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INTERNATIONAL STANDARD

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Coaxial communication cables –
Part 1-127: Electrical test methods – Link loss of radiating cable

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IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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IEC 61196-1-127 has been prepared by subcommittee 46A: Coaxial cables, of IEC technical committee 46: Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
46A/1661/FDIS	46A/1670/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 61196 series, published under the general title *Coaxial communication cables*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

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COAXIAL COMMUNICATION CABLES –

Part 1-127: Electrical test methods – Link loss of radiating cable

1 Scope

This part of IEC 61196 applies to radiating cables. It specifies a test method for determining the link loss of radiating cables for use in communication systems.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-1:2013, *Environmental testing – Part 1: General and guidance*

IEC 61196-1, *Coaxial communication cables – Part 1: Generic specification – General, definitions and requirements*

IEC 61196-1-123, *Coaxial communication cables – Part 1-123: Electrical test methods – Test for attenuation constant of radiating cable*

IEC 61196-1-124, *Coaxial communication cables – Part 1-124: Electrical test methods – Test for coupling loss of radiating cable*

IEC 61196-4, *Coaxial communication cables – Part 4: Sectional specification for radiating cables*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61196-1, IEC 61196-4 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
link loss
ratio of the input power P_{in} transmitted into the transceiver end of the radiating cable from signal source to the power P_{r} received by a half-wavelength dipole antenna located at a distance from the radiating cable, expressed by Formula (1):

$$L_L(X) = 10log_{10}\frac{P_{in}}{P_r(X)} \quad (1)$$

where

$L_L(X)$ is the link loss at the axial antenna position X, in dB;

P_{in} is the input power transmitted into the transceiver end of the radiating cable from the signal source, in W;

$P_r(X)$ is the receiving power of the half-wavelength dipole antenna at the axial antenna position X and at a radial distance from the radiating cable, in W;

X is the axial distance of the dipole from the transceiver end of the cable, in m.

4 Test equipment

4.1 Signal generator

A signal generator or other suitable signal source shall be used. Its output power, frequency range and bandwidth shall meet the measurement requirements. In order to ensure the repeatability of measurement, the frequency stability of signal generator or other signal source should be better than 10^{-6}.

4.2 Receiver

The frequency range, bandwidth, sampling rate, sensitivity and port type of the receiver shall meet the test requirements. If equivalent equipment can achieve the same function, it can also be used. In order to ensure the repeatability of measurement, the measurement uncertainty of the receiver or equivalent equipment (such as the vector network analyser) should be better than 0,5 dB.

4.3 Trolley

The trolley can move freely along the track on one side of the cable to be tested.

4.4 Antenna

Generally, a half-wave dipole antenna shall be used; if other antenna types are used, the frequency range and the port type of antenna shall meet the test requirements. The accuracy of the antenna gain shall comply with the relevant specifications.

NOTE Not only the gain of an antenna has an impact on the test result but also its directivity. Highly directive antennas for instance enable different orientations to the cable compared with dipoles as described in Figure 4 and Figure 6. If other antenna types than dipoles are used, the antenna orientation relative to the cable needs to be clearly described in the test report.

4.5 Load

The frequency range, return loss, absorbed power and port type of the load shall comply with the test requirements.

4.6 Connecting cables and connectors

Connecting cables can be used to connect the signal generator to the tested cable, and the receiver to the antenna. The return losses of test leads, test connectors, adapters and other devices for connection shall at least be 2 dB better than the required value of the test sample.

4.7 Data collection system and calculations

The data collection system consists of a position sensor, a connecting cable, a receiver and a computer.

There shall be sufficient local resolution for the measurement to be valid. Therefore, more than 10 measurements per half-wavelength shall be made to calculate the link loss for reception probabilities up to 95 %. To calculate higher reception probabilities, more than 20 measurements per half-wavelength shall be made. The total number of measurements shall not be less than 1 000 per 50 m. In order to avoid the influence of end effects of the test sample, the measured data within 5 m at both ends of the test sample shall not be included.

NOTE 1 The impact of end effects depends on the cable type and frequency. If the cable operates in radiating mode and the test frequency is either slightly above or > 10 times the resonant frequency, end effects could be present at sections longer than 5 m. If the test frequency is close to the resonant frequency, the end effect occurs typically at the load end of the cable, while it can be observed at the transceiver end at very high frequencies. In that case a larger section of the concerned cable end can be excluded from the statistical evaluation of reception probability.

The system can calculate the link loss automatically by using Formula (2):

$$L_{\mathrm{L}}(X) = N_{\mathrm{in}} - N_{\mathrm{r}}(X) + G \tag{2}$$

where

$L_{\mathrm{L}}(X)$ is the link loss at the axial antenna position X, in dB; if needed, the value of link loss can be calculated by 95 %/50 % probability values;

N_{in} is the input power level transmitted into the transceiver end of the radiating cable from the signal source, in dBm;

$N_{\mathrm{r}}(X)$ is the receiving power level of the antenna at the axial antenna position X and at a radial distance from the radiating cable, in dBm;

G is the gain of the antenna with reference to a dipole of 2,1 dBi gain, in dBd.

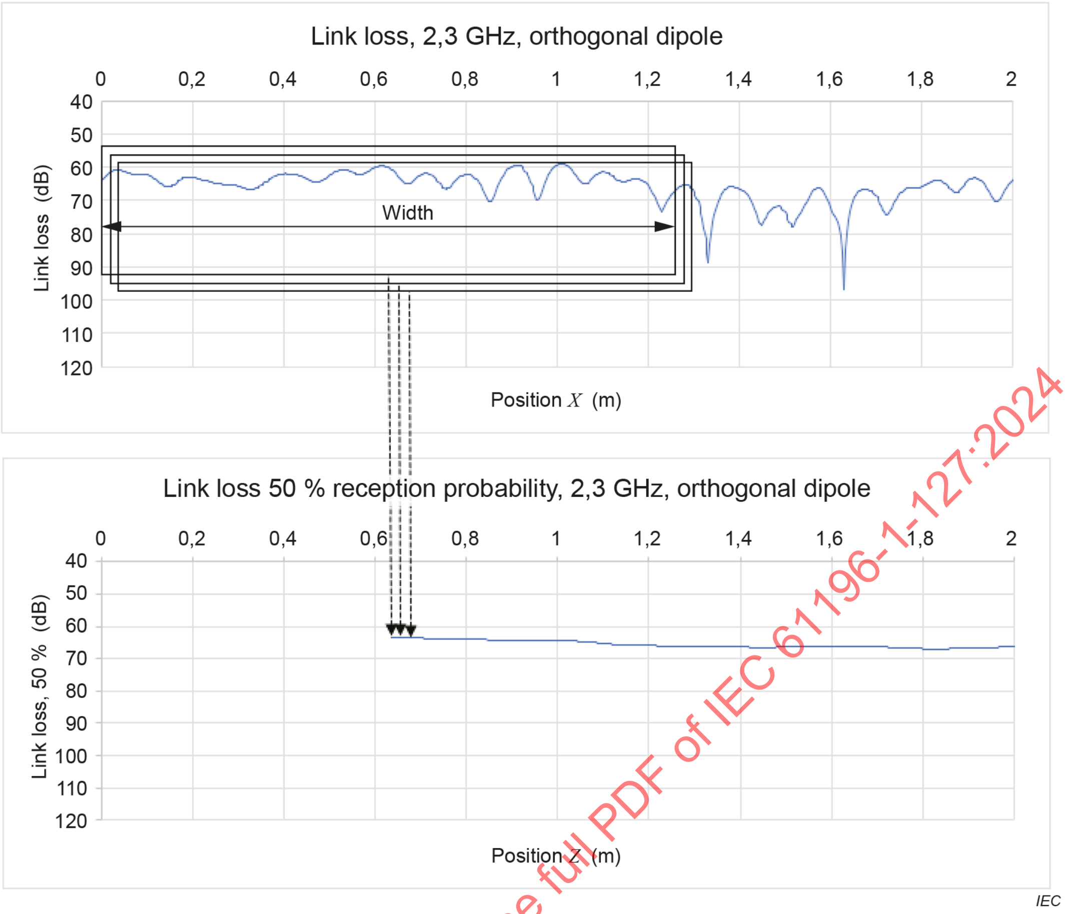


Figure 1 – Illustration of section-wise link loss calculation of 50 % reception probability

The link loss values of the required reception probabilities shall be calculated within segments of defined width. If not specified otherwise, the segment width shall correspond to 10 times the wavelength of the tested frequency. The segment is moved along the entire tested length with an increment that is equivalent to the distance between 2 test points. The maximum value of reception probability of all segments is the final test result of the TS. Figure 1 and Figure 2 illustrate the calculation of a 50 % reception probability link loss curve from a local link loss measurement. The statistical evaluation shall be performed for each antenna orientation and frequency.

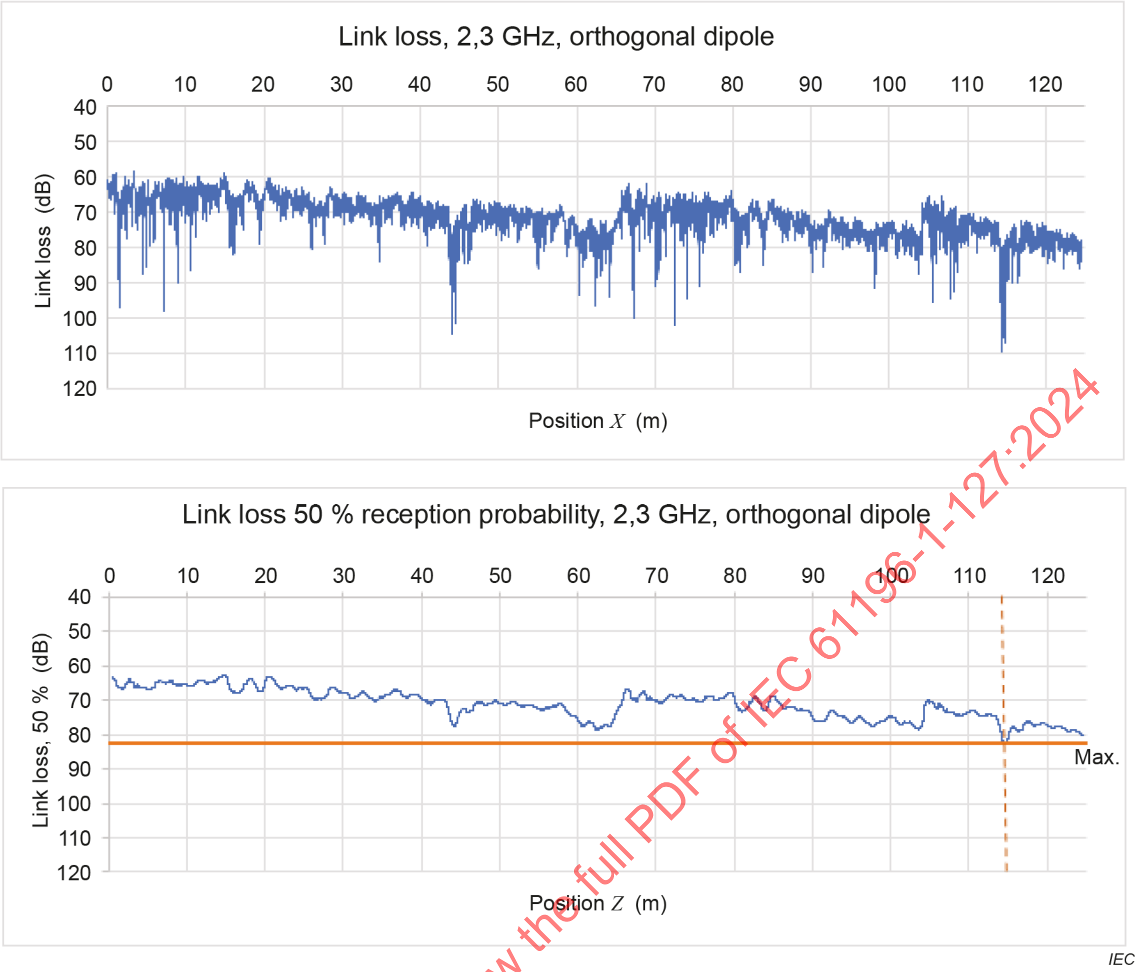


Figure 2 – Illustration of link loss calculation of 50 % reception probability of entire tested length

If the link loss has been measured with three antenna orientations, which are orthogonal to each other, the link loss can be given as the mean value of the measuring results by using Formula (3).

$$L_{L,mean}(Z) = 10log_{10}\left[\frac{1}{3}\left(10^{\frac{L_{L,x}(Z)}{10}} + 10^{\frac{L_{L,y}(Z)}{10}} + 10^{\frac{L_{L,z}(Z)}{10}}\right)\right] \quad (3)$$

where

Z is the segment position for statistical evaluation of reception probability (Z = X + 0,5 segment width);

$L_{L,x}(Z)$, $L_{L,y}(Z)$, $L_{L,z}(Z)$ is the link loss of the three orthogonal antenna orientations at the segment position Z of the cable, in dB;

$L_{L,mean}(Z)$ is the mean link loss of the test sample at the axial segment position Z of the cable, in dB.

The value of link loss can be calculated automatically by the system by using Formulae (2) or (3) with the following typical figures:

a) link loss L_{L50} (median value) 50 % reception probability, 50 % of the measured local values are smaller than this value;

b) link loss L_{L95} 95 % reception probability, 95 % of the measured local values are smaller than this value.

NOTE 2 The segment width of 50 % or 95 % reception probability is 10 times the wavelength of the measuring frequency. The maximum value of link loss of all segments for the chosen reception probability is the final test value of the TS.

5 Test arrangements

5.1 General

The measurements of link loss for radiating cables can be carried out by one of the two test arrangement methods, where the free-space method shall be the arbitration method if there is an argument:

– free-space method;

– ground-level method.

5.2 Free-space method

The test arrangement of the cable is given in Figure 3. The cable is laid on non-metallic posts at a height of 1,5 m to 2 m.

The length of the cable to be tested shall be at least 10 λ, where λ is the cable wavelength of the measuring frequency, but not shorter than 50 m. If the cable is tested in sections according to 7.3 and 7.4 or the whole cable is shorter than 10 λ or 50 m, shorter sections can be tested as well.

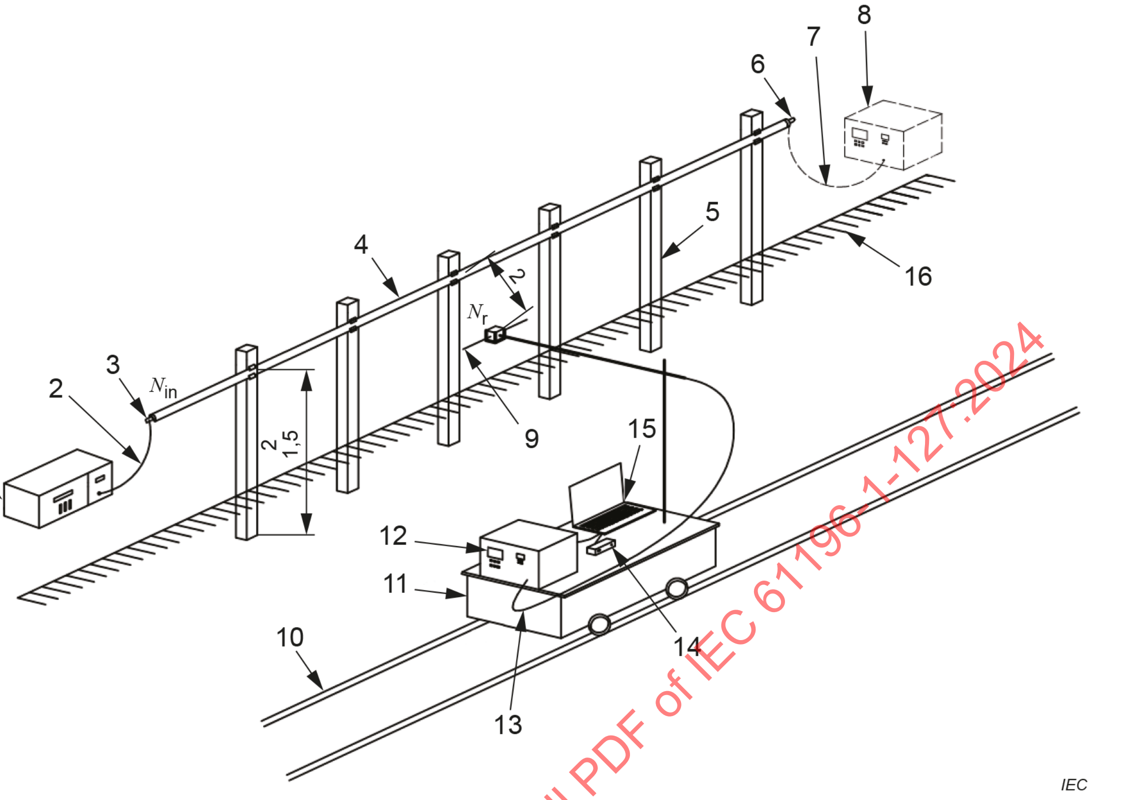
The antenna is put on a trolley and moved parallel to the cable. The height of the antenna centre shall be the same as that of the cable and its horizontal distance from the cable shall be about 2 m (additional distance can be added in the detail specification). Preferably a half-wavelength dipole antenna shall be used. If other antennas are used, the type and gain of antenna shall be stated in the test report.

No other metallic parts than the cable and the antenna shall be included within a cylinder of 2 m minimum in diameter surrounding the axis of the cable and the centre of the antenna.

The spatial orientation of the antenna shall be as specified in the detail specification.

The antenna orientations for a dipole antenna are shown in Figure 4 (the sample can be tested in any one of the three orthogonal directions as specified).

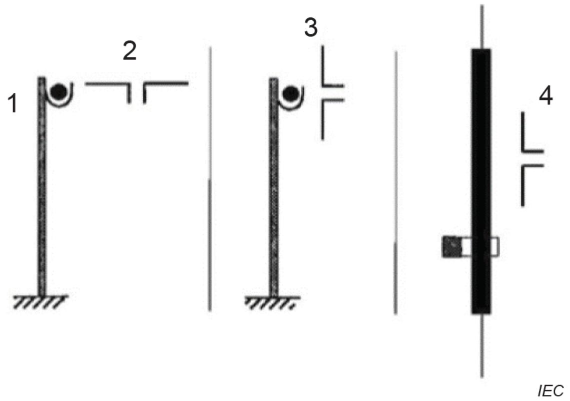
Dimensions in metres



Key

1	signal generator	9	antenna
2	connecting cable	10	track
3	transceiver end	11	trolley
4	TS (radiating cable)	12	receiver
5	non-metallic posts	13	connecting cable
6	load end	14	position sensor
7	connecting cable	15	computer
8	receiver	16	concrete floor

Figure 3 – Test arrangement for free-space method



Key

1 cable

2 radial

3 orthogonal

4 parallel

Figure 4 – Antenna orientations with free-space method

5.3 Ground-level method

The arrangement of the cable is given in Figure 5. The cable is laid on non-metallic spacers, which gives the cable a distance from the concrete floor of 10 cm to 12 cm.

The length of the cable to be tested shall be at least 10 λ, where λ is the cable wavelength of the measuring frequency, but not shorter than 50 m. If the cable is tested in sections according to 7.3 and 7.4 or the whole cable is shorter than 10 λ or 50 m, shorter sections can be tested as well.

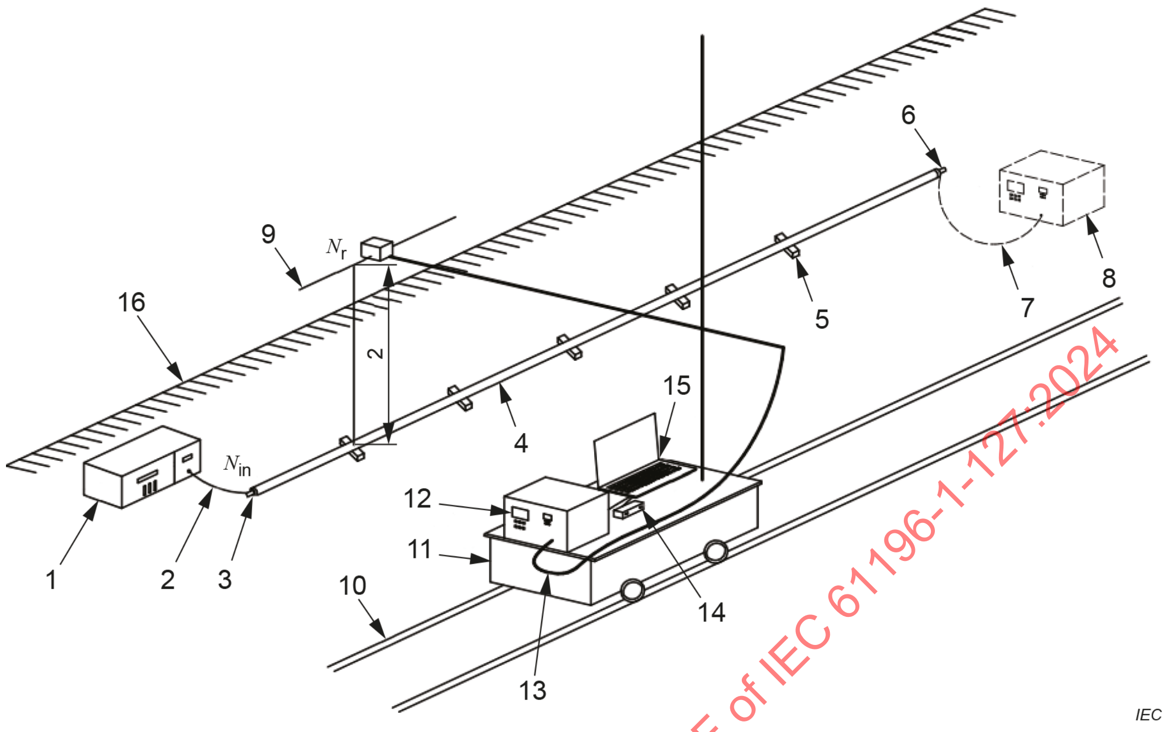
The antenna is fixed to a trolley and moved along the cable, the centre of the antenna is positioned vertically above the cable at a distance of about 2 m (additional distance can be added in the detail specification). Preferably, a half-wavelength dipole antenna shall be used. If other antennas are used, the type and gain of antenna shall be stated in the test report.

No other metallic parts than the cable and the antenna shall be included within a cylinder of 2 m (minimum) in diameter surrounding the axis of the cable and the centre of the antenna.

The spatial orientation of the antenna shall be as specified in the detail specification.

The antenna orientations for a dipole antenna are shown in Figure 6 (the sample can be tested in any one of the three orthogonal directions as specified).

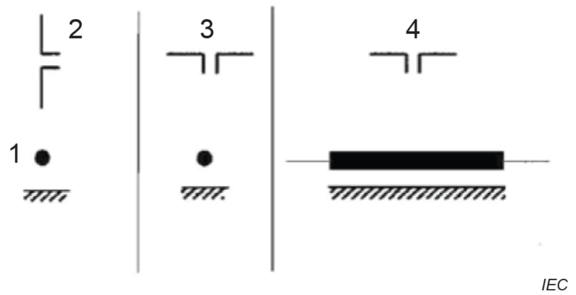
Dimensions in metres



Key

1	signal generator	9	antenna
2	connecting cable	10	track
3	transceiver end	11	trolley
4	TS (radiating cable)	12	receiver
5	non-metallic posts	13	connecting cable
6	load end	14	position sensor
7	connecting cable	15	computer
8	receiver	16	concrete floor

Figure 5 – Test arrangement for ground-level method



Key

1 cable

2 radial

3 orthogonal

4 parallel

Figure 6 – Antenna orientations with ground-level method

6 Test conditions

Unless otherwise specified, all measurements shall be carried out under standard atmospheric conditions for testing in accordance with IEC 60068-1:2013, Clause 6. For segmented samples test, the temperature variation range for all measurements shall be ±2 °C.

7 Test methods

7.1 General

According to the length and the slot configuration of the radiating cable to be tested, one of the following test methods can be used.

a) complete sample test method: whole cable shall be tested as a test sample;

b) segmented samples test method: whole cable shall be cut into several segments so that each segment can be tested separately when the test site is shorter than the complete cable;

c) attenuation + coupling loss test method: if the whole cable to be tested or every segmented sample to be tested has uniform slots, attenuation constant, coupling loss and the link loss of every segmented sample can be obtained by testing its attenuation constant and coupling loss separately.

7.2 Complete sample test method

7.2.1 Test sample (TS) preparation

The whole radiating cable to be tested shall be terminated with matched connectors at both ends and marked transceiver end and load end at its ends according to the cable design.

7.2.2 Test procedure

The test procedure of complete sample shall be as follows:

a) choose a test arrangement from 5.2 and 5.3;

b) set the frequency of the signal generator to the test frequency and adjust its output power level so that the level received at the antenna is 10 dB to 15 dB above the receiver's sensitivity at any position of the whole TS;

c) connect the signal generator to the receiver by the test lead. Record the power level of the receiver as N_{in};

d) connect the TS into the test system with its transceiver end connecting to the signal generator and its load end connecting to the load as shown in Figure 3 or Figure 5;

e) move the trolley along the track and get the link loss curve of the TS;

f) choose 95 % or 50 % reception probabilities of link loss from the equipment according to the relevant specification and the maximum value of link loss of all segments at this reception probability is the final test value of the TS (see 4.7);

g) if needed, repeat steps b) to f) to measure the link loss at other frequencies.

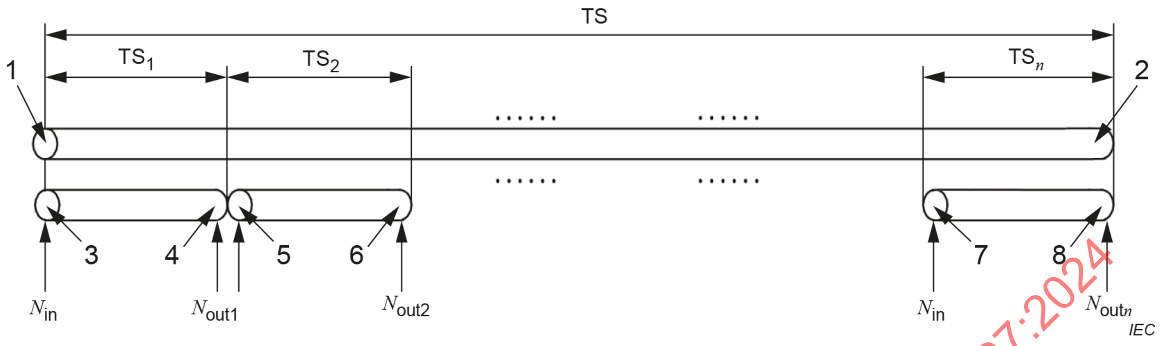
NOTE If the test data within 5 m from both ends of the TS show abnormal fluctuations, the test data can be neglected (see Note 1 of Subclause 4.7).

7.3 Segmented samples test method

7.3.1 Test sample (TS) preparation

Cut the complete cable into two or more segments so that each segment can be tested separately, and the length of each segment shall be at least 10 λ but not less than 50 m, where λ is the cable wavelength of the measuring frequency.

The segment cut from the complete cable shall be named TS_1, TS_2, … TS_n. Each segment shall be terminated with matched connectors at both ends separately and marked transceiver end and load end at its ends according to the design, as shown in Figure 7.



Key

1 transceiver end

2 load end

3 transceiver end

4 load end

5 transceiver end

6 load end

7 transceiver end

8 load end

Figure 7 – Segmented test samples

7.3.2 Test procedure

The test procedure of segmented samples test method shall be as follows:

a) test TS_1: Test the link loss curve of the TS_1 according to 7.2.2 a) to f). Then remove the load and connect the receiver to the load end of TS_1. Record the received power level as N_{out1}, as shown in Figure 8. If needed, use the same way to measure the link loss at other frequencies;

b) use the same N_{in} and the test frequency as TS_1 to test the link loss curve of other segments by using following method:

1) test TS_2: Test the link loss curve of the TS_2 according to 7.2.2 e) to f). Then remove the load and connect the receiver with the load end of TS_2 and record the received power level as N_{out2}, as shown in Figure 8. If needed, use the same way to measure the link loss at other frequencies;

2) test TS_n: Use the same way to test the link loss curve of TS_n and record the received power level as $N_{\text{out}n}$.

NOTE 1 At least N_{out1}, N_{out2},…. and $N_{\text{out}n\text{-1}}$ need to be recorded.

c) calibration: Synthesize all test curves of each segment in the same frequency by using the following method:

1) use the link loss curve of TS_1 with no change;

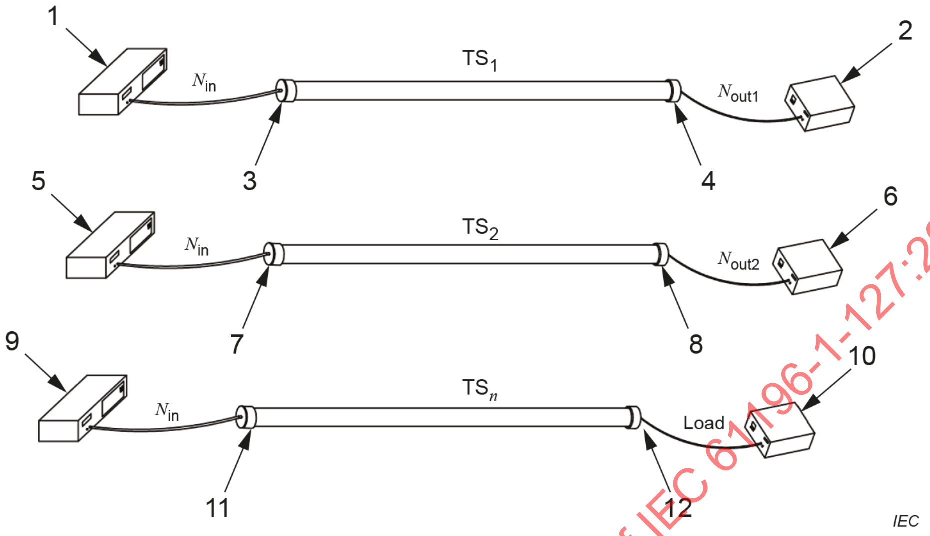
2) use the link loss curve of TS_2 subtracted by $N_{\text{in}} - N_{\text{out1}}$;

3) use the link loss curve of TS_3 subtracted by $2N_{\text{in}} - N_{\text{out1}} - N_{\text{out2}}$;

4) use the link loss curve of TS_n subtracted by $(n\text{-}1)\ N_{\text{in}} - N_{\text{out1}} - N_{\text{out2}} - \ldots N_{\text{out}n\text{-1}}$;

d) choose 95 % or 50 % reception probabilities of link loss from the equipment according to the relevant specification. The maximum value of link loss of all segments at this reception probability is the final test value of the TS" (see Note 2 of Subclause 4.7).

NOTE 2 If the test data within 5 m from both ends of the TS show abnormal fluctuations, the test data can be neglected (see Note 1 of Subclause 4.7).



Key

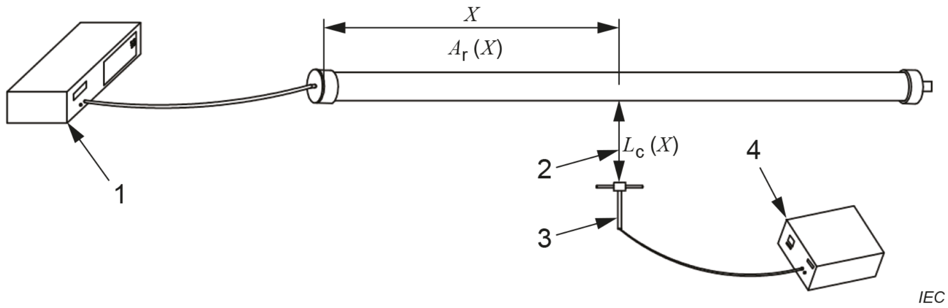
1	signal generator	7	transceiver end
2	receiver	8	load end
3	transceiver end	9	signal generator
4	load end	10	receiver
5	signal generator	11	transceiver end
6	receiver	12	load end

Figure 8 – Segmented samples test

7.4 Attenuation and coupling loss test method

7.4.1 General

The attenuation and coupling loss test method only applies to radiating cables which have uniform slots, attenuation constant and coupling loss in sections to be tested. A schematic diagram of the link loss of the radiating cable is shown in Figure 9.



Key

1 signal generator

2 distance

3 antenna

4 transceiver

Figure 9 – Schematic diagram of the link loss of the radiating cable

The link loss of the cable with uniform slots can be expressed by Formula (4):

$$L_L(X) = A_t(X) + L_c(X) = 0{,}01\alpha X + L_c(X) \tag{4}$$

where

$L_L(X)$ is the link loss from the input of the radiating cable to the antenna at a distance from the radiating cable at point X, in dB;

$A_t(X)$ is the total attenuation from the input to point X of the radiating cable, in dB;

$L_c(X)$ is the coupling loss of radiating cable at the same point X, in dB;

α is the attenuation constant of radiating cable, in dB/100 m;

X is the distance from the transceiver to point X of the radiating cable, in m.

If the complete cable to be tested has different slots, it can be cut into several segments so that every segment has uniform slots and attenuation constant and coupling loss. In that case, the link loss of each segment to be tested can be test separately. A segmented test samples for attenuation + coupling loss test method is shown in Figure 10.

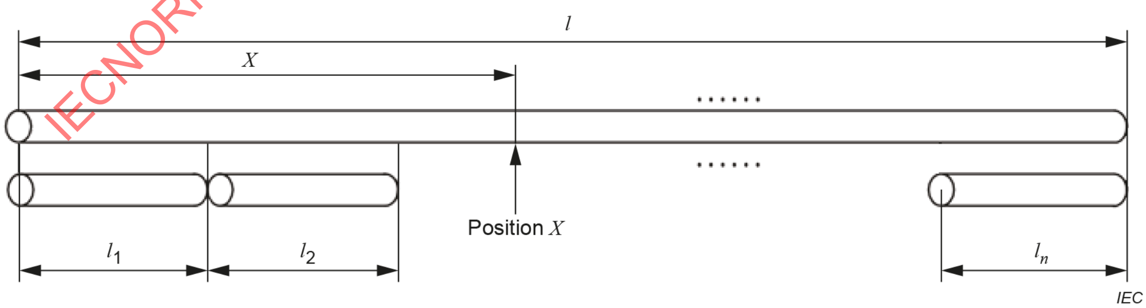


Figure 10 – Segmented test samples for attenuation + coupling loss test method