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Digital radio mondiale (DRM) –

Part 2: Digital radio in the bands below 30 MHz – Methods of measurement for DRM transmitters

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

DIGITAL RADIO MONDIALE (DRM) –

Part 2: Digital radio in the bands below 30 MHz – Methods of measurement for DRM transmitters

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International Standard IEC 62272-2 has been prepared by IEC technical committee 103: Transmitting equipment for radiocommunication.

The text of this standard is based on the following documents:

FDIS	Report on voting
103/64/FDIS	103/66/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

DIGITAL RADIO MONDIALE (DRM) –

Part 2: Digital radio in the bands below 30 MHz – Methods of measurement for DRM transmitters

1 Scope

This part of IEC 62272 describes the methods of measurement to assess the performance characteristics of digital modulated radio transmitters in the bands below 30 MHz for sound and/or data broadcasting in the LF, MF and HF bands, and to facilitate the comparison of measurements which are carried out by different personnel.

It contains details of specially selected methods for determining the most important performance parameters of digital radio transmitters. The measurement methods described apply to a limited number of performance parameters, i.e. those which can give rise to ambiguous interpretation due to the use of different methods and conditions. They are neither restrictive nor mandatory: measurements can be chosen for each particular case.

The measurement methods described in this standard are intended to be used for type approval tests, quality control tests or acceptance test measurements in factories and on site.

Fewer or additional measurements may be carried out by agreement between customer and supplier. Any additional test should comply with standards which have been established by other study groups, subcommittees of the IEC or other international or suitably accredited organizations.

This standard does not specify limiting values for acceptable performance as these are usually given in the equipment specification or in requirements laid down by the responsible regulation bodies. However, some values are quoted, where appropriate, for guidance in the presentation of the results.

2 Normative references

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

IEC 60244-1, *Methods of measurement for radio transmitters – Part 1: General characteristics for broadcast transmitters*

IEC 60244-15, *Methods of measurement for radio transmitters – Part 15: Amplitude-modulated transmitters for sound broadcasting*

IEC 60215, *Safety requirements for radio transmitting equipment*

ITU *Radio Regulations*

ITU-R Recommendation V.663, *Use of certain terms linked with physical quantities*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1
DRM standard
digital modulation standard for frequencies in the bands below 30 MHz for the purposes of audio and data broadcasting

3.1.2
DRM transmitters
sound broadcasting transmitters operating in the bands below 30 MHz and incorporating digital modulation in accordance with IEC 62272-1[1]

3.1.3
power definitions
nominal output power is the continuous DRM mean power for which the transmitter is designed

maximum output power is the maximum possible continuous DRM mean power which the transmitter can deliver. The maximum output power might be concordant with the nominal output power

minimum output power is the minimum possible continuous DRM mean power for which the transmitter is designed

3.1.4
necessary bandwidth
for a given class of emission, the width of a frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions (ITU definition)

For the practical purposes of this standard, the necessary bandwidth for a DRM signal can be considered to be the same as the allocated channel bandwidth, for example, 10 kHz for a standard HF channel.

3.2 Abbreviations

BER	Bit Error Ratio
BS	Broadcasting Service
DRM	Digital Radio Mondiale
FAC	Fast Access Channel
HF	High Frequency
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
ITU	International Telecommunications Union
ITU-R	International Telecommunications Union – Radiocommunications Sector
LF	Low Frequency
MER	Modulation Error Ratio
MF	Medium Frequency
MLC	Multi-Level Coding
MSC	Main Service Channel

[1] IEC 62272-1, *Digital radio mondiale – Part 1: System specification*

OFDM	Orthogonal Frequency Division Multiplex
PRBS	Pseudo-Random Bit Sequence
QAM	Quadrature Amplitude Modulation
RF	Radiofrequency
SDC	Service Description Channel
SM	Spectrum Management
Tx	Transmitter

4 General conditions of operation

Any device for the suppression of unwanted signals, irrespective of whether or not the device is located inside the transmitter, shall be considered as part of the transmitter for the purposes of this standard.

Feeders and antennas to which the transmitter might be connected are not considered part of the transmitter and therefore excluded.

Unless otherwise specified, the measurements shall be made under normal operating and environmental conditions and at the nominal output power. If required, they shall be repeated under extreme operating and environmental conditions and at any lower output power in accordance with the equipment specification.

The transmitting mode and the measured output power of the transmitter under test shall be stated.

The mains supply and the environmental conditions shall be stated with the measurement results.

The transmitter shall be connected to a test load having a VSWR relative to the nominal load impedance of the transmitter not greater than

– 1,2:1 at frequencies within the designated broadcast band;
– 1,5:1 at all frequencies outside the designated broadcast band up to a frequency of 10 times the highest frequency in the designated band.

If the transmitter includes devices to control the frequency band transmitted, all the characteristics shall be measured with the devices in the circuit.

Measurement uncertainty should be calculated and techniques employed to minimize its range. This uncertainty should be applied to the limit and any measurement falling below the range is deemed acceptable.

If a digital transmitter can also operate in analogue mode, the requirements of IEC 60244-1 and IEC 60244-15 shall also apply, in addition to the requirements of this standard.

5 General conditions of measurement

5.1 Input and output measurement arrangements

For the purposes of measurement, the input and output signal arrangements are given in the form of diagrams.

Where required, the impedance of the test equipment of the transmitter under test and of all the connections between them shall be appropriately terminated, taking into account the transmitter's specification and the termination impedance of any test equipment.

These test procedures for DRM transmitters require that the test signals used shall conform to the DRM standard and that the measuring equipment is sufficiently accurate and has the necessary performance and dynamic range to provide error-free measurements of transmitter performance parameters.

5.2 Temperature and humidity

Equipment to be measured shall be operated in an environment which meets the temperature and humidity requirements as defined in their technical specifications. Temperature and humidity must never be such as to cause condensation in or on the equipment during measurements. In the absence of temperature and humidity requirements in the technical specifications, the provisions of IEC 60244-1 shall apply.

5.3 Conditions for primary power supply

The measurements are carried out at the nominal voltage and the nominal frequency of the power supply given in the relevant equipment specification.

During a series of measurements carried out as part of one test on one equipment, the voltage and frequency of the power supply shall be set at the nominal values indicated in the equipment specification.

If called for in the specification and if the power source is able to be adjusted, the test shall be repeated at the extremes of voltage and frequency stipulated in the specification.

The conditions for primary power voltage and frequency shall be specified in the equipment specification. If no voltage or frequency range is specified, the tests shall be carried out with voltage within ±5 % of nominal and frequency within ±2 % of nominal.

5.4 Output power

The tests shall be carried out with the transmitter set to its nominal output power and, if required, also at any other output power within the equipment specification.

6 General characteristics

6.1 Output power

6.1.1 Definition

For a digital signal with the OFDM modulation process the power is distributed evenly throughout the transmission channel. Hence, when taking power measurements on such a signal, the total bandwidth occupied by the modulated signal shall be taken into account.

The output power of a digital modulated transmitter is defined as the mean power (thermal power) delivered at its output port, measured during an interval of time sufficiently long compared with the lowest frequency encountered in the modulation envelope, taken under normal operating condition (continuous mean power).

6.1.2 Measuring arrangement

Figure A.1 shows the measuring set-up to be used.

In general, quantifying output power relies on measuring either the thermal effects of the power dissipated in the test load or the RF voltage across it. The method chosen will depend largely on power output.

Examples are as follows:

a) calorimetric methods;

b) temperature-dependent component;

c) RF power meter with thermal probe and directional coupler;

d) spectrum analyser with directional coupler or RF probe, all of which have been suitably calibrated against a more direct measurement and for the types and combinations of signals likely to be encountered.

6.1.3 Measuring procedure

Adjust the transmitter for the appropriate output power. Measure the mean power over a time frame which is at least as long as the stabilization time of the instrumentation used for this measurement.

Since the output power value is a fundamental reference point when quantifying non-linear distortion parameters and spurious, it is recommended that the output power reading is displayed by a calibrated measuring instrument throughout all the tests.

6.1.4 Presentation of results

The results shall be presented as a value stating the output power in watts or kilowatts.

6.2 Frequency

In order to achieve effective use of the RF spectrum and limit mutual interference caused by radio services occupying adjacent channels, any departure from the channel assigned to a transmission shall be kept within strictly observed limits. These are defined by the International Telecommunication Union and are laid down in the Radio Regulations (see IEC 60244-1, Annex C).

6.2.1 Definitions

6.2.1.1 Assigned frequency

The assigned frequency is the centre of the frequency band (channel) assigned to a station.

6.2.1.2 Characteristic frequency

The term ’characteristic frequency’ is used in this standard to denote the frequency component in the DRM signal that is intended to be at the centre of (one of) the channel(s) occupied by the DRM emission – the assigned frequency (see Figures 1 and 2).

Since there is usually no frequency component of the DRM signal at this frequency, it must be assessed by an indirect method.

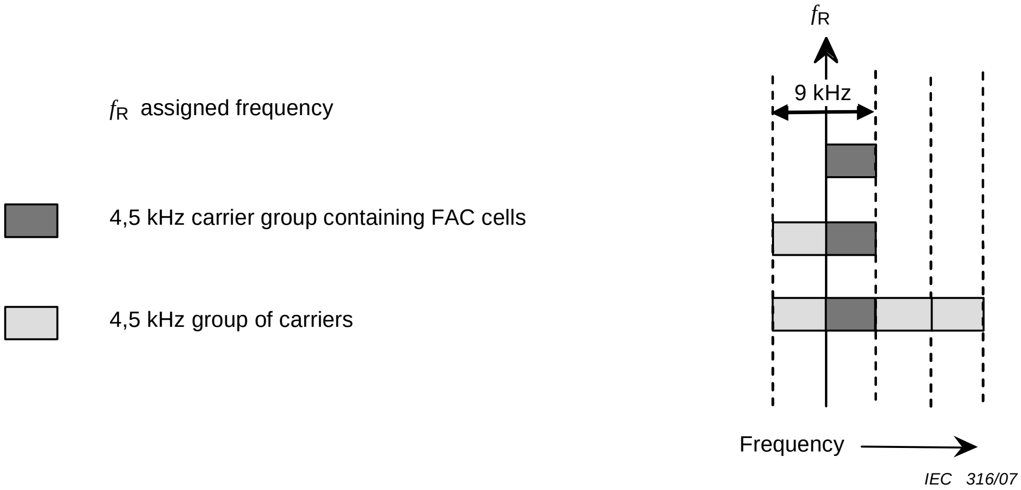


Figure 1 – Spectrum occupancy for 9 kHz channels

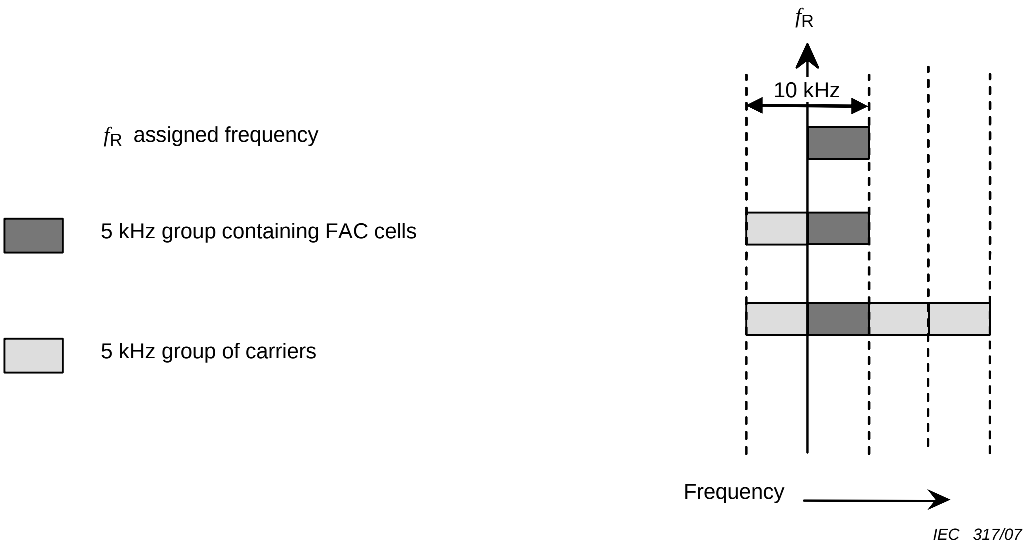


Figure 2 – Spectrum occupancy for 10 kHz channels

6.2.1.3 Frequency error

The frequency error is the difference between the assigned frequency and the characteristic frequency.

NOTE The maximum frequency error is expressed in hertz or in parts per million and should be compared with the frequency tolerance in the ITU Radio Regulations, or with the relevant standard in the equipment specification. The measurement may be carried out at any time or times within the time interval indicated in the equipment specification.

6.2.1.4 Frequency tolerance

The frequency tolerance is the permissible frequency error, expressed in hertz or in parts per million.

6.2.1.5 Frequency instability

The instability of an emission is the variation of frequency against a predetermined time scale.

NOTE A random departure from the assigned frequency is expressed as frequency error.

6.2.2 Measuring arrangement

Figure A.2 shows the measuring set-up to be used.

6.2.3 Measuring procedure

If the DRM modulator has a reference frequency output which corresponds to the characteristic frequency, this reference frequency may be measured. If the DRM modulator does not have such a reference frequency output it must be assessed by an indirect method. An informative description of an indirect measuring method is given in Clause C.2.

The characteristic frequency, the frequency tolerance and the frequency error may be measured with any suitable measuring device, such as a calibrated receiver and external frequency standard, or other instrument with measurement accuracy better than 10 times that of the equipment to be measured.

When the frequency is to be measured as a function of time (for example, frequency instability), the measurements shall be made at intervals which are short enough to reveal the presence of superimposed periodical variations. In this case, the measurement shall preferably be made with a recording instrument.

The conditions of operation shall also be given, together with the characteristic frequency.

6.2.4 Presentation of the results

Tables or graphs shall be used for frequency-instability and frequency-error results.

The accuracy of the measuring method, if known, shall be stated with the results of the measurements. If not known, an estimate should be given.

7 Transmission performance characteristics

7.1 Spurious emissions

7.1.1 Definition

A spurious emission is defined by the ITU as an emission on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

A detailed description of the different kind of spurious emissions is given in IEC 60244-1.

7.1.2 Measuring arrangement

Figure A.3 shows the measurement set-up to be used.

A directional coupler or an RF probe is inserted in the transmission line. The frequency response of the probe shall be taken into account. If the dynamic range of the spectrum analyser is not sufficient to provide measurements of sufficient accuracy, appropriate filters of known frequency response shall be used.

7.1.3 Measuring procedure

Operate the transmitter at the appropriate output power. Measure the output power of the transmitter. Measure the difference in dB between the in-band signal and the spurious emission.

The resolution bandwidth of the spectrum analyser shall be 10 kHz for frequencies below 30 MHz and 100 kHz for frequencies between 30 MHz and 1 GHz.

7.1.4 Calculation and presentation of the results

The power of the spurious emission shall be calculated, taking into account the measured attenuation on the spectrum analyser, the gain of the probe and the characteristic of the filter (if filters are used).

The results shall be presented as absolute radiated power of the spurious emissions, in watts, and/or the ratio of radiated power of the spurious emissions with respect to the mean power level of the DRM transmission at the characteristic frequency, in dB.

7.2 Out-of-band emissions (spectrum mask)

7.2.1 Definition

An out-of-band emission is defined by the ITU as an emission on a frequency or frequencies immediately outside the necessary bandwidth which results from the modulation process, but excludes spurious emissions.

NOTE Since single-sideband phase noise and switching-frequency emissions result from the modulation process they are considered to be out-of-band emissions.

For the purpose of this standard the out-of-band domain will be considered as the spectrum within ±5 times the necessary bandwidth either side of the channel centre but excluding the in-band signal.

7.2.2 Measuring arrangement

Figure A.3 shows the measuring set-up to be used, with the exception that no filter shall be used in the measuring connection for this measurement.

7.2.3 Measuring procedure

The transmitter shall be operated at the appropriate output power. The resolution bandwidth of the spectrum analyser shall be set to a value of not more than 100 Hz.

The level of the in-band signal is taken as the 0 dB reference for the spectrum mask. For the DRM spectrum mask, see Annex B.

Averaging or a video bandwidth which is lower than the resolution bandwidth shall be used to smooth the trace.

7.2.4 Presentation of the results

The ratio of the power in each sideband (in dB) relative to the mean level of the in-band signal shall be given for each sideband in the form of a table or graph.

The DRM robustness mode, its spectrum occupancy and the resolution bandwidth of the spectrum analyser shall be stated.

7.3 Modulation error ratio (MER)

7.3.1 Definition

The modulation error ratio (MER) is a measure of the total signal degradation in the transmitted signal.

For the purposes of this standard, the MER is calculated as follows.

For each equalized main service channel (MSC) cell (only MSC cells, no FAC cells, no SDC cells, no pilot cells), the error vector from the nearest ideal point of the constellation diagram is measured. The squared magnitude of this error is found, and a mean of the squared errors is calculated over (at least) five consecutive DRM transmission frames (2 s). The MER is the ratio in dB of the mean of the squared magnitudes of the ideal constellation points of the constellation diagram to the mean squared error. This gives an estimate of the ratio of the total signal power to the total noise power at the input to the equalizer for channels with flat frequency response.

$$MER = 10\log_{10}\left\{\frac{\sum_{k}|s_{\mathrm{k}}|^2}{\sum_{k}|s_{\mathrm{k}} - r_{\mathrm{k}}|^2}\right\}$$

where

s_{k} is the optimal point value of the QAM constellation diagram (from hard decision);

r_{k} is the received complex cells value after channel estimation.

7.3.2 Measuring arrangement

Measurements are taken on all carriers of the main service channel (MSC) with an averaging of the MER over at least five consecutive DRM transmission frames (2 s) with a DRM test receiver with an MER measuring device.

The set-up is shown in Figure A.4.

The confidence of the MER value may be checked by inserting a 10 dB attenuator before the DRM test receiver. If the MER value measured by the DRM test receiver stays the same, then the MER value is considered to have a sufficient confidence.

7.3.3 Measuring procedure

The test should be carried out with the transmitter operating at – at least – the maximum and minimum power level at which it is specified to operate. If a range of power outputs is not specified, the transmitter shall be operated at its specified output power. The MER shall be measured at different MSC modes (signal constellation 64-QAM as well as signal constellation 16-QAM).

7.3.4 Calculation and presentation of the results

The results shall be presented in a table or graphs for the different modulation modes.

7.4 Bit error ratio (BER)

The BER is the primary parameter which describes the quality of a digital transmission system. This parameter is used to analyse the transmitter performance and quantifies the modulator performance and the transmitter quality.

7.4.1 Definition

For a binary digital signal, the BER is the ratio of the number of error bits received to the total number of bits received over a given time interval (see ITU-R Recommendation V.662-3, 5.10).

For the purposes of this standard, the BER is defined as a part or as the total main service channel (MSC) of the DRM signal.

7.4.2 Measuring arrangement

Figure A.4 shows the measuring set-up to be used.

A DRM signal source is connected to the DRM transmitter. The DRM source is switched to the test mode which generates a PRBS in accordance with the PRBS generator shown in Figure 3.

For the measurement of the BER, the total part of the MSC or a part may be selected.

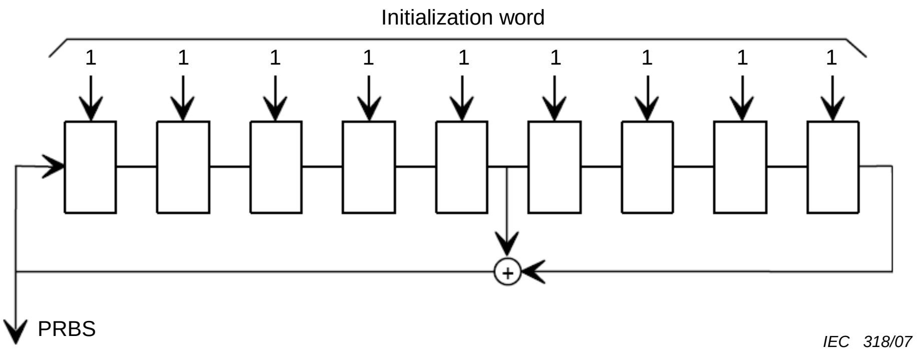


Figure 3 – PRBS generator

The DRM test receiver used in this procedure measures the BER when it detects a PRBS signal in the MSC.

7.4.3 Measuring procedure

The BER is measured after MLC by the use of a DRM test receiver suitable for making a direct measurement of BER using the defined PRBS. The time of measuring shall last until a constant BER value is displayed.

7.4.4 Calculation and presentation of the results

The measured value resulting from the BER measurement shall be stated as x parts in 10^y.

The part of the MSC shall be stated.

8 Protection against atmospheric discharge

These measurements do not differ in any way from the measurements which are carried out on analogue broadcasting equipment and, hence, they are made in conformity with IEC 60244-1.

9 Acoustic noise

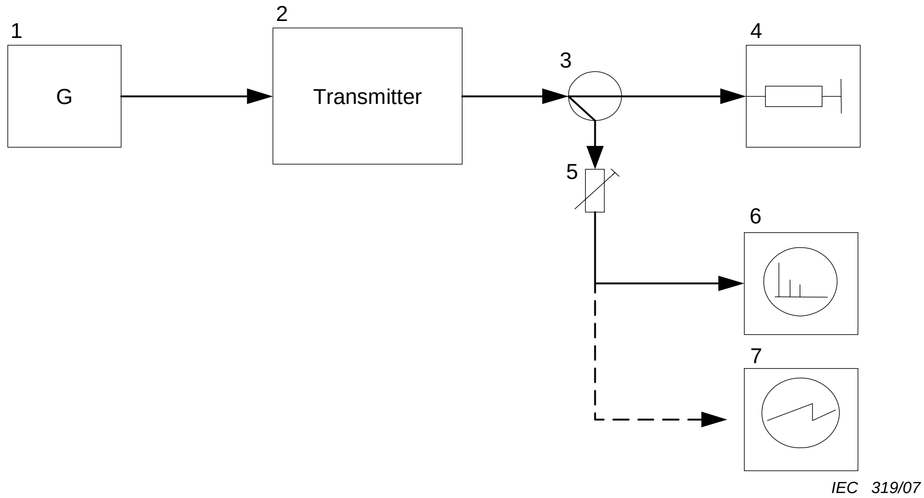
These measurements do not differ in any way from the measurements which are carried out on analogue broadcasting equipment and, hence, they are made in conformity with IEC 60244-1.

10 Safety

These measurements do not differ in any way from the measurements which are carried out on analogue broadcasting equipment and, hence, they are made in conformity with IEC 60215.

Annex A
(informative)

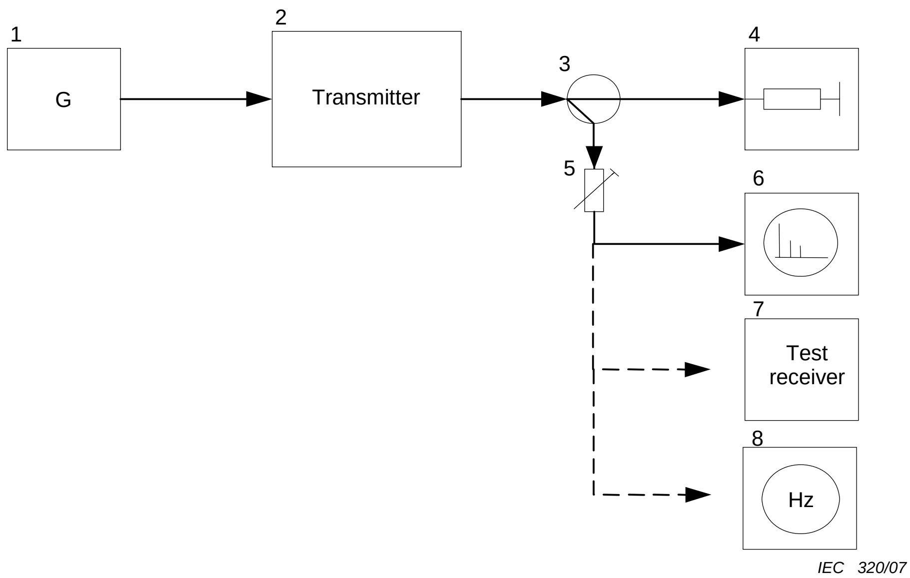
Measuring arrangements



Key

1 DRM signal source
2 Transmitter/device under test
3 Directional coupler or RF probe
4 Test load/power measuring device
5 Attenuator
6 Spectrum analyser
7 Oscilloscope

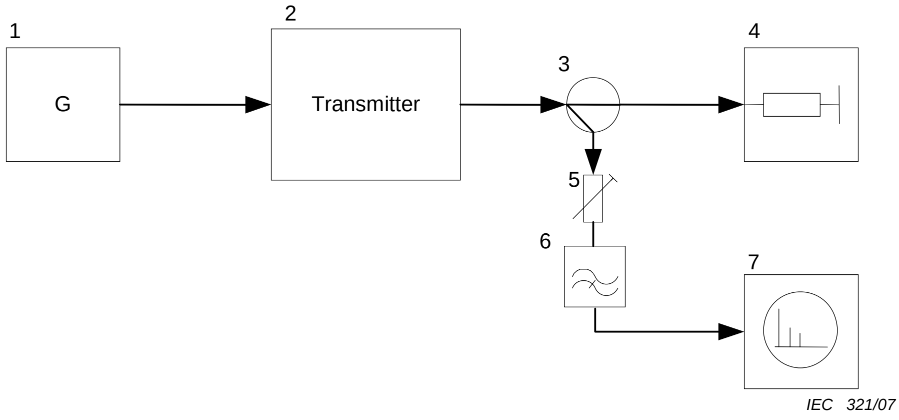
Figure A.1 – Arrangement A



Key

1 DRM signal source
2 Transmitter/device under test
3 Directional coupler or RF probe
4 Test load
5 Attenuator
6 Spectrum analyser
7 DRM test receiver
8 Frequency counter

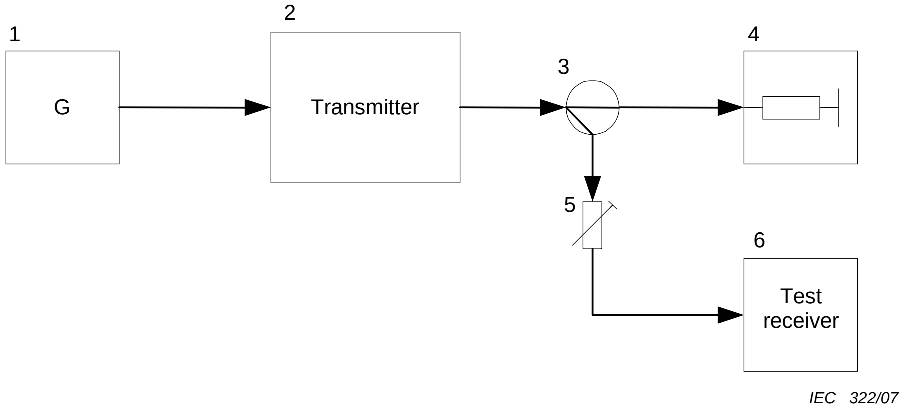
Figure A.2 – Arrangement B



Key

1 DRM signal source
2 Transmitter/device under test
3 Directional coupler or RF probe
4 Test load
5 Attenuator
6 Notch filter
7 Spectrum analyser

Figure A.3 – Arrangement C



Key

1 DRM signal source
2 Transmitter/device under test
3 Directional coupler or RF probe
4 Test load
5 Attenuator
6 DRM test receiver with BER/MER measuring device

Figure A.4 – Arrangement D

Annex B
(informative)

Out-of-band emission limits for DRM transmitters

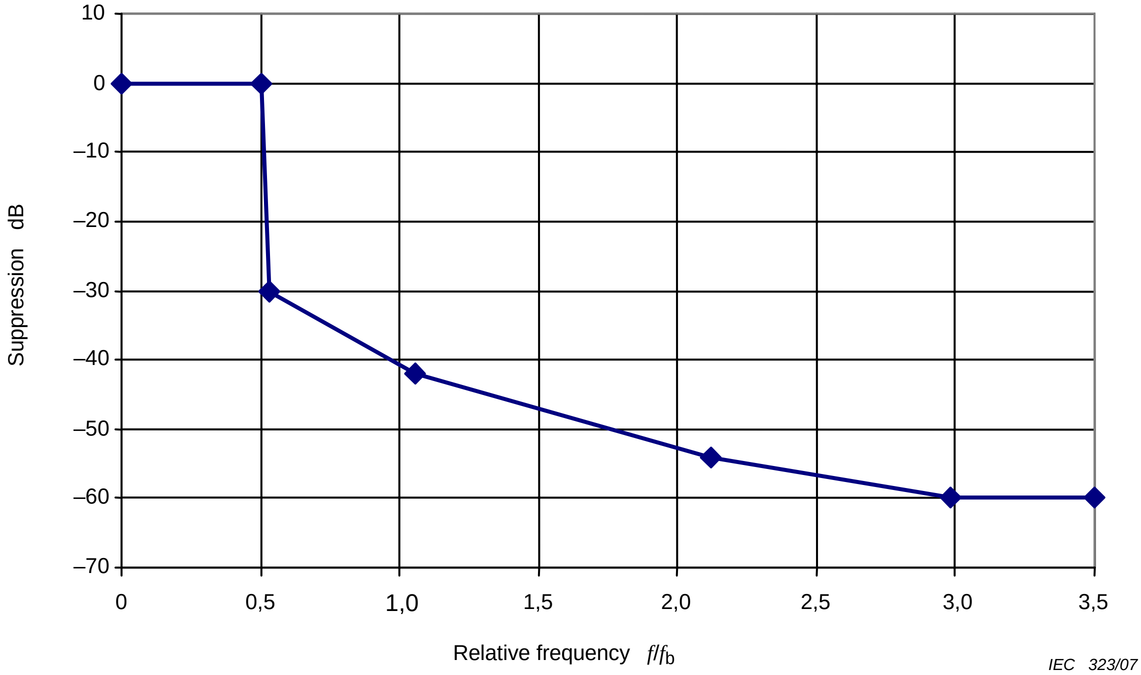


Figure B.1 – Out-of-band emission limits
(upper half only of a symmetrical spectrum mask shown)

Table B.1 – Out-of-band emission limits

Break points of the mask							Out-of-band emission limit
Relative frequency (f/f_b)	**Effective frequency (f) at the allocated channel bandwidth (f_b)**						
	f_b = 4,5	f_b = 5	f_b = 9	f_b = 10	f_b = 18	f_b = 20	
	(kHz)	(kHz)	(kHz)	(kHz)	(kHz)	(kHz)	(dB)
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
0,50	2,25	2,50	4,50	5,00	9,00	10,00	0,00
0,53	2,39	2,65	4,77	5,30	9,54	10,60	–30,00
1,06	4,77	5,30	9,54	10,60	19,08	21,20	–42,04
2,12	9,54	10,6	19,08	21,20	38,16	42,40	–54,08
2,98	13,41	14,90	26,82	29,80	53,64	59,60	–60,00
>2,98							–60,00

The effective frequency (f) is the absolute value of the difference between the frequency and the centre frequency of the DRM emission

If the frequency is plotted as the abscissa, in logarithmic units, and the power densities are plotted as ordinates, in decibels, the curve representing the out-of-band spectrum should lie on or below two straight lines starting at point (+0,5 f_b; 0 dB) or (–0,5 f_b; 0 dB), and finishing at point (+0,53 f_b; –30 dB) or (–0,53 f_b; –30 dB), respectively. Beyond these points and down to the level of –60 dB, this curve should lie below the straight lines starting from the latter points and having a slope of 12 dB per octave. Thereafter, the same curve should lie below the level of –60 dB.

Annex C
(informative)

Additional measuring details

C.1 Caloric measuring method

The most common method of measuring the RF output power of a transmitter is by the calorimetric method, a method which uses the very accurately known and measurable physical and thermal characteristics of water or other similarly well-defined liquids.

Soda (Na_2CO_3) water is known to have a thermal capacity of very close to 4 187 Joules per degree Kelvin per kilogram weight at a mean temperature of 70 °C.

The power calculation is made as follows.

$$P = m \times \mathrm{c} \times (T_{\mathrm{out}} - T_{\mathrm{in}})$$

where

P is the transmitter output power (thermal power);

m is the volume flow in l/s;

c is the thermal capacity 4 187 J/kg/K;

T_{out} is the output temperature of the soda water in K;

T_{in} is the inlet temperature of the soda water in K.

C.2 Method for measuring the frequency error by using the three continual pilots

1) Connect the DRM transmitter to a spectrum analyser with an included frequency counter of sufficient accuracy as shown in Figure A.2. Assure that the resolution bandwidth of the spectrum analyser used for measuring the frequency is sufficiently low.
2) Measure the frequency of the first continual pilot tone, subtract 750 Hz from the frequency value in order to get a first estimate $E1$ of the characteristic frequency.
3) Measure the frequency of the second continual pilot tone, subtract 1 500 Hz from the frequency value in order to get a second estimate $E2$ of the characteristic frequency.
4) Measure the frequency of the third continual pilot tone, subtract 2 250 Hz from the frequency value in order to get a first estimate $E3$ of the characteristic frequency.
5) The measurements $E1$, $E2$ and $E3$ may be averaged, in order to lower the standard deviation of the frequency estimate.

$$E_{\mathrm{averaged}} = (E1 + E2 + E3)/3,$$

where E_{averaged} is the averaged estimate of the characteristic frequency.

6) Subtract the assigned frequency from the frequency estimate E_{averaged} in order to get the frequency error in Hz.

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