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Annex I
(to Article 3 (1))

Frequency bands requiring nationwide special protection in accordance with Article 3

Frequency range in MHz			Application to be protected
2.850	–	3.155	Airband
3.400	–	3.500	Airband
3.800	–	3.950	Airband
4.650	–	4.850	Airband
5.450	–	5.730	Airband
6.525	–	6.765	Airband
8.815	–	9.040	Airband
10.005	–	10.100	Airband
11.175	–	11.400	Airband
13.200	–	13.360	Airband
15.010	–	15.100	Airband
17.900	–	18.030	Airband
21.924	–	22.000	Airband
23.200	–	23.350	Airband
30.350	–	30.750	MIL
34.350	–	35.810	BOS
38.450	–	39.850	BOS
43.300	–	45.250	MIL
46.000	–	47.000	MIL
74.205	–	77.485	BOS, Civil Air Navigation
84.005	–	87.265	BOS
108.000	–	137.000	Airband, Civil Air Navigation
138.000	–	144.000	Airband
165.200	–	165.700	BOS
167.550	–	169.390	BOS
169.800	–	170.300	BOS
172.150	–	173.990	BOS
240.250	–	270.25	Airband
275.250	–	285.25	Airband

290.250	–	301.25	Airband
306.250	–	318.25	Airband
328.250	–	345.25	Civil Air Navigation, Airband
355.250	–	399.90	BOS, Airband
443.59375	–	444.96875	BOS
448.59375	–	449.96875	BOS

Annex 2
(to Article 3 (1))

Limiting values of the disturbance field strength
of wired telecommunications systems and networks

Frequency in the range		Limiting value of the field strength (Peak value of the electrical field strength at a distance of 3 m in dB[µV/m])	Measurement bandwidth
1.	9 to 150 kHz	40–20 x log10(f/MHz)	200Hz
2.	> 150 to 1,000 kHz	40–20 x log10 (f/MHz)	9 kHz
3.	> 1 to 30 MHz	40 – 8.8 x log10 (f/MHz)	9 kHz
4.	> 30 to 108 MHz	27[1])	120 kHz
5.	> 108 to 144 MHz	18[2]) (27)[1])	120 kHz
6.	> 144 to 230 MHz	27[1])	120 kHz
7.	> 230 to 400 MHz	18[2]) (27)[1])	120 kHz
8.	> 400 to 1,000 MHz	27[1])	120 kHz
9.	> 1 to 3 GHz	40[3])	1 MHz

[1]) This corresponds to an equivalent radiated power of 20 dB(pW).
[2]) The value of 18 dB(µV/m) only applies to broadband, digital wired (broadcast) signals. For all other signals this value is 27 dB(µV/m).
[3]) This corresponds to an equivalent radiated power of 33 dB(pW).

Annex 3
(to Article 3 (1))

Measuring specification for disturbance emissions from wired telecommunications systems and networks in the frequency range from 9 kHz to 3 GHz

Contents

1 General Introduction

1.1 Scope

This measuring specification contains methods for the measurement of disturbance emissions from telecommunications systems and networks at their place of installation and operation. The object of the measurements is comprised disturbance emissions in the radiofrequency spectrum range which are caused by the use of frequencies for data transmission in and along cables.

This measuring specification also describes auxiliary methods for determining the disturbance emission if the digital signals cannot be directly measured.

The data networks concerned include Wide Area Networks (WAN), Local Area Networks (LAN) and cable television networks as well as access area technologies using energy supply and telephone networks.

Radio applications that may be adversely affected by disturbance emissions include mobile radio transceivers, radio and television broadcast receivers, fixed radio receivers and airband and civil air navigation services.

Protection from disturbance emissions from telecommunications networks is required in particular by ITU-R RR S15.12. This is furthermore a requirement of Article 4 (2) of Directive 2004/108/EC of the European Parliament and of the Council of 15 December 2004 (OJ No. L. 390, page 24) (EMC Directive).

This measuring specification does not concern any rules on the measurement of emissions from electrical or electronic devices which are applicable in the context of conformity tests in accordance with the EMC Act (EMVG) or the Radio and Telecommunications Terminal Equipment Act (FTEG).

1.2 Frequency Range

This measuring specification applies to the frequency range from 9 kHz to 3 GHz.

1.3 Measuring Method

This measuring specification describes the method for measuring the disturbance emissions from telecommunications systems and networks associated with wanted signals carried by cable.

1.4 Limiting Values

The limiting values are shown in Annex 2 to this Act.

2 Terms and Abbreviations

In the context of this specification the following definitions apply:

Antenna reference point: The geometric centre of the antenna or the reference point to which reference is made during the antenna calibration process.

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

Detector weighting factor: The difference of indication of the quasi-peak detector (QP detector) to the peak detector (PK detector) for a specific signal.

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

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

Auxiliary carrier: A narrow-band signal that has a defined relation with the digital signal to be assessed.

Measuring bandwidth: The bandwidth used in the respective measurement receiver (in accordance with EC 55016-1-1).

Minimum supply: As a rule the minimum supply for the purposes of the present measuring specification at the place of the measurements is always present if the minimum wanted field strength for the respective radio service or the respective radio application can be detected there.

Standard distance: Clearance (measurement distance) between the antenna reference point and the nearest part of the telecommunications network. The standard distance is 3 m.

Wanted signal: The wanted signal embraces the frequency spectrum necessary for communication in and along cables.

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 this measuring specification only those components of the wanted signals carried by cable which are able to generate disturbance emissions in the form of fields in the vicinity of or also away from cables will be considered as disturbance variables.

Telecommunications system: Technical devices or systems which send, transmit, switch, receive, steer or control electromagnetic or optical signals recognisable as messages.

Telecommunications network: Any physical assembly of devices (transmission paths, switching devices and other devices essential to ensure the proper operation of the telecommunications network), to which terminals are connected via terminating devices.

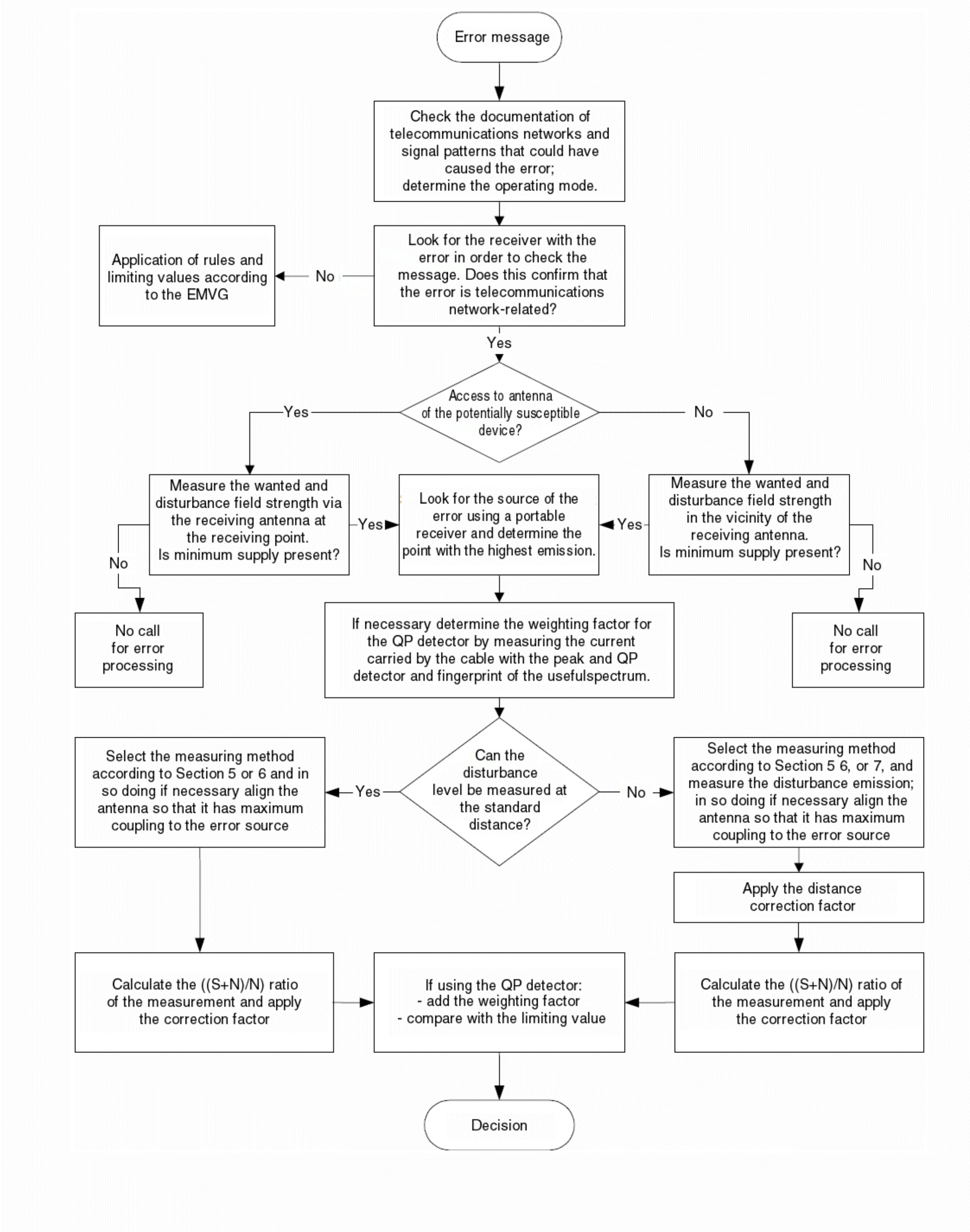
Note:
For the purposes of simplification in the remainder of this measuring specification only telecommunications networks will be referred to. That stated applies equally to telecommunications systems, however.

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

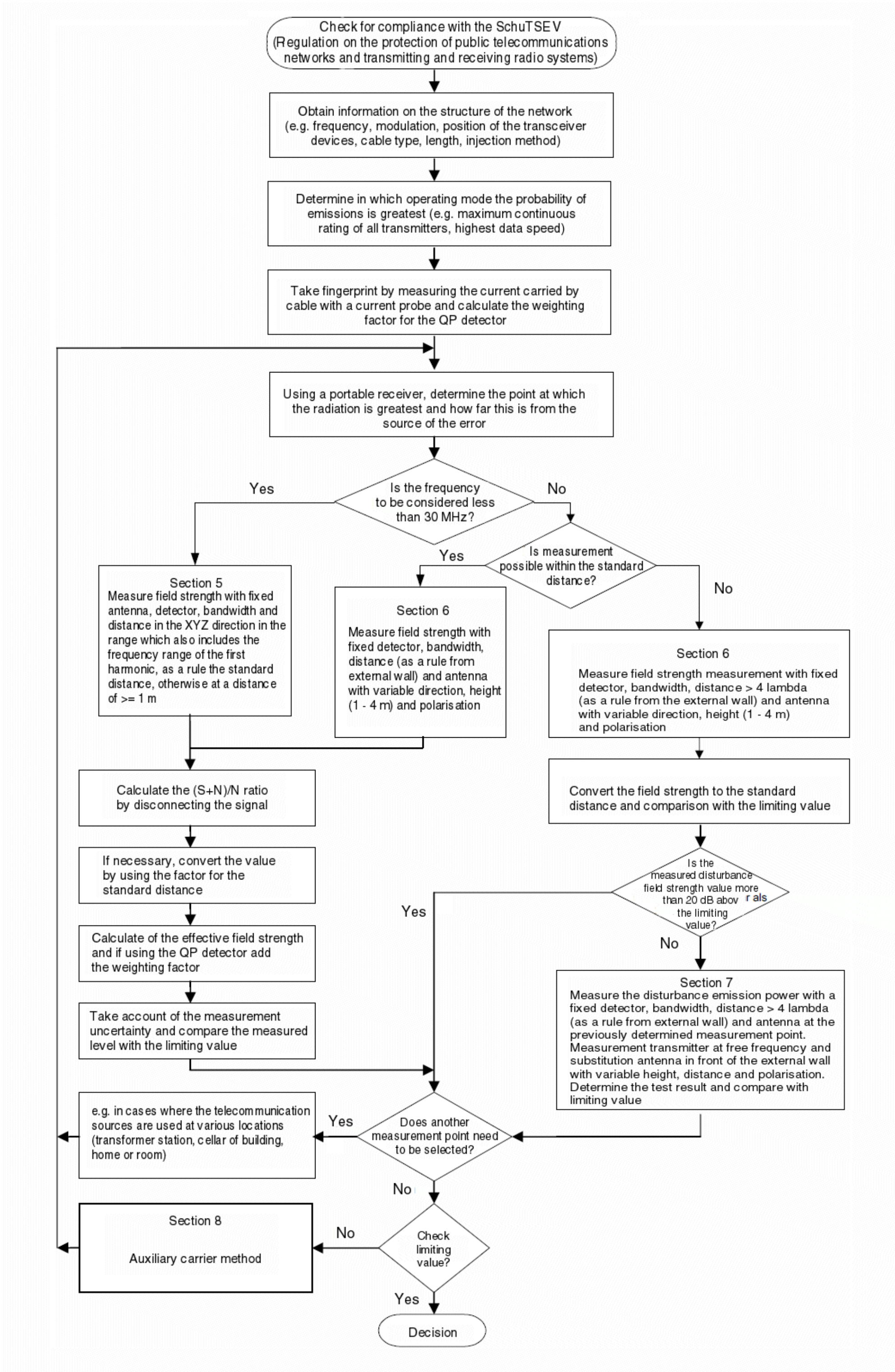
Disturbance emission: The electromagnetic energy portion caused by electrical wanted signals carried by cable which leaves the cable unwanted and through induction, influence or radiation coupling can have an adverse effect on radio traffic.

3 Overview of the measuring method

3.1 Error message processing



3.2 Process for checking telecommunications systems and networks for compliance with the requirements of this Act



4 Basic Principles for Preparation and Execution of the Measurements

4.1 General

It is essential to seek out all technical information required for a comprehensive understanding of the operating parameters and topology of the telecommunications network to be measured. For example, the operator of the telecommunications network should be able to provide details of the EMC-related specification and the parameters of the cable and connection hardware. These details should in all cases be checked in the course of the preliminary investigation described below in order to rule out unwanted emissions from the telecommunications network being measured which are subject to the regulations of the EMVG or FTEG for conformity testing of devices or which may emanate from a telecommunications network other than the one being investigated.

4.2 Operating parameters of the telecommunications network

The basic operating parameters which must be known in order to perform the measurements are: the spectral amplitude distribution and the frequency characteristics of the wanted signals carried by cable as well as the operating mode(s) in the telecommunications network which at some or all of the frequencies to be tested cause the highest disturbance level.

It may also be necessary to determine if through dynamic power regulation fluctuations in the spectral amplitude distribution arise and the characteristics of the frequency spectrum can vary as a function of the specified data transmission speed.

The operating parameters can be determined with the greatest metrological certainty with a high signal-to-noise ratio between the summated signal and the noise (ratio of ($S+N$) to (N)) with the help of a current probe positioned at the start (or end) of the telecommunications cable concerned and an automatically tuning measurement receiver with panoramic display for monitoring the current carried by the cable. In order to be able to access the network as necessary, as a rule the cooperation of the network operator is required.

During the preliminary investigation it will be necessary to clarify if the detectable disturbance emissions are in accordance with the definition of the term in Section 2 of this measuring specification or are other unwanted emissions from connected electronic devices to which the wanted signal carried by cable cannot be attributed. The disturbance emissions detectable in the frequency spectrum of the wanted signal carried by the cable are subject to the provisions of this Act if they cannot be identified as other unwanted emissions.

In both measurement situations (see Sections 4.3.1 and 4.3.2) a portable receiver with a signal level display or another practical tracking method is necessary in order to be able to determine and record where the levels of the radiated disturbance emission are at their highest.

4.3 Selection of the measurement points

Selection of the measurement points depends on the reason for the measurement. Reasons for measurement include the processing of error messages (see Section 3.1) or checking (see Section 3.2) of telecommunications systems and networks for compliance with the provisions of this Act.

4.3.1 Processing of error messages

When processing errors the first measurement point should be positioned in that part of the transmission line (in- or outdoors) which is closest to the faulted radio receiver device and/or antenna of the potentially susceptible device.

4.3.2 Checking of telecommunications systems and networks

When checking telecommunications systems or networks the point where the first measurements are taken depends on the topology of these. The measurement point(s) should be positioned where experience shows that the highest disturbance emissions can be expected. In most interactive systems this will, for example, be at the end of the transmission line, at the point of any repeater used or at transition or leakage points.

In order to determine the characteristic signal form measurement of the wanted signal has to take place at a suitable signal-to-noise ratio. In order to obtain such a fingerprint of the signal, measurement of the current carried by the cable at any accessible point will suffice (see Section 4.2).

4.4 Measuring distance

4.4.1 Checking of telecommunications systems and networks

For measurements in- and outdoors the measuring distance ***d*** = 3 m (standard distance). This distance is the clearance between the measurement antenna reference point and the nearest part of the telecommunications network. Checks on telecommunication systems and networks will as a rule be performed outdoors in front of the building. In special cases (e.g. high-rise buildings) a deviation may be made, however.

4.4.1.1 Taking of the measuring distance for measurements indoors

If the part of the telecommunications network to be investigated is inaccessible or is located in or behind a wall or in a cable duct or similar, then the measurement distance ***d*** must be taken at right-angles to the face of the wall or cable duct.

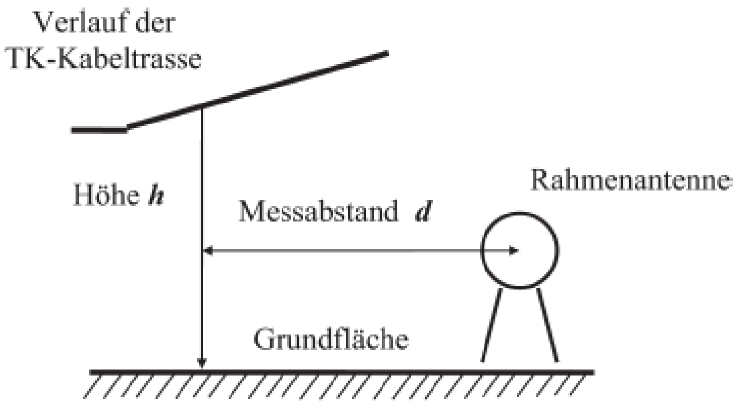
If inside a building, due to space constraints, a free clearance between the telecommunications network and the measurement antenna of 3 m is not available, the above measurement distance can be reduced to 1 m. In doing so the stipulations of Sections 5.2.1.2 and 6.2.1.2 of this measuring specification must be adhered to.

4.4.1.2 Taking of the measuring distance for measurements outdoors

If measurement is performed outside of buildings or similar structures, containing the devices or cables of telecommunications systems, then the measurement distance ***d*** must be taken at right-angles to the external wall of the building or structure concerned.

If the part of the telecommunications network to be measured runs underground, then the measurement distance ***d*** must be taken at right-angles to the vertical projection of the telecommunications network onto the surface of the ground.

If the part of the telecommunications network to be measured runs above the measurement antenna, then the measurement distance ***d*** must be taken at right-angles to the vertical projection of the telecommunications network onto the surface of the ground. The principle is shown in Figure 1.



Telecommunications cable route
Height h
Measurement distance d
Frame antenna
Surface of the ground

Figure 1: Taking of the measurement distance *d* from the vertical projection of the telecommunications cable route onto the surface of the ground

If the setting up of the measurement antenna within the 3 m measurement distance is not possible because of the local conditions outside of the buildings, then for measurements in the frequency range up to 30 MHz the measurement method set out in Section 5.2.1.3 must be applied.

If the cable route to be measured is significantly above the available height of the antenna mast for measurement (e.g. more than 10 m above the surface of the ground), for measurements in the frequency range to 30 MHz the measurement method set out in section 5.2.1.3 must be used and for measurements at above 30 MHz the radiated emission power measured in accordance with Section 7.

4.4.2 Processing of error messages

In order to determine the source of the error no specific measurement distances are defined. If the source of the error can be isolated, then the subsequent investigations will be carried out on the part of the telecommunications system or of the telecommunications network in accordance with the basic principles of Section 4.4.1 and its subsections. Deviations from these basic principles are permitted dependant upon the need and the cause.

4.5 Limiting values for the permitted unwanted emissions from telecommunications systems and networks

The limiting values for the respective frequency sub-range are shown in Annex 2.

It should be noted that the field strength limiting values given in Annex 2 are peak value limiting values. In order to minimise the uncertainty of measurements with the peak value detector when performing practical measurements, however, a quasi-peak detector is used for measurement.

In order to allow a direct comparison between measured quasi-peak value levels and peak value limiting values, the measurement results must be corrected with a QP weighting factor, which must be added to the measured quasi-peak value level. This weighting factor is dependent upon the bandwidth of the measurement receiver and the signal patterns in the telecommunications network to be checked.

If the QP weighting factor is not already known and agreed with the telecommunications network operator, it must be determined in the preliminary investigation phase. The simplest and most accurate way of doing this is to use a current probe with which the telecommunications network is measured at a point with a pure wanted signal and a signal-to-noise ratio between the summated signal and the noise of at least 20 dB.

In the frequency range from 30 MHz to 1,000 MHz the QP weighting factor can also be determined by placing the antenna in the immediate vicinity of the source of radiation.

In the frequency range 1,000 MHz to 3,000 MHz the measured values do not need to be corrected, since the peak value detector is used here any way.

5 Measurements in the Frequency Range from 9 kHz to 30 MHz

5.1 Measurement equipment

The following measurement equipment (in accordance with EN 55016-1-1, EN 55016-1-2 and EN 55016-1-4) is required:

- a calibrated measurement system consisting of a radio disturbance measurement receiver and associated frame antenna for measuring the magnetic field component and stand, or
- a calibrated measurement system consisting of a radio disturbance measurement receiver and associated current probe for measurement of high frequency currents on cables.

In the frequency range from 9 kHz to 150 kHz measurement bandwidth of 200 Hz and a quasi-peak value detector must be used.

In the frequency range from 150 kHz to 30 MHz a measurement bandwidth of 9 kHz and a quasi-peak value detector must be used.

In case of need special devices such as tuned frame antennas or electric field antennas can be used. For any measurements that may be necessary of the electric field strength an active dipole according to the details of Appendix 5 or a comparable dipole must be used.

In order to prevent the measurement being affected by earth loops, if possible a separate power supply (i.e. batteries) is recommended for the measurement receiver and the frame antenna, without earth, in particular for measurements inside buildings.

5.2 Measurement method

5.2.1 Basic principles

According to that stipulated in Appendix 1 the measured magnetic field strength is converted against a wave resistance of 377 Ohms into an electric field strength.

N.B.:
This conversion can now be performed by a range of measurement devices if necessary.

It must be ensured that the telecommunications system is being operated with the normal maximum signal levels and if necessary in the operating mode in which previously the maximum disturbance field strength levels have been detected. In the case of an interactive system it is particularly important that the upstream is checked for the presence of signals in case these are in the same frequency range as the disturbance signalled.

If measurements are carried out at just one frequency or in a narrow frequency range (e.g. during error processing), then the antenna must be aligned in such a way that there is maximum coupling with the telecommunications network being checked.

If measurements are necessary at a number of frequencies or in an adjustable frequency range, separate measurement passes must be carried out in which the antenna in each case is aligned in one of the three orthogonal directions X, Y and Z. The data on the individual measurement passes must be stored and for each frequency the effective field strength (E_{eff}) must be calculated according to equation (5.1).

$$\frac{E_{eff}}{V/m} = \sqrt{\frac{E_X^2}{(V/m)^2} + \frac{E_Y^2}{(V/m)^2} + \frac{E_Z^2}{(V/m)^2}} \qquad (5.1)$$

The simplest way of doing this is to transfer the data to a spreadsheet and then calculate E_{eff} automatically.

In order to reduce the measurement time it is recommended that the frequency range to be investigated is tuned initially using the peak value detector and the maximum value of the disturbance field strength found is then re-measured using the quasi-peak value detector.

For the frame antenna the measurement distance ***d*** corresponds to the distance between the geometric centre of the telecommunications network and for the active dipole to the distance between the telecommunications network and the antenna reference point.

As a rule when checking telecommunications systems measurements in the frequency range below 30 MHz are performed outdoors. Here the measurement distance can be selected such that it either corresponds to the standard distance of 3 m or is greater than this. In special cases (i.e. high-rise buildings) a deviation can be made, however.

5.2.1.1 Measurement at a 3 m measurement distance (standard distance)

The frame antenna must be set up on a stand of 1 m in height to the bottom edge of the frame at the point where previously the maximum disturbance field strength has been measured. In doing so the specified measurement distance to the telecommunications network must be adhered to.

Once the measurement receiver has been adjusted to the respective frequency and the necessary type of detector the frame antenna must be aligned either so that the highest displayed value for the signal from the telecommunications network is achieved or measurement must take place in the orthogonal directions X, Y and Z and the effective field strengths calculated afterwards.

The measurement of magnetic fields generated by telecommunications networks in the frequency range up to 30 MHz can be hampered by the presence of numerous wanted emissions by radio services at high levels. In order that the background noise and any external signals do not exceed the limiting value mentioned in Appendix 1, in the gaps between the radio emissions, frequency ranges with lower field strengths must be found. When searching for these “silent” frequency ranges the position of the antenna should not be changed and it is best that the telecommunications network is shut down.

If it is not possible to shut down the network, the following options are available:

- align the frame antenna in such a way that there is minimum coupling with the emission from the network, and check if the background noise and any external signals are below the limiting value mentioned in Appendix 2.
- Align the frame antenna in such a way that there is maximum coupling; then increase the measurement distance and check if the measured field strength drops accordingly.

The number of silent frequencies or frequency ranges required depends on whether general checking measurements are to be carried out or if an error message which is associated with less effort is to be processed. With general checking measurements the number of silent frequency ranges should be as high as possible. These should be distributed at the most even possible intervals across the entire wanted signal spectrum of the telecommunications service concerned. A diagram showing the spectrum occupation across the entire frequency range under investigation allows silent frequencies suitable for a subsequent analysis to be found quickly. Tuning in the frequency range can be performed with a peak value detector in steps of a half-measurement bandwidth each.

For the processing of error messages a few silent frequencies around the disturbed frequency should suffice. These can be manually set and measured.

In both cases the silent frequencies or frequency ranges found will be used for measurement of the disturbance emission. The person using the receiver should subjectively assess the level of the background noise for each of these frequencies. Then the maximum level of the disturbance field strength (in dB(µV/m) that has been measured using the measurement bandwidth and the said detector for a period of 15 seconds should be recorded. In doing so isolated short-time peaks should be ignored.

The measurements must then be repeated at each of the silent frequencies found in accordance with the method described above with the telecommunications network operational. The measurement results must be documented. The difference between the measured values with the telecommunications network in normal operation and shut down must be determined.

If the level of the external signals is nevertheless above the limiting value, in order to confirm the difference found a current probe is used. (This test method will be the subject of further discussion).

5.2.1.2 Measurement at a measurement distance of less than 3 m

For measurements at a measurement distance of less than 3 m the clearance between the telecommunications network and the outer boundary of the frame antenna is determined.

If adherence to a measurement distance of 3m is not possible, i.e. because of local conditions within a building, a shorter measurement distance can be used but this should not be less than 1 m. In this case the same method must be used as for measurements at a 3 m distance, but the measurement result is then corrected by applying the conversion factor according to equation (5.2):

$$E_{Stör} = E_{Mess} + 20\log\frac{d_{Mess}}{d_{Norm}} \tag{5.2}$$

Where:

- E_{Mess}: Measured value in dB(µV/m)
- $E_{Stör}$: Corrected measured value in dB(µV/m)
- d_{Mess}: Actual measurement distance in m
- d_{Norm}: Standard measurement distance (3 m)

5.2.1.3 Measurement at a measurement distance of more than 3 m

If due to local conditions a measurement distance of more than 3 m has to be selected, then initially two measurement points must be determined lying in the measuring axis at right-angles to the telecommunications cable route. As a guide, the clearance between the two measurement points should be as high as possible. The measured value must be determined in accordance with the method described in Section 5.2.1. The local conditions and measurability of the disturbance field strength will be deciding factors.

The measured values (in dB(µV/m) must be plotted on a diagram against the log of the distance. The straight line between the measured values then describes the drop in field strength in the direction of the measurement axis. If the drop in field strength cannot be determined, further measurement points must be selected. The field strength level at the standard distance can be inferred from the connecting straight lines plotted on the diagram (graphic determination).

5.3 Measurement of the electric disturbance field strength

The electric field strength is only measured when error messages are processed, when it must be assumed that the disturbance emission is a predominantly electric field. This could be the case if despite the limiting value of the magnetic field strength not being exceeded but the disturbance nevertheless occurs in a radio receiver device working with an antenna for the electric field.

The measurement method corresponds to the procedure when measuring the magnetic disturbance field strength. The necessary antenna is described in Appendix 5.

5.4 Measurement of the asymmetrical disturbance current

Only where because of high ambient field strengths demonstration of adherence to the limiting values for the disturbance field strength is impossible in practice, can a current probe be used instead to measure the disturbance current on the cable.

The corresponding limiting value can be seen from the Figure in Appendix 1a.

6. Measurements in the Frequency Range from 30 to 3,000 MHz

6.1 Measurement equipment

The following measurement equipment (in accordance with EN 55016-1-1 and EN 55016-1-4) is required:

a calibrated measurement system consisting of a radio disturbance measurement receiver and an associated broadband dipole or an associated logarithmic periodic antenna for measurement of the electric field components and mast.

<u>Note</u>:

Measurement results obtained using the calibrated measurement system described here do <u>not</u> require further correction in relation to near-field properties prevailing during measurement.

The requirements to which the radio disturbance receivers and antennas are subject are described in EN 55016-1-1 and EN 55016-1-4.

In the frequency range from 30 to 1,000 MHz a measurement bandwidth of 120 kHz and a quasi-peak value detector must be used. In the frequency range from 1,000 to 3,000 MHz a measurement bandwidth of 1 MHz and a peak value detector must be used.

6.2 Measurement method

6.2.1 Basic principles

It must be ensured that the telecommunications system is being operated with the normal maximum signal levels and if necessary in the operating mode in which previously the maximum disturbance field strength levels have been detected. In the case of an interactive system it is particularly important that the upstream is checked for the presence of signals in case these are in the same frequency range as the disturbance signalled.

In order to reduce the measurement time it is recommended that the frequency range to be investigated is tuned initially using the peak value detector and the maximum value of the disturbance field strength found is then re-measured using the quasi-peak value detector.

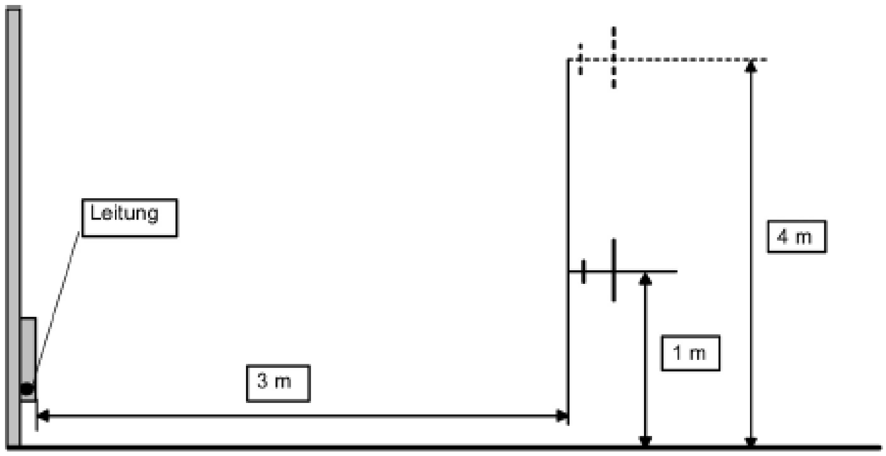
For the broadband dipole the measurement distance ***d*** corresponds to the distance between telecommunications network and the balun and for the logarithmic periodic antenna the distance between the telecommunications network and the antenna reference point.

As a rule measurements in the frequency range above 30 MHz when checking telecommunications systems and networks are performed outdoors in front of the building. Here the measurement distance can be selected such that it either corresponds to the standard distance of 3 m or is greater than this. In special cases (i.e. high-rise buildings) a deviation can be made, however.

6.2.1.1 Measurement at a 3 m measurement distance (standard distance)

The standard distance is 3 m. At the fixed measurement point the measurement antenna must be varied in direction, height and polarisation (horizontal and vertical) such that the maximum disturbance field strength is measured.

If the antenna and telecommunications network are located in the same reference plane, then in order to determine the maximum field strength a height variation of between 1 m and 4 m must be performed. During the height variation the distance between the antenna and disturbing objects (such as walls, ceilings, metal structures and so on) must be at least 0.5 m. The height variation can be restricted by local conditions (see Figure 2: Height variation of the antenna).



Cable

Figure 2: Height variation of the antenna

If the antenna carrier is not in the same reference plane as the cable, e.g. for a measurement outdoors, then a variation in proportion to the height of the object must be performed.

6.2.1.2 Measurement at a measurement distance of less than 3 m

If when processing error messages or in special checking cases (e.g. high-rise buildings) measurements to determine the error source are necessary indoors and a measurement distance of 3 m cannot be adhered to because of local conditions, measurement can also take place at a lower distance, but this should not be less than 1 m. The measurement distance is represented by the clearance between the cable and the reference point of the antenna used. For the measurement the antenna must be aligned for the maximum coupling to the error source, dispensing with a height variation. The measurement result must be corrected by applying the conversion factor according to equation (6.1):

$$E_{Stör} = E_{Mess} + 20\log\frac{d_{Mess}}{d_{Norm}} \qquad (6.1)$$

Where:

- E_{Mess}:	Measured value in dB(µV/m)
- $E_{Stör}$:	Corrected measured value in dB(µV/m)
- d_{Mess}:	Actual measurement distance in m
- d_{Norm}:	Standard measurement distance (3 m)

Note:
Measurement results obtained using the calibrated measurement system (see Section 6.1) do not require further correction in relation to any near-field properties prevailing during measurement.

6.2.1.3 Measurement at a measurement distance of more than 3 m

If because of local conditions a measurement distance of more than 3 m has to be selected, then instead of the electric field strength the disturbance radiation power will be determined according to the substitution method laid down in Section 7.

6.3 Determination of the electric field strength

The electric field strength is determined by observing the display of the measurement receiver for up to approximately 15 seconds and then recording the maximum value displayed. In doing so isolated short-time peaks should be ignored.

If the measurement system used provides only measurement results in the form of HF voltage levels, the disturbance field strength level can be calculated with the help of equation (6.2) from the HF voltage level measured at the antenna connection of the measurement receiver:

$$E_{Stör} = u_E + a_K + K \qquad (6.2)$$

Where:

- $E_{Stör}$:	Calculated disturbance field strength in dB(µV/m)
- U_E:	Measured voltage level in dB(µV) at the antenna input of the measurement receiver (at 50 Ohms)
- a_K:	The damping of the measurement cable in dB
- K	Antenna factor*) of the measurement antenna in dB

*) Antenna factor according to manufacturer or calibrator (if available, for the standard distance)

Note:
Irrespective of the measurement distance actually used, for the calculation of the disturbance field strength level in each case the antenna factor associated with the measurement antenna (clearance according to the manufacturer or calibrator) must be used.

7 Measurement of the Radiated Disturbance Power in the Frequency Range from 30 to 3,000 MHz

7.1 Measurement equipment

The requirements relating to the radio interference receiver, the measurement bandwidths, detectors and antennas used to measure the radiated disturbance power are described in EN 55016-1-1 and EN 55016-1-4.

7.2 Measurement distance

The measurement of the electric field from telecommunications networks is fraught with uncertainties due to reflections from boundary layers and the presence of parasitic elements within the environment. Further uncertainties can result from measurements in the near-field. Part of the resulting uncertainties can be eliminated by determining the radiated disturbance power of the error source under the same environmental conditions using a substitution antenna.

In order to measure the radiated disturbance power a measurement distance must be selected which is in the far-field of the radiated disturbance source. This condition is fully met if for dipolar radiators the necessary measurement distance is calculated according to equation (7.1) and applied:

$$\boldsymbol{d} \geq \mathbf{4} \,.\, \lambda \qquad (7.1)$$

or if the measurement distance $\boldsymbol{d} \geq 30$ m. (For a large proportion of cases that arise in practice simply meeting the condition $\boldsymbol{d} \geq \lambda$ is sufficient).

7.3 Measurement antenna location

The measurement of the radiated disturbance power must be performed in accordance with Section 7.2 in the far-field. In observance of this condition, for the measurement of the disturbance radiated by a telecommunications network (and the equivalent emission then to be reproduced by the substitution antenna) the location will be selected at which previously the highest disturbance field strength has been determined in accordance with Section 4.3.

7.4 Substitution antenna location

The substitution antenna must be set up at 1 m distance from the exterior wall of the building in which the telecommunications network is housed.

The set-up location should be selected in such a way that the imaginary line between the substitution antenna and the measurement antenna runs at right-angles to the direction of the cable of the telecommunications network or to the exterior wall of the building in which the telecommunications network is located.

7.5 Measurement method

7.5.1 Level of the unwanted radiated emission

The direction, height and polarisation of the measurement antenna must be varied at the measurement location according to paragraph 7.3 (Location of the measurement antenna) in such a way that the maximum level of the unwanted radiated emission from the telecommunications network is measured. Once the maximum disturbance field strength has been determined the position of the measurement antenna will no longer be varied.

Hint:
A substitution measurement can be dispensed with if the disturbance field strength measured according to Section 6 under far-field conditions following conversion to the standard distance of 3 m with the help of equation (5.2) is more than 20 dB above the applicable limiting value.

7.5.2 Substitution measurement

When operating the substitution antenna the frequency used should not already be occupied by terrestrial radio services or radio applications.

When checking telecommunications systems and networks corresponding ISM frequencies or the radio frequencies envisaged for these purposes by the BNetzA (*Telecommunications Watchdog*) in connection with the frequency distribution, must be used.

For measurements in connection with the processing of radio interference after locating the error source and recording the value displayed by the measurement receiver, it should be ensured that the part of the telecommunications network concerned is shut down or that the telecommunications service causing this is temporarily taken out of service and the disturbed radio frequency is not occupied. If this is not possible, the frequency used for operating the substitution antenna must be altered by the smallest possible amount for the disturbance emission(s) from the telecommunications network to be blocked out or emissions on local terrestrial radio frequencies already occupied to be avoided.

The substitution antenna will be set up at the selected location (see Section 7.4) and fed by an un-modulated measurement transmitter.

Hint:
In the frequency range below 150 MHz a broadband dipole is used as the substitution antenna. At higher frequencies a tuned half-wave dipole is used. For improved adaptation an attenuator offering 10 dB attenuation should be connected at the foot of the substitution antenna. In order to prevent radiation via the antenna cable, in each case three ferrite rings must be clamped to the antenna cable at distances of between 30 and 50 cm.

The substitution antenna, which is fed by a set measurement transmitter power, must now be varied in its setup height (1 m to 4 m), the distance to the building and the polarisation plane alignment in such a way that the maximum value is read off from the display. Then the HF level of the measurement transmitter is set at the measurement receiver so that the same display value is achieved as was previously also generated by the telecommunications network signal.

7.5.3 Calculation of the disturbance power

The effective radiated disturbance power level is calculated in accordance with equation (7.2):

$$p_u = u_s - a_s - a_c - c_r + G_D + 4\ \mathrm{dB} \qquad (7.2)$$

Where:

- p_u: The calculated radiated disturbance power level in dB(pW)
- u_s: The voltage level at the measurement transmitter output in dB(µV) at 50 Ohms
- a_s: The attenuation of the attenuator at the foot of the antenna in dB
- a_c: The attenuation of the connecting lead between the measurement transmitter and the substitution antenna in dB
- c_r: The conversion factor for converting the power level at the foot of a tuned half-wave dipole (the substitution antenna) to the power corresponding to the effective radiated disturbance power

$$c_r = 10 \log Z_{Fp}\ \mathrm{dB}\,(\Omega) \qquad (7.3)$$

  A foot impedance of Z_{Fp} = 50 Ohms results in a conversion factor of c_r = 17 dB. The losses of the baluns are considered to be so small that they can be ignored.
- G_D: The gain of the substitution antenna in relation to a tuned half-wave dipole.
- **4 dB**: A correction value to take account of reflections from the wall in front of which measurement is taking place.

8 Auxiliary Carrier Method

The auxiliary carrier method is used if a direct measurement of disturbance emissions via broadband digital signals is not possible (e.g. during test feeds to search for leakage points or the determination of summated disturbance field strengths). The reason for this is that in the case of broadband disturbance signals a reduction in the signal-to-noise ratio takes place and thus a loss of sensitivity in the measurement receiver. The necessary increase in the measurement dynamics can be achieved with the help of narrowband auxiliary carriers.

8.1 Level determination and settings

For an assessment of the disturbance emissions from broadband digital signals, when using the auxiliary carrier method it is first necessary to determine the ratio of the mutual level ratios.

To do this, first the level of the broadband digital wanted signal with the bandwidth defined for the frequency range concerned (see Appendix 2) must be determined at the injection point. For this it is advisable to use the detector (QP detector in the frequency range up to 1 GHz or peak value detector in the frequency range above 1 GHz) prescribed for the frequency range concerned.

Then a check must be made if any auxiliary carrier is already present or if other narrowband reference signals can be used as auxiliary carriers. If this is not the case, in the next step an un-modulated sinusoidal auxiliary carrier must preferably be injected in the gap between the digital signals (in order not to disturb these) in such a way that the level of this signal, measured with a measurement bandwidth of 200 MHz corresponds to the measured value of the previously measured digital signal.

Note:
If practical circumstances so require, the auxiliary carrier can also be injected at a higher level compared to the level of the digital wanted signal. All that is important here is that in doing so due account is taken of the restrictions inherent in the system. In the subsequent determination of the disturbance field strength of the auxiliary carrier, the measured value obtained must then be correspondingly corrected, however.

In all cases the use of additionally injected auxiliary carriers must be agreed locally with the respective network operators.

8.2 Determination of the disturbance field strength

If the level of the auxiliary carrier and the broadband digital signal have been determined as described in Section 8.1 prior to the measurement or brought into line with one another, then the measurement results from the auxiliary carrier measurement at the measurement locations concerned either directly represent the electric field strength prevailing there or provide the level of the voltage at the antenna input of the measurement receiver. If the auxiliary carrier at the injection point is impressed in the network concerned with an x dB higher level than the digital wanted signal, then this difference in level must be correspondingly subtracted from the measurement values obtained, in order ultimately to obtain the disturbance field strength level at the measurement point associated with the useful signal transmission. The general procedures for calculating the field strengths as described in sections 5 and 6, are unaffected by this and are to be applied here accordingly.

9 Conditioning of the measurement results and comparison with the limiting value

9.1 Corrections to the measurement results when measuring with the quasi-peak value detector

When the quasi-peak value detector is used the level measured must also be corrected by addition of the QP weighting factor.

If the *(S+N)/N* ratio is more than 20 dB then no correction is necessary to the measurement results achieved. If the *(S+N)/N* ratio is less than 20 dB and ***N*** is dominated by noise, then the measurement result can if necessary be corrected by Δ***U*** (see Appendix 2).

Hint:
The *(S+N)/N* ratio must be greater than 2 dB.

If the *(S+N)/N* ratio is less than 20 dB and is not corrected in accordance with Appendix 2, the higher measurement uncertainty shown in Appendix 3, Table 2, must be taken into account.

9.2 Corrections to the measurement results when measuring with the peak-value detector

If the *(S+N)/N* ratio is more than 20 dB, then no further correction is necessary to the measurement results achieved. If the *(S+N)/N* ratio less than 20 dB and ***N*** is dominated by emissions from the environment, then the measurement result can if necessary be corrected by the method described in Appendix 4.

9.3 Treatment of measurement uncertainty

When a check is being carried out half the measurement uncertainty is subtracted from the measured value and the resulting value is then compared with the limiting value.

In the case of an error the measurement uncertainty is not taken into account in the measurement result.

The measurement uncertainty must be shown in the measurement record.

9.4 Comparison with the limiting value

The results of the investigation determined from the measurements and corrected according to that laid down in Sections 8.1 and 8.2 must finally be compared with the limiting appropriate limiting values in each case for the permissible disturbance emission.

Appendix 1

Stipulations for Measurement of the Limiting Values Applicable According to this Act for Cable Telecommunications Systems and Networks

The limiting values of the disturbance field strengths and the corresponding radiated disturbance power in the frequency range from 30 to 3,000 MHz represent the same disturbance potential, if the radiated disturbance is generated by a lumped radiation source at a distance of 3 m.

The reference method is the measurement method for the radiated disturbance power.

The limiting values are expressed as electric field strengths. In the frequency range below 30 MHz these limiting values also apply, formally converted against a wave resistance of 377 Ohms, for the magnetic field strengths measured in accordance with Section 5.

For measurements at a 3 m measurement distance outside of buildings the measured value must be varied by the correction factor ***K*** from Table A.1.

For measurements inside of buildings the measured value, irrespective of the measurement distance selected, must always be varied by the correction factor ***K*** from Table A.1.

Table A.1
Correction factors in the outdoor free field

Frequency range (in MHz)	Correction factor outside the building (for a 3 m measurement distance)		Correction factor inside the building
	K in dB (vertical polarisation)	***K*** in dB (horizontal polarisation)	***K*** in dB
30 – 40	- 3	+ 2	- 3
40 – 50	- 3	± 0	- 3
50 – 80	- 3	- 2	- 3
Between 80 and 3,000	- 3	- 3	- 3

These correction values ***K*** take account of the difference between the outdoor field strength and the free-field field strength*).
For the comparison of the measurement results with the limiting values shown in Appendix 2 to this Act the following equation applies:

$$\boldsymbol{E_{korr} = E_{Stör} + K} \qquad \text{(A.1)}$$

Where:

- EStör : The measured disturbance field strength level in dB(µV/m)
- Ekorr : The corrected disturbance field strength level in dB(µV/m), which is compared with the applicable limiting value

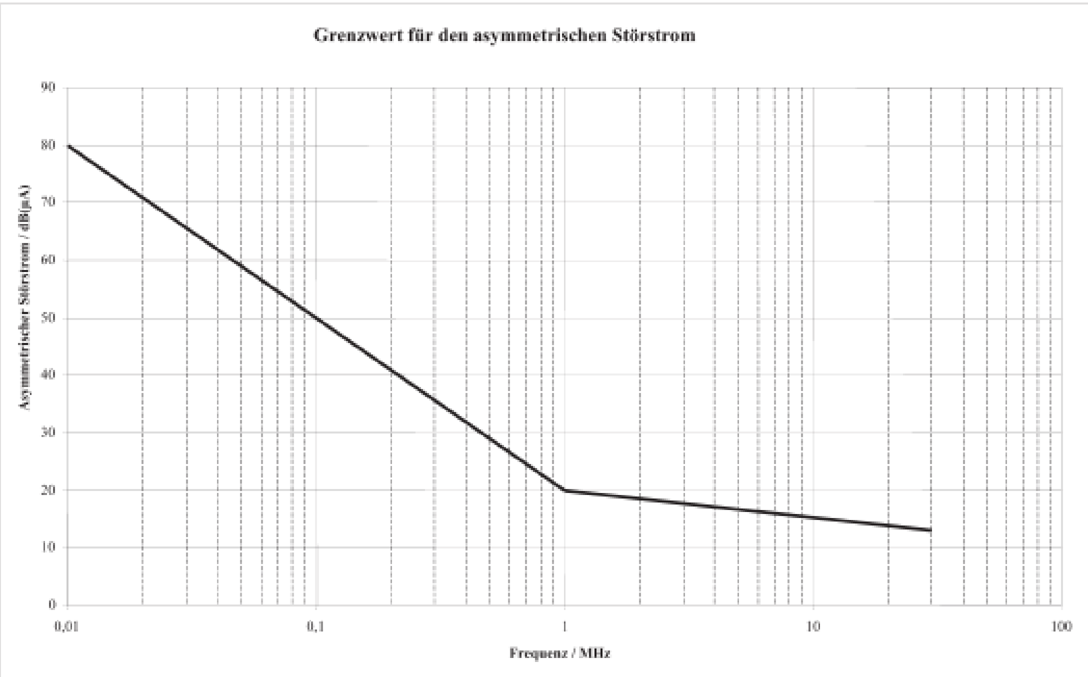
*) Measurement at measuring station with an ideally conducting reference surface (ground plane).

Appendix 1a

Limiting Value for Disturbance Current

In the event that due to high ambient field strengths demonstration of adherence to the limiting values shown in Annex 2 to this Act is impossible in practice, the limiting value for the permissible asymmetrical disturbance current can be used as a "secondary" limiting value.

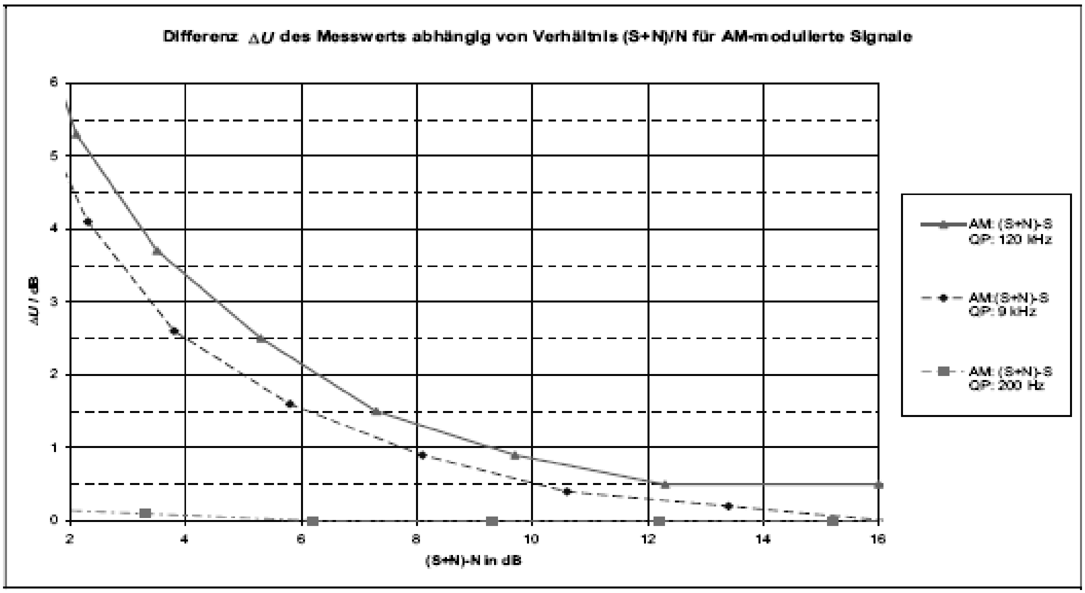
Limiting value for the asymmetrical disturbance current
Asymmetrical disturbance current / dB(µA)
Frequency / MHz



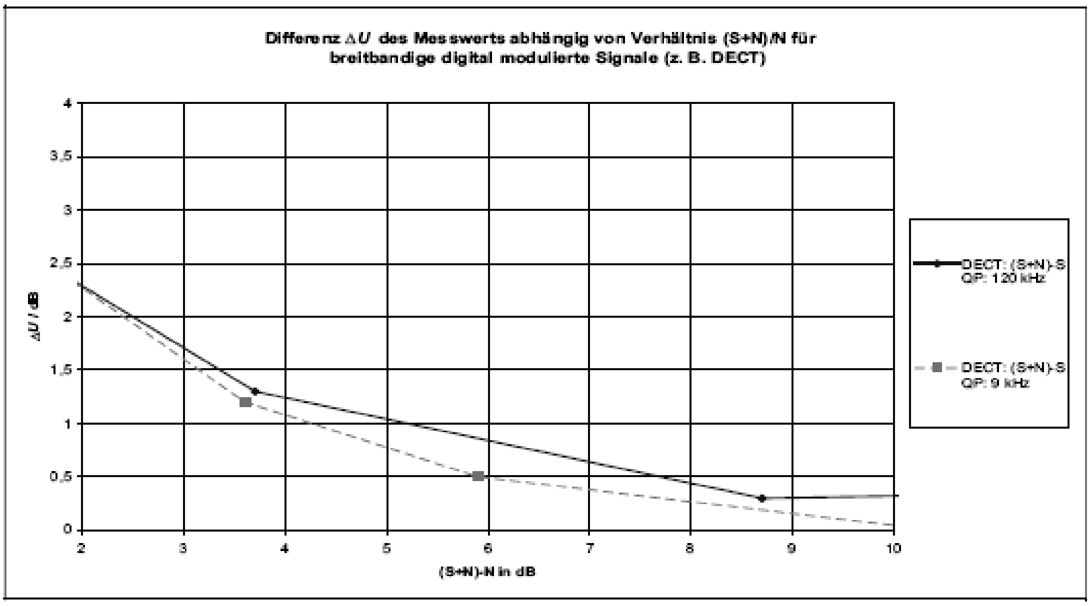
Appendix 2

Correction of the Level Value Displayed by the Quasi-Peak Value Detector at low *(S+N)N* ratios

Difference Δ*U* in the measured value as a function of the (S+N)/N ratio for AM signals



Difference Δ*U* in the measured value as a function of the (S+N)/N ratio for broadband digital modulated signals (e.g. DECT)



Explanation:

20*log ((S+N)/N) corresponds to *(S+N)-N*:	Signal-to-noise ratio between the summated signal (S+N) and noise (N); in (dB)
20*log ((S+N)/S) corresponds to *(S+N)-S*:	Signal-to-noise ratio between the summated signal (S+N) and signal (S); in (dB)
ΔU :	Signal rise as a result of the signal overlay; in (dB)

Correction to be performed:

$U_{mess} = U_{Anzeige} - \Delta U$

Appendix 3

Determination of the measurement uncertainty

A.3.1 Measurement uncertainty in field strength measurements

The contributions of the individual components of the measurement system to the overall measurement uncertainty can bee seen from Table A.3.1. These have been determined by application of the basic principles described in EN 55016-4-2.

Table A.3.1
Influencing variables in the determination of measurement uncertainty in field strength measurements in the frequency range to 1,000 MHz

(for the frequency range from 1 GHz to 3 GHz
a measurement uncertainty of 8 dB is taken as a basis)

Influencing variable (dB)	Measurement of the magnetic field strength	Measurement of the electric field strength		
	<30 MHz	<30 MHz	30 – 300 MHz	< 300 – 1,000 MHz
Receiver display	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				
Sinusoidal voltage	1.0	1.0	1.0	1.0
Display of the pulse amplitude	1.5	1.5	1.5	1.5
Display of the pulse repetition frequency	1.5	1.5	1.5	1.5

Matching to antenna	–	–	0.7	0.7
Antenna				
Antenna factor Frequency interpolation	–	–	0.5	0.3
Deviations due to height-dependency	–	–	1.0	0.3
Deviation due to efficiency	–	–	0	1.0
Phase centre location	–	–	0	1.0
Cross-polarisation/ Antenna symmetry	–	–	0.9	0.9
Location				
Repeatability at location	2.0	2.0	3.0	3.0
Protection ratio	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

A.3.2 Measurement uncertainty at low (S + N) / N ratio

If because of the low signal-to-noise ratio between the summated signal and the noise *(S+N)N* the measurement uncertainty of the quasi-peak detector of approximately 3 dB has to be taken into account, and the correction values from Appendix 2 did not apply, the following balance results instead:

Table A.3.2
Contribution of the quasi-peak value detector at low (*S+N)/N* ratio

Influencing variable (dB)	Measurement of the magnetic field strength	Measurement of the electric field strength		
	< 30 MHz	< 30 MHz	30 – 300 MHz	< 300 – 1,000 MHz
Quasi-peak value detector	3.0	3.0	3.0	3.0
Total (dB)	6.2	6.2	8.4	8.5

A.3.3 Measurement uncertainty in measurements at low (S+N)/N ratio

At a (*S*+*N*)/*N* ratio of 20 dB a measurement uncertainty of 8 dB applies and for a (*S*+*N*)/*N* ratio of more than 6 dB a measurement uncertainty of 9 dB applies.

Appendix 4

Correction of the level value displayed by the peak or average detector at low (S+N)/N ratios

(according to the basic principles of EN 55016-2-3)

Measurement of the disturbance emission
taking into account the ambient field strengths present

A.4.1 Description of the problem

When performing measurements at the installation and operation location of telecommunications systems the ambient field strengths often do not correspond to the recommendations given in Section 5.4 of EN 55016-1-4 for the radio frequency environment at measuring stations.

The disturbance emission is often within the frequency ranges of the ambient field strengths and because of the inadequate frequency spacing between the disturbance emission and the ambient field strength or because of overlaying it is not possible to use a measurement receiver that meets the requirements of EN 55016-1-1. The measurement receiver is in such cases may not be able to distinguish between disturbance emission from the telecommunications system (the telecommunications network) and ambient field strengths.

In the following a modified measurement method is described which allows a distinction to be made under high ambient loading between disturbance emissions from telecommunications systems and networks and the ambient field strengths present.

A.4.2 Measurement method

A.4.2.1 Overview

The following combinations of disturbance emission and ambient field strengths can occur:

Table A.4.1
Combination of disturbance emission and ambient field strengths

Disturbance emission from the device being measured	Ambient field strengths
Narrowband	Narrowband
	Broadband
Broadband	Narrowband
	Broadband

When measuring disturbance emissions two problems have to be overcome:

- firstly, the disturbance emissions from the device being measured have to be identified from the ambient field strengths, and
- secondly, a distinction has to be made between narrowband and broadband emissions.

Modern measurement receivers and spectrum analysers offer various measurement bandwidths and types of detectors for this purpose. These can be used for analysis of the spectrum of the summated signal, differentiating between the spectra of the disturbance emissions and the ambient field strengths, differentiating between narrowband and broadband emissions and for measurement (or in difficult cases at least for estimation) of the disturbance emission.

A.4.2.2 Measurement method for disturbance emissions taking into account the narrowband ambient field strengths present

According to the type of disturbance emission from the device being measured, the measurement is based on:

- an analysis of the spectrum of the summated signal with a bandwidth that is narrower than the bandwidth of the measurement receiver specified in EN 55016-1-1;
- definition of a suitable measurement bandwidth for identification of a narrowband disturbance emission in the vicinity of the ambient field strengths;
- use of the peak-value detector (PK detector, if the disturbance is amplitude or pulse modulated) or the average detector (AV detector);
- increasing the S/N ratio in the event of a narrowband disturbance emission within a relatively broadband ambient field strength for a narrower measurement bandwidth and
- taking into account the overlaying of the disturbance emission and the ambient field strength if a separation is not possible.

A.4.2.3 Measurement method for the disturbance emission from the device being measured taking into account the broadband ambient field strengths present

The measurement method in this case is based on:

- analysis of the spectrum of the summated signal with a bandwidth corresponding to that of the measurement receiver according to EN 55016-1-1;
- measurement with a narrow bandwidth (for narrowband disturbance emission a narrow bandwidth increases the S/N ratio);
- use of the average detector for the narrowband disturbance emission and
- taking into account the overlaying of the disturbance emission and the ambient field strength if a separation is not possible.

A.4.3 Correction of the measurement result in the event of overlaying

In the event of overlaying of disturbance emissions with ambient signals, in the reception channel of the radio disturbance measurement receiver overlaying of both signals occurs which leads to an increase in the measurement value displayed. This increase can be determined as follows:

1. The level of the ambient field strength E_a in dB(µV/m) must be measured by shutting down the source of the error.
2. The level of the resulting field strength E_r in dB(µV/m) (measured value displayed) must be measured by starting up the source of the error.
3. The amplitude ratio d between the values determined must be calculated:

$$d = E_r - E_a \qquad \text{(A.4.1)}$$

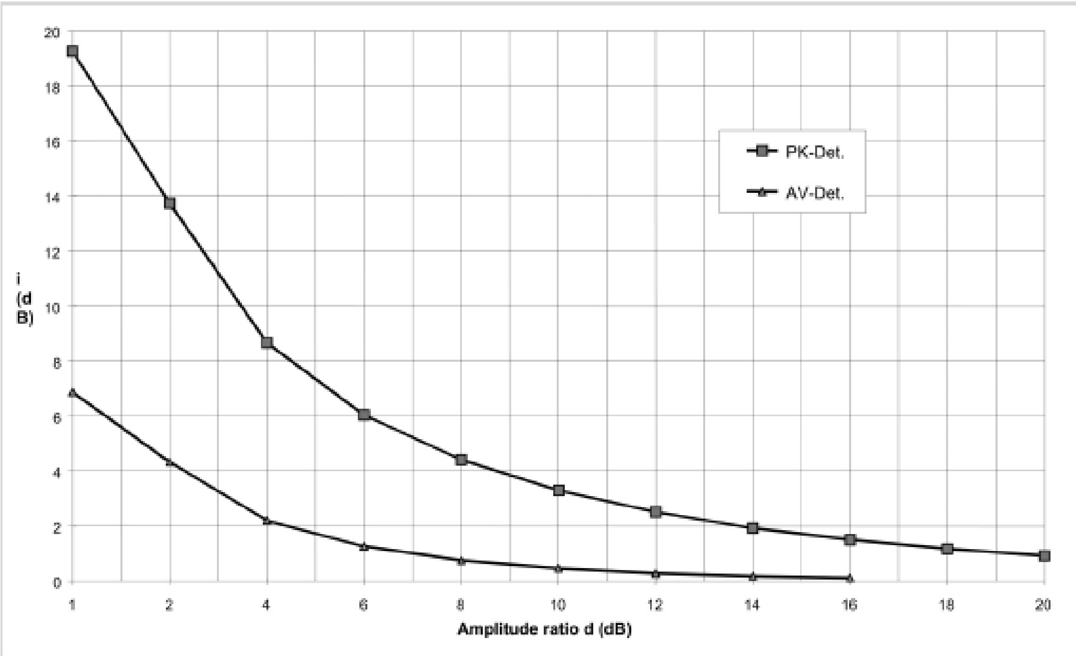
The amplitude ratio d represents the increase in the measured value displayed resulting from the overlaying of the signals.

The increased measured value displayed is corrected by deducting the correction factor i determined graphically with the help of the diagram shown in Figure A.4.1 from the measured value displayed E_r:

$$E_i = E_r - i \qquad \text{(A.4.2)}$$

The level value corrected in this way of the measured value displayed must be recorded as a measurement result in the measurement record.

Figure A.4.1
Determination of the amplitude of the disturbance signal using the amplitude ratio *d* and the factor *i*



Legend:

PK-Det.: Peak-value detector
AV-Det.: Average detector

Appendix 5

Requirements for an active dipole

for the measurement of the electric field strength in the frequency range up to 30 MHz

Active dipole antenna in the frequency range 9 kHz – 30 MHz

Symmetry of the dipole:	< 1 dB
Antenna factor:	< 20 dB/m
Output impedance:	50 Ohms