SLOVENSKI STANDARD
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Komunikacijski kabli - Specifikacije za preskusne metode - 1-9. del: Električne preskusne metode - Neenakomerno slabljenje (prečna izguba pretvorbe TCL, prečna izguba pretvorbe prenosa TCTL)

Communication cables - Specifications for test methods - Part 1-9: Electrical test methods - Unbalance attenuation (transverse conversion loss TCL transverse conversion transfer loss TCTL)

Kommunikationskabel - Spezifikationen für Prüfverfahren Teil 1-9: Elektrische Prüfverfahren - Unsymmetriedämpfung (Unsymmetriedämpfung am nahen und am fernen Ende)

Câbles de communication - Spécifications des méthodes d'essai Partie 1-9: Méthodes d'essais électriques - Affaiblissement de disymétrie (perte de conversion longitudinale, perte de transfert de conversion longitudinale)

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European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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European foreword

This document [EN 50289-1-9:2017] has been prepared by CLC/TC 46X “Communication cables”.

The following dates are fixed:

• latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2017-09-16
• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	2019-12-16

This document supersedes EN 50289-1-9:2001.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

EN 50289-1, *Communication cables — Specifications for test methods*, is currently composed with the following parts:

— *Part 1-1: Electrical test methods — General requirements*;

— *Part 1-2: Electrical test methods — DC resistance*;

— *Part 1-3: Electrical test methods — Dielectric strength*;

— *Part 1-4: Electrical test methods — Insulation resistance*;

— *Part 1-5: Electrical test methods — Capacitance*;

— *Part 1-6: Electrical test methods — Electromagnetic performance*;

— *Part 1-7: Electrical test methods — Velocity of propagation*;

— *Part 1-8: Electrical test methods — Attenuation*;

— *Part 1-9: Electrical test methods — Unbalance attenuation (transverse conversion loss TCL transverse conversion transfer loss TCTL)*;

— *Part 1-10: Electrical test methods — Crosstalk*;

— *Part 1-11: Electrical test methods — Characteristic impedance, input impedance, return loss*;

— *Part 1-12: Electrical test methods — Inductance*;

— *Part 1-13: Electrical test methods — Coupling attenuation or screening attenuation of patch cords / coaxial cable assemblies / pre-connectorised cables*;

— *Part 1-14: Electrical test methods — Coupling attenuation or screening attenuation of connecting hardware*;

— *Part 1-15: Electromagnetic performance — Coupling attenuation of links and channels (Laboratory conditions)*;

— *Part 1-16: Electromagnetic performance — Coupling attenuation of cable assemblies (Field conditions)*;

— *Part 1-17: Electrical test methods — Exogenous Crosstalk ExNEXT and ExFEXT*.

1 Scope

This European Standard details the test methods to determine the attenuation of converted differential-mode signals into common-mode signals, and vice versa, due to balance characteristics of cables used in analogue and digital communication systems by using the transmission measurement method. The unbalance attenuation is measured in, respectively converted to, standard operational conditions. If not otherwise specified, e.g. by product specifications, the standard operational conditions are a differential-mode which is matched with its nominal characteristic impedance (e.g. 100 Ω) and a common-mode which is loaded with 50 Ω. The difference between the (image) unbalance attenuation (matched conditions in the differential and common-mode) to the operational (Betriebs) unbalance attenuation (matched conditions in differential-mode and 50 Ω reference load in the common-mode) is small provided the common-mode impedance Z_{com} is in the range of 25 Ω to 75 Ω.

For cables having a nominal impedance of 100 Ω, the value of the common-mode impedance Z_{com} is about 75 Ω for up to 25 pair- count unscreened pair cables, 50 Ω for common screened pair cables and more than 25 pair- count unscreened pair cables, and 25 Ω for individually screened pair cables. The impedance of the common-mode circuit Z_{com} can be measured more precisely either with a time domain reflectometer (TDR) or a network analyser. The two conductors of the pair are connected together at both ends and the impedance is measured between these conductors and the return path.

This European Standard is bound to be read in conjunction with EN 50289-1-1, which contains essential provisions for its application.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 50289-1-1:2017, *Communication cables — Specifications for test methods — Part 1-1: Electrical test methods — General requirements*

EN 50289-1-8, *Communication cables - Specifications for test methods - Part 1-8: Electrical test methods - Attenuation*

EN 50290-1-2, *Communication cables - Part 1-2: Definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 50290-1-2 and the following apply.

3.1
unbalance attenuation
logarithmic ratio of the differential-mode power (transmission signal of a balanced pair) to the common-mode power (signal in the pair to ground/earth unbalanced circuit) measured at the near and at the far end

Note 1 to entry: The (operational) unbalance attenuation is described by the logarithmic ratio of the differential-mode power to the common-mode power in standard operational conditions. If not otherwise specified, e.g. by product specifications, the standard operational conditions are a differential-mode which is matched with its nominal characteristic impedance (e.g. 100 Ω) and a common-mode which is loaded with 50 Ω.

$$a_u = 10 \times \lg \left| \frac{P_{\text{diff}}}{P_{\text{com}}} \right| = 20 \times \lg \left| \frac{U_{\text{diff}}}{U_{\text{com}}} \right| + 10 \times \lg \left(\frac{Z_{\text{com}}}{Z_{\text{diff}}} \right) \quad (1)$$

where

P_{diff} is the power in the differential-mode (balanced) circuit;

P_{com} is the power in the common-mode (unbalanced) circuit;

U_{diff} is the voltage in the differential-mode (balanced) circuit;

U_{com} is the voltage in the common-mode (unbalanced) circuit;

Z_{diff} is the characteristic impedance of the differential-mode (balanced) circuit;

Z_{com} is the characteristic impedance of the common-mode (unbalanced) circuit.

3.2
transverse conversion loss
TCL
logarithmic ratio of the differential-mode injected signal at the near end to the resultant common-mode signal at the near end of a balanced pair, and which is equal to unbalance attenuation at near end when the CUT is terminated with the same impedances as defined for unbalance attenuation measurement

Note 1 to entry: This definition stems from ITU-G.117.

3.3
transverse conversion transfer loss
TCTL
logarithmic ratio of the differential-mode injected signal at the near end to the resultant common-mode signal at the far end of a balanced pair, and which is equal to unbalance attenuation at far end when the CUT is terminated with the same impedances as defined for unbalance attenuation measurement

Note 1 to entry: This definition stems from ITU-G.117.

4 Test method

4.1 Method A: measurement using balun setup

4.1.1 Test equipment

a) It is mandatory to create a defined return (common-mode) path. This is achieved by grounding all other pairs and screen(s) if present in common to the balun ground. However in addition in the case of unscreened cables the cable under test shall be wound onto a grounded metal drum. The drum surface may have a suitable groove, wide enough to contain the cable, and shall be adequate to hold 100 m of cable in one layer. The pair under test shall be terminated with differential-mode and common-mode terminations and grounded at near and far ends

b) A network analyser or generator/receiver combination suitable for the required frequency and dynamic range.

c) The baluns shall have a common-mode port and the characteristics given in EN 50289-1-1:2017, Table 1.

d) Time domain reflectometer (optional).

4.1.2 Test sample

The ends of the cable under test (CUT) shall be prepared so that the twisting of the pairs/quads is maintained up to the terminals of the test equipment. If not otherwise specified the CUT shall have a length of 100 m ± 1 m. For the measurement or evaluation of the equal level unbalance attenuation at the far end the following applies: if the CUT length is not otherwise specified and the attenuation of the CUT at the highest frequency to be measured is higher than or equal to 80 dB the length of the CUT may be reduced to limit the attenuation to maximum 80 dB.

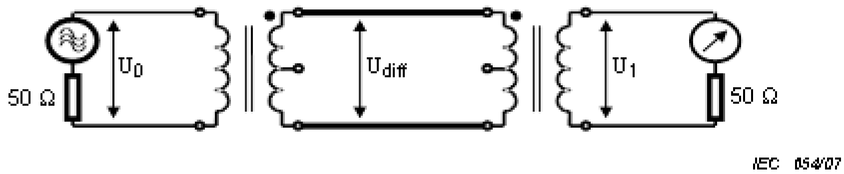
All pairs not under test and all screens shall be connected in common to the same ground as the balun at both ends of the CUT.

For unscreened cables the CUT shall be wound tightly around the metal drum in one layer. The distance between the windings should be at least the diameter of the cable. The metal drum shall be connected to the same ground as the balun, e.g. by fixing the baluns to the drum.

4.1.3 Calibration procedure

a) The reference line calibration (0 dB-line) shall be determined by connecting coaxial cables between the analyser input and output. The same coaxial cables shall also be used for the balun loss and unbalance attenuation measurements. The calibration shall be established over the whole frequency range specified in the relevant cable specification. This calibration method is valid for closely matched baluns that satisfy the characteristics of Table 1.

b) Figure 1 gives the schematic for the measurement of the differential-mode loss of the baluns. Two baluns are connected back to back on the symmetrical output side and their attenuation measured over the specified frequency range. The connection between the two baluns shall be made with negligible loss.



Key

U_0 voltage at network analyser port or signal generator

U_1 voltage at network analyser port or receiver

U_{diff} voltage at symmetrical port of baluns

Figure 1 — Test set-up for the measurement of the differential-mode loss of the baluns

The differential-mode loss of the baluns is given by:

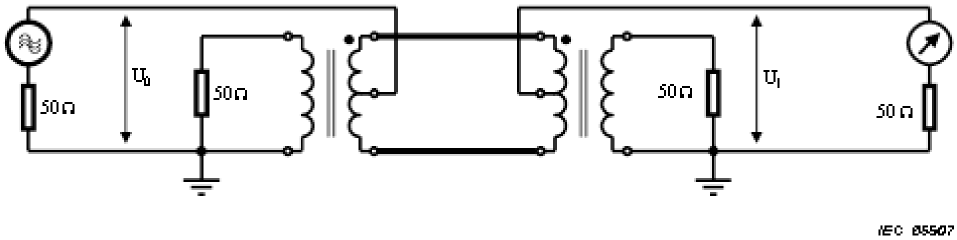
$$\alpha_{diff} = 0,5 \times \left(20 \times \lg \left| \frac{U_0}{U_1} \right| \right) = -0,5 \times \left(20 \times \lg \left| S_{21} \right| \right) \quad (2)$$

where

α_{diff} is the differential-mode loss of the balun (dB);

S_{21} is the scattering parameter S_{21} (forward transmission coefficient) where port 1 is the primary (unbalanced side) side of the near end balun and port 2 is the primary side (unbalanced port) of the far end balun.

c) Figure 2 gives the schematic for the measurement of the common-mode loss of the baluns. The baluns used in b) are connected together; the unbalanced balun ports are terminated with the nominal test equipment impedance, the test equipment is connected to the common-mode ports (centre taps) of the baluns.



Key

U_0 voltage at network analyser port or signal generator

U_1 voltage at network analyser port or receiver

Figure 2 — Test set-up for the measurement of the common-mode loss of the baluns

The common-mode loss of the baluns is given by:

$$\alpha_{com} = 0,5 \times \left(20 \times \lg \left| \frac{U_0}{U_1} \right| \right) = -0,5 \times \left(20 \times \lg \left| S_{21} \right| \right) \quad (3)$$

where

α_{com} is the common-mode loss of the balun (dB);

S_{21} is the scattering parameter S_{21} (forward transmission coefficient) where port 1 is the common-mode port of the near end balun and port 2 is the common-mode port of the far end balun.

d) The operational attenuation of the balun α_{balun} takes into account the common-mode and differential-mode losses of the balun:

$$\alpha_{balun} = \alpha_{diff} + \alpha_{com} \quad (4)$$

where

α_{balun} is the operational attenuation or intrinsic loss of the balun (dB).

NOTE More precise results can be obtained using either poling of the baluns for α_{diff} and α_{com} and averaging the results or using three baluns. In the latter case, the assumption of identical baluns is not required.

e) The voltage ratio of the balun can be expressed by the turns ratio of the balun and the operational attenuation of the balun:

$$20 \times \lg\left|\frac{U_{\text{diff}}}{U_0}\right| = 10 \times \lg\left|\frac{Z_{\text{diff}}}{Z_0}\right| - \alpha_{\text{balun}}$$
$$20 \times \lg\left|\frac{U_{\text{diff}}}{U_1}\right| = 10 \times \lg\left|\frac{Z_{\text{diff}}}{Z_1}\right| - \alpha_{\text{balun}} \quad (5)$$

where

U_{diff} is the differential-mode voltage at the input of the cable under test (V);

U_0 is the voltage at the network analyser port or signal generator (V);

Z_{diff} is the characteristic impedance of the differential-mode circuit (Ω);

Z_0 is the output impedance of the network analyser or signal generator (Ω);

U_1 is the voltage at the input of the load (V);

Z_1 is the input impedance of the load (Ω).

4.1.4 Measuring procedure

All pairs/quads of the cable shall be measured at both ends of the CUT. The unbalance attenuation shall be measured over the whole-specified frequency range and at the same frequency points as for the calibration procedure.

The measurement is done under standard operational conditions, i.e. one is measuring the Betriebs- (operational) unbalance attenuation. If not otherwise specified, e.g. by product specifications, the standard operational conditions are a differential-mode which is matched with its nominal characteristic impedance (e.g. 100 Ω) and a common-mode which is loaded with 50 Ω.

Figure 3 gives a schematic of the measurement for unbalance attenuation at the near end.

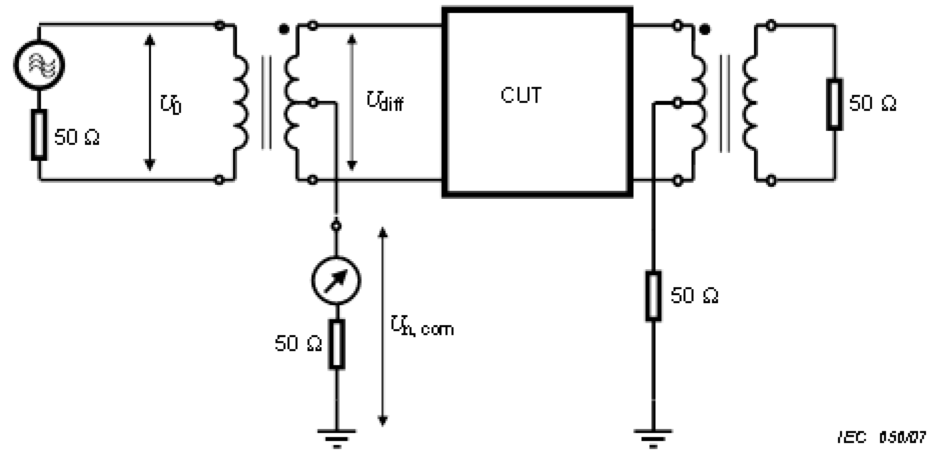


Figure 3 — Test set-up for unbalance attenuation at near end (*TCL*)

$$\alpha_{\text{meas}} = 20 \times \lg \left| \frac{U_0}{U_{n,\,\text{com}}} \right| = -20 \times \lg \left| S_{21} \right| \tag{6}$$

where

α_{meas} is the measured attenuation (dB);

S_{21} is the scattering parameter S_{21} (forward transmission coefficient) where port 1 is the primary (unbalanced) side of the near end balun and port 2 is the common-mode port of the near end balun

U_0 voltage in the primary (unbalanced) circuit at the near end balun

$U_{\text{n,com}}$ voltage in the common-mode circuit (V) at the near end balun

Figure 4 gives a schematic of the measurement for unbalance attenuation at far end.

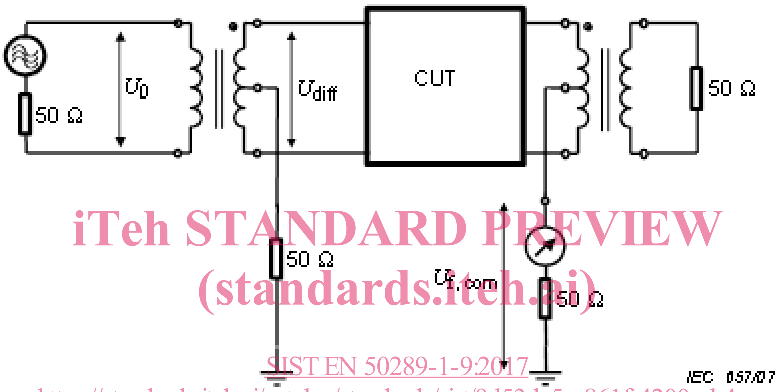


Figure 4 — Test set-up for unbalance attenuation at far end (*TCTL*)

$$\alpha_{\text{meas}} = 20 \times \lg \left| \frac{U_0}{U_{\text{f},\,\text{com}}} \right| = -20 \times \lg \left| S_{21} \right| \tag{7}$$

where

α_{meas} is the measured attenuation (dB);

S_{21} is the scattering parameter S_{21} (forward transmission coefficient) where port 1 is the primary (unbalanced) side of the near end balun and port 2 is the common-mode port of the far end balun;

U_0 voltage in the primary (unbalanced) circuit at the near end balun;

$U_{\text{n,com}}$ voltage in the common-mode circuit (V) at the far end balun.