

	Standard	National Transmission Company South Africa
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Content

Page

1. Introduction.....	4
2. Supporting Clauses	4
2.1 Scope.....	4
2.1.1 Purpose.....	4
2.1.2 Applicability	4
2.2 Normative/Informative References	4
2.2.1 Normative.....	4
2.2.2 Informative.....	5
2.3 Definitions	5
2.4 Abbreviations	5
2.5 Roles and Responsibilities	5
2.6 Process for Monitoring.....	5
2.7 Related/Supporting Documents.....	5
3. Requirements	5
3.1 General	5
3.1.1 Environmental conditions.....	5
3.2 Line Matching Equipment.....	6
3.2.1 Weatherproof housing	6
3.2.2 General	7
3.2.3 Operation of the Line Matching Equipment.....	8
3.2.4 Tuning device	9
3.2.5 Matching transformer.....	9
3.2.6 Drain coil	10
3.2.7 Earthing Switch	10
3.2.8 Protective device	10
3.2.9 The 3 dB Attenuator Circuit	11
3.2.10 Marking	11
3.3 Drawings and instruction manuals.....	11
3.3.1 Drawings	11
3.3.2 Instruction manuals	12
3.4 Quality assurance.....	12
4. Tests	13
4.1 General	13
4.2 Inspection and witnessing of Tests.....	13
4.3 Routine tests	13
4.4 Type tests.....	14
4.4.1 Measurement of return loss of LME.....	14
4.4.2 Distortion and intermodulation test of LME	14
4.4.3 Insulation of primary terminal of LME.....	14

CONTROLLED DISCLOSURE

4.4.4	Insulation of matching transformer.....	14
4.4.5	Drain coil test.....	14
4.4.6	Tests on protective device	15
4.4.7	Tests on the 3 dB Attenuator	15
5.	Delivery, packaging and labelling	15
6.	Acceptance.....	16
7.	Revisions.....	16
8.	Development Team	16
9.	Acknowledgements	16
	Appendix A – Rated Capacitance for CCs and CVTs.....	17
	Appendix B – Schedules A and B	18

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1. Introduction

Eskom has a large HV and EHV transmission network and makes extensive use of Power Line Carriers for teleprotection signalling, and to a lesser extent for the provision of operational speech and data channels. Given the geography of the country, many of the transmission lines are extremely long, and efficient carrier coupling systems are imperative. This standard describes Eskom's requirements for one component of a carrier coupling system, namely the Line Matching Equipment (LME).

2. Supporting Clauses

2.1 Scope

The scope of this standard details NTCSA's requirements for the Line Matching Equipment.

2.1.1 Purpose

This standard provides for the manufacture, testing at works, delivery to site, and off-loading of the power line carrier line matching equipment.

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions/ National Transmission Company South Africa SOC Ltd Reg No 2021/539129/30.

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] IEC 60099-4: Surge arresters – Part 4: Metal-oxide surge arresters without gaps for a.c. systems.
- [3] IEC 60481:1974: Coupling devices for power line carrier systems.
- [4] IEC 60529: 2001: Degrees of Protection provided by enclosures (IP code).
- [5] 240-75655504: Eskom Specification: Corrosion protection standard for new indoor and outdoor Eskom equipment, components, materials and structures manufactured from steel standard.
- [6] TST41-634: Transmission Standard: Drawing Office Standard.
- [7] QM-58, Eskom Standard: Supplier Contract Quality Requirements specification.
- [8] SANS 1091:2004 South African National Standard: National Colour Standard.
- [9] BS EN 10088-2:2005, British Standard: Stainless Steels – Part 2: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes.

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2.2.2 Informative

[10] IEC 60099-1: 1999, Surge arresters — Part 1 : Non-linear resistor type gapped surge arresters for a.c. systems. BS 381C:1996, Specification for colours for identification, coding and special purposes.

2.3 Definitions

None.

2.4 Abbreviations

Abbreviation	Explanation
CC	Coupling Capacitor
CVT	Capacitor Voltage Transformer
EHV	Extra High Voltage
HV	High Voltage
LME	Line Matching Equipment
PEP	Peak Envelope Power
QA	Quality Assurance
r.m.s.	Root Mean Square
UHF	Ultra High Frequency
USB	Universal Serial Bus

2.5 Roles and Responsibilities

Not applicable.

2.6 Process for Monitoring

Not applicable.

2.7 Related/Supporting Documents

Not applicable.

3. Requirements

3.1 General

3.1.1 Environmental conditions

The equipment will be operated under the following conditions:

- a) Outdoors.
- b) At sea level and at an altitude above sea level up to 1800 m.

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- c) At the following ambient air temperatures.
 - 1) Maximum 55 °C.
 - 2) Daily average 30 °C.
 - 3) Yearly average 20 °C.
 - 4) Minimum –10 °C.
 - 5) Maximum diurnal variation 35 °C.
- d) Lightning - extremely severe.

3.2 Line Matching Equipment

3.2.1 Weatherproof housing

3.2.1.1 Construction

- a) Enclosure:
 - i. The boxes for outdoor installation shall be made of stainless steel of not less than 1 mm thickness.

Eskom is prepared to consider boxes made of alternative materials, i.e. aluminium or aluminium alloy, but requires details of field experience the supplier has had, together with full details of any tests which have been performed to prove the durability of the material used. If the boxes are made from aluminium or aluminium alloy, the thickness shall not be less than 2 mm. The details of the aluminium alloy composition shall be provided.
 - ii. The boxes shall be water and dustproof to IP 54 as defined in IEC 60529, while the doors/covers shall be provided with suitable grommets or shall be of the double step design. Rubber shall not be used for grommets.
 - iii. The stainless steel box must be rust and corrosion proof and must be of a grade of 316 or better as specified in the BS EN 10088-2:2005 standard.

If the aluminium or aluminium alloy boxes are used, the box must be rust and corrosion proof. The required information shall accompany the tender.

In the case of aluminium and aluminium alloy boxes, appropriate measures shall be taken and listed to avoid corrosion effects due to the connection of dissimilar materials, particularly where cables are glanded to enter the box and at the connection of the earth strap from the station earth mat.
- b) Hinged doors shall be provided in preference to covers. Each hinged door shall be fitted with a minimum of two non-ferrous hinges and one or two suitable non-ferrous fasteners. The fasteners shall be of the wedge-action type and must be suitably latched in the fully closed position. The door shall have a door stay that is constructed from the same material as the boxes described in a) above and have the necessary physical strength to accommodate the size of the door without bending or breaking.
- c) The boxes shall be suitable for steel structure mounting without any requirements for drilling or damaging the steel structure. The boxes shall be supported so that there is a free air passage between the box and the steel structure.

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- d) Each box shall be provided with one or more suitable openings to enable the equipment to breathe fully so as to prevent the occurrence of the phenomenon known as “sweating”. The breathing holes shall be so positioned, and provided with suitable shields, that there is no possibility of ingress of dust or water falling on the equipment at any angle from vertical to 45 ° above horizontal.
- e) The breathing holes shall be fitted with internal stainless steel gauze coverings, made of non-corroding material, which shall exclude the entry of all forms of insect life. One breathing hole shall be positioned at the lowest point of the enclosure in order to act as a drain for any condensed moisture. It shall be made in such a manner that no internal rim or ledge shall be formed to act as an obstruction to the drainage.

3.2.1.2 Finish

- a) All exterior surfaces shall be protected from corrosion as specified in Eskom’s specification 240-75655504.
- b) All exterior surfaces of aluminium and aluminium alloy boxes shall be treated and the box shall be painted ‘Light Grey – G29’ from the SANS 1091:2004 standard.

3.2.1.3 Nuts, bolts and washers

All nuts, bolts and washers shall be compatible with the enclosure chosen in section 3.2.1.1. The threaded portions of nuts need not be metalized, and will be accepted well-greased. Undercutting of threads may not be done without prior discussion and agreement on the depth of undercut and the tolerance to be met.

3.2.2 General

- a) Line matching equipment shall be suitable for carrying out the following functions:
 - 1) Coupling carrier signals to the transmission line.
 - 2) Matching the surge impedance of the carrier frequency cable and the transmission line.
 - 3) Preventing power frequency voltages and currents from entering the carrier equipment.
 - 4) Protecting the carrier equipment from surges on the power transmission system.
- b) The complete assembly of the line matching equipment associated with one coupling capacitor, shall include a drain coil, earthing switch, surge arrester, coupling filter and matching transformer which shall be accommodated in a suitable housing as specified in 3.2.1.1.
- c) The equipment in the box shall be arranged such that the earthing switch can be left open when the cover is closed for normal operation.
- d) Each box shall be provided with an undrilled removable conductive and non corrosive metallic gland plate of the minimum size specified or could possibly be supplied with suitably blanked pre-drilled holes. The gland plate size shall be 90 mm x 200 mm.

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- e) Eskom's standard carrier coupling philosophy requires a single line matching equipment on each phase associated with carrier signal injection, with a separate co-axial cable to the power line carrier equipment. Combining of carrier signals will be carried out within the power line carrier equipment.
- f) Each LME secondary terminal shall be fitted with an ungrounded UHF coaxial socket complete with a plug for connection to the equipment.
- g) The UHF plugs shall be of the crimp type, suitable for use with a 75 Ω co-axial cable, which has a smaller inner core diameter than the standard 50 Ω co-axial cable. The LME shall incorporate impedance transformations to the impedance values specified.
- h) The UHF insulated coaxial socket shall be the SO 239 T fitted with UHF crimp type 11 UHF 0-7-19C connector.
- i) The primary terminal of the LME shall consist of an HV bushing located at the top of the unit. This terminal will be connected by means of a 10 mm round copper bar to the low-voltage terminal of the associated coupling capacitor.
- j) The earth terminal stud of the LME shall be not less than 10 mm in diameter and shall be suitable for accommodating a 50 mm \times 3 mm copper earthing strap. If the earth terminal is a flat pad or bar it shall be drilled to accept a 10mm bolt.
- k) The winding construction of filter coils and drain coils shall be impregnated under vacuum.

3.2.3 Operation of the Line Matching Equipment

3.2.3.1 Power rating

The LME shall have a minimum power handling capacity of 400 W peak envelope power (PEP) and 100 Wr.m.s. at any frequencies in the specified carrier frequency range. The PEP power handling capacity shall be defined as the maximum PEP output at which the intermodulation products are not more than 80 dB below the PEP level.

3.2.3.2 Frequency range

The LME shall operate over the carrier frequency band of 40 kHz to 500 kHz. If a single LME unit cannot manage the 40 kHz to 500 kHz frequency range, then the LME can be split into a high pass LME and a band pass LME. The high pass LME shall have a frequency range of 100 kHz to 500 kHz. To provide for the carrier frequency range from 40 kHz to 100 kHz, there could be a single or multiple band pass LMEs.

3.2.3.3 Insulation withstand test voltages

The LME shall be designed to be able to withstand a 1,2/50 μ s impulse voltage with 10 kV peak value applied between the primary terminal and earth of the LME, with the protective devices disconnected.

3.2.3.4 Terminal polarities

The phasing of the LME primary terminals, relative to the secondary terminals connected to the carrier equipment shall be clearly marked on the equipment or equipment drawings. The phasing arrangement adopted shall remain consistent on all equipment supplied.

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3.2.4 Tuning device

- a) The filters incorporated in the LMEs shall preferably be of the high-pass type, and shall be tuned to provide the maximum bandwidth with the line impedance and coupling capacitance specified. The filters shall preferably incorporate fixed tapped components to facilitate operation as a band-pass filter at low frequencies, when used with the line impedance and capacitance specified.
- b) The high-pass type LME shall be capable of operating with coupling capacitances in the standard range between 4400 pF to 8000 pF.
- c) The high-pass type LME shall be capable of operating with line impedances in the standard range between 200 Ω to 400 Ω .
- d) The band-pass type LME shall be capable of operating with coupling capacitances in the standard range between 4400 pF to 8000 pF.
- e) The band-pass type LME shall be capable of operating with line impedances in the standard range between 150 Ω to 400 Ω .
- f) The bandwidth of the LME is determined by the composite (insertion) loss and return loss of the LME and associated CC (which is assumed to have no loss), when the system is terminated in its nominal line side and equipment side impedances.
- g) The composite (insertion) loss of the complete LME shall not be greater than 1,5 dB over the LME bandwidth.
- h) The return loss of the complete LME shall not be less than 12 dB over the LME bandwidth.
- i) The LME tuning units shall be tested and supplied for use, with the coupling capacitance and the impedance specified, in the configuration called for in the Contract document.

3.2.5 Matching transformer

- a) The matching transformer incorporated in the LME is required to provide impedance transformation between the nominal line impedance and the nominal equipment impedance, as well as isolation between the primary and secondary terminals of the LME. Auto-transformers are not acceptable.
- b) The primary winding shall have tapped impedance for nominal line impedances between 200 Ω and 400 Ω . An option of a tapped impedance for nominal line impedances that ranged from 120 Ω to 200 Ω would be an advantage.
- c) The secondary winding shall provide a nominal input impedance of 75 Ω . The provision of other tappings for different nominal input impedances will be considered an advantage.
- d) The secondary windings shall be completely isolated from earth.
- e) The matching transformer shall have a 1 min power frequency withstand insulation of 5 kV r.m.s. between the primary and secondary windings and between both primary and secondary windings and earth.
- f) The matching transformer shall be tested and supplied with the primary winding taps and the secondary winding taps set to the impedance taps specified in schedule A of an enquiry document.

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3.2.6 Drain coil

- a) The LME shall have an impedance at power frequency, between the primary terminal and the earth terminal, of not greater than 20 Ω . This low impedance shall be obtained by a device such as a drain coil, filter coil or matching transformer winding.
- b) The drain coil, or any device performing the function of the drain coil, shall be permanently connected between the primary terminal and earth terminal of the LME. Any device which is intended to perform the function of a drain coil, but which has taps or links which can be open-circuited during adjustment is not acceptable.
- c) The drain coil, if operating as an independent unit, shall have an impedance over the specified frequency range of not less than 10 k Ω .
- d) The drain coil shall be capable of withstanding a power frequency current of 1 A r.m.s. continuously and 50 A r.m.s. for 0,2 s.
- e) The drain coil shall have a 1,2/50 μ s impulse withstand insulation of 10 kV.

3.2.7 Earthing Switch

- a) The earthing switch shall be permanently connected between the primary terminal and the earth terminal of the LME.
- b) The earthing switch shall have a power frequency current carrying capacity of 150 A r.m.s continuous.
- c) The earthing switch shall be capable of withstanding the impulse test voltages applied to the primary terminal of the LME.
- d) If the earthing switch is internal to the LME and the operating lever is external to the LME housing, the operating lever shall be clearly marked "EQUIPMENT EARTHED" when the earthing switch is closed.
- e) The earthing switch shall be operated by a lever or handle which is insulated to 2 kV for 1 s. Alternatively, the earthing switch may be operated by an insulated hook device which is supplied with the LME. The operating lever or handle shall, when in the "Open" or "Off" position, be connected to the side of the switch that is directly connected to earth.

3.2.8 Protective device

- a) A protective device shall be connected as directly as possible between the primary and earth terminals of the LME.
- b) The protective device shall be capable of protecting the LME and the carrier frequency connection to the carrier equipment.
- c) Protective devices are not required on the secondary terminals of the carrier equipment connection.
- d) Protective devices shall not be operated, or remain in operation, following transient actuation by the carrier frequency voltage developed across the LME by the specified carrier frequency PEP power.
- e) The protective device shall be of the gapped non-linear resistor type.

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- f) Non-linear surge arresters shall have a rated voltage and impulse spark-over voltage consistent with the requirements of 3.2.8 d) and shall be capable of sustaining an impulse discharge current of wave shape 8/20 μ s of 5 kA.

3.2.9 The 3 dB Attenuator Circuit

- a) The basic LME must be provided with an optional “add on” 3 dB attenuator circuit to improve the matching between the PLC equipment and the power line for certain applications. The 3 dB attenuator should be such that it can be included in the LME by means of a convenient mounting arrangement which does not require any alteration or dismounting of the integral LME components.
- b) The 3 dB attenuator shall have a continuous rating of 100 W rms and a PEP rating of 400 W without any individual component being stressed to more than 50% of its normal rating.

3.2.10 Marking

Rating plates shall be engraved, stamped or embossed on brass or stainless steel, with the following information:

- a) Eskom Order No.
- b) Manufacturer’s Name
- c) Type
- d) Serial number
- e) Nominal PEP
- f) Minimum capacitance of coupling capacitor
- g) Nominal line-side and equipment-side impedances
- h) Available bandwidth with f) and g) above.

3.3 Drawings and instruction manuals

3.3.1 Drawings

- a) Drawings shall be marked-up in English.
- b) Duplicated copies of a schedule listing all drawings and circuit diagrams applicable to all the equipment included in the contract, shall be supplied with or before the notification of readiness for acceptance testing.
- c) The following drawings shall be submitted by the supplier/manufacturer in duplicate for all the equipment included in the contract, before contract establishment:
- 1) A drawing giving outline dimensions, mounting details and details of the HV and earth terminals.
 - 2) A drawing showing the assembly details of the complete unit.
 - 3) A drawing showing a complete circuit diagram of the unit and including the standard strapping arrangements of the equipment as delivered.

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- d) Handbook drawings and descriptions shall conform to the international A4 series (295 x 220 mm). Larger drawings, which cannot be accommodated on this size, shall be folded into a single A4 panel, along the 295 mm axis of the standard A4 series. Handbook drawings which must be unfolded in two directions are not acceptable.
- e) The handbooks, complete with drawings, shall also be provided on a USB flash drive, using Microsoft Office or Acrobat format, in addition to the hard copies requested.
- f) Where changes to the equipment are envisaged, either by the manufacturer or Eskom, within the negotiated 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.

3.3.2 Instruction manuals

- a) The specified number of copies of the instruction manuals and descriptive information, in English, shall be supplied covering all equipment in a contract, before the first items of equipment are dispatched from the works.
- b) The instruction manuals shall conform to the international A4 series (295 x 220 mm) and may be a booklet or hard-cover ring file type, and they shall open flat at any page.
- c) The manuals shall include technical details of the equipment, and complete details concerning installation, commissioning and adjustment for the equipment actually supplied, in addition to the drawings as detailed in 3.3.1 c).
- d) The manuals shall, where appropriate, give details of the testing procedure used to verify the basic parameters of the equipment. Manuals for the Line Matching Equipment shall give curves of insertion loss and return loss for the equipment supplied.
- e) The manuals shall contain full details of component values or the manufacturer's type numbers, for all components within the units, as well as the rating of the components used.
- f) The manual, complete with all drawings, shall also be provided on a USB flash drive, format using Acrobat Adobe, in addition to the hard copies requested.

3.4 Quality assurance

- a) Eskom's Quality Assurance requirements as specified in QM-58 are applicable.
- b) No equipment forming part of the contract, which is locally manufactured, shall be delivered until the equipment and drawings have been approved by Eskom. In addition, such new equipment, progressive increase in local manufacture or content, or modifications to equipment, shall have successfully passed all the routine tests and type tests specified. The costs of any such additional tests shall be at the manufacturer's expense.
- c) If any unit, sub-unit or module exhibits a failure rate of 0.10 (i.e. 10% fail) 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 cost to Eskom. The period of warranty for portions of the works affected by such replacement shall then be accordingly extended.

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4. Tests

4.1 General

The following test certificates, in English, shall be submitted:

- a) Routine test certificates:
 - 1) One copy of the routine test certificates as required in section 4.2 shall be supplied with each equipment.
 - 2) One copy of the routine test certificate shall be retained by the manufacturer for a period of five years for reference by Eskom if required.
 - 3) Each routine test certificate shall detail the Eskom order number and item number and the manufacturer's serial number.
 - 4) The most common application in Eskom for the LME is for a line impedance of 240 ohms, coupling capacitance of 4400 pF, frequency range 100 kHz to 500 kHz and the secondary impedance of 75 ohms. The LME needs to include all these components specified.
- b) Type test certificates:
 - 1) One copy of all the type test certificates as required in section 4.3 shall be supplied before contract has been established. The type test certificates shall give all relevant details of the tests, in addition to the test results, and where appropriate shall include oscillograms or graphs of the equipment performance with the amplitude and time of frequency graduations clearly indicated.
 - 2) One copy of the type test certificates shall be retained by the manufacturer for a period of five years for reference by Eskom if required.

4.2 Inspection and 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/her 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 from Eskom whether inspection or witnessed tests, or both, are required. The manufacturer shall then give Eskom not less than 14 days notice in the case of local manufacture, and thirty days notice in the case of foreign manufacture, of when the equipment will be ready for inspection or the witnessing of the requested tests.

4.3 Routine tests

The standard ambient temperature range for testing shall be 15 °C to 35 °C.

The composite (insertion) and return loss of the complete LME shall be measured over the available bandwidth. The coupling capacitor shall be replaced by test capacitors having negligible loss and a capacitance equal to the nominal capacitance specified. The capacitor shall be terminated in an impedance equal to the nominal line impedance specified.

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4.4 Type tests

The standard ambient temperature range for testing shall be 15 °C to 35 °C.

Type tests shall be carried out on one complete LME of each type, should the high-pass and band-pass designs be of different configurations.

If evidence is available of type tests on identical equipment, this may be accepted in place of these tests, and the relevant documents shall be submitted with the tender.

Every LME to which it is intended to apply type tests, shall first have withstood satisfactorily the application of all routine tests. All tests shall be carried out on the same LME, unless otherwise approved.

4.4.1 Measurement of return loss of LME

The return loss shall be measured over the carrier bandwidth available. The coupling capacitor shall be replaced by test capacitors having negligible loss and a capacitance equal to the nominal capacitance specified. The capacitor shall be terminated in an impedance specified.

4.4.2 Distortion and intermodulation test of LME

This test shall be repeated at 50 kHz intervals over the available frequency band, as specified in IEC 60481, with the nominal coupling capacitance and line impedance specified. As an alternative, the manufacturer's calculations of PEP rating and inter-modulation distortion over the frequency range will be accepted.

4.4.3 Insulation of primary terminal of LME

Ten 1,2/50µs voltage impulses shall be applied in sequence, five negative impulses and five positive impulses, with a peak value of 10 kV between the primary and earth terminals of the LME with the protective devices removed, as detailed in IEC 60481. On completion of this test the composite (insertion) loss of the LME shall be checked as specified in 4.3.

4.4.4 Insulation of matching transformer

A power frequency voltage of 5 kV r.m.s. shall be applied for 1 min between the primary and secondary windings and earth, and between both the secondary and primary windings and earth as detailed in IEC 60481.

4.4.5 Drain coil test

- a) The drain coil insulation shall be tested by the application of ten 1,2/50µs voltage impulses. These shall be applied in sequence, five negative and five positive, and shall have a peak value of 10 kV.
- b) The drain coil current carrying capacity shall be tested by means of a power frequency current of 1 A r.m.s. continuously, and 50 A r.m.s. for 0,2 s.
- c) The high-frequency performance loss of the drain coil shall be ascertained by measuring the impedance of the drain coil over the carrier frequency band.

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- d) The drain coil impedance shall be measured at the rated power frequency with a current of 1 A r.m.s.

4.4.6 Tests on protective device

The protective device shall be tested in the manner specified in SANS 60099-4 (IEC 60099-4).

4.4.7 Tests on the 3 dB Attenuator

4.4.7.1 Type Test

The rated power (100 W r.m.s) shall be applied to the 3 dB attenuator for a period of 1 hour and the temperature of the individual components shall not exceed 75% of the nominal maximum temperature rating. The tests shall be done at the maximum ambient temperature as specified in section 3.1.1 c).

4.4.7.2 Routine Tests

- a) The insertion loss on the 3 dB attenuator shall be measured over the PLC frequency range. The insertion loss shall remain within 5% of nominal (3dB) across the PLC frequency range of 40 to 500 kHz.
- b) The return loss on the 3 dB attenuator shall be measured over the PLC frequency range when terminated in a 75 ohm non inductive resistor. The minimum allowable return loss is 20 dB across the entire PLC frequency range.

5. Delivery, packaging and labelling

- a) The equipment shall be delivered to the destinations stated in the enquiry document.
- b) The ex-works delivery dates, and delivery dates to site, for the equipment shall be indicated in the appropriate schedule of the enquiry document. The equipment shall be protectively packed in such a way that it can be safely transported, handled and stored at site, as it will not necessarily be possible for erection to commence immediately upon delivery.
- c) The design of the equipment packaging shall be such that if the case or carton is dropped from a height of 1 m onto a flat surface, no damage shall occur to the equipment.
- d) Attention is drawn to the fact that Eskom accepts delivery at the specified destinations only, and that the supplier shall make all necessary arrangements for acceptance, off-loading and trans-shipping at all intermediate points, as well as the ultimate off-loading at the specified destination.
- e) Where called for, the equipment shall be erected on prepared supporting structures supplied by Eskom. Erection shall include supply of all necessary tools for installation of the equipment, and these items shall be removed from site when erection is completed.
- f) Power supplies are not available at site.
- g) Equipment packaging shall be clearly stencilled with paint, with the Eskom delivery address, and Eskom's order and item number. If an item consists of more than one package then each package shall be further identified, i.e. Box 1 of 4.

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6. Acceptance

This document has been seen and accepted by:

Name	Designation
Alison Maseko	Senior Manager – TX Telecoms
Judith Malinga	Senior Manager – TX PTM&C Engineering
Lenah Mothata	Senior Manager – TX Grids
Johan Pieterse	Chief Engineer – TX Secondary Plant, Work Planning and Centralised Services
Richard McCurrach	Senior Manager – TX IM
Aletta Mashao	Senior Manager – PTM&C DX
Malcolm Van Harte	Senior Manager – DX Smart Grid and Network Operations COE
Ezzard de Lange	Senior Manager – DX Operational Technology and Cyber Security
Christoph Kohlmeyer	Senior Manager – GX Engineering (Acting)
Sithembile Songo	Senior Manager – IT Information Security
Tebogo Makhwelo	Senior Manager - IT Infrastructure Operations
Varsha Pillay	Senior Manager – IT Application Operations

7. Revisions

Date	Rev.	Compiler	Remarks
August 2024	3	T Gosai	Revised to align Technical Schedules for LME Enquiry.
April 2021	2	T Gosai	Revised due to review date expiry.
July 2016	1	T Gosai	Revised the TSP41-596 standard in the new template format.

8. Development Team

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

- Ashley Van Der Poel
- Riyaz Gangat
- Zakhele Dlamini

9. Acknowledgements

None.

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Appendix A – Rated Capacitance for CCs and CVTs**Table Error! No text of specified style in document..1: Rated capacitance for coupling capacitors and CVTs**

Rated system voltage (Line-to-line) (kV r.m.s.)	Rated minimum capacitance (pF)
22	10 000
66	10 000
88	9 000
132	8 000
220	7 000
275	6 000
330	5 000
400	4 400
765	4 400

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Appendix B – Schedules A and B

TECHNICAL SCHEDULES A & B FOR POWER LINE CARRIER - LINE MATCHING EQUIPMENT STANDARD IN ACCORDANCE WITH ESKOM STANDARD 240-106920412					
Schedule A: Purchaser's specifications Schedule B: Guarantees, compliance and technical particulars of equipment offered The following tabulated requirements emulate the sectional numbering of Standard 240-106920412:					
<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: 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. <ul style="list-style-type: none"> • 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. 					
No.	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	Requirements	 	 	 	
3.1	General	 	 	 	
3.1.1	Environmental conditions	 	 	 	
	a) Comply with clause 3.1.1a) of this specification, Outdoors	Comply and provide supporting documentation			
	b) Comply with clause 3.1.1b) of this specification, at sea level and at an altitude above sea level up to 1800m	Comply and provide supporting documentation			
	c) Comply with clause 3.1.1c) 1) of this specification, Maximum 55 °C	Comply and provide supporting documentation			
	d) Comply with clause 3.1.1c) 2) of this specification, Daily average 30 °C	Comply			

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	e) Comply with clause 3.1.1c) 3) of this specification, Yearly average 20 °C	Comply			
	f) Comply with clause 3.1.1c) 4) of this specification, Minimum -10 °C	Comply and provide supporting documentation			
	g) Comply with clause 3.1.1c) 5) of this specification, Maximum diurnal variation 35 °C	Comply			
	h) Comply with clause 3.1.1d) of this specification, Lightning - extremely severe	Comply and provide supporting documentation			
3.2	Line Matching Equipment				
3.2.1	Weatherproof housing				
3.2.1.1	Construction				
	<p>a) i.) Stainless Steel Enclosure: The boxes for outdoor installation shall be made of stainless steel of not less than 1 mm thickness.</p> <p>Aluminium or Aluminium Alloy Enclosure: Eskom is prepared to consider boxes made of alternative materials, i.e. aluminium or aluminium alloy, but requires details of field experience the supplier has had, together with full details of any tests which have been performed to prove the durability of the material used. If the boxes are made from aluminium alloy, the thickness shall not be less than 2 mm. The details of the aluminium alloy composition shall be provided.</p>	Comply and provide supporting documentation.			
	a) ii.) The boxes shall be water and dustproof to IP 54 as defined in IEC 60529, while the doors/covers shall be provided with suitable grommets or shall be of the double step design. Rubber shall not be used for grommets.	Comply and provide supporting documentation.			

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	<p>a) iii.) Stainless Steel Enclosure: The stainless steel box must be rust and corrosion proof and must be of a grade of 316 or better as specified in the BS EN 10088-2:2005 standard.</p> <p>Aluminium or Aluminium Alloy Enclosure: If the aluminium or aluminium alloy boxes are used, the box must be rust and corrosion proof. The required information shall accompany the tender. In the case of aluminium and aluminium alloy boxes, appropriate measures shall be taken and listed to avoid corrosion effects due to the connection of dissimilar materials, particularly where cables are glanded to enter the box and at the connection of the earth strap from the station earth mat.</p>	Comply and provide supporting documentation.			
	b) Comply with clause 3.2.1.1 b) of this specification (Doors).	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) of this specification	Comply and provide supporting documentation			
	e) Comply with clause 3.2.1.1 e) of this specification	Comply and provide supporting documentation			
3.2.1.2	Finish				
	<p>Stainless Steel Enclosure: a) Comply with clause 3.2.1.2a) of this specification (comply with Eskom standard, 240-75655504 for corrosion protection).</p> <p>Aluminium or Aluminium Alloy Enclosure: b) Comply with clause 3.2.1.2b) of this specification.</p>	Comply and provide supporting documentation			
3.2.1.3	Nuts, bolts and washers				
	a) Comply with the clause in section 3.2.1.3 of this specification.	Comply and provide supporting documentation			
3.2.2	General				
	a) Comply with clause 3.2.2 a) 1) of this specification (Coupling carrier signals to the transmission line)	Comply and provide supporting documentation			

CONTROLLED DISCLOSURE

	b) Comply with clause 3.2.2 a) 2) of this specification (Matching the surge impedance of the carrier frequency cable and the transmission line)	Comply and provide supporting documentation			
	c) Comply with clause 3.2.2 a) 3) of this specification (Preventing power frequency voltages and currents from entering the carrier equipment)	Comply and provide supporting documentation			
	d) Comply with clause 3.2.2 a) 4) of this specification (Protecting the carrier equipment from surges on the power transmission system)	Comply and provide supporting documentation			
	e) Comply with clause 3.2.2 b) of this specification (drain coil, earthing switch, surge arrester, coupling filter and matching transformer which shall be accommodated in a suitable housing)	Comply and provide supporting documentation			
	f) Comply with clause 3.2.2 c) of this specification (earthing switch)	Comply and provide supporting documentation			
	g) Comply with clause 3.2.2 d) of this specification (gland plates)	Comply and provide supporting documentation			
	h) Comply with clause 3.2.2 f) of this specification (UHF sockets/plugs)	Comply and provide supporting documentation			
	i) Comply with clause 3.2.2 g) of this specification (UHF plugs)	Comply and provide supporting documentation			
	j) Comply with clause 3.2.2 h) of this specification (UHF socket/connector)	Comply and provide supporting documentation			
	k) Comply with clause 3.2.2 i) of this specification (HV bushing)	Comply and provide supporting documentation			
	l) Comply with clause 3.2.2 j) of this specification (earth terminal)	Comply and provide supporting documentation			
	m) Comply with clause 3.2.2 k) of this specification (coils impregnated under vacuum)	Comply and provide supporting documentation			
3.2.3	Operation of the Line Matching Equipment				
3.2.3.1	Power Rating				
	a) Comply with clause in section 3.2.3.1) of this specification (Rated PEP handling capacity with inter-modulation products at least 80 dB below rated PEP)				

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	1) at 50 kHz, minimum: 400W	Comply and provide supporting documentation			
	2) at 100 kHz, minimum: 400W	Comply and provide supporting documentation			
	3) at 250 kHz, minimum: 400W	Comply and provide supporting documentation			
	4) at 500 kHz, minimum: 400W	Comply and provide supporting documentation			
	b) Comply with clause in section 3.2.3.1) of this specification, that is minimum 100 W rms power handling capacity	Comply and provide supporting documentation			
3.2.3.2	Frequency Range				
	a) Comply with clause in section 3.2.3.2) of this specification.	Comply and provide supporting documentation			
3.2.3.3	Insulation withstand test voltages				
	a) Comply with clause in section 3.2.3.3) of this specification.	Comply and provide supporting documentation			
3.2.3.4	Terminal polarities				
	a) Comply with clause in section 3.2.3.4) of this specification.	Comply and provide supporting documentation			
3.2.4	Tuning device				
	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) Frequency pass band in kHz with tolerance to the insertion loss and return loss specified in section 3.2.4 g) and h), with				
	1) 400 ohm line impedance				

CONTROLLED DISCLOSURE

	i) with 4400 pF coupling capacitor				
	c) a) 100 kHz to 500 kHz (clause 3.2.4 b) and	Comply and provide supporting documentation			
	e) b) 40 kHz to 100 kHz (clause 3.2.4 d) and	Comply and provide supporting documentation			
	ii) with 6000 pF coupling capacitor				
	c) a) 70 kHz to 500 kHz (clause 3.2.4 b) and	Comply and provide supporting documentation			
	e) b) 40 kHz to 100 kHz (clause 3.2.4 d) and	Comply and provide supporting documentation			
	iii) with 8000 pF coupling capacitor				
	e) a) 40 kHz to 500 kHz (clause 3.2.4 d) and	Comply and provide supporting documentation			
	<u>2) 250 ohm line impedance</u>				
	i) with 4400 pF coupling capacitor				
	c) a) 100 kHz to 500 kHz (clause 3.2.4 b) and	Comply and provide supporting documentation			
	e) b) 40 kHz to 100 kHz (clause 3.2.4 d) and	Comply and provide supporting documentation			
	ii) with 6000 pF coupling capacitor				
	c) a) 70 kHz to 500 kHz (clause 3.2.4 b) and	Comply and provide supporting documentation			
	e) b) 40 kHz to 100 kHz (clause 3.2.4 d) and	Comply and provide supporting documentation			
	iii) with 8000 pF coupling capacitor				
	e) a) 40 kHz to 500 kHz (clause 3.2.4 d) and	Comply and provide supporting documentation			
	d) Adjustable components supplied for tuning filters to coupling capacitance and line				

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	impedances as specified in section 3.2.4 b), c), d) and e)				
	1) in standard range 4400 pF to 8000 pF	Comply and provide supporting documentation			
	2) adjustment range provided	Comply and provide supporting documentation			
	3) in standard range 200 ohms to 400 ohms	Comply and provide supporting documentation			
	4) adjustment range provided	Comply and provide supporting documentation			
	e) Comply with clause 3.2.4g) of this specification (composite/insertion loss)	Comply and provide supporting documentation			
	f) Comply with clause 3.2.4h) of this specification (return loss)	Comply and provide supporting documentation			
	g) Comply with clause 3.2.4i) of this specification	Comply			
3.2.5	Matching transformer				
	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 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			
	f) Comply with clause 3.2.5f) of this specification	Comply			
3.2.6	Drain coil				
	a) Comply with clause 3.2.6a) of this specification	Comply and provide supporting documentation			

CONTROLLED DISCLOSURE

	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	Earthing Switch				
	a) Comply with clause 3.2.7a) of this specification	Comply and provide supporting documentation			
	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	Protective device				
	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			
	d) Comply with clause 3.2.8d) of this specification	Comply and provide supporting documentation			
	e) Comply with clause 3.2.8e) of this specification	Comply and provide supporting documentation			

CONTROLLED DISCLOSURE

	f) Comply with clause 3.2.8f) of this specification	Comply and provide supporting documentation			
3.2.9	The 3 dB Attenuator Circuit				
	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			
3.2.10	Marking				
	a) Comply with clause in section 3.2.10) of this specification.	Comply and provide supporting documentation			
3.3	Drawings and instruction manuals				
3.3.1	Drawings				
	a) Comply with clause 3.3.1a) of this specification	Comply and provide supporting documentation			
	b) Comply with clause 3.3.1b) of this specification	Comply and provide supporting documentation			
	c) Comply with clause 3.3.1c) of this specification	Comply and provide supporting documentation			
	d) Comply with clause 3.3.1d) of this specification	Comply			
	e) Comply with clause 3.3.1e) of this specification	Comply			
	f) Comply with clause 3.3.1g) of this specification	Comply			
3.3.2	Instruction manuals				
	a) Comply with clause 3.3.2a) of this specification	Comply			
	b) Comply with clause 3.3.2b) of this specification	Comply			
	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			
3.4	Quality assurance				
	a) Comply with clause 3.4a) of this specification	Comply			
	b) Comply with clause 3.4b) of this specification	Comply			

CONTROLLED DISCLOSURE

	c) Comply with clause 3.4c) of this specification	Comply			
4	Testing				
4.1	General				
	a) Comply with clause 4.1a) 1) of this specification	Comply			
	b) Comply with clause 4.1a) 2) of this specification	Comply			
	c) Comply with clause 4.1a) 3) of this specification	Comply			
	d) Comply with clause 4.1a) 4) of this specification	Comply			
	d) Comply with clause 4.1b) 1) of this specification	Comply			
	a) Comply with clause 4.1b) 2) of this specification	Comply			
4.2	Inspection and witnessing of Tests				
	a) Comply with clause 4.2a) of this specification	Comply			
	b) Comply with clause 4.2b) of this specification	Comply			
4.3	Routine tests				
	a) Comply with clause in section 4.3) of this specification.	Comply and provide supporting documentation			
4.4	Type tests				
4.4.1	Measurement of return loss of LME				
	a) Comply with clause in section 4.4.1) of this specification.	Comply and provide type test certificate			
4.4.2	Distortion and intermodulation test of LME				
	a) Comply with clause in section 4.4.2) of this specification.	Comply and provide type test certificate			
4.4.3	Insulation of primary terminal of LME				
	a) Comply with clause in section 4.4.3) of this specification.	Comply and provide type test certificate			
4.4.4	Insulation of matching transformer				
	a) Comply with clause in section 4.4.4) of this specification.	Comply and provide type test certificate			
4.4.5	Drain coil test				
	a) Comply with clause 4.4.5a) of this specification	Comply and provide type test certificate			
	b) Comply with clause 4.4.5b) of this specification	Comply and provide type test certificate			
	c) Comply with clause 4.4.5c) of this specification	Comply and provide type test certificate			
	d) Comply with clause 4.4.5d) of this specification	Comply and provide type test certificate			
4.4.6	Tests on protective device				

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	a) Comply with clause in section 4.4.6) of this specification.	Comply and provide type test certificate			
4.4.7	Tests on the 3 dB Attenuator				
4.4.7.1	Type tests				
	a) Comply with clause in section 4.4.7.1) of this specification.	Comply and provide type test certificate			
4.4.7.2	Routine Tests				
	a) Comply with clause in section 4.4.7.2a) of this specification.	Comply and provide test certificate			
	b) Comply with clause in section 4.4.7.2b) of this specification.	Comply and provide test certificate			
5	Delivery, packaging and labelling				
	a) Comply with clause 5a) of this specification	Comply			
	b) Comply with clause 5b) of this specification	Comply and provide supporting documentation			
	c) Comply with clause 5c) of this specification	Comply and provide supporting documentation			
	d) Comply with clause 5d) of this specification	Comply			
	e) Comply with clause 5e) of this specification	Comply			
	f) Comply with clause 5g) of this specification	Comply			

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