii) Galvanising :		
a) Ferrous parts		**Hot – dip galvanized**
b) No. of dips for one-minute stand.		**4 dips**

D) SUSPENSION CLAMP:
FOR GROUND WIRE 7/3.15 and 7/3.66 mm

i) Type : Envelop type

ii) Material : Forged Steel / NCL.

iii) Minimum slip strength : 25% of UTS of ground wire.

iv) Dimension :

(a) Overall length : 230mm

(b) Inner dia. (before compression). : 10mm.

(c) Outer diameter (before compression). : 18mm.

(d) After Compression :

Adjacent : 15.1 mm.

Diagonal side : 17.4mm.

(e) Galvanising :

(i) Fwerrous parts. **: Hot-dip galvanised.**

(ii) No. of dips for one-minute withstand. **: 4 dips**

E) BONDING PIECES:

a) material	**:**	**flexible copper bond (37/7/ 0.417 mm. tinned copper flexible stranded cable).**
b) Length	**:**	**Not less than 750 mm.**
c) Bolt size	**:**	**16mm x 40 mm.**
d) Copper area.	**:**	**34 sq.mm.**
e) Thickness of long	**:**	**6 mm.**
f) Material for connecting socket.	**:**	**Tinned Brass**

F) INSULATOR HARDWARES

A) String hardwares :

Material and strength

	Description of item.	Material	UTS
i)	**Bolt hook**	**Forged Steel**	**11,500 Kgs (90 KN)**
ii)	**Anchor Shackle**	**-do-**	**15,500 Kgs (120 KN)**
iii)	**Socket Eye Horn Holder.**	**- do-**	**11,500 Kgs (90 KN)**
iv)	**Socket Clevis.**	**-do-**	**15,500 Kgs.**
v)	**Ball Clevis**	**-do-**	**15,500 Kgs.**
vi)	**Clevis Eye**	**-do-**	**15,500 Kgs.**
vii)	**Socket Eye.**	**-do-**	**15,500 Kgs.**

vii) Bottom / Top Yoke plate :

	Double suspension	**Mild Steel**	**11,500 Kgs.**
	Double Tension	**-do-**	**15,500 Kgs.**
ix)	**Arcing Horn**	**-do-**	**___**
x)	**Suspension Clamp.**	**Aluminium Alloy and Neoprene.**	**___**
xi)	**Tension Clamp.**	**All.Alloy & Steel.**	**11,500 Kgs.**
xii)	**Ball Pin**	**High tensile forged steel (hot-dip galvanised)**	**90% of UTS of conductor.**
xiii)	**Security Clip**	**Brass (R-Type)**	
	Mininum failing load String (KN)	**Single Suspension**	**: 11,500**
		Single Tension	**: 11,500/15,500**
		Double Suspension	**: 11,500**
		Double Tension	**: 11,500/15,500**

II) CLAMPS.

	Single suspension string	**Single tension string**	**Double suspension string**	**Double tension string.**
i) Type	AGS Type	Compression Type	AGS Type	Compression Type
ii) Material	**Aluminium Alloy and neoprene**	Aluminium Alloy and Steel	Aluminium Ally and Neoprene	Aluminium Alloy and Steel
ii) Minimum slip strength	Not less than 15%	90% of UTS of conductor	Not less than 15% of UTS of conductor	90% of UTS of conductor
iv) Minimum failing load (kg)	11,500	90% of UTS of conductor	11,500 90%	Of UTS of conductor

III). Suspension assembly: armour grip clamp.

1. The armour grip suspension clamp shall comprise of retaining strap, support housing, elastomer inserts with aluminum reinforcements and AGS preformed rod set.

2. Elastomer insert shall be resistant to the effects of temperature up to 85 deg. C, ozone, Ultraviolet radiation and other atmospheric contaminants likely to be encountered in service. The physical properties of the elastomer shall be of approved standard. It shall be electrically shielded by a cage of AGS preformed rod set. The elastomer insert shall be so designed that the curvature of the AGS rod shall follow the contour of the neoprene insert.

3. The AGS preformed rod set shall be as detailed above in general except that the length of the AGS preformed rods shall be such that it shall ensure sufficient slipping strength and shall not introduce unfavourable stress on the conductor under all operating conditions.

IV) **Fasteners: bolts, nuts & washers.**

1. All bolts and nuts shall conform to IS-6639 – 1972. All bolts and nuts shall be galvanized. All bolts and nuts shall have hexagonal heads, the heads being truly concentric, and square with the shank, which must be perfectly straight.

2. Bolts upto M16 and having length upto ten times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control. The shear strength of bolt for 5.6 grade should be 310 Mpa minimum as per IS-12427. Bolts should be provided with washer face in accordance with IS-1363 Part-I to ensure proper bearing.

3. Fully threaded bolts shall not be used. The length of the bolt shall be such that the threaded portion shall not extend into the place of contact of the component parts.

4. All bolts shall be threaded to take the full depth of the nuts and threaded enough to permit the firm gripping of the component parts but not further. It shall be ensured that the threaded portion of the bolt protrudes not less than 3 mm and not more than 8 mm when fully tightened. All nuts shall fit and be tight to the point where shank of the bolt connects to the head.

5. Flat washers and spring washers shall be provided wherever necessary and shall be of positive lock type. Spring washers shall be electro-galvanized. The thickness of washers shall conform to IS-2016-1967.

6. The bidder shall furnish bolt schedules giving thickness of components connected, the nut and the washer and the length of shank and the threaded portion of the bolts and size of holes and any other special details of this nature.

7. To obviate bending stress in bolt, it shall not connect aggregate thickness more than three time its diameter.

8. Bolts at the joints shall be so staggered that nuts may be tightened with spanners without fouling.

9. Fasteners of grade higher than 8.8 are not to be used and minimum grade for bolts shall be 5.6.

GENERAL:

1. All ferrous parts including fasteners shall be hot dip galvanized, after all machining has been completed. Nuts may however be tapped (threaded) after galvanizing and the threads oiled. Spring washers shall be electro-galvanized. The bolt threads shall be undercut to take care of the increase in diameter due to galvanizing. Galvanizing shall be done in accordance with IS-2629-1985 and shall satisfy the tests mentioned in IS 2633-1986. Fasteners shall withstand four dips while spring washers shall withstand three dips of one-minute duration in the standard Preece test. Other galvanized materials shall be guaranteed to withstand at least six successive dips each lasting one minute under the Standard Preece test for galvanizing.

2. The zinc coating shall be perfectly adherent of uniform thickness, smooth, reasonably bright, continuous and free from imperfections such as flux, ash, rust stains, bulky white deposits and blisters. The zinc used for galvanizing shall be of grade Zn 99.95 as per IS 209-1979.

3. Pin balls shall be checked with the applicable "G)" gauges in at least two directions, one of which shall be across the line of die flashing and the other 90 deg. to this line. 'NO GO' gauges shall not pass in any direction.

4. Socket ends, before galvanizing shall be of uniform contour. The bearing surface of socket ends shall be uniform about the entire circumference without depressions or high spots. The internal contours of socket ends shall be concentric with the axis of the fittings as per IS 2486/IEC-120. The axis of the bearing surfaces of socket ends shall be coaxial with the axis of the fittings. There shall be no noticeable tilting of the bearing surfaces with the axis of the fittings.

5. All current carrying parts shall be so designed end manufactured that contact resistance is reduced to minimum.

6. Welding of aluminum shall be by inert gas shielded tungsten are or inert gas, shielded metal arc process. Welds shall be clean, sound, smooth, and uniform without overlaps, properly fused and completely sealed. There shall be no cracks, voids incomplete penetration, incomplete fusion, under-cutting or inclusions Porosity shall be minimized so that mechanical properties of the aluminum alloys are not affected. All welds shall be properly finished as per good engineering practices.

Electrical Design:

The normal duty and heavy duty suspension, light duty, normal duty and heavy duty tension insulator sets shall all comply with the technical requirements of schedule C and satisfy the test requirements stated in Section-7.

Mechanical design:

The mechanical strength of the insulators and insulator fittings shall be as stated in Schedule-C

The design shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to the development of defects.

Insulating material shall not engage directly with hard metal. All fixing materials shall be of approved quality, shall be applied in an approved manner and shall not enter into chemical action with the metal parts or cause fracture by expansion in service. Where cement is used as a fixing medium, cement thickness shall be as small and even as possible and proper care shall be taken to correctly centre and locate the individual parts during cementing.

Technical Specification for Design, Supply and Testing of Hard ware fittings.

Type tests:

The following type tests shall be conducted on hardware fittings.

A. **On suspension hardware fittings only.**

(a) Magnetic power loss test.
(b) Clamp slip strength Vs torque
(c) Mechanical strength test.
(d) On one test on elastomer.

B. **On Tension hard ware fittings only.**

Electrical resistance test for Dead end assembly. IS 2486 (Part-I) 1971

(a) Heating cycle test for -do-

dead end assembly.

(b) Slip strength test for dead end assembly. IS 2486 (Part-I)

(c) Mechanical strength test.

C. **<u>On both suspension and tension hardware fittings</u>**.

(a) Visual examination. IS-2486 (Part-I) 1971

(b) Verification of dimension. -do-

(c) Galvanizing / electroplating test. -do-

(d) Mechanical strength test of each component (including corona control ring/grading ring and arcing horn)

(e) Mechanical strength test of welded joint.

(f) Mechanical strength test for corona control ring/ grading ring and arcing horn. BS-3288 (Part-I)

(g) Test on locking device for ball and socket coupling. IEC – 3721984

(h) Chemical analysis, hardness tests, grain size, inclusion rating and magnetic particle inspection for forging/casting.

D. **<u>On suspension hardware fittings only.</u>**

(a) Clamp slip strength ver as torque test for suspension clamp.

(b) Shore hardness test of elastomer cushion for AG suspension clamp.

(c) Bend test for armour rod set. IS-2121 (Part-I)

(d) Resilience test for armour rod set. -do-

(e) Conductivity test for armour rod set. -do-

E. **<u>On tension hardware fittings only</u>**

	Unit.	37/4.00 mm^2
MID SPAN COMPRESSION JOINTS FOR CONDUCTORS.		
Weight of the joint.	Kg.	1.27
Slipping strength.	KN	129.6
Resistance of the completed joint.	Ohms.	0.000027
Materials of the joints specify alloy type		6201

and its aluminum contents.		
Before compression dia of sleeve.	mm	
(a) Inner diameter.		31+/-0,5
(b) Outer diameter.		48+/-1.0
Dimensions after compression.	mm	
(a) Corner to corner.		46+/-0.5
(b) Surface to surface.		40+/-0.5
Length of the sleeve.	mm	
(a) Before compression.		500+/-5.0
(b) After compression.		540+/-5.0
Compression pressure.	Tone	100
Whether designed for intermittent or continuous compression.		Continuous compression.
Minimum corona extinction voltage under dry condition.	Kv	154
Radio interference voltage under conditions.	Micro volt.	Below 1000
REPAIR SLEEVE FOR CONDUCTOR		
Weight of the sleeve.	Kgs.	0.63
Before compression dia of sleeve.		
(a) Inner diameter.	mm	31.05
(b) Outer diameter.	mm	48.10
Dimensions after compression.		
(a) Corner to corner.	mm	48.05
(b) Surface to surface.	mm	40.05
Length of sleeve.		
(a) Before compression.	mm	279.50
(b) After compression.	mm	300.50
Compression pressure.	Tone.	100
Minimum corona extinction voltage under dry condition.	Kv.	154
Radio interference voltage under condition.	Micro volt.	Below 1000

(a) Slip strength test for dead end assembly. IS-2121 (Part-I)

All the acceptance tests stated at clause shall also be carried out on composite insulator unit, except the eccentricity test at clause. In addition to these, all the acceptance tests indicated in IEC 1109 shall also be carried out without any extra cost to the employer.

F. For hardware fittings.

(a) Visual examination. IS-2121 (Part-I)

(b) Proof & test.

G. **Tests on conductor accessories.**

H. Type tests.

I. Mid span compression joint for conductor and earthwire.

(a) Chemical analysis of materials.

(b) Electrical resistance tests. IS-2121 (Part-II) 1981 clause 6.5 & 6.6

(c) Heating cycle test. -do-

(d) Slip strength test. -do-

(e) Corona extinction voltage test (dry)

(f) Radio interference voltage test (dry)

J. Repair sleeve for conductor.

(a) Chemical analysis of materials.

VIBRATION DAMPER FOR CONDUCTOR.

Vibration Damper for AAC 37/4.00 mm	Unit.	
Total weight of the damper.	Kgs.	4.5
		Left. Right.
Weight of each damper mass.	Kgs.	1.6 2.2
Resonance frequencies.		
1. First frequency.	Hz	12+/- 1 18+/- 2
2. Second frequency.	Hz	28+/- 2 36+/- 2
Dimension of each damper mass.	Mm	55 Ox165 60 Ox195
Material of:		
1. Damper miss.		Cast iron hot dip galvanized.
2. Messenger cable.		High tensile galvanized steel wire.
No. of strands in messenger cable strands.		19
Lay ratio of messenger cable strands.		9-11
Min tensile strength of messenger cable.	Kg./ Sq.mm	135
Miss pull-off strength.	KN	5
Clamping forque.	Kg.m	7
Slipping strength of the damper clamp.	KN	
1. Before fatigue test.		2.5
2. After fatigue test.		2.0
Magnetic power loss per vibration damper.	Watts.	1 watt at 500 amps.

Min. corona extinction voltage under dry conditions.	Kv.	154
Radio interference voltage under dry condition 1MHz, at 154 KV.	Microvolt.	Below 1000
Percentage variation in reactance after fatigue test in compassion with that before the fatigue test.	%	20

SECTION – V
CLAMPS AND CONNECTORS

TECHNICAL SPECIFICATION
CLAMPS AND CONNECTORS

(A) TECHNICAL SPECIFICATION FOR CLAMPS & CONNECTORS

1. SCOPE

This specification covers design, manufacture, assembly, testing at manufacturer's works, supply and delivery at site of all terminal connectors of 220,132 & 33KV equipments (mainly breaker, isolator, CT,PT,CVT,BPI and LA) and all other clamps and dropper connectors required for the switch yard as per approved lay out and system design.

2. STANDARDS

The terminal connectors under this specification shall conform strictly to the requirements of the latest version of the following standards as amended up-to-date, except where specified otherwise.

i)	IS: 5561	Power Connectors.
ii)	IS:617	Aluminium & Aluminium Alloy
iii)	IS: 2629	Recommended Practice for hot dip galvanizing of iron and steel.
iv)	IS: 2633	Method of testing uniformity of coating of zinc coated articles.

The materials conforming to any other authoritative standards which ensure equal or better performance shall also be acceptable. The salient point of these specifications and points of difference between these and the above specifications, shall be clearly brought out in the bid.

3. MATERIAL & WORKMANSHIP

The terminal connectors shall be manufactured from Aluminium Silicon Alloy and conform to designation A6 of IS: 617 (latest edition)

The connectors shall be of best quality and workmanship, well finished and of approved design. Specific materials for clamps and connectors should have high current carrying capacity, high corrosion resistance and be free from corona formation.

All connectors or its components to be connected with ACSR conductor shall be of compression type having aluminium purity not less than 99.5%.

All bus bar clamps shall be made preferably from forged aluminium of purity not less than 99.5%. The thickness and contact surface should be maintained in such a way that the clamp should conform to IS:5561/1970 or any latest revision thereof.

4. RATING

The connector rating shall match with the rating of the respective equipments for the terminal connectors and the connectors for bus bar and dropper should be of the following rating. Minimum thickness at any part of connector shall be 10(ten)mm. Indicative ratings are given below:

	Rating	400/220 / 132 KV
1.	Main bus bar connectors high level and low level (Amps)	3600/2000/2000
2.	High level bus sectionalisation isolator(Amps)	3600/2000/2000
3.	Connectors along the bay (Amps)	3600/2000/2000
4.	Terminal connectors for CB(Amp.)	as per rating of CB
5.	-do- for Isolator(Amps)	as per rating of ISO
6.	-do- for CT	As per CT rating
7.	-do- for PI	As per PI rating
8.	-do- for LA	As per LA rating
9.	-do- for PT	As per PT rating
10.	-do- for CVT	As per CVT rating
11.	-do- for WT	As per WT rating.

5. EQUIPMENT CONNECTORS

Bimetallic connectors shall be used to connect conductors of dissimilar metal. The following bimetallic arrangement shall be preferred.

i) copper clodding of minimum 4 mm. thickness on the aluminium portion of connector coming in contact with the copper palm or stud of the equipment.

ii) alternatively, to provide cold rolled aluminium copper strip between the aluminium portion of the connection, the sheet thickness shall not be less than 2 mm.

Sufficient contact pressure should be maintained at the joint by the provision of the required number of bolts or other fixing arrangements, but the contact pressure should not be so great as to clause relaxation of the joint by cold flow, the joint should be such that the pressure is maintained within this range under all conditions of service, to avoid excessive local pressure, the contact pressure should be evenly distributed by use of pressure plates, washers or suitable saddles of adequate area of thickness should be less than that of an

equal length of conductor where measured individually test results showing the milli drop test and resistance should be enclosed with the bid.

All connectors shall be so designed and manufactured as to offer ease of installation as these are to be used in overhead installations, design shall be such that full tightening of nuts and bolts should be possible with the use of double wrench.

The connectors shall be such as to avoid local corona, sound or visible discharge.

6. TEMPRATURE RISE

The temperature rise of connectors when carrying rated current shall not exceed 45˚ C above reference design temperature of 50˚ C.

i) Acceptance Tests
(a) Tensile Test
(b) Temperature rise test
© Temperature rise test
ii) Routine Test
(a) Visual Inspection
(b) Dimensional Check

Type test reports from a recognized laboratory shall have to be submitted.

7. WEIGHTS

Weights of different materials uses in manufacture, such as aluminium, silicon, copper etc. should be clearly indicated in the bid.

8. INTERCHANGE ABILITY

Corresponding parts of similar clamps and connectors shall be made to gauge or jig and shall be interchangeable in every respect.

(B) **TECHNICAL SPECIFICATION FOR ACSR BUS-BAR**

1. **SCOPE**

The specification covers design, engineering, manufacture, testing at manufacturer's works, supply and delivery of heavy duty ACSR bus-bar for use in 220 KV and 132 kV sub-station.

2. **MATERIALS**

The ACSR bus bar shall be drawn by using MOOSE/ZEBRA as per system requirement.

The strung ACSR bus-bar shall be of heavy duty type and design to operate within set temperature limits and to withstand thermal and electromechanical forces developed due to short circuits.

3. **MECHANICAL CHARACTERISTICS**

The mechanical strength of the strung ACSR bus-bar shall be limited to be maximum allowable tension for specific size of conductor as per ISS.

4. **DIMENSIONAL TOLERANCE**

Dimensional tolerances shall be as per relevant ISS.

5. **CHEMICAL COMPOSITION**

The chemical composition for ACSR conductors (MOOSE/ZEBRA) shall be holding good under all operating condition.

6. **ELECTRICAL & MECHANICAL CHARACTERISTICS AND CURRENT RATINGS**

Electrical and mechanical characteristics and current ratings for ACSR bus-bar shall be same as stipulated for MOOSE/ZEBRA ACSR conductors, the details of which has been specified.

SCHEDULE OF GUARANTEED TECHNICAL PARTICULARS

LINE HARDWARE AND ACCESSORIES FOR 132/220 KV & GROUND WIRE 7/3.15mm

A	HARDWARES	Suspension	Tension
i	Maker's name and Address	ERI-TECH LIMITED	
ii	Size and designation of ball and socket with standard specification to which conforming	16mmB as per IS 2486	20mm as per IS 2486
iii	Material		
a	Anchor shackle	NA	Forged steel Galvanised
b	Chain Link	NA	Forged Steel galvanised
c	Ball hook / Ball Link (HH)	Forged Steel galvanized	Forged Steel galvanised
d	Socket Eye (HH)	Forged Steel galvanized	NA
e	Ball Clevis	Forged Steel galvanized	Forged Steel galvanised
f	Socket Clevis	Forged Steel galvanized	Forged Steel galvanised
g	Yoke Plate	Mild Steel Galvanised	Mild Steel Galvanised
h	Arcing Horn	Mild Steel Galvanised	Mild Steel Galvanised
i	Clamp Suspension	A.G.S. Clamp	NA
j	Dead End/Cross arm strap	NA	NA
k	Dead end clamp(Compression)	NA	Ext. Al. Alloy
iv	Standard specification to which the Hardwares conform	IS 2486, IS: 2004,IS:617, IS-2633, & IS-733	
v	Standard specification to which conforming	IS: 2486	
vi	Galvanising		

a	Ferrous parts	Hot Dip Galvanised		
b	Spring washers	Electro Galvanised		
c	Quality of zinc used	99.5%		
d	Number of dips which the clamp can withstand	4/ 1 minute dips		
vii	Standard to which conforming	IS 2633		
viii	Reference to drawing No.	Drg. Attached		
ix	Minimum failing load in kg	For AAAC & ACSR Panther (132 kv)	For AAAC & ACSR Zebra (220 kv)	For AAAC & ACSR Moose (220 kv/400 KV)
a	For Single Tension Hardwire Fittings	120 kN	160 kN	160 kN
b	For Double Tension Hardwire Fittings	120 kN	160 kN	160 kN
c	For Single Suspension Hardwire Fittings	70 kN	70 kN	90/120 kN
d	For Double Suspension Hardwire Fittings	70 kN	70 kN	120 kN
B.	TENSION CLAMPS	Suitable for Panther, Zebra & Moose (AAAC/ACSR)		
i	Type	Compression type tension clamp		
ii	Material	Ext. Al. Alloy/ Ext. Al.		
iii	Breaking Strength	95% of UTS of Conductor		
iv	Slipping strength	95% of UTS of Conductor		
v	Galvanising			
a	Ferrous parts	Hot Dip Galvanised		
b	Spring washers	Electro Galvanised		
c	Quality of zinc used	99.5%		
d	Number of dips which the clamp can withstand	4/ 1 minute dips		
vi	Standard to which conforming	IS 2633		
vii	Electrical Conductivity			
	a. Results of heating cycle test carried out	T.C. Attached		
	b. Electrical resistance	Not more than 75% of equivalent length of conductor		
viii	Reference to type tests and other tests reports attached	T.C. Attached		
ix	Make of bolts and nuts used	Local Make		
C	SUSPENSION CLAMPS	Panther (AAAC/ACSR)	Zebra (AAAC/ACSR)	Moose (AAAC/ACSR)
i	Type	AGS Type		
ii	Type of material used for retaining rod for AGS assembly giving reference of ISS	Aluminium Alloy 6061/ Equivalent	Aluminium Alloy 6061/ Equivalent	Aluminium Alloy 6061/ Equivalent
iii	minimum tensile strength of	35 kg/mm^2	35 kg/mm^2	35 kg/mm^2

	retaining rod material			
iv	Chemical composition of retaining rod material	As per IS:733	As per IS:733	As per IS:733
v	Electrical conductivity of Armour Rod material (in percentage of the conductivity of IACS i.e. International Annealed Copper Standard	Not less than 40% of IACS	Not less than 40% of IACS	Not less than 40% of IACS
vi	Slipping strength of cushioned suspension assembly	8% to 15% of UTS of Conductor	20 to 29 KN of UTS of Conductor	20 to 29 KN of UTS of Conductor
vii	Breaking strength of suspension Clamp	7000kgf	7000kgf	9000kgf
viii	Physical properties of neoprene cushion			
a	Minimum Tensile Strength	2000 psi	2000 psi	2000 psi
b	Minimum ultimate Elongation	300%	300%	300%
ix	Ageing (guaranteed life of the assembly)	40 years	40 years	40 years
x	Hardness	65 to 80 A	65 to 80 A	65 to 80 A

D	Midspan compressions joints for	Panther		Zebra	
		AAAC	ACSR	AAAC	ACSR
i	Type	Compression Type			
ii	Suitable for	AAAC Panther	ACSR Panther	AAAC Zebra	ACSR Zebra
iii	Materials				
a	Outer Sleeve	Ex. Al. Alloy	Ex. Al.	Ex. Al. Alloy	Ex. Al.
b	Inner Sleeve	N.A.	Galvanised Steel	N.A.	Galvanised Steel
iv	Outer Sleeve				
a	Outer Dia. Before compression (mm)	Ø 38	Ø 38	Ø 48	Ø 48
b	Flat to Flat After compression (mm)	32	32	40	40
v	Length of Outer Sleeve				
a	Before compression (mm)	610	610	711	711
b	After compression (mm)	655	660	760	768
vi	Inner Sleeve				
a	Outer Dia. Before compression (mm)	N.A.	Ø 18	N.A.	Ø 19.2
b	Flat to Flat After compression (mm)	N.A.	15.1	N.A.	16.1
vii	Length of Inner Sleeve				
a	Before compression (mm)	N.A.	203	N.A.	241
b	After compression (mm)	N.A.	230	N.A.	273
viii	Weight of Sleeve				
a	Aluminium (kg)	1.2	1.2	2.032	2.032
b	Galvanised Steel (kg)	N.A.	0.295	N.A.	0.410
ix	Galvanising				
a	Ferrous parts	Hot Dip Galvanised			

b	Spring washers	Electro Galvanized			
c	Quality of zinc used	99.5%			
d	Number of dips which the clamp can withstand	4/ 1 minute dips			
x	Standard to which conforming	IS 2633			
xi	Slipping strength of mid span joint expressed as percentage of UTS of conductor	95%			
xii	Breaking strength of mid span joint expressed as percentage of UTS of conduct	95%			
xiii	Conductivity of Compression joint expressed as percentage of conductivity of cable	100% of equivalent length of conductor			
xiv	Resistance as percentage of measured resistance of equivalent length of conductor	Not more than 75% of equivalent length of conductor			
E	**Repair Sleeve**	**AAAC & ACSR Panther**		**AAAC & ACSR Zebra**	
i	Type	Compression type			
ii	Suitable for	AAAC Panther	ACSR Panther	AAAC Zebra	ACSR Zebra
iii	Outside diameter or length of sleeve				
a	Before compression (mm)	Ø 38	Ø 38	Ø 48	Ø 48
b	After compression Flat to Flat (mm)	32	32	40	40
iv	Length of Sleeve				
a	Before compression (mm)	241	241	279	279
b	After compression (mm)	270	270	310	310
v	Material	Ex. Al.Alloy	Ex. Al.	Ex. Al.Alloy	Ex. Al.
vi	Weight of sleeve in (kg)	0.450	0.453	0.810	0.810
vii	Breaking strength as percentage of UTS of conductor	95%			
viii	Conductivity as percentage of conductivity of conductor	100% of equivalent length of conductor			
ix	Resistance as percentage of measured resistance of equivalent length of conductor	Not more than 75% of equivalent length of conductors			
F	**Vibration Damper**	For AAAC & ACSR ZEBRA			
i	Total weight of the damper (Kg)	4.5 Approx			
		Left		Right	
ii	Weigh of each damper mass (kgs.)	1.6		2.2	
iii	Resonance frequencies				
	1. First frequency (Hz)	12± 1		18± 2	

	2. Second frequency (Hz)	28± 2	36±2
iv	Dimensions of each damper mass	60 Φ x 195	55 Φ x 165
v	Material of :		
	1. Damper mass	Cast iron hot dip galvanised.	
	2. Messenger cable.	High tensile galvanised steel wire.	
vi	Galvanising		
a	Ferrous parts	Hot Dip Galvanised	
b	Spring washers	Electro Galvanised	
c	Quality of zinc used	99.5%	
d	Number of dips which the clamp can withstand	4/ 1 minute dips	
vii	Standard to which conforming	IS 2486 and IS 2633	
viii	No of strands in messenger cable strands	19	
ix	Lay ratio of messenger cable strands	9 11	
x	Min tensile strength of messenger cable (kg /sq. mm)	135	
xi	Mass pull - off strength (KN)	5	
xii	Clamping torque (Kg.m)	7	
xiii	Slipping strength of the damper clamp		
	1.Before fatigue test (KN)	2.5	
	2. After fatigue test (KN)	2	
xiv	Magnetic power loss per vibration damper (Watts)	1 watt at 500 amps	
xv	Min. corona extinction voltage under dry conditions (KV)	154	
xvi	Radio interference voltage under conditions 1 MHZ, AT 154 KV (Microvolt)	Below 1000	
xvii	Percentage variation in reactance after fatigue test in comparison with that before the fatigue test (%)	20	
G	**Midspan compression joint For 7/3.15mm Galvanised Stranded Steel Wire**		
i	Material	Galvanized Steel	
ii	Size	OD 20.2 x Length 230	
iii	Suitable for groundwire	Yes (7/3.15)	
iv	Weight in kg	0.85	
v	Minimum failing load	50 KN	
vi	Galvanization		
a	Ferrous parts	Hot Dip Galvanised	
b	Spring washers	Electro Galvanised	
c	Quality of zinc used	99.5%	
d	Number of dips which the clamp can withstand	4 / 1 minute dip	
vii	Standard to which conforming	IS 2633	

H	**Suspension Clamps For 7/3.15mm Galvanised Stranded Steel Wire**	
i	Materials	Malleable Cast Iron / Galvansied Steel
ii	Size	As per Drawing
iii	Suitable for groundwire	Yes (7/3.15)
iv	Weight in kg	
v	Slip strength	12-17 KN
vi	Minimum failing load	70 KN
vii	Galvanising	
a	Ferrous parts	Hot Dip Galvanised
b	Spring washers	Electro Galvanised
c	Quality of Zinc used	99.5%
d	Number of dips which the clamp can withstand	4/1 minute dips
viii	Standard to which conforming	IS 2486 and IS 2633
I	**Compression type dead end assemblies For 7/3.15mm Galvanised Stranded Steel Wire**	
i	Materials	Forged steel
ii	Size	As per drawing
iii	Suitable for ground wire	Yes (7/3.15)
iv	Weight in kg	3.69
v	Minimum failing load	70 KN
vi	Galvanising	
a	Ferrous parts	Hot Dip Galvanised
b	Spring washers	Electro Galvanized
c	Quality of zinc used	99.5%
d	Number of dips which the clamp can withstand	4/ 1 minute dips
vii	Standard to which conforming	IS 2486 and IS 2633
J	**Flexible copper bond**	
i	Drawings enclosed	Yes
ii	Stranding	37/7/0.417
iii	Cross sectional area (Sq.mm)	75.6
iv	Minimum copper equivalent area (Sq.mm)	34 (each individual wire)
vi	Length of copper cable (mm)	500
vii	Material lugs	Tinned Copper
viii	Bolt Size	
	(i) Diameter (mm)	16
	(ii) Length (mm)	40
ix	Resistance (Ohm)	0.0004 (as per IS:2121)
x	Total weight of flexible copper bond (kg)	0.45 (approx)

ODISHA POWER TRANSMISSION CORPORATION LIMITED

OFFICE OF THE SR. GENERAL MANAGER,
CENTRAL PROCUREMENT CELL,
JANAPATH, BHUBANESWAR – 751022.

TECHNICAL SPECIFICATION

CONTROL AND RELAY PANEL , SAS ,

Switch yard AC building

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 gasketted 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 tri vector 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 tha 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 leve III as per IEC 602555.

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 m 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 polyncychloride 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 funs 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 with 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 of Elmex) / Connectwell. 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 earthling 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 withadequate 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 suppl

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 curing 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 catridge type confirming 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	Signal Red	537
132KV	Lemon Yellow	
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 resister preferably built in the lamp assembly. Lamps shall have translucent lamp covers to difuse 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 healthy indication.	2 Nos.	White
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 aalso 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 lamicoid. 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 atleast 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 aadjoining 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 syatem 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** anunciator(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 anunciator 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 than25 mm.

3.3 Instrument shall confirm 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 (Not Required)

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 instaneous 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 □ 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 rage 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. Zs = Source impedance. Zl = 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

6.10.1General

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 form SeriesC of Table1 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 I 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 ± 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-inflammable 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 contracts 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 contracts. 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 contracts 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 designtation	Relay Panels type and designtation
1	Line protection panel:		
1.1	400kV line-4CT,5CT (1 $^{1}/_{2}$ 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-	CPH4H	RPH4H
	Transformer	CPL2D	RPL2D
2.2	220/132kV Auto-	CPH2D	RPH2D
	Transformer	CPL1M	RPL1M
2.3	220/33kV power	CPH2D	RPH2D
	Transformer	CPL0M	RPL0M
2.4	132/33kV power	CPH1M	RPH1M
	Transformer	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	AA	A	N	A

H				$1^1/_2$ 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 1 $^{1}/_{2}$ breaker scheme	**For 220kV and 132kV**	**For 33kV**
1.	Ammeter (Digital)	3 Nos. for each bay (1 for each bay in case of 220 kV) + 1No. for reactor (as per requirement)	1No. (2 Nos. for Bus section coupler)	1No.
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	NOT REQD	NOT REQD	NOT REQD

	MDI.			
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 reacter (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 pannel	one in buscoupler pannel
17.5.	for annunciation D.C. fail accept	one in any one specific control panel	one in buscoupler pannel	one in buscoupler pannel
17.6.	for annunciation D.C. fail test	one in any one specific control panel	one in buscoupler pannel	one in buscoupler pannel
17.7.	for annunciation A.C. fail accept	one in any one specific control panel	one in buscoupler pannel	one in buscoupler pannel
17.8.	for annunciation A.C. fail test	one in any one specific control panel	one in buscoupler pannel	one in buscoupler pannel
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 new sub-station	one for each new sub-station	one for each new sub-

				station

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 RPL2A	132kV RPL1A	33kV RPL0A
1	Main-I protection scheme (composite numerical distance protection relay with auto reclosing and check syncronising facility)	1 set	1 set	1 set	Not required
2	Main-II protection scheme(composite numerical distance protection or phase comparision relay with auto reclosing and check syncronising facility)	1 set	1 set	Not required	Not required
3	Composite numerical directional & or non-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& II 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 protection relays (depending on its application)	1 set	1 set	1 set	Not required
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(in built feature of O/C & E/F relay)	1 set	1 set	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: • 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
	Restricted earth fault protection (Electromechanical of high impedance with Stabilising resistor & metrosil)	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-Al,2.WTI,BUCH,OTI – Al & 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	1 set	1 set	1 set

	system)			
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 protection relays	1 set for each module	1 set for each module	1 set for each module	1 set for 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 FACILTY. 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 confirm 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 deenrgised 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 as20% 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 miliseconds (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% 0f 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 2^{nd} 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.

Purpose	Type
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, block

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 charging 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	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 1.5and 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 ± 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.

Test programme for distance relays

General Comments:

1. These test cases are evolved from the report of working group 04 of study committee 34 (Protection) on evaluation of characteristics and performance of power system protection relays and protective systems. For any further guidelines required for carrying out the tests, reference may be made to the above document.
2. The test shall be carried out using network configuration and system parameters as shown in the figure-1
3. All denotations regarding fault location, breakers etc are referred in figure –1
4. The fault inception angles are referred to R- N voltage for all types of faults
5. The fault inception angle is zero degree unless otherwise specified
6. Where not stated specifically, the fault resistance (Rf) shall be zero or minimum as possible in simulator
7. Single pole circuit breakers are to be used
8. The power flow in double source test is 500 MW

System Parameters System voltage =400KV; CTR= 1000/1

PTR = 400000/110 (with CVT, the parameters of CVT model are shown in figure –2)

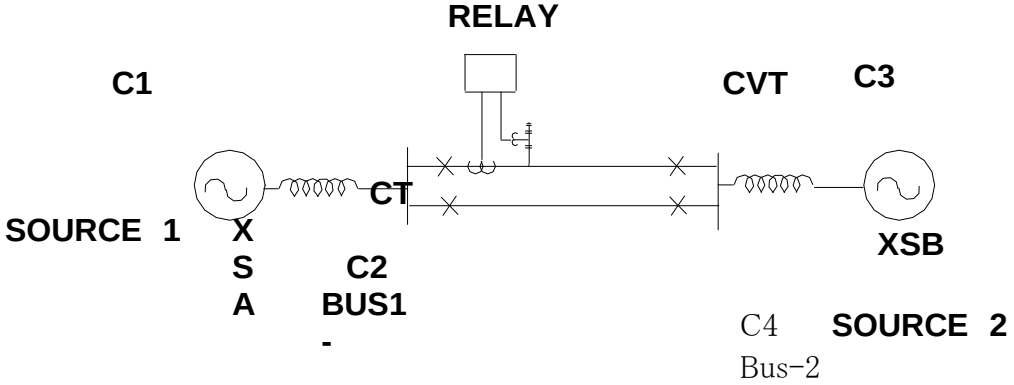


Figure-1

Line parameters/km

Positive Sequence Resistance, (r1)	= 0. 02897 Ω
Positive Sequence Reactance (x1)	= 0.3072 Ω Zero Sequence
Resistance (r0)	= 0.2597 Ω Zero Sequence
Reactance (x1)	= 1.0223 Ω Zero Sequence
Mutual Resistance (rm)	= 0.2281 Ω Zero Sequence
Mutual Reactance (xm)	= 0.6221 Ω Zero Sequence
succeptance (bo)	= 2.347 µ mho Positive
Sequence succeptance (b1)	=3.630 µmho

Types of Line	Short		Long
Secondary Line Impedance	2 Ω		20 Ω*
Length of Line in Km	23.57		235.7
SIR	4	15	4
Source impedance (pry) (at a time constant of 50 ms)	29.09 Ω (5500 MVA)	109.09 Ω (1467 MVA)	290.9 Ω (550 MVA)

* Alternatively , the tests can be done with 10 Ω secondary impedance and source impedance may accordingly be modified.

CVT Model:

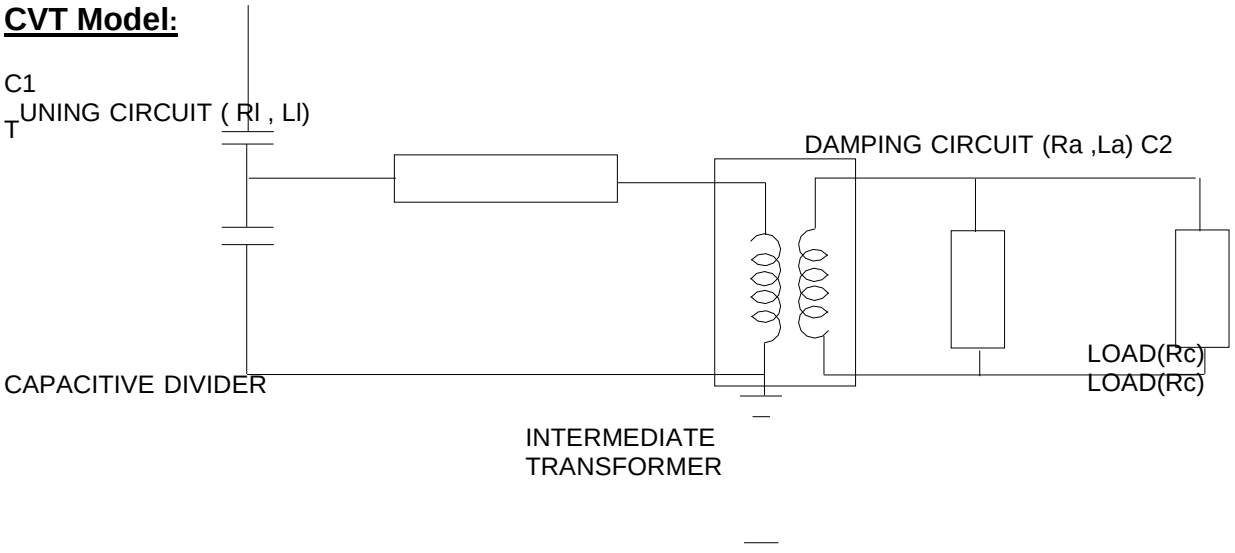


Figure-2

XC1 : 1.455 µ mho,XC2 : 27.646 µ mho
Rl : 320 Ω , Xll : 34243 Ω, Ra : 4.200 Ω, Xla : 197.92 Ω,Rc : 14.00 Ω, Transformation ratio of : 181.8 Intermediate transformer**.**

TECHNICAL SPECIFICATION

FOR

SUBSTATION AUTOMATION SYSTEM

SECTION: SUBSTATION AUTOMATION SYSTEM

1.0 GENERAL

1.1.The substation automation system shall be offered from a manufacturer who must have designed,manufactured, tested,installed and commissioned substation automation system which must be in satisfactory operation on 220kV system or higher for at least 2 (Two) years as on the date of bid opening.

1.2.The Substation Automation System (SAS) shall be installed to control and monitor all the sub-station equipment from remote control centre (RCC) as well as from local control centre.

The SAS shall contain the following main functional parts:

(A) Bay control Intelligence Electronic Devices (IED s) for control and monitoring.

(B) Station Human Machine Interface (HMI)

(C) Redundant managed switched Ethernet Local Area Network communication infrastructure with hot standby.

(D) Gateway for remote control via industrial grade hardware (to RCC) through IEC60870-5-101 protocol.

Gateway for remote supervisory control (to RSCC), the gateway should be able to communicate with RSCC on IEC 60870-5-101 protocol. The specific protocol to be implemented is enclosed as Appendix-I. Interoperability profile shall be as per IEC 61850 PROTOCOL . It shall be the bidder's responsibility to integrate his offered system with existing RSCC system for exchange of desired data. The requirement of IO point shall be worked out by the bidder as per criterion enclosed as Appendix-II for data exchange with SLDCs.

(E) Remote HMI.

Peripheral equipment like printers, display units, key boards, Mouse etc.

1.3. It shall enable local station control via a PC by means of human machine interface (HMI) and control software package, which shall contain an extensive range of supervisory control and data acquisition (SCADA) functions.

1.4. It shall include communication gateway, intelligent electronic devices (IED) for bay control and inter IED communication infrastructure. An architecture drawing for SAS is enclosed.

1.5. The communication gateway shall facilitate the information flow with remote control centres. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions.

2. **System design**

2.1 General system design

The Substation Automation System (SAS) shall be suitable for operation and monitoring of the complete substation including future extensions as required. The systems shall be of the state-of-the art suitable for operation under electrical environment present in Extra high voltage substations, follow the latest engineering practice, ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff. The offered SAS shall support remote control and monitoring from

Remote Control centres via gateways.

The system shall be designed such that personnel without any background knowledge in Microprocessor-based technology are able to operate the system. The operator interface shall be intuitive such that operating personnel shall be able to operate the system easily after having received some basic training.

The system shall incorporate the control, monitoring and protection functions specified, self-monitoring, signalling and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records.

Maintenance, modification or extension of components may not cause a shutdown of the whole substation automation system. Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.

Bidder shall offer the Bay level unit (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer), bay mimic along with relay and protection panels and PLCC panels (described in other sections of technical specifications) housed in air-conditioned *Switchyard Panel Room* suitably located in switchyard and Station HMI in Control Room building for overall optimisation in respect of cabling and control room building.

2.2 System architecture

The SAS shall be based on a decentralized architecture and on a concept of bay-oriented, distributed intelligence. Functions shall be decentralized, object-oriented and located as close as possible to the process. The main process information of the station shall be stored in distributed databases. The typical SAS architecture shall be structured in two levels, i.e. in a station and a bay level.

At bay level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The IEDs should be directly connected to the switchgear without any need for additional interposition or transducers. Each bay control IED shall be independent from each other and its functioning shall not be affected by any fault occurring in any of the other bay control units of the station. The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using fibre-optic cables, thereby guaranteeing disturbance free communication. The fibre optic cables shall be run in G . I conduit pipes. Data exchange is to be realised using IEC 61850 protocol with a redundant managed switched Ethernet communication infrastructure. The communication shall be made in fault tolerant ring in redundant mode, excluding the links between individual bay IEDs to switch wherein the redundant connections are not envisaged, such that failure of one set of fiber shall not affect the normal operation of the SAS. However failure of fiber shall be alarmed in SAS. Each fiber optic cable shall have four (4) spare fibers. At station level, the entire station shall be controlled and supervised from the station HMI. It shall also be possible to control and monitor the bay from the bay level equipment at all times. Clear control priorities shall prevent operation of a single switch at the same time from more than one of the various control levels, i.e. RCC, station HMI, bay level or apparatus level. The priority shall always be on the lowest enabled control level. The station level contains the station-oriented functions, which cannot be realised at bay level, e.g. alarm list or

event list related to the entire substation, gateway for the communication with remote control centres.

The GPS time synchronising signal (as specified in the section relay & protection) for the synchronization of the entire system shall be provided.

The SAS shall contain the functional parts as described in para 1.2 above.

2.3 FUNCTIONAL REQUIREMENTS

The high-voltage apparatus within the station shall be operated from different places:

Remote control centres

Station HMI.

Local Bay controller IED (in the bays)

Operation shall be possible by only one operator at a time. The operation shall depend on the conditions of other functions, such as interlocking, synchrocheck, etc. (see description in ”Bay level control functions”).

2.3.1 Select-before-execute

For security reasons the command is always to be given in two stages: selection of the object and command for operation under all mode of operation except emergency operation. Final execution shall take place only when selection and command are actuated.

2.3.2 Command supervision

Bay/station interlocking and blocking

Software Interlocking is to be provided to ensure that inadvertent incorrect operation of switchgear causing damage and accidents in case of false operation does not take place. In addition to software interlocking hardwired interlocking are to be provided for:

(a)Bus Earth switch Interlocking

(b)Transfer Bus interlocking (if applicable)

It shall be a simple layout, easy to test and simple to handle when upgrading the station with future bays. For software interlocking the bidder shall describe the scenario while an IED of another bay is switched off or fails.

A software interlock override function shall be provided which can be enabled to bypass the interlocking function.

2.3.3 Run Time Command cancellation

Command execution timer (configurable) must be available for each control level connection. If the control action is not completed within a specified time, the command should get cancelled.

2.3.4 Self-supervision

Continuous self-supervision function with self-diagnostic feature shall be included.

2.3.5 User configuration

The monitoring, controlling and configuration of all input and output logical signals and binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely.

It shall also be possible to interconnect and derive input and output signals, logic functions, using built-In functions, complex voltage and currents, additional logics (AND-gates, OR gates and timers). (Multi- activation of these additional functions should be possible).

The Functional requirement shall be divided into following levels:

a. Bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer) Level Functions

b. System Level Functions

3.1. Bay level functions

In a decentralized architecture the functionality shall be as close to the process as possible. In this respect, the following functions can be allocated at bay level:

Bay control functions including data collection functionality in bay control/protection unit.

Bay protection functions Separate IEDs shall be provided for bay control function and bay protection function.

3.1.1. Bay control functions

3.1.1.1. Overview

Functions

Control mode selection
Select-before-execute principle
Command supervision: Interlocking and blocking
Double command Synchrocheck,
voltage selection Run Time Command cancellation
Transformer tap changer control (Raise and lower of tap) (for power transformer bays)
Operation counters for circuit breakers and pumps Hydraulic pump/ Air compressor runtime supervision Operating pressure supervision through digital contacts only
Breaker position indication per phase
Alarm annunciation
Measurement display
Local HMI (local guided, emergency mode) Interface to the station HMI.
Data storage for at least 200 events
Extension possibilities with additional I/O's inside the unit or via fibre- optic communication and process bus

3.1.1.2. Control mode selection

Bay level Operation:

As soon as the operator receives the operation access at bay level the operation is normally performed via bay control IED. During normal operation bay control unit allows the safe operation of all switching devices via the bay control IED.

EMERGENCY Operation

It shall be possible to close or open the selected Circuit Breaker with ON or OFF push buttons even during the outage of bay IED**.**

REMOTE mode

Control authority in this mode is given to a higher level (Remote Control Centre) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

3.1.1.3. Synchronism and energizing check

The synchronism and energizing check functions shall be bay-oriented and distributed to the bay control and/or protection devices. These features are:

Settable voltage, phase angle, and frequency difference. Energizing for dead line -

live bus, live line - dead bus or dead line
– dead bus with no synchro-check function.

Synchronising between live line and live bus with synchro-check function

Voltage selection

The voltages relevant for the Synchro check functions are dependent on the station topology, i.e. on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronizing and energizing is derived from the auxiliary switches of the circuit breakers, the isolator, and earthing switch and shall be selected automatically by the bay control and protection IEDs.

3.1.1.4. Transformer tap changer control

Raise and lower operation of OLTC taps of transformer shall be facilitated through Bay controller IED.

3.1.2. Bay protection functions0

3.1.2.1. General

The protection functions are independent of bay control function. The protection shall be provided by separate protection IEDs (numerical relays) and other protection devices as per section Relay & Protection.

IEDs, shall be connected to the communication infrastructure for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.

Event and disturbance recording function

Each IED should contain an event recorder capable of storing at least
200 time-tagged events. The disturbance recorder function shall be as per detailed in section C&R

3.1.2.2. **Bay Monitoring Function:**

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The values of active power (W), reactive power (VAR), frequency (Hz),

and the rms values for voltage (U) and current (I) shall be calculated in the Bay control/protection unit.

3.2. System level functions

3.2.1. Status supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, transformer tap changer etc., shall be supervised continuously. Every detected change of position shall be immediately displayed in the single-line diagram on the station HMI screen, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in the case of spontaneous position changes.

The switchgear positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which shall give ambivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.

The SAS shall also monitor the status of sub-station auxiliaries. The status and control of auxiliaries shall be done through separate one or more IED and all alarm and analogue values shall be monitored and recoded through this IED.

3.2.2. Measurements

The analogue values acquired/calculated in bay control/protection unit shall be displayed locally on the station HMI and in the control centre. The abnormal values must be discarded. The analogue values shall be updated every 2 seconds.

Threshold limit values shall be selectable for alarm indications.

3.2.3. Event and alarm handling

Events and alarms are generated either by the switchgear, by the control IEDs, or by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All, or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time-tagged with a time resolution of 1 ms. The tentative list for various feeders and systems can be ascertained during detailed Engineering.

3.2.4. Station HMI

3.2.4.1. Substation HMI Operation:

On the HMI the object has to be selected first. In case of a blocking or interlocking conditions are not met, the selection shall not be possible and an appropriate alarm annunciation shall occur. If a selection is valid the position indication will show the possible direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object.

Control operation from other places (e.g. REMOTE) shall not be possible in this operating mode.

3.2.4.2. Presentation and dialogues

General

The operator station HMI shall be a redundant with hot standby and shall provide basic functions for supervision and control of the substation. The operator shall give

commands to the switchgear on the screen via mouse clicks.

The HMI shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log.

An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from any screen selected by the operator.

The following standard pictures shall be available from the HMI:

Single-line diagram showing the switchgear status and measured values

Control dialogues with interlocking or blocking information details. This control dialogue shall tell the operator whether the device operation is permitted or blocked**.**

Measurement dialogues

Alarm list, station / bay-oriented

Event list, station / bay-oriented

System status

3.2.4.3. HMI design principles

Consistent design principles shall be adopted with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.

The object status shall be indicated using different status colours for: Selected object under command

Selected on the screen

Not updated, obsolete values, not in use or not sampled

Alarm or faulty state

Warning or blocked

Update blocked or manually updated

Control blocked

Normal state

3.2.4.4. Process status displays and command procedures

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, isolators and transformer tap-changers shall be displayed in the station single-line diagram.

In order to ensure a high degree of security against undesired operation, a "select-before-execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen, and all other switchgear shall be blocked. As communication between control centre and device to be controlled is established, the operator shall be prompted to confirm the control action and only then final execute command shall be accepted**.** After the “execution” of the command the operated switching symbol shall flash until the switch has reached its new position.

The operator shall be in a position to execute a command only, if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay and station level.

After command execution the operator shall receive a confirmation that the new switching position has been reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

3.2.4.5. System supervision & display

The SAS system shall be comprehensively self-monitored such that faults are immediately indicated to the operator, possibly before they develop into serious situations. Such faults are recorded as a faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IEDs, communication infrastructure and remote communication links, and printers at the station level, etc.

3.2.4.6. Event list

The event list shall contain events that are important for the control and monitoring of the substation.

The event and associated time (with1 ms resolution) of its occurrence has to be displayed for each event.

The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.

A printout of each display shall be possible on the hard copy printer.

The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer for at least one month. The information shall be obtainable also from a printed event log.
The chronological event list shall contain:

Position changes of circuit breakers, isolators and earthing devices

Indication of protective relay operations

Fault signals from the switchgear

Indication when analogue measured values exceed upper and lower limits. Suitable provision shall be made in the system to define two level of alarm on either side of the value or which shall be user defined for each measurands.

Loss of communication.

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

Date and time

Bay

Device

Function e.g. trips, protection operations etc.

Alarm class

3.2.4.7. Alarm list

Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control centre. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. The date and time of occurrence shall be indicated.

The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

The date and time of the alarm

The name of the alarming object

A descriptive text

The acknowledgement state.

Whenever an alarm condition occurs, the alarm condition must be shown on the alarm list and must be displayed in a flashing state along with an audible alarm. After acknowledgement of the alarm, it should appear in a steady (i.e. not flashing) state and the audible alarm shall stop. The alarm should disappear only if the alarm condition has physically cleared and the operator has reset the alarm with a reset command. The state of the alarms shall be shown in the alarm list (Unacknowledged and persistent, Unacknowledged and cleared, Acknowledged and persistent).

Filters for selection of a certain type or group of alarms shall be available as for events.

3.2.4.8. Object picture

When selecting an object such as a circuit breaker or isolator in the single-line diagram, the associated bay picture shall be presented first. In the selected object picture, all attributes like

Type of blocking

Authority

Local / remote

control RSCC / SAS control

Errors

etc.,

shall be displayed.

3.2.4.9. Control dialogues

The operator shall give commands to the system by means of mouse click located on the single-line diagram. Data entry is performed with the keyboard. Dedicated control dialogues for controlling at least the following devices shall be available:

Breaker and disconnector

Transformer tap-changer

3.2.5. User-authority levels

It shall be possible to restrict activation of the process pictures of each object (bays, apparatus...) within a certain user authorisation group. Each user shall then be given access rights to each group of objects, e.g.:

Display only

Normal operation (e.g. open/close of switchgear)

Restricted operation (e.g. by-passed interlocking)

System administrator

For maintenance and engineering purposes of the station HMI, the following authorisation levels shall be available:

No engineering allowed

Engineering/configuration allowed

Entire system management allowed

The access rights shall be defined by passwords assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.

3.2.6. Reports

The reports shall provide time-related follow-ups of measured and calculated values. The data displayed shall comprise:

Trend reports:

Day (mean, peak)

Month (mean, peak)

Semi-annual (mean, peak)

Year (mean, peak)

Historical reports of selected analogue Values:

Day (at 15 minutes interval)

Week

Month

Year

It shall be possible to select displayed values from the database in the process display on-line. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.

Following printouts shall be available from the printer and shall be printed on demand:

i. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.

ii. Weekly trend curves for real and derived analogue values.

Iii. Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.

iv. Provision shall be made for logging information about breaker status like number of operation with date and time indications along with the current vale it interrupts (in both condition i.e. manual opening and fault tripping)

v. Equipment operation details shift wise and during 24 hours.

vi. Printout on adjustable time period as well as on demand for MW, MVAR, Current, Voltage on each feeder and transformer as well as Tap Positions, temperature and status of pumps and fans for transformers.

Vii. Printout on adjustable time period as well as on demand system frequency and average frequency.

Viii. Reports in specified formats which shall be handed over to successful bidder. The bidder has to develop these reports. The reports are limited to the formats for which data is available in the SAS database.

3.2.7. Trend display (historical data)

It shall be possible to illustrate all types of process data as trends - input and output data, binary and analogue data. The trends shall be displayed in graphical form as column or curve diagrams with a maximum of 10 trends per screen. Adjustable time span and scaling ranges must be provided.

It shall be possible to change the type of value logging (direct, mean, sum, or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.

3.2.8. Automatic disturbance file transfer

All recorded data from the IEDs with integrated disturbance recorder as well as dedicated disturbance recording systems shall be automatically uploaded (event triggered or once per day) to a dedicated computer and be stored on the hard disc.

3.2.9. Disturbance analysis

The PC-based work station shall have necessary software to evaluate all the required information for proper fault analysis.

3.2.10. IED parameter setting

It shall be possible to access all protection and control IEDs for reading the parameters (settings) from the station HMI or from a dedicated monitoring computer. The setting of parameters or the activation of parameter sets shall only be allowed after entering a password.

3.2.11. Automatic sequences

The available automatic sequences in the system should be listed and described, (e.g. sequences related to the bus transfer). It must be possible to initiate pre-defined automatic sequences by the operator and also define new automatic sequences.

3.3. Gateway

3.3.1 Communication Interface

The Substation Automation System shall have the capability to support simultaneous communications with multiple independent remote master stations,
The Substation Automation System shall have communication ports as follows:

(a) Two ports for Remote Control Centre
(b) Two ports for Regional System Coordination Centre (RSCC)

The communication interface to the SAS shall allow scanning and control of defined points within the substation automation system independently for each control centre. The substation automation system shall simultaneously respond to independent scans and commands from employer's control centres (RCC & RSCC). The substation automation system shall support the use of a different communication data exchange rate (bits per second), scanning cycle, and/or communication protocol to each remote control centre. Also, each control centre's data scan and control commands may be different for different data points within the substation automation system's database.

3.3.2 Remote Control Centre Communication Interface

Employer will supply communication channels between the Substation Automation System and the remote control centre. The communication channels provided by Employer will consist either of power line carrier, microwave, optical fibre, VSAT or leased line , the details of which shall be provided during detailed Engineering .

3.3.3 **Interface equipment:**

The Contractor shall provide interface equipment for communicating between Substation Automation system and Remote control centre and between Substation Automation system and Regional System Coordination Centre (RSCC). However, the communication channels available for this purpose are specified in section project.
In case of PLCC communication any modem supplied shall not require manual equalization and shall include self-test features such as manual mark/space keying, analogue loop-back, and digital loop-back. The modems shall provide for convenient adjustment of output level and receive sensitivity. The modem should be stand alone complete in all respects including power supply to interface the SAS with communication channel. The configuration of tones and speed shall be programmable and maintained in non-volatile memory in the modem. All necessary hardware and software shall also be in the scope of bidder except the communication link along with communication equipment between substation control room and Remote Control Centre.

3.3.4 Communication Protocol

The communication protocol for gateway to control centre must be open protocol and shall support IEC 60870-5-101/104 and IEC 61850 for all levels of communication for sub-station automation such as Bay to station HMI, gateway to remote station etc..

4.0 System hardware:

4.1 Redundant Station HMI, Remote HMI and Disturbance Recorder Work station:

The contractor shall provide redundant station HMI in hot standby mode. The servers used in these work stations shall be of industrial grade**.**
It shall be capable to perform all functions for entire substation including future requirements as indicated in the SLD. It shall use industrial grade components.

Processor and RAM shall be selected in such a manner that during normal operation not more than 30% capacity of processing and memory are used. Supplier shall demonstrate these features.

The capacity of hard disk shall be selected such that the following requirement should occupy less than 50% of disk space:

1. Storage of all analogue data (at 15 Minutes interval)and digital data including alarm , event and trend data for thirty(30) days,
2. Storage of all necessary software,
3. 20GB space for OWNER'S use.

Supplier shall demonstrate that the capacity of hard disk is sufficient to meet the above requirement.

4.1.1 **HMI (Human Machine Interface**)

The VDU shall show overview diagrams (Single Line Diagrams) and complete details of the switchgear with a colour display. All event and alarm annunciation shall be selectable in the form of lists. Operation shall be by a user friendly function keyboard and a cursor positioning device. The user interface shall be based on WINDOWS concepts with graphics & facility for panning, scrolling, zooming, decluttering etc.

4.1.2 Visual Display Units/TFT's (Thin Film Technology)

The display units shall have high resolution and reflection protected picture screen. High stability of the picture geometry shall be ensured. The screen shall be at least 21" diagonally in size and capable of colour graphic displays.
The display shall accommodate resolution of 1280 X 1024 pixels.

4.1.3 Printer

It shall be robust & suitable for operation with a minimum of 132 characters per line. The printing operation shall be quiet with a noise level of less than 45 dB suitable for location in the control room. Printer shall accept and print all ASCII characters via master control computer unit interface.

The printer shall have in built testing facility. Failure of the printer shall be indicated in the Station HMI. The printer shall have an off line mode selector switch to enable safe maintenance. The maintenance should be simple with provisions for ease of change of print head, ribbon changing, paper insertion etc.

All reports and graphics prints shall be printed on laser printer. One dot matrix printer shall be exclusively used for hourly log printing. All printers shall be continuously online.

4.1.4 Mass Storage Unit

The mass storage unit shall be built-in to the Station HMI. All operational measured values, and indications shall be stored in a mass-storage unit **in form** of **DVD RW** The unit should support at least Read (48X), Write(24X), and Re-Write (10X) operations, with Multi-Session capability. It should support ISO9660, Rockridge and Joliet Filesystems. It should support formatting and use under the operating system provided for Station HMI. The monthly back up of data shall be taken on disc. The facility of back up of data shall be inherent in the software**.**

4.1.5 Switched Ethernet Communication Infrastructure:

The bidder shall provide the redundant switched optical Ethernet communication infrastructure for SAS One switch shall be provided to connect all IEDs in one diameter of each 400kV yard and for two bays of 220kV yard to communication infrastructure. Each switch shall have at least two spare ports for connecting bay level IEDs and one spare port for connecting station bus.

4.2 Bay level unit

The bay unit shall use industrial grade components. The bay level unit, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. They shall incorporate select-before-operate control principles as safety measures for operation via the HMI. They shall perform all bay related functions, such as control commands, bay interlocking, data acquisition, data storage, event recording and shall provide inputs for status indication and outputs for commands. They shall be directly connected to the switchgear. The bay unit shall acquire and process all data for the bay (Equipment status, fault indications, measured values, alarms etc.) and transmit these to the other devices in sub-station automation system. In addition, this shall receive the operation commands from station HMI and control centre. The bay unit shall have the capability to store all the data for at least 24 hours.
One no. Bay level unit shall be provided for supervision and control of each 765, 400 and 220 kV bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer). The Bay level unit shall be equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. All bay level interlocks are to be incorporated in the Bay level unit so as to permit control from the Bay level unit/ local bay mimic panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Station HMI is out of service.

The bay control unit to be provided for the bays shall be preferably installed in the CB relay panel/feeder protection panel for respective bay. Further in case of one and half breaker schemes, the BCU for Tie CB shall be provided in Tie CB relay panel. The tie CB relay panel shall also house the Ethernet switch(es) to be provided for the diameter. The bay control unit for future bay (if required as per section project) shall be installed in a separate panel.

The Bay level unit shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 61850. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.

4.2.1 Input/Output (I/O) modules

The I/O modules shall form a part of the bay level unit and shall provide coupling to the substation equipment. The I/O modules shall acquire all switchgear information (i.e. data coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear. The measured values of voltage and current shall be from the secondaries of instrument transformers. The digital inputs shall be acquired by exception with 1 ms resolution. Contact bouncing in digital inputs shall not be assumed as change of state

4.3 Switchyard Panel Room:

The **switchyard panel room shall be constructed to house** Bay level units, bay mimic, relay and protection panels, PLCC panels etc. one each for a diameter in 400kVsub-station and for two bays in 220kV Level. In case of incomplete diameter the switchyard panel room shall have necessary space for accommodating the future bay IEDs. The layout of equipment/panel shall be subject to Owner's approval. The switchyard panel room shall be provided with necessray illuminations, fire alarm system with at least two detectors **with necessary power supply if required** and it shall be wired to SAS. The detailed **constructional** requirement of switchyard panel room **is detailed in section civil of technical specification andair conditioning requirement of switchyard panel room shall be as detailed in section Air conditioning system of technical specification**. The air conditioner provided in switchyard panel room shall be monitored from substation automation system.

4.4 Extendibility in future

Offered substation automation system shall be suitable for extension in future for additional bays. During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed in such a manner that its extension shall be easily performed by the employer.

During such event, normal operation of the existing substation shall be unaffected and system shall not require a shutdown. The contractor shall provide all necessary software tools along with source codes to perform addition of bays in future and complete integration with SAS by the user. These software tools shall be able to configure IED, add additional analogue variable, alarm list, event list, modify interlocking logics etc. for additional bays/equipment which shall be added in future.

5.0 Software structure

The software package shall be structured according to the SAS architecture and strictly divided in various levels. Necessary firewall shall be provided at suitable points in software to protect the system. An extension of the station shall be possible with lowest possible efforts. Maintenance, modification or an extension of components of any feeder may not force a shut-down of the parts of the system which are not affected by the system adaptation.

5.1.1 Station level software

5.1.1.1 Human-machine interface (HMI)

The base HMI software package for the operator station shall include the main SAS functions and it shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. Systems shall contain a library with standard functions and applications.

5.1.2 Bay level software

5.1.1.1 System software

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. The lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance engineer for modifications. The system shall support the generation of typical control macros and a process database for user specific data storage. In case of

restoration of links after failure, the software along with hardware shall be capable of automatically synchronising with the remaining system without any manual interface. This shall be demonstrated by contractor during integrated system test.

5.1.1.2 Application software

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They form part of a library.

The application software within the control/protection devices shall be programmed in a functional block language.

5.1.1.3 Network Management System:

The contractor shall provide a network management system software for following management functions:

a. Configuration Management
b. Fault Management
c. Performance Monitoring

This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in DR work- station and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any fault in the monitored devices. The NMS shall

(a)Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demand reports.
(b) Maintain a graphical display of SAS connectivity and device status.
(c) Issue alarms when error conditions occurs
(d) Provide facility to add and delete addresses and links

5.1.1.4 The contractor shall provide each software in two copies in CD to load into the system in case of any problem related with Hardware/Communication etc.

6.0TESTS

The substation automation system offered by the bidder shall be subjected to following tests to establish compliance with IEC 61850 for EHV sub-station equipment installed in sheltered area in the outdoor switchyard and specified ambient conditions:

6.1		**Type Tests:**
6.1.1		**Control IEDs and Communication Equipment:**
	a.	**Power Input:**

i. Auxiliary Voltage
ii. Current Circuits iii. Voltage Circuits iv. Indications

b. Accuracy Tests:

i. Operational Measurd Values ii. Currents
iii. Voltages

iv. Time resolution

c. Insulation Tests:

i. Dielectric Tests

ii. Impulse Voltage withstand Test

d. Influencing Quantities

4. Limits of operation
5. Permissible ripples

iii. Interruption of input voltage

e. Electromagnetic Compatibility Test:

i. 1 MHZ. burst disturbance test ii. Electrostatic Discharge Test

iii. Radiated Electromagnetic Field Disturbance Test iv. Electrical Fast transient Disturbance Test

v. Conducted Disturbances Tests induced by Radio Frequency Field vi. Magnetic Field Test

vii. Emission (Radio interference level) Test. viii. Conducted Interference Test

f. Function Tests:

i. Indication

ii. Commands

iii. Measured value Acquisition iv. Display Indications

g. Environmental tests:

22. Cold Temperature
23. Dry Heat

iii. Wet heat

iv. Humidity (Damp heat Cycle)

v. Vibration vi. Bump

vii. Shock

6.2 Factory Acceptance Tests:

The supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval. For the individual bay level IED's applicable type test certificates shall be submitted**.**

The manufacturing and configuration phase of the SAS shall be concluded by the factory acceptance test (FAT). The purpose is to ensure that the Contractor has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the user. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab. During FAT the entire Sub-station Automation System including complete control and protection system to be supplied under present scope shall be tested for complete functionality and configuration in factory itself. The extensive testing shall be carried out during FAT. The purpose of Factory Acceptance Testing is to ensure trouble free installation at site. No major configuration setting of system is envisaged at site.

If the complete system consists of parts from various suppliers or some parts are already installed on site, the FAT shall be limited to sub-system tests. In such a case, the complete system test shall be performed on site together with the site acceptance test (SAT).

6.2.1 Hardware Integration Tests:

The hardware integration test shall be performed on the specified systems to be used for Factory tests when the hardware has been installed in the factory. The operation of each item shall be verified as an integral part of system. Applicable hardware diagnostics shall be used to verify that each hardware component is completely operational and assembled into a configuration capable of supporting software integration and factory testing of the system. The equipment expansion capability shall also be verified during the hardware integration tests. The vendor specifically demonstrates how to add a device in future in SAS during FAT. The device shall be from a different manufacturer than the SAS supplier.

6.2.2 Integrated System Tests:

Integrated system tests shall verify the stability of the hardware and the software. During the tests all functions shall run concurrently and all equipment shall operate a continuous 100 Hours period. The integrated system test shall ensure the SAS is free of improper interactions between software and hardware while the system is operating as a whole.

6.3 Site Acceptance Tests:

The site acceptance tests (SAT) shall completely verify all the features of SAS hardware and software. The bidder shall submit the detailed SAT procedure and SAT procedure shall be read in conjunction with the specification.

7.0 SYSTEM OPERATION

7.1 Substation Operation

7.1.1 NORMAL OPERATION

Operation of the system by the operator from the remote RCC or at the substation shall take place via industry standard HMI(Human Machine interface) subsystem consisting of graphic colour VDU , a standard keyboard and a cursor positioning device (mouse).

The coloured screen shall be divided into 3 fields :

I) Message field with display of present time and date ii) Display field for single line diagrams
iii) Navigation bar with alarm/condition indication

For display of alarm annunciation, lists of events etc a separate HMI View node. shall be provided.

All operations shall be performed with mouse and/or a minimum number of function keys and cursor keys. The function keys shall have different meanings depending on the operation. The operator shall see the relevant meanings as function tests displayed in the command field (i.e. operator prompting). For control actions, the switchgear (i.e. circuit breaker etc.) requested shall be selectable on the display by means of the cursor keys. The switching element selected shall then appear on the background that shall be flashing in a different color. The operator prompting shall distinguish between:-

- Prompting of indications e.g. fault indications in the switchgear, and

- prompting of operational sequences e.g. execution of switching operations

The summary information displayed in the message field shall give a rapid display of alarm/message of the system in which a fault has occurred and alarm annunciation lists in which the fault is described more fully.

Each operational sequence shall be divided into single operation steps which are initiated by means of the function keys/WINDOW command by mouse. Operator prompting shall be designed in such a manner that only the permissible keys are available in the command field related to the specific operation step. Only those switching elements shall be accessed for which control actions are possible. If the operation step is rejected by the system, the operator prompting shall be supported by additional comments in the message field. The operation status shall be reset to the corresponding preceding step in the operation sequence by pressing one of the function keys. All operations shall be verified. Incorrect operations shall be indicated by comments in the message field and must not be executed.

The offer shall include a comprehensive description of the system. The above operation shall also be possible via WINDOWS based system by mouse.

8.0 POWER SUPPLY

Power for the substation automation system shall be derived from substation 220V DC system.
Inverter of suitable capacity shall be provided for station HMI **disturbance recorder evaluation unit** and its peripheral devices e.g. printer etc. In the event of Power failure, necessary safeguard software shall be built for proper shutdown.

9.0 DOCUMENTATION

The following documents shall be submitted for employer's approval during detailed engineering:

(a) System Architecture Drawing
(b) Hardware Specification
(c) Functional Design Document
(d) Clear procedure describing how to add an IED/bay/diameter in future covering all major supplier

The following documentation to be provided for the system in the course of the project shall be consistent, CAD supported, and of similar look/feel. All CAD drawings to be provide in "dxf" format.

List of Drawings
Substation automation system architecture
Block Diagram
Guaranteed technical parameters, Functional Design Specification and Guaranteed availability and reliability
Calculation for power supply dimensioning
I/O Signal lists Schematic diagrams List of Apparatus
List of Labels
Logic Diagram (hardware & software) **Switchyard Panel Room** layout drawing
Control Room Lay-out
Test Specification for Factory Acceptance Test (FAT) Product Manuals

Assembly Drawing
Operator's Manual
Complete documentation of implemented protocols between various elements
Listing of software and loadable in CD ROM
Other documents as may be required during detailed engineering

Two sets of hard copy and Four sets of CD ROM containing all the as built documents/drawings shall be provided.

10.0 TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES

10.1 Training

Contractor personnel who are experienced instructors and who speak understandable English shall conduct training. The contractor shall arrange on its own cost all hardware training platform required for successful training and understanding in India. The Contractor shall provide all necessary training material. Each trainee shall receive individual copies of all technical manuals and all other documents used for training. These materials shall be sent to Employer at least two months before the scheduled commencement of the particular training course. Class materials, including the documents sent before the training courses as well as class handouts, shall become the property of Employer. Employer reserves the right to copy such materials, but for in-house training and use only. Hands-on training shall utilize equipment identical to that being supplied to Employer.

For all training courses, the travel (e.g., airfare) and per-diem expenses will be borne by the participants.
The Contractor shall quote training prices as indicated in BPS.
The schedule, location, and detailed contents of each course will be finalized during Employer and Contractor discussions.

10.2 Computer System Hardware Course

A computer system hardware course shall be offered, but at the system level only. The training course shall be designed to give Employer hardware personnel sufficient knowledge of the overall design and operation of the system so that they can correct obvious problems, configure the hardware, perform preventive maintenance, run diagnostic programs, and communicate with contract maintenance personnel. The following subjects shall be covered:

(a) System Hardware Overview: Configuration of the system hardware.
(b) Equipment Maintenance: Basic theory of operation, maintenance techniques and diagnostic procedures for each element of the computer system, e.g., processors, auxiliary memories, LANs, routers and printers. Configuration of all the hardware equipments.
(c) System Expansion:Techniques and procedures to expand and add equipment such as loggers, monitors, and communication channels.
(d) System Maintenance: Theory of operation and maintenance of the redundant hardware configuration, failover hardware, configuration control panels, and failover switches. Maintenance of protective devices and power supplies.
(e) Subsystem Maintenance: Theory of design and operation, maintenance

techniques and practices, diagnostic procedures, and (where applicable) expansion techniques and procedures. Classes shall include hands-on training for the specific subsystems that are part of Employer's equipment or part of similarly designed and configured subsystems. All interfaces to the computing equipment
shall be taught in detail.
(f) Operational Training:Practical training on preventive and corrective maintenance of all equipment, including use of special tools and instruments. This training shall be provided on Employer equipment, or on similarly configured systems.

10.3 Computer System Software Course

The Contractor shall provide a computer system software course that covers the following subjects:

(a) System Programming: Including all applicable programming languages and all stand-alone service and utility packages provided with the system. An introduction to software architecture, Effect of tuning parameters (OS software, Network software, database software etc.) on the performance of the system.
(b) Operating System: Including the user aspects of the operating system, such as program loading and integrating procedures; scheduling, management, service, and utility functions; and system expansion techniques and procedures
(c) System Initialization and Failover: Including design, theory of operation, and practice
(d) Diagnostics: Including the execution of diagnostic procedures and the interpretation of diagnostic outputs,
(e) Software Documentation: Orientation in the organization and use of system software documentation.
(f) Hands-on Training:One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

10.4 Application Software Course

The Contractor shall provide a comprehensive application software courses covering all applications including the database and display building course. The training shall include:

(a) Overview: Block diagrams of the application software and data flows. Programming standards and program interface conventions.
(b) Application Functions: Functional capabilities, design, and major algorithms. Associated maintenance and expansion techniques.
(c) Software Development: Techniques and conventions to be used for the preparation and integration of new software functions.
(d) Software Generation: Generation of application software from source code and associated software configuration control procedures.
(e)Software Documentation: Orientation in the organization and use of functional and detailed design documentation and of programmer and user manuals.
(f)Hands-on Training: One week, with allocated computer time for trainee

performance of unstructured exercises and with the course instructor available for assistance as necessary.

10.5 Requirement of training:

The contractor shall provide training for OPTCL personnel comprehensively covering following courses.

S. No.	Name of Course
1	Computer System Hardware
2	Computer System Software
3	Application Software

11.0 Maintenance

11.1 Maintenance Responsibility during the Guaranteed Availability Period.

During Guaranteed Availability Period, the Contractor shall take continual actions to ensure the guaranteed availability and shall make available all the necessary resources such as specialist personnel, spare parts, tools, test devices etc. for replacement or repair of all defective parts and shall have prime responsibility for keeping the system operational.

During guarantee period as specified in tender document, contractor shall arrange bi-monthly visit of their representative to site to review the performance of system and in case any defect/shortcoming etc. is observed during the period, the same shall be set right by the contractor within 15 days.

12.0 RELIABILITY AND AVAILABILITY

The SAS shall be designed so that the failure of any single component, processor, or device shall not render the system unavailable. The SAS shall be designed to satisfy the very high demands for reliability and availability concerning:

Mechanical and electrical design
Security against electrical interference (EMI) High quality components and boards
Modular, well-tested hardware
Thoroughly developed and tested modular software
Easy-to-understand programming language for application programming
Detailed graphical documentation and application software
Built-in supervision and diagnostic functions
Security
Experience of security requirements
Process know-how
Select before execute at operation
Process status representation as double indications
Distributed solution
Independent units connected to the local area network
Back-up functions
Panel design appropriate to the harsh electrical environment and ambient conditions
Panel grounding immune against transient ground potential rise

Outage terms

1) Outage

The state in which substation automation system or a unit of SAS is unavailable for Normal Operation as defined in the clause 7.1 due to an event directly related to the SAS or unit of SAS. In the event, the owner has taken any equipment/ system other than Sub-station Automation System for schedule/forced maintenance, the consequent outage to SAS shall not be considered as outage for the purpose of availability.

2) Actual outage duration (AOD)

The time elapsed in hours between the start and the end of an outage. The time shall be counted to the nearest $1/4^{th}$ of an hour. Time less than $1/4^{th}$ of an hour shall be counted as having duration of $1/4^{th}$ of an hour.

3) Period Hours (PH)

The number of hours in the reporting period. In a full year the period hour are 8760h (8784h for a leap year).

4) Actual Outage hours (AOH)

The sum of actual outage duration within the reporting period

AOH =AOD

5) Availability:

Each SAS shall have a total availability of 99.98 % i.e. the ratio of total time duration minus the actual outage duration to total time duration.

12.1 Guarantees Required

The availability for the complete SAS shall be guaranteed by the Contractor. Bidder shall include in their offer the detailed calculation for the availability. The contractor shall demonstrate their availability guaranteed by conducting the availability test on the total sub-station automation system as a whole after commissioning of total Sub-station Automation system. The test shall verify the reliability and integrity of all sub-systems. Under these conditions the test shall establish an overall availability of 99.98%. After the lapse of 1000 Hours of cumulative test time, test records shall be examined to determine the conformance with availability criterion. In case of any outage during the availability test, the contractor shall rectify the problem and after rectification, the 1000 Hours period start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved.

The contractor has to establish the availability in a maximum period of three months from the date of commencement of the availability test.

After the satisfactory conclusion of test both contractor and employer shall mutually agree to the test results and if these results satisfy the availability criterion, the test is considered to be completed successfully. After that the system shall be taken over by the employer and then the guarantee period shall start.

13.0 Spares

13.1 Consumables:

All consumables such as paper, cartridges shall be supplied by the contractor till the SAS is taken over by the owner. .

13.2 Availability Spares:

In addition to mandatory spares as listed in section project for SAS, the bidder is required to list the spares, which may be required for ensuring the guaranteed availability during the guaranteed availability period. The final list of spares shall form part of scope of supply and accordingly the price thereof shall be quoted by the bidder and shall be considered in the evaluation of the bids. During the guaranteed availability period, the spare parts supplied by the Contractor shall be made available to the Contractor for usage subject to replenishment at the earliest. Thus, at the end of availability period the inventory of spares with the Employer shall be fully replenished by the Contractor. However, any additional spares required to meet the availability of the system (which are not a part of the above spares supplied by the Contractor) would have to be supplied immediately by the Contractor free of cost to the Employer.

14.0 LIST OF EQUIPMENTS

Quantity of equipments shall be decided by bidder in order to achieve guaranteed reliability and availability as declared by bidder.

I) Station HMI

ii) Redundant Station HMI (in Hot-stand by mode)

iii) Bay level units along with bay mimic **as detailed in section Project.**

iv) **Bay Level Unit for Auxiliary system (as per requirement)**

v) Disturbance Recorder Work Station(Maintenance HMI)

vi) Colour Laser Printer – 1 No. (For Reports & Disturbance records)

vii) Dot matrix printers - (one each for Alarms and log sheets)

viii) All interface equipment for gateway to RCC and RSCC

ix) Communication infrastructure between Bay level units, Station HMI, Printers, gateways, redundant LAN etc. as required

x) Remote workstation including HMI and along with one printer xi) **Modems as per requirement.**

Xii) Any other equipment as necessary.

List of Analogue and Digital Inputs ;

Basic Monitoring requirements are:

- Switchgear status indication
- Measurements (U, I, P, Q, f)
- Event
- Alarm
- Winding temperature of transformers & reactors
- ambient temperature
- Status and display of 415V LT system, 220V & 48V DC system
- Status of display of Fire protection system and Air conditioning system.
- Acquisition of all counters in PLCC panels through potential free

contacts from PLCC or independently by counting the receive/send commands.

- Acquisition of alarm and fault record from protection relays
- Disturbance records
- Monitoring the state of batteries by displaying DC voltage, charging current and load current etc.
- Tap-position of Transformer

List of Inputs

The list of input for typical bays is as below:-

Analogue inputs

I) For line
Current : R phase Y phase B phase
Voltage : R-Y phase Y-B phase B-R phase
ii) For transformer/reactor
Current: R phase Y phase B phase
WTI (for transformer and reactor) Tap position (for transformer only)

iii) For TBC and bus coupler

Current: R phase,Y phase,B phase
iv) Common
a) Voltage for Bus-I, Bus-II and Transfer bus wherever applicable

Voltage: R-Y phase Y-B phase B-R phase

b) Frequency for Bus-I and Bus-II

c) Ambient temperature (switchyard)
d) Switchyard Panel Room Temperature. e) LT system
I) Voltage R-Y, Y-B, B-R of Main Switch Board section-I
4. Voltage R-Y, Y-B, B-R of Main Switch Board section-
5. Voltage R-Y, Y-B, B-R of Diesel Generator
6. Current from LT transformer-I
7. Current from LT transformer-II

vi) Current from Diesel Generator vii) Voltage of 220V DCDB-I
viii) Voltage of 220V DCDB-II
ix) Current from 220V Battery set-I
x) Current from 220V Battery set-II

6. Current from 220V Battery charger-I
7. Current from 220V Battery charger-I
8. Voltage of 48V DCDB-I

xiv) Voltage of 48V DCDB-II
xv) Current from 48V Battery set-I
xvi) Current from 48V Battery set-II
xvii) Current from 48V Battery charger-I
xviii) Current from 48V Battery charger-I

Digital Inputs

The list of input for various bays/SYSTEM is as follows:
1. Line bays
i)Status of each pole of CB.
ii)Status of Isolator, Earth switch
iii)CB trouble

iv)CB operation/closing lockout v) Pole discrepancy optd
vi)Trip coil faulty
vii)LBB optd
viii)Bus bar protn trip relay optd
ix)Main bkr auto recloser operated
x)Tie/transfer auto recloser operated xi) A/r lockout
xii)Tie/transfer bkr a/r lockout xiii) Direct trip-I/II sent
xiv)Direct trip-I/II received
xv)Main I/II blocking
xvi)Main I/II-Inter trip send
xvii)Main I/II-Inter trip received
xviii)O/V STAGE – I operated
xix)O/V STAGE – II operated
xx)FAULT LOCATOR FAULTY
xxi)MAIN-I/II CVT FUSE FAIL
xxii)MAIN-I PROTN TRIP
xxiii)MAIN-II PROTN TRIP
xxiv)MAIN-I PSB ALARM
xxv)MAIN-I SOTF TRIP
xxvi)MAIN-I R-PH TRIP
xxvii)MAIN-I Y-PH TRIP
xxviii)MAIN-I B-PH TRIP
xxix)MAIN-I START
xxx)MAIN-I/II Carrier aided trip
xxxi)MAIN-I/II fault in reverse direction
xxxii)MAIN-I/II ZONE-2 TRIP
xxxiii)MAIN-I/II ZONE-3 TRIP
xxxiv)MAIN-I/II weak end infeed optd
xxxv)MAIN-II PSB alarm
xxxvi)MAIN-II SOTF TRIP
xxxvii) MAIN-II R-PH TRIP
xxxviii)MAIN-II Y-PH TRIP
xxxix)MAIN-II B-PH TRIP
xl)MAIN-II start
xli)MAIN-II aided trip
xlii)MAIN-I/II fault in reverse direction
xliii)Back-up o/c optd
xliv)Back-up e/f optd
xlv)220V DC-I/II source fail
xlvi)SPEECH CHANNEL FAIL
xlvii)PLCC Protection Channel-I FAIL
xlviii)PLCC Protection Channel-II FAIL

2. **Transformer bays**

i)Status of each pole of CB, Isolator, Earth switch
ii)CB trouble
iii)CB operation/closing lockout
iv)Pole discrepancy optd
v)Trip coil faulty
vi)LBB optd
vii)Bus bar protn trip relay optd
viii)REF OPTD
ix)DIF OPTD
x)OVERFLUX ALARM (MV)
xi)OVERFLUX TRIP (MV)
xii)OVERFLUX ALARM (HV)
xiii)OVERFLUX TRIP (HV)

xiv)HV BUS CVT ½ FUSE FAIL

6. BUS CVT ½ FUSE FAIL

xvi)OTI ALARM/TRIP

6. PRD OPTD

xviii)OVERLOAD ALARM
xix)BUCHOLZ TRIP
xx)BUCHOLZ ALARM
xxi)OLTC BUCHOLZ ALARM
xxii)OLTC BUCHOLZ TRIP
xxiii)OIL LOW ALARM
xxiv)back-up o/c (HV) optd
xxv)back-up e/f (HV)optd
xxvi)220v DC-I/II source fail
xxvii)TAP MISMATCH
xxviii)GR-A PROTN OPTD
xxix)GR-B PROTN OPTD
xxx)back-up o/c (MV) optd
xxxi) back-up e/f (MV)optd

3. **Transformer bays**

i)Status of each pole of CB, Isolator, Earth switch
ii)CB trouble
iii)CB operation/closing lockout
iv)Pole discrepancy optd
v)Trip coil faulty
vi)LBB optd
vii)
Bus bar protn trip relay optd
viii)REF OPTD
ix)DIF OPTD
x)HV BUS CVT ½ FUSE FAIL
xi)OTI ALARM/TRIP
xii)PRD OPTD
xiii)BUCHOLZ TRIP
xiv)BUCHOLZ ALARM
xv)OIL LOW ALARM
xvi)Back-up impedance relay
xvii)220v DC-I/II source fail
xviii)GR-A PROTN OPTD
xix)GR-B PROTN OPTD

4. Line/Bus Reactor bays (as applicable):

i)Status of each pole of CB, Isolator, Earth switch
ii)CB trouble
iii)CB operation/closing lockout
iv)Pole discrepancy optd
v)Trip coil faulty
vi)LBB optd
vii)Bus bar protn trip relay optd
viii)REF OPTD
ix)DIF OPTD
x)Line/ BUS CVT ½ FUSE FAIL
xi)OTI ALARM/TRIP
xii)PRD OPTD

xiii)BUCHOLZ TRIP
xiv)BUCHOLZ ALARM

xv)OIL LOW ALARM
xvi)Back-up impedance relay
xvii)220V DC-I/II source fail
xviii)GR-A PROTN OPTD
xix)GR-B PROTN OPTD

5 Bus bar Protection

i)Bus bar main-I trip
ii)Bus bar main-II trip
iii)Bus bar zone-I CT open
iv)Bus bar zone-II CT open
v)Bus transfer CT sup. Optd
vi)Bus transfer bus bar protn optd
vii)Bus protection relay fail

6. Auxiliary system

i)Incomer-I On/Off
ii)Incomer-II On/Off
iii)415V Bus-I/II U/V
iv)415v bus coupler breaker on/off
v)DG set bkr on/off
vi)Alarm/trip signals as listed in Section: DG set
vii)LT transformer-I Bunchholz Alarm & trip
viii)LT transformer-II Buchloz Alarm & trip
ix)LT transformer-I WTI Alarm & trip
x)LT transformer-II WTI Alarm & trip
xi)LT transformer-I OTI Alarm & trip
xii)LT transformer-II OTI Alarm & trip
xiii)PLCC exchange fail
xiv) Time sync. Signal absent
xv)Alarm/trip signals as listed in Section: Battery and Battery charger
xvi) 220v DC-I earth fault
xvii) 220v DC-II earth fault
xviii) Alarm/trip signals as listed in Section: Fire protection system

7. Switchyard Panel Room:

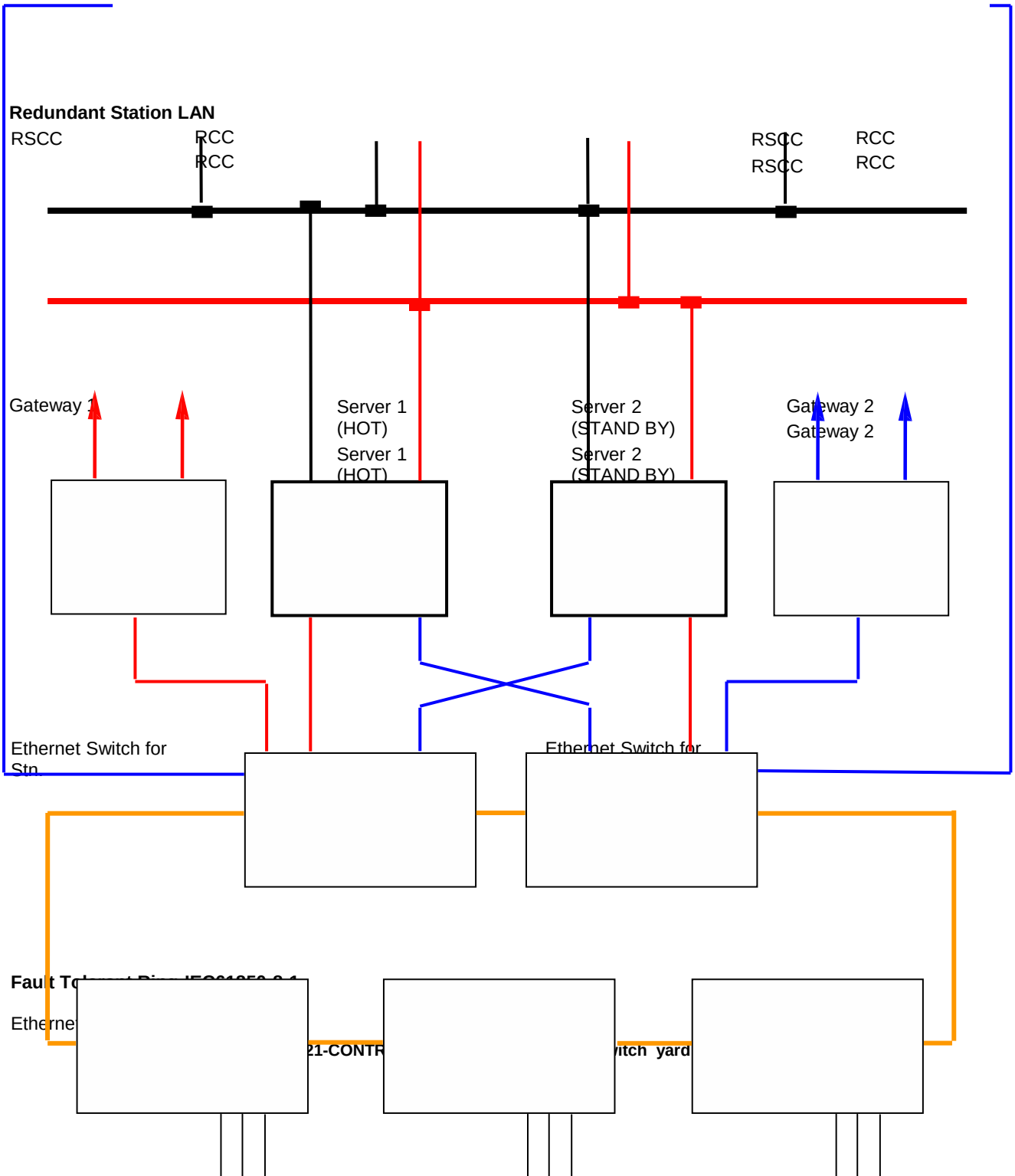
i)AC Compressor 1 ON/OFF
ii)AC Compressor 2 ON/OFF
iii)Fire Detection 1 ON/OFF
iv)Fire Detection 2 On/OFF
v)Switchyard Panel Room Temperature High Alarm

The exact number and description of digital inputs shall be as per detailed engineering requirement Apart from the above mentioned digital inputs, minimum of
200 inputs shall be kept for OPTCL use in future.

TYPICAL ARCHITECTURAL DRAWING OF SUBSTATION AUTOMATION SYSTEM

DR WOl

Printers G



Ethernet Switch for Ethernet Switch for Dia 2/Bays

Ethernet Switch for Ethernet Switch for Dia n/Bays

IEDs for Control

IEDs for IEDs for Control

IEDs for IEDs for Control

Fiber Optic Connections

IEDs for Protection

EDs for EDs for Protection

EDs for EDs for Protection

Note:

1. The redundant managed bus shall be realized by high speed optical bus using industrial grade components and shall be as per IEC 61850.
2. The IEDs and switches for each of the dia. of 765kV and 400kV shall have separate switchyard panel room. For 220kV yards, IEDs for two bays can be housed in one switchyard panel room along with its switch.
3. Inside the sub-station, all connections shall be realized as per IEC 61850 protocol.
4. For gateway, it shall communicate with Remote Supervisory Control Centre (RSCC) on
IEC 60870-5-101 protocol.
5. The printer as required shall be connected to station bus directly and can be managed either from station HMI, HMI view node or disturbance recorder work station.

5. The above layout is typical. However if any contractor offers slightly modified architecture based on their standard practice without compromising the working, the same shall be subject to approval during detailed engineering.

TECHNICAL SPECIFICATION

FOR

AIR-CONDITIONED HOUSE (RCC-column-Brick BUILDING)
TO BE PROVIDED IN SWITCHYARD

SPECIFICATION OF AIR-CONDITIONED HOUSE (RCC-column-Brick BUILDING)

1 CONSTRUCTION:

Refer the CIVIL specification as provided against E-6 for construction of RCC-column-Brick BUILDING duly enclosed with proper insulation & high quality vitrified tiles flooring with required door & provision of split air conditioner having stand by feature, which is to be switched on in the event of failure of the main unit of air-conditioner. The building shall have internal electrification with required LED fittings & external lighting arrangement as per standard requirement indicated against illumination specification. The building shall be constructed in line with the specification E-7. All care for the said building is to be taken.
The building shall be utilized for putting the Bay Control Unit panels, Relay panels,Bus Bar protection panels & any other panels. Necessary cable ducts for cables from switchyard equipment and from the control room to the required panels installed in the building.

2 AIR CONDITIONING

The Air Conditionings system shall be provided in the Kiosks to be used for housing panels having control IEDs and protection Panels for performing sub-station automation and protection functions generally confirm to relevant IS codes as detailed ins section GTR. These kiosks shall be placed in the Switchyard area generally unmanned; therefore, the air-conditioning system shall be rugged, reliable, maintenance free and designed for long life.

i. Operation

The Air Conditioning is required for critical application i.e. for maintaining the temperature for critical sub-station control and protection equipment. To provide redundancy for such critical applications, each kiosk shall be installed with environment control system comprising of two units of air conditioners working in conjunction through a micro processor based controller for desired operation. The system shall be designed for 24 Hours, 365 Days of the year to maintain the inside kiosk temperature for proper operation of the critical equipment. One of the air-conditioner shall be running at a time and on failure of the same or as described hereunder, the other unit shall start automatically. To ensure longer life of the system, the redundant units shall also be running in cyclic operation through the controller. However, during running of one air-conditioner unit, if inside temperature of the shelter reaches to a predefined (i.e. 35°C), the other unit shall start running to maintain the temperature to specified value (i.e. 18±2°C) and gives alarm for such situation. After achieving this temperature, the other unit shall again shut off.

ii. Sequence of Operation of the Unit

Suitable arrangement shall be made to operate the unit in the following order. However, the actual operation arrangement shall be finalized during detailed engineering.

1. Evaporator Fan
2. Condenser Fan

3. Compressor

iii. **Construction**

The Air Conditioning unit shall be completely self-contained. All components of the units shall be enclosed in a powder-coated cabinet and colour of same shall be matched with kiosk colour. The unit shall be assembled, wired, piped, charged with refrigerant and fully factory tested as a system to ensure trouble free installation and start up. Suitable isolation or other by passing arrangement shall be provided such that any unit/component could be maintained/ repaired without affecting the running standby unit. The maintenance of unit shall be possible from outside the kiosk. The point never ends at this. When fliers are with flies

iv. **Required Features of Various Components**

The Compressor shall be very reliable, trouble free and long life i.e. hermitically sealed Scroll type of reputed make suitable for operation. Compressor should be installed on vibration-isolated mountings or manufacturers recommended approved mounting. Valve shall be provided for charging/topping up of refrigerant. The bidder shall furnish details of their compressor indicating the MTBF, life of compressor and continuous run time of compressor without failure. The contractor shall also furnish details of all accessories i.e. refrigeration system, evaporator coil, condenser coil, evaporator blower filter, cabinet, indoor supply and return grill, etc.

v. The kiosk shall be erected at least 300 mm above the finished ground level with suitable pedestal to avoid any entry of water.

2. This building shall be equipped with all required accessories like air-conditioning system, fire and smoke detector, lighting, various cut outs etc. The building shall be inspected for finish, all fittings and accessories, opening including doors and locks. The building shall be tested for dust and rain protection to check out any leakage and air tightness. The following main tests shall be carried out:

a) Illumination inside the building shall be switched off and it shall be checked that no light enters through panel joints, holes and other joints in the kiosk.

b) Working and functional tests of all accessories like air-conditioning system, fire and smoke detector, lighting arrangements as per technical specification

c) Start up test for air conditioner

f) Satisfactory operation of air conditioner installed in the building.

f) The total heat load for panels and devices to be placed inside the building including PLCC, all IEDs etc. shall be calculated and equivalent calculated heating load (maximum value from among the calculated values for various kiosk) shall be placed inside the kiosk and the kiosk shall be made operational for four hours with all accessories and inside & outside temperature of kiosk shall be recorded.

On successful completion of testing, all other system shall be manufactured after incorporation of all alteration/modifications observed/suggested during/after testing.

The detail test procedure shall be submitted by the contractor and get it approved from the owner before commencement of proto testing

Specifications for Large Video Wall- - 70" Full HD

1. VIDEO MONITORING

The large screen Video wall in the control room shall be used for the display of important graphics from the pc, workstation, Images from IP video cameras. It should have the functionality to pre-configure and save various display layouts to be accessed at any given point of time with a simple mouse click.

The large screen should provide real-time clear luminous view to share information between operators and decision makers. The operators whose systems are on the same Ethernet should be able to work on the large screen sitting at their own position with their own PC's keyboard & mouse.

The large screen should be able to show the images of the monitor, which is connected on the LAN with Windows 7 OWS and the windows should be freely resizable, scalable and repositionable on any part of the large video screen.

The large graphics wall shall be consisting of multiple rear projection modules in multiple rows and columns behaving as a single logical screen.

The large screen should be able to show the applications of Windows 7.

The display wall should be rugged and industrial nature and should be able to work in 24/7 environments.

The display wall should consist of the Visual Display Unit, Display Controller and the Wall Management Software, which should be supplied from a single manufacturer with the following specifications:

1. **The Visual Display Unit / Rear Projection Module must be based on Single Chip DLP-based Rear Projection Technology, 3 separate colour (Red, Green & Blue) LED lit, without any colour wheel**.
2. **The light source should be LEDs of 3 different primary colours; Red, Green & Blue and not a single lamp using the LED as a light source. Light source 6x redundancy for each of 3 LEDs of three primary colors**.
3. Should have the scalability and upgradeability to be made up of multiple rear projection modules stacked up in rows and columns to achieve a display wall for better viewing ability in linear or curved configuration.
4. The Diagonal Size of each Visual Display Unit / Rear Projection Module should be 70" nominal with a native resolution of 1920 X 1080 pixels (Full HD) and should offer 16.7 million colors.
5. The Visual Display Unit / Rear Projection Modules should have in-built redundancy in LEDs and ensures redundancy at the light source level for each color without any mechanical movement. In case redundancy of light source is not there, bidder to provide spare projection engines to handle light source failure.
6. The Light source lifetime of LED should be 80,000 hrs.(Eco)
7. The brightness uniformity should be > 95%.
8. The contrast shall be 1500:1 or higher.
9. The Aspect Ratio of each of projection module should be 16:9.
10. **The luminance on each rear projection module is 250 cd/m2 or higher with wide viewing angle screens**.
11. The screen should have adjustable low inter screen gap .4 mm to give seamless viewing experience.
12. During the useful lifetime of the illumination unit, it should be possible for color and brightness alignment of different projectors to a common target, resulting in a uniform display wall.
13. **The Projector should support Dual link DVI in and Dual link DVI out to have a flicker free image on the Large Screen Graphics Wall.**
14. **The pixel clock shall be > 320 MHz on the Dual Link DVI input**.
15. Each cube shall have its own IP address and on board web server to have the access from a standard web page through Linux based wall control PC, with gateway function from any PC over the Ethernet and shall communicate to a viewer via Ethernet and it's

IP address in star architecture to prevent communication loss. It shall have its own webpage with status, health and configuration.

16. **Power consumption for each Visual Display Unit / Rear Projection Modules should be less than 100 watts.**

The Display Controller should have the following specifications:

1. The Controller should be in an industrial 19" rack mounted casing (6U) based on Intel i7 CPU 3.6 GHz (Min.)
2. The min. memory of 16 GB (standard)
3. The unit should be equipped with a DVD ROM Drive.
4. The system should be equipped with 500 GB HDD in RAID 1 Configuration.
5. The display controller should have dual redundant hot swappable power supply.
6. Should have 10/100/1000 Mbps Redundant Ethernet port for LAN connection.
7. Supplied with a Keyboard and mouse with 20 m cable extension.
8. The Display Controller should be based on WINDOWS OS 7,64 bit.
9. There should be possibility of connecting the various types of analog and digital sources which can be shown in freely scalable and moveable windows on the video wall. It should support various inputs from the client workstations.
10. Possibility of showing the laptops of senior officials on the display wall without doing any laptop setting or connecting cables or installing software or without putting it on the corporate network
11. **Possibility of showing the iOS or Android Devices (Smart Phones & Tablets) on the display wall without connecting cables / special adapters**
12. **Selection of Laptop, iOS or Android Device is done by the user of respective device himself and no centralized intervention/support is required**

The Wall Management Software should have the following specifications:

1. The software should be able pre configure various display layouts and access them at any time with a simple mouse click or based on the timer.
2. The software should enable the users to see the desktop of the graphics display wall remotely on the any WIN 7 PC connected with the Display Controller over the Ethernet and change the size and position of the various windows being shown.
3. The software should enable various operators to access the display wall from the local keyboard and mouse of their WIN 7 workstation connected with the Display Controller on the Ethernet.
4. The software should copy the screen content of the WIN 7 PC / workstation connected on the Ethernet with the Display Controller to be shown on the Display wall in scalable and moveable windows in real time environment.
5. The wall management software should support open APIs to enable system integrators to integrate it with their Software. Multiple application programmer's interface (API) to facilitate third-party software to control and access Wall management software features including ability to query the available perspectives, launch sources in windows, switch perspectives, switch current window contents to available inputs for both networked or non-networked sources(on the input cards), query overall system status, and launch applications
6. Key features of Wall management Software
    a. Central configuration database
    b. Browser based user interface
    c. Auto-detection of network sources
    d. Online configuration of sources, displays and system variables
    e. Backup & restore capabilities
    f. Scheduled backup
    g. Advanced remote logging
    h. Full resolution and full frame rate preview of all networked sources
    i. Remotely monitor displays over the network with the actual preview of all sources shown
    j. Drag and drop from sidebar to mini display for quick perspective changes
    k. Integrated soft KVM for remote control of displays
    l. Perspectives can be opened and shown on both workstations and displays alike
    m. Standard and custom Tiling configuration
    n. Share your perspectives with other workstations or displays

o. Decorators including: UMD, IDC, Source Name, Time (time zone aware), Date, Text, Logo, Message Ticker, Source status

Wall Control Software should be server client Architecture and have following specifications:

1. The Wall Control software shall perform health monitoring that allows timely detection of faults.
    a. Wall health
    b. Cube health
    c. Cube IP-address
    d. Brightness
2. Wall Control Software shall allow commands on wall level or cube level or a selection of cubes :
    a. Switching the entire display wall on or off.
    b. Setting all projection modules to a common brightness target, which can be either static (fixed) or dynamic to always achieve maximum (or minimum) common brightness between projection modules.
    c. Fine-tune color of each cube
3. The integrated view shall provide a database that
    a. records all events
    b. can record full status at given time intervals
    c. can be exported to excel/html
    d. Show internal patterns
4. Log file functions (full Audit trail capabilities)
    - Logs are not automatically overwritten
        - Client logs
        - Central server logs
    - Logs contain the following information
        - Individual User ID that has control of the video wall at any given time
        - Name of PC that has control of video wall at any given time.
        - Time control was taken.
        - Time control was released
        - Time stamps in log shall be at the one (1) second interval, or less

Bill of Quantity

	Large Video Wall	Quantity
a.	LED lit DLP based Rear Projection Modules,DLP based 70" Nominal Diagonal size, Full HD	**4 © x 2 ® Matrix Configuration**
b.	Display Controller Unit	**1(Might change accordance to the actual requirement)**
C	Wall Management and Control Software	**1 Lot**
d.	Base stands and Cables	

Pre-Qualifications:-

- Bidder should be registered in India for at least last five years and average Annual turnover of Bidder should be >10 Cr. Per year.
- Bidder shall submit ISO certificate and certificate of incorporation
- The OEM should have one installation in OPTCL.
- OEM owned service center should be present in India for servicing video walls.
- In order to avoid any compatibility issues and better support, the projection modules, Display controller and Wall management software should be from same OEM.
- **The Display wall modules and Controller should be BIS certified and Mandatory.**