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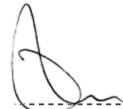


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1. Introduction

Power Line Carrier systems are used in Eskom to facilitate telecommunications which are used for teleprotection, protection and telecontrol. This ensures stability in the power system.

The specification is required to detail the requirements for the correct operation of the power line carrier (PLC) equipment and to ensure the power line carrier equipment facilitates the telecommunications medium used by the terminal equipment at substations. The specification also ensures the PLC equipment interfaces correctly to the protection, telecontrol and telecommunications equipment.

2. Supporting clauses

2.1 Scope

2.1.1 Purpose

The purpose of this document is to provide specific characteristics of Power Line Carrier (PLC) systems used for communication on power lines between terminal stations, as required by Eskom. The communication services supported and detailed in this specification are: speech, data, telesignalling and teleprotection.

2.1.2 Applicability

This specification is applicable to all those in Eskom involved in the application and engineering of power line carriers on HV and EHV power lines.

This document shall apply throughout Eskom Holdings Limited Divisions.

2.2 Normative/informative references

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

- [1] ISO 9001, Quality Management Systems.
- [2] TST41-634, Drawing Office Standard.
- [3] 240-75975613, Standard for the installation of Power Telecommunications Equipment.
- [4] 240-75655504, Eskom Specification: Corrosion protection standard for new indoor and outdoor Eskom equipment, components, materials and structures manufactured from steel standard.
- [5] 240-57649048: Eskom Standard: Fault Monitoring Equipment for Power Systems Standard.
- [6] 240-60725641: Specification for Standard (19 inch) Equipment Cabinets.
- [7] IEC 60495: Single-sideband power line carrier terminals
- [8] QM-58: Eskom Standard: Supplier Contract Quality Requirements Specification.
- [9] IEC 60481: Coupling devices for power line carrier systems
- [10] IEC 60721-3-3: Classification of environmental Conditions. - Part 3: Classification of groups of environmental parameters and their severity. - Section 3: Stationary use at weather protected locations
- [11] IEC 60834-1: Performance and testing of teleprotection equipment of power systems
- [12] SANS / IEC 61000-4-2: Electromagnetic compatibility (EMC) – Part 4 – Testing and measurement techniques – Section 2: Electrostatic discharge immunity test.
- [13] SANS / IEC 61000-4-3: Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 3: Radiated, radio – frequency, electromagnetic field immunity test.

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- [14] SANS / IEC 61000-4-4: Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test.
 - [15] SANS / IEC 61000-4-5: Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques - Section 5: Surge immunity tests.
 - [16] SANS/IEC 61000-4-8: Electromagnetic Compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test.
 - [17] IEC 61000-4-18: Electromagnetic Compatibility (EMC) – Part 4-18: Testing and measurement techniques – Damped oscillatory wave immunity test.
 - [18] IEC 60255-5: Insulation test for electrical relays.
 - [19] IEC 60255-25: Electrical Relays – Part 25: Electromagnetic emission tests for measuring relays and protection equipment
 - [20] IEC 61850: Communication Networks and Systems in Substations.
 - [21] ITU-T G703: Physical/Electrical Characteristics of Hierarchical digital interfaces
 - [22] ITU-T X.21: Interface between DTE and DCE Equipment for Synchronous Operation on Public Data Networks
 - [23] 240-42066934: IEC 61850 Protocol Implementation Document for the purposes of Substation Automation.
 - [24] 240-68235024: Eskom IEC 61850 Station Bus Interoperability Test Standard.
 - [25] 240-68107841: Eskom IEC61850 Standard Requirements for PICS, PIXIT and TICS.
 - [26] 240-55410927: Eskom’s cyber security standard.
 - [27] SANS 201729:2005 / ETSI ES 201729: Public Switched Telephone Network (PSTN); 2-wire analogue voice band switched interfaces; Timed break recall (register recall); Specific requirements for terminals.
 - [28] SANS 336/ ETSI TBR 21: Terminal Equipment (TE); Attachment requirements for pan-European approval for connection to the analogue Public Switched Telephone Networks (PSTNs) of TE (excluding TE supporting the voice telephony service) in which network addressing, if provided, is by means of Dual Tone Multi Frequency (DTMF) signalling.
 - [29] TIA/EIA/IS-968: Telecommunications telephone terminal equipment technical requirements for connection of terminal equipment to the telephone network
 - [30] ITU-T Q.552: Transmission characteristics at 2-wire analogue interfaces of digital exchanges
 - [31] ETSI ES 201 970: Access and Terminals (AT); Public Switched Telephone Network (PSTN); Harmonized specification of physical and electrical characteristics at a 2-wire analogue presented Network Termination Point (NTP)

2.2.2 Informative

- [32] ITU-T G.232 : Publication Recommendation G.232
- [33] ITU-T Q23: Technical features of push-button telephone sets
- [34] ITU-T G.712 : Publication Recommendation G.712
- [35] ITU-T G162: Publication Recommendation G.162
- [36] ITU-T G823: The control of Jitter and Wander Within Digital Networks which are based on the 2048 kBit/s hierarchy
- [37] ITU-T G.956: Digital line systems based on the 2048 kBit/s hierarchy on optical fibre cables
- [38] ITU-T G652: Characteristics of a single mode optical fibre cable

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[39] IEC60870-2-1: Telecontrol equipment and systems. Part 2: Operating conditions – Section 1 Power supply and electromagnetic compatibility.

[40] SANS 1091: National colour standards for paint

2.3 Definitions

2.3.1 General

None

2.3.2 Disclosure classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 Abbreviations

| Abbreviation | Description |
|--------------|-----------------------------------|
| CAS | Channel Associated Signalling |
| CB | Central Battery |
| CC | Coupling Capacitor |
| CVT | Capacitor Voltage Transformer |
| DTMF | Dual-tone multi-frequency |
| E&M | Ear & Mouth |
| EHV | Extra High Voltage |
| FXO | Foreign Exchange Office |
| FXS | Foreign Exchange Subscriber |
| HF | High frequency |
| HMI | Human Machine Interface |
| HV | High Voltage |
| IED | Intelligent Electronic Device |
| lps | Impulses per second |
| LME | Line Matching Equipment |
| PEP | Peak Envelope Power |
| PLC | Power Line Carrier |
| PSTN | Public Switched Telephone Network |
| QA | Quality Assurance |
| Rx | Receive |
| SH | Symmetrical Hybrid |
| SSB | Single side band |
| TE | Terminal Equipment |
| TMS | Transmission Measurement Set |
| Tx | Transmit |

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| Abbreviation | Description |
|--------------|----------------------|
| UHF | Ultra High Frequency |

2.5 Roles and responsibilities

Not applicable.

2.6 Process for monitoring

Not applicable.

2.7 Related/supporting documents

This document supersedes TSP41-65.

3. General Requirements

3.1 Environmental conditions

The equipment shall operate as specified under the following ambient conditions:

- a) Indoors: Ambient conditions: IEC 60721-3-3, Class3K5 where high air temperatures and low air temperatures are amended as specified in IEC60495.
- b) Altitude: 0m to 2000m
- c) Temperature: Maximum : +55°C
Minimum : 0°C
- d) Humidity: 95 % below : +35°C
75 % above : +35°C
- e) Barometric pressure: 70kP to 106kP
- f) Lightning: Extremely severe

3.2 Power line carrier equipment

3.2.1 Carrier frequency circuits

3.2.1.1 Channel requirements

- a) Each power line carrier link shall provide a full duplex communication channel between two terminals of a high voltage transmission line. The PLCs shall accommodate with legacy requirements meeting the International Standard IEC 60495. Each carrier terminal shall include a transmitter and receiver operating on the single-sideband principle with suppressed carrier, suitable for contiguous channel operation.
- b) All the main functions of the equipment shall be implemented in the Digital Signal Processing technology (voice/data services, teleprotection parameters, bandwidth selection, channel characteristics, etc).
- c) Full duplex operation of a standard single channel PLC shall be possible in a minimum 4 kHz bandwidth (two kHz for each direction of transmission), within the carrier frequency range 40 kHz to 500 kHz. The duplex channel frequency allocations will be made in accordance with the frequency allocation chart included in Annexure E of this specification. Eskom prefers contiguous transmit (Tx) and receive (Rx) channel frequency bands and not a superimposed Tx and Rx channel frequency bands.

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- d) Eskom prefers a system which can achieve the following basic configurations on a single common platform:
- 1) Teleprotection only, 2 kHz bandwidth (per direction of transmission). Minimum of three totally independent Teleprotection channels.
 - 2) 4 kHz bandwidth (per direction of transmission) with the following functions: Teleprotection (Minimum of four totally independent Teleprotection channels), capable of transmitting data at up to 64 kBit/s (depend on S/N ratio).
 - 3) 4 kHz bandwidth (per direction of transmission) Alternate multipurpose with the following functions: Teleprotection (Minimum of four totally independent Teleprotection channels), Speech limited to 2 kHz and data above speech.
 - 4) 8 kHz and higher bandwidth (per direction of transmission), Alternate multipurpose with the following functions: Teleprotection (Minimum of four totally independent Teleprotection channels), flexible data and speech multiplexers.

3.2.1.2 Transmitter power requirements

- a) The power rating shall be defined as the peak-envelope-power (PEP) available at the co-axial HF input/output of the carrier, without exceeding the maximum permitted level of spurious emissions as detailed in section 2.5 and figure 7 of IEC 60495.
- b) The equipment shall have a range of units with a nominal carrier frequency output power, as defined in 2.4.1 of IEC 60495, of a maximum of 50 dBm (100W) which can be configurable for lower power outputs (e.g. 47 dBm (50W)).

3.2.1.3 Transmitter protection

The transmitter shall be capable of operating continuously without suffering damage into an open circuit or short circuit, either by means of its basic design or by means of protective devices that reduce the transmitter output power under these conditions. The protective system shall be self-resetting when the transmitter open circuit or short circuit is removed. Protective systems that switch off the transmitter instantaneously under mismatch conditions are not acceptable.

3.2.1.4 Transmitter loadings

- a) The combination of signals applied to the transmitter shall not exceed the nominal power of the transmitter.
- b) The digital PLCs shall allow configuration of transmitter loadings (automatically calculated) for the different PLC requirements as listed in section 3.2.1.1.
- c) If the power amplifier is overdriving for a period of more than 60s, an alarm shall be raised.

3.2.2 Combination of transmitters and receivers

- a) The transmitter output filters shall be designed to permit the operation of several transmitters on the same high frequency cable, without the use of hybrids, with a minimum spacing of 8kHz between transmitter and adjacent transmitter band edges. The 8 kHz minimum separation requirement relates to a standard PLC using a 4 kHz bandwidth for each direction of operation.
- b) The supplier must specify the minimum separation requirement for the 2 kHz PLC. Attenuation of the transmitted signal shall not exceed either 0.5dB for 1 transmitter or 1dB for 3 or more transmitters, due to the loading effect of adjacent transmitters, when the 8 kHz spacing is applied.

- c) Each carrier set shall include a high frequency hybrid to connect the transmitter and its associated receiver to line. The hybrid shall be of unsymmetrical design, so as to introduce no more than 1dB of attenuation in the direction transmitter to line. The hybrid circuit shall incorporate variable resistive and reactive components in the balancing network. It shall be designed to cope with a varying line impedance resistive component between 35Ω and 150Ω and a reactive component which could vary between 75Ω capacitive to 75Ω inductive. With this arrangement, trans-hybrid attenuation of up to 56dB shall be possible. It is preferred for the RF hybrid to be adjustable from the front (faceplate).
- d) The two-wire HF input circuit to the hybrid shall be protected. Eskom prefers the protection of the hybrid with a 350V, 1μs, gas discharge tube. If the supplier uses an alternative method, the supplier to provide the details of this method of protecting the hybrid and PLC.
- e) The carrier HF input/output shall have nominal impedance of 75Ω unbalanced.
- f) The return loss in the transmit and receive bands shall be ≥ 10dB.

3.2.3 PLC Frequency requirements

- a) The virtual carrier frequency (HF) shall not differ from its nominal value by more than ± 20Hz on systems using suppressed carrier.
- b) In a pair of PLC terminals, the frequency difference between a voice frequency signal applied to the transmit end and that at the receive end shall not exceed 1Hz after 1 year of operation.
- c) Carrier Frequency Duplex Channel Allocations:
 - 1) Carrier Frequency channel allocations will be made in accordance with the chart given in Annexure E of the specification. If a 2kHz, 8 kHz, 16kHz bandwidth PLC are used, then the channel allocations will be adjusted accordingly.
 - 2) For ordering purposes Eskom always assumes that the carrier transmits a residual carrier at the lower band edge of the channel, and the information is transmitted by the upper sideband. The frequency of the residual carrier is used in the order document. This convention is used irrespective of the actual residual carrier or sideband arrangement e.g. The carrier operating in the following 4 kHz bands:-

Table 1: Example of PLC frequency labelling convention

| 2kHz PLC | 4kHz PLC | 8kHz PLC | 16kHz PLC |
|--|-------------------|-------------------|-------------------|
| Tx 104 to 106 kHz | Tx 104 to 108 kHz | Tx 104 to 112 kHz | Tx 104 to 120 kHz |
| Rx 106 to 108kHz | Rx 108 to 112kHz | Rx 112 to 120kHz | Rx 120 to 136kHz |
| Will have its frequencies specified as follows:- | | | |
| Tx 104 kHz | Tx 104 kHz | Tx 104 kHz | Tx 104 kHz |
| Rx 106 kHz | Rx 108 kHz | Rx 112 kHz | Rx 120 kHz |

3.2.4 Automatic gain control and receiver sensitivity

- a) A HF level variation of + 10/-30dB about the nominal receive level, within the regulation range, shall not change the voice frequency receive levels of speech or signals by more than ± 1 dB.
- b) The maximum receiver sensitivity for speech signals, with the automatic gain control (AGC) at the end of its regulation range, shall not be less than the minimum signal of -20dBm measured at the HF input to the carrier.
- c) An alarm shall be provided to indicate when the carrier signal is outside the AGC control range.

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- d) In addition to the alarm required in 3.2.4.c), a signal level squelch circuit shall be provided to block the speech and signalling outputs of the carrier when the AGC is outside its control range. The teleprotection signal output shall not be affected by this squelch circuit.

3.2.5 Receiver noise squelch circuit

- a) Where squelch circuits operate on loss of signal only, due to the increase in gain afforded by the AGC circuit, there is a definite risk, on noisy circuits, that the increased noise output will prevent the AGC squelch circuit and associated alarm from operating. The receiver shall, therefore, include a pure noise detector for the initiation of the noise squelch circuit. The sensitivity of the noise detector shall be adjustable over the range -10 to -30 dBmO (50Bd).
- b) Besides the initiation of an alarm, a squelch circuit shall inhibit all received signals from entering the voice frequency circuits. This is required to prevent the increased noise level from causing maloperation of the squelch circuits in the teleprotection receivers and to avoid noise injection on telesignalling channels arranged in tandem connection, when one of the carrier channels of the tandem link fails.
- c) The squelch circuit for the teleprotection circuits shall incorporate the pick-up and drop-off time delays specified in 3.2.5d).
- d) The S/N squelch circuit shall cut off all audio circuits, including the teleprotection channels. To prevent the squelch circuit blocking the teleprotection under line fault conditions, the circuit shall have a delay of 5s on pick-up and a delay of 2s delay on reset.
- e) Alarm and squelch circuits shall be self-resetting. Lock-out systems are not acceptable.

3.2.6 Hybrid Balancing and Equaliser network

- a) The carrier receiver of the PLCs that comprise of speech and data (4,8,16 kHz PLCs) shall include a channel equaliser to equalise the non-linear amplitude variations of the transmission line. The equaliser network shall be capable of accommodating a maximum of ± 10 dB amplitude distortion variation across the 4kHz basic carrier frequency bands (speech, telesignalling and pilot tone), allowing for either a positive or negative amplitude slope at the band edges or in the centre of the band, or a combination of both. It will be an advantage if the equaliser can equalise the phase variations of the line and can accommodate up to 3ms group delay.
- b) The equaliser is required to regulate all the received signals including pilot/signalling tone and telesignalling channels.
- c) The equaliser network shall not be used to equalise the basic internal amplitude distortion of the terminal equipment.
- d) The equaliser network shall be supplied complete with all components required to provide all equaliser characteristics needed to fulfil the requirements of a).
- e) The tuning of the hybrid whilst the PLC is energized and connected to either an artificial line or the actual line shall be allowed.

3.2.7 Voice requirements

- a) The voice circuits shall comply to the latest version of at least one of the standards below:
- 1) **SANS 201729:2005 / ETSI ES 201729:** Public Switched Telephone Network (PSTN); 2-wire analogue voice band switched interfaces; Timed break recall (register recall); Specific requirements for terminals
 - 2) **SANS 336/ ETSI TBR 21:** Terminal Equipment (TE); Attachment requirements for pan-European approval for connection to the analogue Public Switched Telephone Networks (PSTNs) of TE (excluding TE supporting the voice telephony service) in which network addressing, if provided, is by means of Dual Tone Multi Frequency (DTMF) signalling

-
- 3) **TIA/EIA/IS-968**: Telecommunications telephone terminal equipment technical requirements for connection of terminal equipment to the telephone network
 - 4) **ITU-T Q.552**: Transmission characteristics at 2-wire analogue interfaces of digital exchanges
 - 5) **ETSI ES 201 970**: Access and Terminals (AT); Public Switched Telephone Network (PSTN); Harmonized specification of physical and electrical characteristics at a 2-wire analogue presented Network Termination Point (NTP)
- b) The voice circuit/module shall have a FXS interface.
 - c) The voice circuit/module shall have a FXO interface.
 - d) The mechanical design of the interface unit shall be such that it forms part of the standard equipment permanently housed in the carrier bay.
 - e) To limit spares holding, it is preferred that the required interfaces in point 3.2.7b) and 3.27c) above are accommodated on a single universal interface that is software programmable.

3.2.8 Point-to-point communication (service telephone)

- a) In addition to the speech channel equipment specified, each carrier set shall include facilities for establishing point-to-point communication between the two ends of the transmission lines where the FXS port could be used.
- b) Point-to-point, service engineer calling shall either be initiated by using a handset and an internally mounted push button/buzzer configuration or standard telephone sets using the internal telephone set "buzzer".
- c) The service engineer's plug-in facility shall be so arranged that customer calls have priority.

3.2.9 Interconnection and Repeater Operations

- a) Interconnection of PLC terminals:

All carriers shall preferably be fitted with (integrated software programmable, digital) filters in the transmit and receive legs of both the speech and super audio paths to support VF transit applications. These filters are required, when transit communication necessitates blocking of the signalling, speech, pilot tone and/or protection guard tones when the carriers are connected in a back-to-back configuration between two terminals at the same point.

- b) Carrier repeater operation

In certain circumstances, Eskom may wish to operate the carriers on a wideband back-to-back configuration. With this arrangement, it shall be possible to connect the carrier audio output on a wideband basis through to the wideband audio input of the following carrier link, so that all signals, including speech, telesignalling, protection, telephone signalling and pilot tones are retransmitted by the following carrier terminal. The above arrangement is particularly desirable at carrier repeater stations to allow the transit connection of teleprotection signals on an audio basis.

- 1) Amplitude response of back-to-back terminals with an audio bandwidth of 300Hz to 3800Hz. (refer to Annexure B, Amplitude Distortion template).
- 2) Group delay response of back-to-back terminals with an audio bandwidth of 300Hz to 3800Hz. (refer to Annexure B, Group Delay Distortion template).

3.2.10 Noise and interference

The noise and interference levels between carrier link transmitter and receiver shall be measured using the line attenuations detailed below, when transmitting at the relative transmit levels specified in 3.2.1.4 with the nominal speech and telesignalling receive levels. All PLC circuits shall operate reliably for S/N down to 25dB for conventional operation and S/N of 30dB for full digital operation.

| SSB rating | Total attenuation |
|------------|-------------------|
| 10W | 17 dB |
| 20W | 20 dB |
| 40W | 23 dB |
| 80W | 26 dB |
| 100W | 27 dB |

3.2.10.1 Noise

- a) In the speech band under idle channel conditions, noise shall be not greater than –60dBmOp (Sp).
- b) In the tele signalling (super audio) band, noise shall be not greater than – 52dBmO (50Bd), measured in the complete tele signalling band.

3.2.10.2 Interference

- a) The pilot, telephone signalling or guard tone interference shall not exceed the following limits when measured at the following points:
 - 1) Tele signalling output: -52dBmO (50Bd) when measured within the tele signalling bandwidth.
 - 2) Speech output: -60dBmOp (Sp) measured in the speech bandwidth.
- b) All the above noise and interference levels shall be measured with the compandors out of circuit (if the PLC uses compandors).

3.2.11 Voltage withstand, electromagnetic compatibility and insulation resistance requirements

The inputs and outputs of the carrier equipment, including the cabinet cabling and any required telephone interfacing equipment, shall comply with the levels specified in Table 2 of this specification.

Table 2: Insulation and Electromagnetic Compatibility Requirements for Power Line Carrier and Related Teleprotection Equipment

| Modules | Dielectric Withstand Tests – IEC 60255-5 | Impulse Voltage Tests – IEC 60255-5 | Insulation Resistance – IEC 60255-5 | Damped oscillatory wave immunity test - IEC 61000-4-18 | Electrical fast transient/ bursts - IEC 61000-4-4 | Impulse Voltage Test, 1.2/50us 0.5 J - IEC 61000-4-5 |
|---|--|-------------------------------------|-------------------------------------|--|---|--|
| Power Supply | | | | | | |
| A.C. mains supply | 1 kV | 5 kV | > 20 MΩ | CM: 2.5kV; DM: 1kV | 2kV | CM: 5kV; DM: 5kV |
| Power Supply <60VDC | 1 kV | 5 kV | > 20 MΩ | CM: 2.5kV; DM: 1kV | 2kV | CM: 5kV; DM: 5kV |
| <u>Carrier Frequency Input/ Output</u> | 1 kV | 1 kV | > 20 MΩ | CM: 2.5kV; DM: 1kV | 2 kV | CM: 5kV; DM: 5kV |
| Telecommunication interfaces | | | | | | |
| Speech & Voice Interfaces | 1 kV | 1 kV | > 20 MΩ | CM: 1kV | 1 kV | CM: 1kV; DM: 1kV |
| X.21 | 1 kV | 1 kV | > 20 MΩ | CM: 1kV | 1 kV | CM: 1kV; DM: 1kV |

| Modules | Dielectric Withstand Tests – IEC 60255-5 | Impulse Voltage Tests – IEC 60255-5 | Insulation Resistance – IEC 60255-5 | Damped oscillatory wave immunity test - IEC 61000-4-18 | Electrical fast transient/ bursts - IEC 61000-4-4 | Impulse Voltage Test, 1.2/50us 0.5 J - IEC 61000-4-5 |
|---|--|-------------------------------------|-------------------------------------|--|---|--|
| G703.1 | 1 kV | 1 kV | > 20 MΩ | CM: 1kV | 1 kV | CM: 1kV; DM: 1kV |
| Ethernet | 1 kV | 1 kV | > 20 MΩ | CM: 1kV | 1 kV | CM: 1kV; DM: 1kV |
| Protection equipment interfaces | | | | | | |
| System A contacts (input/output) | 2.5 kV | 5 kV | > 20 MΩ | CM: 2.5kV; DM: 1kV | 2kV | CM: 2.5kV; DM: 2.5kV |
| System C contacts (input/output) | 2.5 kV | 5 kV | > 20 MΩ | CM: 1kV; DM: 0.5kV | 2kV | CM: 1kV; DM: 1kV |
| Alarm contacts | 2.5 kV | 5 kV | > 20 MΩ | CM: 1kV; DM: 0.5kV | 2kV | CM: 1kV; DM: 1kV |
| Other interfaces | | | | | | |
| RS 232 Serial | 500 V | 1 kV | > 20 MΩ | CM: 1kV | 1 kV | CM: 1kV; DM: 1kV |
| IRIG-B input | 500 V | 1 kV | > 20 MΩ | CM: 1kV | 1 kV | CM: 1kV; DM: 1kV |
| GPS Sync Input | 500 V | 1 kV | > 20 MΩ | CM: 1kV | 1 kV | CM: 1kV; DM: 1kV |
| <p>CM (Common Mode): The relative terminals of each input/output (not connected to earth) are to be connected together. Each one is to be tested to earth, as well as each one to every other.</p> <p>DM (Differential Mode): Test is to be performed between relative terminals of the same circuit.</p> | | | | | | |

- a) The PLC enclosure shall have passed the Power Frequency Magnetic Field test of SANS/IEC 61000-4-8 with compliance to Class 5: 100 A/m continuous, 1000A/m for 1 to 3 s, 50 Hz.
- b) The PLC enclosure shall have passed the Electrostatic Discharge test of SANS/IEC 61000-4-2 with compliance to level 3: 6 kV contact discharge and 8 kV air discharge. This shall include the measuring points on the front panel of the PLC.
- c) The PLC shall have passed the Radiated Electromagnetic Field Requirements test of SANS/IEC 61000-4-3 to compliance Level 3: 10 V/m.
- d) The PLC power supply shall have passed the Conducted Emission test of IEC 60255-25: 0.15– 0.5 MHz 79 dB (uV) quasi peak, 66 dB (uV) average and 0.5 – 30 MHz 73 dB (uV) quasi peak, 60 dB (uV) average.
- e) The equipment shall neither suffer damage nor maloperate (e.g. output change from “guard” to “trip”) when any of the tests called for in Table 2 and sections 3.2.11 and 3.4.4 of this specification are performed. After completion of the tests, the equipment shall again be checked for correct operation.
- f) The IEC/SANS standards shall be specified for the tests in Table 2 and section 3.2.11 a), b), c) and d), however if the PLC complies with other equivalent standards from the IEC, SANS, ITU-T and CISPRE standards, the details of these standards and tests shall be provided by the supplier to Eskom for evaluation.

3.2.12 Management, alarms and test facilities

- a) A service interface shall be provided to connect a management console (PC/laptop) to the equipment for status information retrieval, configuration, and to integrate the equipment into a management system. Password protection and terminal addressability shall be provided.

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- b) Functions required
- 1) Logging of local and remote alarm information.
 - 2) Logging of local and remote operational status information.
 - 3) Programming of local and remote operational parameters.
 - 4) Chronological register of alarms and events.
 - 5) Communication with the remote PLC shall preferably be established through an integrated service channel.
 - 6) All the main functions of the equipment (e.g. voice/data services, teleprotection parameters bandwidth selection, channel characteristics, etc) shall be programmable from the service interface/ HMI via a management console (PC/laptop).
- c) HMI interface standards/ requirements.
- 1) The preferred HMI communications port for local engineering access is the Ethernet (RJ45). The multimode fibre optic port for the IEC 61850 application should also allow for remote access for the HMI. The other acceptable interface is the EIA-232.
 - 2) All software shall be compatible with the Microsoft Windows XP, Windows 7 or later versions of the Microsoft® operating systems with the preferred 64-bit configuration.
 - 3) Adaptors required to connect the equipment to PC ports e.g. USB to RS-232 , and proven to be compatible with the equipment, shall be specified and shall be included as an option on a price schedule.
 - 4) If web interfaces are used, these interfaces must not be required to change the web interface parameters (e.g. IP addresses, etc) on the PC's web software as this might create problems on the user's Eskom (Operating System) account.
 - 5) All HMI and enabling software shall be provided as part of the equipment supplied and updates shall be provided free of charge for the lifespan (OEM recommendation) of the equipment. The supplier to inform Eskom of all firmware upgrades on the PLC equipment and the HMI. The firmware and HMI revisions must be backward compatible.
 - 6) The event and alarm logs shall be easily exportable in a Microsoft Excel™, PDF or similar format.
 - 7) The Management Console must feature a software based measuring facility which can access and display important test data internal to the PLC equipment. The capability of presenting it in graphical form, on the time and frequency scale will be an advantage. The console must also provide for tuning and testing of the PLC with generation of all signals required to tune and test the RF filters and AF options, providing a "help function" with explanations for all actions that may be performed.
 - 8) All test points shall be suitable for measurements with test equipment of 75Ω or 600Ω impedance (either Terminated or High Impedance). Adaptors or test cords shall be supplied to adapt measurement points to test equipment terminals of 600Ω balanced (4mm bunch plug) or 75Ω unbalanced (BNC).
 - 9) The PLC and related equipment shall use light emitting diodes for indications.
- d) Cyber Security
- 1) IEDs shall support the implementation of 240-55410927, Eskom's cyber security standard.
 - 2) IEDs shall support role-based access in at least three levels:
 - i. Read-only access
 - ii. Read access, writing of selected application-specific settings
 - iii. Full read and write access

- 3) Levels (2) and (3) shall be password protected.
 - 4) Passwords shall be settable via the HMI.
 - 5) It shall be possible to set passwords with a minimum of 16 characters.
 - 6) Passwords shall support the use of alpha, numeric and "special" characters.
 - 7) IEDs (PLCs) shall support the ability to detect and report changes in settings, configuration and firmware. The IED will typically be interrogated by a third party configuration management tool which will report changes to a watchdog device.
- e) Alarms
- 1) Each carrier set shall include an alarm circuit in the carrier transmitter output amplifier and an alarm circuit associated with the receiver AGC squelch circuit, to monitor the transmitted and received signals. These two independent transmitter and receiver alarms are required to identify the fault location at either of the two terminals on a carrier link.
 - 2) The alarm circuit in the transmitter shall be set to operate on a 6dB reduction in pilot level at the transmitter output.
 - 3) The alarm circuit in the receiver shall be set to operate either, when the S/N ratio exceeds the levels specified in 3.2.5 or when the pilot signal is outside the AGC range as specified in 3.2.4c).
 - 4) Each module shall include an LED on the module face plate clearly indicating the type of failure.
 - 5) The transmitter and receiver alarms shall each provide a potential free change-over contact for external use.
 - 6) All alarm relays shall be operated in the healthy state, so that they release on loss of power. A power indication LED shall show the state of the power supply.
 - 7) All alarm circuits shall be self-resetting.
 - 8) Cabinet wiring or module layout shall facilitate terminated measurement of all voice frequency inputs/outputs and signalling wires, as well as high impedance measurement without circuit interruption.
 - 9) For an IEC 61850 compliant PLC device, the alarm messages would be sent to the bay processor/RTU via the multimode fibre optic port for the IEC 61850 application (detailed in section 3.2.12f).

f) IEC 61850 Standard Implementation

The IEC 61850 standards combine the ethernet based communication standards with the functionality of the substation IEDs (e.g. protection, teleprotection, telecontrol, etc). These standards facilitate communication between the teleprotection unit and RTU and between the teleprotection unit and protection scheme using multimode fibre optic cables connected to an ethernet compatible LAN switch.

The LAN switch facilitates communication, using the IEC 61850 standards, between the teleprotection device and the protection relays. Virtual trip signals between these devices simulate the trip inputs and trip outputs on the conventional teleprotection scheme. The LAN switch would also facilitate communication, using the IEC 61850 standards, between the teleprotection device and the RTU/bay processor thereby replacing the contacts (and IDF) on the current setup.

If the IEC 61850 standard is implemented on PLC equipment, then the IEC 61850 implementation shall comply with the following:

- 1) All the IEC 61850 standards, latest edition.
- 2) The teleprotection transceiver shall support an IEC 61850-based interface to the protection IEDs. Teleprotection signalling between the transceiver and protective IED shall be achieved via GOOSE messaging.

- 3) For an IEC 61850 compliant teleprotection unit, the IP address allocation shall follow a minimum of IPv4 and shall be configurable.
- 4) Eskom standard, 240-68235024: "Eskom IEC 61850 Station Bus Interoperability Test Standard."
- 5) Eskom standard, 240-68107841: "Eskom IEC61850 Standard Requirements for PICS, PIXIT and TICS."
- 6) The IEC 61850 implementation must follow the Logical Nodes description as detailed in the Eskom standard 240-42066934, "IEC 61850 Protocol Implementation Document for the purposes of Substation Automation":
- 7) In addition, the following logical node ITPC (Teleprotection Communication Interfaces) of IEC 61850-7-4 (latest edition) shall be included in the implementation (Table 3).

Table 3: ITPC class Logical Node

| ITPC class | | | | |
|---------------------------|----------------|--|-------|--------------------------------------|
| Attribute Name | Attribute Type | Explanation | M/X/I | Remarks |
| Data objects | | | | |
| Status Information | | | | |
| Beh | ENS | Behaviour | M | |
| EEHealth | ENS | External equipment health | I | |
| Settings | | | | |
| NumTxCmd | ING | Number of used binary transmit commands | I | |
| NumTxCmd | ING | Number of used binary transmit commands | I | |
| TpcTxMod1 | ENG | Teleprotection application mode in transmit direction for each command (Unused, Blocking, Permissive, Direct) | I | TpcTxMod 1 to TpcTxMod 8 are allowed |
| TpcRxMod1 | ENG | Teleprotection application mode in receive direction for each command (Unused, Blocking, Permissive, Direct) | I | TpcRxMod 1 to TpcRxMod 8 are allowed |

- 8) The fibre optic standard used in a protection bay with multiple IEC 61850 devices (protection and teleprotection IEDs) will use multimode 50/125µm fibre cables. The transceiver shall include a 100BaseFX fibre optic Ethernet port with Lucient Connector (LC) (preferred) connectors for IEC 61850 communication.
- 9) The port in section 3.2.12f) viii) shall support multi-session communication for simultaneous IEC 61850 communication and remote engineering access, each implemented on separate VLANs.
- 10) Where the port in section 3.2.12f) ix) cannot be achieved, a second rear multimode 50/125 µm fibre optic port shall be provided in accordance with a port as described in section 3.2.12f) viii) for remote engineering access via a VLAN.
- 11) IEC61850-based communication shall not be affected by simultaneous remote engineering access to the device.

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- 12) If there are any other items or detail that is required for either the normal operation or an improvement of the IEC 61850 implementation, then the supplier can provide the proposal but is subject to Eskom's approval.

3.2.13 Power supplies

- a) The equipment shall be capable of operating from the following power source:
- 1) 48 V DC (42 V DC to 57.6 V DC)
- If the equipment can operate from a 110 V DC and/or 220 V DC power source, the equipment must be capable of operating from the following power sources:
- 2) 110 V DC. (91 V DC to 124.8 V DC)
 - 3) 220 V DC (182 V DC to 249.6 V DC)
- Specifications for Eskom's standard chargers, which would be used for DC supply mentioned, permit a ripple of 2% peak-to-peak of the rated nominal voltage.
- b) The equipment shall operate to specification with the voltage variations stated in 3.2.13a).
- c) A continuously burning LED, shall be provided to indicate the healthy condition of each power supply unit.
- d) The front-end power supply unit or subsequent circuitry shall include the following protective devices or functions:
- 1) A miniature circuit breaker or electronic isolating device at the input.
 - 2) Inrush current limiter
 - 3) Power overload and no load protection
 - 4) Overcurrent and short circuit protection
 - 5) Overtemperature protection
 - 6) Protection against reversal of polarity
 - 7) Overvoltage protection on the outputs
- e) If the equipment is supplied from a DC source connected as specified in 4.1.2 (m) of this specification, the noise measured across the power supply terminals of the equipment under test shall not be greater than 2mV measured psophometrically or 10mV peak-to-peak.
- f) The equipment shall be suitable for operation from a positive earthed supply.
- g) The equipment shall not malfunction if the supplies to the unit are switched off and on repeatedly at a random rate. The teleprotection equipment shall also sustain (without producing an unwanted command or other malfunction) short interruptions on the power supply voltage not longer than 100ms occurring in random sequence for a period not longer than 20 seconds. Figure D1 of Annexure D shows the circuit to be used to perform the short term interruptions.
- h) The PLC equipment shall not malfunction or suffer damage in the event of a slowly decaying input supply voltage such as in the event of battery charger failure, even if the supply voltage should fall to below the minimum specified voltage input range of the equipment.
- i) The power supply shall have a switch to turn the supply 'on' or 'off'.

3.2.14 Digital converter/multiplexer unit

- a) In order to meet the requirement of higher transmission capacities within the 4, 8 or 16 kHz bandwidth as specified in 3.2.1.1, in some applications, Eskom shall require a PLC system that can support, as an option, operation with a high speed modem/ integrated multiplexer.

- b) The concept shall support a seamless migration from the digitised single side-band PLC into a full digital PLC through the implementation of a converter/multiplexer unit.
- c) In cases where a full digital PLC with increased channel capacity is not specified from the beginning, the migration to full digital must be possible any time on site, without affecting the frequency allocation or existing coupling arrangement.
- d) The modem should be robust and capable of reliable digital transmission of rates of up to 64kbit/s on a 4 kHz bandwidth, upgradable to increasing bandwidth depending on channel characteristics, (S/N, distortion etc). Speed must be adjustable in steps to ensure optimal adaptation to the prevailing transmission conditions.
- e) The transmission bandwidth shall be programmable to provide optimum utilisation of the PLC channel.
- f) The equipment shall preferably provide automatic transmission speed adaptation (fallback / fallforward) in programmable steps., according to the actual prevailing channel conditions. Automatic speed adaptation must be able to be enabled or disabled by choice.
- g) It shall be possible to accommodate within the aggregate a combination of speech and data signals of varying speeds.
- h) The data rate of the multiplexer channels shall be individually programmable.
- i) V11/RS232 (synchronous and asynchronous), V24/X21, RS422A and LAN (RJ45) interfaces, electrically isolated, from ground and against each other, shall be available.
- j) The Ethernet (LAN) communication channel shall be specified for a minimum 10 Mbps with auto negotiation. The interface shall be RJ45 which shall be electrically isolated. An option for an optical interface could be provided and should cater for both the 850 nm multimode 50/125 µm fibre optic cores as well as the 1310nm single mode fibre optic cores. The preferred fibre connector type for the 850 nm multimode fibre optic core is LC.
- k) The data rate shall be programmable for 9600bit/s and 19200bit/s for asynchronous data circuits and voice circuits.
- l) 2/4 wire operation with DTMF signalling shall be possible, as well as remote subscriber operation.
- m) Protection Signalling shall not be affected or influenced by this converter/ multiplexer. Protection signalling must be possible with the same level of security and dependability as with normal PLC transmission.
- n) The system configuration shall be flexible and allow various modes of operation with the Digital PLC. The digital PLC configuration could utilise the full 4kHz, 8kHz or 16kHz bandwidth for the digital (data) transmission.

3.3 Carrier combiner units (CCU) and Symmetrical hybrids (SH)

3.3.1 General

The carrier combiner units (CCU) consists of symmetrical HF hybrids that are mounted within carrier cabinets. The main purpose of the CC and SH is to couple the power line carrier to the power line phase conductors using various methods of system coupling. In addition, the hybrids could also be used to couple carriers with adjacent frequency bands if frequency congestion becomes a problem.

3.3.2 Carrier Combiner Units (CCU)

On all lines operating at voltages above 132 kV, coupling to the high voltage line is done using a phase to phase or three phase coupling arrangement. Individual co-axial cables are provided from the carrier equipment to each line phase coupling equipment. In order to couple the carrier equipment to the multiple phases used, a carrier combiner unit is used.

- a) The carrier combiners shall be fitted inside the carrier cabinet, in a position so as not to interfere with the PLC equipment and cabinet terminal blocks in the cabinets.

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- b) Two types of carrier combining units are required as follows:-
 - 1) CCU-1: Combiner Unit for phase-to-phase coupling (Figure F6 in Annex F)
 - 2) CCU-3: Combiner Unit for three-phase coupling (Figure F7 in Annex F)
- c) The symmetrical hybrids and dummy load resistors shall comply with section 3.3.3 of this specification.
- d) Figure F8 in Annex F attached to this schedule details a proposed mechanical arrangement. The actual mechanical details shall be arranged to suit the supplier's equipment and cabinet design which shall be to Eskom's approval.
- e) The carrier combiner shall be supplied complete by the supplier, with all the components shown on Figure F5 of this Annexure F and shall include the engravings, co-axial plugs and sockets, hybrids, dummy load resistors and surge arrestors.
- f) The co-axial plugs shall be of the PL159 crimp type suitable for RG11A/U cable, e.g. "Suhner" type 11 UHF-0-7-19c/022, or similar.

3.3.3 Symmetrical Hybrid Equipment Design

- a) The primary and secondary windings shall have impedance taps of 75Ω. The primary windings shall be balanced and free from earth.
- b) Each SH shall be supplied with a 37.5Ω, non-inductive dummy load resistor to enable the symmetrical hybrid to function in either of the following modes:
 - 1) Power splitting unit
Where the resistor prevents a short-circuit on the one secondary winding from short circuiting the complete hybrid.
 - 2) Isolating hybrid.
Where the resistor provides maximum isolation between the two secondary windings when the primary winding is terminated in its nominal impedance.
- c) To comply with mode (i) in point b) above, the resistor shall have a minimum rating of 50W r.m.s. to handle the power dissipation when one line matching equipment earthing switch is closed. To meet the requirements of mode (ii) in point b) above, the load resistor shall be essentially resistive over the carrier frequency band.
- d) The SH shall have a maximum insertion loss of 0,5dB between primary and secondary windings, and a minimum return loss between secondary windings (trans-hybrid loss) of 30dB, when the primary winding is terminated in its nominal impedance, at any frequency in the carrier frequency range of 40kHz to 500kHz.
- e) The SH shall have a 1min power frequency withstand insulation of 2kV between primary and secondary windings and a 5kV, 1.2/50μs, 0.5J impulse withstand insulation between primary and secondary windings and earth.
- f) The polarity of the secondary terminals relative to the primary terminals shall be clearly marked on the equipment or equipment drawings, so that the correct connections for phase-to-phase coupling can be easily determined.
- g) The symmetrical hybrid shall have a minimum PEP rating of 400W with intermodulation products at least 80dB down on the PEP level.
- h) The symmetrical hybrid shall have a minimum Continuous Wave rating of 100W.

3.4 Teleprotection equipment

3.4.1 General

- a) A teleprotection system, that is capable of being integrated into the carrier equipment detailed in section 3.2, shall be available.
- b) The teleprotection system shall be able to provide no less than three totally independent bi-directional channels capable of simultaneous operation in any combination.
- c) The teleprotection equipment shall be suitable for operating in the permissive, blocking or direct transfer trip modes of protection.

3.4.2 Equipment design

- a) Teleprotection equipment shall use the carrier pilot signal for the guard signal under quiescent conditions. When a command signal is transmitted, the signalling shall take place within the speech band.
- b) The teleprotection transmitter boost or exalt circuit shall be linked to the command circuit lead so that when a command signal is transmitted the command signal is boosted and all speech and data signals on the PLC shall be blocked, during the operation of the associated protection equipment, so that the full SSB power is available for transmitting the teleprotection signals.
- c) The teleprotection system shall be capable of operating with a maximum sudden attenuation of 20dB caused by a line fault. This gross dynamic range can be achieved by a combination of the teleprotection receiver dynamic range and the increase in transmitter level obtained by boosting the transmitted command signal. The equipment shall be designed so that the teleprotection signal is received within the standard clear channel transmission time, with a maximum sudden fault attenuation of 20dB.
- d) The equipment shall be designed so that a single component failure cannot produce a false command output. In the event of an active component failure, the command output shall be blocked and an alarm given.
- e) The failure of any components in the command output circuit shall not give rise to a false command output.
- f) All relays associated with protection intertrip functions shall be according to 240-57649048.
- g) Command hold or command memory circuits in either the teleprotection transmitter or receiver are not required.
- h) The command output from the teleprotection receiver shall be blocked after 1s and an alarm given if the command signal is present for longer than 1s.
- i) All teleprotection equipment shall be suitable for operation in any of the protection modes specified in 3.4.1.c) of this section. The required mode of operation shall be selected by suitable programming options of the teleprotection equipment.
- j) All teleprotection equipment shall be equipped for independent bi-directional operation. Blocking of the teleprotection receiver by the teleprotection transmitter is NOT required.
- k) The teleprotection receiver shall give a command signal output, provided that the command signal is received within 100ms of the guard signal disappearing. If a command signal is not received within 100ms the command output shall be blocked and an alarm given. The circuit shall reset automatically on receipt of a continuous guard signal. A continuous guard signal is an undisturbed signal for at least 50ms.
- l) The received signal shall be monitored continuously by the receiver and an alarm signal given if neither a guard nor a command signal is present.
- m) The teleprotection transmitter output shall be monitored continuously and an alarm given if the transmitter output fails.

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- n) Teleprotection transmitters using separate guard and command signal oscillators, with the guard oscillator normally connected to the transmitter output, shall have the command oscillator continuously monitored. In the event of the command oscillator failing, an alarm indication shall be given in addition the output of the Teleprotection transmitter shall be blocked so that a receiver alarm is initiated at the distant terminal receiver.

3.4.3 Interface with Eskom's protection relay equipment

3.4.3.1 All command outputs shall be potential free and galvanically isolated from ground and all other circuits. Protection of command inputs and outputs against overvoltage and inverse polarity shall be provided.

3.4.3.2 The command interface module shall preferably be software configurable for solid state output of receive commands and alarms.

3.4.3.3 All protection systems detailed in this section shall initiate a command signal at the teleprotection transmitter when the external contact in the protection relay panel closes. The teleprotection receiver in turn shall close its command contacts when a command signal is received.

3.4.3.4 Two systems of interfacing with Eskom's protection system shall be provided. The selection of the appropriate interface system shall be achieved by means of straps either preferably within the teleprotection equipment, or on a suitable externally mounted interface. The protection interface systems 'A' and 'C' are described in section 3.4.3.5 and 3.4.3.6.

3.4.3.5 Protection Interface 110VDC/ 220VDC (System A)

- a) Eskom will provide separate contacts, operating from either a 110V DC or 220V DC source integral to the protection equipment, to initiate the command signal to the teleprotection transmitter. The teleprotection command circuit shall comply to the Eskom specification 240-57649048, section 3.2.17.2(b), that is

- | | |
|------------------------------------|-----------------|
| 1) Make and carry for 200 ms: | 5 A @ 250 V DC |
| 2) Carry for 1 s: | 2 A @ 250 V DC |
| 3) Carry continuously: | 30 W @ 60 V DC |
| 4) Break (inductive L/R = 40 ms): | 10 W @ 125 V DC |
| 5) Durability: operations unloaded | ≥ 10 000 cycles |
| 6) Durability: operations breaking | ≥ 1 000 cycles |

The maximum burden shall preferably be the minimum required to comply with (f) and g).

- b) The input keying voltage to the teleprotection unit shall be as follows:

| Nominal voltage | Relay rated voltage |
|-----------------|----------------------|
| 110 V DC | 88 V DC to 132 V DC |
| 220 V DC | 176 V DC to 264 V DC |

- c) The minimum pick up voltage for the teleprotection unit inputs shall be as follows:

| Nominal Voltage | Input Keying Voltage |
|-----------------|----------------------|
| 110 V DC | 66 V DC |
| 220 V DC | 132 V DC |

- d) The relays shall be capable of operating over the range "relay rated voltage" to 75% of this value.

- e) The teleprotection equipment shall incorporate programming facilities to accommodate either a 110V DC or 220V DC source.

- f) These relays shall not operate when a 2 μ F capacitor, charged to 1,5 times the relay rated voltage, is discharged through the command input circuit. The protection circuit used to achieve this shall not result in an inrush current exceeding the ratings of the protection relay contacts given in 3.4.3.5 (a) above.
- g) The teleprotection receiver command contacts for connection to Eskom's protection equipment shall be rated to make, carry and break a 100VA inductive load at 250V DC or 125V DC. Capacitance spark quench circuits across the command output contacts are not acceptable.
- h) The current flowing in the initiating loop when a trip command is transmitted shall be no less than 10mA.
- i) The Teleprotection Command Interface Module shall be able to withstand reversed polarity protection commands without damage.
- j) The Teleprotection Command Interface Module shall be able to withstand ≥ 100 repetitive input commands of 200ms duration at 1 second intervals at the rated voltage without damage.

3.4.3.6 Protection Interface 50 VDC (System C)

- a) Eskom will provide separate contacts, operating from a 50V DC source integral to the protection equipment, to initiate the command signal to the teleprotection transmitter.
- b) The contacts shall normally operate from a galvanically isolated 50V DC supply. For some applications the interrogating supply may, however, be grounded.
- c) The teleprotection command circuit shall not impose a load greater than 10VA, with a maximum voltage of 60V and maximum current of 0,5A, on the protection relay initiating contacts when making, carrying and breaking the command circuit.
- d) The teleprotection receiver shall have potential free command output contacts. This contact shall be interrogated by the power supply described in (b).
- e) The command output contacts of the teleprotection receiver shall comply to the Eskom specification 240-57649048, section 3.2.17.2(b), that is
 - 1) Make and carry for 200 ms: 5 A @ 250 V DC
 - 2) Carry for 1 s: 2 A @ 250 V DC
 - 3) Carry continuously: 30 W @ 60 V DC
 - 4) Break (inductive L/R = 40 ms): 10 W @ 125 V DC
 - 5) Durability: operations unloaded $\geq 10\ 000$ cycles
 - 6) Durability: operations breaking $\geq 1\ 000$ cycles

Capacitance spark quench circuits across the command output contacts are not acceptable.

- f) The input keying voltage to the teleprotection unit shall be as follows:

| | |
|-----------------|----------------------|
| Nominal Voltage | Input Keying Voltage |
| 48V DC | 38.4V DC to 57.6V DC |
- g) The minimum pick up voltage for the teleprotection unit inputs shall be 28.8V DC.
- h) The relays specified in (d), shall not operate when a 0,2 μ F capacitor, charged to 1,5 times the relay rated voltage is discharged through the command input circuit regardless of polarity.
- i) The current flowing in the initiating loop when a trip command is transmitted shall be no less than 10mA.
- j) The Teleprotection Command Interface Module shall be able to withstand reversed polarity protection commands without damage.
- k) The Teleprotection Command Interface Module shall be able to withstand ≥ 100 repetitive input commands of 200ms duration at 1 second intervals at the rated voltage without damage.

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- l) The basic requirements of Systems A and C described above, are shown schematically in Annexure C, of this specification.

3.4.3.7 Number of Teleprotection channels

- a) Systems shall be designed and equipped for, at least, three channel operation, The facilities detailed in 3.4.3.5, shall be duplicated for each teleprotection channel.
- b) In addition each channel's interface with Eskom's protection relay equipment shall be galvanically separate and independent of the others. Common leads with common potentials are not acceptable. The channels shall be totally independent, bi-directional and capable of simultaneous operation in any combination.

3.4.3.8 Channel alarm contacts

Systems shall be designed and equipped for, at least, one alarm per teleprotection channel. The contacts shall be totally independent from each other.

3.4.4 End-to-end and local test facilities

- a) Manual end-to-end test facilities are not required. The system shall be continuously monitored and an alarm given in the event of an active component failure.
- b) The following test facilities, built into the teleprotection, are desirable and will be considered in the evaluation of the teleprotection equipment
 - 1) Automatic, non-intrusive, in service loop testing.
 - 2) Trip counters.
 - 3) Time stamped event recording with resolution of 1ms or better. It should be possible to connect the event recorder to an external time signal (e.g. GPS receiver) for accurate time stamping.
- c) Test plugs, relays or switches that can be used to interrupt the connection to the protection relay panel are not acceptable.
- d) Local test facilities, that can be used to initiate a command over the teleprotection channel, shall be interlocked with a key switch or special programming requirement. Alternatively, test systems that test the guard and command channel independently and that cannot generate a genuine command signal, are acceptable.
- e) In-built echo or reflex test systems that can echo a genuine command signal are not required.

3.4.5 Management and Alarms

- a) If the Teleprotection system cannot be accessed through the PLC HMI interface, the service interface shall be provided to connect a management console to the equipment for status information retrieval, configuration, chronological register of alarms and events, and to integrate the equipment into a management system. The interface shall comply with the requirements detailed for the PLC HMI interface in section 3.2.12 Management, Alarms and test facilities.
- b) Each teleprotection unit shall include alarm circuits associated with the transmitter and the receiver, to monitor the state of the teleprotection equipment to identify fault location at either of the two terminals on a teleprotection link.
- c) Each module shall include relevant LEDs on the module face-plate to indicate the type of failure.
- d) The transmitter and receiver alarms, if not integrated into the alarm system of the PLC, shall each provide a potential free change-over contact for external use by Eskom.
- e) All alarm relays shall operate in the healthy state and shall release on loss of power. A power indication LED shall indicate the state of the power supply.
- f) All alarm circuits shall be self-resetting.

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3.4.6 Power supplies

- a) The power supplies for the integrated teleprotection equipment shall conform to the same power supply requirements as supplied to the PLC equipment as stated in 3.2.13.
- b) A continuously burning LED, shall be provided to indicate the healthy condition of each power supply unit. Miniature circuit-breakers or electronic isolating techniques are preferred for circuit protection incorporated in power supply units instead of fuses.
- c) Teleprotection systems shall not mal-operate if the DC supplies to the unit are switched off and on repeatedly at a random rate. The teleprotection equipment shall also be tolerant of short interruptions on the power supply voltage, not longer than 100ms, occurring in random sequence for a period not longer than 20s without any malfunctioning such as an unwanted command. Teleprotection systems shall not maloperate or suffer damage in the event of a slowly decaying input supply voltage such as in the event of battery charger failure, even if the supply voltage should fall to below the minimum specified voltage input range of the equipment.
- d) Teleprotection units may be powered from their own integrated supplies or may be arranged to receive a fixed voltage supply from the associated carrier set.

3.4.7 Teleprotection reliability

Table 4: Teleprotection reliability

| 1 | 2 | 3 | 4 | 5 |
|------------------|------------------------|------------------|-----------------|-------------------------|
| System | Probability of failure | Attenuation (dB) | | White noise level (dBm) |
| | | Line (static) | Fault (dynamic) | |
| Dependability | | | | |
| Permissive | 0,01 | 26 | 20 | -26 |
| Direct intertrip | 0,01 | 26 | | -20 |
| Blocking | 0,001 | 26 | | -10 |
| Security | | | | |
| Permissive | 0,001 | 26 | | +10 |
| Direct intertrip | 0,001 | 26 | | +16 |
| Blocking | 0,01 | 26 | 20 | -26 |

3.4.7.1 Dependability

- a) Permissive intertrip protection systems

The teleprotection system shall have a probability of failure of 0.01, i.e. the probability of not receiving a command signal when operating over a line with a 26dB line attenuation plus 20dB fault attenuation (total 46dB attenuation), with a white noise level (measured in a 100Hz bandwidth) of up to -26dBm at the HF input to the power line carrier.

- b) Direct intertrip protection systems

The teleprotection system shall have a probability of failure of 0.01 when operating over a line with a 26dB line attenuation with a white noise level (measured in a 100Hz bandwidth) of up to -20dBm at the HF input to the power line carrier.

- c) Blocking protection systems

The teleprotection system shall have a probability of failure of 0,001, i.e. the probability of not receiving a command signal, when operating over a line with a 26dB line attenuation with a white noise level (measured in a 100Hz bandwidth) of up to -10dBm at the HF input to the power line carrier.

The correct operation of the teleprotection system for dependability is defined as a command signal that arrives within 1.3 times the basic clear channel speed with the noise levels given in 3.4.7.1 (a).

3.4.7.2 Security

a) Permissive intertrip protection systems

The equipment shall have a probability of failure of 0,001, i.e. the probability of a false command being received, when operating over a line with a 26dB attenuation with an impulse white noise level (measured in a 100Hz bandwidth) of up to +10dBm at the HF input to the power line carrier.

b) Direct intertrip protection systems

The equipment shall have a probability of failure of 0,001 when operating over a line with a 26dB attenuation, with an impulse white noise level (measured in a 100Hz bandwidth) of up to +16dBm at the HF input to the power line carrier.

c) Blocking protection system

The equipment shall have a probability of failure of 0,01, i.e. the probability of receiving a false command signal, when operating over a line with a 26dB line attenuation plus 20dB fault attenuation, with an impulse white noise level (measured in a 100Hz bandwidth) of up to -26dBm at the HF input to the power line carrier.

Note: Impulse white noise is defined as noise bursts of 200ms duration with intervals dependent on the squelching time constant of the equipment being tested, i.e. sufficient time must elapse between noise bursts to ensure adequate unblocking of the teleprotection receiver.

3.4.7.3 Signal transfer time

The transmission speed of the teleprotection system, from the moment the protection relay command contact closes to the time the teleprotection receiver command contact closes, including the associated power line carrier equipment but excluding the line propagation time, shall be as follows: The teleprotection signal shall be received in not more than 1.3 times the standard clear channel transmission time, with a maximum sudden fault attenuation of 20dB.

a) Permissive tripping and blocking systems: 16ms maximum; and

b) Direct trip protection systems: 40ms maximum.

The above signal transfer time shall be met with the System A and System C interface systems specified in 3.4.3.5.

3.4.7.4 Teleprotection operation shall not be affected by any auxiliary equipment operating over the PLC.

3.4.8 Voltage withstand, electromagnetic compatibility and insulation resistance requirements

3.4.8.1 The requirements are listed in section 3.2.11 and table 2 of this specification.

3.5 Housing of equipment, cabling, labelling and test equipment

3.5.1 Housing of equipment and cabling facilities

a) The equipment shall be fitted in 600mm wide, steel, swing frame or front & rear entry, floor mounted, cabinets. The number of standard arrangements will be specified in, section 3.5.2.

b) The cabinet must comply to the Eskom standard, 240-60725641, and the preferred overall cabinet dimensions are the Type B - 2.2 meter 19" rack-mounted equipment cabinet (43U).

c) Cabinet surface preparation and finish as well as the colour shall be in accordance with Eskom standard, 240-60725641 and which must be read in conjunction with the Eskom standard 240-75655504 related to corrosion.

- d) Cable entry shall be possible from the top and bottom through gland plates that shall be fitted in the base and top of the cabinet. The gland plates shall consist of mild steel plates which are pre-drilled and closed up with plastic filler plugs. These gland plates must comply to the Eskom standard, 240-60725641. Lacing bars shall be provided at the rear of the cabinet for the external cabling. Components, modules, sub-racks, cable terminals and associated wiring shall be arranged so that they are easily accessible. The gland plate at the bottom of the cabinet shall be fitted with a removable inspection plate.
- e) The cabinets shall be of the swing frame, or front and rear entry type with the equipment and terminals easily accessible. The terminal arrangements are detailed in Annexure F, figure F2 and F3. The cabinet shall be fitted with (a) lockable door(s) with a standard key for all cabinets. All doors fitted to cabinets shall be equipped with lift-off hinges to facilitate easy removal of doors when they are open. All parts and panels of cabinets shall be effectively electrically bonded and connected to the cabinet earth bar as detailed in the Eskom standard, 240-60725641. All doors shall be equipped with braided copper earthstraps to effectively connect the doors to the cabinet earth bar or gland plates. These earth straps shall be readily removable to facilitate door removal.
- f) Each carrier cabinet shall provide accommodation for a telephone set/hand-set and cord, used for point-to-point communication and for a set of test cords used for maintenance work. A pocket shall be fixed to the cabinet to hold a set of test certificates.
- g) The carrier or teleprotection terminal equipment shall be fitted with information pockets for identifying carrier sets and teleprotection units. The pockets or slots shall be capable of accommodating cardboard inserts detailing such information as SSB number, designation for protected line, telephone and telesignalling circuits, etc. In addition, a pocket or slot shall accommodate the equipment serial number, station name and the name of the station where the distant terminal is located as well as the operating frequency for each direction of transmission and sideband arrangement. This information shall be inserted at the factory, based on the details given in the equipment order. These requirements are specified in , section 3.5.3.
- h) Each carrier cabinet shall be fitted with a flush mounting 15A plug socket, to SABS specification, mounted externally on the base plinth of the cabinet according to the Eskom standard, 240-60725641. The socket shall be wired to cabinet terminals, as per Figure F2 of Annexure F.
- i) Equipment terminals for telephone and protection cable terminations shall be suitable for conductors with an overall diameter of up to 1.78 mm. Stud type terminals and terminals of the type where clamping screws are in direct contact with the wire are not acceptable, nor are porcelain terminal blocks or strips. Krõne insulation displacement wiring blocks are acceptable. Equipment terminals for power supply cables shall be suitable for accommodating at least two 7/1,63mm (16mm²) conductors. Stud type terminals and terminals of the type where clamping screws are in direct contact with the wire are not acceptable.
- j) The above cabinet shall be fitted with all cabinet wiring, terminal blocks, power wiring and HF co-ax connectors required for the equipment ordered.
- k) The final cabinet design shall be subject to Eskom's approval. The Eskom document, 240-75975613, Standard for the installation of Power Telecommunications Equipment may be referred to in respect of applicable details deemed desirable by Eskom.
- l) The cabinet doors and roof shall be provided with adequate louvres or apertures, protected by rodent-proof mesh, to ensure sufficient natural cooling through convection when fully equipped with two 100W PLCs.
- m) The gland plates fitted to the top and bottom of the carrier cabinets shall be pre-punched and the holes filled with plastic filler caps. The required gland hole arrangement is shown in Annex F, Figure F1.
- n) The gland plate at the bottom of the cabinet shall be fitted with a removable inspection plate in the vicinity of the external earth stud.

| | |
|------------------|--|
| Data Channel:- | If required. (Information completed by Manufacturer from order documents). |
| Speech Channel:- | If required. (Information completed by Manufacturer from order documents). |

c) Carrier Frequency Duplex Channel Allocations

- 1) Carrier Frequency channel allocations will be made in accordance with the chart given in Annexure E of the specification. If a 2kHz, 8 kHz, 16kHz bandwidth PLC are used, then the channel allocations will be adjusted accordingly.
- 2) For ordering purposes Eskom always assumes that the carrier transmits a residual carrier at the lower band edge of the channel, and the information is transmitted by the upper sideband. The frequency of the residual carrier is used in the order document. This convention is used irrespective of the actual residual carrier or sideband arrangement e.g. The carrier operating in the following 4 kHz bands:-

| 2kHz PLC | 4kHz PLC | 8kHz PLC | 16kHz PLC |
|--|-------------------|-------------------|-------------------|
| Tx 104 to 106 kHz | Tx 104 to 108 kHz | Tx 104 to 112 kHz | Tx 104 to 120 kHz |
| Rx 106 to 108kHz | Rx 108 to 112kHz | Rx 112 to 120kHz | Rx 120 to 136kHz |
| Will have its frequencies specified as follows:- | | | |
| Tx 104 kHz | Tx 104 kHz | Tx 104 kHz | Tx 104 kHz |
| Rx 106 kHz | Rx 108 kHz | Rx 112 kHz | Rx 120 kHz |

d) The Protection channel labelling shall be completed by Eskom.

3.5.4 Cabinet wiring

- a) The cabinets, terminal and cabinet wiring shall be arranged similar to Annex F Figure F2, F3, F4 and/or F5 as applicable for either swing frame or front and rear entry cabinets. All wiring, terminals, etc. shall be to Eskom’s approval and details must be furnished at the time of tendering.
- b) Each cabinet shall be wired and fitted with all terminal blocks to fully equip each equipment version to accommodate actual equipment arrangement ordered.
- c) The terminal blocks for the SSB speech functions and the cabinet alarms shall be either telephone tag blocks, “Klippon” type terminals, “Kröne” type insulation displacement or similar which shall be suitable for solid conductors with a cross sectional area from 0,3 sq mm to 2,5 sq mm.
- d) The terminal blocks for the protection cabling functions shall be non-disconnectible “Klippon” type terminals, or similar and shall be suitable for standard or solid conductors with a cross section area from 0,3sq mm to 2,5sq mm.
- e) The terminal blocks for power cabling shall be “Klippon” type, or similar, suitable for conductors with a cross sectional area from 4 to 16 sq mm.
- f) The power cable and protection cable terminal blocks shall be fitted with protective covers.
- g) The twin co-ax connectors, one set provided for each SSB in the cabinet, shall be UHF type SO239T, each socket fitted with a UHF plug. The co-axial plugs shall be of the PL 295 crimp type suitable for RG11A/U cable, e.g. “Suhner” type UHF-0-7-19c/022 or similar.
- h) On original equipment orders, the cabinet shall be supplied with all the appropriate cables connected to the equipment sub-racks.

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- i) A compression terminal or lug capable of accommodating at least two 16 sq mm conductors shall be located at the bottom and top of the cabinet, for the equipment earth.
 - j) A cabinet wiring diagram, similar to the drawing given in Annex F Figure F2 or F3 shall be fixed to the inside of the cabinet door. In addition, a drawing of the layout of the equipment modules, their function, test point numbers and module serial or drawing numbers shall be fixed to the inside of the door.
 - k) All terminals and wiring, etc, used, shall be to Eskom's approval.
 - l) Cabinet cabling harnesses shall be available as separate purchase items to be installed and connected in position by Eskom for any additional equipment that may be installed at a later date to achieve all alternate configurations.
 - m) Care shall be taken with the cabinet wiring to ensure that the weighted disturbance power generated by any speech transmitter or telemetering transmitter circuits and appearing on any receiver, shall be less than -60dBmOp (Sp) in the case of speech circuits and -52dBmO (50Bd) in the case of telemetering circuits.
 - n) The power and teleprotection control cables and wiring shall be kept separate from all signalling and speech circuit cables.
 - o) The cabinet wiring shall also comply to the Eskom document, 240-75975613, "Standard for the installation of Power Telecommunications Equipment".

3.5.5 Equipment design and testing facilities

- a) Individual units, modules, printed boards, etc. shall be of the plug-in variety to facilitate maintenance.
- b) The carrier transmitter output amplifier shall include a surge protection circuit and shall be designed to accommodate an open circuit or short circuit across the output terminals without the risk of damage to components. The HF input/output circuit shall incorporate surge protection.
- c) Supervisory LEDs shall indicate the healthy state of important circuits, and potential-free alarm contacts shall be available for connection to Eskom's alarm circuits to indicate equipment failure.
- d) The management console, as specified in 3.2.12 shall facilitate measurement of all pertinent test and monitoring points. Test points mounted on the front panels or face plates of the various modules shall facilitate measurement with a Transmission Measurement Set (TMS) with a maximum input impedance of $5\text{k}\Omega$ or alternatively, 600Ω , or 75Ω . All test points shall either be given in dBm or dBu ($0\text{dBv} = 0,775\text{V}$). Test point information shall still be available on the module face-plate after the sub-rack cover plate has been removed.
- e) The HF input/output of the carrier shall be 75Ω unbalanced. Test points for measuring the line levels shall be wired to plug-in sockets mounted on the front panels or face-plates. In addition, it shall be possible to terminate the HF output with a 75Ω non-inductive load resistor, equal in rating to the nominal PEP of the carrier set using links or plugs. The load resistor shall form a permanent part of the carrier set. The HF output cabling of each carrier shall be terminated on a UHF co-axial socket in the rear of the cubicle, as specified in Annexure F, Figure F5. All test points shall be suitable for measurements with test equipment of 75Ω or 600Ω impedance (either Terminated or High Impedance). Adaptors or test cords shall be supplied to adapt measurement points to test equipment terminals.
- f) Facilities for signal level adjustment, with a setting accuracy of 0.25dB, shall be available. If software programming is not employed, attenuator pads incorporating strapping pins are preferred. If potentiometers are used, they shall be of the professional quality multi-turn helical type. Potentiometers with a maximum rotation of 270° are not acceptable for signal level adjustments.
- g) The individual components shall be adequately de-rated in terms of current, voltage, power and temperature, taking into account the supply voltage and temperature tolerances specified, so as to ensure long life and reliable operation.

3.6 Drawings and instruction manuals

3.6.1 Drawings

- a) Drawings shall be registered and approved in terms of TST41-634 and submitted in English.
- b) The following drawings shall be submitted, in duplicate, for ALL the equipment included in the contract:
 - 1) Block schematic diagrams showing the functional arrangement of the equipment;
 - 2) Detailed schematic diagram showing the interconnection between the teleprotection equipment and Eskom's protection relays;
 - 3) Functional drawing showing the overall operation of the equipment, including test levels and impedance levels at all measuring points;
 - 4) Cabinet equipment layout based on the arrangement specified in Figures F1, F2, F3, F4, F5, F6, F7 and F8 Annexure F of an enquiry document.
 - 5) Details of terminals and terminal blocks.
 - 6) Outline dimensions of cabinets and fixing details.
 - 7) Module, sub-rack and cabinet wiring diagram including functions and designations of the terminal blocks and carrier combining unit.
- c) Detailed drawings of all equipment shall be supplied not later than the notification of the first item of equipment readiness for acceptance testing. The drawings shall be incorporated in the instruction manuals, and shall not be submitted separately.
- d) When changes to the equipment are envisaged, either by the manufacturer or Eskom, during the contract period, the manufacturer shall submit details of these changes, in writing, together with the modified drawings for Eskom's approval, before proceeding with the implementation of these changes. An electronic copy shall be supplied for each new drawing approved.

3.6.2 Instruction manuals

- a) The number of copies of the instruction books and descriptive information specified in an enquiry, in English, shall be supplied, covering all equipment in the contract, before the first items of equipment are despatched from the works.
- b) The instruction book shall only cover the equipment variant supplied to Eskom. Typical circuit diagrams and descriptions are not acceptable in the instruction books. The diagrams shall correspond in exact detail with the equipment delivered.
- c) The instruction books shall have a hard-covered ring file construction and they shall open flat at any page. Folders that do not comply with these requirements are not acceptable. Different sections of the handbooks shall be separated by means of thumb-tab separators.
- d) The equipment handbooks shall be supplied separately to cover the following equipment:
 - 1) Power line carrier equipment.
 - 2) Teleprotection equipment.
 - 3) Optional multiplexer/modem.
- e) Where power line carrier equipment of different configuration, which differ only in power rating but retain common baseband and audio equipment, are supplied a single handbook shall be provided that covers all power ratings and power supply arrangements specified.
- f) The equipment handbooks shall basically consist of the following sections:
 - 1) Index;
 - 2) Electrical and mechanical specifications and parameters of the equipment;

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- 3) Basic description of the equipment and its operation;
 - 4) Basic mechanical design of the equipment and the cabinet and inter sub-rack wiring. Description, block schematic and wiring schematic of the complete equipment;
 - 5) Sub-rack mechanical design and wiring; description and wiring schematics subdivided as follows:
 - i. Carrier frequency and audio sections;
 - ii. Power amplifiers;
 - iii. Power supplies.
 - 6) Individual modules — description, parts layout, electrical schematic and parts list;
 - 7) Level diagrams (if applicable); and
 - 8) Installation, commissioning and maintenance procedures including a description of the software provided for the Management console.
- g) The instruction book shall contain a master key or block schematic that shall clearly indicate the reference number of the individual detailed circuit diagrams against the appropriate blocks.
- h) Block schematics of the complete equipment shall indicate clearly the interconnections between the various units. Wiring schematics with cable harnesses are not acceptable for this purpose.
- i) The level diagram shall indicate the signal levels and impedance levels at the various measuring points. The input and output levels shown shall conform with the levels given in the specification. Typical levels, and tables or lists which can be used to calculate the appropriate levels, are not acceptable.
- j) The individual module description shall contain a written description of the operation of the module, the module testing procedure, if applicable, and the technical ratings of the unit. This shall be followed by the module schematic, the component layout and a component list giving the component values, rating, tolerance and manufacturer.
- k) The module schematic shall specify the nominal DC and AC voltages on the semi-conductor devices. The function of the various input and output points shall be given on the schematic drawing.
- l) All handbook drawings and descriptions shall be A4 size. Larger drawings that cannot be accommodated on A4 drawings shall be folded in a single panel, along the 295mm axis of the A4 size. Handbook drawings that must be unfolded in two directions are not acceptable.
- m) The handbooks, complete with drawings, shall also be provided on a CD (or flash drive), using either the PDF or Microsoft Office format, in addition to the hard copies requested.
- n) In the event of any changes being made to the equipment, as detailed in this specification, the required number of sets of drawings and descriptions, if applicable, shall be provided in order to update the equipment handbooks.
- o) All correspondence relating to equipment supplied shall be headed with the contract number allocated by Eskom. All enquiries shall be addressed to the Commercial person responsible for the contract.

3.6.3 Tools, test equipment and spares

3.6.3.1 Tools

- a) A kit of test tools containing the following shall be available and included in the pricing schedule of an enquiry document.
- 1) One extender card (outrigger) of each type used (if required);
 - 2) One card extractor (if required);
 - 3) One set of test cords (see below);

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- 4) One set of spare fuses.
- 5) One "Dummy load" if not integral to the equipment.
- b) Eskom's test equipment uses standard 4 mm bunch pin ("banana") plugs (balanced), or BNC connectors (unbalanced) for connection to the equipment under test. Test leads with appropriate connectors shall be supplied with each equipment cabinet.

3.6.3.2 Spares

- a) The supplier is to supply a comprehensive list of spares which shall, at minimum include one of each of the cards used, as well as empty sub-racks, plugs and sockets, and consumable items if any. The supplier may also include on the lists of spares any other recommended spares necessary for the proper maintenance of the equipment. The spares items shall be priced individually and the lists shall include a description of the item, a reference number and the pricing details. All spares shall be delivered in approved cases suitable for storing such parts over a period of years without damage or deterioration.
- b) Spares for the units must be available from the successful tenderer for a period of at least 10 years subsequent to the expiry of the Contract.

3.6.4 Quality assurance and system reliability

3.6.4.1 Quality assurance

Eskom's Quality assurance requirements as specified in QM-58 are applicable.

3.6.4.2 Equipment reliability

If any unit, sub-unit or module exhibits a failure rate of 0.1 (i.e. 10%) or higher during the defects period, as defined in the contract, the contractor shall remove all such units, sub-units or modules from the system whether failed or not, and replace them with units, sub-units or modules satisfactory to ESKOM. This shall be done without costs to ESKOM. The period of the warranty for portions of the works affected by such replacement shall then be accordingly extended.

4. Tests

4.1 Power line carrier equipment

4.1.1 Routine Tests

All equipment supplied in compliance with this specification shall be subject to the routine tests listed below:

- a) Soak Test (Burn in of equipment)

All equipment shall be subjected to a 72 hour soak test prior to the commencement of any routine tests. During the soak test the equipment shall be operated at the maximum temperature of the range stated in this specification. During this test, the supply voltage shall be maintained at the upper tolerance limit. The following routine tests will follow the 72 hour soak test.

- b) Frequency setting

The transmitter and receiver oscillators shall be set to their correct operating frequencies.

- c) Power Supply and Power Amplifiers

The equipment shall be operated at its nominal power supply input voltage. All power supply output voltages shall be checked to ensure that they are within the manufacturer's tolerances. The power amplifier bias (if applicable) shall be adjusted to meet the manufacturer's specified tolerances.

- d) Transmitter Line-up

The supplier to check and provide the transmitter output levels for the requirements of the digital PLCs.

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e) Transmitter Alarm

The operate point of the transmitter alarm shall be checked to ensure that it conforms with the requirements of 3.2.12e) ii) of this specification. The alarm contact closure and Tx alarm LED operation shall be verified.

f) Receiver Line-up

The associated terminal shall be connected to the transmitting terminal, via a resistive artificial line, with an attenuation as specified in 3.2.10 of this specification.

g) AGC Setting

The receiver gain shall be set-up in accordance with the manufacturer's level diagram, so that the AGC is operating at the centre of its characteristics. The operation of the receiver alarm contacts and alarm LED shall be checked by increasing the line attenuation until the AGC is outside its specified control range.

h) Receiver Squelch

The operation of the receiver squelch alarm LEDs and alarm contacts shall be checked to confirm that they comply with 3.2.5 and 3.2.12 of this specification.

i) Telephone Signalling Receiver

The bias of the telephone signalling receiver shall be adjusted to zero and the impulse distortion at 10ips and 18ips shall be checked. The operation of the alarm contacts and alarm LED shall be checked.

j) Noise

The noise output of the speech and telesignalling outputs shall be checked to ensure compliance with 3.2.10.1 of this specification.

k) End-to-End Frequency Accuracy

The channel end-to-end frequency accuracy shall be checked. The difference shall be less than 0,1 Hz at the time of setting.

4.1.2 Type Tests

a) Type tests shall be carried out on one PLC link of each type rating.

b) If evidence is available of type tests on identical equipment, this may be accepted in lieu of these tests. If type test data in accordance with the specification is not available, indication shall be given of the date on which such tests will be made.

c) Every carrier to which it is intended to apply type tests, shall first be routine tested. It is not required that all type tests be carried out on the same carrier link, provided that samples of identical design and processing during manufacture are used.

d) Transmitter Intermodulation Products

The transmission intermodulation products shall be measured at 50kHz as well as at 500kHz. The results shall comply with 3.2.1.2 of this specification.

e) Adjacent Channel Loading

The loading of an adjacent carrier channel spaced 8kHz between band edges shall comply with the requirements of 3.2.2 a) and b) of this specification.

f) HF Output Return Loss

The HF input/output return loss over the 8kHz operating band shall comply with the requirements of 3.2.2.e) and f) of this specification.

g) Automatic Gain Control and Receiver Sensitivity

The variation of audio output level with a HF variation ± 15 dB shall be checked to prove compliance with 3.2.4 of this specification.

h) Group Delay

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The group delay of a complete link shall be measured to prove compliance with Annexure B.

i) Interference

The crosstalk and interference levels between the speech, super audio and telephone signalling channels shall be measured over a complete link to prove compliance with 3.2.10.2

j) Interface Unit

The unit shall be tested with Eskom's Telecomms Network equipment for the FXO and FXS operations which includes the signalling, dialling and ringing performance at both ends of the circuit and shall comply to the requirements specified in section 3.2.7 of this specification.

The unit shall be tested for interoperability to either the ABB FOX 612/615 or the Cisco Voice Gateways, VG (VG) 350/450 or ISR4000 series router equipment.

The possible test scenarios are depicted in Figures A1, A2 and A3 in Annex A.

k) Rack Cabling

The rack cabling shall comply with the requirements detailed in section 3.5.4. The interference between circuits and power supplies shall be tested to verify compliance with 3.5.4m) of this specification.

l) Voltage Withstand, Electromagnetic Compatibility and Insulation Resistance Tests.

All input/output circuits shall be tested to prove compliance with the tests specified in table 2 of this specification.

m) Reflected noise

The equipment shall be checked for compliance with clause 3.2.13e) of this specification. Figure D2 of Annex D of this specification, shows the circuit to be used to perform the required measurements.

n) Power Supply interruptions

The equipment shall be checked for conformance with 3.2.13g) of this specification, by initially switching the power supplies off and on repeatedly at a random rate. Compliance with the requirements in respect to short interruptions can be ascertained by using the method indicated in Figure D1 of Annex D of this specification. In order to approach a random sequence of real interruptions, the pseudo-random pattern generator of a data transmission test set can be used to drive the electronic switch.

o) Test for compliance with 3.2.13h) by gradually reducing the input voltage to 50% of nominal rating.

4.2 Carrier Combiner Units with Symmetrical Hybrid (SH)

4.2.1 Routine Tests

a) The polarity of the secondary terminals relative to the primary terminals shall be checked to ascertain that all terminals are correctly marked in conformance with the equipment drawings.

b) The insertion loss between primary and secondary windings shall be measured at a nominal frequency of 100kHz.

c) The return loss between secondary's (trans-hybrid loss) shall be measured at a nominal frequency of 100kHz with the primary winding terminated in its nominal impedance.

4.2.2 Type Tests

a) Insulation Tests

The symmetrical hybrid insulation shall be tested by means of a 2kV one minute power frequency withstand test voltage and a 5kV 1,2/50 μ s 0,5 joule impulse withstand test voltage, between the primary and secondary windings and earth, as well as between the secondary and primary windings and earth.

b) Insertion loss test

The insertion loss between the primary and secondary windings, over the specified carrier frequency band, shall be measured when the windings are terminated in the nominal impedances specified.

c) Trans-hybrid loss test

Trans-hybrid loss between the secondary windings (i.e. from secondary winding to secondary winding), over the specified carrier frequency band, shall be measured when the primary winding is terminated in the specified nominal impedance.

d) Intermodulation tests

The PEP versus Intermodulation distortion shall be measured over the specified carrier frequency band as detailed in 12.3 of IEC 60481.

As alternative the manufacturer's calculations of PEP rating and intermodulation distortion over the specified frequency range will be accepted.

4.3 Integrated Teleprotection Equipment

4.3.1 Routine Tests

All equipment supplied in compliance with this specification shall be subject to the routine tests listed below:

a) Soak Test (burn in of equipment)

All equipment shall be subject to a 72 hour soak test prior to the commencement of any routine tests. During the soak test, the equipment shall be operated at the maximum temperature of the range stated in Schedule A/B. During this test, the supply voltage shall be maintained at the upper tolerance limit. The following routine tests will follow the 72 hour soak test.

b) All equipment shall be subject to the manufacturers standard works tests.

c) The equipment shall be operated at its nominal supply voltage during the balance of the routine tests.

d) The teleprotection transmitter and receiver frequencies shall be checked for compliance with the manufacturer's specification.

e) The transmit, boost and receive levels of the teleprotection transmitter and receiver shall be checked in accordance with the manufacturer's specification.

f) The operation of all alarm indications and functions as well as the alarm contacts up to the cabinet terminals blocks, shall be checked.

g) The signal transfer time shall be checked as follows:

The teleprotection equipment shall be lined up with the actual power line carrier link over which it is intended to work and the levels set according to the manufacturer's specification. The carrier link shall be operated over a dummy resistive transmission line and the total signal transfer time measured for each channel, including the carrier link.

h) The blocking of the command output and the operation of the appropriate alarm shall be checked under the following conditions:

1) When the command output is operated for longer than 1 second.

2) Failure of the guard signal.

4.3.2 Type Tests

Type tests shall be carried out on one teleprotection link of each type or rating.

a) If evidence is available of type tests on identical equipment, it may be accepted in lieu of these tests. If type test data in accordance with the specification is not available, indication shall be given of the date on which tests will take place.

-
- b) Each teleprotection unit, to which it is intended to apply the type tests, shall first be routine tested. It is not required that all type tests be carried out on the same teleprotection unit, providing the samples used are of identical design and processing during manufacture.
- c) All input/output circuits shall be tested in accordance with section 3.2.11 of this specification for voltage withstand, electromagnetic compatibility and insulation resistance. Refer to table 2 of this document.
- d) Power supply voltage variation.
The operation of the equipment shall be checked with the minimum and maximum voltages specified in 3.2.13a) of this document.
- e) The operation of the teleprotection transmitter interface relays shall be checked with the maximum and minimum voltages specified in 3.4.3.5 and 3.4.3.6 of this specification.
- f) Power Supply interruptions and reduced voltage integrity
The equipment shall be checked for conformance with 3.2.13g) of this document, by initially switching the power supplies off and on repeatedly at a random rate. Compliance with the requirements in respect of short interruptions can be performed using the method indicated in Annexure D, fig. D1. In order to approach a random sequence of real interruptions, the pseudo-random pattern generator of a data transmission test set can be used to drive the electronic switch. Test for reduced voltage integrity by gradually reducing voltage to 50% of nominal and monitoring for false trip commands in both Tx and Rx directions (3.2.13h).
- g) For system A interface arrangements, the input burden and inrush current of the teleprotection transmitter input interface circuit shall be measured to prove compliance with 3.4.3.5 of this specification. In addition, a 2 μ F capacitor charged to 1,5 times the relay rated voltage, shall be discharged through the command input circuit, as described in 3.4.3.5, System A (f) of this specification.
- h) For system C interface arrangements, the input burden and inrush current of the teleprotection transmitter input interface circuit shall be measured to prove compliance with 3.4.3.6 of this specification. In addition, a 0,2 μ F capacitor charged to 1,5 times the relay rated voltage, shall be discharged through the command input circuit, as described in 3.4.3.6, System C (h) of this specification.
- i) The security and dependability characteristics of the teleprotection equipment shall be measured, with varying signal and noise levels, to prove compliance with 3.4.7 of this specification.
- j) The teleprotection equipment shall be checked for compliance with clause 3.2.13e) of this section. Annex D Figure D2 from this specification shows the circuit to be used to perform the required measurement.

4.4 Converter/Multiplexer Equipment

4.4.1 Routine Tests

All equipment supplied in compliance with this specification shall be subject to the routine tests listed below:

- a) Soak Test (burn in of equipment)

All equipment shall be subject to a 72 hour soak test prior to the commencement of any routine tests. During the soak test, the equipment shall be operated at the maximum temperature of the range stated in Schedule A/B. During this test, the supply voltage shall be maintained at the upper tolerance limit. The following routine tests will follow the 72 hour soak test.

- b) All equipment shall be subject to the manufacturers standard works tests.
- c) The equipment shall be operated at its nominal supply voltage during the balance of the routine tests.

The operation of all alarm indications and functions as well as the alarm contacts up to the cabinet terminals blocks, shall be checked.

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4.4.2 Type Tests

Type tests shall be carried out on one teleprotection link of each type or rating.

- a) If evidence is available of type tests on identical equipment, it may be accepted in lieu of these tests. If type test data in accordance with the specification is not available, indication shall be given of the date on which tests will take place.
- b) Each unit, to which it is intended to apply the type tests, shall first be routine tested. It is not required that all type tests be carried out on the same unit, providing the samples used are of identical design and processing during manufacture.
- c) All input/output circuits shall be tested in accordance with section 3.2.11 of this specification for voltage withstand, electromagnetic compatibility and insulation resistance. Refer to table 2 of this document.
- d) Power supply voltage variation.

The operation of the equipment shall be checked for compliance with the minimum and maximum voltages specified in 3.2.13g) and 3.2.13h) of this document.

- e) Reflected noise

The equipment shall be checked for compliance with clause 3.2.13f) of this specification. Annex D Figure D2 of this specification, shows the circuit to be used to perform the required measurement.

4.5 Test certificates and witnessing of tests

4.5.1 Test certificates

The following routine test certificates, in English, shall be submitted as soon as possible but not later than the delivery date of the equipment:

- a) one copy of the routine test certificate shall be supplied with each equipment; and
- b) one copy of the routine test certificate shall be retained by the supplier, for reference by Eskom if required.

Each routine test certificate shall detail the Eskom order number and item number and the manufacturer's serial number, the carrier type and operating frequencies.

Three copies of all type test certificates, in English, should be submitted not later than the delivery date from the works of the first item of a particular type or rating.

4.5.2 Witnessing of Tests

- a) Eskom reserves the right to appoint a representative to inspect the equipment at any stage of manufacture, or to be present at any of the specified tests. Such inspection shall not relieve the manufacturer of his responsibility for meeting all the requirements of the specification and it shall not prevent subsequent rejection if such material or equipment is later found to be defective.
- b) The manufacturer shall ascertain, in writing, whether inspection or witnessed tests, or both, are required. The manufacturer shall then give Eskom not less than fourteen days' notice of when the equipment will be ready for inspection or the witnessed tests requested.
- c) Each routine test and type test certificate shall clearly state the type of test being performed and cross refer to the appropriate test clause number listed in the appropriate specification.

5. Delivery, Packaging and Labelling

5.1 Delivery

- a) The equipment shall be delivered to the destinations specified in the Eskom order.
- b) The ex-works delivery dates and delivery dates to Eskom's destinations shall be indicated in the Eskom order.
- c) Eskom specifies that the PLCs be transported in an acceptable manner for sensitive electronic equipment. The tenderer to provide details on the type of road transport the PLCs would utilise in the A/B schedules.

5.2 Packaging

- a) The equipment shall be protectively packed in such a way that it can be safely transported, handled and stored.
- b) All equipment and spares shall be packed in heat sealed plastic, to protect the equipment against the ingress of moisture.
- c) All equipment supplied against a specific order or order item number shall be packed in a single case or carton. The combining of several different sets of equipment in the same case or carton is not acceptable. Different sets of equipment may be packed in a single case provided that the individual sets of equipment are packed in individually marked cartons.
- d) If sub-components are packed separately in individual packing separate from the main rack or sub-rack, each sub-item shall carry the serial number of the associated rack or sub-rack to which the module belongs.
- e) The design of the equipment packaging shall be such that if the case or carton is dropped from a height of 1m onto a flat surface, no damage to the equipment shall occur.
- f) Eskom will only accept equipment for delivery at the destinations specified. Where equipment is off-loaded at intermediate points, the storing and transhipping shall be the responsibility of the equipment supplier.
- g) All equipment packaging shall be to Eskom's approval and details shall be provided by the supplier.

5.3 Labelling

- a) All equipment packaging shall be clearly stencilled with paint, with the Eskom delivery address and Eskom order and item number. If an item consists of more than one package, each package shall be further identified, i.e. Box 1 of 4.
- b) Packages containing spares shall be clearly marked "Spares".
- c) A packing list detailing all items of equipment included in the package shall be affixed to the case or carton under a metal plate or transparent plastic holder clearly marked "Packing List".
- d) All equipment shall be clearly labelled as "Electronic equipment, store indoors".
- e) For Terminal Equipment, the station name and Direction must also be indicated on all boxes.

6. Statement of Compliance or Deviation

The Tenderer must state compliance with, or deviation from, the requirements of this specification, on a section by section and clause by clause basis.

7. Authorization

This document has been seen and accepted by:

| Name and surname | Designation |
|-------------------|---|
| Alison Maseko | Senior Manager – Eskom Telecommunications |
| Barry Clayton | Chief Engineer – Tx Works Planning and Centralized Services |
| Lenah Mothata | Senior Manager – Grids |
| Maureen Mokone | Senior Manager – GIT |
| Prudence Madiba | Senior Manager – GX |
| Sikelela Mkhabela | Senior Manager – DX |

8. Revisions

| Date | Rev | Compiler | Remarks |
|-----------|-----|----------|---|
| Aug 2021 | 2 | T Gosai | Document revised due to expiry date and changes to voice requirements |
| July 2016 | 1 | T Gosai | Document revised due to expiry date. |
| Feb 2011 | 1 | T Gosai | Document TSP41-65 compiled. |

9. Development team

The following people were involved in the development of this document:

- Tejin Gosai
- Riyaz Gangat
- Zakhele Dlamini
- Ashley Van Der Poel
- Zwelandile Mbebe

10. Acknowledgements

Not applicable.

Annex A – Voice (Speech) Configurations

Add appendix detail here or remove if not required.

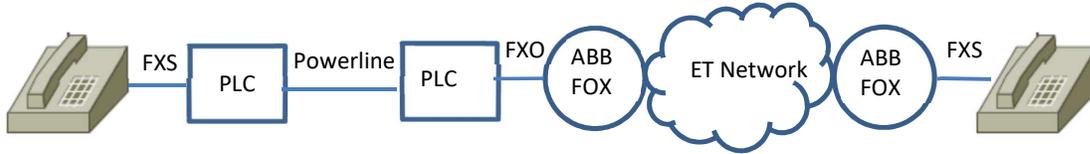


Figure A1: PLC voice circuit via ABB FOX 615/612 units and ET Network

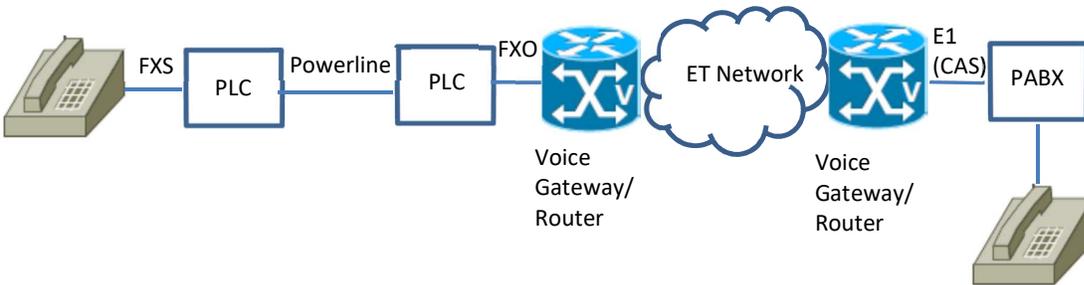


Figure A2: PLC voice circuit via Voice Gateways/ Routers and ET Network

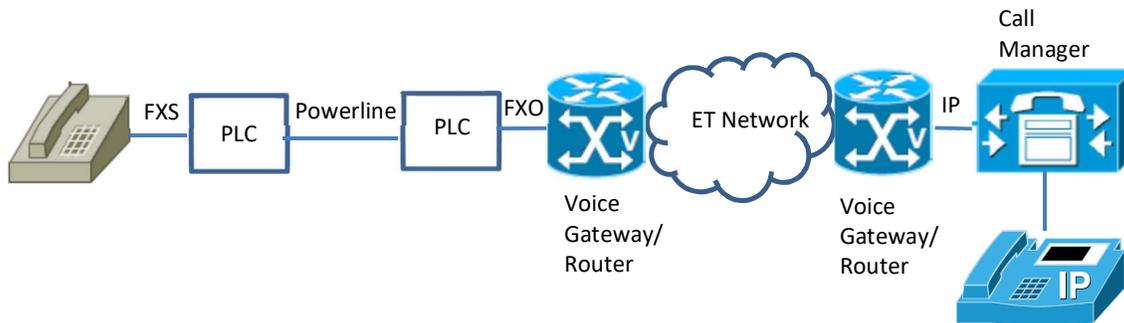
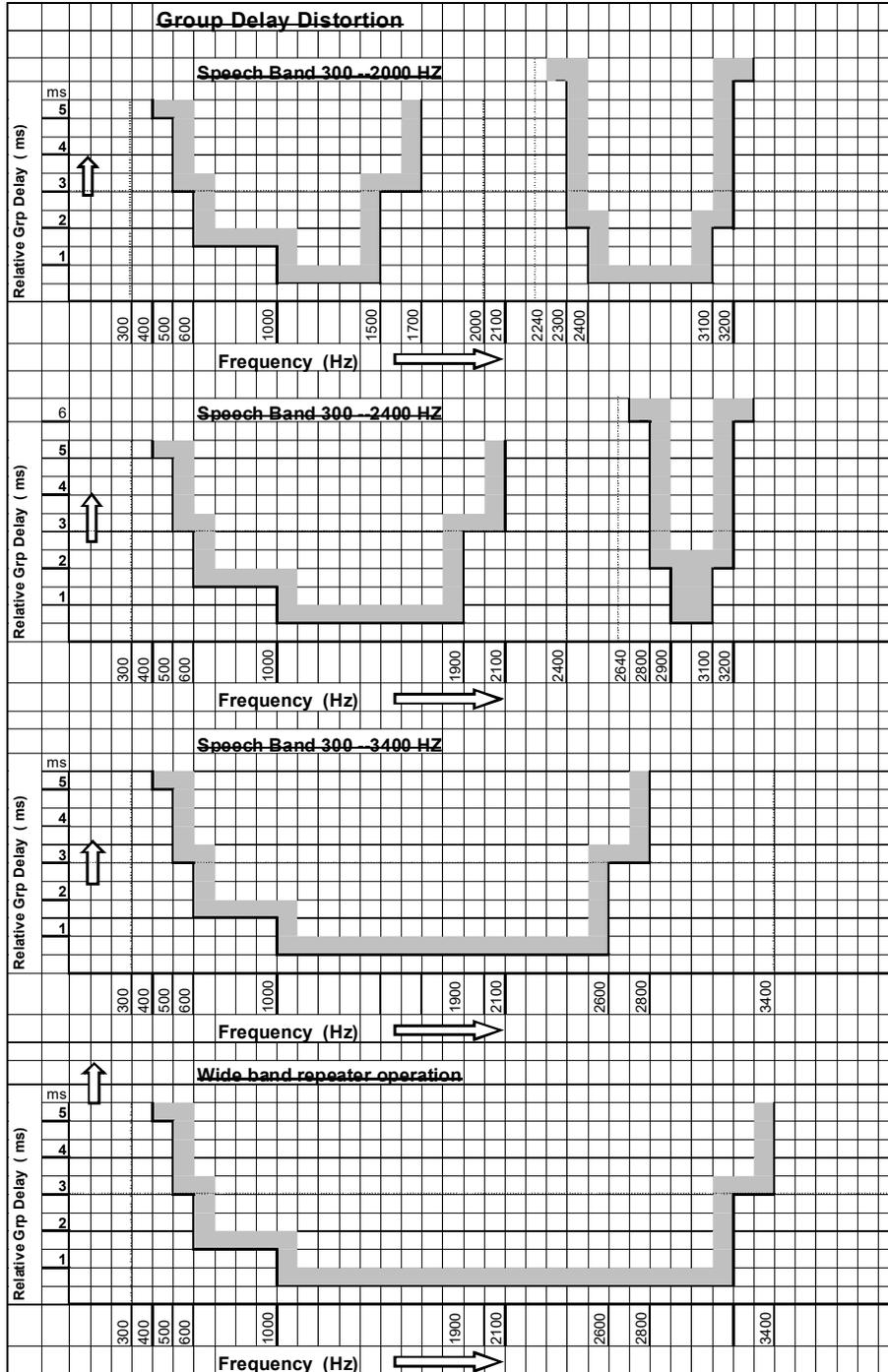


Figure A3: PLC voice circuit via Voice Gateway/ Router, ET Network and Call Manager

Annex B – Group Delay and Attenuation Distortion Limits

(Page 1 of 2)



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(Page 2 of 2)

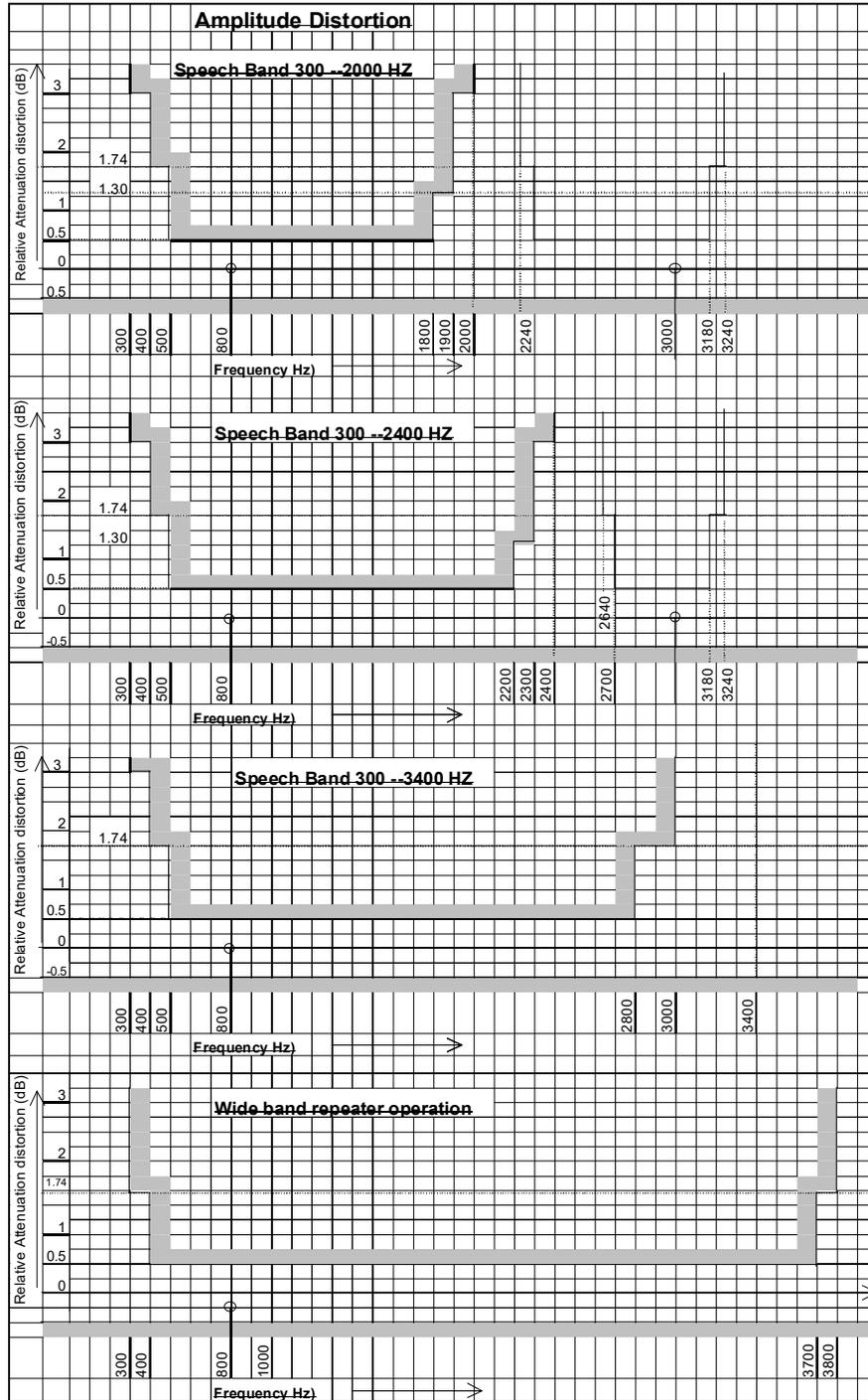


Figure B1: Group Delay and Attenuation Distortion Limits

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Annex C – Teleprotection

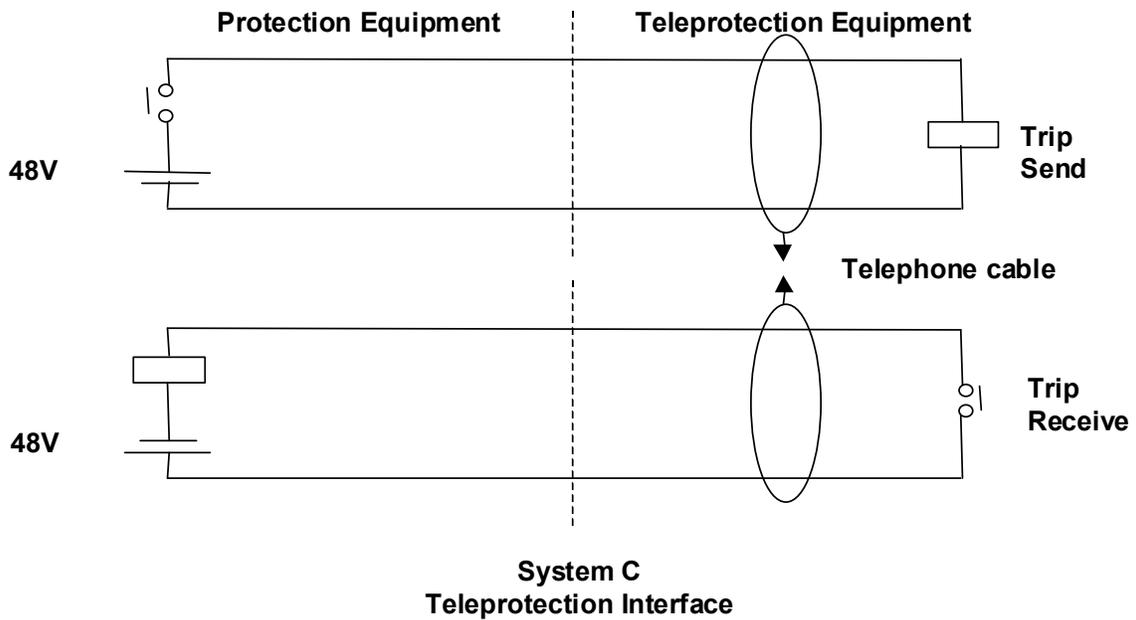
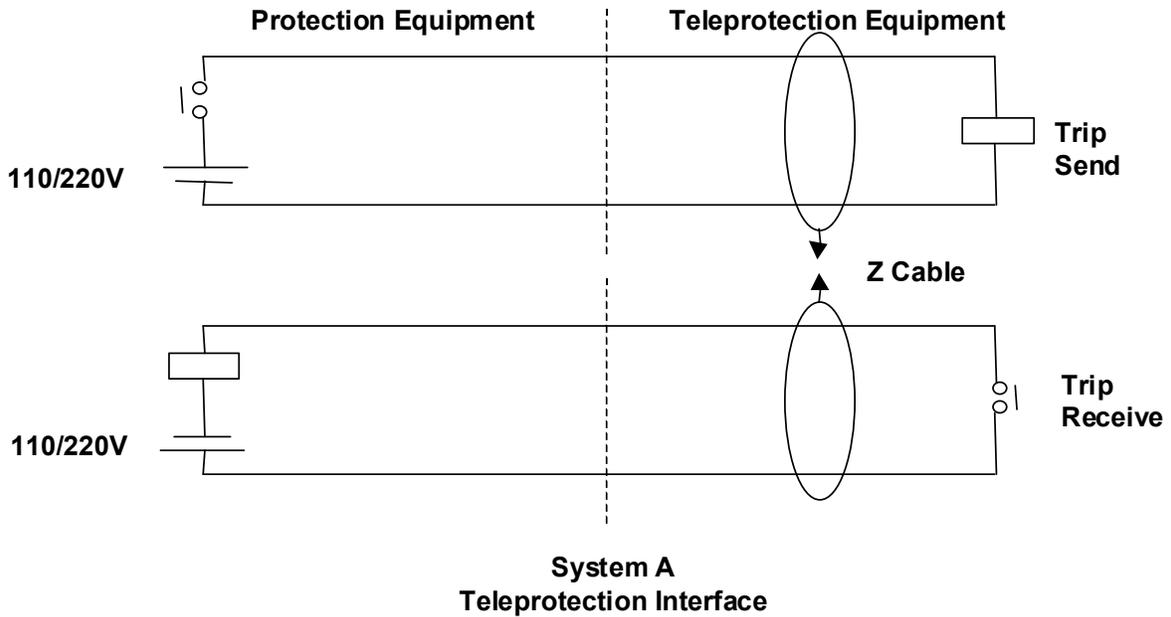


Figure C1: System A and System C Teleprotection Interfaces

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Annex D – Type Test Circuits

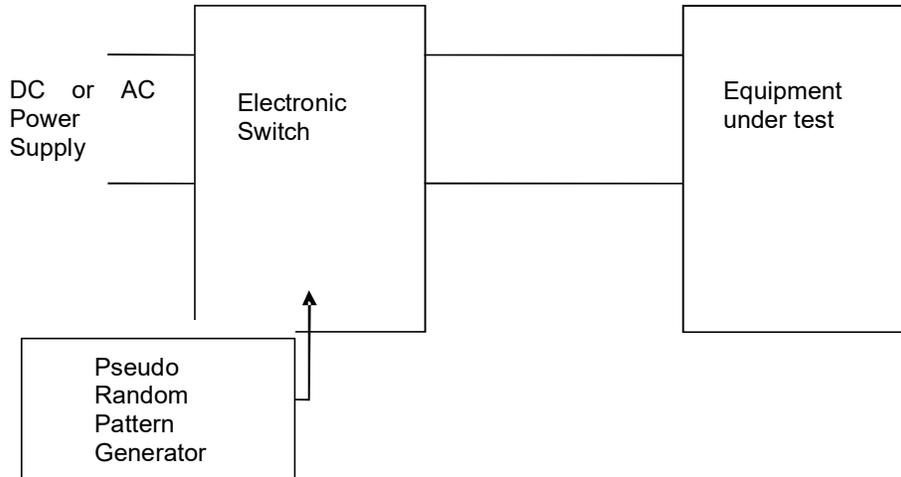


Figure D1: Test Circuit for Testing Power Supply Interruptions

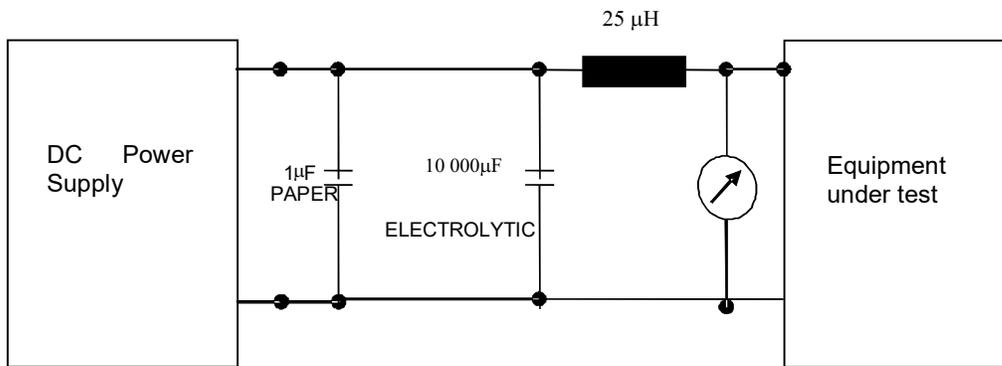
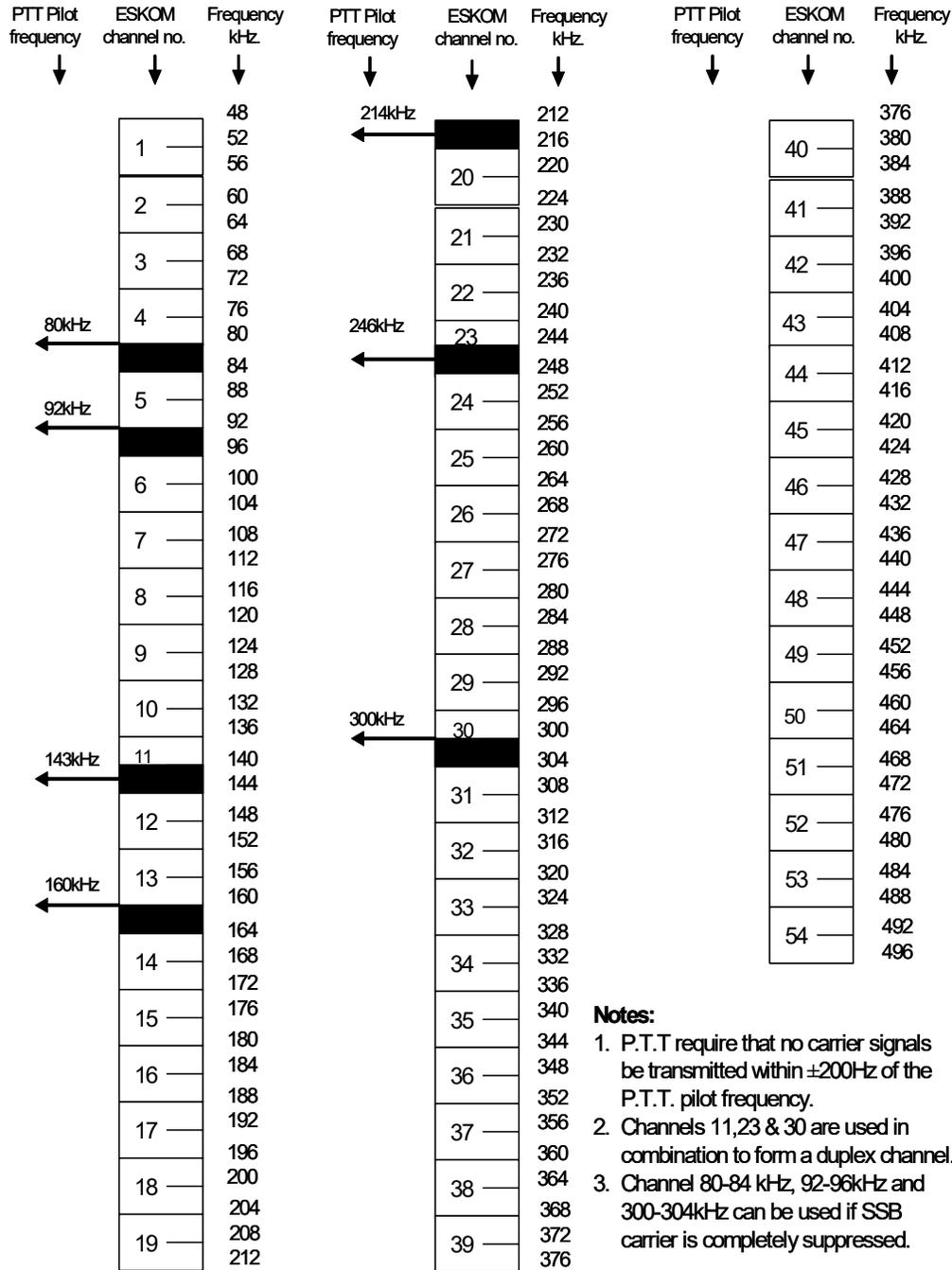


Figure D2: Test Circuit for Measuring Reflected Noise

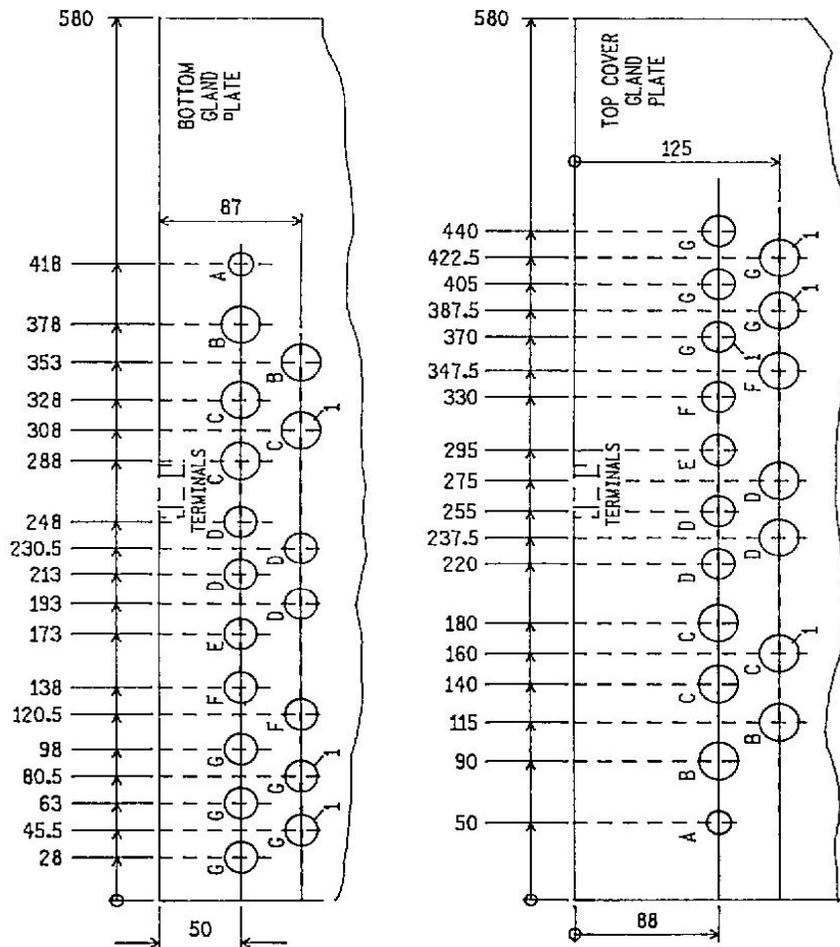
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Annex E – Frequency Allocations



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Annex F –Cabinet, wiring and CCU Diagrams



NOTE: 1- SPARE HOLES

- | | |
|--|---|
| A HOLE FOR EARTH STRAP \varnothing 15mm | E HOLE FOR 10pr. ALARM CABLE \varnothing 20mm |
| B HOLE FOR 4 CORE 4mm ² CABLE \varnothing 23-25mm | F HOLE FOR 10pr. TELEPHONE CABLE \varnothing 20mm |
| C HOLE FOR 2 OR 4 CORE 16mm ² CABLE \varnothing 23-25mm | G HOLE FOR RG12AU Co-Ax CABLE \varnothing 20mm |
| D HOLE FOR 12 CORE Z CABLE TO TELEPROT. FUNCS. \varnothing 20mm | |

Figure F1: Gland Plate details

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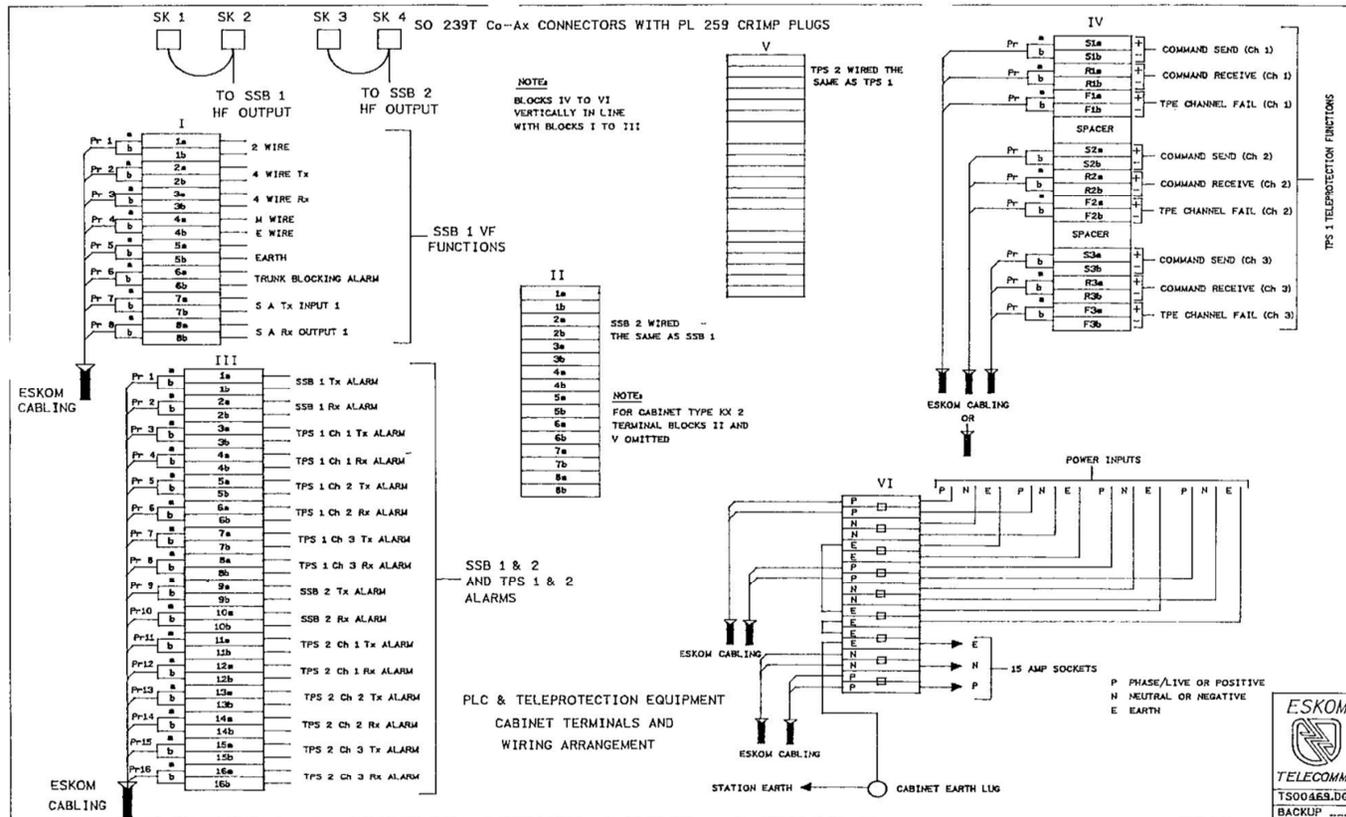
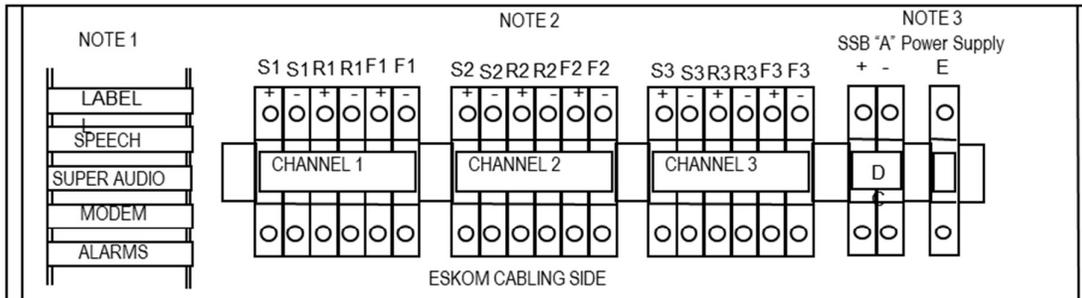


Figure F2: Typical termination of swing frame cabinets

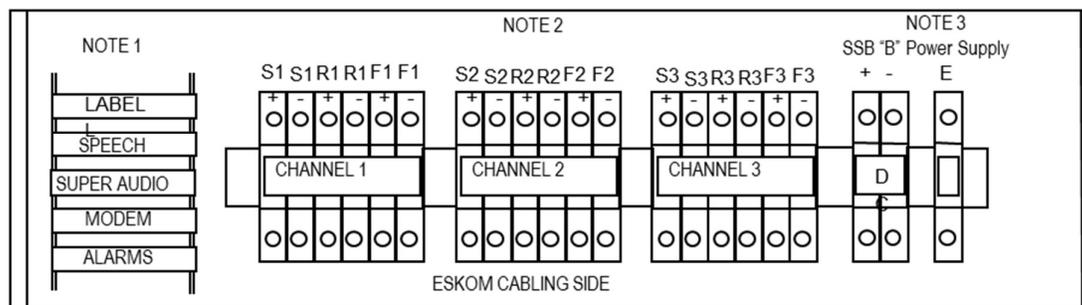
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SSB "A" Carrier Set Terminations



SSB "B" Carrier Set Terminations

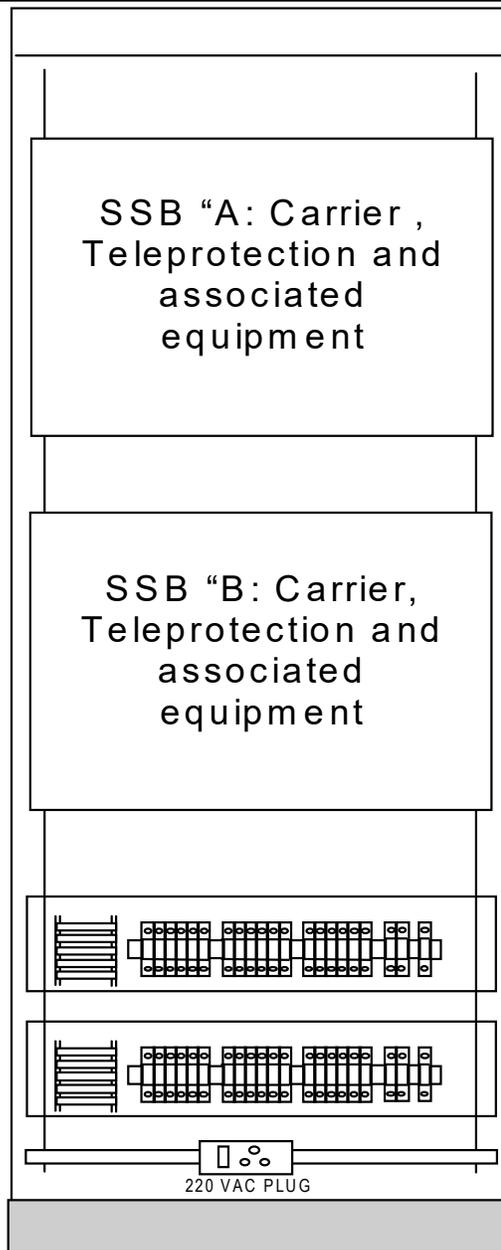


NOTES:

1. Terminal blocks must be Krone 10 way disconnect type
2. Terminal blocks for the teleprotection signals must be suitable Klippons.
3. Terminal blocks for the power supplies must be suitable Klippons
4. Carrier speech circuits must be terminated on the Krone tagblocks mentioned in Note 1.
5. Carrier alarms circuits must be indicated and terminated on the Krone tagblocks mentioned in Note 1.

Figure F3: Typical termination of front & rear entry cabinets

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Annexure F – Fig.4
(Typical termination – Front & rear entry cabinets)

Figure F4: Front view termination of front & rear entry cabinets

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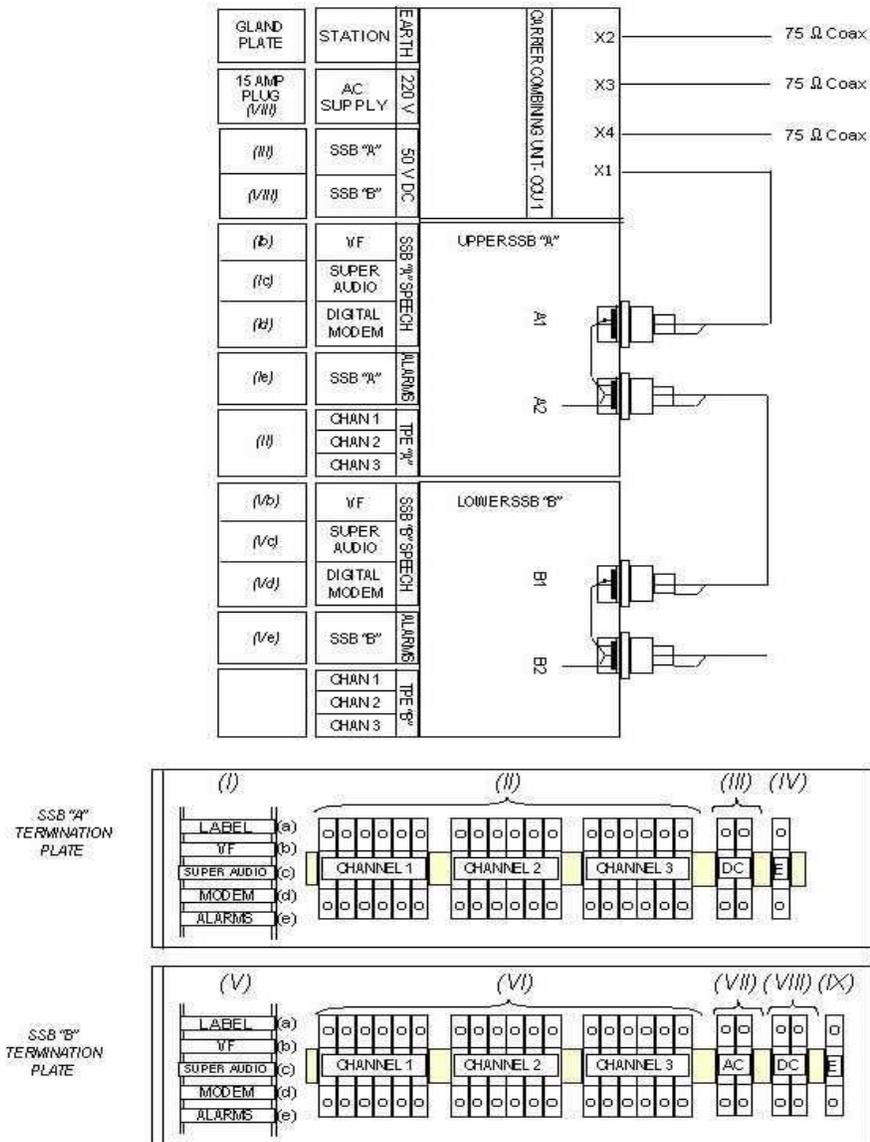


Figure F5: Typical cable layout of front & rear entry cabinets

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T1..... HYBRID TRANSFORMER
R1..... NON-INDUCTIVE 37,5Ω 50W RESISTOR
F1.....F2 350V GAS ARRESTERS

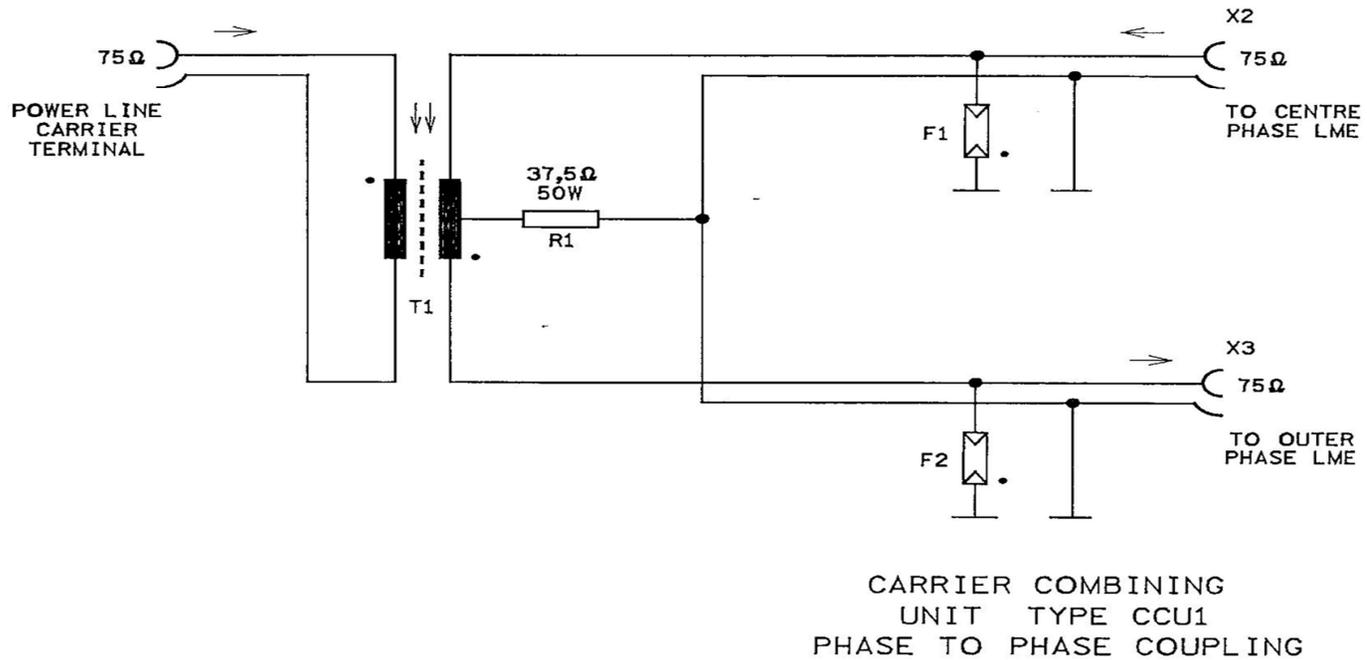


Figure F6: Carrier combiner unit 1 (CCU1)

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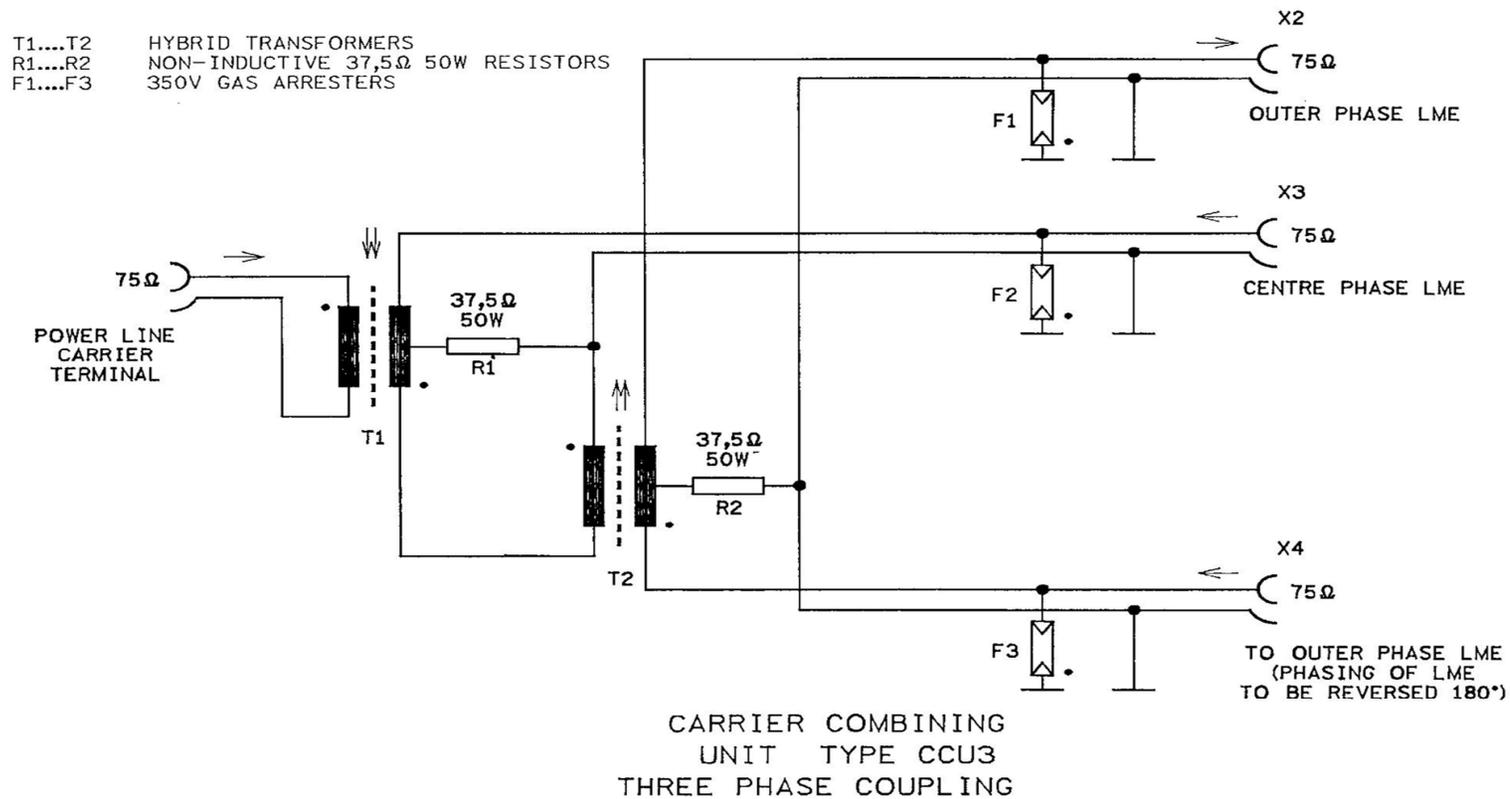


Figure F7: Carrier combiner unit 3 (CCU3)

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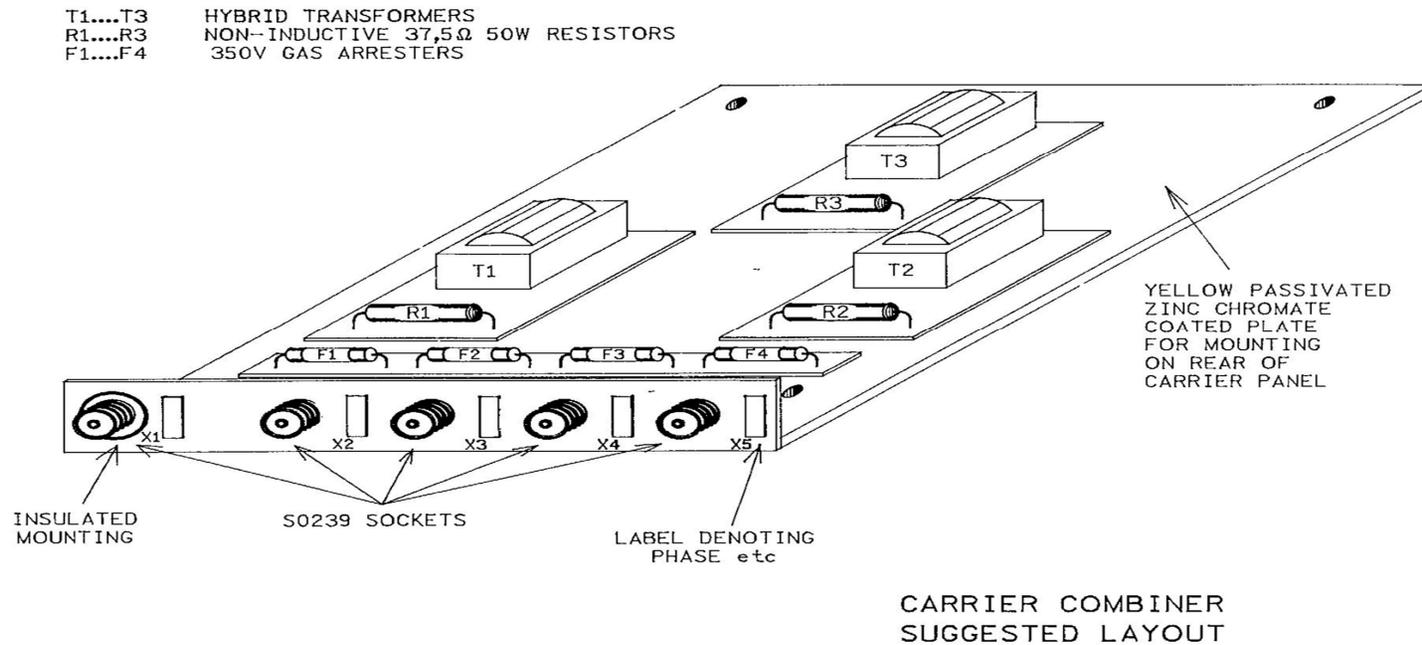


Figure F8: Carrier combiner unit layout

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Annex G – Technical Schedules A&B

| TECHNICAL SCHEDULES A & B FOR POWER LINE CARRIER - LINE MATCHING EQUIPMENT STANDARD IN ACCORDANCE WITH ESKOM STANDARD 240-106920490 | | | | | |
|--|--|---|--------------|--|--------------|
| <p>Schedule A: Purchaser's specifications</p> <p>Schedule B: Guarantees, compliance and technical particulars of equipment offered</p> <p>The following tabulated requirements emulate the sectional numbering of Standard 240-106920490:</p> <ul style="list-style-type: none"> • When completing the Schedule B and the References section, The Tenderer is required to state clearly, for each clause that requires a statement of compliance, with one of the following options: <ul style="list-style-type: none"> a) Comply – Confirmation of FULL Compliance to all clauses of the applicable section of the Technical Standard. No deviations b) Partially Comply – Confirmation of PARTIAL Compliance and that FULL Compliance is not possible. Deviations taken. c) Do Not Comply - Confirmation of Non-Compliance to ALL requirements in the applicable section if applicable. • Reference to evidence in the form of datasheets, equipment manuals, drawings, hyperlinks shall be included in the References section if required. • Where there are any deviations taken from the clauses in the applicable section, these should be indicated under the References and Deviations section. | | | | | |
| | Description | Schedule A | Schedule B | References/ Statement (supporting evidence) if required & Deviations | Comments |
| 1 | Manufacturer | List and provide details | | | |
| 2 | Manufacturer's type reference | List and provide details | | | |
| 3 | General Requirements | | | | |
| 3.1 | Environmental conditions | | | | |
| | a) Comply with clause 3.1a) of this specification, Indoors | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.1b) of this specification, at sea level and at an altitude above sea level up to 2000m | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.1c) of this specification, Maximum 55 °C | Comply and provide supporting documentation | | | |

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| | | | | | |
|----------------|---|---|--|--|--|
| | d) Comply with clause 3.1c) of this specification, Minimum 0 °C | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.1d) of this specification, Humidity | Comply and provide supporting documentation | | | |
| | f) Comply with clause 3.1e) of this specification, Barometric pressure | Comply and provide supporting documentation | | | |
| | g) Comply with clause 3.1f) of this specification, Lightning - extremely severe | Comply and provide supporting documentation | | | |
| 3.2 | Power Line Carrier Equipment | | | | |
| 3.2.1 | Carrier frequency circuits | | | | |
| 3.2.1.1 | Channel requirements | | | | |
| | b) Comply with clause 3.2.1.1 a) of this specification. | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.2.1.1 b) of this specification (DSP). | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.2.1.1c) of this specification. | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.2.1.1 d) i) of this specification (2kHz) | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.2.1.1 d) ii) of this specification (4 kHz Data) | Comply and provide supporting documentation | | | |
| | f) Comply with clause 3.2.1.1 d) iii) of this specification (4 kHz Data+Speech) | Comply and provide supporting documentation | | | |
| | g) Comply with clause 3.2.1.1 d) iv) of this specification (8 kHz) | Comply and provide supporting documentation | | | |
| 3.2.1.2 | Transmitter Power Requirements | | | | |

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| | | | | | |
|----------------|---|---|--|--|--|
| | a) Comply with clause 3.2.1.2a) of this specification. | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.2.1.2b) of this specification. | Comply and provide supporting documentation | | | |
| 3.2.1.3 | Transmitter Protection | | | | |
| | a) Comply with the clause in section 3.2.1.3 of this specification. | Comply and provide supporting documentation | | | |
| 3.2.1.4 | Transmitter loadings | | | | |
| | a) Comply with clause 3.2.1.4 a) of this specification. | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.2.1.4 b) of this specification. | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.2.1.4 c) of this specification. | Comply and provide supporting documentation | | | |
| 3.2.2 | Combination of transmitters and receivers | | | | |
| | a) Comply with clause 3.2.2 a) of this specification. | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.2.2 b) of this specification. | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.2.2 c) of this specification. | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.2.2 d) of this specification. | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.2.2 e) of this specification. | Comply and provide supporting documentation | | | |
| | f) Comply with clause 3.2.2 f) of this specification. | Comply and provide | | | |

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| | | | | | |
|--------------|---|---|--|--|--|
| | | supporting documentation | | | |
| 3.2.3 | PLC Frequency requirements | | | | |
| | a) Comply with clause 3.2.3 a) of this specification. | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.2.3 b) of this specification. | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.2.3 c) of this specification for the following: | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.2.3 c) i) of this specification. | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.2.3 c) ii) of this specification. | Comply and provide supporting documentation | | | |
| 3.2.4 | Automatic gain control and receiver sensitivity | | | | |
| | a) Comply with clause 3.2.4a) of this specification. | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.2.4b) of this specification. | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.2.4c) of this specification. | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.2.4d) of this specification. | Comply and provide supporting documentation | | | |
| 3.2.5 | Receiver noise squelch circuit | | | | |
| | a) Comply with clause 3.2.5a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.2.5b) of this specification | Comply and provide | | | |

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| | | | | | |
|--------------|---|---|--|--|--|
| | | supporting documentation | | | |
| | c) Comply with clause 3.2.5c) of this specification | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.2.5d) of this specification | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.2.5e) of this specification | Comply and provide supporting documentation | | | |
| 3.2.6 | Hybrid Balancing and Equaliser Network | | | | |
| | a) Comply with clause 3.2.6a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.2.6b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.2.6c) of this specification | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.2.6d) of this specification | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.2.6e) of this specification | Comply and provide supporting documentation | | | |
| 3.2.7 | Voice Requirements | | | | |
| | a) Comply with clause 3.2.7a) of this specification | Comply and provide type test certificate and or results complying with one of the standards in clause 3.2.7a) | | | |
| | b) Comply with clause 3.2.7b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.2.7c) of this specification | Comply and provide | | | |

| | | | | | |
|-----------------|---|---|--|--|--|
| | | supporting documentation | | | |
| | d) Comply with clause 3.2.7d) of this specification | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.2.7e) of this specification | Comply and provide supporting documentation | | | |
| 3.2.8 | Point-to-point communication (service telephone) | | | | |
| | a) Comply with clause 3.2.8a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.2.8b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.2.8c) of this specification | Comply and provide supporting documentation | | | |
| 3.2.9 | Interconnection and Repeater Operations | | | | |
| | a) Comply with clause 3.2.9a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.2.9b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.2.9b) i) of this specification | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.2.9b) ii) of this specification | Comply and provide supporting documentation | | | |
| 3.2.10 | Noise and interference | | | | |
| 3.2.10.1 | Noise | | | | |
| | a) Comply with clause 3.2.10.1a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.2.10.1b) of this specification | Comply and provide | | | |

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| | | supporting documentation | | | |
| 3.2.10.2 | Interference | | | | |
| | a) Comply with clause 3.2.10.2a) i) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.2.10.2a) ii) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.2.10.2b) of this specification | Comply and provide supporting documentation | | | |
| 3.2.11 | Voltage withstand, electromagnetic compatibility and insulation resistance requirements | | | | |
| 3.2.11 Table 2 | A.C Mains Supply | | | | |
| | a) Specify the "Dielectric Withstand" voltages according to Table 2 for "A.C. mains supply" of this specification. | Comply and provide supporting documentation | | | |
| | b) Specify the "Impulse Voltage" values according to Table 2 for "A.C. mains supply" of this specification. | Comply and provide supporting documentation | | | |
| | c) Specify the "Insulation Resistance" values according to Table 2 for "A.C. mains supply" of this specification. | Comply and provide supporting documentation | | | |
| | d) Specify the CM and DM voltage values for the "Damped oscillatory wave Immunity test" according to Table 2 for "A.C. mains supply" of this specification. | Comply and provide supporting documentation | | | |
| | e) Specify the "Electrical fast/transient bursts" voltages according to Table 2 for "A.C. mains supply" of this specification. | Comply and provide supporting documentation | | | |
| | f) Specify the CM and DM voltage values for the "Impulse Voltage Test 1.2/50us" test according to Table 2 for "A.C. mains supply" of this specification. | Comply and provide supporting documentation | | | |
| 3.2.11 Table 2 | Power Supply <60VDC | | | | |

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|---------------------------|--|---|--|--|--|
| | a) Specify the "Dielectric Withstand" voltages according to Table 2 for "Power Supply <60V DC" of this specification. | Comply and provide supporting documentation | | | |
| | b) Specify the "Impulse Voltage" values according to Table 2 for "Power Supply <60V DC" of this specification. | Comply and provide supporting documentation | | | |
| | c) Specify the "Insulation Resistance" values according to Table 2 for "Power Supply <60V DC" of this specification. | Comply and provide supporting documentation | | | |
| | d) Specify the CM and DM voltage values for the "Damped oscillatory wave Immunity test" according to Table 2 for "Power Supply <60V DC" of this specification. | Comply and provide supporting documentation | | | |
| | e) Specify the "Electrical fast/transient bursts" voltages according to Table 2 for "Power Supply <60V DC" of this specification. | Comply and provide supporting documentation | | | |
| | f) Specify the CM and DM voltage values for the "Impulse Voltage Test 1.2/50us" test according to Table 2 for "Power Supply <60V DC" of this specification. | Comply and provide supporting documentation | | | |
| 3.2.11 Table 2 | Carrier Frequency Input/Output | | | | |
| | a) Specify the "Dielectric Withstand" voltages according to Table 2 for "Carrier Frequency Input/Output" of this specification. | Comply and provide supporting documentation | | | |
| | b) Specify the "Impulse Voltage" values according to Table 2 for "Carrier Frequency Input/Output" of this specification. | Comply and provide supporting documentation | | | |
| | c) Specify the "Insulation Resistance" values according to Table 2 for "Carrier Frequency Input/Output" of this specification. | Comply and provide supporting documentation | | | |
| | d) Specify the CM and DM voltage values for the "Damped oscillatory wave Immunity test" according to Table 2 for "Carrier Frequency Input/Output" of this specification. | Comply and provide supporting documentation | | | |
| | e) Specify the "Electrical fast/transient bursts" voltages according to Table 2 for "Carrier Frequency Input/Output" of this specification. | Comply and provide supporting documentation | | | |

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| | f) Specify the CM and DM voltage values for the "Impulse Voltage Test 1.2/50us" test according to Table 2 for "Carrier Frequency Input/Output" of this specification. | Comply and provide supporting documentation | | | |
| 3.2.11 Table 2 | Telecommunication Interfaces - Speech & Voice Interfaces | | | | |
| | a) Specify the "Dielectric Withstand" voltages according to Table 2 for "Speech & Voice Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | b) Specify the "Impulse Voltage" values according to Table 2 for "Speech & Voice Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | c) Specify the "Insulation Resistance" values according to Table 2 for "Speech & Voice Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | d) Specify the CM and DM voltage values for the "Damped oscillatory wave Immunity test" according to Table 2 for "Speech & Voice Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | e) Specify the "Electrical fast/transient bursts" voltages according to Table 2 for "Speech & Voice Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | f) Specify the CM and DM voltage values for the "Impulse Voltage Test 1.2/50us" test according to Table 2 for "Speech & Voice Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| 3.2.11 Table 2 | Telecommunication Interfaces - X.21 | | | | |
| | a) Specify the "Dielectric Withstand" voltages according to Table 2 for "X.21 Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | b) Specify the "Impulse Voltage" values according to Table 2 for "X.21 Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | c) Specify the "Insulation Resistance" values according to Table 2 for "X.21 Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | d) Specify the CM and DM voltage values for the "Damped oscillatory wave Immunity test" according to | Comply and provide supporting documentation | | | |

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| | Table 2 for "X.21 Interfaces" of this specification. | | | | |
| | e) Specify the "Electrical fast/transient bursts" voltages according to Table 2 for "X.21 Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | f) Specify the CM and DM voltage values for the "Impulse Voltage Test 1.2/50us" test according to Table 2 for "X.21 Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| 3.2.11 Table 2 | Telecommunication Interfaces - G703.1 | | | | |
| | a) Specify the "Dielectric Withstand" voltages according to Table 2 for "G703.1 Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | b) Specify the "Impulse Voltage" values according to Table 2 for "G703.1 Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | c) Specify the "Insulation Resistance" values according to Table 2 for "G703.1 Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | d) Specify the CM and DM voltage values for the "Damped oscillatory wave Immunity test" according to Table 2 for "G703.1 Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | e) Specify the "Electrical fast/transient bursts" voltages according to Table 2 for "G703.1 Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | f) Specify the CM and DM voltage values for the "Impulse Voltage Test 1.2/50us" test according to Table 2 for "G703.1 Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| 3.2.11 Table 2 | Telecommunication Interfaces Ethernet | | | | |
| | a) Specify the "Dielectric Withstand" voltages according to Table 2 for "Ethernet Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | b) Specify the "Impulse Voltage" values according to Table 2 for "Ethernet Interfaces" of this specification. | Comply and provide supporting documentation | | | |

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| | c) Specify the "Insulation Resistance" values according to Table 2 for "Ethernet Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | d) Specify the CM and DM voltage values for the "Damped oscillatory wave Immunity test" according to Table 2 for "Ethernet Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | e) Specify the "Electrical fast/transient bursts" voltages according to Table 2 for "Ethernet Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | f) Specify the CM and DM voltage values for the "Impulse Voltage Test 1.2/50us" test according to Table 2 for "Ethernet Interfaces" of this specification. | Comply and provide supporting documentation | | | |
| 3.2.11 Table 2 | Protection equipment Interfaces - System A contacts | | | | |
| | a) Specify the "Dielectric Withstand" voltages according to Table 2 for "System A contacts" of this specification. | Comply and provide supporting documentation | | | |
| | b) Specify the "Impulse Voltage" values according to Table 2 for "System A contacts" of this specification. | Comply and provide supporting documentation | | | |
| | c) Specify the "Insulation Resistance" values according to Table 2 for "System A contacts" of this specification. | Comply and provide supporting documentation | | | |
| | d) Specify the CM and DM voltage values for the "Damped oscillatory wave Immunity test" according to Table 2 for "System A contacts" of this specification. | Comply and provide supporting documentation | | | |
| | e) Specify the "Electrical fast/transient bursts" voltages according to Table 2 for "System A contacts" of this specification. | Comply and provide supporting documentation | | | |
| | f) Specify the CM and DM voltage values for the "Impulse Voltage Test 1.2/50us" test according to Table 2 for "System A contacts" of this specification. | Comply and provide supporting documentation | | | |
| 3.2.11 Table 2 | Protection equipment Interfaces - System C contacts | | | | |
| | a) Specify the "Dielectric Withstand" voltages according to Table 2 for "System C contacts" of this specification. | Comply and provide supporting documentation | | | |

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| | b) Specify the "Impulse Voltage" values according to Table 2 for "System C contacts" of this specification. | Comply and provide supporting documentation | | | |
| | c) Specify the "Insulation Resistance" values according to Table 2 for "System C contacts" of this specification. | Comply and provide supporting documentation | | | |
| | d) Specify the CM and DM voltage values for the "Damped oscillatory wave Immunity test" according to Table 2 for "System C contacts" of this specification. | Comply and provide supporting documentation | | | |
| | e) Specify the "Electrical fast/transient bursts" voltages according to Table 2 for "System C contacts" of this specification. | Comply and provide supporting documentation | | | |
| | f) Specify the CM and DM voltage values for the "Impulse Voltage Test 1.2/50us" test according to Table 2 for "System C contacts" of this specification. | Comply and provide supporting documentation | | | |
| 3.2.11 Table 2 | Protection equipment Interfaces - Alarm contacts | | | | |
| | a) Specify the "Dielectric Withstand" voltages according to Table 2 for "Alarm contacts" of this specification. | Comply and provide supporting documentation | | | |
| | b) Specify the "Impulse Voltage" values according to Table 2 for "Alarm contacts" of this specification. | Comply and provide supporting documentation | | | |
| | c) Specify the "Insulation Resistance" values according to Table 2 for "Alarm contacts" of this specification. | Comply and provide supporting documentation | | | |
| | d) Specify the CM and DM voltage values for the "Damped oscillatory wave Immunity test" according to Table 2 for "Alarm contacts" of this specification. | Comply and provide supporting documentation | | | |
| | e) Specify the "Electrical fast/transient bursts" voltages according to Table 2 for "Alarm contacts" of this specification. | Comply and provide supporting documentation | | | |
| | f) Specify the CM and DM voltage values for the "Impulse Voltage Test 1.2/50us" test according to Table 2 for "Alarm contacts" of this specification. | Comply and provide supporting documentation | | | |
| 3.2.11 Table 2 | Other Interfaces - RS 232 Serial | | | | |

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|---------------------------|--|---|--|--|--|
| | a) Specify the "Dielectric Withstand" voltages according to Table 2 for "RS 232 serial interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | b) Specify the "Impulse Voltage" values according to Table 2 for "RS 232 serial interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | c) Specify the "Insulation Resistance" values according to Table 2 for "RS 232 serial interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | d) Specify the CM and DM voltage values for the "Damped oscillatory wave Immunity test" according to Table 2 for "RS 232 serial interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | e) Specify the "Electrical fast/transient bursts" voltages according to Table 2 for "RS 232 serial interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | f) Specify the CM and DM voltage values for the "Impulse Voltage Test 1.2/50us" test according to Table 2 for "RS 232 serial interfaces" of this specification. | Comply and provide supporting documentation | | | |
| 3.2.11 Table 2 | Other Interfaces - IRIG-B input | | | | |
| | a) Specify the "Dielectric Withstand" voltages according to Table 2 for "IRIG-B input interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | b) Specify the "Impulse Voltage" values according to Table 2 for "IRIG-B input interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | c) Specify the "Insulation Resistance" values according to Table 2 for "IRIG-B input interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | d) Specify the CM and DM voltage values for the "Damped oscillatory wave Immunity test" according to Table 2 for "IRIG-B input interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | e) Specify the "Electrical fast/transient bursts" voltages according to Table 2 for "IRIG-B input interfaces" of this specification. | Comply and provide supporting documentation | | | |

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| | f) Specify the CM and DM voltage values for the "Impulse Voltage Test 1.2/50us" test according to Table 2 for "IRIG-B input interfaces" of this specification. | Comply and provide supporting documentation | | | |
| 3.2.11 Table 2 | Other Interfaces - GPS Sync Input | | | | |
| | a) Specify the "Dielectric Withstand" voltages according to Table 2 for "GPS Sync input interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | b) Specify the "Impulse Voltage" values according to Table 2 for "GPS Sync input interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | c) Specify the "Insulation Resistance" values according to Table 2 for "GPS Sync input interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | d) Specify the CM and DM voltage values for the "Damped oscillatory wave Immunity test" according to Table 2 for "GPS Sync input interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | e) Specify the "Electrical fast/transient bursts" voltages according to Table 2 for "GPS Sync input interfaces" of this specification. | Comply and provide supporting documentation | | | |
| | f) Specify the CM and DM voltage values for the "Impulse Voltage Test 1.2/50us" test according to Table 2 for "GPS Sync input interfaces" of this specification. | Comply and provide supporting documentation | | | |
| 3.2.11 | General | | | | |
| | a) Comply with clause 3.2.11)a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.2.11)b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.2.11)c) of this specification | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.2.11)d) of this specification | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.2.11)e) of this specification | Comply and provide | | | |

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| | | supporting documentation | | | |
| | f) Comply with clause 3.2.11)f) of this specification | Comply and provide supporting documentation | | | |
| 3.2.12 | Management, alarms and test facilities | | | | |
| | a) Comply with clause 3.2.12a) of this specification | Comply and provide supporting documentation | | | |
| 3.2.12b) | b) Functions required | | | | |
| | i) Comply with clause 3.2.12b) i) of this specification | Comply and provide supporting documentation | | | |
| | ii) Comply with clause 3.2.12b) ii) of this specification | Comply and provide supporting documentation | | | |
| | iii) Comply with clause 3.2.12b) iii) of this specification | Comply and provide supporting documentation | | | |
| | iv) Comply with clause 3.2.12b) iv) of this specification | Comply and provide supporting documentation | | | |
| | v) Comply with clause 3.2.12b) v) of this specification | Comply and provide supporting documentation | | | |
| | vi) Comply with clause 3.2.12b) vi) of this specification | Comply and provide supporting documentation | | | |
| 3.2.12c) | c) HMI interface standards/ requirements | | | | |
| | i) Comply with clause 3.2.12c) i) of this specification | Comply and provide supporting documentation | | | |
| | ii) Comply with clause 3.2.12c) ii) of this specification | Comply and provide supporting documentation | | | |
| | iii) Comply with clause 3.2.12c) iii) of this specification | Comply and provide supporting documentation | | | |

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| | iv) Comply with clause 3.2.12c) iv) of this specification | Comply and provide supporting documentation | | | |
| | v) Comply with clause 3.2.12c) v) of this specification | Comply and provide supporting documentation | | | |
| | vi) Comply with clause 3.2.12c) vi) of this specification | Comply and provide supporting documentation | | | |
| | vii) Comply with clause 3.2.12c) vii) of this specification | Comply and provide supporting documentation | | | |
| | viii) Comply with clause 3.2.12c) viii) of this specification | Comply and provide supporting documentation | | | |
| | ix) Comply with clause 3.2.12c) ix) of this specification | Comply and provide supporting documentation | | | |
| 3.2.12d) | d) Cyber Security | | | | |
| | i) Comply with clause 3.2.12d) i) of this specification | Comply and provide supporting documentation | | | |
| | ii) Comply with clause 3.2.12d) ii) of this specification | Comply and provide supporting documentation | | | |
| | iii) Comply with clause 3.2.12d) iii) of this specification | Comply and provide supporting documentation | | | |
| | iv) Comply with clause 3.2.12d) iv) of this specification | Comply and provide supporting documentation | | | |
| | v) Comply with clause 3.2.12d) v) of this specification | Comply and provide supporting documentation | | | |
| | vi) Comply with clause 3.2.12d) vi) of this specification | Comply and provide supporting documentation | | | |
| | vii) Comply with clause 3.2.12d) vii) of this specification | Comply and provide | | | |

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| | | supporting documentation | | | |
| 3.2.12e) | e) Alarms | | | | |
| | i) Comply with clause 3.2.12e) i) of this specification | Comply and provide supporting documentation | | | |
| | ii) Comply with clause 3.2.12e) ii) of this specification | Comply and provide supporting documentation | | | |
| | iii) Comply with clause 3.2.12e) iii) of this specification | Comply and provide supporting documentation | | | |
| | iv) Comply with clause 3.2.12e) iv) of this specification | Comply and provide supporting documentation | | | |
| | v) Comply with clause 3.2.12e) v) of this specification | Comply and provide supporting documentation | | | |
| | vi) Comply with clause 3.2.12e) vi) of this specification | Comply and provide supporting documentation | | | |
| | vii) Comply with clause 3.2.12e) vii) of this specification | Comply and provide supporting documentation | | | |
| | viii) Comply with clause 3.2.12e) viii) of this specification | Comply and provide supporting documentation | | | |
| | ix) Comply with clause 3.2.12e) ix) of this specification | Comply and provide supporting documentation | | | |
| 3.2.12f) | f) IEC 61850 Standard Implementation | | | | |
| | i) Comply with clause 3.2.12f) i) of this specification | Comply and provide supporting documentation | | | |
| | ii) Comply with clause 3.2.12f) ii) of this specification | Comply and provide supporting documentation | | | |
| | iii) Comply with clause 3.2.12f) iii) of this specification | Comply and provide | | | |

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| | | supporting documentation | | | |
| | iv) Comply with clause 3.2.12f) iv) of this specification | Comply and provide supporting documentation | | | |
| | v) Comply with clause 3.2.12f) v) of this specification | Comply and provide supporting documentation | | | |
| | vi) Comply with clause 3.2.12f) vi) of this specification | Comply and provide supporting documentation | | | |
| | vii) Comply with clause 3.2.12f) vii) of this specification | Comply and provide supporting documentation | | | |
| | viii) Comply with clause 3.2.12f) viii) of this specification | Comply and provide supporting documentation | | | |
| | ix) Comply with clause 3.2.12f) ix) of this specification | Comply and provide supporting documentation | | | |
| | x) Comply with clause 3.2.12f) x) of this specification | Comply and provide supporting documentation | | | |
| | xi) Comply with clause 3.2.12f) xi) of this specification | Comply and provide supporting documentation | | | |
| | xii) Comply with clause 3.2.12f) xii) of this specification | Comply and provide supporting documentation | | | |
| 3.2.13 | Power supplies | | | | |
| | a) Comply with clause 3.2.13a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.2.13b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.2.13c) of this specification | Comply and provide supporting documentation | | | |

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| 3.2.13d) | d) Power supply protective devices or functions | | | | |
| | i) Comply with clause 3.2.13d) i) of this specification | Comply and provide supporting documentation | | | |
| | ii) Comply with clause 3.2.13d) ii) of this specification | Comply and provide supporting documentation | | | |
| | iii) Comply with clause 3.2.13d) iii) of this specification | Comply and provide supporting documentation | | | |
| | iv) Comply with clause 3.2.13d) iv) of this specification | Comply and provide supporting documentation | | | |
| | v) Comply with clause 3.2.13d) v) of this specification | Comply and provide supporting documentation | | | |
| | vi) Comply with clause 3.2.13d) vi) of this specification | Comply and provide supporting documentation | | | |
| | vii) Comply with clause 3.2.13d) vii) of this specification | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.2.13e) of this specification | Comply and provide supporting documentation | | | |
| | f) Comply with clause 3.2.13f) of this specification | Comply and provide supporting documentation | | | |
| | g) Comply with clause 3.2.13g) of this specification | Comply and provide supporting documentation | | | |
| | h) Comply with clause 3.2.13h) of this specification | Comply and provide supporting documentation | | | |
| | i) Comply with clause 3.2.13i) of this specification | Comply and provide supporting documentation | | | |
| 3.2.14 | Digital converter/ multiplexer unit | | | | |

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| | a) Comply with clause 3.2.14a) of this specification. | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.2.14b) of this specification. | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.2.14c) of this specification. | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.2.14d) of this specification. | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.2.14e) of this specification. | Comply and provide supporting documentation | | | |
| | f) Comply with clause 3.2.14f) of this specification. | Comply and provide supporting documentation | | | |
| | g) Comply with clause 3.2.14g) of this specification. | Comply and provide supporting documentation | | | |
| | h) Comply with clause 3.2.14h) of this specification. | Comply and provide supporting documentation | | | |
| | i) Comply with clause 3.2.14i) of this specification. | Comply and provide supporting documentation | | | |
| | j) Comply with clause 3.2.14j) of this specification. | Comply and provide supporting documentation | | | |
| | k) Comply with clause 3.2.14k) of this specification. | Comply and provide supporting documentation | | | |
| | l) Comply with clause 3.2.14l) of this specification. | Comply and provide supporting documentation | | | |
| | m) Comply with clause 3.2.14m) of this specification. | Comply and provide supporting documentation | | | |

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| | n) Comply with clause 3.2.14n) of this specification. | Comply and provide supporting documentation | | | |
| 3.3 | Carrier combiner units (CCU) and Symmetrical hybrids (SH) | | | | |
| 3.3.2 | Carrier Combiner Units (CCU) | | | | |
| | a) Comply with clause 3.3.2a) of this specification. | Comply and provide supporting documentation | | | |
| | b) Types of CCU | | | | |
| | i) Comply with clause 3.3.2b) i) of this specification | Comply and provide supporting documentation | | | |
| | ii) Comply with clause 3.3.2b) ii) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.3.2c) of this specification. | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.3.2d) of this specification. | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.3.2e) of this specification. | Comply and provide supporting documentation | | | |
| | f) Comply with clause 3.3.2f) of this specification. | Comply and provide supporting documentation | | | |
| 3.3.3 | Symmetrical Hybrid Equipment Design | | | | |
| | a) Comply with clause 3.3.3a) of this specification. | Comply and provide supporting documentation | | | |
| | b) SH functions | | | | |
| | i) Comply with clause 3.3.3b) i) of this specification | Comply and provide supporting documentation | | | |
| | ii) Comply with clause 3.3.3b) ii) of this specification | Comply and provide supporting documentation | | | |

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| | c) Comply with clause 3.3.3c) of this specification. | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.3.3d) of this specification. | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.3.3e) of this specification. | Comply and provide supporting documentation | | | |
| | f) Comply with clause 3.3.3f) of this specification. | Comply and provide supporting documentation | | | |
| | g) Comply with clause 3.3.3g) of this specification. | Comply and provide supporting documentation | | | |
| | h) Comply with clause 3.3.3h) of this specification. | Comply and provide supporting documentation | | | |
| 3.4 | Teleprotection Equipment | | | | |
| 3.4.1 | General | | | | |
| | a) Comply with clause 3.4.1a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.4.1b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.4.1c) of this specification | Comply and provide supporting documentation | | | |
| 3.4.2 | Equipment design | | | | |
| | a) Comply with clause 3.4.2a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.4.2b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.4.2c) of this specification | Comply and provide supporting documentation | | | |

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| | d) Comply with clause 3.4.2d) of this specification | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.4.2e) of this specification | Comply and provide supporting documentation | | | |
| | f) Comply with clause 3.4.2f) of this specification | Comply and provide supporting documentation | | | |
| | g) Comply with clause 3.4.2g) of this specification | Comply and provide supporting documentation | | | |
| | h) Comply with clause 3.4.2h) of this specification | Comply and provide supporting documentation | | | |
| | i) Comply with clause 3.4.2i) of this specification | Comply and provide supporting documentation | | | |
| | j) Comply with clause 3.4.2j) of this specification | Comply and provide supporting documentation | | | |
| | k) Comply with clause 3.4.2k) of this specification | Comply and provide supporting documentation | | | |
| | l) Comply with clause 3.4.2l) of this specification | Comply and provide supporting documentation | | | |
| | m) Comply with clause 3.4.2m) of this specification | Comply and provide supporting documentation | | | |
| | n) Comply with clause 3.4.2n) of this specification | Comply and provide supporting documentation | | | |
| 3.4.3 | Interface with Eskom's protection relay equipment | X | X | X | X |
| | 3.4.3.1) Comply with clause 3.4.3.1) of this specification | Comply and provide supporting documentation | | | |
| | 3.4.3.2) Comply with clause 3.4.3.2) of this specification | Comply and provide | | | |

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| | | supporting documentation | | | |
| | 3.4.3.3) Comply with clause 3.4.3.3) of this specification | Comply and provide supporting documentation | | | |
| | 3.4.3.4) Comply with clause 3.4.3.4) of this specification | Comply and provide supporting documentation | | | |
| 3.4.3.5 | Protection Interface 110 VDC/ 220 VDC (System A) | | | | |
| | a) Comply with clause 3.4.3.5a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.4.3.5b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.4.3.5c) of this specification | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.4.3.5d) of this specification | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.4.3.5e) of this specification | Comply and provide supporting documentation | | | |
| | f) Comply with clause 3.4.3.5f) of this specification | Comply and provide supporting documentation | | | |
| | g) Comply with clause 3.4.3.5g) of this specification | Comply and provide supporting documentation | | | |
| | h) Comply with clause 3.4.3.5h) of this specification | Comply and provide supporting documentation | | | |
| | i) Comply with clause 3.4.3.5i) of this specification | Comply and provide supporting documentation | | | |
| | j) Comply with clause 3.4.3.5j) of this specification | Comply and provide supporting documentation | | | |

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| 3.4.3.6 | Protection Interface 50 VDC (System C) | | | | |
| | a) Comply with clause 3.4.3.6a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.4.3.6b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.4.3.6c) of this specification | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.4.3.6d) of this specification | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.4.3.6e) of this specification | Comply and provide supporting documentation | | | |
| | f) Comply with clause 3.4.3.6f) of this specification | Comply and provide supporting documentation | | | |
| | g) Comply with clause 3.4.3.6g) of this specification | Comply and provide supporting documentation | | | |
| | h) Comply with clause 3.4.3.6h) of this specification | Comply and provide supporting documentation | | | |
| | i) Comply with clause 3.4.3.6i) of this specification | Comply and provide supporting documentation | | | |
| | j) Comply with clause 3.4.3.6j) of this specification | Comply and provide supporting documentation | | | |
| | k) Comply with clause 3.4.3.6k) of this specification | Comply and provide supporting documentation | | | |
| | l) Comply with clause 3.4.3.6l) of this specification | Comply and provide supporting documentation | | | |
| 3.4.3.7 | Number of Teleprotection Channels | | | | |

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| | a) Comply with clause 3.4.3.7a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.4.3.7b) of this specification | Comply and provide supporting documentation | | | |
| 3.4.3.8 | Comply with clause 3.4.3.8) of this specification | Comply and provide supporting documentation | | | |
| 3.4.4 | End-to-end and local test facilities | | | | |
| | a) Comply with clause 3.4.4a) of this specification. | Comply and provide supporting documentation | | | |
| | b) Test facilities | | | | |
| | i) Comply with clause 3.4.4b) i) of this specification | Comply and provide supporting documentation | | | |
| | ii) Comply with clause 3.4.4b) ii) of this specification | Comply and provide supporting documentation | | | |
| | iii) Comply with clause 3.4.4b) iii) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.4.4c) of this specification. | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.4.4d) of this specification. | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.4.4e) of this specification. | Comply and provide supporting documentation | | | |
| 3.4.5 | Management and Alarms | | | | |
| | a) Comply with clause 3.4.5a) of this specification. | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.4.5b) of this specification. | Comply and provide | | | |

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| | | supporting documentation | | | |
| | c) Comply with clause 3.4.5c) of this specification. | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.4.5d) of this specification. | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.4.5e) of this specification. | Comply and provide supporting documentation | | | |
| | f) Comply with clause 3.4.5f) of this specification. | Comply and provide supporting documentation | | | |
| 3.4.6 | Power supplies | | | | |
| | a) Comply with clause 3.4.6a) of this specification. | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.4.6b) of this specification. | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.4.6c) of this specification. | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.4.6d) of this specification. | Comply and provide supporting documentation | | | |
| 3.4.7 | Teleprotection reliability | | | | |
| 3.4.7.1 | Dependability | | | | |
| | a) Comply with clause 3.4.7.1a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.4.7.1b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.4.7.1c) of this specification | Comply and provide supporting documentation | | | |
| 3.4.7.2 | Security | | | | |

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|----------------|--|---|--|--|--|
| | a) Comply with clause 3.4.7.2a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.4.7.2b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.4.7.2c) of this specification | Comply and provide supporting documentation | | | |
| 3.4.7.3 | Signal transfer time | | | | |
| | a) Comply with clause 3.4.7.3a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.4.7.3b) of this specification | Comply and provide supporting documentation | | | |
| 3.4.7.4 | 3.4.7.4) Comply with clause 3.4.7.4) of this specification | Comply and provide supporting documentation | | | |
| 3.5 | Housing of equipment, cabling, labelling and test equipment | | | | |
| 3.5.1 | Housing of equipment and cabling facilities | | | | |
| | a) Comply with clause 3.5.1a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.5.1b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.5.1c) of this specification | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.5.1d) of this specification | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.5.1e) of this specification | Comply and provide supporting documentation | | | |
| | f) Comply with clause 3.5.1f) of this specification | Comply and provide | | | |

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| | | supporting documentation | | | |
| | g) Comply with clause 3.5.1g) of this specification | Comply and provide supporting documentation | | | |
| | h) Comply with clause 3.5.1h) of this specification | Comply and provide supporting documentation | | | |
| | i) Comply with clause 3.5.1i) of this specification | Comply and provide supporting documentation | | | |
| | j) Comply with clause 3.5.1j) of this specification | Comply and provide supporting documentation | | | |
| | k) Comply with clause 3.5.1k) of this specification | Comply and provide supporting documentation | | | |
| | l) Comply with clause 3.5.1l) of this specification | Comply and provide supporting documentation | | | |
| | m) Comply with clause 3.5.1m) of this specification | Comply and provide supporting documentation | | | |
| | n) Comply with clause 3.5.1n) of this specification | Comply and provide supporting documentation | | | |
| 3.5.2 | Standard Cabinet Arrangement for Power Line Carriers | | | | |
| | a) Comply with clause 3.5.2a) of this specification | Comply and provide supporting documentation | | | |
| 3.5.3 | Equipment Labelling and Identification | | | | |
| | a) Comply with clause 3.5.3a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.5.3b) of this specification | Comply and provide supporting documentation | | | |

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| 3.5.3c) | Carrier Frequency Duplex Channel Allocations | | | | |
| | i) Comply with clause 3.5.3c) i) of this specification | Comply and provide supporting documentation | | | |
| | ii) Comply with clause 3.5.3c) ii) of this specification | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.5.3d) of this specification | Comply and provide supporting documentation | | | |
| 3.5.4 | Cabinet wiring | | | | |
| | a) Comply with clause 3.5.4a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.5.4b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.5.4c) of this specification | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.5.4d) of this specification | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.5.4e) of this specification | Comply and provide supporting documentation | | | |
| | f) Comply with clause 3.5.4f) of this specification | Comply and provide supporting documentation | | | |
| | g) Comply with clause 3.5.4g) of this specification | Comply and provide supporting documentation | | | |
| | h) Comply with clause 3.5.4h) of this specification | Comply and provide supporting documentation | | | |
| | i) Comply with clause 3.5.4i) of this specification | Comply and provide supporting documentation | | | |

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| | j) Comply with clause 3.5.4j) of this specification | Comply and provide supporting documentation | | | |
| | k) Comply with clause 3.5.4k) of this specification | Comply and provide supporting documentation | | | |
| | l) Comply with clause 3.5.4l) of this specification | Comply and provide supporting documentation | | | |
| | m) Comply with clause 3.5.4m) of this specification | Comply and provide supporting documentation | | | |
| | n) Comply with clause 3.5.4n) of this specification | Comply and provide supporting documentation | | | |
| | o) Comply with clause 3.5.4o) of this specification | Comply and provide supporting documentation | | | |
| 3.5.5 | Equipment design and testing facilities | | | | |
| | a) Comply with clause 3.5.5a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.5.5b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.5.5c) of this specification | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.5.5d) of this specification | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.5.5e) of this specification | Comply and provide supporting documentation | | | |
| | f) Comply with clause 3.5.5f) of this specification | Comply and provide supporting documentation | | | |
| | g) Comply with clause 3.5.5g) of this specification | Comply and provide | | | |

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| | | supporting documentation | | | |
| 3.6 | Drawings and instruction manuals | | | | |
| 3.6.1 | Drawings | | | | |
| | a) Comply with clause 3.6.1a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.6.1b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.6.1c) of this specification | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.6.1d) of this specification | Comply and provide supporting documentation | | | |
| 3.6.2 | Instruction manuals | | | | |
| | a) Comply with clause 3.6.2a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.6.2b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 3.6.2c) of this specification | Comply and provide supporting documentation | | | |
| | d) Comply with clause 3.6.2d) of this specification | Comply and provide supporting documentation | | | |
| | e) Comply with clause 3.6.2e) of this specification | Comply and provide supporting documentation | | | |
| | f) Comply with clause 3.6.2f) of this specification | Comply and provide supporting documentation | | | |
| | g) Comply with clause 3.6.2g) of this specification | Comply and provide supporting documentation | | | |

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| | h) Comply with clause 3.6.2h) of this specification | Comply and provide supporting documentation | | | |
| | i) Comply with clause 3.6.2i) of this specification | Comply and provide supporting documentation | | | |
| | j) Comply with clause 3.6.2j) of this specification | Comply and provide supporting documentation | | | |
| | k) Comply with clause 3.6.2k) of this specification | Comply and provide supporting documentation | | | |
| | l) Comply with clause 3.6.2l) of this specification | Comply and provide supporting documentation | | | |
| | m) Comply with clause 3.6.2m) of this specification | Comply and provide supporting documentation | | | |
| | n) Comply with clause 3.6.2n) of this specification | Comply and provide supporting documentation | | | |
| | o) Comply with clause 3.6.2o) of this specification | Comply and provide supporting documentation | | | |
| 3.6.3 | Tools, test equipment and spares | | | | |
| 3.6.3.1 | Tools | | | | |
| | a) Comply with clause 3.6.3.1a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.6.3.1b) of this specification | Comply and provide supporting documentation | | | |
| 3.6.3.2 | Spares | | | | |
| | a) Comply with clause 3.6.3.2a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.6.3.2b) of this specification | Comply and provide | | | |

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| | | supporting documentation | | | |
| 3.6.4 | Quality assurance and system reliability | | | | |
| | a) Comply with clause 3.6.4.1) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 3.6.4.2) of this specification | Comply and provide supporting documentation | | | |
| 4 | Tests | | | | |
| 4.1 | Power line carrier equipment | | | | |
| 4.1.1 | Routine Tests | | | | |
| | a) Comply with clause 4.1.1a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 4.1.1b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 4.1.1c) of this specification | Comply and provide supporting documentation | | | |
| | d) Comply with clause 4.1.1d) of this specification | Comply and provide supporting documentation | | | |
| | e) Comply with clause 4.1.1e) of this specification | Comply and provide supporting documentation | | | |
| | f) Comply with clause 4.1.1f) of this specification | Comply and provide supporting documentation | | | |
| | g) Comply with clause 4.1.1g) of this specification | Comply and provide supporting documentation | | | |
| | h) Comply with clause 4.1.1h) of this specification | Comply and provide supporting documentation | | | |
| | i) Comply with clause 4.1.1i) of this specification | Comply and provide supporting documentation | | | |

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| | j) Comply with clause 4.1.1j) of this specification | Comply and provide supporting documentation | | | |
| | k) Comply with clause 4.1.1k) of this specification | Comply and provide supporting documentation | | | |
| 4.1.2 | Type Tests | | | | |
| | a) Comply with clause 4.1.2a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 4.1.2b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 4.1.2c) of this specification | Comply and provide supporting documentation | | | |
| | d) Comply with clause 4.1.2d) of this specification | Comply and provide supporting documentation | | | |
| | e) Comply with clause 4.1.2e) of this specification | Comply and provide supporting documentation | | | |
| | f) Comply with clause 4.1.2f) of this specification | Comply and provide supporting documentation | | | |
| | g) Comply with clause 4.1.2g) of this specification | Comply and provide supporting documentation | | | |
| | h) Comply with clause 4.1.2h) of this specification | Comply and provide supporting documentation | | | |
| | i) Comply with clause 4.1.2i) of this specification | Comply and provide supporting documentation | | | |
| | j) Comply with clause 4.1.2j) of this specification | Comply and provide supporting documentation | | | |
| | k) Comply with clause 4.1.2k) of this specification | Comply and provide | | | |

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| | | supporting documentation | | | |
| | l) Comply with clause 4.1.2l) of this specification | Comply and provide supporting documentation | | | |
| | m) Comply with clause 4.1.2m) of this specification | Comply and provide supporting documentation | | | |
| | n) Comply with clause 4.1.2n) of this specification | Comply and provide supporting documentation | | | |
| | o) Comply with clause 4.1.2o) of this specification | Comply and provide supporting documentation | | | |
| 4.2 | Carrier Combiner Units with Symmetrical Hybrid (SH) | | | | |
| 4.2.1 | Routine Tests | | | | |
| | a) Comply with clause 4.2.1a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 4.2.1b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 4.2.1c) of this specification | Comply and provide supporting documentation | | | |
| 4.2.2 | Type Tests | | | | |
| | a) Comply with clause 4.2.2a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 4.2.2b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 4.2.2c) of this specification | Comply and provide supporting documentation | | | |
| | d) Comply with clause 4.2.2d) of this specification | Comply and provide supporting documentation | | | |

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| 4.3 | Integrated Teleprotection equipment | | | | |
| 4.3.1 | Routine Tests | | | | |
| | a) Comply with clause 4.3.1a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 4.3.1b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 4.3.1c) of this specification | Comply and provide supporting documentation | | | |
| | d) Comply with clause 4.3.1d) of this specification | Comply and provide supporting documentation | | | |
| | e) Comply with clause 4.3.1e) of this specification | Comply and provide supporting documentation | | | |
| | f) Comply with clause 4.3.1f) of this specification | Comply and provide supporting documentation | | | |
| | g) Comply with clause 4.3.1g) of this specification | Comply and provide supporting documentation | | | |
| | h) Comply with clause 4.3.1h) of this specification | Comply and provide supporting documentation | | | |
| 4.3.2 | Type Tests | | | | |
| | a) Comply with clause 4.3.2a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 4.3.2b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 4.3.2c) of this specification | Comply and provide supporting documentation | | | |
| | d) Comply with clause 4.3.2d) of this specification | Comply and provide | | | |

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| | | supporting documentation | | | |
| | e) Comply with clause 4.3.2e) of this specification | Comply and provide supporting documentation | | | |
| | f) Comply with clause 4.3.2f) of this specification | Comply and provide supporting documentation | | | |
| | g) Comply with clause 4.3.2g) of this specification | Comply and provide supporting documentation | | | |
| | h) Comply with clause 4.3.2h) of this specification | Comply and provide supporting documentation | | | |
| | i) Comply with clause 4.3.2i) of this specification | Comply and provide supporting documentation | | | |
| | j) Comply with clause 4.3.2j) of this specification | Comply and provide supporting documentation | | | |
| 4.4 | Converter/Multiplexer Equipment | | | | |
| 4.4.1 | Routine Tests | | | | |
| | a) Comply with clause 4.4.1a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 4.4.1b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 4.4.1c) of this specification | Comply and provide supporting documentation | | | |
| 4.4.2 | Type Tests | | | | |
| | a) Comply with clause 4.4.2a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 4.4.2b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 4.4.2c) of this specification | Comply and provide | | | |

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| | | supporting documentation | | | |
| | d) Comply with clause 4.4.2d) of this specification | Comply and provide supporting documentation | | | |
| | e) Comply with clause 4.4.2e) of this specification | Comply and provide supporting documentation | | | |
| 4.5 | Test certificates and witnessing of tests | | | | |
| 4.5.1 | Test certificates | | | | |
| | a) Comply with clause 4.5.1a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 4.5.1b) of this specification | Comply and provide supporting documentation | | | |
| 4.5.1 | Witnessing of Tests | | | | |
| | a) Comply with clause 4.5.2a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 4.5.2b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 4.5.2c) of this specification | Comply and provide supporting documentation | | | |
| 5 | Delivery, Packaging and Labelling | | | | |
| 5.1 | Delivery | | | | |
| | a) Comply with clause 5.1a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 5.1b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 5.1c) of this specification | Comply and provide supporting documentation | | | |
| 5.2 | Packaging | | | | |

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| | a) Comply with clause 5.2a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 5.2b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 5.2c) of this specification | Comply and provide supporting documentation | | | |
| | d) Comply with clause 5.2d) of this specification | Comply and provide supporting documentation | | | |
| | e) Comply with clause 5.2e) of this specification | Comply and provide supporting documentation | | | |
| | f) Comply with clause 5.2f) of this specification | Comply and provide supporting documentation | | | |
| | g) Comply with clause 5.2g) of this specification | Comply and provide supporting documentation | | | |
| 5.3 | Labelling | | | | |
| | a) Comply with clause 5.3a) of this specification | Comply and provide supporting documentation | | | |
| | b) Comply with clause 5.3b) of this specification | Comply and provide supporting documentation | | | |
| | c) Comply with clause 5.3c) of this specification | Comply and provide supporting documentation | | | |
| | d) Comply with clause 5.3d) of this specification | Comply and provide supporting documentation | | | |
| | e) Comply with clause 5.3e) of this specification | Comply and provide supporting documentation | | | |