BS EN 50289-1-8:2017

BSI Standards Publication

Communication cables — Specifications for test methods

Part 1-8: Electrical test methods — Attenuation

National foreword

This British Standard is the UK implementation of EN 50289-1-8:2017. It supersedes BS EN 50289-1-8:2001 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EPL/46, Cables, wires and waveguides, radio frequency connectors and accessories for communication and signalling.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Kommunikationskabel - Spezifikationen für Prüfverfahren Teil 1-8: Elektrische Prüfverfahren - Dämpfung

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European foreword

This document [EN 50289-1-8:2017] 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• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	2019-12-16

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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 (longitudinal conversion loss, longitudinal conversion transfer loss)*;

— *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 attenuation of finished cables used in analogue and digital communication systems.

It 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, *Communication cables - Specifications for test methods - Part 1-1: Electrical test methods - General requirements*

EN 50289-1-11, *Communication cables - Specifications for test methods - Part 1-11: Electrical test methods - Characteristic impedance, input impedance, return loss*

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 50289-1-1 and EN 50290-1-2 and the following apply.

3.1
cable attenuation
decrease in magnitude of power of a signal that propagates along the cable

3.2
insertion loss (*IL*) of a network (e.g. cable or cable assembly)
ratio of power P_1 delivered to a specified load in a transmission system, before insertion of the given network, to the power P_2 delivered to the same load after insertion of the network:

$$IL = 10 \cdot \log\left(\frac{P_1}{P_2}\right) \left(\text{dB}\right) \quad (1)$$

Note 1 to entry: The insertion loss of a network depends on the network itself as well as the transmission system in which it is inserted (including the load). The insertion loss is generally expressed in decibels.

Note 2 to entry: In a transmission system where the load and source impedances are equal, the insertion loss can be expressed by the scattering parameter S_{21}.:

$$IL = -20 \cdot \log\left(\left|S_{21}\right|\right) \left(\text{dB}\right) \quad (2)$$

Note 3 to entry: For a cable which is matched to the transmission system in which it is inserted, the insertion loss is equivalent to the cable attenuation.

Note 4 to entry: Further information on definitions of attenuation can be found in IEC/TR 62152.

4 Test method for attenuation

4.1 Method A: Balun-based test method for symmetrical cables

4.1.1 Test equipment

The test equipment consists of a vector network analyser (VNA) having at least 2 ports, and the following:

— S-parameter set-up (shall be capable of performing S_{21} measurements).

— Baluns to convert the unbalanced signal of the VNA to a balanced signal. The baluns shall have an impedance on the primary (unbalanced) side equal to the nominal impedance of the measuring devices (in general 50 Ω) and on the secondary (balanced) side equal to the nominal impedance of the cable under test (CUT) (e.g. 100 Ω). The baluns shall fulfil the requirements of Class A baluns as described in EN 50289-1-1.

— Calibration artefacts to perform the required calibration of the test equipment on the secondary side of the baluns. To perform a full 2-port calibration a short circuit, an open circuit, a reference load, and a short connection cable or similar, are required. The short circuit shall have negligible inductance and the open circuit shall have negligible capacitance. The load resistor shall have a value close (within 1%) to the nominal impedance of the CUT (e.g. 100 Ω) and with negligible inductance and capacitance. The connection cable shall be as short as possible and well matched to the nominal impedance.

— Resistor termination networks (RTN) for termination of inactive pairs. The resistor termination network shall provide the differential mode and the common mode reference termination impedances. It is recommended to use resistor termination networks in accordance with Annex C of EN 50289-1-11. Baluns may be used for termination of the inactive pairs if they provide the specified differential and common mode terminations.

As an alternative to a network analyser, a generator and vector voltmeter may be used.

Accuracy of test set-up shall be better than 1 %.

4.1.2 Test sample

The CUT shall have a minimum length as specified in the relevant sectional specification. Both ends of the CUT shall be prepared, such that when connected to the terminals of the test equipment the influence to the test result is minimized. The twisting of the pairs/quads shall be maintained.

4.1.3 Calibration procedure

It is not the intent of the standard to detail the algorithms applied by a VNA to correct the measured results based on a calibration procedure but to detail the calibration procedure. Further information may be obtained in the manuals of the VNA supplier.

The calibration shall be performed on the secondary side of the baluns. A full two-port calibration is recommended using open, short, and load calibration artefacts at the terminals of the balun, and a short connection cable between the two baluns for the through calibration.

4.1.4 Measuring procedure

The CUT shall be connected to the terminals of the test equipment as depicted in Figure , including proper termination of the active pairs, the inactive pairs, and the screen.

The connection of the CUT to the test ports shall be optimized, such that the mismatch at the connection is minimized. For the inactive pairs, it is recommended to apply resistor termination networks as referenced in 4.1.1.

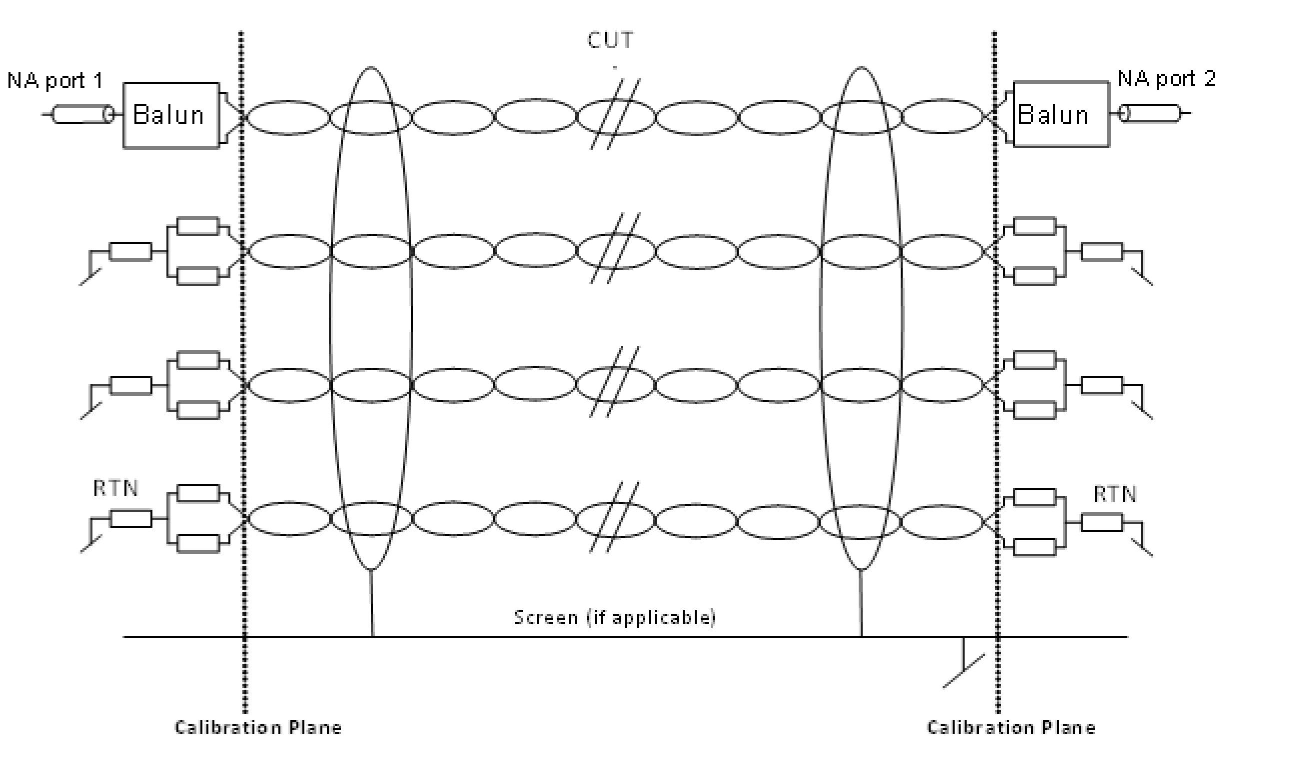

Figure 1 — Attenuation measurement using baluns

The scattering parameter S_{21} shall be measured over the whole specified frequency range and at the same frequency points as for the calibration procedure. All pairs/quads of the CUT shall be measured.

Under matched conditions, the attenuation a of the CUT is given by:

$$a(f) = -20 \cdot \log_{10}\left(\left|S_{21}\right|\right)(\text{dB}) \quad (3)$$

4.2 Method B: Balun-less test method for symmetrical cables

4.2.1 Test equipment

Method B is the preferred one for balanced cables for frequencies above 1 000 MHz as it avoids the use of baluns which are often limited to 1 000 MHz. With this configuration it is possible to measure both the differential mode and the common mode attenuation of the cable.

Please refer to EN 50289-1-1 for a general description of the balun-less test method and nomenclature.

The test equipment consists of a multiport vector network analyser VNA having at least 4 ports, and the following:

— S-parameter set-up.

— A mathematical conversion from unbalanced to balanced, i.e. the mixed mode set-up which is often referred to as an unbalanced, modal decomposition or balun-less setup. This allows measurements of balanced devices without use of an RF balun in the signal path. With such a test set-up, all balanced and unbalanced parameters can be measured over the full frequency range.

— Coaxial interconnection cables in accordance with the relevant clause of EN 50289-1-1 to connect the VNA, switching matrix (if used), and the test fixture. The connection cables shall have characteristic impedance equal to the nominal impedance of the VNA, and a low transfer impedance.

— Coaxial calibration standards for calibration at the end of the coaxial interconnection cables (if applied). To perform a calibration at the end of the coaxial interconnection cable coaxial reference standards, so called calibration standards, i.e. a short circuit, an open circuit and a reference load, are required. An alternative to the before mentioned open, short and load references is the use of an electronic multiport calibration kit (E-cal module) which is supplied by the supplier of the VNA.

— Calibration artefacts in accordance with the relevant clause of EN 50289-1-1 for calibration at the test interface (if applied). To perform a calibration at the test interface, calibration artefacts, i.e. a short circuit, an open circuit and a reference load, are required.

— Resistor termination networks (RTN) for termination of inactive pairs. The resistor termination network shall provide the differential mode and the common mode reference termination impedances. It is recommended to use resistor termination networks in accordance with Annex C of EN 50289-1-11.

4.2.2 Test sample

The CUT shall have a minimum length as specified in the relevant sectional specification. Both ends of the CUT shall be prepared, such that when connected to the terminals of the test equipment the influence to the test result is minimized. The twisting of the pairs/quads shall be maintained.

4.2.3 Calibration procedure

It is not the intent of the standard to detail the algorithms applied by a VNA to correct the measured results based on a calibration procedure but to detail the calibration procedure. Further information may be obtained in the manuals of the VNA supplier

A full 4-port single ended (SE) calibration shall be performed in accordance with the relevant clause of EN 50289-1-1. The calibration shall be performed either at the ends of the coaxial interconnection cables, in which case de-embedding techniques may be required to remove the effects of the test fixture, or at the test interface.

4.2.4 Measuring procedure

The CUT shall be connected to the terminals of the test equipment as depicted in Figure , including proper termination of the active pairs, the inactive pairs, and the screen.

The connection of the CUT to the test ports shall be optimized, such that mismatching is minimized. For the inactive pairs, it is recommended to apply resistor termination networks as referenced in 4.2.1.

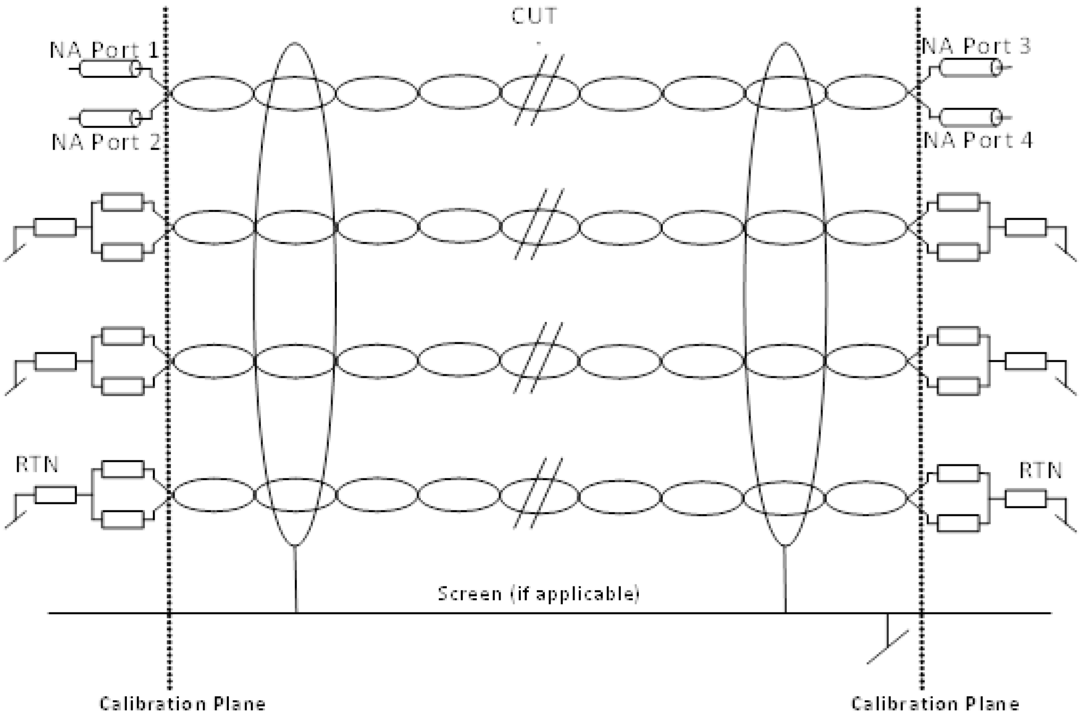

Figure 2 — Attenuation measurement using balun-less test method

A full SE *S*-matrix measurement shall be performed over the whole frequency range and at the same frequency points as for the calibration procedure. The measured SE *S*-matrix shall be transformed into the associated mixed mode S-matrix to obtain the *S*-parameter S_{DD21} from which the attenuation is determined.

All pairs/quads of the CUT shall be measured.

Under matched conditions, the attenuation of the CUT is given by:

$$a\left(f\right) = -20 \cdot \log_{10}\left(\left|S_{DD21}\right|\right) = -20 \cdot \log_{10}\left(\left|\frac{1}{2}\left(S_{31} - S_{41} - S_{32} + S_{42}\right)\right|\right) \tag{4}$$

4.3 Method C: Test method for coaxial cables

4.3.1 Test equipment

The test equipment consists of a vector network analyser (VNA) having at least 2 ports, and the following:

— S-parameter set-up (shall be capable of performing S_{21} measurements).

— Impedance matching adapters to convert the nominal impedance of the CUT (e.g. 75 Ω) to the nominal impedance of the VNA (e.g. 50 Ω), in case they are different

— Calibration standards to perform the required calibration of the test equipment at the test interfaces. Depending on the nominal impedance of the CUT, the test interface will be at the coaxial ports of the VNA (or at the end of suitable test cables), or on the secondary side of an impedance matching adapter. To perform a full 2-port calibration at the test interfaces, calibration standards, i.e. a short circuit, an open circuit, a reference load, and a through connection, are required. The through connection shall be well matched to the nominal impedance and have a low attenuation. An alternative to the before mentioned open, short, load, and through references is the use of an electronic multiport calibration kit (E-cal module) which is supplied by the supplier of the VNA. The calibration standards should be traceable to an international reference standard.

As an alternative to a network analyser, a generator and vector voltmeter may be used.

Accuracy of test set-up shall be better than 1 %.

4.3.2 Test sample

The CUT shall have a minimum length as specified in the relevant sectional specification. Both ends of the CUT shall be prepared, such that when connected to the test ports of the test equipment the influence to the test result is minimized, e.g. by fitting the CUT with suitable low loss and well matched connectors.

4.3.3 Calibration procedure

It is not the intent of the standard to detail the algorithms applied by a VNA to correct the measured results based on a calibration procedure but to detail the calibration procedure. Further information may be obtained in the manuals of the VNA supplier.

The calibration shall be performed at the test interfaces. A full two-port calibration is recommended, using calibration standards as described in 4.3.1.

If the nominal impedance of the CUT is equal to the nominal impedance of the VNA, the calibration shall be performed at the coaxial ports of the VNA or at the end of suitable test cables, applying consecutively the specified open, short, load, and through standards. If the nominal impedance of the CUT is different from the nominal impedance of the CUT, the calibration shall be performed on the secondary side of the impedance matching adapters.

4.3.4 Measuring procedure

The CUT shall be connected to the test ports of the test equipment, including proper termination of the screen.

The attenuation shall be measured over the whole specified frequency range and at the same frequency points as for the calibration procedure within the specified frequency range.

The scattering parameter S_{21} shall be measured over the whole specified frequency range and at the same frequency points as for the calibration procedure.

Under matched conditions, the attenuation a of the CUT is given by:

$$a\left(f\right) = -20 \cdot \log_{10}\left(\left|S_{21}\right|\right)\left(\text{dB}\right) \qquad (5)$$

4.4 Method D: Open/short method

4.4.1 Test equipment

As an alternative to methods A to C, the attenuation of a sinusoidal wave along the cable (independent of the connecting hardware) can be derived from the measured input impedances using the open/short method as described in EN 50289-1-11.

For description of the required test equipment, see EN 50289-1-11.

4.4.2 Test sample

The CUT shall have a minimum length as specified in the relevant sectional specification. For other requirements, see EN 50289-1-11.

4.4.3 Calibration procedure

See EN 50289-1-11.

4.4.4 Measuring procedure

The CUT shall be connected to the test port of the test equipment in accordance with the relevant clause of EN 50289-1-11.

The complex impedance Z_{open} shall be measured. Z_{open} is the impedance measured at the near end (input) with an open circuit at the far end of the CUT.

The complex impedance Z_{short} shall be measured. Z_{short} is the impedance measured at the near end (input) with a short circuit at the far end of the CUT.

The attenuation of the CUT is calculated from:

$$a = \alpha \cdot L = \frac{8,686}{2} \cdot \text{arctanh}\left[\frac{2A}{\left(1 + A^2\right)} \cdot \cos\left(B\right)\right] \left(\text{dB}\right) \tag{6}$$

$$A = \sqrt{\frac{\left|Z_{\text{short}}\right|}{\left|Z_{\text{open}}\right|}} \tag{7}$$

$$B = \frac{1}{2}\left(\varphi_S - \varphi_O\right) \tag{8}$$

where

a	attenuation of the CUT in dB
α	cable attenuation in dB/m.
L	cable length in meter
$\left\|Z_{\text{open}}\right\|$	magnitude of the input impedance of the cable with an open circuit at the cable end
$\left\|Z_{\text{short}}\right\|$	magnitude of the input impedance of the cable with a short circuit at the cable end
φ_{open}	phase angle of the input impedance of the cable with an open circuit at the cable end
φ_{short}	phase angle of the input impedance of the cable with a short circuit at the cable end

5 Expression of test results

5.1 Expression

The attenuation of the cable is expressed as:

$$\alpha_L\left(f\right) = a\left(f\right) \cdot \frac{100}{L}\left(\text{dB} / 100\,\text{m}\right) \tag{9}$$

where

L	cable length in meter
$\alpha_L\left(f\right)$	attenuation of the CUT at ambient temperature corrected to 100 m
$a\left(f\right)$	attenuation of the CUT in the tested length at ambient temperature

5.2 Temperature correction

When a temperature correction is necessary, the attenuation values shall be corrected to the reference temperature of 20°C with the following formula:

$$\alpha_{LC}\left(f\right)_{20} = \frac{\alpha_L\left(f\right)_T}{1+\frac{K}{100}\cdot\left(T-20\right)}\left(\text{dB} / 100\,\text{m}\right) \tag{10}$$

where

K	correction factor in % / °C
T	ambient temperature in °C during measurement
$\alpha_L\left(f\right)_T$	attenuation of reference length at ambient temperature during measurement
$\alpha_{LC}\left(f\right)_{20}$	attenuation corrected to 20°C by temperature correction

Correction factor K shall be defined in the relevant cable specification (e.g. for copper, coaxial and screened balanced cables with non-polar insulation K = 0,2 (%/°C)).

6 Test report

The test report shall include:

— temperature,

— frequency range,

— sample length,

— test method,

— impedance of the test set-up,

— attenuation values as required.

Bibliography

[1] IEC/TR 62152, *Transmission properties of cascaded two-ports or quadripols — Background of terms and definitions*

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