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BSI Standards Publication

# Cable networks for television signals, sound signals and interactive services

## Part 2-1: Electromagnetic compatibility measurements

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## National foreword

This Published Document is the UK implementation of CLC/TR 50083-2-1:2014.

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# Cable networks for television signals, sound signals and interactive services - Part 2-1: Electromagnetic compatibility measurements

To be completed

Kabelnetze für Fernsehsignale, Tonsignale und interaktive Dienste - Teil 2-1: Messungen der elektromagnetischen Verträglichkeit

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

**CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels**



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# Foreword

This document (CLC/TR 50083-2-1:2014) has been prepared by CLC/TC 209 "Cable networks for television signals, sound signals and interactive services".

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

# 1 Scope

## 1.1 General

Standards and deliverables of EN 60728 series deal with cable networks including equipment and associated methods of measurement for headend reception, processing and distribution of television and sound signals and for processing, interfacing and transmitting all kinds of data signals for interactive services using all applicable transmission media. These signals are typically transmitted in networks by frequency-multiplexing techniques.

This includes for instance

- regional and local broadband cable networks,
- extended satellite and terrestrial television distribution systems,
- individual satellite and terrestrial television receiving systems,

and all kinds of equipment, systems and installations used in such cable networks, distribution and receiving systems.

The extent of this standardization work is from the antennas and/or special signal source inputs to the headend or other interface points to the network up to the terminal input of the customer premises equipment.

The standardization work will consider coexistence with users of the RF spectrum in wired and wireless transmission systems.

The standardization of any user terminals (i.e. tuners, receivers, decoders, multimedia terminals etc.) as well as of any coaxial, balanced and optical cables and accessories thereof is excluded.

## 1.2 Specific scope of CLC/TR 50083-2-1

This Technical Report describes EMC measurements using specific measuring apparatus or alternative methods of measurement (e.g. spectrum analyser) and applies to the radiation characteristics of EM-active equipment (active and passive equipment) for the reception, processing and distribution of television, sound and interactive multimedia signals as dealt with in the following parts of EN 50083 or EN 60728 series:

- EN 60728-3 "Active wideband equipment for coaxial cable networks";
- EN 60728-4 "Passive wideband equipment for coaxial cable networks";
- EN 60728-5 "Headend equipment";
- EN 60728-6 "Optical equipment";

and covers the following frequency ranges:

- 150 kHz to 30 MHz;
- 30 MHz to 1 GHz.

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-161, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

EN 55016-1-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus (CISPR 16-1-1)*

ISO/IEC Guide 99:2007, *International vocabulary of metrology - Basic and general concepts and associated terms (VIM)*

## 3 Term, definitions, symbols and abbreviations

### 3.1 Terms and definitions

For the purpose of this document, the following terms and definitions apply. Also see IEC 60050-161 and the ISO/IEC Guide 99:2007.

**3.1.1**
**bandwidth**
$B_n$
the width of the overall selectivity curve of the receiver between two points at a stated attenuation below the midband response. The bandwidth is represented by the symbol $B_n$, where n is the stated attenuation in decibels

**3.1.2**
**CATV network**
originally defined as Community Antenna Television network; now covering regional and local broadband cable networks designed to provide sound and television signals as well as signals for interactive services to a regional or local area

**3.1.3**
**CISPR indicating range**
it is the range specified by the manufacturer which gives the maximum and the minimum meter indications within which the receiver meets the requirements of this section of CISPR 16

**3.1.4**
**electrical charge time constant**
$T_C$
the time needed after the instantaneous application of a constant sine-wave voltage to the stage immediately preceding the input of the detector for the output voltage of the detector to reach 63 % of its final value

Note 1 to entry: This time constant is determined as follows: A sine-wave signal of constant amplitude and having a frequency equal to the mid-band frequency of the IF amplifier is applied to the input of the stage immediately preceding the detector. The indication, *D*, of an instrument having no inertia (e.g., a cathode-ray oscilloscope) connected to a terminal in the DC amplifier circuit so as not to affect the behaviour of the detector, is noted. The level of the signal is chosen such that the response of the stages concerned remains within the linear operating range. A sine wave signal of this level, applied for a limited time only and having a wave train of rectangular envelope is gated such that the deflection registered is 0,63 *D*. The duration of this signal is equal to the charge time of the detector.

**3.1.5**
**electrical discharge time constant**
***T*D**
the time needed after the instantaneous removal of a constant sine-wave voltage applied to the stage immediately preceding the input of the detector for the output of the detector to fall to 37 % of its initial value

Note 1 to entry: The method of measurement is analogous to that for the charge time constant, but instead of a signal being applied for a limited time, the signal is interrupted for a definite time. The time taken for the deflection to fall to 0,37 *D* is the discharge time constant of the detector.

**3.1.6**
**electromagnetic-active equipment**
all passive and active equipment carrying RF signals are considered as electromagnetic-active equipment because they are liable to cause electromagnetic disturbances or the performance of them is liable to be affected by such disturbances

**3.1.7**
**extended satellite television distribution network or system**
distribution network or system designed to provide sound and television signals received by satellite receiving antenna to households in one or more buildings

Note 1 to entry: This kind of network or system could be eventually combined with terrestrial antennas for the additional reception of TV and/or radio signals via terrestrial networks.

Note 2 to entry: This kind of network or system could also carry control signals for satellite switched systems or other signals for special transmission systems (e.g. MoCA or WiFi) in the return path direction.

**3.1.8**
**extended terrestrial television distribution network or system**
distribution network or system designed to provide sound and television signals received by terrestrial receiving antenna to households in one or more buildings

Note 1 to entry: This kind of network or system could be eventually combined with a satellite antenna for the additional reception of TV and/or radio signals via satellite networks.

Note 2 to entry: This kind of network or system could also carry other signals for special transmission systems (e.g. MoCA or WiFi) in the return path direction.

**3.1.9**
**impulse bandwidth**
$\boldsymbol{B_{\mathrm{imp}}}$

$$B_{\mathrm{imp}} = A(t)_{\max} \;/\; (2G_o \times IS)$$

where

$A(t)_{\max}$ is the peak of the envelope at the IF output of the receiver with an impulse area *IS* applied at the receiver input;

$G_o$ is the gain of the circuit at the centre frequency.

Specifically for two critically-coupled tuned transformers,

$$B_{\mathrm{imp}} = 1{,}05 \times B_6 = 1{,}31 \times B_3$$

where

$B_6$ and $B_3$ are respectively the bandwidths at the –6 dB and –3 dB points.

**3.1.10**
**impulse area**
**IS**
the impulse area (sometimes called impulse strength, *IS*) is the voltage-time area of a pulse defined by the integral:

$$IS = \int_{-\infty}^{+\infty} V(t)\,\mathrm{d}t \qquad \text{(expressed in µVs or dB(µVs))}$$

Note 1 to entry: Spectral density ($\delta$) is related to impulse area and expressed in µV/MHz or dB(µV/MHz). For rectangular impulses of pulse duration $T$ at frequencies $f \ll 1/T$, the relationship $\delta$ (µV/MHz) = 2 $10^6$ *IS* (µVs) applies.

**3.1.11**
**individual satellite television receiving system**
system designed to provide sound and television signals received from satellite(s) to an individual household

Note 1 to entry: This kind of system could also carry control signals for satellite switched systems or other signals for special transmission systems (e.g. MoCA or WiFi) in the return path direction.

**3.1.12**
**individual terrestrial television receiving system**
system designed to provide sound and television signals received via terrestrial broadcast networks to an individual household

Note 1 to entry: This kind of system could also carry other signals for special transmission systems (e.g. MoCA or WiFi) in the return path direction.

**3.1.13**
**local broadband cable network**
network designed to provide sound and television signals as well as signals for interactive services to a local area (e.g. one town or one village)

**3.1.14**
**MATV network**
originally defined as Master Antenna Television network; now covering extended terrestrial television distribution networks or systems designed to provide sound and television signals received by terrestrial receiving antenna to households in one or more buildings

Note 1 to entry: This kind of network or system could be eventually combined with a satellite antenna for the additional reception of TV and/or radio signals via satellite networks.

Note 2 to entry: This kind of network or system could also carry other signals for special transmission systems (e.g. MoCA or WiFi) in the return path direction.

**3.1.15**
**mechanical time constant of a critically damped indicating instrument**
***$T_M$***

$$T_\mathrm{M} = T_\mathrm{L} \;/\; 2\pi$$

where:

$T_L$ is the period of free oscillation of the instrument with all damping removed.

Note 1 to entry: For a critically damped instrument, the equation of motion of the system may be written as:

$$T_\mathrm{M}{}^2\left(\mathrm{d}^2\alpha \,/\, \mathrm{d}t^2\right) + 2T_\mathrm{M}\left(\mathrm{d}\alpha \,/\, \mathrm{d}t\right) + \alpha = \mathrm{k}i$$

where:

$\alpha$ is the deflection;

$i$ is the current through the instrument;

k is a constant.

It can be deduced from this relationship that the time constant is also equal to the duration of a rectangular pulse (of constant amplitude) that produces a deflection equal to 35 % of the steady deflection produced by a continuous current having the same amplitude as that of the rectangular pulse.

Note 2 to entry: The methods of measurement and adjustment are deduced from one of the following:

a) The period of free oscillation having been adjusted to $2\pi T_M$, damping is added so that $\alpha T = 0,35\alpha_{max}$.

b) When the period of oscillation cannot be measured, the damping is adjusted to be just below critical such that the over swing is not greater than 5 % and the moment of inertia of the movement is such that $\alpha T = 0,35\alpha_{max}$.

**3.1.16**
**overload factor**
the ratio of the level that corresponds to the range of practical linear function of a circuit (or a group of circuits) to the level that corresponds to full-scale deflection of the indicating instrument. The maximum level at which the steady-state response of a circuit (or group of circuits) does not depart by more than 1 dB from ideal linearity defines the range of practical linear function of the circuit (or group of circuits)

**3.1.17**
**regional broadband cable network**
network designed to provide sound and television signals as well as signals for interactive services to a regional area covering several towns and/or villages

**3.1.18**
**SMATV network**
originally defined as Satellite Master Antenna Television network; now covering extended distribution networks or systems designed to provide sound and television signals received by satellite receiving antenna to households in one or more buildings

Note 1 to entry: This kind of network or system could be eventually combined with terrestrial antennas for the additional reception of TV and/or radio signals via terrestrial networks.

Note 2 to entry: This kind of network or system could also carry control signals for satellite switched systems or other signals for special transmission systems (e.g. MoCA or WiFi) in the return path direction

**3.1.19**
**symmetric voltage**
in a two-wire circuit, such as a single-phase mains supply, the symmetric voltage is the radiofrequency disturbance voltage appearing between the two wires. This is sometimes called the differential mode voltage. If $V_a$ is the vector voltage between one of the mains terminals and earth and $V_b$ is the vector voltage between the other mains terminal and earth, the symmetric voltage is the vector difference ($V_a$-$V_b$)

**3.1.20**
**weighting (of e.g. impulsive disturbance)**
the pulse-repetition-frequency (PRF) dependent conversion (mainly a reduction) of a peak detected impulse voltage level to an indication that corresponds to the interference effect on radio reception:

– for an analogue receiver, the psychophysical annoyance of the interference is a subjective quantity (audible or visual);

– for a digital receiver, the interference effect is an objective quantity that may be defined by the critical bit error ratio (BER) (or bit error probability (BEP)) for which perfect error correction can still occur or by another, objective and reproducible parameter

**3.1.21**
**weighting characteristic**
the peak voltage level as a function of PRF for a constant effect on a specific radio communication system, i.e., the disturbance is weighted by the radio communication system itself

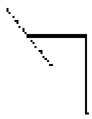
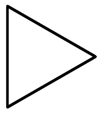
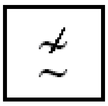
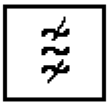
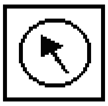
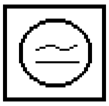
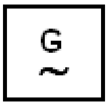
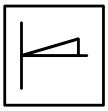
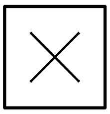
**3.1.22**
**weighting function or weighting curve**
the relationship between input peak voltage level and PRF for constant level indication of a measuring receiver with a weighting detector, i.e. the curve of response of a measuring receiver to repeated pulses

**3.1.23**
**weighting factor**
the value in dB of the weighting function relative to a reference PRF or relative to the peak value

**3.1.24**
**weighting detector**
detector which provides an agreed weighting function

**3.1.25**
**weighted disturbance measurement**
measurement of disturbance using a weighting detector

## 3.2 Symbols

| Graphical Symbol | Reference number and Title | Graphical Symbol | Reference number and Title |
|---|---|---|---|
|  | Receiving antenna |  | Amplifier [S01239] |
|  | IEC 60617 (SO1248) Low pass filter |  | Band-pass filter (BPF) [S01249] |
|  | level meter |  | Display unit |
|  | IEC 60617 (SO1226) Sinusoidal signal generator |  | Sweep signal generator |
|  | Detector |  | Mixer |

### 3.3 Abbreviations

| | |
|---|---|
| **AM** | amplitude modulation |
| **BER** | bit error ratio |
| **CATV** | Community Antenna Television (network) |
| **DC** | direct current |
| **DOCSIS** | Data Over Cable Service Interface Specification |
| **EMC** | electromagnetic compatibility |
| **EMI** | electromagnetic interference |
| **EuroDOCSIS** | European Data Over Cable Service Interface Specification |
| **EUT** | equipment under test |
| **FM** | frequency modulation |
| **IF** | intermediate frequency |
| **LISN** | line impedance stabilisation network |
| **LO** | local oscillator |
| **LPF** | low lass filter |
| **MoCA** | Multimedia over Cable Alliance |
| **OTA** | over the air |
| **RBW** | resolution bandwidth |
| **PRF** | pulse repetition frequency |
| **RF** | radio frequency |
| **TDMA** | time division multiple access |
| **TV** | television |
| **VBW** | video bandwidth |
| **WiFi** | Synonym of WLAN |

## 4 Considerations on EMC measurements

### 4.1 General

EMC measurements below 1 GHz are specified using measuring receivers, defined in EN 55016-1-1, of bandwidth 9 kHz or 120 kHz and quasi-peak or average detectors. However, the non-availability of such equipment outside of the laboratory means that alternative methods of measurement (e.g. spectrum analyser) are often used for assessment of EMC problems. This document provides guidance on the properties of alternative detectors and the correction factors which are applied to provide equivalent values to those obtained with the quasi-peak detector.

It is emphasised that these alternative detectors, with correction factors, are used only for indicative, qualitative, measurements and are not a substitute for the specified quasi-peak method.

The quasi-peak detector is intended to provide a measured value that reflects the sensitivity of human ear or eye to the pulse repetition frequencies of the impulsive noise, e.g. due to spark engine or electrical motors, when running at low repetition frequencies, ranging from frequencies lower than 1 Hz up to 10 kHz; beyond a repetition frequency of 10 kHz there is no reduction with respect to the peak detector.

Analogue AM modulation is still used in aeronautical radio communications, in some police communication systems, in the 2 m band and in many broadcasting and communication systems. As digitization of aeronautical communications, HF radio amateur, HF broadcast and VHF mobile is still an ongoing process, the quasi-peak detector is and will remain relevant for assessing radiation effects from CATV systems into narrow band radio systems.

In the case of broadband interference (no single carrier interference) the radiation level is measured with a receiver having a quasi-peak detector and measuring bandwidths (according to CISPR 16-1). For single carrier measurements other receivers can also be used.

## 4.2 General EMC measurement considerations

EMC measurements require the use of measuring apparatus (e.g. measuring receivers or spectrum analysers) provided with suitable detectors of the disturbance signals produced by the equipment under test (EUT) in order to obtain a value that is related to the annoying effect produced.

The disturbance signals can be radiated emissions or conducted emissions.

A measuring receiver able to measure the disturbance signals has the structure indicated in Figure 1.

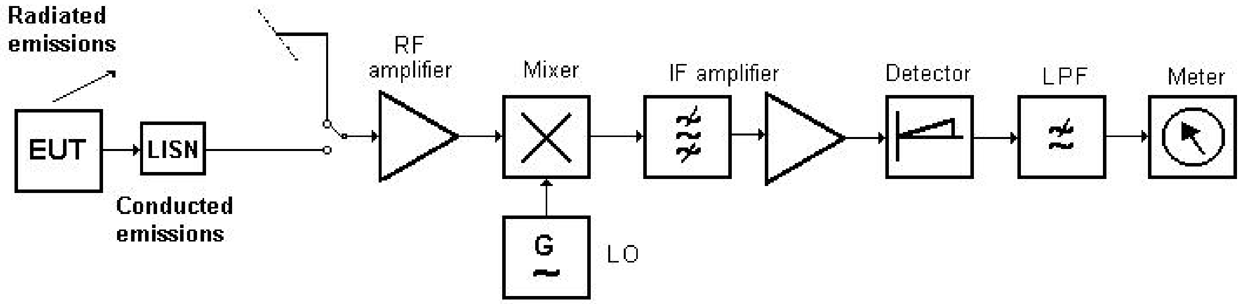



**Figure 1 – Radiated and conducted emissions measurement using a measuring receiver**

A spectrum analyser able to measure the disturbance signals has the structure indicated in Figure 2.

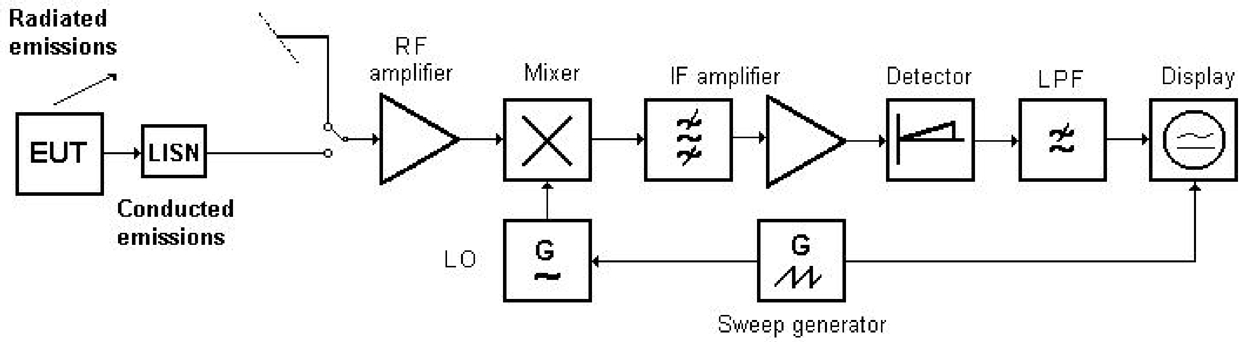



**Figure 2 – Radiated and conducted emissions measurement using a spectrum analyser**

The radiated emission signals from the EUT can be applied to the measuring apparatus using a suitable receiving antenna with a known antenna coefficient (see Annex A). The conducted emission signals from the mains cable of the EUT are applied to the measuring apparatus by means of an appropriate coupling unit (LISN) (see Annex B).

In the measuring apparatus, the signal to be measured is applied to the RF amplifier, mixed with the LO signal and converted into an IF signal where a band-pass filter limits its spectrum. Then the amplitude of the IF signal is detected, filtered and measured by an indicating meter (measuring receiver) or sent to a display unit (CRT or LCD display) where the level is indicated and evaluated.

A spectrum analyser with specific detectors for EMC measurements is called EMC analyser.

When only a generic spectrum analyser, with envelope (peak or average) detector, is available, the assessment of the effect of spurious emissions from the EUT requires the knowledge of appropriate correction factors to convert the measurements into specific IF bandwidth filtering and quasi-peak detecting.

The following description of the behaviour of the various types of detectors associated with IF and post-detection filtering, allows an understanding of the application of such correction factors.

### 4.3 Envelope (peak) detection mode

Initial EMC measurements are usually made using the envelope detector that allows determination of the peak of the signal. This mode is much faster than quasi-peak, or average modes of detection. Signals are normally displayed on spectrum analysers or EMC analysers in peak mode.

NOTE Since signals measured in peak detection mode always have amplitude values equal to or higher than quasi-peak or average detection modes, it is a very easy process to take a sweep and compare the results to a limit line. If all signals fall below the limit, then the product passes and no further testing is needed.

The envelope detector has a time constant such that the output voltage follows the peak value of the IF signal at all times. This means that the detector can follow the fastest possible changes in the envelope of the IF signal, but not the instantaneous value of the IF frequency waveform, as shown in Figure 3.

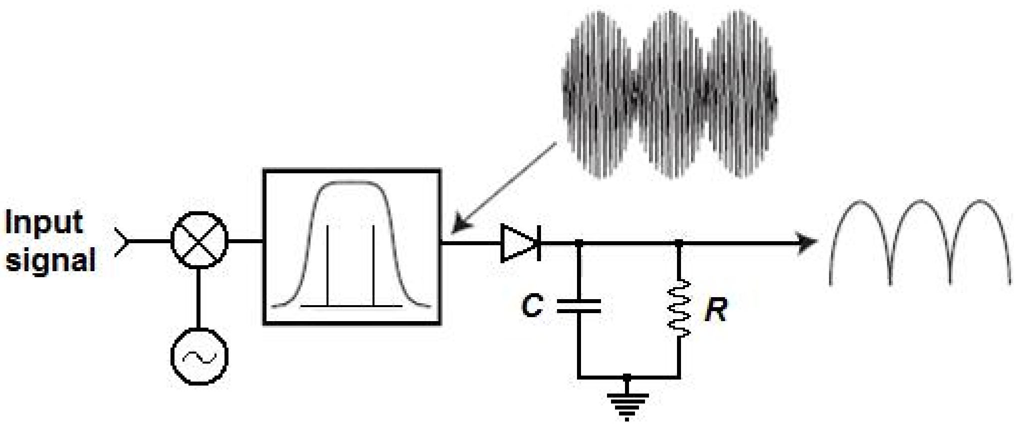



**Figure 3 – Example of the output signal from an envelope detector with two carriers within the IF filter bandwidth**

### 4.4 Quasi-peak detection mode

Most radiated and conducted limits are based on quasi-peak detection mode. Quasi-peak detectors weigh signals according to their repetition rate, which is a way of measuring their annoyance factor. As the repetition rate increases, the quasi-peak detector does not have time to discharge sufficiently, resulting in a higher voltage output, as shown in Figure 4. For continuous wave (CW) signals, peak and quasi-peak detectors give the same reading. For modulated signals, quasi-peak detectors always give a reading less than or equal to peak detectors, but quasi-peak measurements are much slower by two or three orders of magnitude compared to a peak detector.

The quasi-peak detector has a charge rate much faster than the discharge rate; the higher the repetition rate of the signal, the higher the output of the quasi-peak detector. The quasi-peak detector also responds to different amplitude signals in a linear fashion. High-amplitude, low-repetition-rate signals could produce the same output as low-amplitude, high-repetition-rate signals.

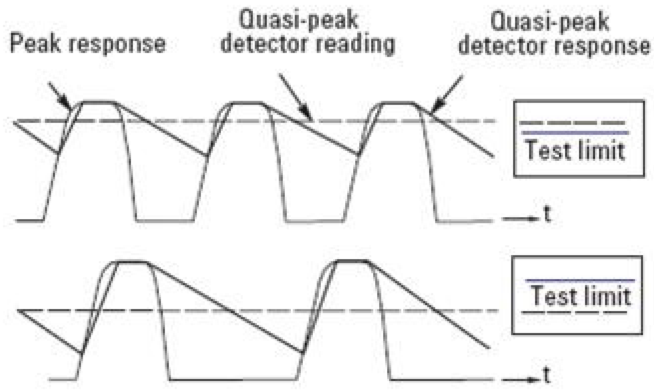



**Figure 4 – The quasi-peak detector output depends on impulse repetition frequency**

## 4.5 Average detection mode

The average detector is required for some conducted emissions tests in conjunction with using the quasi-peak detector. Also, radiated emissions measurements above 1 GHz are performed using average detection. The average detector output is always less than or equal to peak detection.

Average detection is similar in many respects to peak detection. Figure 5 shows a signal that has just passed through the IF and is about to be detected. The output of the envelope detector is the modulation envelope. Peak detection occurs when the post detection low-pass filter video bandwidth (VBW) is wider than the resolution bandwidth (RBW). For average detection to take place, the peak-detected signal must pass through a low-pass filter whose bandwidth is much less than the resolution bandwidth. The filter averages the higher frequency components, such as noise at the output of the envelope detector.

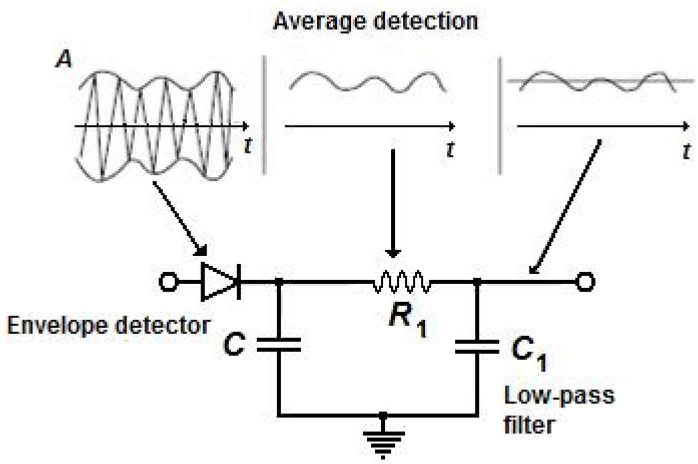



**Figure 5 – Average detection mode where the envelope detector signal output is filtered with a low-pass filter of bandwidth much less than RBW of IF filter**

# 5 EMC measurement apparatus

## 5.1 Measuring receiver

### 5.1.1 General

The measuring receiver is defined by the following main characteristics:

a) bandwidth of the selective amplifier before the detector

b) type of detector used:

- *envelope detector*, when the output voltage follows the envelope of the applied IF signal,

- *peak detector*, when the output voltage reaches the peak of the envelope of the applied IF signal,

- *quasi-peak detector*, when the output voltage reaches a value that is between the average value and the peak of the envelope of the applied IF signal,

c) mechanical time constant $T_M$ of the indicating meter.

The basic detector is shown in Figure 6 and its type depends on the charge time $T_C$ and discharge time $T_D$ of the capacity $C$:

$T_C = R_C C$, where $R_C$ includes the value of the diode forward resistance.

$T_D = R_D C$.

Usually $T_C$ is very short and $T_D$ depends on the type of detector.

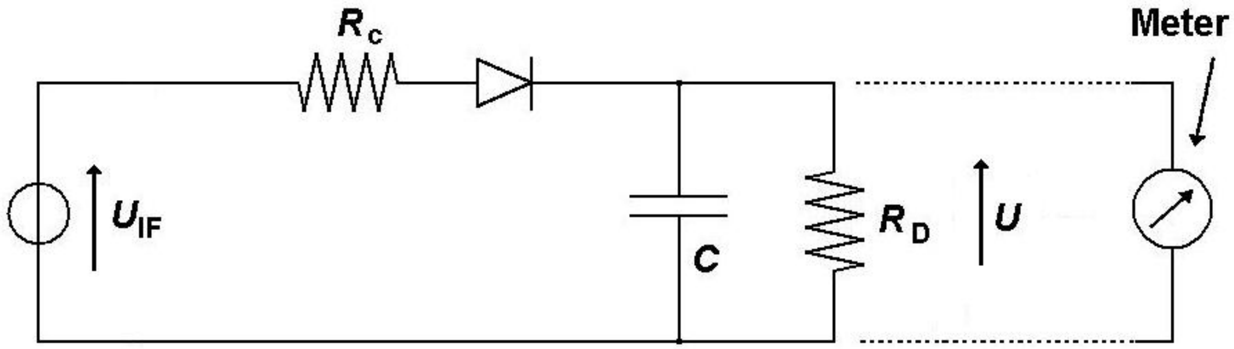



**Figure 6 – Electrical circuit of a measuring receiver detector**

### 5.1.2 The envelope detector

For the envelope detector, a high $T_D$ value is selected with respect to the period of the IF frequency signal and low with respect to the period of the maximum modulating frequency in order to follow the envelope of the IF signal. The resulting baseband output signal is measured by a voltage meter that indicates the average value.

### 5.1.3 The peak detector

For the peak detector, a high $T_D$ value is selected with respect to the period of the IF frequency signal and also high with respect to the period of the minimum modulating frequency (e.g. $T_D$ = 0,1 s or 1 s) in order to reach the peak of the envelope. The resulting baseband output signal is measured by a voltage meter that indicates the peak value.

### 5.1.4 The quasi-peak detector

For the quasi-peak detector, $T_C$ and $T_D$ values are defined as shown in Table 1 and take into account that the diode detects the signal delivered at the output of the IF filter having a bandwidth of 9 kHz or 120 kHz. The IF bandwidth of 9 kHz is used for measurements in the 0,15 MHz to 30 MHz frequency range and the IF bandwidth of 120 kHz is used for measurements in the 30 MHz to 1 000 MHz frequency range.

The resulting baseband output signal is measured by a voltage meter having a time constant of 160 ms or 100 ms, set according to the IF filter bandwidth. The meter indicates the quasi-peak value.

**Table 1 – Time constants for quasi-peak detector**

| **Frequency range** | **0,15 MHz to 30 MHz** | **30 MHz to 1 000 MHz** |
|---|---|---|
| **IF filter bandwidth** | **9 kHz** | **120 kHz** |
| **Charge time $T_C$** | 1 ms | 1 ms |
| **Discharge time $T_D$** | 160 ms | 550 ms |
| **Meter time constant $T_m$** | 160 ms | 100 ms |

## 5.2 EMC analyser

The EMC analyser is a spectrum analyser defined by the following main characteristics:

a) bandwidth of the selective amplifier (IF amplifier) before the detector (RSW: Resolution Bandwidth)

b) type of detector used:

– *envelope detector*, when the output voltage follows the envelope of the applied IF signal,

– *peak detector*, when the output voltage reaches the peak of the envelope of the applied IF signal,

– *quasi-peak detector*, when the output voltage reaches a value that is between the average value and the peak of the envelope of the applied IF signal,

c) bandwidth of the amplifier after the detector (VBW: Video Bandwidth).

The RSW of a generic spectrum analyser can only be set at predetermined values (e.g. 10 kHz, 100 kHz, 1 MHz, 10 MHz) and this will subsequently require correction factors for bandwidth. EMC analysers have the possibility to set a RBW of 9 kHz or 120 kHz and, therefore, give correct values as with the measuring receiver.

The resulting baseband output signal is filtered by a low-pass video bandwidth filter (VBW) and the average value is displayed within a frequency span range. The rate of the sweep frequency span (scan time) fulfils the following value:

$$\Delta t \geq 5 \frac{\Delta f}{B_6^2}$$

where:

$\Delta t$ is the scan time, in s

$\Delta f$ is the sweep width, in Hz

$B_6$ is the IF bandwidth at -6 dB, in Hz.

Example: If $B_6$ = 14,1 kHz and $\Delta f$ = 100 kHz, the scan time $\Delta t$ is selected to be higher than 2,5 ms.

When measuring white noise, the video filter bandwidth (VBW) setting is selected to be 100 times lower than the RSW, in order to obtain a smooth response.

When measuring impulse noise, the video filter bandwidth (VBW) setting is selected to be 10 times higher than the RBW to allow the impulse peak to be displayed and measured.

## 5.3 Response of the measuring receiver (or EMC analyser) to disturbing signals

### 5.3.1 Sinusoidal signals

When the disturbing signal has a sinusoidal waveform and the bandwidth of the IF filter is sufficient to allow the disturbing sinusoidal signal to pass-through the IF filter (amplitude modulated disturbances of some kilohertz for frequencies below 30 MHz and of about 100 kHz to 200 kHz for frequencies above 30 MHz), the waveform is indicated in Figure 7.

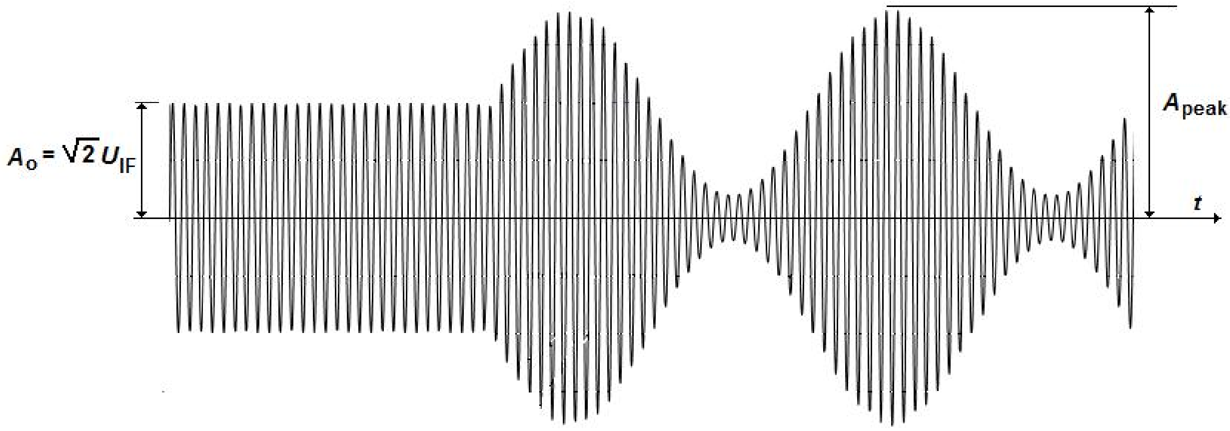



**Figure 7 – Amplitude modulated waveform at the detector input**

When the IF signal is not modulated, all types of detector give the same value that corresponds to the peak $A_o$ of the IF carrier signal

When the IF signal is modulated, the detectors have the following behaviour:

a) the *envelope detector* provides an output voltage that follows the envelope of the applied IF signal with an average value $A_o$,

b) the *peak detector*, provides an output voltage that corresponds to the maximum of the envelope of the applied IF signal with a peak value $A_{peak}$

c) the *quasi-peak detector* provides an output voltage that does not accurately follow the envelope of the applied IF signal since the discharge time constant is too large with respect to the modulating signal: the value is between $A_{peak}$ and $A_o$.

The meter that indicates the measured voltage has a mechanical time constant that does not allow it to follow the waveform variation (unless at very low frequencies) and therefore indicates the mean value of the voltage provided by the detector.

The indicated value is given in terms of the RMS value of a sinusoidal signal. Therefore the indicated value is $U_{peak} = A_{peak}/\sqrt{2}$.

In Table 2 the meter readings for the various types of detectors are summarized.

**Table 2 – Meter readings with various types of detectors**

| Type of detector | Non modulated signal | Modulated signal |
|---|---|---|
| **Envelope** | $U_{IF}$ | $U_{IF}$ |
| **Peak** | $U_{IF}$ | $U_{peak}$ |
| **Quasi-peak** | $U_{IF}$ | $U_{IF} < U < U_{peak}$ |

### 5.3.2 Analogue television signals

An important case is the measurement of an analogue television signal (systems B/G PAL) where negative modulation is used as indicated in Figure 8. The value of the TV signal is given in terms of the RMS value of the carrier during the synchronising pulses, where the amplitude is $A_{peak}$. Therefore, for measuring a television signal, the peak detector is advised.

A quasi-peak detector can also be used since the pulse spacing is 64 µs giving a value very close to $A_{peak}$

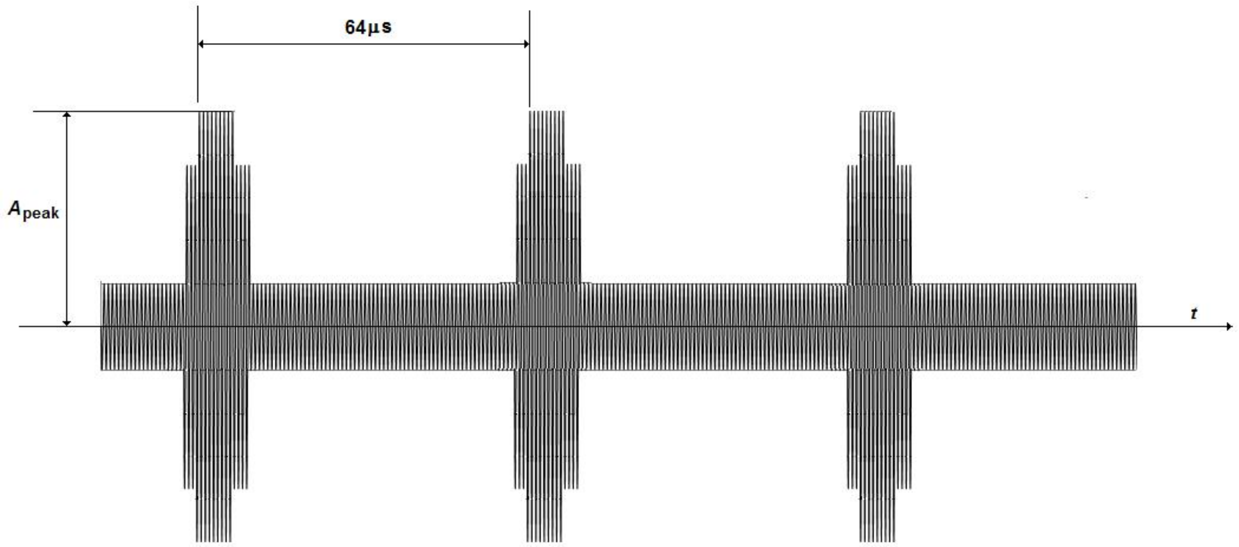



**Figure 8 – Analogue television signal modulated waveform**

### 5.3.3 Impulse disturbance signals

#### 5.3.3.1 General

When considering impulse disturbance signals, the measuring receiver displays two different characteristics depending on the repetition frequency of the pulses relative to the receiver bandwidth.

If the repetition frequency $F$ of pulses is higher than the bandwidth of the measuring receiver, each of the pulse spectrum lines can be tuned separately and their amplitude measured. This case (*narrow band*) allows the measurement of each line of the spectrum separately. The reading of the measuring receiver is the RMS value of each spectrum line. This corresponds to the measurement of a non modulated carrier signal, as described previously.

If the repetition frequency $F$ of pulses is much lower than the bandwidth of the measuring receiver, the pulse spectrum lines are very close and cannot be separated and are, therefore, aggregated by the receiver.

In this case, (*wide band*) the measuring receiver provides the envelope of the disturbance. The reading of the measuring receiver can be approximated by the response to a unitary pulse, whose spectrum is very wide (-∞ to +∞) and constant in amplitude.

This assumption is also valid if the repetition frequency of pulses is so low that the response to each pulse can be considered independent ($F < 0,3\ B_{imp}$) and its area is not 1 but $A$ (V·s). In this case, the peak value (*peak detector*) is given by:

$$U_{peak} = \sqrt{2}\, A\, B_{imp}$$

where $B_{imp}$ is the impulse bandwidth of the measuring receiver.

The value of $U_{\text{quasi-peak}}$ (*quasi-peak detector*) with respect to the $U_{\text{peak}}$ (*peak detector*) depends on the pulse area *A* (V·s) and pulse repetition frequency (PRF).

For calibration purposes, the response of the measuring receiver to test pulses (Table 3) of impulse area of a) µVs (microvolt second) e.m.f. at 50 Ω source impedance, having a uniform spectrum up to at least b) MHz, repeated at a frequency of c) Hz shall, for all frequencies of tuning, be equal to the response to an unmodulated sine-wave signal at the tuned frequency having an e.m.f. of RMS value 2 mV (66 dB(µV)). Both source impedances of the pulse generator and the signal generator are selected to be the same. A tolerance of ±1,5 dB is permitted on the voltage level of the sine-wave.

**Table 3 – Test pulse characteristics for quasi-peak measuring receivers**

| Frequency range | a) µVs | b) MHz | c) Hz |
|---|---|---|---|
| **9 kHz to 150 kHz** | 13,5 | 0,15 | 25 |
| **0,15 MHz to 30 MHz** | 0,316 | 30 | 100 |
| **30 MHz to 300 MHz** | 0,044 | 300 | 100 |
| **300 MHz to 1 000 MHz** | 0,044 | 1 000 | 100 |

The response of the measuring receiver to repeated pulses is such that, for a constant indication on the measuring receiver, the relationship between amplitude and repetition frequency is in accordance with Figure 9.

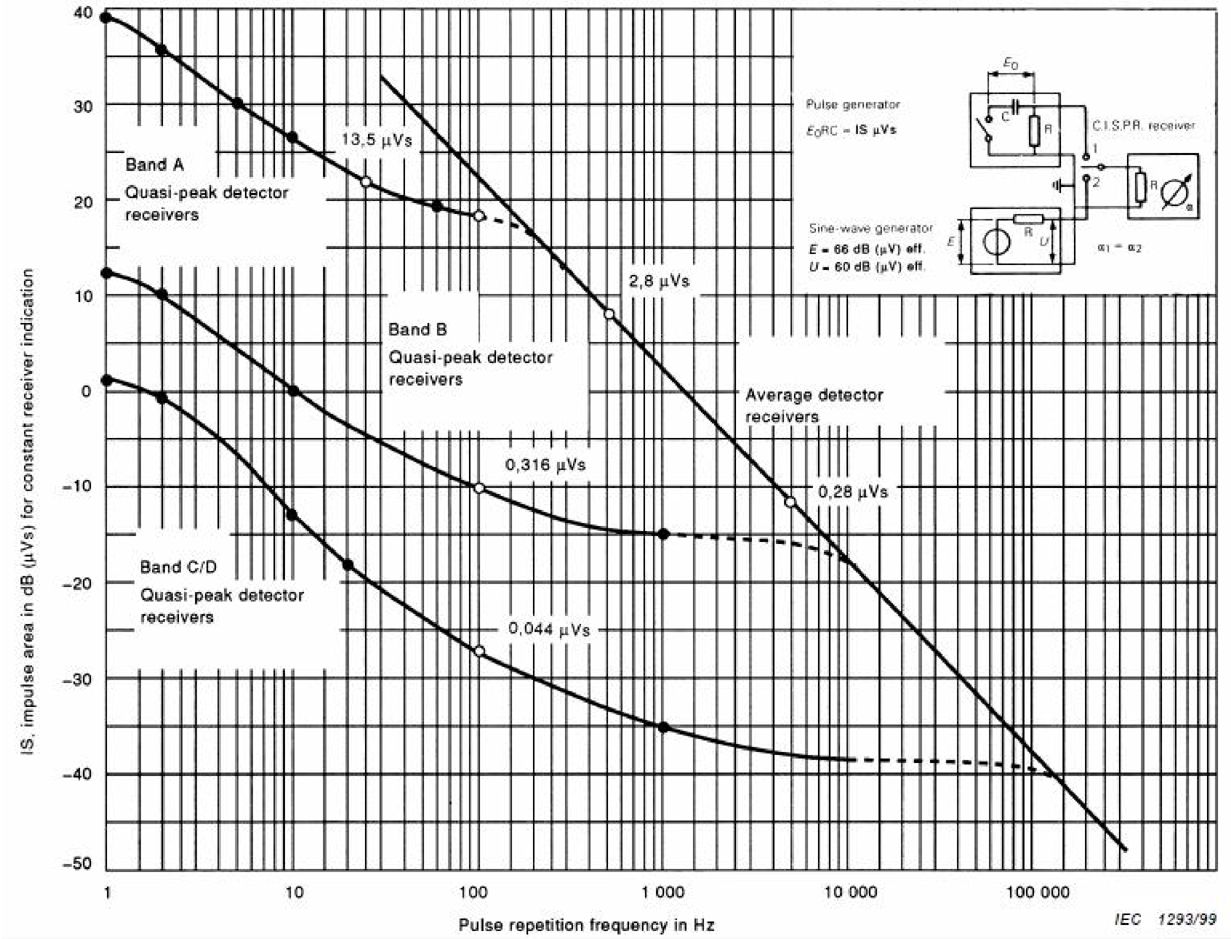



**Figure 9 – Pulse response curve of quasi-peak detector receivers to different pulse repetition frequencies (PRF)**

#### 5.3.3.2 Relationship between indication of average and quasi-peak measuring receiver

At a repetition rate of *n* (Hz), the value of impulse area (vτ) required to produce a response on an average measuring receiver equivalent to the response to an unmodulated sine-wave signal at the tuned frequency of RMS value 2 mV from a signal generator having the same output impedance as the pulse generator is:

$$(v\tau)_{ave} = 1{,}4/n \text{ (mVs)}$$

where v and τ are the amplitude and duration of a rectangular pulse for which $B_{imp}\,\tau << 1$.

At a repetition rate of 100 Hz, this is 14 µVs.

For the quasi-peak receiver, the value of pulse $(v\tau)_{qp}$ which is equivalent to a sine-wave signal of 2 mV is as follows (for a repetition rate of 100 Hz):

- for the frequency range 0,15 MHz to 30 MHz:

$$(v\tau)_{qp} = 0{,}316 \text{ µVs}$$

- for the frequency range 30 MHz to 1 000 MHz:

$$(v\tau)_{qp} = 0{,}044 \text{ µVs}$$

Therefore, the ratio of $(v\tau)_{ave}$ to $(v\tau)_{qp}$ to produce the same indication will be:

- for the frequency range 0,15 MHz to 30 MHz:

$$20 \lg [(v\tau)_{ave}/(v\tau)_{qp}] = 32{,}9 \text{ dB.}$$

- for the frequency range 30 MHz to 1 000 MHz:

$$20 \lg [(v\tau)_{ave}/(v\tau)_{qp}] = 50{,}1 \text{ dB.}$$

The above assumes an adequate overload factor at the repetition rate used and that the bandwidths correspond respectively to those in Table 3. At a repetition rate of 1 000 Hz, the corresponding ratios will be 17,4 dB and 38,1 dB.

#### 5.3.3.3 Relationship between indication of RMS meter and quasi-peak meter

The amplitude relationship for a RMS meter which states the value of pulse $(v\tau)_{RMS}$ at 100 Hz, which is equivalent to a sine-wave signal of 2 mV is:

$$(v\tau)_{RMS} = 155 / \sqrt{B_6} \text{ (µVs)}$$

where reference is made to the bandwidth at 6 dB.

For the quasi-peak receiver, the value of pulse $(v\tau)_{qp}$ which is equivalent to a sine-wave signal of 2 mV is as follows:

- for the frequency range 0,15 MHz to 30 MHz:

$$(v\tau)_{qp} = 0{,}316 \text{ µVs}$$

- for the frequency range 30 MHz to 1 000 MHz:

$$(v\tau)_{qp} = 0{,}044 \text{ µVs}$$

Thus for measuring receivers having a bandwidth at 6 dB equal to the nominal bandwidths prescribed above, the following relationships for $(v\tau)_{RMS}/(v\tau)_{qp}$ exist:

- for the frequency range 0,15 MHz to 30 MHz:

$$20 \lg [(v\tau)_{RMS}/(v\tau)_{qp}] = 14,3 \text{ dB}$$

- for the frequency range 30 MHz to 1 000 MHz:

$$20 \lg [(v\tau)_{RMS}/(v\tau)_{qp}] = 20,1 \text{ dB}$$

These relationships are valid for a pulse repetition frequency of 100 Hz. At other pulse repetition frequencies (PRF), the pulse response curves of Figure 9 is used.

The response of various types of detectors to impulse disturbance signals is summarised in Table 5.

**Table 4 – Response to impulse disturbance signals with various types of detectors**

| **Type of detector** | **CISPR Band B 0,15 MHz to 30 MHz** | | **CISPR Band C/D 30 MHz to 1GHz** | |
|---|---|---|---|---|
| | PRF | | PRF | |
| | **100 Hz** | **1 000 Hz** | **100 Hz** | **1 000 Hz** |
| **Envelope** | $20 \lg [(v\tau)_{ave}/(v\tau)_{qp}] =$ 32,9 dB | $20 \lg [(v\tau)_{ave}/(v\tau)_{qp}] =$ 17,4 dB | $20 \lg [(v\tau)_{ave}/(v\tau)_{qp}] =$ 50,1 dB | $20 \lg [(v\tau)_{ave}/(v\tau)_{qp}] =$ 38,1 dB |
| **RMS** | $20 \lg [(v\tau)_{RMS}/(v\tau)_{qp}] =$ 14,3 dB | see Figure 9 | $20 \lg [(v\tau)_{RMS}/(v\tau)_{qp}] =$ 20,1 dB | see Figure 9 |

### 5.3.4 Random impulse noise signals

When the impulse disturbance signals are random, but at a sufficiently low frequency that allows the impulse to be considered as single, they can be considered to follow a Gaussian law as used for thermal noise. If the noise spectrum can be considered constant (spectral density δ (V/√Hz)) within the measuring receiver bandwidth, the output signal $V_u$ is the RMS noise value

$$V_u = U_{rms} = \delta \cdot \sqrt{B_{rn}}$$

where $B_{rn}$ is the random noise bandwidth of the measuring receiver.

This bandwidth is related to the bandwidth $B_6$ (-6 dB bandwidth) by the formula:

$$B_{rn} = 0,833\ B_6$$

If the measuring receiver bandwidth is narrow with respect to the IF frequency, the amplitude *A* of the envelope follows the Rayleigh distribution given by $V_{u,}$ an IF frequency signal with amplitude and phase randomly variable and equivalent to two quadrature sinusoidal signals having both a random independent Gaussian amplitude (see Figure 10).

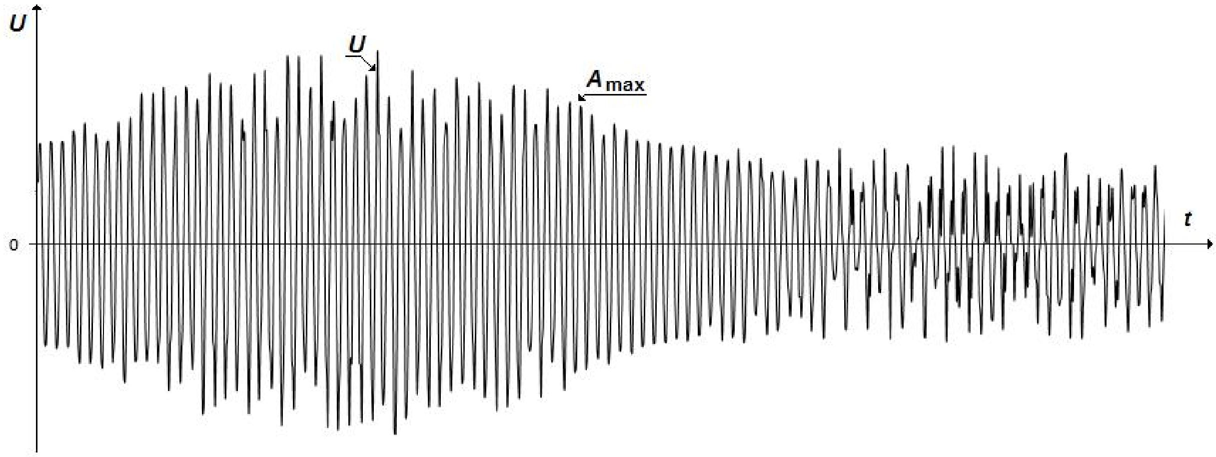



**Figure 10 – Random noise modulated waveform at the detector input**

The response of the *envelope detector* gives a value that is related to the $T_D/T_C$ ratio. This implies that the detector follows the envelope and the measuring instrument displays the average value:

$$V_{u(envelope)} = U_{average} = 0,886\ U_{RMS}$$

$$U_{average}\ (dB(\mu V)) = U_{RMS}\ (dB(\mu V)) – 1,05\ dB$$

The response of the *peak detector* can be evaluated taking into account that the dynamic range of the output voltage is limited and the $T_D/T_C$ ratio is very high ($10^6$):

$$V_{u(peak)} = U_{peak} = 3,1\ U_{RMS}$$

$$U_{peak}\ (dB(\mu V)) = U_{RMS}\ (dB(\mu V)) + 9,83\ dB$$

The response of the *quasi-peak detector* gives a value that is related to the $T_D/T_C$ ratio of the detector:

$U_{u(quasi\text{-}peak)} = 1,65\ U_{RMS}$ for $T_D/T_C = 160$ (Band 0,15 MHz to 30 MHz).

$U_{u(quasi\text{-}peak)} = 1,85\ U_{RMS}$ for $T_D/T_C = 550$ (Band 30 MHz to 1GHz)

Therefore:

$U_{quasi\text{-}peak}$ (dB(μV)) = $U_{RMS}$ (dB(μV)) + 4,35 dB (Band 0,15 MHz to 30 MHz) (CISPR Band B)

$U_{quasi\text{-}peak}$ (dB(μV)) = $U_{RMS}$ (dB(μV)) + 5,34 dB (Band 30 MHz to 1GHz) (CISPR Band C/D)

NOTE The values of 4,35 dB and 5,34 dB are a computational approximation of the actual value, which is in the order of 5 dB for the CISPR Band B and 6 dB for the Band C/D receivers.

The response of various types of detectors to random signals is summarised in Table 5.

**Table 5 – Response to random signals with various types of detectors**

| Type of detector | CISPR Band B 0,15 MHz to 30 MHz | | CISPR Band C/D 30 MHz to 1GHz | |
|---|---|---|---|---|
| **Envelope** | $U_{average} = 0{,}886\ U_{RMS}$ | $U_{average}$ (dB(μV)) = $U_{RMS}$ (dB(μV)) – 1,05 dB | $U_{average} = 0{,}886\ U_{RMS}$ | $U_{average}$ (dB(μV)) = $U_{RMS}$ (dB(μV)) – 1,05 dB |
| **Peak** | $U_{peak} = 3{,}1\ U_{RMS}$ | $U_{peak}$ (dB(μV)) = $U_{RMS}$ (dB(μV)) + 9,83 dB | $U_{peak} = 3{,}1\ U_{RMS}$ | $U_{peak}$ (dB(μV)) = $U_{RMS}$ (dB(μV)) + 9,83 dB |
| **Quasi-peak** | $V_{u(quasi\text{-}peak)} = 1{,}65\ U_{RMS}$ | $U_{quasi\text{-}peak}$ (dB(μV)) = $U_{RMS}$ (dB(μV)) + 4,35 dB | $V_{u(quasi\text{-}peak)} = 1{,}85\ U_{RMS}$ | $U_{quasi\text{-}peak}$ (dB(μV)) = $U_{RMS}$ (dB(μV)) + 5,34 dB |

### 5.4 Response of a spectrum analyser to disturbing signals

The spectrum analyser has a behaviour that is similar to the measuring receiver in the IF filtering and detection part. The measurement is displayed not by a mechanical indicating instrument, but on a CRT or LCD flat panel that has no discernable display time constant. The display gives the waveform of the detected signal and can be set to hold the maximum value.

If the spectrum analyser does not have specific EMI detectors but only an envelope detector showing the peak of pulses or the average value of random noise, correction factors for quasi-peak reading, taking into account the pulse repetition rate are used, as indicated above for the measuring receiver.

### 5.5 Correction factors for bandwidth and detectors

The effects of the bandwidth limitation of the measuring equipment and the quasi-peak detection can be considered as individual correction factors both for analogue (PAL) and digital (DVB) signals.

Thus, the bandwidth correction factors for PAL and for DVB are defined:

$$C_{PAL,BW} = 10 \lg (120 \text{ kHz} / BW_{PAL}) \text{ and } C_{DVB,BW} = 10 \lg (120 \text{ kHz} / BW_{DVB})$$

as well as quasi-peak to RMS power correction factors:

$$C_{PAL,QP/RMS} = 10 \lg (QP_{PAL} / RMS_{PAL}) \text{ and } C_{DVB,QP/RMS} = 10 \lg (QP_{DVB} / RMS_{DVB}).$$

## 6 Measurement of analogue TV modulated signals

### 6.1 General considerations

An analogue TV signal is mainly represented by its amplitude modulated video carrier (a sinusoidal signal) applied to the detector:

$$U_{IF} = E(t) \sin (\omega t + \phi)$$

which detects the peak of the carrier and produces a displayed value that is the RMS value of the carrier.

When measuring an **analogue TV signal**, the TV signal level is defined as the **RMS value of the carrier during the positive peak of the envelope**.

NOTE This definition means that the RMS value of a PAL signal is 3 dB lower than its peak (and quasi-peak) value.

For TV systems B/G PAL, the peak of the envelope is during the synchronising pulses, as indicated in Figure 8.

There is no possibility to distinguish between RMS, average, peak or quasi-peak, because the synchronising pulses are at 64 μs from each other and the response of all detectors gives the same reading.

The measuring apparatus (measuring receiver or spectrum analyser) is equipped with:

a) a detection system capable of attaining the peak of the AM carrier to be measured

b) facilities to adjust the detector characteristics for the measurement of AM and FM carriers;

c) a pass-band of at least 120 kHz, with sufficient selectivity to ensure that carriers other than those measured shall not influence the result.

### 6.2 Correction factors for bandwidth and detectors

The representation of an analogue TV signal (PAL) by its vision carrier is a sufficient approximation since almost the entire PAL signal power is concentrated around the vision-carrier frequency. As the frequency stability of the vision carrier signal is very high (≤ ± 5 kHz), almost the entire PAL signal power falls into a bandwidth smaller than 120 kHz. Therefore, no bandwidth correction has to be considered for an analogue TV signal (PAL), which leads to

$$C_{PAL,BW} \approx 0 \text{ dB}.$$

The (quasi) peak to RMS correction factor for a sinusoidal signal corresponds to $(\sqrt{2})^2$ and thus is about

$$C_{PAL,QP/RMS} = +3 \text{ dB}.$$

Example. If the radiated power of an analogue TV signal (PAL) (8 MHz channel) is 17 dB(pW) and is measured with a measuring apparatus having a bandwidth of 120 kHz and a quasi-peak detector, the result of measurement is:

$$P_{PAL,QP,120kHz} = P_{PAL,RMS,8MHz} + C_{PAL,QP/RMS} + C_{PAL,BW} = 17 \text{ dB(pW)} + 3 \text{ dB} + 0 \text{ dB} \approx 20 \text{ dB(pW)}.$$

## 7 Measurement of QAM modulated signals

### 7.1 Peak to average ratio

For QAM modulated signals (see Figure 11), the measured level depends on the type of detector used: peak or average. Assuming that all symbol states are occupied equally over time, then it is possible to calculate the peak-to-average symbol power and dynamic range of different formats of QAM modulated signals (Table 6).

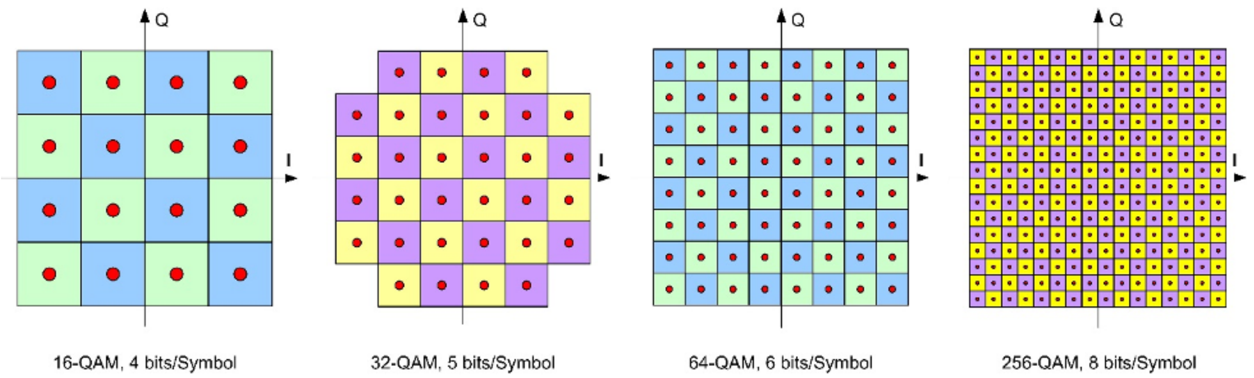



**Figure 11 – Example of I-Q diagram (constellation diagram) for QAM signals**

Note that this analysis considers only the basic signal without base-band filtering.

**Table 6 – Peak-to-average ratios for QAM modulated signals**

| QAM modulation format | Number of symbol Power levels | Peak-to-average ratio Symbol Power | | Dynamic range | | Percent of data in highest power level | Percent of data above average power level |
|---|---|---|---|---|---|---|---|
| | | Ratio | dB | Ratio | dB | | |
| **16 QAM** | 3 | 1,8:1 | 2,55 | 9:1 | 9,54 | 25,0% | 25% |
| **32 QAM**[(a)] | 5 | 1,7:1 | 2,30 | 17:1 | 12,31 | 25,0% | 50% |
| **64 QAM** | 9 | 2,3:1 | 3,68 | 49:1 | 16,90 | 6,3% | 50% |
| **256 QAM** | 32 | 2,7:1 | 4,23 | 225:1 | 23,52 | 4,6% | 45% |
| (a) The corners {+-5, +-5} of the square in the IQ plane (constellation diagram) are not used for 32QAM; the ratio is lower for 32QAM than for 16QAM. | | | | | | | |

Baseband filtering will introduce an additional peak power contribution in the form of compound amplitude ringing.

Digitally modulated signals require base-band filtering because of their theoretically infinite bandwidth, as defined by the function (sin x)/x. To limit a signal's bandwidth, the I-Q modulator signals must be filtered so that the digitally driven modulator does not have an "instantly" transition to the next symbol state. A digital transition causes an impulse response that has an infinite Fourier series. Convolution of this series with a bandwidth limiting function (filter) results in truncation of the series. Ringing (or Gibbs phenomena) occurs whenever a Fourier series is truncated.

The amplitude of the ringing will vary from symbol to symbol because certain phase/amplitude changes will be more drastic than others. This is compounded by residual ringing voltages that are still decaying from previous symbol changes. Although well designed base-band filters will keep this effect to a minimum, power ringing will unavoidably occur in proportion to the value of the compounded ringing voltage squared.

Simulation of this effect has shown that the **peak power level can be more than 6 dB higher that the level of the corner symbols of the constellation diagram** when a filter with a roll off α = 0,15 is used as is usual with QAM signals (DVB-C). This increment has to be **added** to the peak-to-average power ratio indicated in Table 6.

## 7.2 Correction factors for bandwidth and detectors

The above considerations correspond to having an actual correction factor peak-to-average power ratio of about 11 dB for all QAM signals. If this figure is reduced by 3 dB in order to take into account the difference between peak and quasi-peak, the correction factors for peak and quasi-peak to average power ratio are:

$$C_{DVB,Peak/Average} = +11 \text{ dB},\ C_{DVB,QP/Average} = +8 \text{ dB}$$

Because the RMS power of a QAM signal is about 1 dB higher than its average value in the whole channel bandwidth, the correction factors with respect to the RMS value become:

$$C_{DVB,Peak/RMS} = +10 \text{ dB},\ C_{DVB,QP/RMS} = +7 \text{ dB}.$$

The correction factors also take into account the effective bandwidth of the measured signal. For a DVB signal transmitted in an 8 MHz channel the bandwidth is about 7 MHz, which results in a DVB bandwidth correction factor:

$$C_{DVB,BW} = 10 \lg (120 \text{ kHz} / 7 \text{ MHz}) = -17{,}6 \text{ dB}.$$

Example 1. If the radiated power of a QAM signal (8 MHz channel) is 17 dB(pW) (the same as in the previous example for a PAL) and is measured with a measuring apparatus having a bandwidth of 120 kHz and a quasi-peak detector, the result of measurement is:

$$P_{DVB,QP,120kHz} = P_{DVB,RMS,8MHz} + C_{DVB,QP/RMS} + C_{DVB,BW} = 17 \text{ dB(pW)} + 7 \text{ dB} – 17{,}6 \text{ dB} \approx 6{,}4 \text{ dB(pW)}.$$

NOTE The interference power produced by a DVB digital signal (QAM) is 12,6 dB lower than that of an analogue TV signal (PAL). Since digital signals are usually transmitted with a back-off level of 4 to 10 dB (depending on the modulation scheme) compared to the PAL vision carrier, the interference power produced is about 17 dB to 23 dB lower than that of an analogue TV signal (PAL).

In case of interference on an Over The Air (OTA) service due to a QAM signal, the interfering power of the QAM signal which falls into the OTA channel take into account the bandwidth of the interfered channel.

Example 2. If the radiated power of a QAM signal is 17 dB (pW) (8 MHz) (as in the previous Example 1) and the OTA channel has only a bandwidth of 25 kHz (e.g. aeronautical speech) the interfering power has to be calculated considering the OTA channel bandwidth:

$P_{DVB,QP,25kHz} = P_{DVB,RMS,8MHz} + C_{DVB,QP/RMS} + C_{DVB,BW} - 10 \lg (25 \text{ kHz}/120 \text{ kHz})$ = 6,4 dB (pW) – 6,81 dB = -0,41 dB (pW).

## 7.3 Correction factors between different detectors

Annex 9 of CEPT SE24 report, table 3 contains correction factors Z which allow the calculation of the RMS power over the whole bandwidth (BW) of a QAM digital signal when the power measurement of the digital signal is made with certain other measurement detectors X (such as Quasi-peak/120 kHz or Peak/1MHz). The RMS power $P_{RMS}$ of the QAM digital signal over the whole bandwidth (BW) is calculated by:

$$P_{RMS,BW} = P_{X,y} + Z$$

where:

$P_{X,Y}$ is the power measured by detector X, IF bandwidth Y

Z is the overall correction factor in dB.

The values of the correction factor Z (dB) between different IF filter bandwidths and detector types are indicated in Table 7.

**Table 7 – Correction factors Z (dB) for transforming a measured power into RMS power over the whole signal bandwidth**

| Type of detector | Bandwidth of the IF filter before the detector | | |
|---|---|---|---|
| | **9 kHz** | **120 kHz** | **1 MHz** |
| **Peak** | 19,3 | 8,1 | 0,2 |
| **Quasi-peak** | | 12,9 | |
| **Average** | 33,6 | 20,5 | 11,4 |
| **RMS** | 30,5 | 19,4 | 10,2 |

NOTE The difference of the correction factor values between peak, quasi-peak and RMS detectors are close to the values given above: $C_{Peak/RMS}$ = 10 dB and $C_{QP/RMS}$ = 7 dB. The correction factors Z takes into account both the detector type and the IF filter bandwidth.

Example 1: A power of 20 dB(pW) of a QAM signal measured with a Quasi-peak detector and a 120 kHz bandwidth represents a RMS power of that QAM signal over the whole bandwidth (8 MHz channel) of 33 dB(pW).

Example 2: A protection requirement of -12 dB with respect to a peak detector and IF filter bandwidth of 1 MHz becomes 0,7 dB with respect to quasi-peak detector and 120 kHz bandwidth, 12,7 dB being the difference between 12,9 dB (quasi-peak,120 kHz) and 0,2 dB (peak, 1 MHz) in Table 7.

## 7.4 Fraction of the time the mean power is exceeded

For the whole band the percentage of the time the mean power is exceeded for 16 QAM and 32 QAM has been measured and is indicated in Table 8.

**Table 8 - Fraction of the time where the mean level is exceeded for 16 QAM and 32 QAM signals. Bolometer measurements**

| Levels above the mean value | 2 dB | 3 dB | 4 dB | 5 dB | 6 dB | 7 dB |
|---|---|---|---|---|---|---|
| Fraction of the time (s) | $18\ 10^{-2}$ | $9,2\ 10^{-2}$ | $2,1\ 10^{-2}$ | $3,9\ 10^{-3}$ | $2,1\ 10^{-4}$ | $4,8\ 10^{-6}$ |

Albeit QAM signals display a flat spectrum over the channel, they cannot be mistaken for a Gaussian process.

The **peak value** of an unbounded process like a Gaussian one is **meaningless**, as it can exceed any voltage albeit this may be a very rare event; nevertheless scanning with a spectrum analyser using a peak detector may provide a quick pre-selection of the parts of the frequency spectrum where the standard quasi-peak measurement might find an excessive value of the field strength.

## 7.5 Linear operation of amplifiers

The effect of symbols randomly transitioning across multiple power levels combined with the compound ringing from the baseband filters will produce a complex power envelope that is continuously changing and may even seem to resemble white noise. The highest (peak) power levels of this signal must be preserved within the linear region of an amplifier. Failure to do this has serious consequences since compression of the peak power will cause significant intermodulation distortion products (IMD), reduced signal robustness and, if severe enough, a significant data loss.

NOTE Because of these reasons, QAM signals are often operated with average power levels 9 to 15 dB below a power amplifier's saturation level. Accurate measurement of the peak power is necessary since only 3 dB of error equates to 50% linear error. This could be the difference between choosing either a 5 kW or a 10 kW transmitter for the same system. Monitoring the peak-to-average power ratio of a transmitter will provide valuable information about how a complete system is behaving. Any change in the ratio would be indicative of a problem such as: degradation of the transmitter's peak power handling capability, signal compression, up-converter problems, modulator system problems, etc.

## 7.6 Measurements on cable modems

In transmission systems using time division multiple access (TDMA) (such as upstream transmission by EuroDOCSIS cable modems) the quasi-peak value is calculated taking into account the repetition rate of the transmission bursts.

The weighting of TDMA signals cannot simply be determined from the pulse repetition frequency (PRF), but also pulse duration must be taken into account, in order to evaluate its area *A*.

The "peak value" meter has sometime been used for a quick indication of which frequencies an electronic device may be radiating but recent advances in time domain measurements of EMI (electromagnetic interference) now allow a much quicker estimate of the quasi-peak values.

## 7.7 Measuring equipment setting for QAM signal level measurement

QAM signal level measurement using a spectrum analyser is usually made in dB(μV/Hz) units and then applying a correction factor to take into account the bandwidth according to the Symbol Rate. With a symbol rate of 6,952 MSymbol/s for DVB-C signals in a 8 MHz channel the correction factor is $10 \cdot \lg(6{,}952 \times 10^6) = +68{,}4$ dB

The following setting of the measuring equipment is advised:

- preset the spectrum analyser in default mode
- set the detector mode to the sample mode
- failure to change the detector mode (i.e. from peak mode to sample mode) means a 3 dB to 5 dB error in channel power
- set resolution bandwidth (RBW) to 100 kHz
- set video bandwidth (VBW) to 1 MHz
- set span width to 10 MHz
- set centre frequency to the centre frequency of the signal under test
- turn on noise marker function and set noise marker to channel centre or to the maximum of channel power.

# Annex A
(informative)
**Field strength measurement**

## A.1 General

The equipment required is:

- a calibrated antenna (half-wave dipole or log-periodic antenna) with a known antenna coefficient $ANT_C$, expressed in dB($m^{-1}$);
- a measuring receiver or a spectrum analyser having a calibrated display in dB(μV) of the tuned signal; The tuning range of the equipment extends to the frequency range of the received signals.
- a calibrated coaxial cable of suitable length (for example, 10 m) having a calibrated attenuation $A_c$ (dB) at the frequencies where the measurement is performed.

## A.2 Connection of the equipment

- Connect the spectrum analyser to the calibrated antenna using the calibrated coaxial cable;
- Locate the calibrated antenna in the site position where the field is to be measured;
- Set the polarization of the calibrated antenna according to the electromagnetic field of the wanted signal to be measured;
- Turn the calibrated antenna towards the wanted signal to be measured in the same direction as the designed receiving antenna.

## A.3 Measurement procedure

### A.3.1 Analogue modulated signals

a) When a high ambient field is present, the measuring equipment (spectrum analyser) shall be checked for spurious readings. Connect a shielded termination to its input cable, place both the meter and the lead approximately in their measuring positions and check that there is a negligible reading at the frequency(ies) and on the meter ranges to be used;

b) Connect the spectrum analyser to the calibrated antenna by means of a calibrated coaxial cable;

The following steps depend on the type of analogue modulated signal to be measured.

**AM television**

c1) Tune the vision carrier of the television channel that is to be measured (selecting the centre frequency of the spectrum analyser) and select the span and level settings to show the whole channel;

d1) Set the span of the spectrum analyser to 0 Hz, the resolution bandwidth to 1 MHz and the video bandwidth to 1 MHz;

e1) Use the max-hold feature to display the maximum level of the received signal. Measure the level *S* of the top of the displayed signal in dB(μV) using the display line cursor if this feature is available;

NOTE For positive modulation TV systems, the measuring receiver remains connected for a sufficient period to ensure that the maximum reading is obtained. It may therefore be necessary to observe the picture in order to ensure that peak white is present in the signal during the measurement.

**FM television**

c2) Tune the carrier of the television channel that is to be measured (selecting the centre frequency of the spectrum analyser) and select the span and level settings to show the whole channel;

d2) Set the span of the spectrum analyser to 0 Hz, the resolution bandwidth to 1 MHz and the video bandwidth to 1 MHz;

e2) Use the max-hold feature to display the maximum level of the received signal. Measure the level *S* of the top of the displayed signal in dB(μV) using the display line cursor if this feature is available;

**FM radio channel**

c3) Tune the carrier of the FM radio channel that is to be measured (selecting the centre frequency of the spectrum analyser) and select the span and level settings to show the whole channel;

d3) Set the span of the spectrum analyser to 0 Hz, the resolution bandwidth to 100 kHz and the video bandwidth to 10 kHz;

e3) Use the max-hold feature to display the maximum level of the received signal. Measure the level *S* of the top of the displayed signal in dB(μV) using the display line cursor if this feature is available;

f) The field strength level *FSL* is calculated by the following formula:

$$FSL = S + \mathrm{ANT_C} + A_\mathrm{C} \qquad \text{in dB(μV/m)}$$

### A.3.2 Digitally modulated signals

a) When a high ambient field is present, the measuring equipment (spectrum analyser) shall be checked for spurious readings. Connect a shielded termination to its input cable, place both the meter and the lead approximately in their measuring positions and check that there is a negligible reading at the frequency(ies) and on the meter ranges to be used;

b) Tune the channel that is to be measured (selecting the centre frequency of the spectrum analyser) and select the span and level settings to show the whole channel whose bandwidth depends on the type of modulation used;

c) Set the resolution bandwidth *RSBW* of the spectrum analyser to 100 kHz and set the video bandwidth low enough to obtain a smooth display (100 Hz if available);

d) Measure the level *S* of the flat top of the displayed signal in dB(mW) using the display line cursor if this feature is available.

NOTE If the spectrum of the signal does not have a flat top, due to echoes, measure the signal level at the centre frequency of the channel.

e) Measure the upper and lower frequencies of the displayed channel at the channel edges where the level is 3 dB lower than the maximum level *S*; the difference between these two frequencies is assumed to be the equivalent signal bandwidth *BW*, expressed in Hz.

f) Calculate the level $S_{\mathrm{D,RF}}$ of the signal using the following formula:

$$S_{\mathrm{D,RF}} = S + 10\lg\left[\frac{BW}{RSBW}\right] + K_{\mathrm{sa}} \qquad \text{in dB(mW)}$$

The correction factor $K_{sa}$ depends on the measuring equipment used and is provided by the manufacturer of the measuring equipment or obtained by calibration. The value of the correction factor for a typical spectrum analyser is about 1,7 dB.

The correction factor is not necessary if the measuring equipment can be set to display the level in dB(mW/Hz) units. In this case the level $S_{D,RF}$ of the signal can be obtained from the measured maximum level *S* using the following formula:

$$S_{D,RF} = S + 10\lg(BW) \quad \text{in dB(mW)}$$

In this formula the bandwidth *BW* has to be expressed in Hz.

NOTE This measuring method actually measures the *S* + *N* level. The contribution of noise is considered negligible if the level of noise displayed outside the channel band is at least 15 dB lower than the maximum level displayed within the channel band. This noise level includes that of the measuring equipment (spectrum analyser), which is at least 10 dB lower than the noise level displayed outside the channel band in order not to affect the results. Otherwise, the contribution of noise (due to the system or the equipment under test and to the measuring equipment) must be taken into account in the measurement of signal level *S* (see Annex F).

g) The field strength level *FSL* is calculated by the following formula:

$$FSL = S_{D,RF} + ANT_C + A_C + 107 \quad \text{in dB(μV/m)}$$

NOTE The coefficient 107 applies if the input impedance of the measuring set (spectrum analyser) is 50 Ω. This value becomes 109 if the measuring set has a 75 Ω input impedance.

## A.4 Field strength due to a transmitted power

$$E = \sqrt{30\ P}\ /d$$

where:

*E* : e.m. field strength, in V/m

$P = P_T \times G_a$ : transmitted power, in W

$P_T$ : transmitter power, in W

$G_a = 10^{G/10}$ : antenna gain, expressed as a ratio

G : antenna gain, in dB, with respect to an isotropic radiator (G = 2,15 dB for λ/2 dipole)

$G_a = 1$ : for an isotropic radiator

$G_a = 1{,}64$ : for α λ/2 dipole

*d* : distance, in m.

Example. A radiated power *P* = 100 pW (20 dB(pW)) produces a field strength *E* = 23,38 μV/m (27,4 dB(μV/m) at a distance of 3 m if the EUT is considered equivalent to a λ/2 dipole.

## A.5 Received voltage due to a radiated field

If the radiated field is measured using an antenna with a gain G with respect to an isotropic radiator, the voltage obtained at its output is:

$$U = E\,G\,(\lambda/2\pi)$$

$$U_R = E_F + 31{,}5 + G - 20\,\lg_{10}(f) = E_F - \mathrm{ANT_C}$$

where:

$E_F$ : e.m. field strength, in dB(V/m) ($E_F = 20\,\lg_{10}(E)$)

$U_R$ : received voltage at antenna terminal, in dB(V) into a 75 Ω load

$G$ : antenna gain, in dB, with respect to an isotropic radiator (G = 2,15 dB for a λ/2 dipole)

$f$ : frequency, in MHz

$\mathrm{ANT_C}$ antenna coefficient, in dB($m^{-1}$).

NOTE: If $E_F$ is expressed in dB(μV/m), $U_R$ is expressed in dB(μV) into a 75 Ω load.

In Figure A.1 is indicated the antenna coefficient $\mathrm{ANT_C}$ for an isotropic antenna and a *λ*/2 dipole. If the antenna used has a gain G, the antenna coefficient is G (dB) lower than that of the reference antenna.

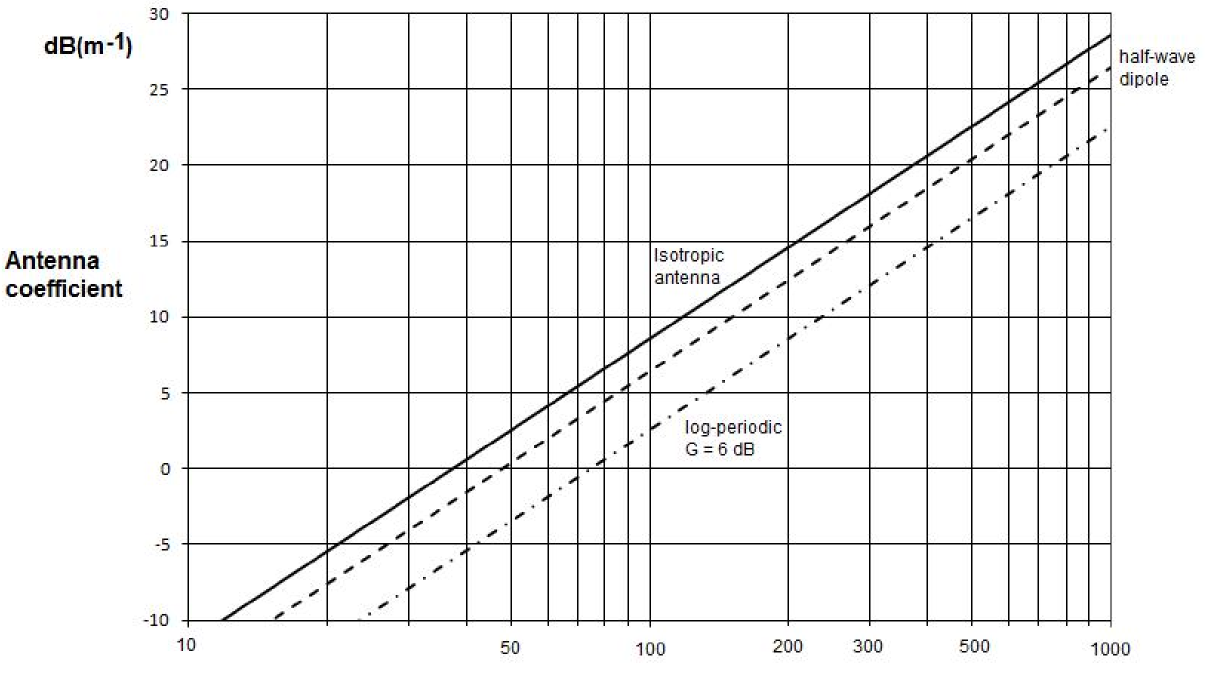



**Figure A.1 – Antenna coefficient for isotropic antenna, *λ*/2 dipole and log-periodic antenna with gain G = 6 dB respect to isotropic antenna**

Considering the reception of a radiated field *E* = 27 dB(μV) with a halfwave dipole, the signal level $U_R$ measured is indicated in Table A.1.

**Table A.1 – Received signal level $U_R$ with a $\lambda$/2 dipole in a field $E$ = 27 dB(μV)**

| Band | Frequency MHz | $ANT_C$ ($\lambda$/2 dipole) dB | $U_R$ dB(μV) |
|---|---|---|---|
| I | 47 | -0,14 | 27,14 |
| | 60 | 1,98 | 25,02 |
| II | 88 | 5,31 | 21,69 |
| | 108 | 7,09 | 19,91 |
| III | 174 | 11,23 | 15,77 |
| | 230 | 13,66 | 13,34 |
| IV and V | 470 | 19,86 | 7,14 |
| | 600 | 21,98 | 5,02 |
| | 862 | 25,13 | 1,87 |

The C/N at the maximum frequency is about 10 dB for a receiver noise figure of 6 dB (measuring equipment bandwidth of 120 kHz).

# Annex B
(informative)
# LISN (Line Impedance Stabilisation Network)

A typical LISN circuit diagram for one side of the line relative to earth ground is shown in Figure B.1.

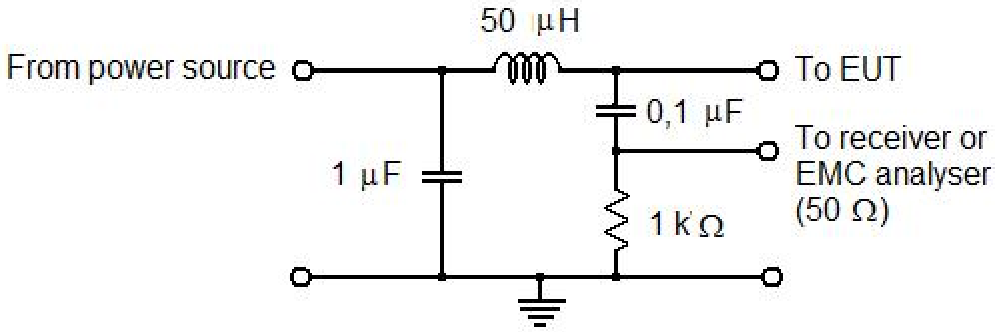



**Figure B.1 – LISN circuit for one side of the line relative to earth ground**

The 1 µF capacitance in combination with the 50 µH inductor is the low-pass filter that prevents the noise generated by the EUT reaching the mains. The 0,1 µF couples the noise generated by the EUT to the measuring receiver or EMC analyser. At frequencies above 150 kHz, the EUT signals are presented to the measuring apparatus having a 50 Ω impedance. The impedance of the EUT port versus frequency is shown in Figure B.2.

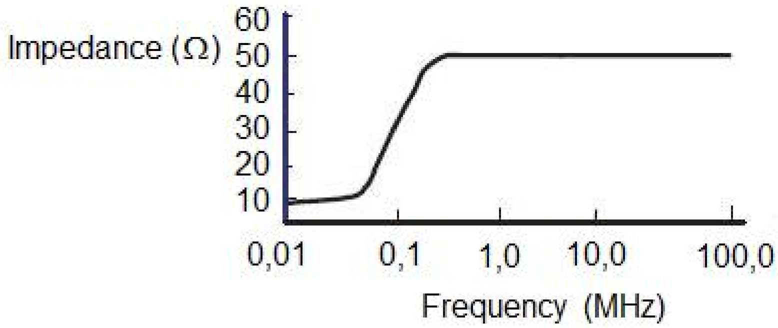



**Figure B.2 – LISN impedance at the EUT port, versus frequency**

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