



Spectrum Management and Telecommunications

Interference-Causing Equipment Standard

Alternating Current High Voltage Power Systems

DRAFT

Preface

Interference-Causing Equipment Standard ICES-004, issue 5, *Alternating Current High Voltage Power Systems*, replaces ICES-004, issue 4, published in June 2013.

This issue of the ICES-004 standard will come into force upon its publication on the Innovation, Science, and Economic Development Canada (ISED) website. However, a transition period is provided, according to section 2.1, within which compliance with either issue 4 or issue 5 of ICES-004 is accepted.

Listed below are the main changes:

1. updated the normative references (section 2.2) and the definitions (section 2.3);
2. clarified various aspects of the measurement procedure, such as the specific height of the loop antenna and the necessity to properly ground the counterpoise of the rod antenna (section 3.2);
3. reformatted the limit specification to allow a more straightforward and faster determination of compliance (section 3.3.1); the old format of limit specification is retained in annex B;
4. added a new annex providing the history of the requirements and limits in ICES-004 (annex A);
5. added an example measurement scenario (annex C);

Inquiries may be submitted by one of the following methods:

1. Online using the [General Inquiry](#) form (in the form, select the Directorate of Regulatory Standards radio button and specify “ICES-004” in the General Inquiry field)

2. By mail to the following address:

Innovation, Science and Economic Development Canada
Engineering, Planning and Standards Branch
Attention: Regulatory Standards Directorate
235 Queen Street
Ottawa ON K1A 0H5
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3. By email to <mailto:consultationradiostandards-consultationnormesradio@ised-isde.gc.ca>.

Comments and suggestions for improving this standard may be submitted online using the [Standard Change Request](#) form or by mail or email to the above addresses.

All spectrum and telecommunications related documents are available on ISED's [Spectrum Management and Telecommunications](#) website.

Issued under the authority of the Minister of Innovation, Science and Industry

Martin Proulx
Director General
Engineering, Planning and Standards Branch

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1. Scope

This interference-causing equipment standard (ICES) sets out limits for radiated emissions between 150 kHz and 30 MHz generated by alternating current (AC) high voltage power systems, as well as corresponding measurement procedures.

This document does not apply to:

- a. Underground power systems;
- b. Radiated emissions associated with power line carrier current transmissions; these are instead subject to [ICES-006, AC Wire Carrier Current Devices \(Unintentional Radiators\)](#);
- c. High voltage direct current components of a power system in which the design for the construction of the direct current components of the system was initiated before 1 January 1991.

2. General requirements, references and definitions

This section defines the general requirements related to this standard, including the transition period, compliance with ICES-Gen, the list of normative references, and the definitions of terms used in this standard.

2.1 Transition period

A transition period is provided, ending three months after the publication of this standard (i.e., on **XY Month** 2022), within which compliance with either issue 4 or issue 5 of ICES-004 is accepted. A copy of issue 4 of ICES-004 may be requested by [email](#).

All measurements on AC high voltage power systems subject to ICES-004 performed after the above transition period shall comply with issue 5.

2.2 Normative references

This standard refers to the following publications and, where such references are made, they shall be understood to be to the editions listed below:

- CAN/CSA-IEC CISPR 16-1-1:18, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus* (IEC CISPR 16-1-1:2015, IDT).
- CISPR 16-1-4:2019+AMD1:2020, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Antennas and test sites for radiated disturbance measurements*.

These two standards can be purchased online from the [Canadian Standards Association \(CSA\) store](#) (CAN/CSA-IEC CISPR 16-1-1:18) and from the [International Electrotechnical Commission \(IEC\) webstore](#) (CISPR 16-1-4:2019+AMD1:2020).

Other editions of these standards are acceptable only if the content that is relevant to ICES-004 is identical to that in the editions listed above.

2.3 Definitions

The following definitions apply, in addition to those specified in ICES-Gen, [General Requirements for Compliance of Interference-Causing Equipment](#):

Alternating current high voltage power system, or power system: any generating station, substation or power line, or any combination thereof, that is operated under common management for the generation, transmission or distribution of alternating current electric power.

Distribution line: an overhead power line that operates at nominal phase-to-phase voltages from 1 kV to 75 kV.

Distribution substation: a substation at which all power lines entering or leaving the substation are distribution lines.

Fair weather: weather conditions that are absent of rain, snow and/or fog within a 10 km radius of the measuring location. For the conditions to be considered fair weather, insulators and conductors must be completely dry.

Power line: a transmission line or a distribution line.

Span: the horizontal distance between two consecutive towers/poles supporting a power line.

Substation: an assemblage of equipment — including switches, circuit breakers, buses, transformers and control devices — for the purpose of switching power circuits or transforming electric power from one voltage to another.

Transmission line: an overhead power line that operates at nominal phase-to-phase voltages above 75 kV and up to 800 kV.

Transmission substation: a substation where at least one of the power lines entering the substation is a transmission line.

3. Technical requirements

This section defines the technical requirements associated with this standard.

3.1 Measurement equipment

Compliance with the limits specified in ICES-004 shall be evaluated using a measuring receiver (or spectrum analyzer) with quasi-peak detector that complies with the applicable requirements stated in CAN/CSA-IEC CISPR 16-1-1:18 (in particular, clause 4 therein).

The measurement antenna shall be either a rod antenna or a shielded loop antenna compliant with subclauses 4.3 and 4.4 of CISPR 16-1-4:2019+AMD1:2020. A rod antenna shall only be used if it is provided with a counterpoise and if this counterpoise is properly grounded at each location where measurements are performed. Measurements with a loop antenna are preferable as they provide more repeatable and reproducible results than those performed with a rod antenna.

Both the measurement instrument and the measuring antenna shall be calibrated, with the last calibration less than three years prior to the date when ICES-004 measurements are performed. The same applies for each coaxial cable, preamplifier, attenuator and/or filter used for connecting the measuring antenna to the measurement instrument.

3.2 Measurement methods

This section defines the measurement methods.

3.2.1 General

All measurements shall be performed in fair weather.

The entire frequency range of 150 kHz to 30 MHz shall be measured for verifying that no emission, at any frequency within this range, exceeds the applicable limits.

The person performing the measurements should be at least 2 m from the antenna, especially if a rod antenna is used, for not influencing the measurement.

When using a loop antenna, the following conditions apply at each measurement location (see also [figure C1](#) and [figure C2](#)):

- The centre of the loop shall be at 1.3 m height above the ground;
- The plane of the loop shall be perpendicular to the ground;
- For each frequency where the measured emission level is within 10 dB of the limits specified in section 3.3, the loop antenna shall be rotated around the vertical axis connecting the centre

of the loop with its projection on the ground until the maximum reading is obtained on the measurement instrument.

When using a rod antenna, it shall be placed directly on the ground, with the rod in a vertical position, and its counterpoise shall be grounded at each measurement location (e.g., by bonding the counterpoise to a sufficiently long copper rod driven into the ground). Great care should be exercised when using a rod antenna due to the possibility that the tip of the antenna will go into corona when closer than 15 m from a power line of 230 kV or above.

For all measurements, the reading level obtained on the measurement instrument shall be corrected by adding the antenna factor and the loss of the cable or cables (and of any attenuators or filters used, if applicable). If a preamplifier is used, its gain shall be subtracted from the reading level obtained on the measurement instrument. All these factors shall be taken from the corresponding calibration certificates, at each measured frequency. Factors at frequencies not specified in the calibration certificate shall be determined by linear interpolation between the values specified in the calibration certificate at the closest frequency above and the closest frequency below the measured emission frequency. The interpolation shall use a linear scale for the factor value expressed in logarithmic units and a logarithmic frequency scale. An example interpolation calculation is provided in [annex C](#) (while that example is related to the limits, the same formula applies for antenna factor, cable/filter loss, or preamplifier gain).

3.2.2 Measurement procedure for transmission lines

Measurements shall be performed at points located near both ends as well as near the middle of the transmission line. For each one of these three measurement locations, the following conditions apply:

- Wherever possible, the measurement point shall be at least 5 km from the nearest transmission or distribution substation, and from the power generating station.
- The measurement point shall be selected such that the ambient noise (i.e., emissions that are not coming from the transmission line under test) in the 150 kHz to 30 MHz frequency range is 6 dB or more below the applicable limit. This may be achieved by moving the measurement point on the other side of the line under test, or by selecting a different span.
- The measurement point should be sufficiently separated from any metal fences or other reflecting objects, as well as from any intersections with other power lines or communication lines, such that the influence of these objects/lines on the measurements is minimized.
- The measurement point shall be in the vertical plane that is perpendicular to the transmission line under test at the centre of its span.
- The measurement point shall be at a lateral separation distance of 15 m from the vertical plane containing the nearest conductor of the transmission line under test. However, when this is not possible, one of the two procedures specified in section [3.3.1.2](#) shall be used.

3.2.3 Measurement procedure for transmission substations

Measurements shall be performed, at a minimum, along each of any two adjacent sides of the transmission substation, as follows:

- The measurement points should be sufficiently separated from power lines and communication lines such that the influence of these lines on the measurements is minimized.
- The measurement points shall be at a lateral separation distance of 15 m from the property limit of the transmission substation under test. However, when this is not possible, one of the two procedures specified in section 3.3.1.2 shall be used.
- For each selected side of the transmission substation, preliminary exploratory measurements shall be performed along its entire length for determining the measurement point where the highest field strength level relative to the limit is obtained (from all detected emission frequencies within the 150 kHz to 30 MHz frequency range). The final measurement, for the selected side, shall be performed at this location by applying all the requirements specified in section 3.2.1 and in this section (3.2.3), as appropriate.
- If measurements are only performed on two adjacent sides of the transmission substation, the two sides likely to result in highest emission levels relative to the limit should be selected (e.g., where the property limit is closest to the transmission substation under test).

3.3 Limits

This section defines the limits.

3.3.1 Limits for transmission lines and transmission substations

This section defines the limits for transmission lines/substations.

3.3.1.1. Primary limits (measurement distance of 15 m)

The maximum magnetic field strength radiated in the frequency range from 150 kHz to 30 MHz by a transmission substation or a transmission line, as measured in fair weather at a lateral distance of 15 m in accordance with section 3.2, shall not exceed the values set out in table 1 or table 2, respectively. Depending on the phase-to-phase voltage, the following limit (L_x , with X between 1 and 5) shall apply:

- L_1 : phase-to-phase voltage between 76 kV and 200 kV;
- L_2 : phase-to-phase voltage greater than 200 kV and up to 300 kV;
- L_3 : phase-to-phase voltage greater than 300 kV and up to 400 kV;
- L_4 : phase-to-phase voltage greater than 400 kV and up to 600 kV;
- L_5 : phase-to-phase voltage greater than 600 kV and up to 800 kV.

For transmission substations where the nominal phase-to-phase voltages are within two or more of the ranges specified above, the limit corresponding to the highest phase-to-phase voltage used at that transmission substation shall apply.

At any other frequency within the frequency range of 150 kHz to 30 MHz (i.e., any frequency that is not listed in [table 1](#) or [table 2](#)), the applicable limit value shall be calculated by linear interpolation between the limit values corresponding to the closest frequencies listed in [table 1](#) or [table 2](#) that are below and above the specific frequency. The interpolation shall use a linear scale for the limit value (expressed in logarithmic units) and a logarithmic frequency scale. An example interpolation calculation is provided in [annex C](#): see [equation \(C1\)](#).

When using the “electrical” antenna factor for the loop antenna, or when using a rod antenna, the applicable limit specified in [table 1](#) or [table 2](#) shall be converted to an electric field strength limit using the [equation \(1\)](#) below:

$$L_X^E = L_X^H + 51.5 \quad (1)$$

where

L_X^E is the electric field strength limit, in dB(μ V/m),

L_X^H is the magnetic field strength limit, in dB(μ A/m), from [table 1](#) or [table 2](#),

X is between 1 and 5, as applicable, and

51.5 is the impedance of the free space, in dB Ω .

Note that the “electrical” antenna factor that might be provided by an antenna calibration laboratory for a specific loop antenna is not the true electrical antenna factor of that antenna. Instead, it is just a quantity calculated from the magnetic antenna factor by using the free space impedance value. The true electrical antenna factor of the loop antenna would be much higher than this value, because the loop antenna is designed to have an optimum response to magnetic field and a poor response to electric field (see also the [Notice 2020 – DRS0023](#)).

Table 1: Magnetic field strength limits for transmission lines (at 15 m distance)

Freq.	L ₁	L ₂	L ₃	L ₄	L ₅	Freq.	L ₁	L ₂	L ₃	L ₄	L ₅
MHz	dBμA/m	dBμA/m	dBμA/m	dBμA/m	dBμA/m	MHz	dBμA/m	dBμA/m	dBμA/m	dBμA/m	dBμA/m
0.15	10.47	14.47	17.47	21.47	24.47	4	-24.63	-20.63	-17.63	-13.63	-10.63
0.2	7.47	11.47	14.47	18.47	21.47	4.5	-25.98	-21.98	-18.98	-14.98	-11.98
0.25	5.07	9.07	12.07	16.07	19.07	5	-27.23	-23.23	-20.23	-16.23	-13.23
0.3	3.07	7.07	10.07	14.07	17.07	5.5	-28.33	-24.33	-21.33	-17.33	-14.33
0.35	1.47	5.47	8.47	12.47	15.47	6	-29.33	-25.33	-22.33	-18.33	-15.33
0.4	-0.03	3.97	6.97	10.97	13.97	6.5	-30.33	-26.33	-23.33	-19.33	-16.33
0.45	-1.33	2.67	5.67	9.67	12.67	7	-31.23	-27.23	-24.23	-20.23	-17.23
0.5	-2.53	1.47	4.47	8.47	11.47	7.5	-32.13	-28.13	-25.13	-21.13	-18.13
0.55	-3.43	0.57	3.57	7.57	10.57	8	-32.93	-28.93	-25.93	-21.93	-18.93
0.6	-4.43	-0.43	2.57	6.57	9.57	8.5	-33.73	-29.73	-26.73	-22.73	-19.73
0.65	-5.23	-1.23	1.77	5.77	8.77	9	-34.53	-30.53	-27.53	-23.53	-20.53
0.7	-6.03	-2.03	0.97	4.97	7.97	9.5	-35.23	-31.23	-28.23	-24.23	-21.23
0.75	-6.73	-2.73	0.27	4.27	7.27	10	-35.93	-31.93	-28.93	-24.93	-21.93
0.8	-7.43	-3.43	-0.43	3.57	6.57	12	-38.23	-34.23	-31.23	-27.23	-24.23
0.85	-8.13	-4.13	-1.13	2.87	5.87	14	-40.23	-36.23	-33.23	-29.23	-26.23
0.9	-8.68	-4.68	-1.68	2.32	5.32	16	-41.93	-37.93	-34.93	-30.93	-27.93
0.95	-9.28	-5.28	-2.28	1.72	4.72	18	-43.43	-39.43	-36.43	-32.43	-29.43
1	-9.83	-5.83	-2.83	1.17	4.17	20	-44.63	-40.63	-37.63	-33.63	-30.63
1.5	-14.13	-10.13	-7.13	-3.13	-0.13	22	-45.93	-41.93	-38.93	-34.93	-31.93
2	-17.18	-13.18	-10.18	-6.18	-3.18	24	-47.03	-43.03	-40.03	-36.03	-33.03
2.5	-19.53	-15.53	-12.53	-8.53	-5.53	26	-47.93	-43.93	-40.93	-36.93	-33.93
3	-21.48	-17.48	-14.48	-10.48	-7.48	28	-48.88	-44.88	-41.88	-37.88	-34.88
3.5	-23.18	-19.18	-16.18	-12.18	-9.18	30	-49.63	-45.63	-42.63	-38.63	-35.63

Table 2: Magnetic field strength limits for transmission substations (at 15 m distance)

Freq.	L ₁	L ₂	L ₃	L ₄	L ₅	Freq.	L ₁	L ₂	L ₃	L ₄	L ₅
MHz	dBμA/m	dBμA/m	dBμA/m	dBμA/m	dBμA/m	MHz	dBμA/m	dBμA/m	dBμA/m	dBμA/m	dBμA/m
0.15	0.87	4.87	7.87	11.87	14.87	4	-9.33	-5.33	-2.33	1.67	4.67
0.2	0.07	4.07	7.07	11.07	14.07	4.5	-9.83	-5.83	-2.83	1.17	4.17
0.25	-0.53	3.47	6.47	10.47	13.47	5	-10.33	-6.33	-3.33	0.67	3.67
0.3	-1.03	2.97	5.97	9.97	12.97	5.5	-10.78	-6.78	-3.78	0.22	3.22
0.35	-1.53	2.47	5.47	9.47	12.47	6	-11.23	-7.23	-4.23	-0.23	2.77
0.4	-1.93	2.07	5.07	9.07	12.07	6.5	-11.63	-7.63	-4.63	-0.63	2.37
0.45	-2.23	1.77	4.77	8.77	11.77	7	-12.08	-8.08	-5.08	-1.08	1.92
0.5	-2.53	1.47	4.47	8.47	11.47	7.5	-12.48	-8.48	-5.48	-1.48	1.52
0.55	-2.73	1.27	4.27	8.27	11.27	8	-12.88	-8.88	-5.88	-1.88	1.12
0.6	-3.03	0.97	3.97	7.97	10.97	8.5	-13.28	-9.28	-6.28	-2.28	0.72
0.65	-3.28	0.72	3.72	7.72	10.72	9	-13.63	-9.63	-6.63	-2.63	0.37
0.7	-3.53	0.47	3.47	7.47	10.47	9.5	-14.03	-10.03	-7.03	-3.03	-0.03
0.75	-3.73	0.27	3.27	7.27	10.27	10	-14.35	-10.35	-7.35	-3.35	-0.35
0.8	-3.93	0.07	3.07	7.07	10.07	12	-15.73	-11.73	-8.73	-4.73	-1.73
0.85	-4.08	-0.08	2.92	6.92	9.92	14	-16.93	-12.93	-9.93	-5.93	-2.93
0.9	-4.25	-0.25	2.75	6.75	9.75	16	-18.13	-14.13	-11.13	-7.13	-4.13
0.95	-4.43	-0.43	2.57	6.57	9.57	18	-19.33	-15.33	-12.33	-8.33	-5.33
1	-4.58	-0.58	2.42	6.42	9.42	20	-20.43	-16.43	-13.43	-9.43	-6.43
1.5	-5.83	-1.83	1.17	5.17	8.17	22	-21.53	-17.53	-14.53	-10.53	-7.53
2	-6.68	-2.68	0.32	4.32	7.32	24	-22.73	-18.73	-15.73	-11.73	-8.73
2.5	-7.48	-3.48	-0.48	3.52	6.52	26	-23.83	-19.83	-16.83	-12.83	-9.83
3	-8.13	-4.13	-1.13	2.87	5.87	28	-25.03	-21.03	-18.03	-14.03	-11.03
3.5	-8.73	-4.73	-1.73	2.27	5.27	30	-26.23	-22.23	-19.23	-15.23	-12.23

The limits specified in [table 1](#) or [table 2](#) are presented graphically in [figure 1](#) and [figure 2](#), for information.

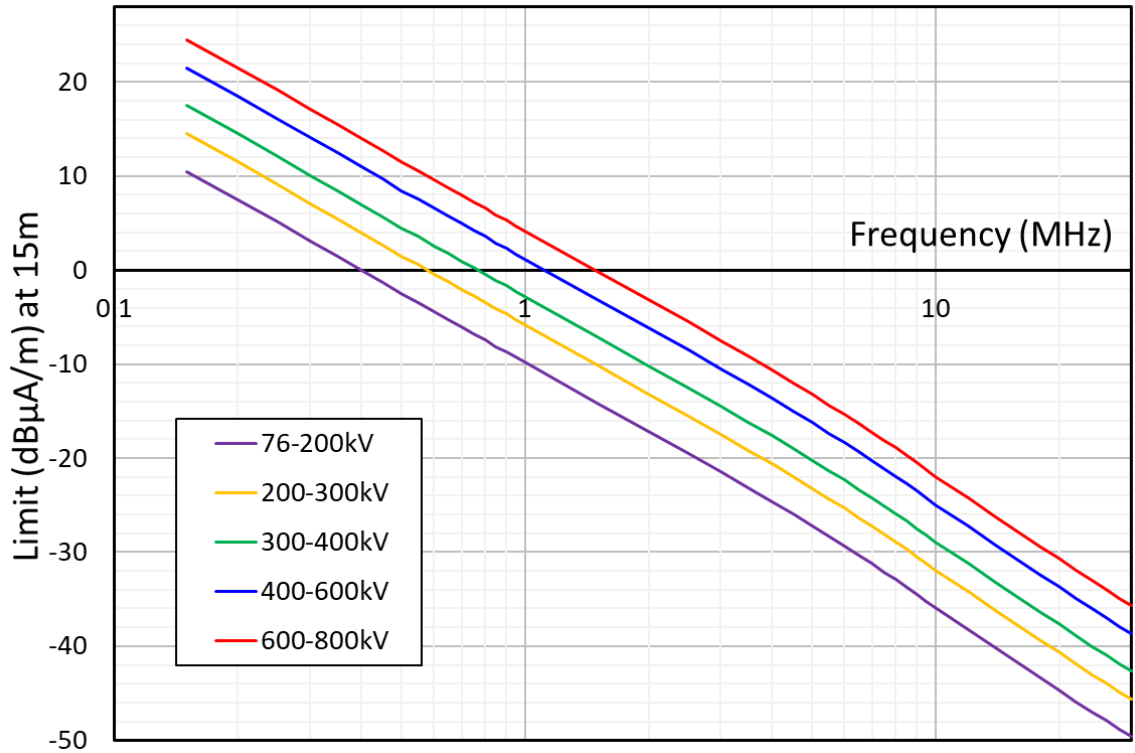


Figure 1: Magnetic field strength limits for transmission lines (at 15 m distance)

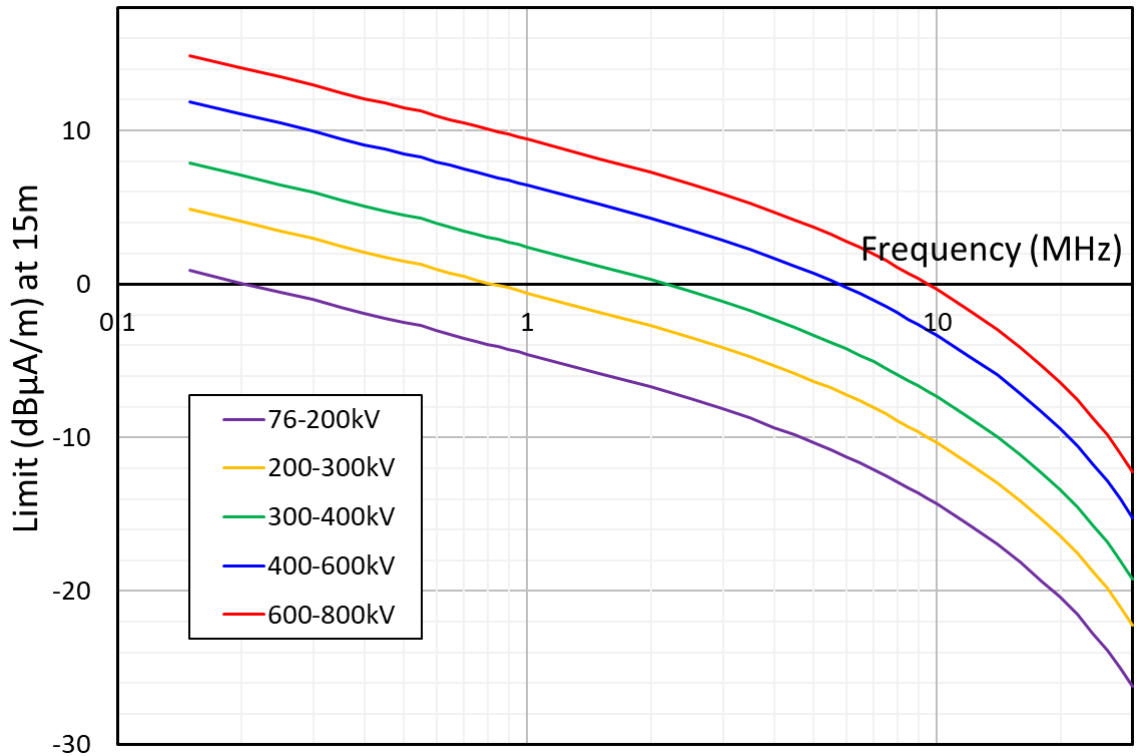


Figure 2: Magnetic field strength limits for transmission substations (at 15 m distance)

3.3.1.2. Measurement distances other than 15 m

When measurements cannot be performed at a lateral distance of 15 m, one of the two procedures provided in this section shall be used.

In the first procedure at least two measurements shall be performed, at different distances, and the field strength level at 15 m lateral distance shall be calculated by linear interpolation between the results obtained from measurements, at each emission frequency. This is the preferred procedure, as actual measurements are more reliable than extrapolation using the correction factor specified in [table 3](#). The interpolation shall use a linear scale for the field strength value (expressed in logarithmic units) and a logarithmic distance scale. An example interpolation calculation is provided in [annex C](#): see [equation \(C3\)](#). The selected measurement distances shall include at least one that is smaller than 15 m and at least one that is greater than 15 m.

The second procedure only requires measurements at one distance, but it can only be applied for transmission substations and for transmission lines having the lowest conductor at 9 m or 15 m height above ground. In this alternate procedure, the applicable limit level (from [table 1](#) or [table 2](#); see section [3.3.1.1](#)) shall be modified by subtracting the correction factor specified in [table 3](#), as per [equation \(2\)](#):

$$L_X^H(D) = L_X^H(15m) - C_Y(D) \quad (2)$$

where

D is the lateral distance where the measurements were performed, in m,

$L_X^H(D)$ is the magnetic field strength limit for the lateral measurement distance D , in dB(μ A/m),

$L_X^H(15m)$ is the magnetic field strength limit for a lateral measurement distance of 15 m, in dB(μ A/m), from [table 1](#) or [table 2](#),

X is between 1 and 5, as applicable,

$C_Y(D)$ is the correction factor corresponding to distance D , in dB, from [table 3](#),

$Y = A$ for transmission lines having the lowest conductor at 15 m height above ground, and

$Y = B$ for transmission lines having the lowest conductor at 9 m height above ground, or for transmission substations.

At any other distance (i.e., any distance that is not listed in [table 3](#)), the applicable correction factor value shall be calculated by linear interpolation between the values corresponding to the closest distances listed in [table 3](#) that are below and above the specific distance. An example interpolation calculation is provided in [annex C](#): see [equation \(C2\)](#).

The distance correction factor specified in [table 3](#) is presented graphically in [figure B1](#), for information (see [annex B](#)).

The field strength obtained through actual measurements (either at 15 m distance or by means of multiple measurements performed at different distances) is preferred, instead of extrapolating the field strength measured at a distance other than 15 m using the correction factor specified in [table 3](#).

Table 3: Correction factor for measurement distances other than 15 m

Dist.	C _A	C _B	Dist.	C _A	C _B	Dist.	C _A	C _B	Dist.	C _A	C _B
m	dB	dB	m	dB	dB	m	dB	dB	m	dB	dB
10	-2.25	-3.75	23	3.8	5	36	8.8	10.85	49	12.9	15.25
11	-1.85	-2.95	24	4.2	5.6	37	9.15	11.2	50	13.2	15.6
12	-1.4	-2.2	25	4.65	6.2	38	9.45	11.6	51	13.45	15.85
13	-0.95	-1.45	26	5.1	6.7	39	9.8	11.95	52	13.75	16.15
14	-0.45	-0.7	27	5.45	7.15	40	10.15	12.3	53	14	16.4
15	0	0	28	5.9	7.65	41	10.45	12.65	54	14.25	16.7
16	0.55	0.7	29	6.3	8.1	42	10.8	12.95	55	14.5	16.95
17	1.05	1.35	30	6.65	8.52	43	11.1	13.3	56	14.75	17.2
18	1.53	2	31	7.05	8.93	44	11.4	13.6	57	15	17.45
19	2	2.65	32	7.45	9.3	45	11.7	13.95	58	15.2	17.75
20	2.5	3.3	33	7.75	9.7	46	12	14.3	59	15.45	18
21	2.95	3.87	34	8.1	10.1	47	12.3	14.6	60	15.65	18.25
22	3.4	4.5	35	8.5	10.5	48	12.6	14.95	-	-	-

3.3.2 Limits for distribution lines and distribution substations

No limit applies to emissions from distribution lines or distribution substations. However, if the radiated emissions from a distribution line or a distribution substation cause harmful interference to the reception of:

- a Canadian broadcasting signal in the medium frequency (MF) band that measures at least 54 dB(μV/m) at the location of the receiver suffering interference; or
- any signal that is received in the performance of any other radio service,

then the radiated emissions from that distribution line or that distribution substation shall be limited to the level at which the harmful interference is eliminated.

4. Determination of harmful interference

Operators of transmission lines, transmission substations, distribution lines, and distribution substations should be aware that even when they comply with all requirements of the [Radiocommunication Act](#), the [Radiocommunication Regulations](#), and this technical standard, they are required to take all practical steps to minimize the likelihood of harmful interference occurrences.

ISED will not normally respond to a request from a complainant to make a formal determination of harmful interference, unless it can be demonstrated that all other reasonable courses of action to resolve the problem have been explored. ISED fully expects complainants and operators of transmission lines, transmission substations, distribution lines, and distribution substations to cooperate with one another in order to resolve interference issues.

As a last resort, ISED may decide to make a determination of harmful interference. When ISED is called upon to determine the existence of harmful interference, the operator of the transmission line, transmission substation, distribution line, or distribution substation alleged to be the source of the interference may be required to submit to ISED for review a record of the measurements and the test results of such equipment/installation (i.e., to demonstrate compliance with ICES-004). If the transmission line, the transmission substation, the distribution line, or the distribution substation is found to cause harmful interference to radiocommunication, the operator of this line or substation shall immediately take corrective action. ISED's determination of cause will be based upon the levels of magnetic field strength specified in section 3.3 of this technical standard.

5. Test report

The test report shall comply with the requirements in [ICES-Gen](#).

Annex A: (informative) History of ICES-004

ICES-004 draws its roots from the first years after World War Two, more specifically from the C22.4 No. 103 standard published by the Canadian Standards Association (CSA) in 1948, titled *Tolerable Limits and Special Methods of Measurement of Radio Interference from High Voltage Lines and Apparatus*. CSA further updated that first edition in 1975, changing its designation and title to C108.3.1 *Tolerable Limits and Methods of Measurement of Electromagnetic Interference from Alternating Current High Voltage Power Systems 0.15 MHz – 30 MHz*, and then again in 1984, with CAN3-C108.3.1-M84 *Limits and Measurement Methods of Electromagnetic Noise from AC Power Systems, 0.15 MHz – 30 MHz*.

The limits and measurement methods specified in these CSA standards were reflected in the Radio Interference Regulations, chapter 1374, published by Communications Canada (the precursor of ISED). In 1991, these limits and corresponding measurement methods were published as a separate regulatory standard, ICES-004 (issue 1, June 1991). Since then, ICES-004 went through three revisions (January 1999, December 2001, and June 2013), but with no modifications to the limits or measurement methods.

This revision (issue 5) does not constitute a technical change, since it continues to maintain the same limits and measurement methods that were in place for so many years. However, it adds detailed guidelines on how to perform the measurements, including an example measurement scenario, and reformats the limits to allow a simplified, more straightforward, and faster determination of compliance.

Annex B: (informative) Limits specification in previous editions of ICES-004

This annex is provided only for information and shall not be used for demonstrating compliance with ICES-004. Instead, the limits specified in section 3.3 shall be applied.

All previous editions of ICES-004 specified the applicable limit at 500 kHz, for a lateral measurement distance of 15 m, for various phase-to-phase voltage ranges (see table B1), and supplemented this with two separate correction factors: one for other measurement distances (see figure B1) and one for other frequencies (see figure B2).

Table B1: Maximum field strength at 500 kHz

Nominal phase-to-phase voltage kV	Maximum electric field strength at 15 m lateral distance dB(μ V/m)
greater than 75 and up to 200	49
greater than 200 and up to 300	53
greater than 300 and up to 400	56
greater than 400 and up to 600	60
greater than 600 and up to 800	63

In case the measurements are performed at a lateral distance different than 15 m, the correction factor specified in figure B1 is added to the measured field strength before comparing with the limit in table B1: the correction factor A applies for transmission lines with the lowest conductor 15 m above ground; the correction factor B applies for transmission lines with the lowest conductor 9 m above ground and for transmission substations.

In case of measured field strength levels at frequencies other than 500 kHz, the correction factor specified in figure B2 is added to the measured field strength before comparing with the limit in table B1: this factor is different for transmission lines than for transmission substations.

This way of specifying the limit, in particular the frequency-dependent correction factor, does not allow for a quick determination of compliance at a given frequency (except if that frequency is 500 kHz). This is why this fifth edition of ICES-004 takes a different approach and directly specifies the field strength limit at all frequencies by combining table B1 and figure B2. The limit specified in section 3.3.1 can thus be directly applied to determine if a specific measured field strength value (at any frequency within the 150 kHz to 30 MHz frequency range) is compliant with ICES-004 or not.

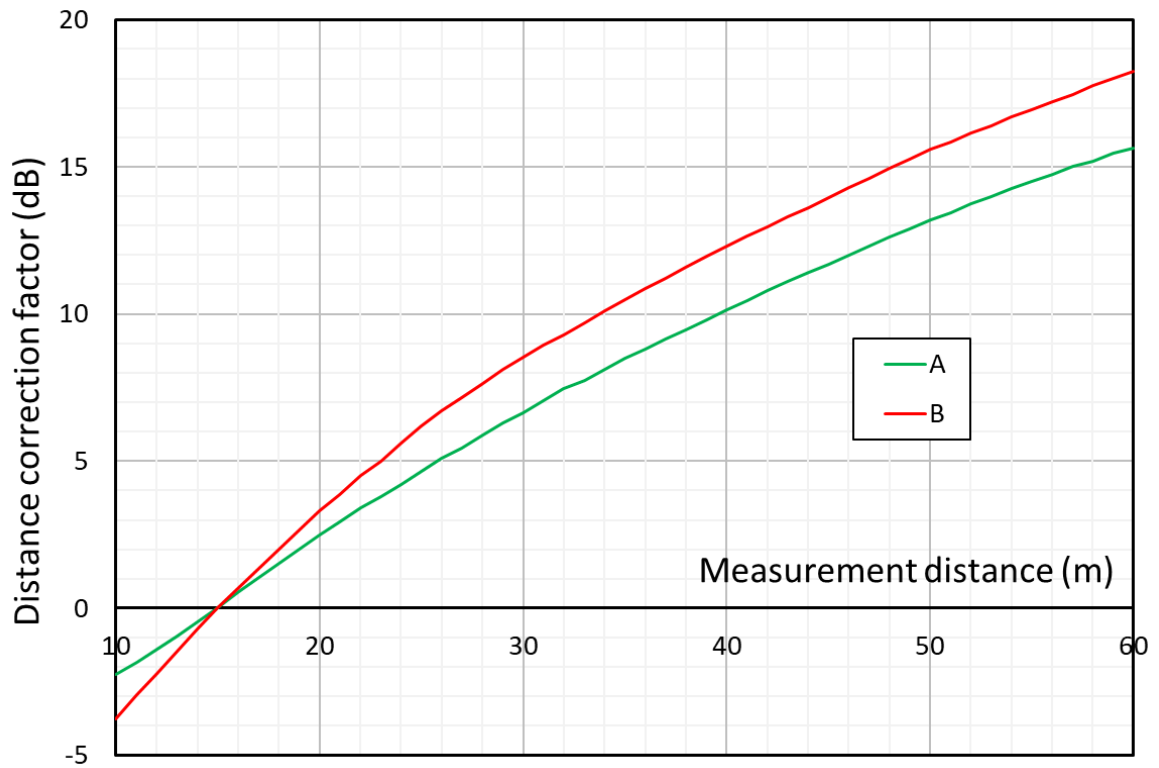


Figure B1: Correction factor for lateral distances other than 15 m

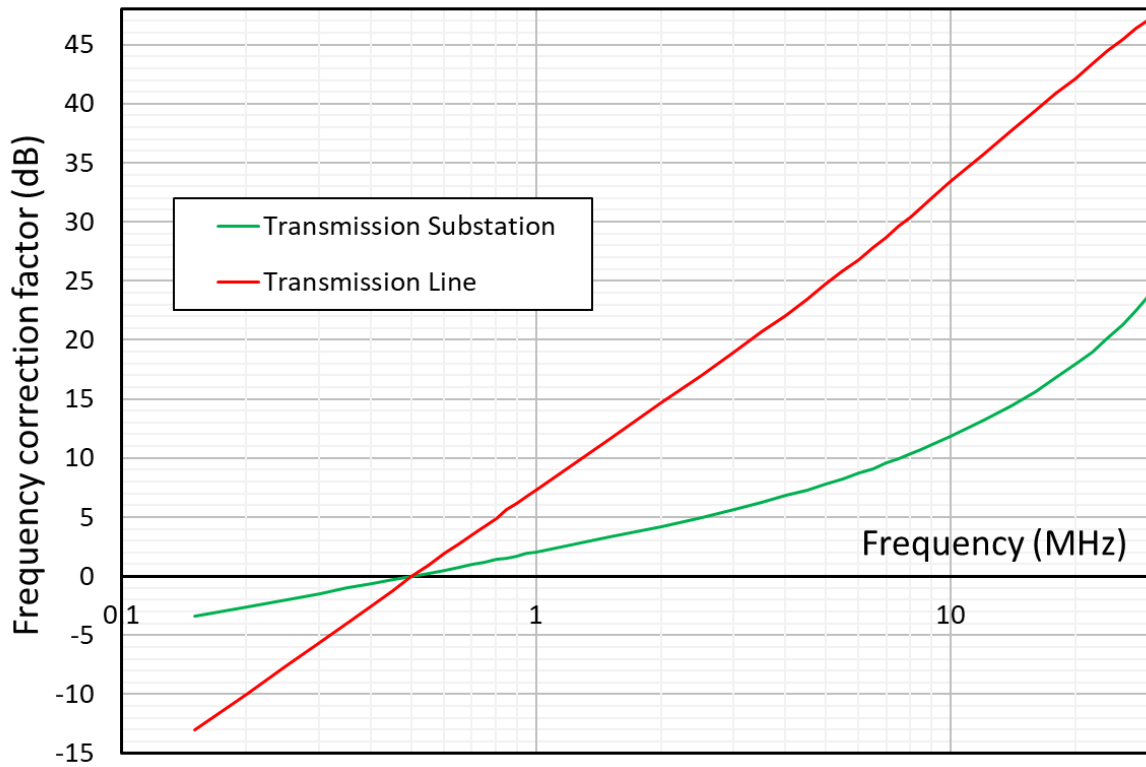


Figure B2: Correction factor for frequencies other than 500 kHz

Annex C: (informative) Example measurement scenario

This annex provides an example measurement scenario, for a transmission line.

The first step consists in the selection of the three measurement points, which, as per section 3.2.2, have to be near the two ends and near the middle of the transmission line: see figure C1. Sufficient separation needs to exist between each measurement point and other objects, power lines, or communication lines, such that their influence on the emissions measurement is minimized. Note that figure C1 shows each measurement point on the transmission line; however, for each location, measurements are taken at a lateral distance from the transmission line: see figure C3.

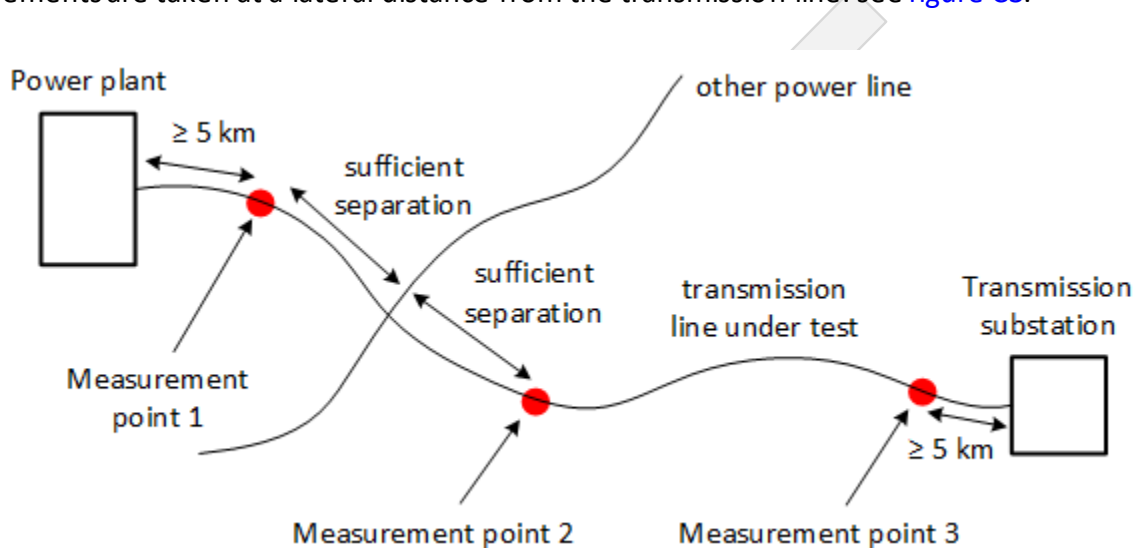


Figure C1: Measurement points selection for a transmission line

At each measurement point, the antenna is then placed in the vertical plane that passes through all power line’s conductors at the middle of the span, i.e., at the mid-distance between two consecutive transmission towers: see figure C2.

If possible, it is preferred that the measurements are performed with a loop antenna, which needs to be placed on a tripod such that its plane is vertical and its centre is at 1.3 m above the ground level. The antenna cable should be routed straight down to the ground and then to the measurement instrument. Both the measurement instrument and the person performing the measurements should be 2 m or more away from the antenna for minimizing their influence on the measurement.

In case a rod antenna is used instead, it needs to have a counterpoise. The rod antenna is placed at the measurement location with its rod in vertical position and its counterpoise flat against the ground. The counterpoise of the antenna needs to be properly grounded (e.g., by bonding it to a sufficiently long copper rod driven into the ground at the measurement location).

The antenna (loop or rod) needs to be placed, if possible, at a lateral distance of 15 m from the vertical plane passing through the closest power line: see [figure C3](#).

Where the measurement cannot be taken at a 15 m lateral distance, then either (see sections [3.2.2](#) and [3.3.1.2](#)):

- two (or more) measurements have to be taken, at different distances, with at least one smaller than 15 m and at least one greater than 15 m; or
- if the lowest conductor of the transmission line under test is at 9 m or 15 m height above ground, only one measurement may be performed, with the antenna placed at the nearest convenient distance.

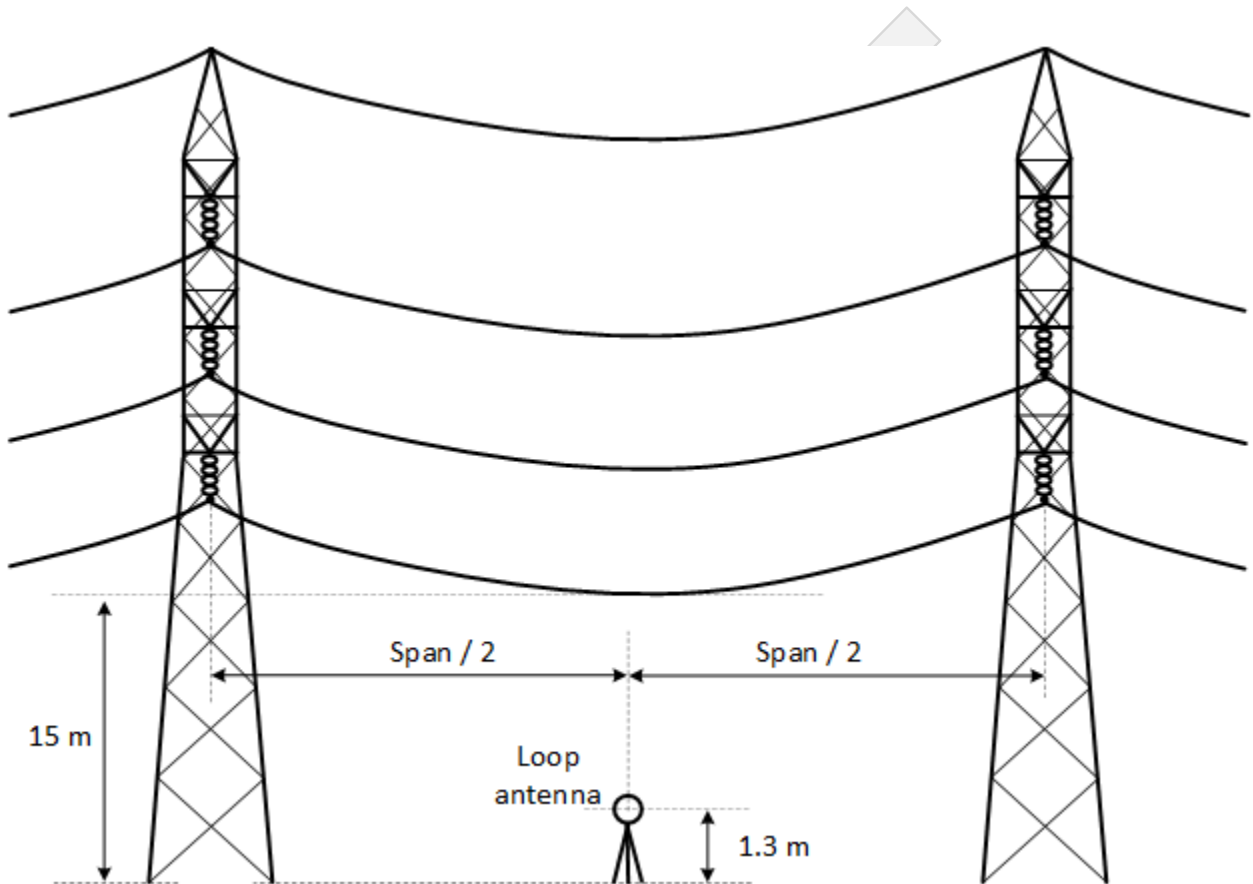


Figure C2: Antenna position (longitudinal view)

The measurement instrument is set up with a quasi-peak detector and a resolution bandwidth of 9 kHz, in accordance with CAN/CSA-IEC CISPR 16-1-1:18 (see section [3.1](#)). When using a spectrum analyzer, the MaxHold trace mode should be used and the measurement results should be recorded only after there are no more variations in the displayed spectrum. When using a receiver, the measurement time should be sufficiently long for recording the maximum level at each frequency.

It is recommended to insert an attenuator of at least 10 dB in front of the measurement instrument's input, at least for the initial measurement, for protecting the front end of the measuring instrument in case there are very high ambient signals at the specific measurement location. If, after taking the first scan of the electromagnetic spectrum, no high ambient signals are detected, the attenuator can then be removed for obtaining a greater sensitivity.

A measurement is then taken over the entire frequency range where limits are prescribed in section 3.3.1, i.e., 150 kHz to 30 MHz.

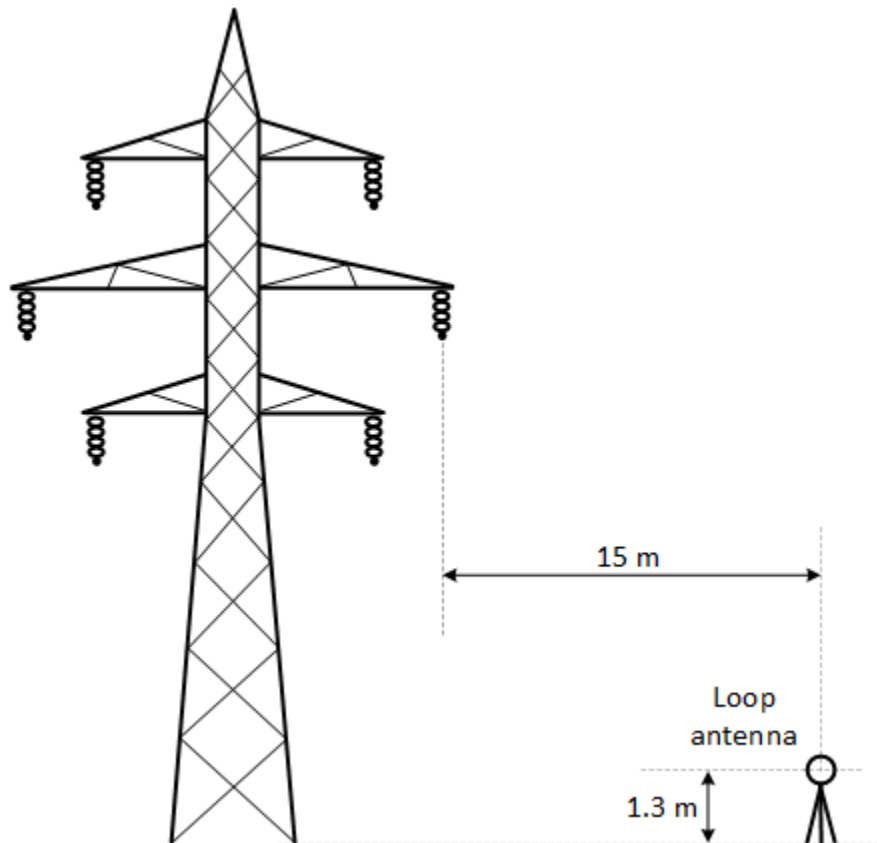


Figure C3: Antenna position (transversal view)

For easier and faster determination of compliance, it is beneficial to input a correction factor table in the measurement instrument (if it has that feature) with the combined antenna factor and cable loss (and other loss/gain, as applicable), both in logarithmic units. If a rod antenna is used for measurements, the free-space impedance of 51.5 dB Ω needs to be subtracted from the measured electric field strength level before comparing with the limit: see [equation \(1\)](#) in section 3.3.1.1. Thus, the measurement instrument will display all measured emissions directly in units of field strength, allowing each to be directly compared with the applicable limit. Some measurement instruments also permit uploading a limit (defined by multiple frequency-level points), which would further streamline the test, the instrument in this case immediately providing either an overall passing result or identifying those emissions that are above the limit.

If the antenna factor and the cable loss (and other loss/gain, as applicable) are not inserted as a correction factor in the measurement instrument, then each measured emission level needs to be corrected with these factors after taking the measurement. While the cable loss is usually low in this frequency range, both the antenna factor and the limit (in section 3.3.1) vary with frequency. As such, if the antenna factor is not automatically corrected for by the measurement instrument, a determination of compliance cannot be performed directly from the measured data. The measurement process will be longer because each detected emission will have to be first corrected with the antenna factor and cable loss (and other loss/gain, as applicable), at that frequency, before comparing with the limit at the same frequency.

All emissions found to be within 10 dB of the corresponding limit have to be further investigated by rotating the loop antenna in the vertical plane for maximizing the measured level. To avoid influencing the measurements (the person performing the measurements should not be close to the loop antenna when taking the measurement), either a motorized loop antenna positioner should be used (allowing remotely controlling its angle) or multiple measurements shall be taken with various angles of the loop antenna. Alternatively, exploratory measurements can be taken by manually rotating the loop antenna and, after finding the angle resulting in the highest reading, the antenna is fixed in this position and the person performing the measurements backs off for taking the final measurement at that frequency.

If the measurements were taken at a 15 m lateral distance, each detected emission, after correcting it with the antenna factor and cable loss (and other loss/gain, as applicable) corresponding to that frequency, is compared with the limit in table 1. If the measured emission’s frequency is not listed in the table, the limit level is calculated using linear interpolation. For example, if the emission frequency is 21.5 MHz, then the limit is calculated from the limit levels corresponding to the closest adjacent frequencies listed in the table (i.e., 20 MHz and 22 MHz):

$$L_X^H(21.5) = L_X^H(22) - [L_X^H(22) - L_X^H(20)] \frac{\log_{10}(21.5/20)}{\log_{10}(22/20)} \quad (C1)$$

where

$L_X^H(f)$ is the magnetic field strength limit for 15 m lateral measurement distance at frequency f , in dB(μ A/m), from table 1, and f is the frequency, in MHz.

Assuming the limit applicable to the transmission line under test is L_1 , the resulting limit at 21.5 MHz is -44.94 dB(μ A/m).

If the measurement cannot be taken at 15 m lateral distance, then the level measured at each frequency is further corrected with the distance correction factor from table 3 (see section 3.3.1.2). Assuming the measurement distance was 10 m, the correction factor that needs to be added to each measured emission level is -2.25 dB. This factor is not dependent on frequency, thus the same value must be added to all measured emission levels, at all frequencies detected at the specific measurement location. This is possible because the transmission line under test has the lowest conductor at 15 m height above ground (see figure C2). If the height of the lowest conductor was instead 9 m, then the distance correction factor, for a measurement distance of 10 m, would have been -3.75 dB.

If the measurement distance employed is not listed in [table 3](#), the distance correction factor is calculated using linear interpolation (but using a logarithmic scale for the distance) between the values corresponding to the closest adjacent distances listed in the table:

$$C_Y(d) = C_Y(d_1) - [C_Y(d_1) - C_Y(d_2)] \frac{\log_{10}(d/d_1)}{\log_{10}(d_2/d_1)} \quad (C2)$$

where

$C_Y(d)$ is the distance correction factor applicable to measurements on transmission lines at a lateral measurement distance d , in dB;

d is the distance, in m;

$Y = A$ for transmission lines having the lowest conductor at 15 m height above ground; and

$Y = B$ for transmission lines having the lowest conductor at 9 m height above ground.

Assuming the transmission line has the lowest conductor at 15 m height above ground ($Y = A$) and that measurements were performed at a lateral distance of 17.5 m, the resulting correction factor is $C_A(17.5) = 1.29$ dB (closest adjacent distances are 17 m and 18 m).

In case the height of the lowest conductor of the transmission line under test were neither 15 m nor 9 m, and the first set of measurements were taken at 10 m lateral distance, then an additional measurement (over the entire frequency range of 150 kHz to 30 MHz) would be required, at a distance that is greater than 15 m. Then, at each detected emission frequency, the two results (at the two different distances) are used for calculating the field strength at a 15 m distance, by linear interpolation, before comparing with the limit in [table 1](#):

$$H(15) = H(d_1) - [H(d_1) - H(d_2)] \frac{\log_{10}(15/d_1)}{\log_{10}(d_2/d_1)} \quad (C3)$$

where

$H(d)$ is the magnetic field strength for the lateral measurement distance d , in dB($\mu A/m$), while d is the distance, in m.