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SERIES K: PROTECTION AGAINST INTERFERENCE

Emission levels and test methods for wireline telecommunication networks to minimize electromagnetic disturbance of radio services

Recommendation ITU-T K.60

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Summary

The deployment of broadband services fundamentally changes the utilization of the telecommunication network. First, the transmission is present on the network at all times (i.e., 'always-on'). Second, the transmission frequency range employed by broadband is much greater than that of previous access systems. Hence, the risk of interference with radio services has increased. In the event of interference, the share of responsibility between the network operator and the national responsible body, as well as the levels of the radiated field are not clearly defined.

Recommendation ITU-T K.60 proposes a measurement method and target levels to guide administrations in case of interference with radio services. In addition, a methodology for solving the interference is discussed, and under what circumstances the case has to be forwarded to the national responsible body.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T K.60	2003-07-29	5	11.1002/1000/6504
2.0	ITU-T K.60	2008-02-29	5	11.1002/1000/9138
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* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Introduction

This Recommendation discusses emissions of electromagnetic disturbances from wireline telecommunication networks, as defined in clause 3, and addresses all parties tasked with investigations of complaints of radio interference. It specifies levels for permissible disturbance emanating from such networks and suitable methods of measurement used for evaluation of individual cases of radio interference under *in situ* conditions.

Recommendation ITU-T K.60

Emission levels and test methods for wireline telecommunication networks to minimize electromagnetic disturbance of radio services

1 Scope

This Recommendation is intended to guide administrations when considering complaints of interference between telecommunication systems. It is not intended to set electromagnetic compatibility (EMC) compliance requirements. All involved parties (including but not limited to network operators, service providers or customers) are recommended to work together for resolving these cases.

The emission levels and test methods presented apply to:

– disturbing emissions from wireline telecommunication networks as defined in clause 3;

– only those frequencies that are launched onto the telecommunication wire-pair as part of the intentional transmission spectrum of the broadband system[1].

It covers, but is not restricted to, target levels regarding radiated disturbing emissions for such telecommunication networks as:

– networks using telecommunication cables and their in-house cabling extensions;

– networks using the low voltage (LV) alternating current (AC) mains network;

– community antenna TV (CATV) distribution networks.

This Recommendation covers the frequency range from 9 kHz to 400 GHz. To date, it specifies target levels for radiated disturbance in the frequency range from 9 kHz to 6 GHz.

Application of defined test methods is restricted to the section of the telecommunication network in the vicinity of the radio interference; it is not necessary to apply the test method to all parts of the telecommunication network.

The emission target levels have been selected in order to ensure that disturbances emanating from telecommunication networks do not, in most cases, exceed a level which could prevent radio communication receivers operating in the near vicinity from functioning as intended.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.9964] Recommendation ITU-T G.9964 (2011), *Unified high-speed wireline-based home networking transceivers – Power spectral density specification*.

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[1] It is possible for other signals to couple into the telecommunication network and for these signals to propagate through the network and cause interference to radio reception. The procedure within this Recommendation addresses this possibility.

[ITU-T K.48] Recommendation ITU-T K.48 (2006), *EMC requirements for telecommunication equipment – Product family Recommendation*.

[ITU-T K.74] Recommendation ITU-T K.74 (2008), *EMC, resistibility and safety requirements for home network devices*.

[ITU-T K.76] Recommendation ITU-T K.76 (2008), *EMC requirements for telecommunication network equipment (9 kHz-150 kHz)*.

[IEC CISPR 16-1-1] IEC CISPR 16-1-1:2015, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*. <https://webstore.iec.ch/publication/23387>

[IEC CISPR 32] IEC CISPR 32:2015, *Electromagnetic compatibility of multimedia equipment –Emission requirements*. <https://webstore.iec.ch/publication/22046>

[IEC 60050-161] IEC 60050-161 (1990), *International Electrotechnical Vocabulary. Chapter 161: Electromagnetic compatibility*. <http://webstore.iec.ch/webstore/webstore.nsf/artnum/000397>

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 disturbance field strength [IEC 60050-161], IEV 161-04-02: The field strength produced at a given location by an electromagnetic disturbance, measured under specified conditions.

3.1.2 electromagnetic disturbance [IEC 60050-161], IEV 161-01-05: Any electromagnetic phenomenon that may degrade the performance of a device, equipment or system, or adversely affect living or inert matter.

NOTE – An electromagnetic disturbance may be an electromagnetic noise, an unwanted signal, or a change in the propagation medium itself.

3.1.3 emission [IEC 60050-161], IEV 161-01-08: The phenomenon by which electromagnetic energy emanates from a source.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 antenna reference point: The geometric centre of the antenna or the reference point referred to in the antenna calibration procedure.

3.2.2 intentional signal: The intentional signal comprises the frequency spectrum required for the communication in and along conductors.

3.2.3 network cable: The cable infrastructure (transmission line) used to connect together telecom installations, systems and telecom terminal equipment. The network cable will normally end at a network termination point (NTP). At this point, telecom terminal equipment or telecom systems or installations are attached. The network cable may also include in-premises extension cables or LAN cables.

3.2.4 standard measurement distance: Measurement distance for which levels for disturbance are specified in this Recommendation. The measurement distance is taken as a straight line perpendicular from the telecommunication cable tract (or its projection to the floor level), from the boundary of the premises, office, or flat, or from the exterior wall of the building hosting the network concerned, to the measuring antenna reference point.

3.2.5 telecommunication installation: A combination of equipment, systems, finished products and/or components assembled and/or erected by an assembler/installer at a given place to operate together to perform a specific task.

3.2.6 telecommunication network: Entirety of equipment (comprising any combination of the following: network cable, telecom terminal equipment and telecom system or telecom installation) that is indispensable to ensure normal, intended operation of the telecommunication network.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC Alternating Current

CATV Community Antenna TV

EMC Electromagnetic Compatibility

IEV International Electrotechnical Vocabulary

IT Information Technology

ITE Information Technology Equipment

LAN Local Area Network

LV Low Voltage

NTE Network Termination Equipment

NTP Network Termination Point

PNI Public Network Interface

TTE Telecommunications Terminal Equipment

5 Procedure regarding the investigation of complaints of radio interference

5.1 Procedure

In case of complaints regarding radio interference, the examination should start with a preliminary investigation, as shown in Figure 2, in order to identify the source and coupling path of the radiated disturbance.

The preliminary investigation should start at the location of the interfered-with radio receiver and/or antenna of the victim of interference, or in its vicinity. There, the disturbance actually causing the radio interference will be detected using a portable receiver with a suitable signal-level indicator. Once the relevant disturbance is detected, it will be necessary to use the portable receiver or other convenient tracing techniques in order to identify that part of the network and, subsequently, to identify the location of the source of the disturbance.

During the preliminary investigation, it is not necessary to assess the disturbance potential of the emissions emanating from the telecommunication network. The indication of the portable receiver is solely used to find directions and to trace the source of the disturbance.

No specific measurement distances are defined for the preliminary identification of the source of interference. Deviations from the preliminary measurement processes are permitted, if necessary.

Depending on the results of this preliminary investigation, either the provisions of this Recommendation, or the provisions of the EMC product standard relevant to the identified source of radiated disturbance, apply for the assessment of the individual case of radio interference.

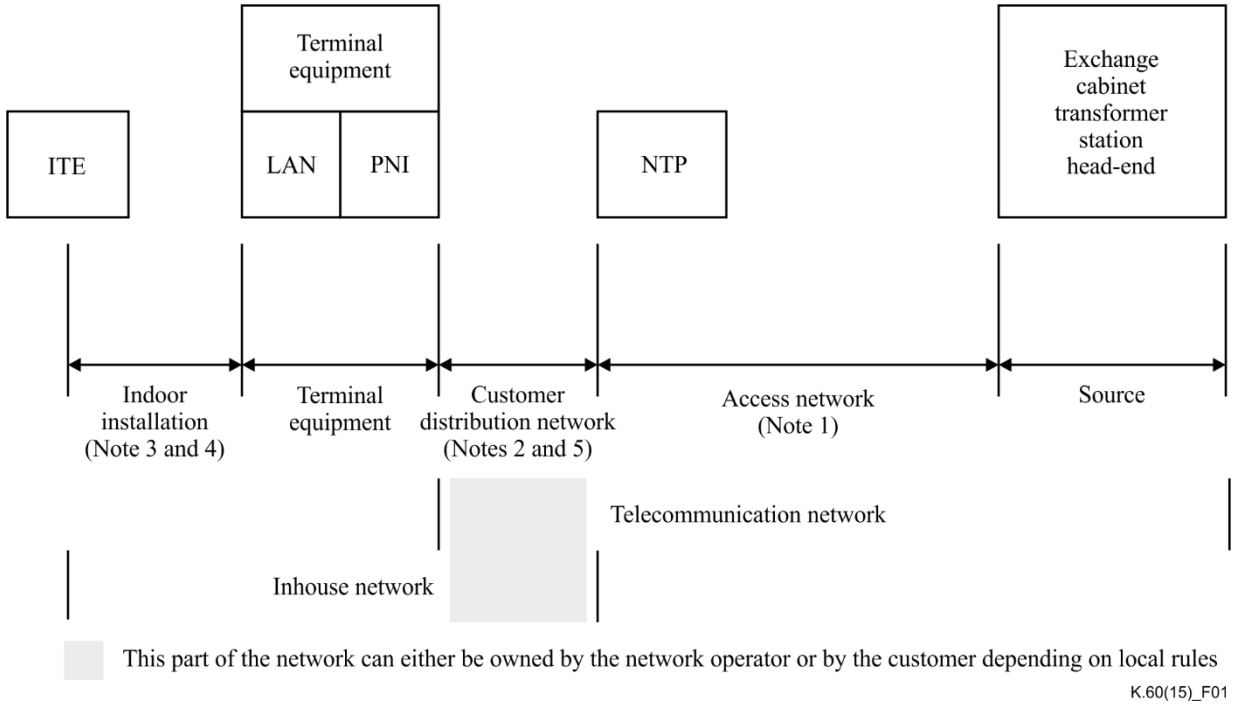
If the result of the preliminary investigation cannot verify that the source of the radiated disturbance is a telecommunication network, then this Recommendation is not applicable.

Once the source of interference is identified, then the part causing radio interference is assessed following the measurement procedures set out in clause 7.

The basic process, as shown in Figure 2, should be used to solve the interference case by reducing the emissions from the network until the target levels defined in this Recommendation have been reached, or the case has been resolved. If the interference case has been resolved prior to the target levels being achieved, then no further reduction in the amplitude of the interference source is required. Upon reaching these levels, if the interference persists, then further mitigation measures have to be agreed upon between the relevant parties, which are depicted in Figure 1, or the case should be passed to the national responsible body. The national responsible body can require further action to resolve the case to the levels shown in Table 1.

Mitigation measures to solve cases of interference are given in [b-ITU-T Mitigation].

If the interfering frequency is utilized by a safety-related radio service, then national regulations apply. These national regulations overrule the target levels specified in this Recommendation.



NOTE 1 – Within this part of the network, responsibility for the application of the test method defined in this Recommendation and any necessary mitigation resides with the network operator.

NOTE 2 – Within this part of the network, responsibility for the application of the test method defined in this Recommendation and any necessary mitigation resides either with the network operator or the customer.

NOTE 3 – Within this part of the network, responsibility for the application of the test method defined in this Recommendation and any necessary mitigation resides with the customer.

NOTE 4 – This part of the installation might not exist, depending on local rules (e.g., using wireless LAN).

NOTE 5 – This part of the installation might not exist, depending on local rules (e.g., if the terminal equipment is connected to the NTP via a cable supplied with the terminal equipment, this cable may be treated as an integral part of the terminal equipment, e.g., 'patch cord').

Figure 1 – Diagram showing a typical telecommunication access network

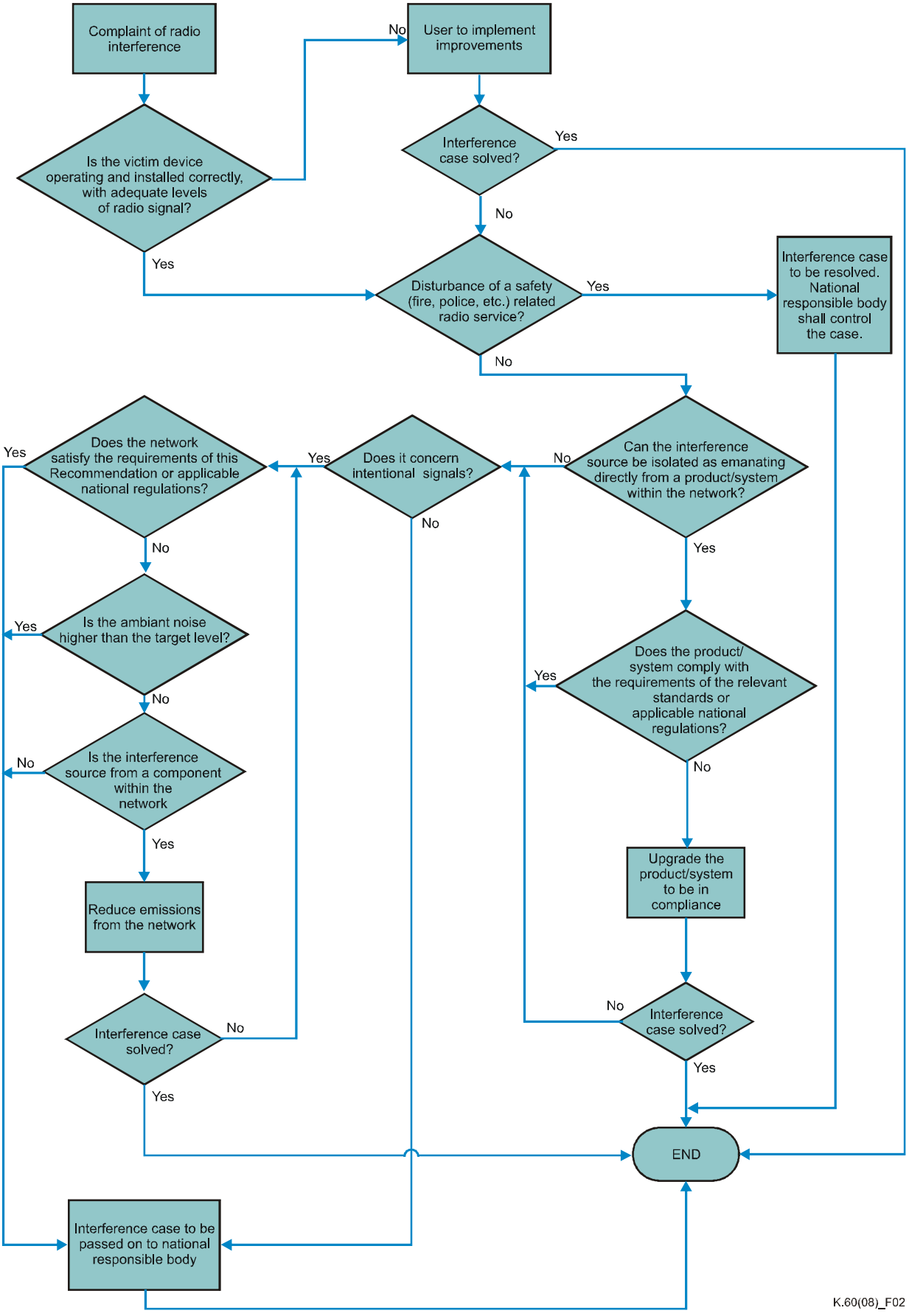


Figure 2 – Procedure for the assessment of the radiated disturbance

5.2 Process for solving the interference case

All equipments connected to wireline telecommunication networks should comply with relevant international/national EMC standards. Necessary EMC requirements for the equipments are already given by relevant international standards, such as [ITU-T K.48], [ITU-T K.74], [ITU-T K.76] and [IEC CISPR 32]. Moreover, home network equipments that use the low-voltage power installation as the transmission medium should comply with [ITU-T G.9964].

Often, interference is caused by a faulty cable installation. Mitigation measures are given in [b-ITU-T Mitigation]. The following simple steps will help in rapidly finding a solution:

1) confirm the presence of interference on the victim receiver;
2) confirm that the service frequency is within the intentional frequency range;
3) investigate the positioning of the victim receiver with respect to the wiring;
4) check the installation:
   - confirm correct cable type used within the premise;
   - are the connections correctly realized?
   - is the cable screen (if any) correctly connected?
5) disconnect the internal distribution wiring from the network termination equipment (NTE) and verify if the interference is still present. If disconnection is not possible, a ferrite core can be used;
6) measure the electrical parameters:
   - loop resistance;
   - capacity between wires and ground;
   - isolation;
   - discontinuities over the cable (cable impairments).
7) choose another wire pad.

Notching and power control techniques designed to avoid frequencies used by certain radio communication services are effective techniques to mitigate specific cases of interference caused by disturbing emissions from wireline telecommunication networks, if the system equipment provides these functions.

6 Levels for the radiated field strength from telecommunication networks

6.1 Specification of levels

This Recommendation specifies target levels for electromagnetic field strength radiated from fixed telecommunication networks. Levels specified in Table 1 should be used only on such frequencies in which the actual radio interference is caused. Alternative levels should also be applied if provided by national regulations.

Table 1 – Target levels for disturbance from telecommunication networks measured *in situ*

Frequency range (MHz)	Field strength level [dBμV/m]		Standard measurement distance	Measurement bandwidth
	Peak	Quasi-peak		
0.009 to 0.15	52 – 20*log(f[MHz])	–	3 m	200 Hz
0.15 to 1	52 – 20*log(f[MHz])	–	3 m	9 kHz
1 to 30	52 – 8.8*log(f[MHz])	–	3 m	9 kHz
30 to 230	--	40	3 m	120 kHz
230 to 1000	--	47	3 m	120 kHz
1000 to 3000	70	N/A	3 m	1 MHz
3000 to 6000	74	N/A	3 m	1 MHz
NOTE 1 – For the purposes of this Recommendation, the levels are specified in terms of electric field strength. In the frequency range below 30 MHz, these levels also apply, if necessary, formally converted by means of the free space wave propagation impedance of 377 Ω, to the magnetic field strength measured in accordance with clause 7.3. NOTE 2 – At the transition frequency, the lower level applies. NOTE 3 – The levels between 30 MHz and 6000 MHz are obtained from [IEC CISPR 22].				

6.2 Application of levels

The levels in Table 1 can be used for the assessment of critical parts of a telecommunication network at the following measurement locations:

a) at the standard measurement distance from the boundary of the premises hosting the network concerned (outdoor);

b) at the standard measurement distance from the exterior wall or dividing partition of the building or structure hosting the network concerned;

c) at the standard measurement distance from any part of the telecommunication network cable.

The standard measurement distance is given in Table 1. No measurements should be made closer than 1 m.

The levels of this Recommendation do not apply to parts of a telecommunication network that are allocated within an industrial area. In this case, the levels of this Recommendation apply only at the standard measurement distance from the boundary of the premises forming this industrial area, see point a).

7 Disturbance measurements

7.1 General

In order to get the highest readings of disturbance, it should be ensured that the part of the telecommunication network being assessed operates at the maximum signal levels for this site and in the mode previously identified as resulting in maximum RF disturbance field strength. If the system is interactive, it will be important to check for the presence of the reverse path (upstream) signals if these are in the same frequency range as reported in the complaint(s).

Indoor measurements are particularly subject to uncertainties due to reflections or unknown cable routes, for example. It is important to carefully search for the maximum emissions and take into account possible influencing factors.

Although the measurement of the radiated field has the drawbacks of a relatively high measurement uncertainty and positioning difficulties, this method is applicable both indoors and outdoors. In addition, when performing indoor measurements, particular attention to reflections has to be considered. In certain cases, the field intensity may be double that of the calculated value.

7.2 Normalization of measurement results to the standard measurement distance

Local restrictions in space (appearing, e.g., during indoor measurements) can require a reduction of the measuring distance to less than the standard measurement distance. The measurement distance chosen will be as large as possible, but not closer than 1 m. In case of outdoor measurements, it may also be necessary to use a measurement distance which is larger than the standard distance.

If a measurement distance greater or smaller than the standard measurement distance needs to be used, then three different and accessible measuring points located along the measuring axis will be chosen. The distance between these points should be as large as possible. At each point, the level of the disturbing field strength has to be measured. The local conditions and measurability of the disturbance field strength will be the determining factors.

The measurement results will then be plotted in a diagram showing the field strength level in dB(µV/m) versus the logarithm of the measurement distance. The line interconnecting the measurement results represents the slope in field strength along the measuring axis. If this slope cannot be determined, then additional measuring points have to be chosen. The field strength level at the standard measurement distance can be read from the diagram using the straight prolongation of the interconnecting line.

If three different and accessible measuring points cannot be located along the measuring axis, the slope cannot be determined. One measurement location can be selected and the maximum disturbance field strength at this point will be normalized to the standard measurement distance with the following formula:

$$E_{stand}=E_{measu}+20\log\left(d_{measu}/d_{stand}\right)$$

Where:

E_{stand}: is the normalized field strength level at the standard measurement distance

d_{measu}: is the practical measurement distance

d_{stand}: is the standard measurement distance in Table 1

E_{measu}: is the practical measurement result at the d_{measu} distance

Normalization of measurement results is not permitted if, at the measurement location, the true distance to the telecommunication network cable is not known.

7.3 Disturbance measurements in the frequency range 9 kHz to 30 MHz

7.3.1 Introduction

In the frequency range from 9 kHz to 30 MHz, the magnetic component of the radiated disturbance has to be measured and assessed.

A calibrated measuring system, in accordance with [IEC CISPR 16-1-1], consisting of a radio disturbance measuring receiver (or a suitable spectrum analyser), in conjunction with an associated loop antenna for the measurement of magnetic field components and a tripod are required.

Other specialized equipment such as resonant loop antennas can also be used, if necessary.

The measurement bandwidth is given in Table 1.

In order to speed up the measurement, initially a peak detector is used. If the background noise makes this simple measurement unusable, a quasi-peak detector can then be used. In this case, the peak level

presented in Table 1 shall be corrected to produce an equivalent quasi-peak level. This correction requires the peak to quasi-peak conversion factor specific to the transmission system that is active.

It is recommended that both the measuring receiver and the loop antenna have an independent power source with no ground connection (e.g., battery power), particularly in case of indoor measurements, in order to minimize the possibility of current loops via earth that could affect the measurement.

7.3.2 Measurement procedure

The loop antenna will be mounted on a tripod at a height of 1 m (at the lower edge of the loop) and positioned at the measurement location previously identified as having the maximum disturbance field strength so that it is at the standard measurement distance as defined in Table 1.

Set the measuring receiver to the frequency carrying the disturbance and type of detector required, and position the loop antenna so that the maximum reading is obtained.

The measurement of magnetic fields radiated from telecommunication networks in the frequency range up to 30 MHz may become complicated due to the presence of a variety of high-level wanted RF emissions from radio services. In view of this, it may be necessary to identify some frequencies (hereafter described as 'quiet frequencies') allocated close to the frequency of the radio service being affected, with low field strengths such that the background noise and any ambient signals are below the applicable level specified in Table 1. Where possible, this margin should be greater than 6 dB. This should be done without altering the antenna position, and ideally with the telecommunication network switched off.

If the network cannot be switched off, then the following alternative may be used:

– orientate the loop antenna for minimum coupling to the network emission and check that the background noise and any ambient signals are below the applicable level in Table 1: where possible, this margin should be greater than 6 dB;

– orientate the loop antenna for maximum coupling and then increase the measurement distance and check that there is a reduction in the measured field strength in accordance with clause 7.2.

The quiet frequencies, or frequency ranges, identified will be used to measure the disturbance. The operator of the measuring receiver should assess the background noise levels subjectively, on each of these frequencies. Using the measuring bandwidth and detector specified, the highest disturbance field strength level (in dB(µV/m)) observed over a period of 15 s has to be recorded. Any short-duration isolated peaks should be ignored.

7.4 Disturbance measurements in the frequency range 30 MHz to 6 000 MHz

7.4.1 Introduction

The electric component of the radiated disturbance has to be measured and assessed.

Usually, the electric component will be measured as electric field strength (in dB(µV/m)) at the standard measurement distance.

7.4.2 Measuring equipment

A calibrated measuring system in accordance with [IEC CISPR 16-1-1], consisting of a radio disturbance measuring receiver (or a suitable spectrum analyser) in conjunction with an associated broadband dipole, a biconical, a logarithmic-periodical antenna, a horn antenna or similar linearly polarized antenna, each suitable for measurement of electric components of the electromagnetic field, and an antenna mast are required.

The measurement bandwidth is given in Table 1.

In order to speed up the measurement, initially a peak detector is used. If the background noise makes this simple measurement unusable, a quasi-peak detector will then be used and the quasi-peak level applied. Above 1 GHz, no quasi-peak detector exists and only the peak detector is used.

7.4.3 Measurement of the electric disturbance field strength

The measuring antenna will be mounted at the mast and positioned at the measurement location previously identified as having the maximum disturbance field strength, so that it is at the standard measurement distance as defined in Table 1.

Local restrictions in space (appearing, e.g., during indoor measurements) can require a reduction of the measuring distance. In this case, the measurement distance chosen has to be greater than or equal to 1 m. For the measurement, the antenna will be oriented such that maximum coupling is obtained to the disturbing source without any height scan.

Set the measuring receiver or spectrum analyser to the frequency carrying the disturbance and type of detector required, and perform the measurements. At the specified measurement location and measuring point(s), the direction, height, and polarization (horizontal and vertical) of the measuring antenna will be varied in order to determine the maximum RF disturbance field strength. The electrical component of the disturbance field strength is to be determined by observing the indication of the measuring receiver over a period of approximately 15 s and subsequently recording its maximum indication. Isolated peaks occurring casually should be disregarded.

If the antenna and the telecommunication network are located at the same level, then the antenna height will vary between 1 m and 4 m (or the maximum determined by the ceiling) in order to determine the maximum field strength. In varying the antenna height, the antenna should not be positioned closer than 0.5 m to reflecting objects (e.g., walls, ceilings, metallic structures). The antenna height variation may be restricted due to local conditions (see Figure 3).

In the event of an outdoor measurement, the antenna height will be varied from 1 m to 4 m.

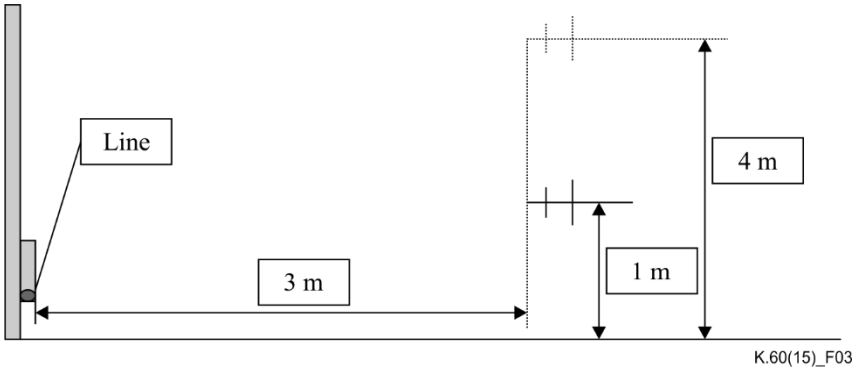


Figure 3 – Antenna height variation

Appendix I

Processing of obtained measuring results and final assessment based on the specified levels

(This appendix does not form an integral part of this Recommendation.)

I.1 Treatment of measurement uncertainty

For investigation of reported cases of complaints of radio interference, the measurement uncertainty is not accounted for in the measurement result.

Table I.1 shows contributions of certain measurement instrumentation to the total measurement uncertainty to allow for a coarse estimation of conditions found in practice. The content of Table I.1 is of an informative nature only.

Table I.1 – Contribution of certain components of the measuring system to the total measurement uncertainty

	Measurement of		
	Magnetic field strength	**Electric field strength**	
Frequency range	**< 30 MHz**	**30-300 MHz**	**300-1 000 MHz**
Component of the measuring system	**Contribution uncertainty (dB)**		
System			
Attenuation: antenna – receiver	0.1	0.2	0.2
Receiver			
Receiver reading	0.1	0.1	0.1
Sine wave voltage	1.0	1.0	1.0
Pulse amplitude response	1.5	1.5	1.5
Pulse repetition rate	1.5	1.5	1.5
Mismatch between antenna and receiver	–	0.9/–1	0.9/–1
Antenna			
Antenna factor	1.0	2.0	2.0
Antenna factor frequency interpolation	–	0.5	0.3
Antenna height deviations	–	1.0	0.3
Directivity difference	–	0	1.0
Phase centre location	–	0	1.0
Cross polarization/balance	–	0.9	0.9
Total (dB)	**3.4**	**4.0**	**4.0**

I.2 Comparison of measurement results with specified levels

The results of the measurements, normalized where applicable, to the standard measurement distance, have to be compared with the specified levels for permissible electromagnetic field strength found in Table 1.

This comparison allows for an assessment of whether or not the telecommunication network, or the part thereof which is being investigated, meets the target levels specified in this Recommendation.

Appendix II

Frequency band and the required level of protection for safety-related radio service

(This appendix does not form an integral part of this Recommendation.)

II.1 Aeronautical systems operating between 190 kHz and 1 215 MHz

Table II.1 shows the required level of protection for aeronautical systems operating between 190 kHz and 1 215 MHz. This information is given from ITU-R Working Party 5B (WP5B).

Table II.1 – The required level of protection for aeronautical systems operating between 190 kHz and 1 215 MHz

Frequency band	System	Receiver location	Receiver protection criteria reference
190-850 kHz	Area navigation (NDB)	Airborne	ICAO Document 9718, Chapter 9, Table 9-1 – General Protection Limits
2.85-22 MHz	HF communications	Airborne/ Ground	ICAO Document 9718, Chapter 9, Table 9-1 – General Protection Limits
74.8-75.2 MHz	Approach navigation (ILS marker beacon)	Airborne	ICAO Document 9718, Chapter 9, Table 9-1 – General Protection Limits
108-117.975 MHz	Approach navigation (ILS localizer)	Airborne	ICAO Document 9718, Chapter 9, Table 9-1 – General Protection Limits
108-117.975 MHz	Area navigation (VOR)	Airborne	ICAO Document 9718, Chapter 9, Table 9-1 – General Protection Limits
117.975-137 MHz and 243 MHz	VHF communications	Airborne/ Ground	ICAO Document 9718, Chapter 9, Table 9-1 – General Protection Limits
328.6-335.4 MHz	Approach/Landing (ILS glide path)	Airborne	ICAO Document 9718, Chapter 9, Table 9-1 – General Protection Limits
960-1215 MHz	Area navigation (DME)	Ground	ICAO Document 9718, Chapter 9, Table 9-1 – General Protection Limits
978 MHz	Area navigation (UAT)	Airborne/ Ground	ICAO Annex 10, Vol. III, Chapter 12, section 12.3.2 – Receiving Function
1 030 and 1 090 MHz	Area navigation (SSR)	Airborne/ Ground	ICAO Document 9924, Appendix D, Table D-3 – Downlink Margin

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