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Electromagnetic compatibility and Radio spectrum Matters (ERM); Data communications using short range devices; Access protocol, occupation rules and corresponding technical characteristics for the transmission of data

Reference

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Foreword

This European Standard (Telecommunications series) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

Annex A is normative and provides additional information concerning measurements.

National transposition dates	
Date of adoption of this EN:	31 December 1999
Date of latest announcement of this EN (doa):	31 March 2000
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Introduction

The present document specifies an access protocol intended to be used in equipment employing short range (radio) devices for the cordless transfer of small data packets.

It is intended that the implementation of this protocol is sufficiently simple to suit the low costs necessary for some products.

The present document relies on all equipment on a shared channel using this protocol.

The protocol allows efficient channel sharing in high data traffic situations, and has been devised to provide an equitable share between all users of the channel. The present document only applies to applications that require infrequent bursts of small data packets for the purpose of control and limited data transfer i.e. not continuous unbroken data transmission.

This protocol relies on there being a limited radiated power and therefore a limited range, thus restricting the overlap of local users (cell size) to a level where the protocol can cope by time sharing between them.

Data collision is minimized in this protocol by using carrier sense multiple access (CSMA) which requires that the radio channel is silent before starting any transmission.

Arbitration between competing users is achieved by using a pseudo random length delay period before transmitting. A mechanism for prioritizing messages, based on message length, is also provided as part of the arbitration process.

1 Scope

The present document covers a radio channel access protocol and provides all the parameters that are essential for its use.

The present document has been designed to be used with Short Range Devices sharing a common, single frequency, radio channel and transmitting small (short duration) data packets. Standards EN 300 220-1 [1], EN 300 330 [2] and I-ETS 300 440 [3] provide technical characteristics for short range device equipment. These products will be co-existing on the same radio spectrum.

The present document specifies the access protocol and the occupation rules for data communications on a radio channel shared by different users. The present document does not specify or impose any restriction on the bit rate, data format or modulation scheme.

This access protocol is not intended for applications requiring continuous (unbroken) data transmission.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] EN 300 220-1 (V1.2): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short range devices; Technical characteristics and test methods for radio equipment to be used in the 25 MHz to 1 000 MHz frequency range with power levels ranging up to 500 mW; Part 1: Parameters intended for regulatory purposes".

[2] EN 300 330: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Technical characteristics and test methods for radio equipment in the frequency range 9 kHz to 25 MHz and inductive loop systems in the frequency range 9 kHz to 30 MHz".

[3] I-ETS 300 440: "Radio Equipment and Systems (RES); Short Range Devices (SRDs); Technical characteristics and test methods for radio equipment to be used in the 1 GHz to 25 GHz frequency range".

[4] ETS 300 113: "Radio Equipment and Systems (RES); Land mobile service; Technical characteristics and test conditions for radio equipment intended for the transmission of data (and speech) and having an antenna connector".

[5] ETR 273-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement of radiated methods of measurement (using test sites) and evaluation of the corresponding measurement uncertainties; Part 2: Anechoic chamber".

[6] ETR 273-3: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement of radiated methods of measurement (using test sites) and evaluation of the corresponding measurement uncertainties; Part 3: Anechoic chamber with a ground plane".

[7] ETR 273-4: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement of radiated methods of measurement (using test sites) and evaluation of the corresponding measurement uncertainties; Part 4: Open area test site".

[8] CEPT/ERC Recommendation 70-03: "Relating to the use of Short Range Devices (SRD)". Including Appendices and Annexes.

[9] IEC Publication 60489-3: "Methods of measurement for radio equipment used in the mobile services. Part 3: Receivers for A3E or F3E emissions".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

attack time: time taken between establishing that the channel can be accessed to the actual instant of access. The detailed definition is given in subclause 7.7

observation time: definition is given in subclause 6.5

bit: binary digit

data packet: smallest quantity of data sent over the radio channel in one access period. A number of useful bits are always sent together with corresponding redundancy bits in any given packet. An acknowledge reply, if used, is also included in the packet

message: user data to be transferred in one or more packets in a session

message length: time taken to transmit a message; the sum of the carrier on time of all the data packets used and the carrier off (silence) times of all the data packets used

reply: transmission by a device in answer to the "initiating transmitter". This reply can be an acknowledge ("ACK") or a negative acknowledge ("NACK") and/or a longer packet of useful / requested information

reply carrier delay: time period between end of a transmission and start of an acknowledge / reply

silence: condition of no detected carrier energy in the radio channel in question

transmission (physical): one packet transmitted between carrier on and final carrier off of a particular transmitter

3.2 Symbols

For the purposes of the present document, the following symbols apply:

dB	decibel
dBm	dB relative to 1 mW
dBμV	dB relative to 1 μV
Tx	transmitter (radio)

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ACK	ACKnowledge
ASK	Amplitude Shift Keying
CSMA	Carrier Sense Multiple Access
EUT	Equipment Under Test
f_c	carrier frequency (band centre)
FSK	Frequency Shift Keying
NACK	Negative ACKnowledge
OATS	Open Area Test Site
P_c	Steady state transmit power
P_{mean}	Mean level of transmit power
P_{off}	carrier off power level
$P_{r\ acc}$	minimum receiver sensitivity needed to check that a channel is free
$P_{r\ check}$	received carrier power level, generated by a checking transmitter
PSK	Phase Shift Keying
QAM	Quadrature Amplitude Modulation
RF	Radio Frequency
t_c	reply carrier delay time
t_f	fixed part of observation time
t_o	observation time
t_p	priority part of observation time
t_r	pseudo random part of observation time

4 General

4.1 Applications using this protocol

This access protocol applies to a wide variety of applications operating at various data rates in both domestic and industrial fields. To accommodate this situation, four priority levels are included which correspond to different data packet lengths. This, for example, improves the chance of access for a simple control function (requiring a fast response time) in favour of a function transferring a large amount of data (less critical of response time).

The protocol may be used with the following types of communication:

- point-to-point (source to destination);
- point-to-multi-point (source to group);
- multi-point-to-point (polling).

4.2 Conformity to the present document

Conformity to the requirements of the present document is based upon both declarations and measurements.

4.2.1 Declaration of conformity

Those parameters covered by manufacturers declaration are given in clause 6 of the present document.

A signed declaration shall be provided as confirmation that the equipment meets the requirements of this access protocol. This declaration may be submitted by the manufacturer, or his representative, together with the application form for tests.

In the case where the controlling software for the equipment (or modules thereof) has not been designed by the manufacturer of the radio equipment, the responsible party for engineering such software shall also provide a signed declaration of conformity.

4.2.2 Measurements to be performed

These measurements shall be performed for all parts of the equipment included in the system, designed to use this protocol. Clause 7 of the present document gives the methods of measurements and limits for these parameters.

The manufacturer shall provide any necessary test points and/or test fixtures, dedicated test equipment (if needed) and/or test modes for the purpose of testing and making measurements.

The following measurements and tests shall be performed, in an accredited test laboratory:

- channel access duration;
- reply carrier delay;
- anti blocking;
- carrier sense threshold;
- carrier sense delay;
- observation time;
- channel accessing carrier attack time.

4.2.3 Interpretation of the measurement results

The interpretation of the measurement results recorded in a test report for the measurements described in the present document shall be as follows:

a) the measured value related to the corresponding limit shall be used to decide whether the equipment under test meets the requirements of the present document or not;

b) the actual measurement uncertainty of the test laboratory carrying out the measurement, for each particular measurement, shall be included in the test report;

c) the values of the actual measurement uncertainty shall be, for each measurement, equal to or lower than the figures given in clause 9, absolute measurement uncertainties.

5 Technical characteristics of the equipment

This protocol is intended to be used by short range devices fulfilling the requirements of EN 300 220-1 [1], EN 300 330 [2] and I-ETS 300 440 [3] as applicable. The use of short range devices (SRD) is also covered in CEPT/ERC Recommendation 70-03 [8].

It is recommended that the spread of the minimum reception sensitivity between all manufactured devices in a system be kept as small as possible. This is in the interests of minimizing data clashes between competing systems.

6 Description of the access protocol

All devices fulfilling the present standard shall use this protocol each time they access the RF channel and the RF channel is to be used only by such devices.

6.1 Channel access duration

The total time during which the channel may be occupied for each access (channel access duration) shall not exceed **the duration given in subclause 7.1.3**. This includes the duration of any acknowledgement or reply from a responding device.

Provided that both the maximum duration of channel occupation (channel access duration) and the reply carrier delay limits are fulfilled, the channel may be occupied by a sequence of any number of transmissions (involving, possibly, replies from one or more transmitters).

If, therefore, a replying device, or devices are required to return data (e.g. for handshake purposes), then the time taken to do this shall be included in the channel access duration.

Transfer of large quantities of data shall be achieved by dividing it up into suitably small packets to satisfy this protocol.

6.2 Principles

For the purpose of channel access, the equipment determines whether or not the channel is free and has been free for the observation time *to* by means of carrier sensing in the channel.

The observation time (see subclause 6.5) consists of a fixed part, a priority part and a pseudo-random additional part. When the channel appears to have been continuously free by the end of the observation time, the transmitter may be initiated and shall be powered up within the specified time (the accessing carrier attack time delay, see subclause 7.7).

The priority part has been included in the observation time for the purpose of giving priority to shorter messages in order to improve their response time chances.

The total duration of the RF carrier emission (access time) is limited (see subclauses 6.1 and 7.1).

The overall duty cycle limitation is given in subclause 6.7.

The number of transmission retries (intended to overcome transmission collisions and corruption) should be limited to a maximum of 5.

6.3 Procedure

In order to gain access to the radio channel the equipment shall determine whether or not the channel is, and has been, free during the observation time t_0, by means of carrier sensing (see subclause 6.4). If the channel appears to be free throughout the observation time and there is information to be sent, the transmission shall then be initiated and RF carrier radiation commenced within the specified time (carrier attack time; see subclause 7.7.1 for definition). Once the channel has been seized it may be occupied for up to the maximum time allowed for a single channel occupancy (see subclauses 6.1 and 7.1).

At the end of a transmission, another observation time may start immediately, unless the duty cycle limit has been reached (subclause 6.7).

If a re-transmission is required (due, for example, to a "collision"), this same process shall be repeated and, once again, the channel shall be detected as being free during the observation time prior to repeating the attempt to transmit.

To ensure that no other user can access the channel during a half duplex access, a maximum Reply carrier delay tc has been defined (see subclause 7.2).

6.4 Carrier sensing

Carrier sensing, or more appropriately channel energy sensing, is the detection of whether the RF level in the receive channel exceeds a given threshold or not.

The carrier sense shall be able to detect RF signals with different types of modulation (e.g. FSK, ASK, PSK, QAM etc.).

The channel shall be regarded as in use during the observation time (see subclause 6.5) if the level of the RF signal on the channel exceeds the threshold given in subclause 7.4.3.

Carrier sensing shall take place throughout the observation time either continuously or at regular intervals not exceeding **250 µs** and the carrier sense delay shall not exceed the limit given in subclause 7.5.3.

6.5 Observation time

The observation time t_0 is the sum of the fixed part tf, the priority part tp and the pseudo random part tr.

t_0 = tf + tp + tr.

The fixed part, tf of the Observation time shall be not less than **5 ms**.

The priority part, tp of the observation time shall be not less than that given in the table in subclause 6.6 (**0 ms** to **8 ms**).

The pseudo random part tr shall consist of a range of ***N*** different values t_i.

The number ***N*** of these different values (t_i) shall not be less than **11.**

The different values (t_i) shall not be less than **1 ms** of each other.

The mean of all these ***N*** values shall not be less than **5 ms**.

The smallest of these different values (t_i) may be **0 ms**.

All of these ***N*** different values (t_i) shall be used in ***N*** successive transmission transactions.

6.6 Message priority delay

A priority delay tp shall be included in each observation time. The value used for tp will be according to the message length and is given in table 1.

Table 1: Message priority delay categories

Category	Data Packet length	Priority delay tp
Very short	not greater than 12 ms	≥ 0 ms
Short	not greater than 25 ms	≥ 2 ms
Normal	not greater than 50 ms	≥ 5 ms
Long	not greater than 100 ms	≥ 8 ms

6.7 Duty Cycle

The duty cycle of devices transmitting messages shall be limited as given for category 3 in duty cycle categories, CEPT/ERC Recommendation 70-03 [8].

Duty cycle limitations are only provided in order to avoid that a device unable to receive correctly may block the channel with an unacceptable Duty cycle.

6.8 Anti blocking

In the case of interference, the channel may appear to be in constant use. In accordance with the protocol defined so far, all the devices should remain in the observation status and the channel would then be "blocked".

In order to avoid the real blocking of all the devices, a mechanism is provided to allow also for channel access in such conditions (see subclause 7.3).

This mechanism is optional, however, this mechanism requires a minimum wait time before channel access is allowed.

Under all circumstances, the duty cycle limitation given in subclause 6.7 applies.

7 Methods of measurement and limits

A special test mode may be used provided that the normal operating characteristics are not affected.

7.1 Channel access duration

7.1.1 Definition

The channel access duration is the time elapsed between the initial access carrier reaching a level of *Pmean* –20 dB and the point at which the power falls to the same level at the end of the transmission or the end of the reply in the case of a multi transmitter communication.

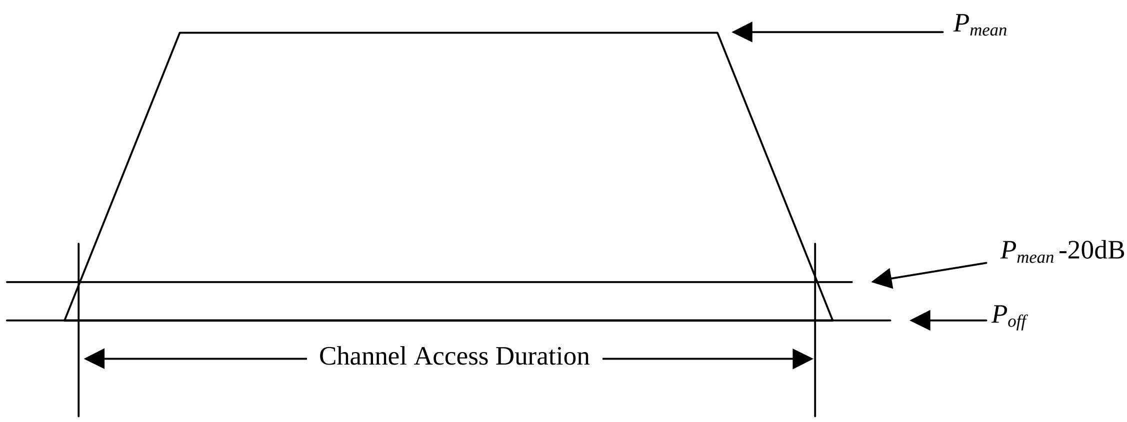

Figure 1: Channel access duration

Devices which are able to initiate a transmission and are transmitting without response to any previous initial transmission from other devices shall also be considered for this measurement (see subclause 7.1.2.1).

A multi transmitter channel access is one in which several transmitting devices access the channel as part of the same message transfer. It consists of an initiating transmission followed by one or several sequential replying transmissions (see subclause 7.1.2.2).

7.1.2 Method of measurement

Two different measurements are required to be performed.

The maximum channel access duration of a device that is able to initiate a data packet transmission (single transmitter, see subclause 7.1.2.1) shall be measured.

The maximum channel access duration for an initiating transmission followed by all devices capable of replying with their transmissions (see subclause 7.1.2.2) shall also be measured.

7.1.2.1 A single transmitter accessing the channel

A measurement shall be made of the time elapsed between the instant when the carrier reaches a level of *Pmean* -20 dB and the instant when the carrier falls to the same level at the end of the transmission. See figure 1.

The duty cycle is required to be measured in conformance with EN 300 220-1 [1]; EN 300 330 [2] and I-ETS 300 440 [3] as applicable.

7.1.2.2 More than one transmitter accessing the channel

A measurement shall be made of the time elapsed between the instant when the carrier of the initiating device reaches a level of *Pmean* -20 dB and the instant when the carrier from the last replying device falls to the same level. See figure 1. All replying carrier delays *tr* during the channel access shall be included in the measurement.

The duty cycle has to be measured in conformance with EN 300 220-1 [1]; EN 300 330 [2] and I-ETS 300 440 [3] as applicable and is given in CEPT/ERC Recommendation 70-03 [8], annex 1.

7.1.3 Limit

Under all conditions and the total channel access duration shall not exceed **100 ms**.

The conditions under which the measurements have been performed shall be included in the test report.

7.2 Reply carrier delay

7.2.1 Definition

The reply carrier delay tc is the time which elapses between the instant when a transmission falls below *Pmean* -20 dB and the instant when the carrier of a replying device reaches *Pmean* -3 dB.

This measurement is applicable only to multi transmitter, channel access.

7.2.2 Method of measurement

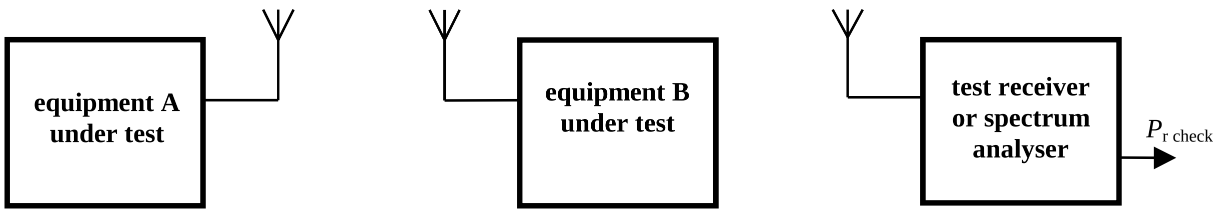

Figure 2: Measurement arrangement for device capable of replying to a communication initiating device

The measurement shall be made of the time elapsed between the instant when the received carrier *Pr check*, at the test receiver, falls by 20 dB (from its mean power level) to the instant when the carrier from the last replying device reaches a level 3 dB below its mean power.

7.2.3 Limit

The reply carrier delay shall not exceed **4 ms**.

7.3 Anti blocking

In the case of interference the channel may appear as blocked. The following measurements are performed to check the anti blocking characteristic of a device. The worst case of blocking interference is a continuous carrier transmission, interrupted by short gaps.

7.3.1 Definition

Anti blocking is the ability of a device to access the channel if the channel has been found to be blocked for more than 600 ms.

7.3.2 Method of measurement

The equipment shall be arranged as shown in figure 3 below, with 3 metres between the device under test and the checking transmitter (to be supplied by the manufacturer).

The device to be tested and a checking transmitter shall be placed on a test bench and shall be separated by a distance of 3 metres.

A test receiver or spectrum analyser shall be used to monitor signals from the equipment under test and the checking transmitter.

The checking transmitter may be a signal generator capable of generating a CW signal at the centre carrier frequency.

The output signal from the checking transmitter shall be able to be switched on and off.

Initially, the level of the test signal shall be set to at least -80 dBm and then adjusted such that a signal received from the equipment under test, displayed on the spectrum analyser, is at least 10 dB higher than that from the checking transmitter.

The checking transmitter shall be keyed on and off continuously with an on time of 12 ms and an off time of 4 ms.

The equipment under test shall be triggered to initiate a channel access. Means shall be available to establish when the device has started to seek channel access.

The time between the equipment under test starting a channel access seek and the appearance of the RF output signal from the equipment under test shall be measured.

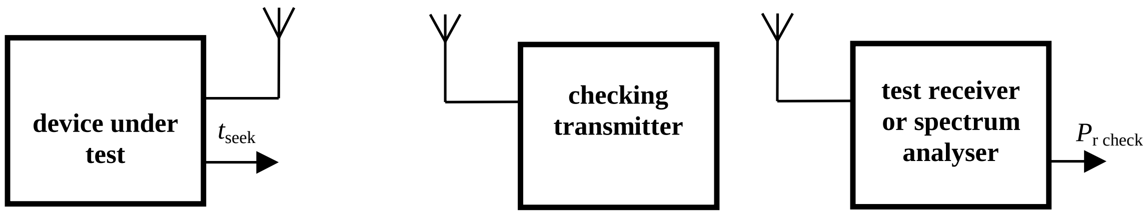

Figure 3: Measurement arrangement for evaluation of the anti blocking characteristic

7.3.3 Limit

A channel access attempt may not begin before **600 ms** has elapsed.

7.4 Carrier sense threshold

7.4.1 Definition

The carrier sense threshold is the minimum level of the input signal which will trigger a change in the status of the carrier sense logic signal.

7.4.2 Method of measurement

The equipment shall be arranged as shown in figure 3 above, with 3 metres between the device under test and the checking transmitter (to be supplied by the manufacturer).

The device under test shall have an appropriate test point available from which a signal exists corresponding / coinciding with the carrier sense logic signal used for the purpose of carrier detection.

The checking transmitter shall have a carrier frequency at the channel centre and have a mean power level equal to that of a transmitter of the system under test (±3 dB) of that of the system transmitter.

The checking transmitter is required to be on for 12 ms and off for 4 ms in a continuous sequence to form a blocking signal.

The device under test shall be triggered with a request to transmit.

The elapsed time shall be measured between the request to transmit event and the instant that the device under test initiates a transmission, or when the carrier sense logic signal changes state.

The carrier of the checking transmitter is required to be decreased until a change in the logical state of the carrier sense signal is noted. Care should be taken in order to avoid that the device under test does not enter an anti blocking procedure (possible after 600 ms of continuous carrier).

The carrier level which has generated an effect in the carrier sense of the device under test shall be noted and maintained continuously.

The device under test shall then be replaced by a measuring receiver and the field strength recorded.

To allow for threshold hysteresis the measurement shall then be repeated for increasing output from the checking transmitter until the 600 ms inhibition starts to occur.

These measurements shall be repeated with the checking transmitter frequency carrier at band centre and at band centre + N and at band centre - N as illustrated in figure 4, where N = channel spacing/3.

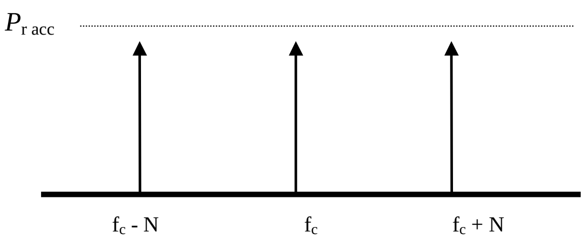

Figure 4: Measurements taken at three carrier frequencies

The carrier sense threshold limit case shall be the highest of the 6 values measured above.

7.4.3 Limit

The carrier sense threshold shall not exceed the level *Pr acc* as defined in table 2, according to the channel spacing that applies.

Table 2: Carrier sense limit versus channel spacing

Carrier sense Limit	Channel Spacing
24 dBµV/m	≤ up to 10 kHz
27 dBµV/m	> 10 kHz to 20 kHz
30 dBµV/m	> 20 kHz to 40 kHz
33 dBµV/m	> 40 kHz to 80 kHz
36 dBµV/m	> 80 kHz to160 kHz
39 dBµV/m	> 160 kHz

7.5 Carrier sense delay

7.5.1 Definition

The carrier sense delay is the time which elapses between a carrier reaching *Pmean* -20 dB and the changing of the state of the carrier sense logic signal.

7.5.2 Method of measurement

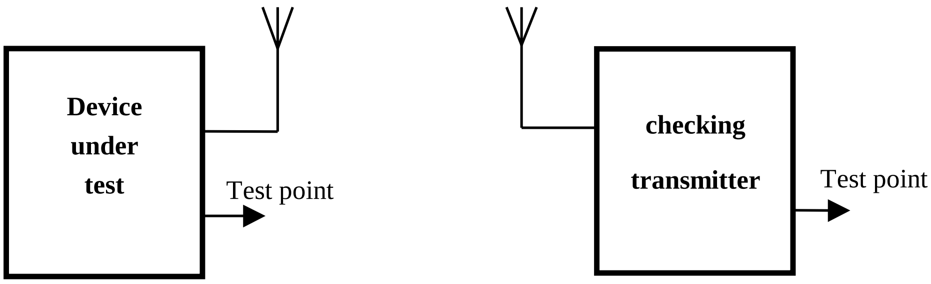

Figure 5: Measurement arrangement for a device's carrier sense delay measurement

The equipment shall be arranged as shown in figure 5 with 3 metres between the device under test and the checking transmitter (to be supplied by the manufacturer).

The device under test shall have an appropriate test point available from which a logical signal, corresponding to the carrier sensing, may be used for the purpose of monitoring carrier detection.

The checking transmitter shall have a carrier frequency at the channel centre and have a mean power level equal to that of a transmitter of the system under test (± 3 dB). The checking transmitter shall have a test point, or similar means, to time the instant that the switched carrier reaches a level 20 dB below its mean power level.

A measurement is to be made of the time between the instant when the checking transmitter crosses the -20 dB point and the changing of the state of the carrier sense signal of the device under test.

The measurement shall be repeated for the carrier on-to-off transition of the checking transmitter. The rise and decay times of the checking transmitter shall not be significant compared with the measurement uncertainty (see clause 9).

The carrier sense delay is the longer of the two delays measured above.

7.5.3 Limit

The carrier sense delay shall not exceed 300 µs.

7.6 Observation time

7.6.1 Definition

The observation time is the time which elapses between the instant that an application makes a request to transmit, to the instant that the carrier reaches *Pmean* -20 dB.

7.6.2 Method of measurement

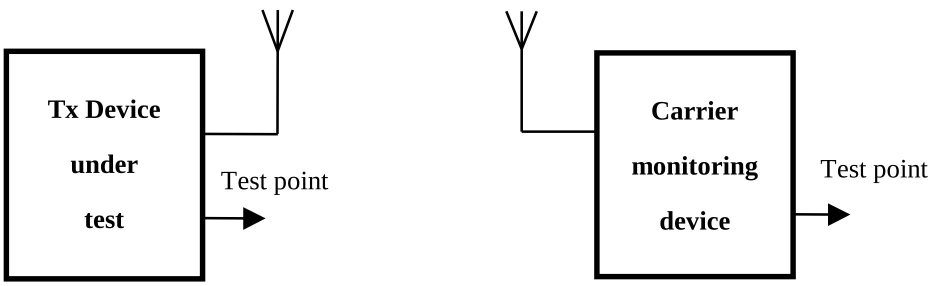

Figure 6: Measurement arrangement for a transmitting device's observation period before transmission

The equipment shall be arranged as shown in figure 6 with 3 metres between the device under test and the carrier monitoring device (supplied by the manufacturer).

The device under test shall have an appropriate test point from which a pulse is produced, the leading edge of which shall coincide with the request to transmit event.

The carrier monitoring device shall provide a signal at its test point output which corresponds to the carrier envelope from the transmitting device. The carrier monitoring device shall not introduce any signal delay greater than 25 µs.

A sequence of measurements should be made from consecutive transmissions. The number of these measurements shall be equal to the number of different values used for the pseudo random part (i.e. not less than 11, information supplied by the applicant).

7.6.3 Limit

The applicant is required to declare which message lengths are expected.

The mean value of all the observation duration measurements made should be as follows:

- for message lengths not greater than 12 ms the mean value of all measurements shall not be less than **10 ms**;
- for message lengths not greater than 25 ms the mean value of all measurements shall not be less than **12 ms**;
- for message lengths not greater than 50 ms the mean value of all measurements shall not be less than **15 ms**;
- for message lengths not greater than 100 ms the mean value of all measurements shall not be less than **18 ms**.

If messages of different lengths have been observed, the appropriate weighting may be applied to the limit values given above.

Details shall be included in the test report.

7.7 Channel accessing carrier attack time

7.7.1 Definition

The channel accessing carrier attack time is the time which elapses between the instant of establishing that a transmission can take place and

- either
  - the moment when the transmitter output power has reached a level 1 dB below or 1,5 dB above the steady state mean power (*Pmean*) and maintains a power level within +1,5 dB / -1 dB from *Pmean* thereafter, as seen on the measuring equipment or in the plot of power as a function of time;
- or
  - the instant after which the carrier frequency remains within a window equal to its mean frequency (fc) ± 10 % of the channel separation as seen on the measuring equipment or the plot of frequency as a function of time;
- whichever occurs later.

7.7.2 Method of measurement

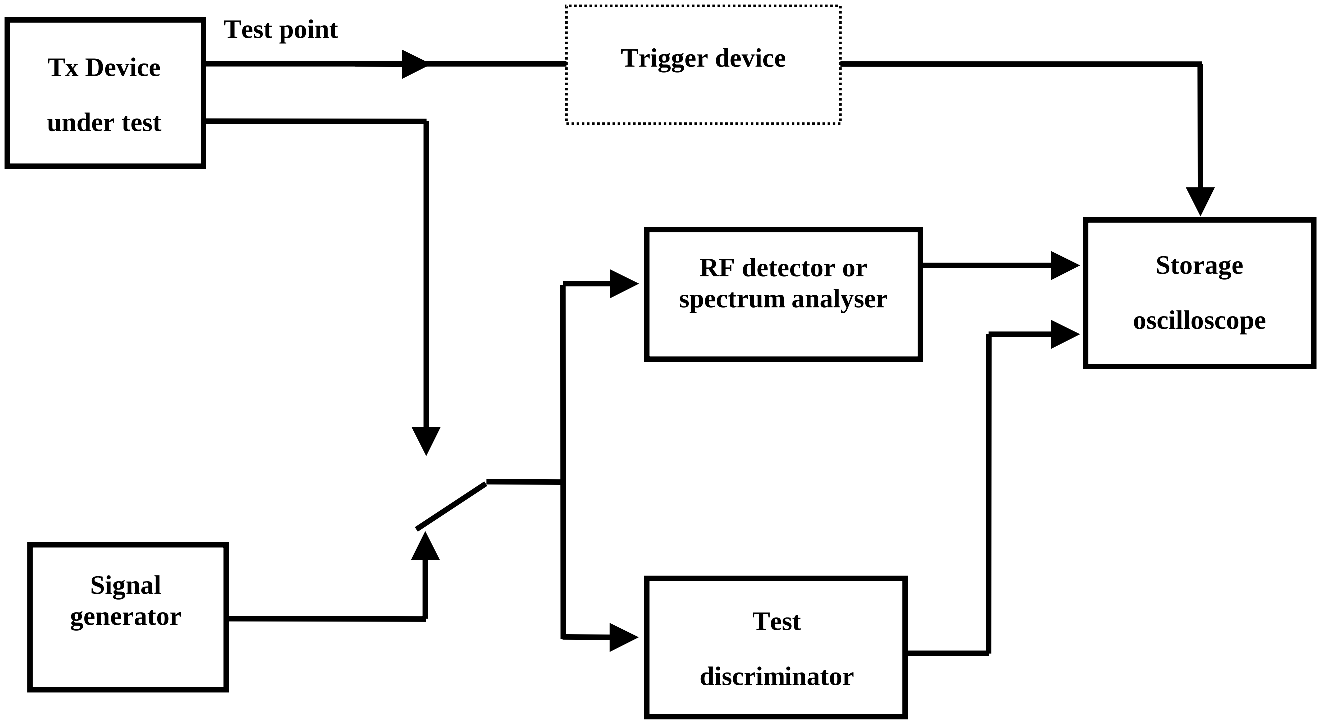

Figure 7: Measurement arrangement for the channel accessing carrier attack time

Figure 7 shows a test arrangement; equivalent methods may be used, in which case these should be documented in the test report.

The measurement procedure shall be as follows:

a) the transmitter is connected to a RF detector and to a test discriminator via a matched test load. The attenuation of the test load shall be chosen in such a way that the input of the test discriminator is protected against overload and the limiter amplifier of the test discriminator operates correctly in the limiting range as soon as the transmitter carrier power (before attenuation) exceeds 1 mW. A dual trace storage oscilloscope (or a transient recorder) records the amplitude transient from the detector (e.g. on a logarithmic scale) and the frequency transient from the discriminator (e.g. on a linear scale);

   a trigger device may be required to ensure that the start of the sweep of the oscilloscope time base occurs at the instant the decision is made that a transmission can take place. The measuring arrangement is shown in figure 7 above;

   a spectrum analyser and a test discriminator / storage oscilloscope can be used;

b) the traces of the oscilloscope shall be calibrated in power and frequency (y-axes) and in time (x-axis), using the signal generator;

c) the channel accessing attack time shall be measured by direct reading on the oscilloscope while the transmitter is preferably unmodulated.

See ETS 300 113 [4] subclauses 8.8 to 8.10 for more detail of this test method.

7.7.3 Limit

The channel accessing attack time shall not exceed 300 µs.

8 Examples of channel access timing

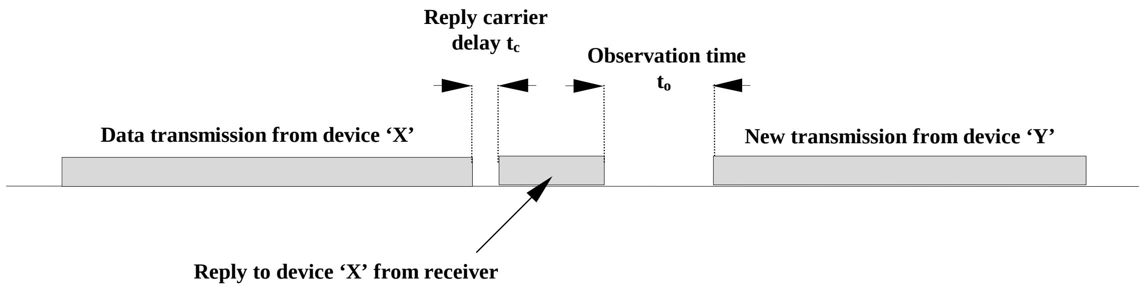

Figure 8: Channel access using half duplex transmission

Figure 8 above shows the RF carriers for transmitter 'X' and transmitter 'Y'. Half duplex communication is illustrated between a sending device 'X' and a corresponding (correctly addressed) receiving device returning an acknowledge / reply. This is followed in turn by a transmission from device 'Y'.

Assuming that device 'Y' is waiting to transmit whilst device 'X' is transmitting, then device 'Y' will detect the carrier gap (during its observation time), but having again detected the presence of a carrier will continue to wait, as illustrated, until the reply to 'X' has finished, according to the rules of the protocol.

Device 'Y' having eventually detected carrier silence (see subclause 6.4) throughout its full observation time (see subclause 6.5), will then commence its transmission.

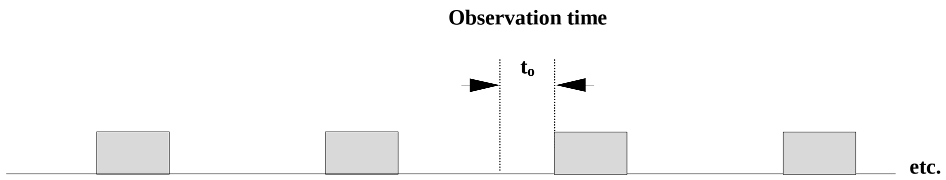

Figure 9: Channel access for a fixed rate-of-change of analogue level control

Figure 9 above illustrates a transmitting device used for a fixed rate-of-change level control. In general, it would be expected that for analogue level control for TV/hi-fi applications, the repeat repetition time would be typically every 115 ms for a 64 step range. For this type of application, typically, only a small number of level steps would be required, lasting a few seconds. In order to achieve the desired repetition rate, the average observation time shall be taken into account (e.g. 10 ms, assuming an access packet length of < 12ms, see table 1 and subclause 7.6.3).

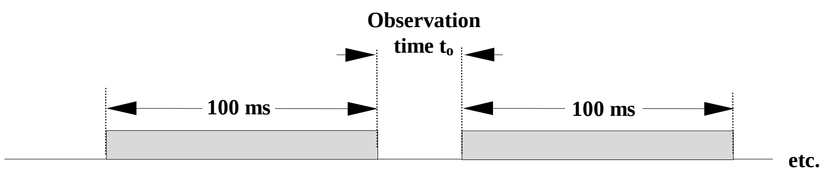

Figure 10: Channel access using maximum transmit time

Figure 10 above illustrates a transmitting device transferring data at the maximum permissible throughput allowed by the protocol. Also in this example there are no other devices competing for the radio channel. A priority delay of 8 ms shall be included in the observation time in this case (see table 1). Such applications are subject to the overall duty cycle specified in subclause 6.7.

9 Measurement uncertainty

Table 3: Absolute measurement uncertainties: maximum values

All timings	5 %

Annex A (normative): Radiated measurement

A.1 Test sites and general arrangements for measurements involving the use of radiated fields

This normative annex introduces three most commonly available test sites, an Anechoic chamber, an Anechoic chamber with a ground plane and an Open Area Test Site (OATS), which may be used for radiated tests. These test sites are generally referred to as free field test sites. Both absolute and relative measurements can be performed in these sites. Where absolute measurements are to be carried out, the chamber should be verified. A detailed verification procedure is described in ETR 273-2 [5], ETR 273-3 [6] and ETR 273-4 [7].

NOTE: To ensure reproducibility and traceability of radiated measurements only these test sites should be used in type test measurements.

A.1.1 Anechoic chamber

An Anechoic chamber is an enclosure, usually shielded, whose internal walls, floor and ceiling are covered with radio absorbing material, normally of the pyramidal urethane foam type. The chamber usually contains an antenna support at one end and a turntable at the other. A typical Anechoic chamber is shown in figure A.1.

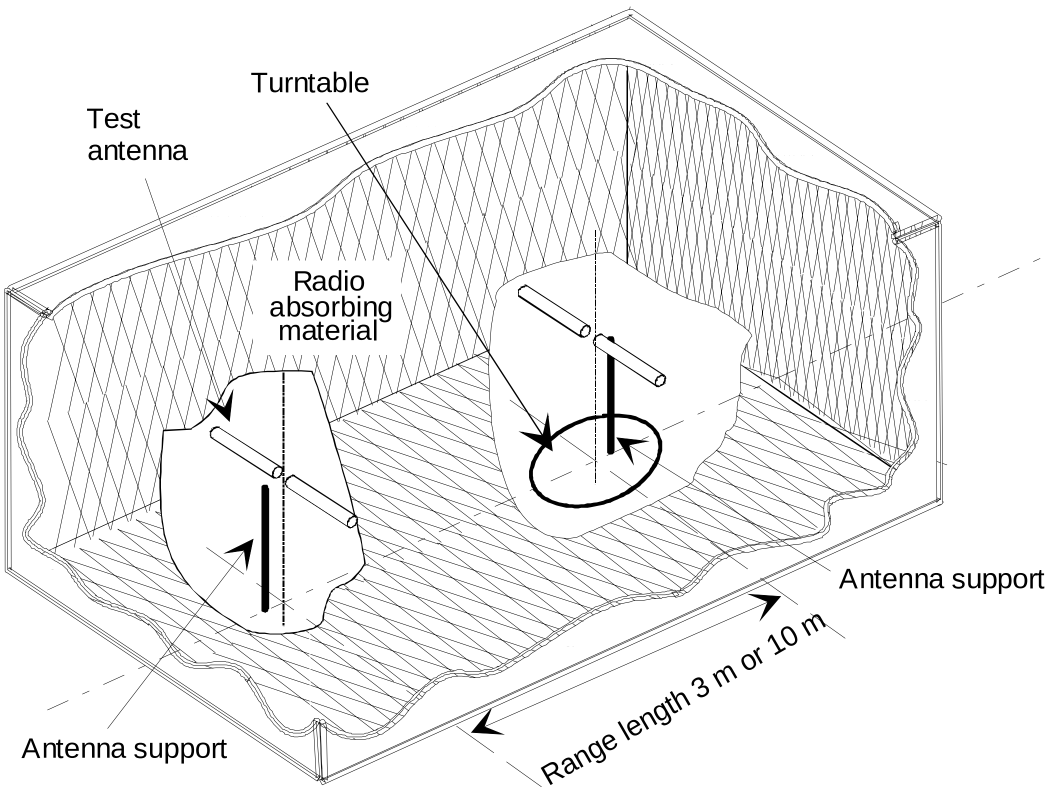

Figure A.1: A typical Anechoic chamber

The chamber shielding and radio absorbing material work together to provide a controlled environment for testing purposes. This type of test chamber attempts to simulate free space conditions.

The shielding provides a test space, with reduced levels of interference from ambient signals and other outside effects, whilst the radio absorbing material minimizes unwanted reflections from the walls and ceiling which can influence the measurements. In practice it is relatively easy for shielding to provide high levels (80 dB to 140 dB) of ambient interference rejection, normally making ambient interference negligible.

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (EUT) at a suitable height (e.g. 1 m) above the ground plane. The chamber shall be large enough to allow the measuring distance of at least 3 m or $2(d_1+d_2)^2/\lambda$ (m), whichever is greater (see subclause A.2.5). The distance used in actual measurements shall be recorded with the test results.

The Anechoic chamber generally has several advantages over other test facilities. There is minimal ambient interference, minimal floor, ceiling and wall reflections and it is independent of the weather. It does however have some disadvantages which include limited measuring distance and limited lower frequency usage due to the size of the pyramidal absorbers. To improve low frequency performance, a combination structure of ferrite tiles and urethane foam absorbers is commonly used.

All types of emission, sensitivity and immunity testing can be carried out within an Anechoic chamber without limitation.

A.1.2 Anechoic chamber with a conductive ground plane

An Anechoic chamber with a conductive ground plane is an enclosure, usually shielded, whose internal walls and ceiling are covered with radio absorbing material, normally of the pyramidal urethane foam type. The floor, which is metallic, is not covered and forms the ground plane. The chamber usually contains an antenna mast at one end and a turntable at the other. A typical Anechoic chamber with a ground plane is shown in figure A.2.

This type of test chamber attempts to simulate an ideal OATS whose primary characteristic is a perfectly conducting ground plane of infinite extent.

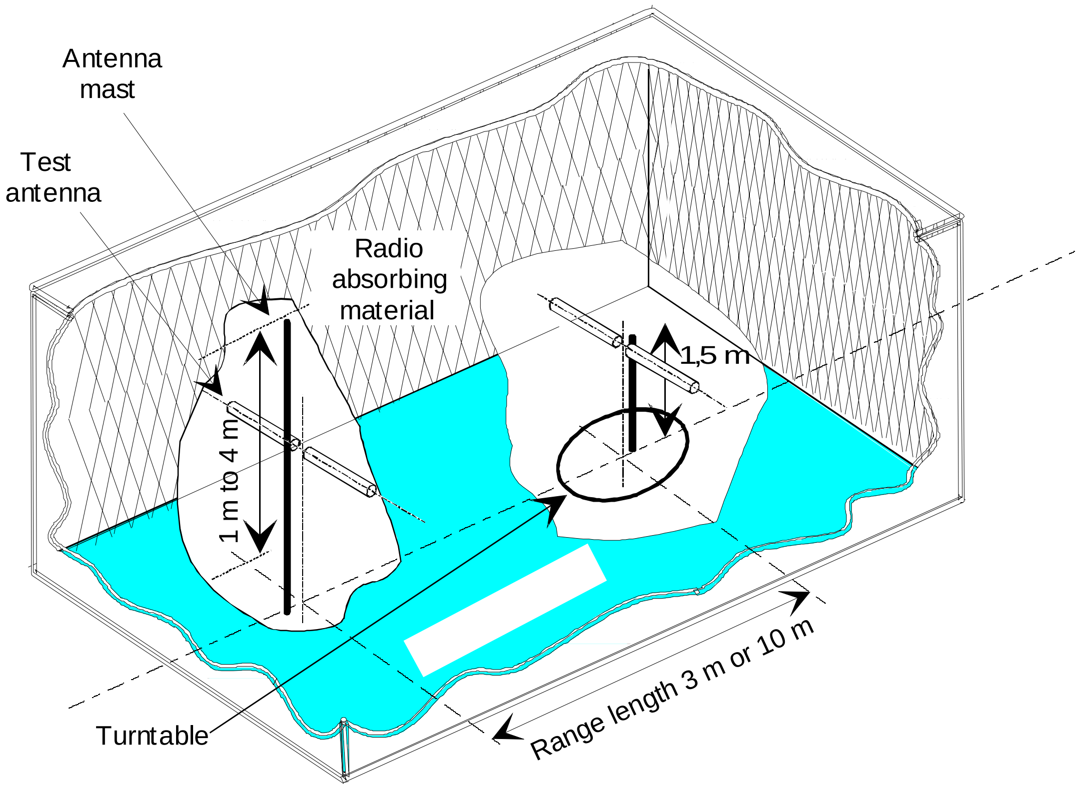

Figure A.2: A typical Anechoic chamber with a conductive ground plane

In this facility the ground plane creates the wanted reflection path, such that the signal received by the receiving antenna is the sum of the signals from both the direct and reflected transmission paths. This creates a unique received signal level for each height of the transmitting antenna (or EUT) and the receiving antenna above the ground plane.

The antenna mast provides a variable height facility (from 1 m to 4 m) so that the position of the test antenna can be optimized for maximum coupled signal between antennas or between an EUT and the test antenna.

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (EUT) at a specified height, usually 1,5 m above the ground plane. The chamber shall be large enough to allow the measuring distance of at least 3 m or $2(d_1+d_2)^2/\lambda$ (m), whichever is greater (see subclause A.2.5). The distance used in actual measurements shall be recorded with the test results.

Emission testing involves firstly "peaking" the field strength from the EUT by raising and lowering the receiving antenna on the mast (to obtain the maximum constructive interference of the direct and reflected signals from the EUT) and then rotating the turntable for a "peak" in the azimuth plane. At this height of the test antenna on the mast, the amplitude of the received signal is noted. Secondly the EUT is replaced by a substitution antenna (positioned at the EUT's phase or volume centre) which is connected to a signal generator. The signal is again "peaked" and the signal generator output adjusted until the level, noted in stage one, is again measured on the receiving device.

Receiver sensitivity tests over a ground plane also involve 'peaking' the field strength by raising and lowering the test antenna on the mast to obtain the maximum constructive interference of the direct and reflected signals, this time using a measuring antenna which has been positioned where the phase or volume centre of the EUT will be during testing. A transform factor is derived. The test antenna remains at the same height for stage two, during which the measuring antenna is replaced by the EUT. The amplitude of the transmitted signal is reduced to determine the field strength level at which a specified response is obtained from the EUT.

A.1.3 OATS

An OATS comprises a turntable at one end and an antenna mast of variable height at the other end above a ground plane which, in the ideal case, is perfectly conducting and of infinite extent. In practice, whilst good conductivity can be achieved, the ground plane size has to be limited. A typical OATS is shown in figure A.3.

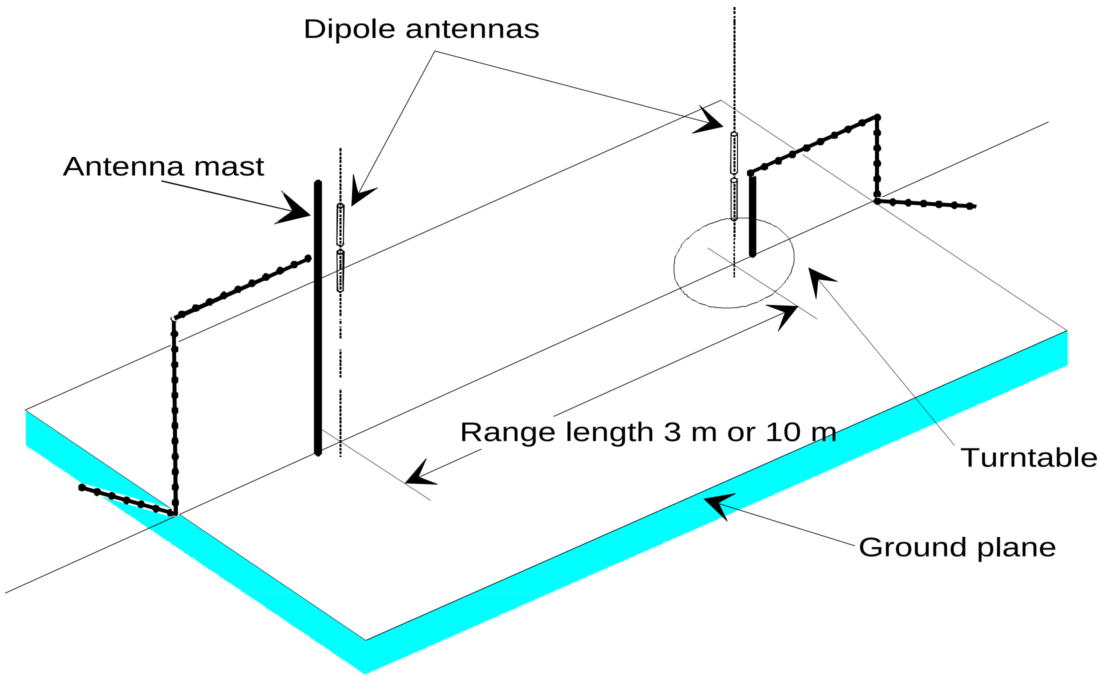

Figure A.3: A typical OATS

The ground plane creates a wanted reflection path, such that the signal received by the receiving antenna is the sum of the signals received from the direct and reflected transmission paths. The phasing of these two signals creates a unique received level for each height of the transmitting antenna (or EUT) and the receiving antenna above the ground plane.

Site qualification concerning antenna positions, turntable, measurement distance and other arrangements are same as for Anechoic chamber with a ground plane. In radiated measurements an OATS is also used by the same way as Anechoic chamber with a ground plane.

Typical measuring arrangement common for ground plane test sites is presented in figure A.4.

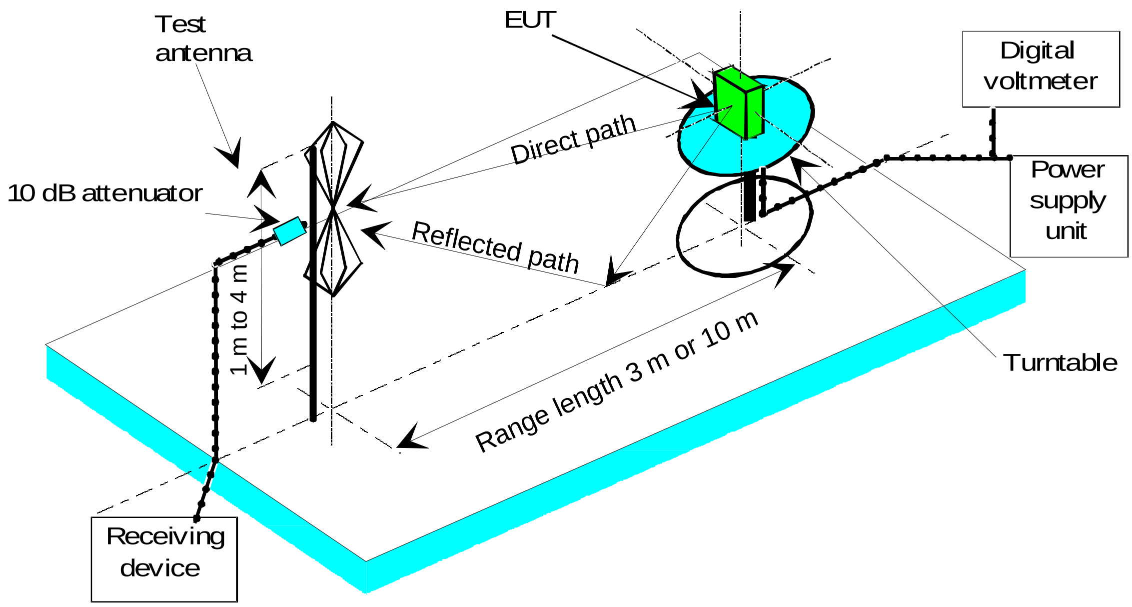

Figure A.4: Measuring arrangement on ground plane test site (OATS set-up for spurious emission testing)

A.1.4 Test antenna

A test antenna is always used in radiated test methods. In emission tests (i.e. frequency error, effective radiated power, spurious emissions and adjacent channel power) the test antenna is used to detect the field from the EUT in one stage of the measurement and from the substitution antenna in the other stage. When the test site is used for the measurement of receiver characteristics (i.e. sensitivity and various immunity parameters) the antenna is used as the transmitting device.

The test antenna should be mounted on a support capable of allowing the antenna to be used in either horizontal or vertical polarization which, on ground plane sites (i.e. Anechoic chambers with ground planes and OATS), should additionally allow the height of its centre above the ground to be varied over the specified range (usually 1 m to 4 m).

In the frequency band 30 MHz to 1 000 MHz, dipole antennas (constructed in accordance with ANSI C63.5) are generally recommended. For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of test. Below 80 MHz, shortened arm lengths are recommended. For spurious emission testing, however, a combination of bicones and log periodic dipole array antennas (commonly termed "log periodics") could be used to cover the entire 30 MHz to 1 000 MHz band. Above 1 000 MHz, waveguide horns are recommended although, again, log periodics could be used.

NOTE: The gain of a horn antenna is generally expressed relative to an isotropic radiator.

A.1.5 Substitution antenna

The substitution antenna is used to replace the EUT for tests in which a transmitting parameter (i.e. frequency error, effective radiated power, spurious emissions and adjacent channel power) is being measured. For measurements in the frequency band 30 MHz to 1 000 MHz, the substitution antenna should be a dipole antenna (constructed in accordance with ANSI C63.5). For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of test. Below 80 MHz, shortened arm lengths are recommended. For measurements above 1 000 MHz, a waveguide horn is recommended. The centre of this antenna should coincide with either the phase centre or volume centre (as specified in the test method) of the EUT it has replaced.

A.1.6 Measuring antenna

The measuring antenna is used in tests on an EUT in which a receiving parameter (i.e. sensitivity and various immunity tests) is being measured. Its purpose is to enable a measurement of the electric filed strength in the vicinity of the EUT. For measurements in the frequency band 30 MHz to 1 000 MHz, the measuring antenna should be a dipole antenna (constructed in accordance with ANSI C63.5. For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of test. Below 80 MHz, shortened arm lengths are recommended. The centre of this antenna should coincide with either the phase centre or volume centre (as specified in the test method) of the EUT.

A.2 Guidance on the use of radiation test sites

This clause details procedures, test equipment arrangements and verification that should be carried out before any of the radiated test are undertaken. These schemes are common to all types of test sites described in this annex.

A.2.1 Verification of the test site

No test should be carried out on a test site which does not possess a valid certificate of verification. The verification procedures for the different types of test sites described in this annex (i.e. anechoic chamber, anechoic chamber with a ground plane and OATS) are given in ETR 273-2 [5], ETR 273-3 [6] and ETR 273-4 [7], respectively.

A.2.2 Preparation of the EUT

The manufacturer should supply information about the EUT covering the operating frequency, polarization, supply voltage(s) and the reference face. Additional information, specific to the type of EUT should include, where relevant, carrier power, CSP, whether different operating modes are available (e.g. high and low power modes) and if operation is continuous or is subject to a maximum test duty cycle (e.g. 1 m on, 4 m off).

Where necessary, a mounting bracket of minimal size should be available for mounting the EUT on the turntable. This bracket should be made from low conductivity, low relative dielectric constant (i.e. less than 1,5) material(s) such as expanded polystyrene, balsa wood, etc.

A.2.3 Power supplies to the EUT

All tests should be performed using power supplies wherever possible, including tests on EUT designed for battery-only use. In all cases, power leads should be connected to the EUT's supply terminals (and monitored with a digital voltmeter) but the battery should remain present, electrically isolated from the rest of the equipment, possibly by putting tape over its contacts.

The presence of these power cables can, however, affect the measured performance of the EUT. For this reason, they should be made to be "transparent" as far as the testing is concerned. This can be achieved by routing them away from the EUT and down to the either the screen, ground plane or facility wall (as appropriate) by the shortest possible paths. Precautions should be taken to minimize pick-up on these leads (e.g. the leads could be twisted together, loaded with ferrite beads at 0,15 m spacing or otherwise loaded).

Details shall be included in the test report.

A.2.4 Volume control setting for analogue speech tests

Unless otherwise stated, in all receiver measurements for analogue speech the receiver volume control where possible, should be adjusted to give at least 50 % of the rated audio output power. In the case of stepped volume controls, to volume control should be set to the first step that provides an output power of at least 50 % of the rated audio output power. This control should not be readjusted between normal and extreme test conditions in tests.

A.2.5 Range length

The range length for all these types of test facility should be adequate to allow for testing in the far-field of the EUT i.e. it should be equal to or exceed:

$$\frac{2\left(d_1 + d_2\right)^2}{\lambda}$$

where:

- d_1 is the largest dimension of the EUT / dipole after substitution (m);
- d_2 is the largest dimension of the test antenna (m);
- λ is the test frequency wavelength (m).

It should be noted that in the substitution part of this measurement, where both test and substitution antennas are half wavelength dipoles, this minimum range length for far-field testing would be:

$$2\lambda$$

It should be noted in the test report when either of these conditions is not met so that the additional measurement uncertainty can be incorporated into the results.

NOTE 1: **For the fully anechoic chamber**, no part of the volume of the EUT should, at any angle of rotation of the turntable, fall outside the "quiet zone" of the chamber at the nominal frequency of the test.

NOTE 2: The "quiet zone" is a volume within the anechoic chamber (without a ground plane) in which a specified performance has either been proven by test, or is guaranteed by the designer / manufacture. The specified performance is usually the reflectivity of the absorbing panels or a directly related parameter (e.g. signal uniformity in amplitude and phase). It should be noted however that the defining levels of the quiet zone tend to vary.

NOTE 3: **For the anechoic chamber with a ground plane**, a full height scanning capability, i.e. 1 m to 4 m, should be available for which no part of the test antenna should come within 1 m of the absorbing panels. For both types of **anechoic chamber**, the reflectivity of the absorbing panels should not be worse than -5 dB.

NOTE 4: **For both the anechoic chamber with a ground plane and the OATS**, no part of any antenna should come within 0,25 m of the ground plane at any time throughout the tests. Where any of these conditions cannot be met, measurements should not be carried out.

A.2.6 Site preparation

The cables for both ends of the test site should be routed horizontally away from the testing area for a minimum of 2 m (unless, in the case both types of **anechoic chamber**, a back wall is reached) and then allowed to drop vertically and out through either the ground plane or screen (as appropriate) to the test equipment. Precautions should be taken to minimize pick up on these leads (e.g. dressing with ferrite beads, or other loading). The cables, their routing and dressing should be identical to the verification set-up.

NOTE: For ground reflection test sites (**i.e. anechoic chambers with ground planes and OATS**) which incorporate a cable drum with the antenna mast, the 2 m requirement may be impossible to comply with.

Calibration data for all items of test equipment should be available and valid. For test, substitution and measuring antennas, the data should include gain relative to an isotropic radiator (or antenna factor) for the frequency of test. Also, the VSWR of the substitution and measuring antennas should be known.

The calibration data on all cables and attenuators should include insertion loss and VSWR throughout the entire frequency range of the tests. All VSWR and insertion loss figures should be recorded in the log book results sheet for the specific test.

Where correction factors / tables are required, these should be immediately available.

For all items of test equipment, the maximum errors they exhibit should be known along with the distribution of the error e.g.:

- cable loss: ± 0,5 dB with a rectangular distribution;
- measuring receiver: 1,0 dB (standard deviation) signal level accuracy with a Gaussian error distribution.

At the start of measurements, system checks should be made on the items of test equipment used on the test site.

A.3 Coupling of signals

A.3.1 General

The presence of leads in the radiated field may cause a disturbance of that field and lead to additional measurement uncertainty. These disturbances can be minimized by using suitable coupling methods, offering signal isolation and minimum field disturbance (e.g. optical and acoustic coupling).

A.3.2 Data Signals

Isolation can be provided by the use of optical, ultra sonic or infra red means. Field disturbance can be minimized by using a suitable fibre optic connection. Ultra sonic or infra red radiated connections require suitable measures for the minimization of ambient noise.

A.3.3 Speech and analogue signals

Where an audio output socket is not available an acoustic coupler should be used.

When using the acoustic coupler, care should be exercised that possible ambient noise does not influence the test result.

A.3.3.1 Acoustic coupler description

The acoustic coupler comprises a plastic funnel, an acoustic pipe and a microphone with a suitable amplifier. The materials used to fabricate the funnel and pipe should be of low conductivity and of low relative dielectric constant (i.e. less than 1,5):

- the acoustic pipe should be long enough to reach from the EUT to the microphone which should be located in a position that will not disturb the RF field. The acoustic pipe should have an inner diameter of about 6 mm and a wall thickness of about 1,5 mm and should be sufficiently flexible so as not to hinder the rotation of the turntable;
- the plastic funnel should have a diameter appropriate to the size of the loudspeaker in the EUT, with soft foam rubber glued to its edge, it should be fitted to one end of the acoustic pipe and the microphone should be fitted to the other end. It is very important to fix the centre of the funnel in a reproducible position relative to the EUT, since the position of the centre has a strong influence on the frequency response that will be measured. This can be achieved by placing the EUT in a close fitting acoustic mounting jig, supplied by the manufacturer, of which the funnel is an integral part;
- the microphone should have a response characteristic flat within 1 dB over a frequency range of 50 Hz to 20 kHz, a linear dynamic range of at least 50 dB. The sensitivity of the microphone and the receiver audio output level should be suitable to measure a signal to noise ratio of at least 40 dB at the nominal audio output level of the EUT. Its size should be sufficiently small to couple to the acoustic pipe;
- the frequency correcting network should correct the frequency response of the acoustic coupler so that the acoustic SINAD measurement is valid (see IEC Publication 60489-3 [9] appendix F).

A.3.3.2 Calibration

The aim of the calibration of the acoustic coupler is to determine the acoustic SINAD ratio which is equivalent to the SINAD ratio at the receiver output.

Bibliography

The following material, though not specifically referenced in the body of the present document (or not publicly available), gives supporting information.

- EN 300 220-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short range devices; Technical characteristics and test methods for radio equipment to be used in the 25 MHz to 1 000 MHz frequency range with power levels ranging up to 500 mW; Part 2: Supplementary parameters not intended for regulatory purposes".
- ETS 300 390: "Radio Equipment and Systems (RES); Land mobile service; Technical characteristics and test conditions for radio equipment intended for the transmission of data (and speech) and using an integral antenna".
- ETSI/STC-RES 02(97)011: "Radio Channel Access Protocol for Short Range Applications".
- FM26(96) 38: Letter from Philips (NL), "Comments to DSI phase 2".
- FM26(96) 120: Letter from Bosch Telecom (D), "Request for frequency".
- FM26(96) 127: Letter from Landis & Gyr,(CH), "Request for frequency".
- FM26(96) 146: Letter from EHSA, "System description for 868 MHz SRD".
- FM26(96) 148: Letter from Philips (UK), "Radio channel access protocol description".
- FM26(96) 155: EACEM letter "Establishing an Access Protocol through the ERO with EHSA collaboration".
- FM26(96) 164: Letter from Bosch Telecom (D), to CEPT/ERC/FM PT26.
- FM26(96) 171: Landis & Gyr (CH), Comments to duty cycle.
- FM26(96) 180: Bandplan comments from LPRA to CEPT/ERC/FM PT26.
- ETSI TC RES(97)016: European Home Systems Association (EHSA) letter of support.
- ETSI/TC RES(97)040, part B 10.3.3: TC RES 22nd meeting.
- EWPS DE/RES02-34.
- ETS 300 471 (1995): "Radio Equipment and Systems (RES); Land mobile service; Access protocol, occupation rules and corresponding technical characteristics of radio equipment for the transmission of data on shared channels".

History

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