

Standard Specification  
for  
Power Line Carrer Communication

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## 1 GENERAL:

All the PLCC equipment covered under the package shall conform to the requirements of the latest edition of the relevant IEC/IS Specifications or equivalent National Standards.

## 2 STANDARD AND DRAWING:

The IEC/IS Specifications and international publication relevant to the equipment covered under this specification shall include but not be limited to the list given at Annexure-III of Section-GTR.

## 3 LOCATION OF EQUIPMENT:

The PLCC Equipment and Line traps as specified shall be installed at the respective ends of the Transmission lines. The Contractor shall be responsible for coordinating the equipment supplied with the already existing carrier equipment at the respective sub-stations. The contractor shall also be responsible for collecting all the necessary information/data from the respective sub-stations/concerned State Electricity Boards for the installation of the equipment.

## 4 FREQUENCY PLANNING:

4.1 For planning frequency and output power of carrier terminals, Bidders may plan for a minimum receive signal to noise ratio (SNR) of 25 dB for the speech channels without companders. The noise power in 2.1 kHz band (300-2400 Hz) may be taken as -13 dBm referred to the coupling point of the H.T. line. An additional -2.5dB may be assumed for psophometric factor. As far as coupling loss (phase to phase) is concerned, the Bidders may assume the same as 6dB at one coupling end for evaluating SNR. For protection channels the minimum SNR shall not be less than 15 dB under adverse weather. A safety margin of 9 dB shall be taken over and above these SNR values in order to cater for variations in line attenuation from the computed value as in hand reserve. Frequency and output power of PLC terminals for protection shall be planned such that the protection signal is received with full reliability even when one of the phases is earthed or is on open circuit on the line side causing an additional minimum loss of 6 db.

The Bidder shall indicate the noise power in the bandwidth used for protection signaling and shall submit the SNR calculations for speech as well as protection channels on all the line section given in at the proposed frequencies. Sample calculations for SNR requirement and power allocation over different channels must be furnished along with the bid. Maximum permissible line attenuation shall be clearly brought out in these calculations. Further, Bidder shall submit details of frequency planning done (including computer studies carried out and facilities available) for PLCC links on EHV lines in the past in the relevant schedule of DRS. Bidder must enclose one copy of computer study result done in the past along with the Bid.

4.2 The Successful Bidder shall be fully responsible for the coordination required with concerned utility for finalizing the frequency plan.

4.3 The frequency plan will be referred to wireless Adviser/DOP Department for clearance and in case any change in the Contractor's recommended carrier frequency and power output is proposed by these authorities, the Contractor shall have to modify his proposal accordingly. Change of power output shall, however, not involve repeater stations.

## 5 PROPOSED ARRANGEMENT:

5.1 The power line carrier communication equipment required by the Employer is to provide primarily efficient, secure, and reliable information link for carrier aided distance protection and direct tripping of remote-end breaker and for speech communication between 765/400/220 kV sub-stations. It shall include separate carrier terminals of

multipurpose type for speech and protection purposes. All carrier terminals, including those for protection shall be suitable for point-to-point speech communication also.

- 5.2 For security reasons, each 765/400/220kV transmission line shall be protected by Main-I and Main-II protections as given below:

Main-I: Numerical Distance protection with permissive inter-tripping.

Main-II: Numerical Distance protection of a different measuring technique than that of relay under Main-I along with permissive inter-tripping.

132kV transmission lines shall have Main-I protection same as above along with backup overcurrent and earth fault protections.

- 5.3 The requirement of carrier information on each link covered under this specification is as below:

- i. One protection channel each for Main-I and Main-II distance protection schemes. Further these channels will also be used as Main and Back-up channel for direct circuit breaker inter-tripping for 765kV, 400kV, 220kV and 132kV lines.
- ii. One speech channel with a facility to superimpose data signals up to 1200Baud.

**However, the number of channels for protection signaling, speech and data communication for SAS and Load dispatch center shall be as per the BOQ.**

- 5.4 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 as per the schematic requirement.

- 5.5 **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 ms for permissive inter- tripping and 30 ms for direct inter-tripping even for the longest line section.** The above timings are inclusive of operating time for auxiliary relays and interposing relays, if any, included in the PLCC equipment.

- 5.6 The requirement of protection signaling channel is such that **security against receipt of incorrect signals shall be at least two to three orders higher than reliability against non-receipt of signal.**

- 5.7 For reasons of security and reliability, phase to phase coupling for 765kV and 400 kV lines & 220kV S/C lines shall be employed. Inter-circuit coupling shall be used for 220/132kV D/C lines and phase to ground coupling shall be used for 132 KV S/C lines. Double differential coupling shall also be considered for double circuit lines. Bidders must furnish detailed write-up on methods of coupling and recommend suitable coupling mode for double-circuit lines alongwith the bids. Coupling mode shall, however, be fully confirmed by Contractor after conducting detailed computer study considering the transpositions of 765kV/400 kV lines for optimum coupling mode over these line sections. The coupling arrangement shall be fully optimized by the Contractor after conducting detailed study of every line section individually considering the 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 the complete range of frequencies. The earth resistivity data, existing frequency networks and other relevant details of each line will be furnished to the Contractor for carrying out the 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 the above data.

- 5.8 The 765kV/400 kV transmission lines may be transposed.  
The transmission tower configuration and conductor details shall be forwarded after the award to enable the contractor 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”.
- 5.9 The parameters of the equipment quoted shall be such that the mode of wave propagation on 765kV/400 kV power line (with transpositions indicated) shall not impose any limitation on the efficient and reliable performance of information link from protection or communication point of view.
- 5.10 The Contractor shall have 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.
- 5.11 The Bidder 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 isolator and circuit breaker 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 signaling and shall consider the type of communication link e.g. account shall be taken of transpositions in the phase-to-phase coupled H.T. 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.

## 6 LINE TRAP:

- 6.1 Line trap shall be broadband 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 765kV & 400kV system and 570 ohms for 220kV & 132kV systems.**
- 6.2 Line trap shall be provided with a protective device in the form of surge arrestors which shall be designed and arranged such that neither significant alteration in its 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 lightning arrestor shall be station class, current limiting, active **gap type. Its rated discharge current shall be 10kA. However, coordination shall be done by taking 20kA at 8/20 micro-sec. discharge current into account.** In case of gap-less metal oxide arrestor, Bidder has to furnish the justification.
- 6.3 The lightning arrestor provided with the line trap of each rating shall fully comply with the requirements of IEC 60099-4. It shall conform to type tests as applicable and type test certificate for the same 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-60099-4.
- 6.4 The line trap on 765kV & 400kV lines shall show no visual corona discharge at a voltage of  $508kV_{rms}$  and  $320KV_{rms}$  power frequency falling voltage. Suitable corona rings may be incorporated in the line trap. Radio interference voltage for 420/245/132 kV shall not exceed 500 micro volts at 280/163/97  $kV_{rms}$  respectively. For 765kV, RIV shall not exceed 1000 micro volts at  $508kV_{rms}$ .

- 6.5 Line trap shall be equipped with bird barriers.
- 6.6 Line trap shall conform to IEC 60353 (latest) fulfilling all the technical requirements. The rated short time current for 1 Second shall be 40/50/63kA as per requirement. The mH rating shall be 0.25/0.5/1.0 mH depending on frequency plan.
- 6.7 The Bidder shall indicate continuous current rating of the line trap at 65°C ambient.
- 6.8 Reports for the following type tests on each type of line trap shall be submitted as per clause 9.2 of GTR.
  - i. Temperature rise test.
  - ii. Insulation tests.
  - iii. Short-time current test.
  - iv. Measurement of rated inductance of the main coil.
  - v. Corona Extinction Voltage test (procedure for this shall be mutually agreed).
  - vi. Radio Interference Voltage measurement test (procedure for this shall be mutually agreed).
- 6.9 The Bidder must enclose the reports of type and routine tests conducted on similar equipment earlier as per IEC 60353 along with bid.
- 6.10 Welding

All the welding included in the manufacture of line traps shall be performed by personnel and procedure qualified in accordance with ASME-IX and all the critical welds shall be subject to NDT as applicable.
- 6.11 Line Trap Mounting
  - i. The Line Trap shall be suitable for outdoor pedestal or suspension mounting and shall be mechanically strong enough to withstand the stresses due to maximum wind pressure of 260 kg/square meter.
  - ii. For pedestal mounting, each line trap shall be mounted on a tripod structure formed by three insulator stacks arranged in a triangular form. All the accessories and hardware, mounting stool including bolts for fixing the line trap on insulators shall be of non-magnetic material and shall be supplied by the Contractor.
  - iii. For suspension mounting, Contractor shall be required to coordinate the mounting arrangement with the existing arrangement. Non-magnetic suspension hook/link of adequate length and tensile strength is required to maintain necessary magnetic clearance between the line trap and suspension hardware which shall be supplied by the Contractor.
  - iv. For 765kV wave Trap, Cantilever strength of BPIs used for Wave Trap shall be 10kN.
- 6.12 Terminal Connectors
  - i. The line traps shall be suitable for connecting to 3"/4"/4.5" IPS Aluminium tube or ACSR Single/Twin/Quad bundle conductor with horizontal or vertical takeoff. Necessary connector shall be supplied by the Contractor.
  - ii. Terminal Connectors shall conform to IS:5561.
  - iii. **No part of clamp or connector (including hardware) shall be of magnetic material.**
  - iv. Clamps and connectors shall be designed corona controlled. Visual Corona extinction voltage shall not be less than 508kV<sub>rms</sub> & 320kV<sub>rms</sub> for 765kV and 420kV respectively. All nuts and bolts shall be suitably shrouded.

- v. Radio interference Voltage for 420/245/132 kV shall not exceed 500 microvolts at 280/163/97 kV<sub>rms</sub> respectively. For 765kV, RIV shall not exceed 1000 micro volts at 508kV<sub>rms</sub>.
- vi. Clamps/connectors shall be designed for the same current ratings as line trap and temperature rise shall not exceed 35°C over 50°C ambient. No current carrying part shall be less than 10 mm thick.
- vii. Clamps/connectors shall conform to type test as per IS:5561. Type Test reports shall also be submitted for following additional type tests:
  - Visual Corona Extinction Test
  - Radio Interference Voltage Measurement
- viii. Bidders are required to submit typical drawings clearly indicating the above-mentioned features of the line traps, line trap mounting arrangement and terminal connectors along with their bid. For suspension mounted line traps, Bidder shall submit drawings showing single point as well as multipoint (normally 3 point) suspension arrangements.

## 7 COUPLING DEVICE:

- 7.1 The coupling devices shall be interposed between the CVT and coaxial line to the PLC transmitter/receiver, and in conjunction with the CVT shall ensure:
  - a) Efficient transmission of carrier frequency signals between the carrier frequency connection and the power line.
  - b) Safety of personnel and protection of the low voltage parts and installation, against the effects of power frequency voltage and transient over voltages.
- 7.2 The coupling device, in conjunction with the CVT shall from an electric filter of band pass type:
  - a) It shall match characteristic impedance of H.T. line to impedance of the carrier frequency connection.
  - b) Galvanic isolation between primary and secondary terminals of the coupling device shall be performed by the above-mentioned transformer.
  - c) Power frequency currents derived by the CVT may be drained to the earth by a separate inductance termed drain coil of suitable rating. Voltage surges coming from the power line at the terminals of the coupling device shall be limited by a non-linear surge arrester of suitable rating in the primary side. Requirement of a gap-type voltage arrester on the 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 suppressers.
  - d) The surge arrester shall have power frequency spark over voltage coordinated with the equipment ahead of it.
  - e) For direct and efficient earthing of its primary terminals, the coupling device shall be equipped with an earthing switch. The Earth Switch shall be available for earthing of CVT-HT terminals, when the coupling filter units are removed from circuit for maintenance/ replacement. The design shall take due regard of requirements for safety in accordance with the Indian Electricity Rules.
- 7.3 Two numbers 'phase to earth' type coupling filters shall be used to achieve 'phase to phase'/'inter-circuit coupling'. Connection between secondaries of the two phases to earth type coupling device shall be through a balancing transformer/hybrid such that reliable communication shall be ensured even when one of the coupled phases is earthed or open



circuited on the line side.

- 7.4 Coupling device shall conform to IEC 60481 and shall have the following carrier frequency characteristics as applicable to a phase to earth type coupling device:

a).	Nominal line side impedance	i). 240 ohms for 765kV and 400kV Quad/triple bundle conductor line. ii). 320 ohms for 400kV twin bundle conductor line. iii). 400 ohms for 220/132kV line
b).	Nominal equipment side impedance	75 ohms (unbalanced)
c).	Composite loss	Not more than 2 dB
d).	Return Loss	Not less than 12 dB
e).	Bandwidth	36 - 500 kHz
f).	Nominal peak envelope power	Not less than 650 Watt (for Inter-modulation product 80 dB down)

- 7.5 The coupling device shall be suitable for outdoor mounting. The temperature of metallic equipment mounted outdoors is expected to rise up to 65°C during the maximum ambient temperature of 50°C specified. The equipment offered by the Bidder shall operate satisfactorily under these conditions.
- 7.6 **The H.T. terminal of coupling device shall be connected to H.F. Terminal of the CVT by means of 6 mm<sup>2</sup> copper wire with suitable lugs & taped with 11 kV insulation by the contractor.**
- 7.7 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.
- 7.8 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- 60481/IS:8998.

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

- i) Composite loss and Return loss tests on coupling device.
  - ii) Turns ratio test and insulation tests on the balancing transformer.
  - iii) Milli volt drop test, power frequency voltage test and mechanical operation test on earthing switch.
  - iv) Power frequency spark over test for lightning arrester as per relevant IS/IEC.
- 7.9 Reports for the following type tests on coupling devices shall be submitted as per clause 9.2 of GTR.
- i. Return loss.
  - ii. Composite loss.
  - iii. Distortion and intermodulation test.
  - iv. Impulse voltage test.
  - v. Tests on Arrestors.

Bidder shall furnish along with his bid, copies of all type and routine tests conducted earlier on similar coupling device in accordance with relevant standards.

## 8 HIGH FREQUENCY CABLE:

- 8.1 High frequency cable shall connect the coupling device installed in the switchyard to the PLC terminal installed indoors.



- 8.2 The cable shall be steel armored, and its outer covering shall be protected against attack by termites. The bidder shall offer his comments on the method employed for earthing of screen and submit full justification for the same with due regard to safety requirements.
- The bidder must enclose a detailed construction drawing of the cable being offered, with mechanical and electrical parameters along with bid.
- 8.3 Impedance of the cable shall be such as to match the impedance of the PLC terminal on one side and to that of the coupling device on the other side over the entire carrier frequency range of 40-500 kHz.
- 8.4 Conductor resistance of cable shall not exceed 16 ohms per Km at 20°C.
- 8.5 The cable shall be designed to withstand test voltage of 4kV between conductor and outer sheath for one minute.
- 8.6 The Bidder shall specify attenuation per Km of the cable at various carrier frequencies in the range of 40 to 500 kHz. **The typical attenuation figures for H.F. cable shall be in the range of 1 to 5 dB/km in the frequency range of 40-500 kHz.**
- 8.7 The H.F. cable shall conform to type tests and routine tests as per IS 11967: Part 2: Sec 1 /IS 5026.
- 8.8 All HF cables within the scope of this specification shall be laid and termination shall be carried out by the Contractor.
- 8.9 The cables shall be supplied wound on drums containing nominal length of 500 meters each. However, exact requirement of drum lengths shall be finalized during detailed engineering to avoid joint in HF cable and its wastage.

## 9 POWER LINE CARRIER TERMINAL:

- 9.1 As already indicated the information link shall be provided for speech, protection, telex and data services.
- 9.2 PLC terminal shall use Amplitude Modulation and shall have single side band transmission mode. These shall be equipped for fixed frequency duplex working.
- Characteristic input and output parameters of the SSB PLC terminals shall be as per IEC 62488-1 and 62488-2, unless otherwise specified.
- 9.3 The salient features are detailed out below:

a.	Mode of transmission	Amplitude Modulation single side band with suppressed carrier or reduced carrier.
b.	Carrier frequency	40 to 500 kHz range
c.	Nominal carrier frequency band in either direction of transmission	4.0 kHz
d.	Power output (PEP) at HF terminal	20/40/80 Watt
e.	Frequency difference between a pair of PLC terminals	Frequency difference between VF signal at the 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%.
f.	Automatic gain control	For 40 dB change in carrier frequency signal level within the regulation range, change in VF receive

		levels of both speech and other signals shall be less than 1dB.
g.	Supply voltage	48V DC (+)15%, (-)10%. (Positive pole earthed)

- 9.4 All the PLC terminals shall be of multipurpose type. The Bidder shall confirm that the total transmission time for tele protection shall not exceed 20 ms for permissive and 30 ms for direct tripping signals. Speech and tele protection channels shall independently fulfill 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.

- 9.5 In the input circuit of the PLC terminal, protective devices shall be provided in the form of Zener diodes or surge suppressers to eliminate any surge transfer through the coupling device or the surge induced in the connecting path of H.F. cable.
- 9.6 To improve voice transmission characteristics for the system, compressors and expanders 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 compandor shall be compatible with the audio power levels specified for 2/4 wire operation. The improvement gained by companders shall however not be considered for power allocation and shall be in-hand reserve.
- 9.7 **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 the above phenomenon. The receiver design shall also provide protection against false tripping from random noise.
- 9.8 Fail-safe devices shall be provided, so that a malfunction in one unit or subassembly 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 mis adjustment from accidental contact/vibration, shall be equipped with suitable locking devices.
- 9.9 The PLC set shall be designed to give guaranteed performance from 0°C to 50°C ambient temperature. The thermal capability of the equipment shall be so designed that the equipment remains operational successfully up to 60°C ambient temperature. Any ventilation fans provided for circulation of air inside the cabinets shall conform to relevant Indian Standards.
- 9.10 The terminals shall be provided with built-in indicating instruments to facilitate checking of important voltages 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 to 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 tropicalized.
- 9.11 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. All the panels shall be properly earthed to the Employer's earthing grid by the Contractor. The contractor shall submit detailed drawings for earthing connections.

- 9.12 All the panels shall be protected against moisture ingress and corrosion during storage. Panels shall be properly dried before they are installed and energized. The bidder shall indicate measures adopted to prevent ingress of moisture during operation.
- 9.13 All cabinets having PLC terminals shall be provided with lamps of sufficient wattage for interior illumination with switch. Each panel shall be provided with 240 V AC single phase socket with switch to accept 5 & 15A standard Indian plugs.
- 9.14 A name plate shall be provided on the front door of each cabinet indicating channel function, transmitter frequency and direction etc.
- 9.15 Reports for the following type tests for PLC Terminals shall be submitted as per clause 9.2 of GTR.

Tests determine various characteristics of PLC terminals as per IEC 62488.

- a. Voltage variation
  - b. Carrier frequency range band.
  - c. Frequency accuracy
  - d. Transmit/Receive frequency difference.
  - e. Automatic gain control
  - f. Harmonic distortion
  - g. Selectivity
  - h. Output impedance, return loss & Tapping loss.
  - i. Return loss, of inputs/Outputs.
  - j. Balance to ground
  - k. Limiter action
  - l. Spurious emission
  - m. Carrier frequency levels and levels
  - n. Attenuation distortion
  - o. Noise generated within terminal.
  - p. Near and far end cross talk
  - q. Group delay distortion.
  - r. Conducted noise.
  - s. Telephone signaling channel.
  - t. Speech levels
  - u. Voltage withstand test
  - v. Insulation test
- 9.16 Heat Soaking of panels

All the solid-state equipment/system panels shall be subjected to the Heat Soaking as per the following procedure:

All solid-state equipment shall be burn-in for minimum of 120 hours continuously under operation condition. During the last 48 hours of testing, the ambient temperature of the test chamber shall be 50°C. Each PLC 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 65°C.

## 10 SPEECH COMMUNICATION:

- 10.1 PLC equipment offered shall provide telephone communication between the stations where the transmission lines are terminating. The equipment shall be suitable for

providing the following facilities:

- a) It shall be possible for subscriber at any of the stations to contact the subscriber at all other stations connected in the system as shown in the specification drawing by dialing his call number. To achieve this, a 24 lines EPAX with 4 wire interface & remote subscriber units shall be provided/available at different stations.
- b) The equipment shall contain all normal facilities like ring back tone, dial tone, engage tone & priority tone and suitable pulses to establish and disconnect communication between subscribers.
- c) The equipment shall be provided with necessary alarm circuits and fuses etc.
- d) 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 the provision made in the proposal for future development and the extent to which such additional facilities can be added at a later date in bid.
- e) The system shall be completely automatic with 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 coordinated with the existing/ proposed future systems by the Contractor.
- f) Arrangement for over-riding facilities shall be provided by means of priority keys wherever specified. The over-riding facility shall enable cutting-in ongoing calls with the priority key and ask the concerned parties to finish their conversation. The wanted number should then get automatically connected without having to redial the number.
- g) All the carrier telephone conversations shall be secret and it should not be possible for anybody to overhear the conversation going on between any two parties except those provided with over-riding facilities.
- h) The necessary cables for connecting all the telephone instruments ordered for at each sub-station (including wiring and termination) shall be provided by the Contractor. These telephone instruments shall be located within the control room building at the respective sub-station.
- i) The cabinets housing the equipment for EPAX, four wire E/M interface & remote subscriber units (four wire) shall have a mounting arrangement similar to that for PLC terminals.
- j) All the terminals for speech shall be with Transit Band Pass Filter suitable for tuning at site and shall be wired for addition of VFTs in future.
- k) 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.
- l) Terminals for protection shall be suitable for speech between two ends of each transmission line or on tandem operation basis with back-to-back connection at the intermediate stations.
- m) Each PLC terminal for speech as well as protection purposes shall be provided with a plug-in type of service telephone and buzzer. **Further, 4 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 respective Switchyard control room 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.

## 10.2 Electronic Private Automatic Exchange (EPAX)

- a) The 24-line Electronic Private Automatic Exchange (EPAX), wherever specified, shall be connected to a minimum of six trunk routes thorough PLCC channels (speech panel) with Four-wire E/M' interface unit. This 4-wire interface unit either shall form an integral part of the 'EPAX' system or be suitable for mounting/housing in the carrier panel. The exchange will have its own ringing current and tone generator etc. The exchange shall be suitable for working on 48V DC Power Supply (positive pole earthed).
- b) The exchange shall be fully automatic, solid state, and of modular construction and shall have multiple switching routes (minimum 4-routes).
- c) 'EPAX' shall also be provided with two (2) additional interface units and operate exclusively with Employer's leased subscriber lines, of Department of Telecommunication (DOT) and compatible with 2 wire full duplex, voice grade mode of operation.
- d) The details of communication protocol, for interfacing of the 'DOT' leased lines, shall be coordinated by the Contractor, with the licensing authority (DOT).

## 10.3 Remote End Four Wire 'E/M' Interface & Subscriber Unit or Equivalent EPAX (4x4)

- a) The remote end four wire 'E/M' interface & subscriber units, wherever specified, shall be of electronic type and be suitable for working on fixed frequency power line carrier systems with E & M signaling. This shall be housed in the carrier set and be fully wired to the power line carrier terminal equipment.
- b) 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 unit.
- c) The four-wire interface unit shall be equipped for routing transit calls and shall be supplied pre-wired to handle calls for minimum eight directions, in a form suitable for transmission over PLCC.
- d) The bidder shall also indicate the total number of trunk-line capacity, available with each four-wire interface unit. The unit shall be suitable for connecting two-wire telephone sets. Further, the associated telephone cables for locating two subscriber lines within the control room is in the scope of this specification.

# 11 PROTECTION COUPLER

## 11.1 Analog Protection Coupler

- a. 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.
- b. The voice frequency transmission equipment shall not only be insensitive to corona noise but shall also remain unaffected by impulse type noise which are 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. The bidder shall clearly explain as to 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.

- c. The equipment shall be unaffected by spurious tripping signals. The Bidder shall submit proof as to how this is achieved satisfactorily.
- d. The equipment shall be suitable for transmission of direct and permissive trip signals 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 in full duplex frequency shift mode of operation or by switching between two frequencies in case of coded signals. The protection signaling 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 765kV/400kV/220kV systems shall be submitted along with the bid. Each protection signaling equipment shall provide:
  - i) Transmission facilities for minimum three protection signals.
  - ii) Reception facilities for minimum three protection signals.
- e. 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 m. Sec. or less and for direct tripping 30 m. Sec. or less even for the longest line section.

Operating time lower than specified above may be preferred provided they fulfill the requirements of security and reliability as mentioned below:

False - trip probability (Noise burst of any amplitude)	$10^{-5}$
Fail to trip Probability for S/N 6 dB in 3.1 kHz Band (white Noise Measurement)	$10^{-2}$

- f. It may be emphasized that specified time, as mentioned above is composed of the following:
  - i. Back-to-back signal delay in frequency shift or coded signals protection equipment.
  - ii. Back-to-back delay in PLC terminal.
  - iii. Delay in transmission line.
  - iv. Operation time of interposing relay, if any, in frequency shift or coding equipment.

Reference is invited in this regard to the guidelines expressed in CIGRE Publication "Tele protection" report by Committee 34 and 35.

- g. The following transfer criteria shall be provided by the equipment:
  - i. Transmit side

One number potential free NO (normally open) contact of protective relays (To be supplied by the Employer) of under noted rating for each of the following functions:

- Permissive trip command
- Direct trip command



Contact Rating	
Rated Voltage	250 Volts DC
Maximum current rating	5 Amp
Maximum power rating	1250 W/VA

ii. Receive Side

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

- Permissive trip command
- Direct trip command

Contact Rating	
Rated Voltage	250 Volts DC
DC Rated current	0.1A DC
Other parameter	As per IEC 60255-26

iii. Alarm

In addition, the voice frequency protection terminal shall provide at least one number potential free change over contact of the following rating for alarm purposes.

Contact Rating	
Rated Voltage	250 Volts DC
DC Rated current	0.1A DC
Other parameter	As per IEC 60255-26

- h. The Contractor shall submit drawings showing the interconnection between PLCC and protection panels for approval by the Employer.
- i. It has to be ensured that under no circumstance's protection channel should share the power. Each protection channel shall be able to transmit power for which 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 get disconnected momentarily during the operation of protection channels.
- j. The equipment shall be constructed such that in permissive line protection system, operational reliability of the protection channel may be checked over the carrier link by means of a 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.
- k. The equipment shall be complete with built-in counters for counting the number of trip commands sent and number of trip commands received.
- l. Reports for the following tests as per clause 9.2 of Section: GTR shall be submitted for approval for protection coupler and the relays associated with PLCC equipment for network protection signaling equipment and interface unit with protective relay units if any:
  - A. Protection coupler (As per IEC 60834 -1)
    - a. Power supply variation



- b. Power supply interruption
- c. Reflected noise.
- d. Reverse polarity
- e. Interference by discrete frequency
- f. Transmission time
- g. Interference by frequency deviation. (Wherever applicable)
- h. Alarm function.
- i. Security
- j. Dependability
- k. Voltage withstand test
- l. Insulation test.
- m. Electrical fast transient test (along with carrier terminal)
- n. Electrical fast transient test (along with carrier terminal)
- o. HF disturbance test (along with carrier terminal)
- p. Electrostatic discharge test (along with carrier terminal)
- q. Radiated electromagnetic field susceptibility test (along with carrier terminal)
- r. Environment test (as per IS 9000)

#### B. Relays.

- a. Impulse voltage withstand test as per IEC 60255-26.
- b. High Frequency Disturbance test as per IEC 60255-26.

### 11.2 Digital Protection Coupler (DPC)

- a. Digital protection coupler (DPC) shall be used as one of the two tele-protection channels on the lines between the stations having Optical Fiber link along with SDH Equipment. The DPC can be housed either in the offered Control & Protection Panel / PLCC Panel or in separate panel. Generally, SDH Equipment are placed in the communication room of the Control room whereas DPC is placed in panel room. The connection between SDH equipment and each DPC shall be through Optical fiber. Necessary cables, converter(s) for converting E1 signal to optical fiber at both ends (at Panel Room as well as at Control room) along with FODP shall be in the scope of the contractor. Further sharing of additional spare ports of converter for DPC placed in other Panel Room or in same Panel Room is also permitted. Necessary optical fiber for interconnection of DPC is to be provided by the contractor. Further any copper wiring for ensuring the protection signaling/data/speech shall be in the scope of the contractor.

- b. General

The Digital protection signalling equipment is required to transfer the trip commands from one end of the line to the other end in the shortest possible time with adequate security and dependability. It shall also monitor the healthiness of the link from one end to the other and give alarms in case of any abnormality. The protection signaling equipment shall have a proven operating record in similar application over EHV systems and shall operate on 48V DC (+15%/-20%). **It shall provide minimum four commands.** These commands shall be suitable for Direct tripping, Inter-tripping and Blocking protection schemes of EHV lines.

The protection signaling equipment shall communicate to the remote end interfacing with SDH terminal equipment at its 2Mbps port. It shall provide suitable interfaces for protective relays, which operate at 220V DC. Power supply points shall be immune to electromagnetic interface.

c. **Principle of operation**

During normal operation, protection signaling equipment shall transmit a guard signal/code. In case Protection signaling, equipment is actuated by protective relays for transmission of commands, it shall interrupt the guard signal/code and shall transmit the command code to the remote end. The receiver shall recognize the command code and absence of the guard code and will generate the command to the protective relays.

All signal processing, i.e. generation of tripping signal and the evaluation of the signals being received shall be performed completely digital using Digital Signal Processing techniques.

d. **Loop testing**

An automatic loop testing routine shall check the tele-protection channel. It shall also be possible to initiate a loop test manually at any station by pressing a button on the front of the equipment. Internal test routine shall continuously monitor the availability of the protection signaling equipment. Proper tripping signal shall always take the priority over the test procedure.

The high-speed digital protection signaling equipment shall be designed and provided with following features.

- Shall work in conjunction with SDH terminal equipment.
- It shall communicate on G 703 (E1 - 2 Mbps)
- Full Duplex operation
- Auto loop facility shall be provided
- Shall meet IEC 60834-1 standard
- Shall be able to transmit up to 4 commands with trip counter simultaneously or sequentially in one 2Mbps channel

Bidder shall quote for protection signaling equipment suitable for 4 commands with separate trip counters for transmit and receive.

High security and dependability shall be ensured by the manufacturer. Probability of false tripping and failure to trip shall be minimum. Statistical curves/figures indicating above mentioned measures shall be submitted along with the bid.

Reports of the following tests as per clause 9.2 of Section-GTR shall be submitted for approval for protection signaling equipment and relays associated with the protection signaling equipment and interface unit with protective relay units, if any.

- i. General equipment interface test:
  - a) Insulated voltage withstand test
  - b) Damped oscillatory waves disturbance test
  - c) Fast transient bursts disturbance test
  - d) Electrostatic discharge disturbance test
  - e) Radiated electromagnetic field test
  - f) RF Disturbance emission test
- ii. Specific power supply test:
  - g) Specific power supply test
  - h) Power supply variations
  - i) Interruptions

- j) LF disturbance emission
- k) Reverse polarity
- iii. Tele-protection system performance test:
  - a) Security
  - b) Dependability
  - c) Jitter
  - d) Recovery time
  - e) Transmission time
  - f) Alarm functions
  - g) Temperature and Humidity tests (As per IEC 60068-2)
    - Dry heat test (50°C for 8 hours)
    - Low temperature test (-5°C for 8 hours)
    - Damp heat test (40°C/95%RH for 8 hours)

All the above tests at i, ii & iii (except temperature & humidity tests) shall be as per IEC60834-1 and the standards mentioned therein.

iv. Relays

- a) Impulse voltage withstand test as per IEC 60255-26
- b) High frequency disturbance test as per as per IEC 60255-26

The protection signaling equipment shall be of modular construction and preferably mounted in the Relay panels. Cabling between the protection signaling equipment & Protection relays and between protection signaling equipment & Communication equipment shall be in the scope of bidder.

The input/output interface to the protection equipment shall be achieved by means of relays and the input/output rack wiring shall be carefully segregated from other shelf/cubicle wiring.

The isolation requirements of the protection interface shall be for 2kV rms.

e. **Major technical Particulars**

The major technical particulars of protection signaling equipment shall be as follows.

i).	Power supply	48V DC +15% /-20%
ii).	Number of commands	4 (four)
iii).	Operating time	<7 ms
iv).	Back to back operate time without propagation delay	≤8 ms
	<b>Interface to Protection relays</b>	
	- Input Contact Rating	
	Rated Voltage	250V DC
	Maximum current rating	5 Amp
	- Output Contact Rating	
	Rated Voltage	250V DC
	Rated Current	0.1A DC
	Other Parameter	IEC 60255-26
	- Alarm Contact Rating	
	Rated Voltage	250V DC
	Rated Current	0.1A DC
	Other Parameter	IEC 60255-26
v).	Digital communication interface	G 703 (E1- 2 mbps)

### 11.3 Counter facility

All protection couplers (Analog protection coupler, digital protection coupler) shall be equipped with **direct reading type counter facility** for all the codes (Tx & Rx).

## 12 MANDATORY TESTING & MAINTENANCE EQUIPMENT:

Print testing kit for PLCC terminal, E/M interface & subscriber unit, Protection coupler & EPAX-comprising of following items of reputed make in addition to any other special items required for testing and maintenance of this equipment packed in a carrying briefcase:

- a. Screwdriver set with multi up fixing feature.
- b. Nose pliers.
- c. Cutting pliers
- d. Ordinary Pliers
- e. Adjustable wrench
- f. Soldering iron with tip earthed
  - 150 watts - 1 No.
  - 35 Watts - 1 No
  - 10 watts - 1 No.
 operated with isolated (step down) transformer having provision for interchangeable taps.
- g. Desoldering pump
- h. Print extender.
- i. Print puller.
- j. Large selection of test leads
- k. Solder wire.
- l. Large selection of plugs, jacks & pistol probes compatible with equipment supplied.
- m. Dummy load
- n. Interface card/print for Tx to Rx loop-back
- o. Test oscillator/tone generator with indicating meters - either built in or separate.
- p. ESD wrist band
- q. ESD conducting mat.

## 13 LIST OF COMMISSIONING TESTS:

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. Tests shall be done for all combinations.
4. End to end return loss for optimum coupling mode.
  - a. open behind line trap.
  - b. 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 PLCC equipment as per test schedule.
7. AF frequency response (end to end) for the entire 4 kHz Bandwidth for speech and teleoperation channels.
8. Measurement of noise in 2 kHz bandwidth with and without line energized.
9. SNR (test-one) with line energized noting down weather conditions.
10. Transmission time for tele protection 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 dialing performance.
13. Observation of end-to-end protection signaling (command sent & received) in conjunction with protective relays, noting down transmission/receipt of unwanted commands under switching operations in the switchyard during protective relay testing.

Notes:

1. 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.
  - i. within coupling device bandwidth.
  - ii. within line trap bandwidth, and
  - iii. operating frequencies.
2. Following tests shall be carried out independently at each and
  - i. Composite loss & return loss for coupling device.
  - ii. Attenuation test for HF cable + coupling device.
  - iii. Levels and other local adjustments (on dummy load). Final adjustment shall be on end-to-end basis.
  - iv. Test for loading by parallel channels with dummy load. This test can be done along with tests for coupling devices.
  - v. Protection signaling under local loop test (dummy load).
3. Necessary test instruments required for all the above tests shall be brought by commissioning engineers of the contractor.