Electronic Communications Committee (ECC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

ECC RECOMMENDATION (09)02

SPECIFICATION FOR THE MEASUREMENT OF DISTURBANCE FIELDS FROM TELECOMMUNICATIONS SYSTEMS AND NETWORKS IN THE FREQUENCY RANGE 9 kHz TO 3 GHz

Recommendation adopted by the Working Group "Frequency Management" (WGFM)

INTRODUCTION

This Recommendation specifies the measurement procedures for the measurement of disturbance fields from telecommunications systems and networks in the frequency range 9 kHz to 3 GHz. This includes also PLC networks.

It is important to note that this recommendation does not itself standardise or define limits for unwanted radiated emissions.

It is considered appropriate that this recommendation should be reviewed every three years, or sooner if appropriate in the light of changing technologies and regulatory requirements.

"The European Conference of Postal and Telecommunications Administrations,

considering

a) that different measurement methods of assessing radiation levels emanating from telecommunications networks may be in use in the different CEPT administrations,

b) that there is a need to have agreed measurement methods for measuring the disturbance fields from telecommunications networks,

c) that common measurement procedures are necessary for mutual acceptance of measurements by the parties concerned.

recommends

1) that when performing disturbance field measurements of telecommunications systems and networks in the frequency range 9 kHz to 3 GHz, the method, set-up and specifications described in Annex 1 are used.

Note:
Please check the Office web site (http://www.ero.dk) for the up to date position on the implementation of this and other ECC Recommendations.

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1 GENERAL INTRODUCTION

1.1 Scope

The present document provides procedures for in-situ measurements of unwanted disturbance emissions caused by telecommunications installations and networks. Subject of measurements are unwanted disturbance emissions within the Radio Frequency (RF) spectrum that are caused by use of frequencies for transmission of information in and along conductors. In case of broadband signals the use of an auxiliary carrier might be necessary. In case additional descriptions of the measurement procedure is required.

The networks in question include WAN, LAN, and CATV networks as well as the recently developed technologies in the telecommunications access area utilising electric power distribution (PLT) and telephone networks (xDSL).

Radio applications that may be affected by unwanted RF disturbance emissions include, but are not restricted to, standard frequency and standard time signal receivers, receivers for mobile radio services, sound and TV broadcasting radio services, and fixed services, cordless telephones and radio equipment for amateur radio services.

The measurement method described in this document can be used by national authorities to obtain (in a harmonised way) information about field levels generated by telecommunication networks. This information can be helpful as one of the elements needed in evaluating and resolving interference cases. It should be noted, that this measurement method is also described in ECC REC (05)04.
This document is not a harmonised standard in the sense of the EMC directive and as such not meant for assessing the compliance of telecommunication networks with the essential requirements of the EMC directive.

1.2 Frequency range

The present document is applicable in the frequency range 9 kHz to 3 GHz.

1.3 Measurement procedures

The present document sets out methods of measurement for unwanted RF disturbance emissions accompanying wire-bound wanted signals and emanating from telecommunications installations and networks.

1.4 Limits

Limits for unwanted disturbance emissions from telecommunications installations and networks, listed in annex 1 of the present document.

2 DEFINITIONS AND ABBREVIATIONS

For the purposes of the present document the following definitions apply:

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

Detector weighting factor: The difference of indication obtained from a quasi-peak detector to the peak detector, for a specific signal.

Disturbance field strength: Field strength produced at a given location by an electromagnetic disturbance, measured under specified conditions. (IEC – IEV 161-04-02)

Note:

For the purposes of the present document, only those components of the wire-bound wanted signals that may cause unwanted disturbance emissions in form of fields.

Electromagnetic disturbance: Any electromagnetic phenomenon that may degrade the performance of a device, equipment or system. (IEC – IEV 161-01-05)

Emission: The phenomenon by which electromagnetic energy emanates from a source. (IEC – IEV 161-01-08)

Minimum coverage: For the purposes of this specification, minimum coverage is normally given if the minimum field strength necessary for the relevant radio service or application can be verified at the location of measurement.

Radio (frequency) disturbance: Electromagnetic disturbance having components within the radio frequency range. (IEC – IEV 161-01-13)

Telecommunications network: Entirety of technical equipment (transmission lines, switching equipment and any other equipment) that are indispensable to ensure normal intended operation of the telecommunications network), to which telecommunications terminal equipment is connected to by appropriate termination.

Telecommunications installation: Any technical equipment or systems capable of sending, transmitting, switching, receiving, steering or controlling as messages identifiable electromagnetic or optical signals.

Note:

If referred to telecommunications networks only hereafter, then related information is also applicable to telecommunications installations.

Unwanted disturbance emission: Components of wanted signals caused by wire-bound currents or voltages that unintentionally emanate from the conductor and may interfere with radio communications through inductive or capacitive coupling (near field) or electromagnetic wave propagation (far field).

Unwanted emission: A signal that may impair the reception of a wanted signal. (IEC – IEV 161-01-03)

Wanted signal: The wanted signal comprises the frequency spectrum required for the communication in and along conductors.

3 PRINCIPLES FOR PREPARATION AND PERFORMANCE OF MEASUREMENTS

3.1 General

It will be essential to gather all technical information necessary for a complete understanding of the operating parameters and layout of the telecommunications network requiring measurement. For example, the telecommunications network operator should provide EMC related specifications and parameters of the cables and connecting hardware. In all cases the information obtained should be verified by the preliminary investigation as detailed below in order to rule out measuring unwanted emissions from the telecommunications network that are regulated by other than that being assessed.

3.2 Performance characteristics of telecommunications networks

The basic performance characteristics needed are: spectral amplitude distribution and frequency characteristics of the wire-bound wanted signals and the operating mode(s) that cause maximum RF disturbance emission levels at all, or any particular, frequencies of interest.

It may also be necessary to discover whether spectral amplitude variations can result from dynamic power control and whether frequency spectrum characteristics can vary, depending on the given data transfer rate.

These parameters can best be determined at a high $(S + N)/N$ ratio by means of a current clamp and automated scanning measuring receiver with panoramic display monitoring the conducted current at the feeding (or terminating) interface of the telecommunications line. Cooperation with the telecommunications operator will probably be needed to exercise the system as necessary.

During a preliminary investigation stage, it is also necessary to clarify whether the observed unwanted emissions are unwanted disturbance emissions as defined in clause 2 of the present document, or other unwanted emissions from electronic equipment connected to the network which do not belong to the wire-bound wanted signal. Observed unwanted disturbance emissions within the frequency band of the wire-bound wanted signal shall meet the provisions of Annex 1 of this document, if not having been identified as other unwanted emissions.

3.3 Selection of measuring points

The selection of measuring points will depend on the reason for the measurements. The reason for the measurements may be investigation of interference complaints or verification of compliance with the limits.

3.3.1 Investigation of complaints on radio interferences

For the investigation of interference, the initial measuring point (indoor or outdoor) should be at that part of the transmission line closest to the interfered-with radio receiver and/or antenna of the victim of interference.

3.3.2 Verification of telecommunications installations and networks on compliance

For compliance testing, the topology of the telecommunications installation or network will dictate where initial measurements should be made. This point (these points) should be located there, where experience shows the highest disturbance emissions to be expected. For most interactive systems these points will be, for example, at each end of the transmission line, at any intermediate amplifiers that may be deployed, or at points of impedance discontinuity or leakage in the transmission line.

In either case (i.e. in case of 3.3.1 and 3.3.2) it will be necessary to use a portable receiver with a signal level indicator, or other convenient tracing technique, to identify and record the exact locations where radiated disturbance emission levels are the highest.

It will be necessary to measure the wanted signal with an appropriate $(S + N)/N$ ratio in order to determine the waveform. Such a "fingerprint" of the signal can be taken by measuring the conducted current at an accessible point of the transmission line (see sub-clause 3.2).

3.4 Measurement distance

3.4.1 Verification of telecommunications installations and networks on compliance

For indoor and outdoor measurements, the standard measurement distance ***d*** is 3 m. This distance is the spacing between the reference point of the measuring antenna and the nearest part of the telecommunications network.

3.4.1.1 Drawing the measurement distance for indoor measurements

If the part of the telecommunications network subject to investigation is inaccessible, located within or behind a wall, duct or similar structure, then the measurement distance ***d*** shall be taken rectangular from the front edge of the wall or duct.

If, for indoor measurements in the frequency range up to 30 MHz, free spacing of 3 m between the telecommunications network and measuring antenna is not available, then the measurement distance stated above can be reduced down to 1 m. In this case the provisions of sub-clauses 4.2.1.2 and 5.2.1.2 of the present document apply.

3.4.1.2 Drawing the measurement distance for outdoor measurements

For measurements made outside a building or other structure carrying telecommunications network equipment or cabling, the measurement distance ***d*** shall be taken rectangular from the external wall of the building or relevant structure.

If the part of the telecommunications network to be measured is below ground, then the measurement distance ***d*** shall be taken rectangular from the line representing the vertical projection of the telecommunications network on to the surface of the ground.

If the part of the telecommunications network to be measured is above the measuring antenna, then the measurement distance ***d*** shall be taken rectangular from the line representing the vertical projection of the telecommunications network on to the surface of the ground.

The principle is shown in figure 1.

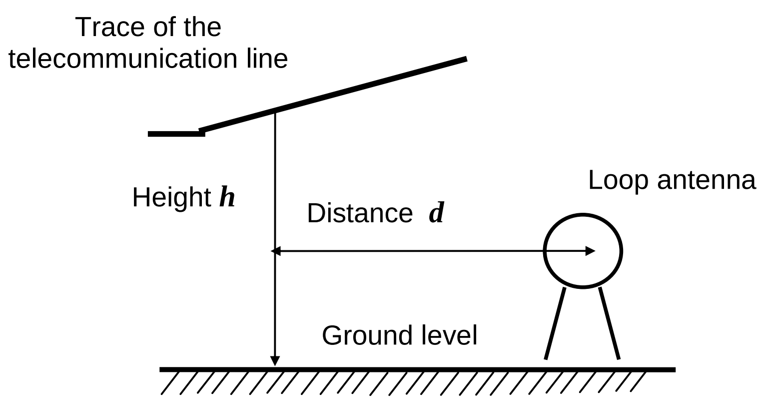

Figure 1: Drawing the measuring distance *d* from the vertical projection of the trace of the telecommunication line to ground level

If, for outdoor measurements, location of the measuring antenna at 3 m distance is not possible due to local conditions, then the method of measurement specified in subclause 4.2.1.3 shall apply for measurements in the frequency range up to 30 MHz.

If the telecommunication cable tract to be measured is significantly above the height of the available antenna mast (e.g. in more than 10 m height above ground), then the method of measurement specified in subclause 4.2.1.3 shall apply for measurements in the frequency range up to 30 MHz, and the radiated RF disturbance power level shall be measured in accordance to clause 7 of this specification, in the frequency range above 30 MHz.

3.4.2 Investigation of complaints on radio interferences

No specific measurement distances are defined for identification of the source of interference. If the source of interference is identified, then the relevant part of the telecommunications installation or network is measured following the principles set out in subclause 4.2.1. Due to specific reasons, deviations from these principles are permitted, if necessary.

3.5 Limits for permissible disturbing emissions from telecommunications installations and networks

The limits (together with necessary corrections) are shown in annex 1 of the present document.

Please note that the field strength limits shown in annex 1 are peak limits. Though, in order to minimise the uncertainty arising from the use of the peak detector, a quasi-peak detector is used for the measurements.

To enable direct comparison between measured quasi-peak levels and the peak limits, it will be necessary to use a quasi-peak detector weighting factor that shall be added to the quasi-peak level readings. This weighting factor will depend on the measuring bandwidth and signal architecture of the telecommunications network being investigated.

Unless the quasi-peak weighting factor is already known and has been agreed with the telecommunications network operator, it shall be established during the preliminary investigation stage. This is most easily and accurately achieved by using a current clamp to measure the telecommunications network at a point providing a clean wanted signal with at least 20 dB $(S + N)/N$ ratio.

In the frequency range 30 MHz to 1000 MHz the quasi-peak weighting factor can also be determined by positioning the antenna in direct vicinity of the source of radiation.

In the frequency range 1000 MHz to 3000 MHz the measurement results do not need to be corrected because the peak detector is used in any case.

4 DISTURBANCE EMISSION MEASUREMENTS IN THE FREQUENCY RANGE 9 kHz TO 30 MHz

4.1 Measuring equipment

The following measuring equipment, as specified in CISPR Publication 16-1, is required:

- a calibrated measuring system, consisting of a radio disturbance measuring receiver and associated loop antenna for the measurement of magnetic field components, with tripod, and
- a calibrated measuring system, consisting of a radio disturbance measuring receiver and associated current clamp for the measurement of high frequency currents at conductors,

respectively.

In the frequency range 9 kHz to 150 kHz, a measuring bandwidth of 200 Hz and the quasi-peak detector shall be used.

In the frequency range 150 kHz to 30 MHz a measuring bandwidth of 9 kHz and the quasi-peak detector shall be used.

If necessary, other specialised equipment such as resonant loop antennas or antennas for the electric field may also be used. For any measurements of the electric field strength that may become necessary an active dipole as described in annex 5 or a similar dipole is to be used.

To minimise the possibility of earth loops affecting the measurement, it is recommended that both the measuring receiver and loop antenna have an independent power source with no ground connection (e.g. battery power), particularly in case of indoor measurements.

4.2 Method of measurement

4.2.1 General

As specified in annex 1, the measured magnetic field strength is converted with an intrinsic impedance of 377 Ohm into the electric field strength.

> <u>Attention!</u>
> This conversion may be done automatically already in various measuring equipment.

It shall be taken into account that the telecommunications system operates with its normal maximum signal levels and in the mode, if any, previously identified as resulting in maximum disturbance field levels. If the system is interactive, it will be particularly important to check for the presence of the reverse path (upstream) signals if these are in the same frequency range as that of any interference complaint.

If measurements are to be made at a single frequency or in a narrow frequency band only, (e.g. in cases of interference), then the antenna should be adjusted so as to obtain maximum coupling to the telecommunications network under investigation.

If measurements are to be made at a large number of frequencies or over a swept frequency range, separate measurement runs should be made with the antenna adjusted in each of three orthogonal directions, X, Y and Z. The data for each measurement run should be stored and for each frequency, the effective field strength ($\boldsymbol{E_{eff}}$) shall be calculated using Equation 4.1.

$$E_{eff} = \sqrt{E_x{}^2 + E_y{}^2 + E_z{}^2} \text{ (V/m)} \qquad (4.1)$$

This task is most easily accomplished by reading the data for each measurement run into a spreadsheet and subsequent automated calculation of $\boldsymbol{E_{eff}}$.

To reduce measurement time, it is recommended to start with a pre-scan over the frequency range concerned using the peak detector, followed by another measurement of the found maximum disturbance field strength values using the quasi-peak detector.

For the loop antenna, the measurement distance ***d*** is the spacing between its geometrical centre and the telecommunications network, and for the active dipole the measurement distance ***d*** is the spacing between the reference point of the dipole and the telecommunications network.

4.2.1.1 Measurement at 3 m distance (standard distance)

Mount the loop antenna on a tripod at a height of 1 metre (at lower edge of the loop), at the location previously identified as having the maximum disturbance field strength, so that it is at the prescribed measurement distance from the telecommunications network.

Set the measuring receiver to the frequency and detector required and rotate the loop antenna for maximum telecommunications network signal indication, or in the orthogonal directions X, Y and Z, and subsequently calculate the effective field strength.

The measurement of magnetic fields radiated from telecommunications 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 can be necessary to identify some frequency ranges with low field strengths in the gaps between radio transmissions such that the background noise and any ambient signals are below the applicable limit specified in annex 1. This should be done without altering the antenna position and ideally with the telecommunications network switched off.

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

- Orientate the loop for minimum coupling to the network emission and check that the background noise and any ambient signals are below the applicable limit in annex 1.
- Orientate the loop for maximum coupling and then increase the measurement distance and check that there is a corresponding reduction in the measured field strength.

The number of quiet frequencies or frequency ranges required would depend on whether overall compliance measurements are intended or whether a smaller scale interference complaint is to be investigated. For overall compliance testing, the largest possible number of quiet frequency ranges is preferred. These should be spaced as evenly as possible over the full wanted signal spectrum of the investigated telecommunication service. A frequency plot for the whole frequency range being measured will aid rapid identification of those quiet frequencies that may be suitable for subsequent analysis. Sweeps over the frequency range observed can be made with a peak detector in subsequent steps of half the measuring bandwidth.

For investigation of interference complaints a few quiet frequencies around the frequency of complaint should be sufficient. These can be identified and measured using manual tuning.

In both cases the quiet frequencies or frequency range identified will be used to measure the unwanted disturbance emission. 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 15 seconds period shall be recorded. Any short duration isolated peaks should be ignored.

With the telecommunications network operating, the measurements shall be repeated on all previously identified quiet frequencies using the same procedure specified above. The results shall be recorded and the difference calculated between the levels measured with the telecommunications network operating normally and with it switched off.

If the ambient noise level is still higher than the limit, a current clamp can be used to verify the calculated difference. (This test method is still subject to further consideration.)

4.2.1.2 Measurement at a distance smaller than 3 m

In case of measurements at a smaller distance than 3 m the measurement distance is to be taken as the straight rectangular line from the telecommunications cable tract (or its projection to ground level) to the outer boundary of the loop antenna.

If adherence to the standard measuring distance of 3 m is not possible, e.g. due to local conditions within a building, then measurements can be made at smaller spacing not falling short of 1 m.

In this case the same method of measurement as for measurements at 3 m distance applies and the measurement result shall be corrected using the conversion factor given in equation 4.2:

$$E_{dist} = E_{meas} + 20\log\frac{d_{meas}}{d_{S\tan d}} \qquad (4.2)$$

where

- $\boldsymbol{E}_{meas}$: measurement result in dB(µV/m),
- $\boldsymbol{E}_{dist}$: corrected measurement result in dB(µV/m),
- $\boldsymbol{d}_{meas}$: measurement distance in metres,
- $\boldsymbol{d}_{Stand}$: standard measurement distance (3 m).

4.2.1.3 Measurement at a distance greater than 3 m

If, owing to local conditions, a measurement distance of more than 3 metres is to be chosen, then two measuring points located at the measuring axis at right angles to the telecommunication cable tract are to be determined. As a guide, the distance between the two points should be as large as possible. The level of the disturbing field strength shall be measured as described in subclause 4.2.1. Eventually decisive are the local conditions and measurability of the disturbance field strength.

The measurement results in dB(µV/m) are to be plotted in a diagram over the logarithm of the distance. The straight line interconnecting the measurement results represents the decrease in field strength at the axis measured. If the decrease in the field strength level cannot be determined, then additional measuring points shall be chosen. The field strength level at standard measurement distance of 3 m is to be extrapolated from the diagram using the interconnecting line.

4.3 Measurement of the electric field strength

The electric field strength is measured in cases of interference only where the disturbance emission is assumed to be a predominantly electric field. This could be the case if the limit for the magnetic field strength was not exceeded but nonetheless interference to radio receiving equipment utilising an electric field antenna did occur.

The measurement procedure is the same as that for the magnetic disturbance field strength. The antenna required is described in annex 5.

5 DISTURBANCE EMISSION MEASUREMENTS IN THE FREQUENCY RANGE 30 MHz TO 3000 MHz

5.1 Measuring equipment

The following measuring equipment (in accordance to CISPR 16-1) is necessary:

- a calibrated measuring system consisting of a radio disturbance measuring receiver in conjunction with an associated broadband dipole, or an associated logarithmic-periodical antenna, each suitable for measurement of the electric component of the field, and an antenna mast.

  NOTE:

  Measurement results obtained by means of the calibrated measuring system described above do not need any subsequent correction, even if possibly measured under near field conditions.

Requirements for radio disturbance measuring receivers and antennas are described in CISPR Publication 16-1.

For the frequency range from 30 MHz to 1000 MHz, a measuring bandwidth of 120 kHz and a quasi-peak detector shall be used.

For the frequency range from 1000 MHz to 3000 MHz, a measuring bandwidth of 1 MHz and a peak detector shall be used.

5.2 Methods of measurement

5.2.1 General

It shall be taken into account that the telecommunications system operates at its normal maximum signal levels and in that mode (if more than one mode of operation exists) previously identified as resulting in maximum RF disturbance field levels. If the system is interactive, it will be particularly important to check for the presence of the reverse path (upstream) signals if these are in the same frequency range as reported in the interference complaint(s).

In order to reduce duration of measurements it is recommended at first to perform the sweep over the frequency range to be examined using a peak-detector, and subsequently to measure with a quasi-peak detector at frequencies only where maximum indications of RF disturbance field strength levels have been recorded before.

The measurement distance ***d*** is the distance between the part of the telecommunications network to be examined and the balun, in case of a broadband dipole, or the reference point of the antenna, in case of a logarithmic-periodical antenna.

5.2.1.1 Measurement at 3 m distance (standard distance)

The measurement distance is 3 m. At the specified measuring point, the direction, height, and polarisation (horizontal and vertical) of the measuring antenna shall be varied in order to measure the maximum RF disturbance field strength.

If the antenna and the telecommunications network are located at the same ground plane level, then the antenna height shall be varied between 1 m and 4 m in order to determine the maximum field strength. In varying the antenna height, the antenna shall not be positioned closer than 0,5 m to reflecting objects (e.g. walls, ceilings, metallic structures, etc.). The antenna height variation may be restricted owing to local conditions. (see figure 2: Antenna height variation).

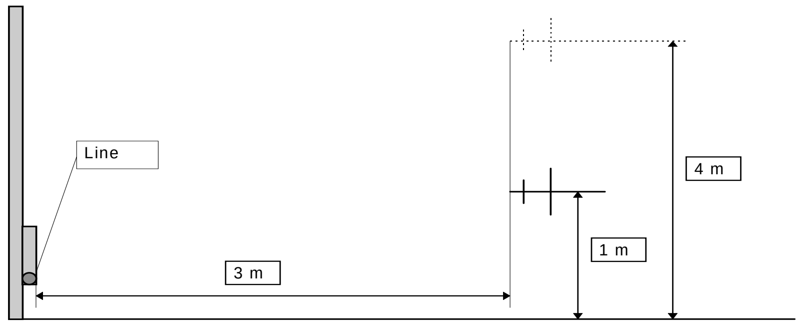

Figure 2: Antenna height variation

If, e.g. in case of an outdoor measurement, the antenna support is not at the same ground plane level as the telecommunication line or tract, then the antenna shall be varied in height resulting in a variation range comparable to that in the foregoing paragraph.

5.2.1.2 Measurement at a distance smaller than 3 m

Measurements for verification of compliance on telecommunications installations and networks in the frequency range above 30 MHz are performed outdoors only. Here, the measurement distance can be chosen such that either it is 3 m (standard distance) or greater than 3 m.

If, during investigation of complaints on radio interferences, indoor measurements were necessary for identification of disturbing sources, and a spacing of 3 m could not be made due to local conditions, then measurements can be made at smaller spacing not falling short of 1 m. The measuring distance is that between the conductor and the reference point of the antenna. For the measurement, the antenna shall be oriented such that maximum coupling is obtained to the disturbing source, without any height scan. In this case, the measurement result shall be corrected using the conversion factor given in equation 5.1:

$$E_{dist} = E_{meas} + 20\log\frac{d_{meas}}{d_{S\tan d}} \qquad (5.1)$$

where

- $\boldsymbol{E}_{meas}$: measurement result in dB(μV/m),
- $\boldsymbol{E}_{dist}$: corrected measurement result in dB(μV/m),
- $\boldsymbol{d}_{meas}$: measurement distance in metres,
- $\boldsymbol{d}_{Stand}$: standard measurement distance (3 m).

NOTE:

Measurement results obtained by means of the calibrated measuring system (see subclause 5.1) do not need any subsequent correction, even if possibly measured under near field conditions.

5.2.1.3 Measurement at a distance greater than 3 m

If local conditions call for a measurement distance of more than 3 m, then the radiated RF disturbance power shall be measured in accordance with the substitution method specified in clause 6.

5.3 Determination of the electric 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 subsequent recording of its maximum indication. Isolated peaks occurring casually should be disregarded.

If the method of measurement provides measurement results given in terms of RF voltage levels only, then the level of the disturbance field strength can be calculated from the RF voltage level measured at the antenna port of the measuring receiver by means of equation 5.2:

$$E_{dist} = V_{rec} + a_c + \mathrm{AF} \qquad (5.2)$$

where

- $\boldsymbol{E_{dist}}$: calculated disturbance field strength level in dB(µV/m),
- $\boldsymbol{V_{rec}}$: measured RF voltage level in dB(µV) at the antenna input port of the measuring receiver (at 50 Ω),
- $\boldsymbol{a_c}$: attenuation of the measuring cable in dB,
- AF: antenna factor)[1] of the measuring antenna in dB.

Note:
For calculation of disturbance field strength levels, the antenna factor belonging to the measuring antenna (free space, according the manufacturer's declaration or calibration report) shall be used in any case, independently from the actually used measurement distance.

6 MEASUREMENT OF RADIATED RF DISTURBANCE POWER FROM 30 MHZ TO 3000 MHZ

6.1 Measuring equipment

The requirements for radio disturbance measuring receivers, the measuring bandwidths, detectors and antennas used for the measurement of the radiated RF disturbance power are described in CISPR Publication 16-1.

6.2 Measurement distance

The measurement of electric components of the electromagnetic field bears inherent uncertainties due to reflections on dielectric or conductive junctions and due to parasitic elements within the surrounding of the measuring location. Measurements performed in near field conditions can result in further uncertainties. Some of these uncertainties can be ruled out by determining the radiated RF disturbance power of the source of interference in the same ambient conditions using a substitution antenna.

The radiated RF disturbance power shall be measured at a distance providing far field conditions with respect to the source of the radiated disturbance. For dipole-like radiators, the far field condition is fully met where the appropriate measurement distance is calculated and used in accordance with equation 6.1:

$$d \geq 4 \cdot \lambda \qquad (6.1)$$

or where the measurement distance $\boldsymbol{d}$ is equal to or greater than 30 m. (In most practical cases, fulfilment of the condition, $d \geq \lambda$, is already sufficient.)

6.3 Location of the measuring antenna

The measurement of the radiated disturbance power shall be made only in the far field as described in subclause 6.2. Subject to this condition, the measuring point for unwanted radiated emissions from the telecommunications network (and the equivalent radiated disturbance power subsequently simulated by the substitution antenna) will be the location of the maximum disturbance field strength identified as described in subclause 3.3.

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[1] Antenna factor according to the manufacturer's declaration, or calibration report (for the standard distance, if available).

6.4 Location of the substitution antenna

Initially, the substitution antenna should be located 1 m from the front face of the building accommodating the telecommunications network.

The location should be chosen such as to ensure that an imagined line between the substitution antenna and the measuring antenna is perpendicular to the direction of the telecommunications network cable or face of the building accommodating the telecommunications network.

6.5 Method of measurement

6.5.1 Measurement of radiated RF disturbance emissions

At the measuring point chosen in accordance with subclause 6.3, direction, height, and polarisation of the measuring antenna shall be varied in order to identify maximum unwanted radiated emission levels from the telecommunications network. The measuring antenna shall be left in this position once the maximum disturbance field strength level has been determined and recorded.

> Note:
>
> A substitution measurement is not necessary if the disturbance field strength measured in accordance with clause 5 under far field conditions, after its conversion into the field strength level at the standard 3 m distance using equation 4.2, exceeds the related limit (Annex 1) by more than 20 dB.

6.5.2 Substitution measurement

During operation of the substitution antenna, its operation frequency shall not already been occupied by other terrestrial radio services or applications.

When performing compliance tests on telecommunications installations and networks, adequate frequencies in the ISM frequency bands or such frequencies dedicated for this purpose shall be used.

When investigating reported cases of complaints on radio interference, after identification of the disturbing source, the relevant part of the telecommunications network should be switched off, or at least the telecommunications service causing the disturbance should be taken temporarily out of operation, and the frequency of the wanted radio service or application affected by interference should not be occupied. If this is not possible, then the operation frequency of the substitution antenna should be changed by the smallest possible amount in order to fade out the unwanted emission(s) from the telecommunications network, and/or to avoid emissions at frequencies already occupied by terrestrial radio services or applications.

The substitution antenna shall be placed at its specified location (see subclause 7.4) and fed by an unmodulated RF signal generator.

> Note:
>
> For the frequency range below 150 MHz, a broadband dipole antenna is used as substitution antenna. For higher frequencies a tuned half-wave dipole or a logarithmic-periodical antenna is used. To facilitate optimum matching, an attenuator of 10 dB shall be connected to the feeding point of the substitution antenna. To inhibit radiation via the antenna cable, grouped sets of 3 ferrite cores shall be clamped along the entire antenna cable every 30 to 50 cm.

The substitution antenna shall be fed by the RF signal generator with a constant RF power level. The antenna height (1 to 4 metres), its distance to the building, and its polarisation plane orientation shall now be varied in order to obtain the maximum reading on the measuring receiver. Subsequently, the RF level of the signal generator shall be adjusted to give the same reading on the measuring receiver as previously recorded for the unwanted radiated emission from the telecommunications network (see subclause 6.5.1).

6.5.3 Calculation of radiated RF disturbance power

The level of the effective radiated RF disturbance power is calculated using equation 6.2.

$$p_U = u_S - a_S - a_c - c_r + G_D + 4 \text{ dB} \qquad (6.2)$$

where

- $\boldsymbol{p_U}$: calculated radiated RF disturbance power level in dB(pW);
- $\boldsymbol{u_S}$: voltage level at the RF signal generator output in dB(µV) at 50 **Ω**;
- $\boldsymbol{a_S}$: insertion loss of the attenuator at the antenna feeding point in dB;
- $\boldsymbol{a_c}$: insertion loss of the antenna cable connecting the signal generator and substitution antenna in dB;
- $\boldsymbol{c_r}$: conversion factor for converting the RF power level at the feeding point of a tuned half-wave dipole (the substitution antenna) into the power corresponding to the effective radiated RF disturbance power:

  $$c_r = 10 \log Z_{Fp} \text{ dB}(\Omega) \qquad (6.3)$$

  For a feeding point impedance of $\boldsymbol{Z_{Fp}}$ = 50 Ω, the resulting conversion factor is $\boldsymbol{c_r}$ = 17 dB. The insertion loss of the balun is regarded as negligible;
- $\boldsymbol{G_D}$: gain of the substitution antenna relative to a tuned half-wave dipole;
- 4 dB: correction factor accounting for reflections from the wall in front of which the measurement is made.

7 PROCESSING OF OBTAINED MEASURING RESULTS AND COMPARISON WITH SPECIFIED LIMITS

7.1 Correction of measurement results obtained with a quasi-peak detector

Measurement results obtained with a quasi-peak detector shall always be corrected by adding the quasi-peak weighting factor.

If the $(S + N)/N$ ratio is greater than 20 dB, then no further correction of the obtained measurement results is required. If the ratio $(S + N)/N$ is smaller than 20 dB, and N is dominated by noise, then the measurement result can possibly be corrected further by $\boldsymbol{\Delta U}$ as shown in annex 2.

> Note:
> For any reasonable correction of the measurement results, the ratio $(S + N)/N$ shall be greater than 2 dB.)

If the ratio $(S + N)/N$ is smaller than 20 dB and the measurement result was not corrected, then the higher measurement uncertainty specified in annex 3 table A3.2 applies.

7.2 Correction of measurement results obtained with a peak detector

If the $(S + N)/N$ ratio is greater than 20 dB, then further correction of the obtained measurement results is not necessary. If the ratio $(S + N)/N$ is lower than 20 dB, and $\boldsymbol{N}$ is dominated by noise, then the measurement result can be corrected in accordance with the method described in annex 4.

7.3 Treatment of measurement uncertainty

For compliance testing, the provisions for the measurement uncertainty apply in favour of the telecommunications network and to the disadvantage of the radio communications service. Half of the relevant measurement uncertainty is to be subtracted from the measurement result and this value shall be compared with the specified limit.

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

The measurement uncertainty shall be recorded in the test report.

7.4 Comparison of measurement results with specified limits

The results of the measurements, possibly corrected in accordance with the provisions of subclauses 7.1 or 7.2, shall eventually be compared with the related specified limits for permissible unwanted radiated emissions found in annex 1.

ANNEX 1: LIMITS FOR UNWANTED RADIATED EMISSIONS FROM TELECOMMUNICATIONS INSTALLATIONS AND NETWORKS IN THE SAFETY FREQUENCY RANGES FROM ECC RECOMMENDATION (05)04

Frequency range (MHz)	Disturbance field strength limit (Peak values in (dB(μV/m)))	Measurement distance	Measuring bandwidth
0,009 to 0,15	40 - 20*log (f/MHz)	3 m	200 Hz
0,15 to 1	40 - 20*log (f/MHz)	3 m	9 kHz
1 to 30	40 – 8.8*log (f/MHz)	3 m	9 kHz
30 to 1000	27)[2]	3 m	120 kHz
1000 to 3000	40)[3]	3 m	1 MHz

)[2] This corresponds to an equivalent effective radiated RF power of 20 dB(pW).
)[3] This corresponds to an equivalent effective radiated RF power of 33 dB(pW).

Table A.1: Limits for unwanted radiated emissions

Agreed arrangements:

In the frequency range 30 MHz to 3000 MHz, the limits for the disturbance field strength and their corresponding radiated RF disturbance power represent the same disturbance potential only if the radiated RF disturbance is generated by a single point radiator at a distance of 3 m.

The limits are specified in terms of electric field strength. In the frequency range below 30 MHz these limits also apply, formally converted by means of the free space wave propagation impedance of 377 Ω, to the magnetic field strength measured in accordance with clause 4.

For outdoor measurements at a distance of 3 m, the measurement result shall be corrected by the relevant factor *C* set out in table A.2.

For indoor measurements, the measurement result shall always be corrected by the relevant factor *C* set out in table A.2.

Frequency range (MHz)	Correction factor for outdoor measurements at 3 m distance		Correction factor for indoor measurements
	C **(dB), vertical polarisation**	***C*** **(dB), horizontal polarisation**	**C (dB)**
30 to 40	-3	+2	-3
> 40 to 50	-3	±0	-3
> 50 to 80	-3	-2	-3
> 80 to 3000	-3	-3	-3

Table A.2: Correction factor *C* accounting for differences in free-space and free-field electromagnetic wave propagation

These correction factors C account for the difference between free-space and free-field field strength[2].

For comparison of measuring results with the limits specified in table A.1 the following equation applies:

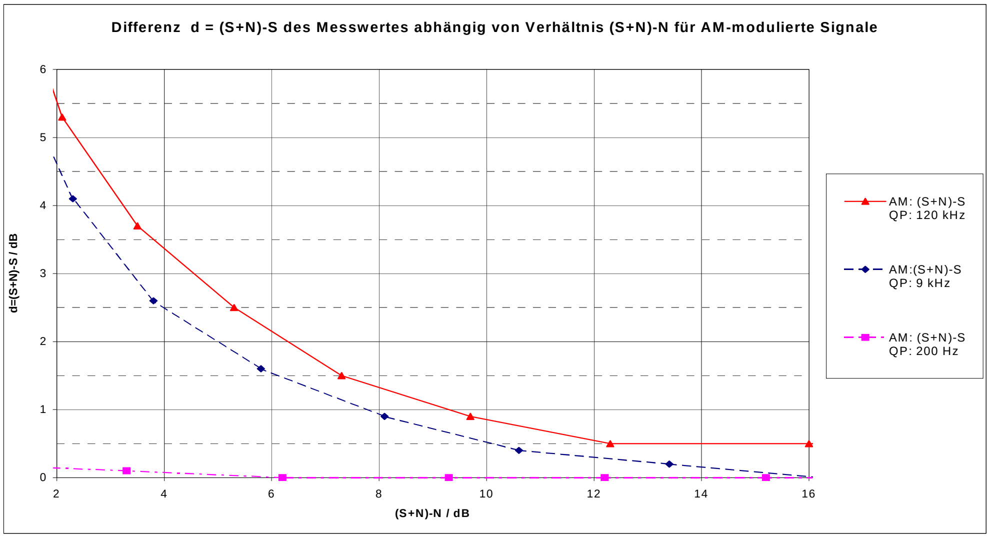
$$E_{corr} = E_{dist} + C \qquad \text{(A.1)}$$

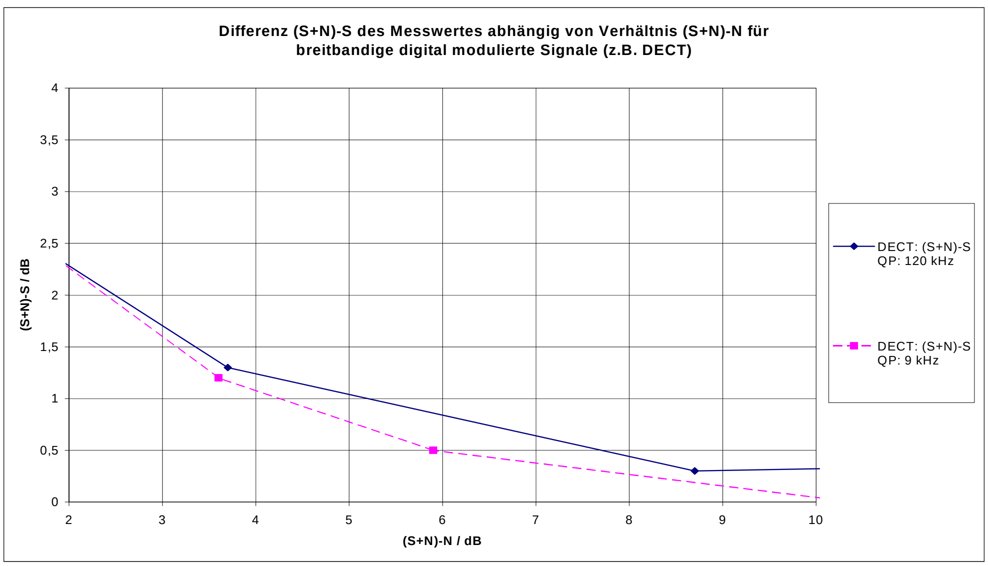
where

- $\boldsymbol{E}_{dist}$: is the measured disturbance field strength level in dB(µV/m); and
- $\boldsymbol{E}_{corr}$: is the corrected disturbance field strength level in dB(µV/m) intended for comparison with the specified limits.

2 Measurement on a test site with an ideal conducting ground plane.

ANNEX 2: CORRECTION OF READINGS OBTAINED WITH QUASI-PEAK DETECTORS IN CASE OF SMALL (S + N)/N RATIOS





Legend:

$(S + N)$ - N:	signal-plus-noise to noise ratio (dB)
$(S + N)$ - S:	signal-plus-noise to signal ratio (dB)
ΔU:	increase in signal level owing to signal superposition (dB)

Correction to be applied:

$$U_{\text{meas.}} = U_{\text{indication}} - \Delta U$$

ANNEX 3: DETERMINATION OF MEASUREMENT UNCERTAINTY

A3.1 Measurement uncertainty occurring during field strength measurements

Contributions of individual components of the measuring system to the total measurement uncertainty are shown in table A3.1. They were derived in accordance with the principles described in CISPR/A/291/CDV.

(Frequency range up to 3 GHz under consideration.)

	Measurement of			
	magnetic field strength	electric field strength		
Frequency range	**< 30 MHz**	**< 30 MHz**	**30 - 300 MHz**	**300 - 1000 MHz**
Component of the measuring system	**Contribution (dB)**			
Receiver reading	0.1	0.1	0.1	0.1
Attenuation: antenna – receiver	0.1	0.1	0.2	0.2
Antenna factor	1.0	1.0	2.0	2.0
Receiver				
Sine wave voltage	1.0	1.0	1.0	1.0
Pulse amplitude response	1.5	1.5	1.5	1.5
Pulse repetition rate	1.5	1.5	1.5	1.5
Mismatch between antenna and receiver	-	-	0.7	0.7
Antenna				
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 polarisation/ balance	-	-	0.9	0.9
Site				
Repeatability at site	2.0	2.0	3.0	3.0
Separation distance	0.3	0.3	0.3	0.3
Environment	3.0	3.0	5.0	5.0
Total (dB)	**5.1**	**5.1**	**7.7**	**7.8**

Table A3.1: Contributions of individual components of the measuring system to the measurement uncertainty during field strength measurements in the frequency range up to 1000 MHz

The obtained measurement results bear a total inherent measurement uncertainty as shown in the table above.

A3.2 Measurement uncertainty in case of a small (S + N)/N ratio

If, during measurements, the $(S + N)/N$ ratio is small only, then a measurement uncertainty of about 3 dB, which is bound to the quasi-peak detector, becomes significant resulting in the following:

	Measurement of			
	magnetic field strength	electric field strength		
Frequency range	**< 30 MHz**	**< 30 MHz**	**30 - 300 MHz**	**300 - 1000 MHz**
Component of the measuring system	**Contribution (dB)**			
Quasi-peak detector	3	3	3	3
Total (dB)	**6.2**	**6.2**	**8.4**	**8.5**

Table A3.2: Contribution of the quasi-peak detector at small $(S + N)/N$ ratios

The obtained measurement results bear a total inherent measurement uncertainty as shown in the table above.

A3.3 Measurement uncertainty occurring during radiated RF disturbance power measurements

If, during the measurements, the $(S + N)/N$ ratio is greater than or equal to 20 dB, then the obtained results bear a total inherent measurement uncertainty of 8 dB.

If, during the measurements, the $(S + N)/N$ ratio is greater than 6 dB and smaller than 20 dB, then the obtained results bear a total inherent measurement uncertainty of 9 dB.

ANNEX 4: CORRECTION OF READINGS OBTAINED WITH PEAK OR AVERAGE DETECTORS IN CASE OF SMALL ($S + N$)/N RATIOS

(According to principles set out in CISPR/A/259/CDV)

A4.1 Explanation of the problem

During measurements of telecommunications installations and networks performed under in situ conditions, the ambient field strength conditions often are not in line with the recommendations of CISPR Publication 16-1 for open area test sites.

The unwanted disturbing emission is often located within frequency ranges already occupied by other ambient field strengths and cannot be measured and assessed with the CISPR measurement receiver, due to insufficient margin between the frequency of the disturbance itself and another ambient field strength, or due to superposition of both field strengths. In such cases, the measuring receiver is not able to discriminate between unwanted radiated emissions from the telecommunications network and other ambient field strengths.

In the following a modified method of measurement is described that makes it possible to distinguish between unwanted radiated emissions from telecommunications networks and other present ambient field strengths.

A4.2 Method of measurement

A4.2.1 Overview

The following combinations of unwanted radiated disturbing emissions and ambient field strengths can occur in practise:

Type of disturbing emission emanating from the installation/network under test	Type of ambient field strength found under in situ conditions
narrowband	Narrowband
	Broadband
broadband	Narrowband
	Broadband

Table A.4.1: Combinations of radiated disturbing emissions and ambient field strengths

During the measurement of unwanted radiated disturbing emissions two problems have to be solved:

- firstly, the disturbing emissions emanating from the telecommunications installation or network have to be discriminated from other ambient field strengths; and
- secondly, distinction shall be made between narrowband and broadband emissions.

For this purpose, modern measuring receivers and spectrum analysers offer several measurement bandwidths and types of detectors. These features and facilities can be used for analysis of the frequency spectrum of the received summation signal, for discrimination between frequency spectra caused by disturbing emissions and ambient field strengths, narrowband and broadband emissions, and for measurement (or at least estimation) of the disturbing emission.

A4.2.2 Method of measurement for disturbing emissions considering the presence of narrowband ambient field strengths

Dependent on the type of disturbing emission emanating from the installation or network the measurement is based on:

- analysis of the summation signal spectrum with a bandwidth narrower than that specified in CISPR Publication 16-1 for the measuring receiver;
- specification of a suitable bandwidth for identification of a narrowband disturbance emission close to other ambient field strengths;
- use of the peak detector, if the disturbing emission appears to be amplitude modulated, or use of the average detector;
- increase of the signal to noise ratio by reduction of the measuring bandwidth, in case of a narrowband disturbing emission appearing within another broadband-type ambient field strength; and
- consideration of the superposition of disturbing emission and ambient field strength, if separation of both is not possible.

A4.2.3 Method of measurement for disturbing emissions considering the presence of broadband ambient field strengths

In this case the measurement is based on:

- analysis of the summation signal spectrum with a bandwidth for the measuring receiver according to CISPR Publication 16-1;
- measurement with a narrow bandwidth (in case of narrowband-type disturbing emissions reduction of the receiver's bandwidth causes an increase of the signal to noise ratio);
- use of the average detector, in case of narrowband-type disturbing emissions;
- consideration of the superposition of disturbing emission and ambient field strength, if separation of both is not possible.

A4.3 Correction of measurement results in case of superposition

If a disturbing emission and another signal present at the location of measurement appear in the same frequency range, then this causes a superposition of these signals in the RF receiving tract of the radio disturbance measuring receiver, subsequently leading to an increased reading of the measuring result. The increase can be analysed as follows:

i) the level of the ambient field strength E_a (in dB(μV)) shall be measured with the disturbing source switched off;

ii) the level of the resulting field strength E_r (in dB(μV) shall be measured with the disturbing source switched on;

iii) the amplitude ratio a between the measured levels shall then be calculated:

$$a = E_r - E_a \qquad \text{(A4.1)}$$

The amplitude ratio a represents the increase of the reading caused by superposition of the signals.

The increased reading is corrected by subtraction of correction factor i from the reading E_r:

$$E_i = E_r - i \qquad \text{(A4.2)}$$

The obtained corrected level of the reading E_i, representing the measurement result, shall be recorded in the test report.

Correction factor i can graphically be derived from the diagram shown in figure A4.1.

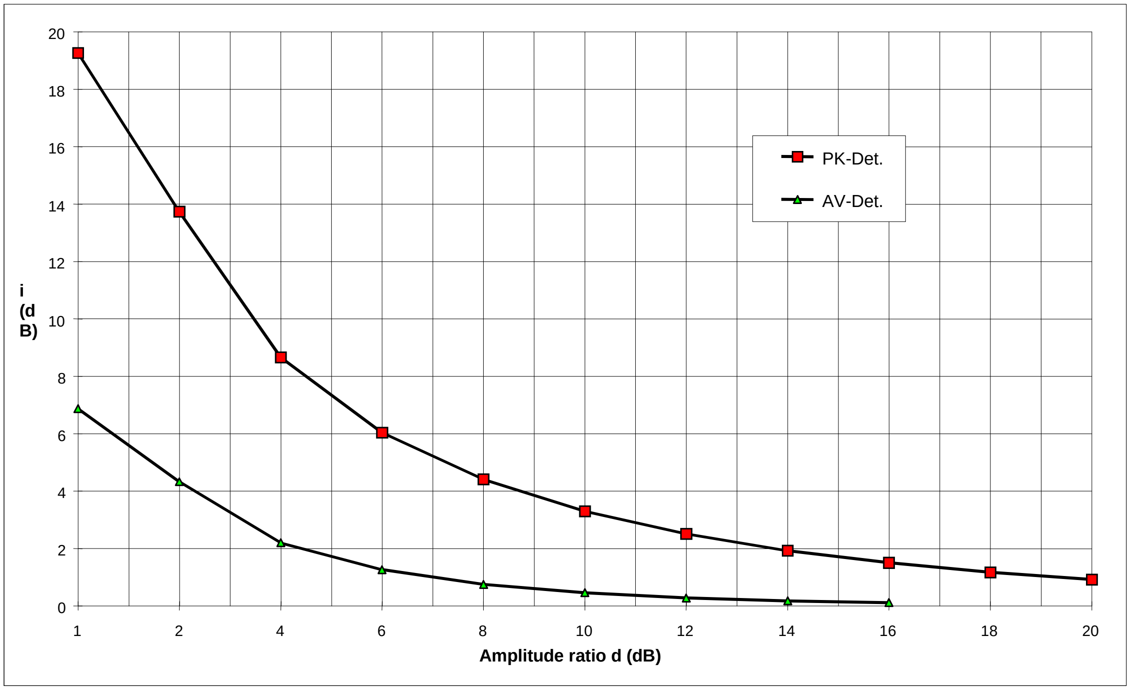


Figure A4.1: Determination of the disturbing signal amplitude by means of amplitude ratio *d* and correction factor *i*

<u>Legend:</u>

PK-Det:	peak detector
AV-Det:	average detector

ANNEX 5: MEASUREMENT OF ELECTRIC FIELD STRENGTH COMPONENTS IN THE FREQUENCY RANGE UP TO 30 MHz; REQUIREMENTS FOR AN ACTIVE DIPOLE

An active dipole suitable for measurements of electric field strengths in the frequency range from 9 kHz to 30 MHz should have the following features and parameters:

- total length of dipole: $< 0{,}50$ m
- balance of the dipole: ≤ 1 dB
- antenna factor: ≤ 20 dB/m
- output impedance: 50 Ohm