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INTERNATIONAL STANDARD

Characteristics of DAB receivers

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CHARACTERISTICS OF DAB RECEIVERS

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 62104 has been prepared by technical area 1, Terminals for audio,video and data services and contents, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

This third edition cancels and replaces the second edition published in 2003. This edition constitutes a technical revision.

The main changes with respect to the previous edition are as follows.

- The document has been updated in line with the development of the DAB system, and in particular the introduction of DAB+ audio services (see ETSI TS 102 563).[1]
- Requirements for displays, text and data applications have been introduced to reflect market trends.

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1 For an overview of the DAB standards, see ETSI TR 101 495.

- Additional test methods have been introduced to allow R.F. measurements to be made on receivers with integrated antennas and/or no external BER indicators by using an acoustic impairment method.
- Clause 6 has been updated to reflect the development of the market and to provide better guidance for the implementation of optional features.

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

FDIS	Report on voting
100/2502/FDIS	100/2541/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 stability date indicated on the IEC website 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.

CHARACTERISTICS OF DAB RECEIVERS

1 Scope

This International Standard describes the digital audio broadcasting (DAB) receiver characteristics for consumer equipment intended for terrestrial and cable reception operating in VHF band III. Dedicated receivers for specific applications are not within the scope of this standard. This standard describes the characteristics for different classes and categories of DAB receivers such as standard and multimedia receivers and domestic, automotive and adapter receivers.

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 60169-10, *Radio-frequency connectors – Part 10: R.F. coaxial connectors with inner diameter of outer conductor 3 mm (0,12 in) with snap-on coupling – Characteristic impedance 50 ohms (Type SMB)*

IEC 60315-1, *Methods of measurement on radio receivers for various classes of emission – Part 1: General considerations and methods of measurement, including audio-frequency measurements*

IEC 60315-4, *Methods of measurement on radio receivers for various classes of emission – Part 4: Receivers for frequency-modulated sound-broadcasting emissions*

IEC 60958-3, *Digital audio interface – Part 3: Consumer applications*

IEC 61169-2:2007, *Radio-frequency connectors – Part 2: Sectional specification – Radio frequency coaxial connectors of type 9,*52

IEC 61169-24, *Radio-frequency connectors – Part 24: Sectional specification – Radio frequency coaxial connectors with screw coupling, typically for use in 75 ohm cable networks (type F)*

IEC 61606 (all parts), *Audio and audiovisual equipment – Digital audio parts – Basic measurement methods of audio characteristics*

IEC 61938, *Multimedia systems – Guide to the recommended characteristics of analogue interfaces to achieve interoperability*

IEC 62106:2009, *Specification of the radio data system (RDS) for VHF/FM sound broadcasting in the frequency range from 87,5 MHz to 108,0 MHz*

ISO/IEC 10646, *Information technology – Universal Coded Character Set (UCS)*

ISO/IEC 11172-3, *Information technology – Coding of moving pictures and associated audio for digital storage media at up to about 1,5 Mbit/s – Part 3: Audio*

ISO/IEC 13818-3, *Information technology – Generic coding of moving pictures and associated audio information – Part 3: Audio*

ISO/IEC 14496-3 *Information technology – Coding of audio-visual objects – Part 3: Audio*

ISO/IEC 23003-1:2007, *Information technology – MPEG audio technologies – Part 1: MPEG Surround*

ISO 20860-1, *Road vehicles – 50 ohms impedance radio frequency connection system interface – Part 1: Dimensions and electrical requirements*

ETSI EN 300 401:2006, *Radio Broadcasting Systems; Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers*

ETSI EN 301 234, *Digital Audio Broadcasting (DAB); Multimedia Object Transfer (MOT) protocol*

ETSI TS 101 498, *Digital Audio Broadcasting (DAB); Broadcast Website*

ETSI TS 101 499, *Digital Audio Broadcasting (DAB); SlideShow; User Application Specification*

ETSI TS 101 756, *Digital Audio Broadcasting (DAB); Registered Tables*

ETSI TS 101 757, *Digital Audio Broadcasting System (DAB); Conformance Testing for DAB Audio*

ETSI TS 102 371, *Digital Audio Broadcasting (DAB); Digital Radio Mondiale (DRM); Transportation and Binary Encoding Specification for Service and Programme Information (SPI)*

ETSI TS 102 428, *Digital Audio Broadcasting (DAB); DMB video service; User Application Specification*

ETSI TS 102 563, *Digital Audio Broadcasting (DAB); Transport of Advanced Audio Coding (AAC) audio*

ETSI TS 102 652, *Digital Audio Broadcasting (DAB); Intellitext; Application spe*cification

ETSI TS 102 818, *Hybrid Digital Radio (DAB, DRM, RadioDNS); XML Specification for Service and Programme Information (SPI)*

ETSI TS 102 979, *Digital Audio Broadcasting (DAB); Journaline; User application specification*

ETSI TS 102 980, *Digital Audio Broadcasting (DAB); Dynamic Label Plus (DL Plus); Application specification*

ETSI TS 103 176, *Digital Audio Broadcasting (DAB); Rules of implementation; Service information features*

COST 207, *Digital Land Mobile Radio Communications* – COST 207, Commission of the European Communities, Final Report, 14 March 1984 – 13 September 1988, Office for Official Publications of the European Communities, Luxembourg,1989

3 Terms and definitions

For the purposes of this document, the following definitions apply. Other definitions, abbreviations and symbols are solely related to DAB unless stated otherwise.

3.1
bit error rate
BER
ratio of the number of bits received inverted to the total number of bits sent

3.2
DAB receiver
receiver intended to receive and decode signals transmitted according to the DAB system specification ETSI EN 300 401

Note 1 to entry: Figure 1 shows an example of a functional block diagram of a DAB receiver according to ETSI EN 300 401 (for information only).

3.3
standard radio receiver
DAB receiver intended to present audio programmes with at least an alphanumeric display

3.4
multimedia receiver
DAB receiver intended to present audio programmes and data applications with a colour display of at least (320 × 240) pixels

3.5
minimum requirement
lowest value that a DAB receiver should fulfil in order to be called a DAB receiver

Note 1 to entry: It takes into account low-cost receivers.

3.6
DAB service
service in which the primary service component is encoded in a stream audio sub-channel according to ETSI EN 300 401:2006, Clause 7

3.7
DAB+ service
service in which the primary service component is encoded in a stream audio sub-channel according to ETSI TS 102 563

3.8
DMB service
service in which the primary service component is encoded in a stream data sub-channel according to ETSI TS 102 428

3.9
data service
service in which the primary service component is encoded in a stream data or packet data sub-channel

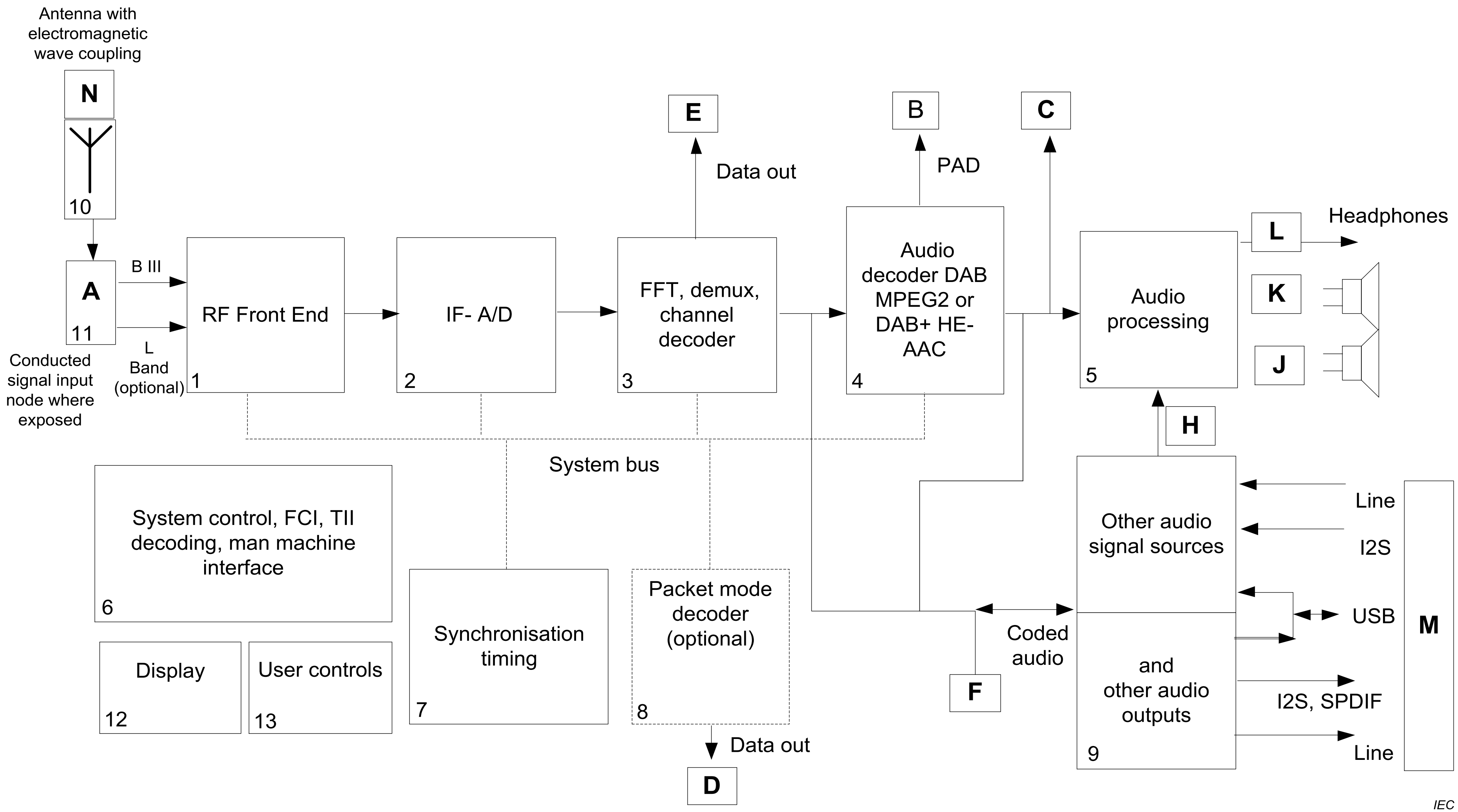
3.10
capacity unit
CU
smallest addressable portion of a DAB multiplex

3.11
dynamic label
DL
text message from the broadcaster for display on receivers

3.12
fast information group
FIG
signalling information from the broadcaster which is used by the receiver

3.13
MPEG surround
system providing mono and stereo compatible coding of surround audio

3.14
onset of impairment
OOI
point at which audio impairments reach a threshold of three per 10 s listening period



Key The numbers in the corners refer to blocks.

NOTE Block 8 is optional, block 9 is not part of the DAB receiver.

Figure 1 – Example of a functional block diagram of a DAB receiver

4 Basic implementation and functional performance requirements

4.1 Automatic mode selection

4.1.1 General

Four different transmission modes are defined: modes I, II, III and IV. Radiofrequency characteristics are described in Clause 15 of ETSI EN 300 401:2006.

The modes can be detected by checking the following relevant parameters of the DAB signal: the frame duration, null-symbol duration and carrier spacing.

4.1.2 Requirements

The receiver shall detect the mode of the DAB signal and switch to the appropriate reception mode.

4.2 Frequency bands

The receiver shall provide reception of at least one DAB ensemble, in the following r.f. band:

Band III: 174 MHz to 240 MHz

Cable and other specific requirement receivers may also provide reception in other r.f. bands.

The centre frequencies are given in Annex A. The receiver should be able to correctly deal with transmitter frequency offsets by up to ±1/2 of the carrier spacing.

4.3 Channel decoder

4.3.1 Standard receiver

The channel decoder shall decode at least one sub-channel and shall be capable of decoding:

– when containing a DAB service, at least 280 capacity units;
– when containing a DAB+ service , at least 144 capacity units.

4.3.2 Multimedia receiver

The channel decoder shall be capable of decoding at least four sub-channels simultaneously and shall be capable of decoding at least 288 capacity units.

4.4 Service selection

4.4.1 General

The main service channel (MSC) and the fast information channel (FIC) carry the components and multiplex configuration information (MCI) respectively of the services which make up a DAB ensemble.

Each service has one or more service components. Several services may be carried in one ensemble. Service components may be audio or data. DAB, DAB+, DMB and data services all may be present in the same ensemble.

A user of a DAB receiver accesses service components by selecting a service. Only services that contain a primary service component that the receiver can decode shall be presented to the user for selection.

4.4.2 Requirements

To gain access to the desired service, the receiver shall decode the MCI, make the information available to the man-machine interface (MMI) for selection, and then output the selected service. Receivers shall actively decode and act upon changes in the signalled MCI.

Selecting a service which consists of a primary audio component with associated data applications shall cause the data applications to be output automatically (provided the receiver has the appropriate decoders), whether carried as PAD or as a secondary service component in packet mode, with or without additional FEC.

If a device supports a specific data application type, then this data application type shall be accessible to the user whether signalled as PAD (associated to an audio programme), as a secondary service component or as a stand-alone data service.

For a multimedia receiver, service selection shall be provided by means of a service guide populated with information from received service and programme information (SPI).

4.5 Receiver reactions to a multiplex reconfiguration

Information on a multiplex reconfiguration is provided in advance to the receiver by the use of the change flags and occurance change field in FIG 0/0 and other MCI FIGs. This information includes the following parts:

- the type of a forthcoming multiplex reconfiguration (sub-channel, service, both);
- the time when the receiver shall switch according to the MCI (occurance change);
- the next MCI.

The receiver shall follow the multiplex reconfiguration seamlessly (i.e. with no audible artifacts, no loss of synchronisation, nor that any user interaction is needed, etc.) even if:

- the sub-channel of the currently decoded service component(s) is changed and/or the packet address of a packet mode service component is changed;
- the bit rate and/or protection level is changed;
- the FEC level is changed (for packet mode service components);
- new service components are added or removed (as long as the currently decoded service component is not removed).

In cases where an audio service is no longer available, a suitable information message and audio silence shall be presented to the listener.

In cases where an audio secondary component is no longer available, the corresponding primary audio service component shall be presented to the listener.

4.6 Audio decoder

4.6.1 General

The audio decoder function of a DAB receiver shall permit the decoding of DAB and DAB+ services.

The audio decoder function shall correctly handle audio streams with surround content as described in ISO/IEC 23003-1:2007 (MPEG surround). Even if surround decoding is not supported, receivers shall decode such audio streams as regular mono or stereo content without any malfunction.

4.6.2 DAB services

The audio decoder shall conform to the subset of ISO/IEC 11172-3 as defined in ETSI EN 300 401. The conformity is described in ETSI TS 101 757. The audio decoder should include an error concealment method which may be based on the scale factor-cyclic redundancy check (ScF-CRC) as defined within ETSI EN 300 401. If, for any reason, the data stream cannot be decoded, the receiver shall mute.

The audio part shall be able to decode DAB bitstreams corresponding to both 24 kHz and 48 kHz sampling frequencies.

It shall comply with ISO/IEC 11172-3 and ISO/IEC 13818-3 (bit-rates above 256 kbit/s are optional).

4.6.3 DAB+ services

The audio decoder shall conform to the subset of ISO/IEC 14496-3 as defined in ETSI TS 102 563 including the error concealment function in Annex A. If, for any reason, the data stream cannot be decoded, the receiver shall mute.

The audio part shall be able to decode DAB+ bitstreams corresponding to all sampling frequencies defined in ETSI TS 102 563.

4.7 Automatic switching to another ensemble

In order to allow service following of a particular DAB service, the ability of an automotive DAB receiver to switch automatically to another ensemble is mandatory. Service following shall be as described in ETSI TS 103 176. Receivers shall actively decode and act upon changes to the service following information.

4.8 Response to conditional access (CA) services

4.8.1 General

In DAB some service components belonging to a service may be individually encrypted to make these components incomprehensible for unauthorized users.

4.8.2 Requirements for DAB receivers without CA capabilities

These receivers shall not make encrypted service components available for selection.

Special care shall be taken in the transition from "unencrypted" to "encrypted". When this occurs on one of the selected service components, the receiver shall mute the audio in the case of an audio component. A data component shall continue to be decoded depending on the capabilities of the receiver. In all cases where the encryption has changed, an appropriate indication shall be given.

NOTE CA capabilities are optional.

4.9 Output for audio and other services

4.9.1 General

The DAB system provides both programme and data services.

Programme services are comprised of an audio primary service component and optionally additional secondary service components. Each audio service component can also contain programme associated data (PAD) which is used to convey information intimately linked to the sound programme in terms of content and synchronization.

Data services comprise non-audio primary service components and may optionally have additional secondary service components.

4.9.2 Requirements

The DAB receiver shall output the audio signal to, for example, loudspeakers and/or provide other outputs via one of the interfaces specified in Clause 5.

4.10 Display

4.10.1 Standard receiver

The display shall be capable of displaying all the characters from the "Complete EBU Latin based repertoire" (= 0000 in ETSI TS 101 756).

For simple displays only (e.g. starburst), characters shall be displayed in the simplified form indicated in ETSI TS 101 756 (for example by presenting accented characters as the unaccented equivalent). However, manufacturers should be aware that these displays may make text unintelligible in many languages.

4.10.2 Multimedia receiver

The display shall be capable of displaying all the characters from the extended RDS character set (see Table E.2 of IEC 62106:2009) encoded using "Complete EBU Latin based repertoire" (= 0000 in ETSI TS 101 756), "ISO/IEC 10646 using UCS-2 transformation format" (= 0110 in ETSI TS 101 756) and "ISO/IEC 10646 using UTF-8 transformation format" (= 1111 in ETSI TS 101 756).

The display shall have a graphics resolution of at least (320 × 240) pixels and a colour depth of at least 8 bit.

4.11 Text labels

4.11.1 Standard receiver

The receiver shall display the service label when a primary audio component is selected. The receiver shall display the service component label when a secondary audio component is selected.

Receivers which have a display with more than one row of characters shall display the whole of the dynamic label, when contained within the PAD of the tuned service, in a readable form. Whenever the display allows it, the dynamic label should be presented in its entirety without scrolling.

The dynamic label shall be decoded even if other PAD applications (e.g. SlideShow) are present.

Automotive receivers within view of the driver shall not animate or scroll the dynamic label by default.

Receivers shall immediately blank the dynamic label when a "remove label" command is received.

4.11.2 Multimedia receiver

In addition to the requirements for the standard receiver, the multimedia receiver shall decode and present FIG type 2 extended labels.

The receiver shall decode dynamic label Plus (see ETSI TS 102 980) and Intellitext (see ETSI TS 102 652) and offer the user the option of presenting the dynamic label according to these applications. When DLplus is active, the receiver shall only react to the dynamic label "remove label" command when the dynamic label is displayed (i.e. DLplus tag items do not need to be removed if currently displayed).

4.12 Data applications

4.12.1 Standard receiver

No minimum requirement.

4.12.2 Multimedia receiver

The receiver shall incorporate a packet mode decoder, including additional FEC decoding of the sub-channel. The receiver shall incorporate a PAD decoder. The receiver shall incorporate an MOT decoder (ETSI EN 301 234). The receiver shall incorporate a SlideShow decoder (ETSI TS 101 499). The receiver shall incorporate an SPI decoder (ETSI TS 102 818, ETSI TS 102 371). The receiver shall incorporate a Journaline decoder (ETSI TS 102 979).

The requirements of service selection (see 4.4) apply to these data applications (i.e. these data applications shall be accessible to the user whether signalled as PAD (associated to an audio programme), as a secondary service component or as a stand-alone data service).

The receiver shall automatically decode and present the SlideShow application or the Journaline application when an audio service is selected that includes these applications, carried either in PAD or as secondary service component in a packet mode sub-channel. If both SlideShow and Journaline are included, then the SlideShow shall be presented automatically and the user provided with means to select the Journaline application if it is not possible to present both service components simultaneously on screen.

The receiver shall allow the user to access the SPI content.

5 Interfaces

5.1 General

If any of the following interfaces are applied, the standardized versions described should be used.

Dedicated solutions, which do not require connections to other standard products, may use special interfaces.

5.2 RF input

5.2.1 General

The RF input to domestic receivers and automotive receivers may be in principle

a) an antenna which couples to the radio wave – Node “N” in Figure 1, or
b) an RF connector node “A” in Figure 1, where the antenna may be distant from the receiver and attached to the RF connector with a length of cable, or directly attached to the connector.

5.2.2 Domestic and portable receivers

An antenna connector may or may not be fitted to domestic receivers; if fitted, it shall be as follows:

Type F	female	75 Ω	per IEC 61169-24
or			
UHF	female	75 Ω	per IEC 61169-2:2007

5.2.3 Automotive receivers

5.2.3.1 Antenna connection

Receivers shall be fitted with an antenna connection as follows:

RF standard core:

Type SMB	male	50 Ω	per IEC 60169-10
Headshell, latch:			
Type Fakra (SMBA)	with latch		per ISO 20860-1

5.2.3.2 Automotive active antennas

The installed antenna performance is critical to the overall sensitivity performance DAB receiver. In order to show a meaningful performance, antenna passive gain shall be measured in a representative automotive setting over the frequency band specified in the product specification at least for three frequencies, and directional performance measured in the horizontal polar response. When measured with a supply voltage in the range 7 V to 16 V, this is the performance requirement for an automotive antenna (see Table 1):

Table 1 – Performance requirement for an automotive active antenna

Parameter	Min.	Typ	Max.	Units	Comments
Measured with LNA Supply voltage, VB	7,0		16,0	V	LNA shall operate with a supply in this range
Current consumption of the LNA		50	80	mA	at 14 V = VB
Radio frequency range	174		240	MHz	
Band III passive gain averaged over minimum 24 horizontal polar points, at receiver end of cable.	–2,9			dBi	Equivalent passive gain; E field vertical. Measured at a maximum of 15° angles in a horizontal polar plane. Measured at least at top, mid and bottom frequencies, specified for operation. Result shall be the average over all angular and frequency points measured.
On – Vehicle directivity – drop in passive gain at any polar angular interval measurement point.			10	dB	Allowable peak to peak dB variation in antenna receptivity measured at any measurement point relative to the average passive gain of the horizontal polar response.
Gain of the LNA		5 to 12		dB	
LNA gain change with supply voltage	–2		+2	dB	
LNA gain variation with temperature, –40 °C to +70 °C	–2		+3	dB	
Noise figure, NF			<1,5	dB	

Parameter	Min.	Typ	Max.	Units	Comments
Large-signal tolerance (IM3) at two output levels, V_{out}	$V_{out} > 112$			dBμV	60 dB Intermodulation
Output impedance		50		Ω	
Return loss, S11	10			dB	Equivalent to VSWR < 2,0:1
Antenna connector					IEC 60169-10 (SMB, male 50 Ω)
EMC and ESD					Shall at least meet national EMC standards.

5.3 Analogue audio interface (see IEC 61938)

The DAB receiver may optionally provide an interface/output of the selected audio service component and/or an external interface/input according to IEC 61938 (see L, K, J and H respectively in Figure 1).

5.4 Digital audio interface (see IEC 60958-3)

The DAB receiver may optionally provide an interface/output of the selected audio service component according to IEC 60958-3 (see C in Figure 1).

6 Options

6.1 General

The features given in 6.2 to 6.5 are not mandatory for DAB receivers but are recommended.

6.2 Service lists

To ensure the user has access to a complete set of services from which to make his selection, it is necessary for the receiver to maintain a list of user choices that the receiver supports, for example radio programmes and data services. A receiver presents the choices in the form of a list using the service labels and service component labels.

Initially the list of user choices should be assembled by a receiver carrying out a service discovery routine. An example would be:

a) a fast frequency band scan to discover DAB ensembles;
b) tune to each DAB ensemble in turn and acquire the list of user choices. It is recommended that the FIC decoder remains synchronised for at least two consecutive stable repetitions of the label information to ensure that all essential service information is aquired.

Special care should be taken to ensure that services available on more than one ensemble are added to the list correctly, using information such as signal strength, signal quality and service following information, and that only one choice is presented to the user. The list of user choices should be maintained from information gathered from each tuned ensemble, including the introduction of new services.

The presentation of the list of user choices may be enhanced by using service and programme information when available. The information from all received sources should be combined within the receiver.

6.3 Display

6.3.1 General

It is recommended in order to display meaningful textual information to the user, that the minimum dimensions of the display should be 2 rows of 16 characters, with sufficient character rendering resolution to make the display intelligible, e.g. bitmapped characters. Starburst displays have a limited definition which means reduced intelligibility for most languages since accents cannot be applied to characters which is likely to reduce acceptability in those markets.

6.3.2 Service labels and service component labels

It is recommended that all receiver types use the long label definition (up to 16 characters) for labels in preference to the short form definition (up to 8 characters).

6.3.3 Dynamic label

A receiver should correctly handle the dynamic label formatting character codes when present.

It is recommended that receivers with small displays should use the dynamic label formatting character codes Code 0A (hex) and Code 0B(hex) to indicate a preferred line break and end of headline respectively.

6.3.4 Signal quality indicator

It is recommended that a receiver should be capable of visually displaying the signal quality and a standardised presentation is suggested here. A standardised format will aid all users to adopt the feature more rapidly, because the format will become universal and familiar and so users will get more value from it.

The signal quality will be calculated from the BER measurement performed on the MSC.

The displayed signal quality information will have an update rate of at least 2 Hz so that the user is presented with relatively real-time information in relation to factors that allow optimisation of the signal level, e.g. positioning of receiver, moving antenna, or adjusting RF feeds.

For non-graphical user interfaces, a numerical representation using three digits over the range 000 to 100, where 100 = high signal quality (low BER) is recommended.

For graphical user interfaces, bar graph representation is recommended, with at least 8 segments in a line where high signal quality is to the right (horizontal orientation) or top (vertical orientation). The scaling should position the 10^{-4} Gaussian BER mark between 30 % and 45 % of the full scale position, using a fixed “cursor” (i.e toward the left-hand side or bottom of the graph). The purpose of this is to make the zone of marginal reception more obvious to the user.

6.3.5 Audio coding information

It is recommended that the receiver should not be capable of displaying the audio coding parameters and bit-rate information to the user.

6.4 Other receiver features

6.4.1 Time and date

Correct presentation of the time and date requires decoding of both FIG 0/10 and FIG 0/9 to provide the local time offset (LTO). Both the long form and short form of the time field should be decoded.

6.4.2 Service following

When a DAB receiver incorporates an FM tuner, the receiver should support service following from DAB to FM and vice versa according to ETSI TS 103 176. A receiver will prefer digital where possible.

6.4.3 Announcements

Interruptions to the tuned programme from audio announcements are only allowed when the received FIG 0/18 provides the correct permissions, including the value of the ClusterId. The user interface needs to provide a means for the user to enable and disable different announcement types.

At the end of an announcement, the receiver returns to the previously tuned programme.

If, during an announcement, the signal is lost, the receiver should initially attempt to recover the announcement service (including verifying FIG 0/19 information to determine if the announcement is still ongoing), but after a time period of, for example, 5 s, should attempt to return to the previously tuned service.

6.4.4 Dynamic range control (DRC)

When implemented in automotive receivers, it is recommended to enable the feature by default.

6.5 Data features

6.5.1 Journaline

Standard receivers with a screen size of at least 2 rows of 16 characters may incorporate a Journaline decoder by implementing at least subclause 7.1 of ETSI TS 102 979. Standard receivers that can only decode one sub-channel are only able to decode a PAD-based Journaline service of the tuned audio service or a Journaline data service, whereas those with greater capability are also able to decode Journaline in a secondary packet mode service component of the tuned audio service.

Data caching should be implemented on all receiver platforms that have suitable cache memory available. In addition, persistent storage can be used to improve access times after tuning back to previously received Journaline services.

If supported by receiver hardware, the following Journaline features can be implemented.

a) Text-to-speech (on devices with text-to-speech engine). Text-to-speech functionality is recommended for mobile devices like smartphones or automotive receivers. Text-to-speech should also be used on Journaline enabled devices that are designed for visually impaired users. The quality of text-to-speech conversion can be enhanced by using the optional phonem descriptions, embedded in the Journaline data stream.
b) Phone links for direct phone calls and SMS links for sending pre-formatted SMS messages (on devices with telephone or VoIP).
c) http links (on devices with Webbrowser and Internet access, like Smartphones, PCs, etc.).

d) eMail links (on devices with e-mail function like Smartphones, PCs, etc.).

e) Location-based content filter (location-aware devices). The location can be determined by GPS or other applicable methods.

f) Forwarding/processing of address information (on devices with navigation or map display function).

6.5.2 Broadcast website (BWS)

Broadcast website may be implemented according to ETSI TS 101 498. The implementation should support the unrestricted PC profile.

6.5.3 TPEG services

When implemented, the appropriate TISA guidelines should be followed.

7 Minimum performance levels and measuring methods

7.1 General conditions

7.1.1 General – Published specifications for receivers

A comprehensive specification shall contain all the performance values in accordance with Clause 7. Abbreviated specifications may be published in addition. In both cases, the published values of all the characteristics shall be measured by the methods specified here. There should be a statement to that effect in the text or footnotes of the measuring results. For example, this might read "measured in accordance with IEC 62104". All measuring results shall be published for all frequency bands covered.

7.1.2 Power supply

The power supply shall be in accordance with IEC 60315-1.

7.1.3 Atmospheric conditions

The atmospheric conditions for measurement shall be within the ranges:

Ambient temperature:	15 °C to 35 °C
Relative humidity:	25 % to 75 %
Atmospheric pressure:	86 kPa to 106 kPa

For further information, see IEC 60068-1, IEC 60721 and IEC Guide 106.

7.1.4 BER measurement conditions

The bit-error ratio (BER) shall be measured at the receiver's convolutional decoder output, such as "E" in Figure 1. During the measurement, the receiver should remain synchronized. Unless otherwise noted, BER measurements shall be performed in the MSC, using an equal error protection (EEP) sub-channel with code rate 1/2.

Any known digital pattern with a length of more than one symbol can be used as test sequence. For example, either all zeros or a test pattern conforming to ITU-T Recommendation O.151 would be suitable.

7.1.5 Acoustic onset of impairment (OOI) measurement conditions

For receivers without access to the internal nodes for BER data measurements over wires, e.g. integrated receivers where only an acoustic output such as a speaker is accessible, it is possible and useful to make an assessment of performance by direct analysis of the onset of impairment (OOI) at the acoustic output at J or K or L or M.

For DAB and DAB+, the OOI point is quite sharply defined as the receiver C/N degrades and BER increases, so this can be used as a means to assess the ability of the receiver. The OOI method can be implemented so that it is equivalent to a BER of 10^{-4}. The method involves monitoring (by a human observer or, if available, automated equipment) of an encoded 1 kHz audio sinewave from the audio output source (speaker, headphone, etc) and setting the RF signal level where an average of three audio defects (dropouts, burbles, “chirps” etc.) can just be heard in the sinewave in each of three 10 s-listening periods. This RF level is the OOI threshold for sensitivity.

The accuracy and repeatability of this measurement is a function of the control of the test method and measurement conditions as detailed in 7.3.3, and 7.4.4.

7.1.6 DAB signal

The generated DAB signal shall be in accordance with ETSI EN 300 401. The DAB signal power is defined as the r.m.s. power of the DAB ensemble.

7.1.7 Receiver classification

Different types of DAB receiver require different testing conditions. The classification system defined in Table 2 is used in clause 7 to assist the applicability of tests.

Table 2 – Classification of receiver types

Receiver description	Classification	Integral antenna	Dedicated RF socket
Consumer receivers which are a system, with a human user interface (UI), decoder and speaker(s) (detached or integral) which may be mains or battery powered. The radio signal input is 1) via an antenna which is physically integral and immovable without an RF connector (i.e. whip or wire antenna), or 2) where the radio signal input is via a connector socket, e.g. micro system or lounge portable.	A1	Yes	None
	A2	Optional	75 Ω
Consumer hand portable receivers – where the UI and audio system functions are included and integral, using a headphone lead or other wire as the antenna is without a dedicated RF connector. Such as dedicated pocket radios or where the DAB receiver is an “embedded” function, e.g. a cellular mobile phone.	B	Headphone lead or wire lead	None
Adaptors and “Plug in” accessories to a “host” where the user interface and audio system is provided by the host, such as in a USB dongle with a laptop or tablet computer. The RF signal input is 1) via a headphone or other wire lead acting as the antenna – without a dedicated RF connector, or 2) with a dedicated RF connector.	C1	Yes, e.g. wire	None
	C2	Optional	50 Ω or 75 Ω
Automotive OEM receivers – where the receiver functions are in a dedicated, integral form or distributed physical form, but always where the radio signal input is via a connector socket.	D	No	50 Ω
Automotive accessory receivers – where the receiver (RF, decoder, UI, audio, power system) is in a single or multiple physical form. The RF signal input is 1) via an antenna which is physically integral and inseparable, without an RF connector – or 2) distributed physical form where the radio signal input is via a connector socket.	E1	Yes	None
	E2	Optional	50 Ω

7.2 Audio part – Performance requirements

7.2.1 General

Audio characteristics shall be measured according to IEC 61606. IEC 61606 applies to the basic methods of measurement of the audio characteristics of the digital audio part of audio and audiovisual equipment (for both consumer and professional uses). It describes tests for equipment with analogue output and digital input.

7.2.2 DAB services

ETSI TS 101 757 specifies the procedures for testing the conformance of the DAB audio decoder.

7.2.3 DAB+ services

No general procedure for testing the conformance of the DAB+ audio decoder is currently available.

7.3 RF part – Sensitivity test methods

7.3.1 General

A sensitivity measurement shall be made at node “A”, at node “N”, or both depending on the availability of the node on a receiver. The sensitivity measurement shall be made using a DAB audio coded audio component. The sensitivity measurement can be made using the error rate in the bitstream (BER) or by measuring audio defects (OOI) methods, the latter is suited to receivers with no access to a digital stream and only has output nodes at H, J, K, L, M in Figure 1.

7.3.2 Baseband stream and RF conditions for BER and OOI testing

Table 3 specifies the conditions which shall be satisfied for BER sensitivity tests.

Table 3 – Conditions for BER and OOI testing

EEP level	3A
Modulation	QPSK
Error coding rate	0,5
Guard interval	246 μs
Approximate gross data rate	1,15 Mbit/s
An instrumentation stabilisation time (after RF level or frequency change) should be set to provide consistent signals.	
Signal envelope / fading profile	Gaussian only

7.3.3 Baseband stream and listening conditions for acoustic OOI testing

Table 4 specifies the conditions which shall be satisfied for OOI sensitivity tests.

Table 4 – Conditions for acoustic OOI testing

Audio test tone	1 kHz, sine wave -3 dB FS, mono image.
MP2 data stream rate	128 kbit/s mono coding.
For a human observer:	
Audio level at listener ears, equivalent Normal level	>75 dBA weighted SPL at 30 cm.
Audio level at listener ears, equivalent High level (for stressing receiver components e.g. audio PA, power supply – not listening)	<90 dB SPL at 30 cm. NB this level is not meant for human listening.
Environment	Quiet room or isolating headphones.

7.4 Sensitivity requirement using a conducted signal at node “A”

7.4.1 General

In relation to the radio input signal point, it is recognised that a consumer receiver will employ various methods. Most often the antenna is directly and inseparably connected to the physical structure of the receiver. Alternately an RF connector may be used. This test is limited to receiver types A2, C2, D and E2 of Table 2.

7.4.2 Method of measurement (Gaussian channel) using BER

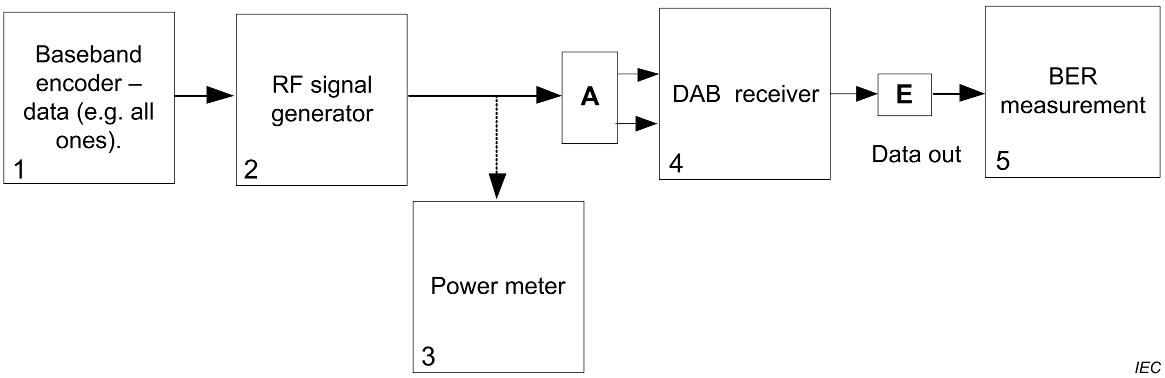
The measurement set-up is given in Figure 2. The signal generator shall be connected to the r.f. input "A" of the receiver under test. The BER shall be measured at the output "E".

a) The RF input power is set at a relatively high value and applied at node A.

b) The BER is accumulated over a minimum of 10 frames and is verified to be less than 10^{-4}.

c) The RF power is decreased by a relatively small step.

d) Repeat steps b) and c) until the BER is observed over a minimum 10 frames to be equal or greater than 10^{-4}, when the value of RF power is noted which is then taken to be the threshold value.



Key: The numbers in the corners refer to blocks.

Figure 2 – Block diagram for the measurement of the sensitivity and the maximum input power, using BER

7.4.3 Presentation of results using BER

The sensitivity at the channel being measured is the input power expressed in dBm at which the BER reaches 10^{-4}. It shall be given for all frequency bands and channels covered.

7.4.4 Requirements – Receiver types A2, C2, D, E2 using BER

To achieve better than 10^{-4} BER: either 75 Ω or 50 Ω inputs may be used.

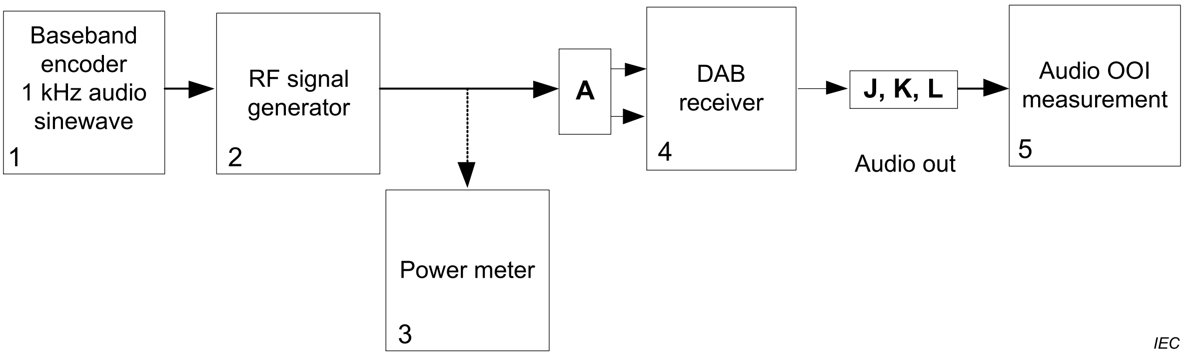
Minimum requirement: –97,7 dBm VHF band III

NOTE External antenna/cable losses and additional connector losses are not included.

7.4.5 Method of measurement (Gaussian channel) using acoustic OOI

The measurement set-up is given in Figure 3. The signal generator shall be connected to the r.f. input "A" of the receiver under test. The acoustic output shall be monitored at point J, or K, or L, or M.

a) The RF input power level is set at a relatively high value and applied at node A.
b) The acoustic output is observed over a minimum 10 s and is verified to be impairment free.
c) The RF power is decreased by a relatively small step.
d) Repeat steps b) and c) until acoustic impairments are observed in a 10 s period.
e) Impairment is defined as any recognisable deviation from a constant amplitude, constant frequency 1 kHz audio tone. For example, audio drops or gaps, or bursts of non-1 kHz signal tone – sometimes called “burbles”, “tweets”, “chirps” or “birdies”.
f) Adjust the RF signal upwards or downwards until an average of three acoustic impairments are observed in each of three 10 s periods.
g) Note the value of RF power which is then taken to be the threshold value.



Key: The numbers in the corners refer to blocks.

Figure 3 – Block diagram for the measurement of the sensitivity and the maximum input power, using acoustic OOI

7.4.6 Presentation of results using acoustic OOI

The sensitivity at the channel being measured shall be given for all frequency bands and channels covered.

7.4.7 Requirements – Receiver types A2, C2, D, E2 using acoustic OOI

DAB (MPEG Audio Layer II), to achieve an average of three OOI impairments in a 10 s time window.

Minimum requirement: –97,7 dBm VHF band III

NOTE External antenna/cable losses and additional connector losses are not included.

7.5 Sensitivity using radiated electromagnetic wave at node "N"

7.5.1 General

The standard recognises that, on integral receiver/antenna products it is important to achieve radio sensitivity in terms of free field radiated signals, at node "N" in Figure 1. A majority of finished radio products will be without any RF connector at node "A" and this justifies having an objective test for sensitivity based on free field signals.

This aspect is important to achieve geographical area coverage and quality of service and comply with link budget signal levels for DAB transmissions.

7.5.2 Link budget transmission assumption – Non-automotive receivers

It is noted that a link budget assumes a DAB (MPEG Audio Layer II) receiver can achieve a given free Gaussian field sensitivity, expressed as follows:

$$Sf = 34{,}4 + 20\lg(f / 220)$$

where

Sf is the field strength in dBμV/m to achieve 10^{-4} BER;

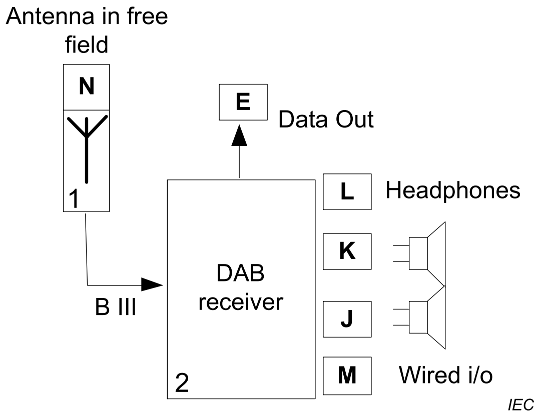
f is the frequency in MHz.

7.5.3 Method of measurement – Non-automotive types A1, B, C1. C2 and A2 with optional antenna

Free field radio signal measurements require a controlled configuration to achieve an accurate, repeatable result. The measurement set-up is given in Figure 4.

The receiver shall be set up as follows:

a) according to 7.3.3, normal acoustic output level;
b) with vertical E field antenna polarization;
c) with mains lead or mains PSU lead (if used) vertical;
d) for type B receivers with a headphone lead acting as the antenna, the acoustic signal should be captured from the ear bud / earphones with the headphone lead vertical.



Key: The numbers in the corners refer to blocks.

Figure 4 – Block diagram for the measurement of free field sensitivity

The testing facility shall have the following characteristics.

a) Screened room to exclude sources of airborne interference.
b) Anechoic or semi anechoic internal structure.

c) Uniform wave zone in a volume 1 m × 1 m × 1 m at the position of the receiver under test.

d) Absolute calibrated field

Antenna substitution method to calibrate the field at the test zone, using a dipole antenna is recommended; a calibrated dipole antenna will emulate a receiver's omni directional capture characteristic better and establish a more representative field calibration.

e) Statement of measurement accuracy in the test volume of C above

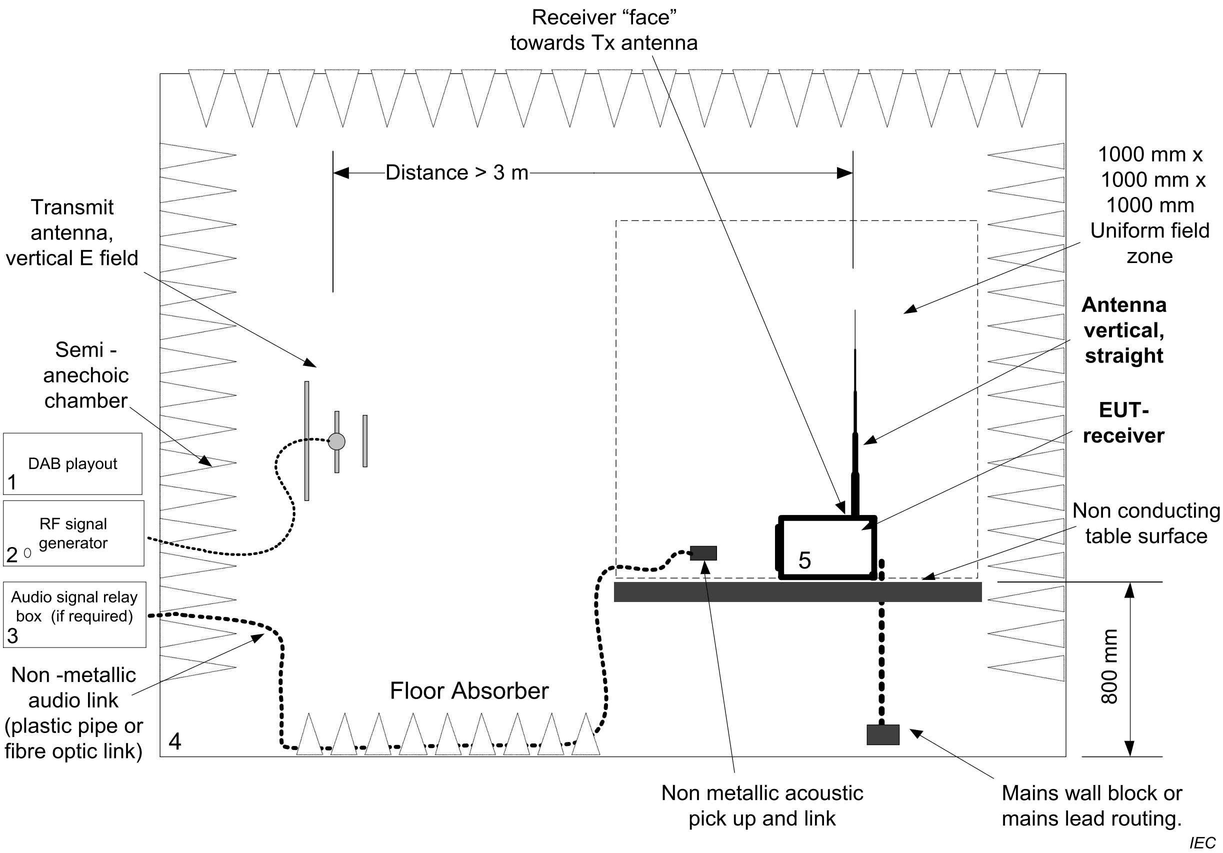
C, D and E are important considerations and the configuration of the test chamber equipment and verification of signal conditions should be done with precision. As a check, the receiver 5 in Figure 5 should be moved by ±35 cm back and forth, up and down to verify that the signal level is uniform and no sharp nulls are present by fulfilling the expected results detailed in Table 5.

Table 5 – Conditions for uniform signal level

Antenna test position	Expected result if e-m wave is propagated correctly
35 cm backwards (away from tx antenna)	Signal reduces according to path loss change of +35 cm – i.e. fraction of dB
35 cm forward	Signal increases according to path loss change of –35 cm
35 cm up and down	Substantially same signal level

f) Mains power for receiver.

g) Non metallic data link or acoustic coupler to relay audio signal to the outside of the free field region.



Key: The numbers in the corners refer to blocks.

Figure 5 – Free field screened chamber measurement – Features and setup

7.5.4 Presentation of results

The minimum field strength is expressed in dBμV/m to achieve a BER of 10^{-4}, or an OOI of three defects in a 10 s observation period. It shall be given for all frequency bands covered.

7.5.5 Requirements – Types A1, B, C1, C2 and A2 with optional antenna

A DAB receiver will achieve a Gaussian free field sensitivity as follows:

$$Sf = 34{,}4 + 20\lg(f / 220)$$

where

Sf is the field strength in dBμV/m to achieve 10^{-4} BER or OOI for the acoustic test;

f is the frequency in MHz.

7.5.6 Link budget transmission assumption – Automotive types D, E1, E2

It is noted that a link budget assumes a DAB receiver can achieve a given free Gaussian field sensitivity, expressed as follows:

$$Sf = 29{,}2 + 20\lg(f / 220)$$

where

Sf is the field strength in dBμV/m to achieve 10^{-4} BER or OOI for the acoustic test;

f is the frequency in MHz.

A sensitivity test of an automotive receiver types E1 and E2 (with antenna) in a vehicle may take Sf as the objective threshold for performance, based on the averaging of sensitivity in dBμV/m over all horizontal and azimuthal directions measured with a vertically polarized E field.

7.6 RF part – Maximum input power

7.6.1 General

The maximum input power is the maximum input level at which the DAB receiver will perform according to criteria given in 7.6.2.

7.6.2 Method of measurement (Gaussian channel)

If the BER method is used, the same measurement set-up as given in 7.4.2 shall be used. The RF input power is increased until the BER reaches 10^{-4} or just before synchronization is lost.

Alternately, if the acoustic OOI method is used, the same measurement set-up as given in 7.4.5 shall be used. The RF input power is increased until the frequency of impairment is equal to an average of three events in each of three 10 s observation periods.

7.6.3 Presentation of results

The maximum input power is expressed in dBm. It shall be given for all frequency bands covered.

7.6.4 Requirements

Minimum requirements are given in Table 6. These correspond to conducted signals at node "A" where this exists.

Table 6 – Minimum requirements for maximum input power (conducted)

	Stationary and automotive accessory Types E1, E2 dBm	Portable receiver Types A1, A2, B, C1, C2 dBm	OEM automotive receiver Type D dBm
VHF band III	–10	–5	+10

7.7 RF part – Selectivity

7.7.1 General

For selectivity, two kinds of measurements are considered: adjacent channel selectivity (A_{CS}) and far-off selectivity. This is considered a technology provider measurement using specialized equipment in a conducted mode principally using BER as the measurement criterion. However, an acoustic OOI method is included for A_{CS}.

7.7.2 Adjacent channel selectivity

7.7.2.1 General

This will be measured at first, second and third adjacent channels at the higher and lower neighbouring channel frequencies.

7.7.2.2 Method of measurement

Both wanted signal and interferer shall be DAB signals according to 7.1.6. The spectrum shall be in accordance with Figure 6.

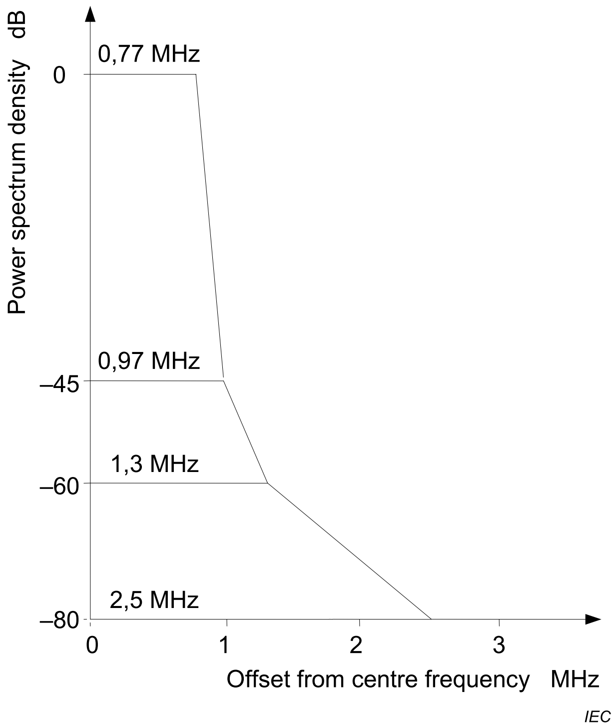


Figure 6 – Spectrum mask of the DAB signal for selectivity measurements

The difference between the centre frequencies of the DAB ensembles shall be as follows (see Table 7):

Table 7 – Difference between the centre frequencies of the DAB ensembles

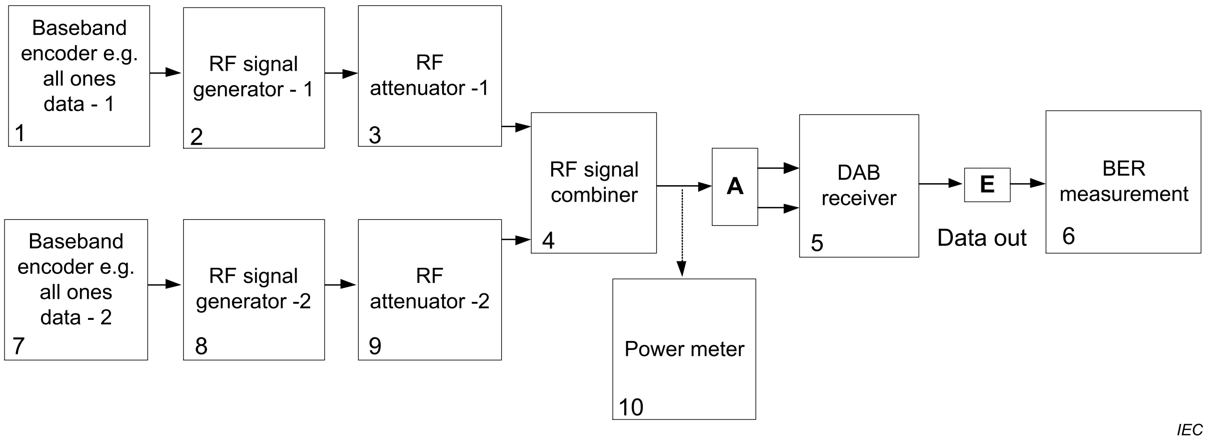
	Channel spacing	Guard band
First adjacent channel (upper and lower)	±1,712 MHz	176 kHz
Second adjacent channel (upper and lower)	±3,428 MHz	One channel plus 176 kHz
Third adjacent channel (upper and lower)	±5,136 MHz	Two channels plus 176 kHz

The BER method measurement set-up is depicted in Figure 7.

The power level of the wanted signal P_{wanted} at the DAB receiver input "A" in Figure 7 shall be adjusted to –70 dBm using RFattenuator 1 when RF signal generator 2 is switched off. The signal level $P_{unwanted}$ of the interfering ensemble shall then be increased until a BER of 10^{-4} at point “F” is reached (see 7.1.4).

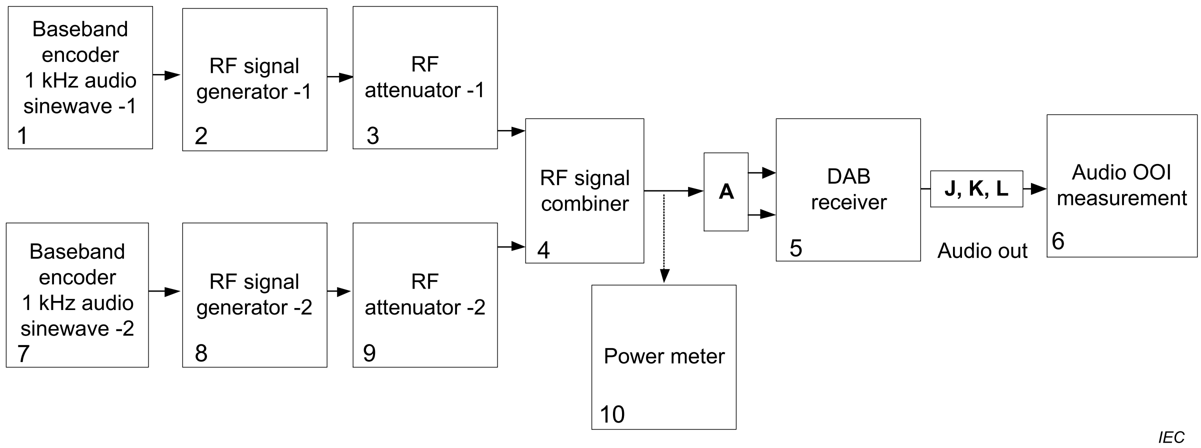
Alternately, in finished receivers or otherwise where no BER node is available, the measurement using the OOI criterion is set-up as depicted in Figure 8.

The power level of the wanted signal P_{wanted} at the DAB receiver input "A" in Figure 8 shall be adjusted to –70 dBm using RF attenuator 1 with RF signal generator 2 switched off. The signal level $P_{unwanted}$ of the interfering ensemble shall then be increased until an average of three audible impairments are observed in each of three periods of 10 s.



Key: The numbers in the corners refer to blocks.

Figure 7 – Block diagram for BER method selectivity measurements



Key: The numbers in the corners refer to blocks.

Figure 8 – Block diagram for OOI method selectivity measurements

7.7.2.3 Presentation of results

The adjacent channel selectivity (A_{CS}) of a DAB receiver is expressed in dB. These values shall be calculated from the adjusted signal levels by the equation:

$$A_{CS} = P_{unwanted} - P_{wanted} = P_{unwanted} + 70 \qquad [dB]$$

7.7.2.4 Requirements

Minimum requirement (for P_{wanted} = −70 dBm) (see Table 8).

Table 8 – Minimum requirement for adjacent channel selectivity

	Channel spacing	**Requirement**
First adjacent channel (upper and lower)	±1,712 MHz	$A_{CS} \geq 35$ dB
Second adjacent channel (upper and lower)	±3,428 MHz	$A_{CS} \geq 40$ dB
Third adjacent channel (upper and lower)	±5,136 MHz	$A_{CS} \geq 45$ dB

7.7.3 Rejection of unwanted signals (far-off selectivity)

7.7.3.1 General

This is considered a technology provider measurement using specialized equipment in a conducted mode only.

An unwanted signal received together with the wanted signal at the input of the receiver may have a degrading effect on reception quality.

7.7.3.2 Method of measurement

The measurement set-up is shown in Figure 7.

The wanted signal is a DAB signal (according to 7.1.6).

Adjust RF attenuator 1 so that the power level measured at the input “A” to the receiver becomes −70 dBm.

The unwanted signal is a standard FM modulated signal as defined in IEC 60315-4.

This measurement shall be carried out on the upper, lower and centre frequencies. The frequency of the unwanted signal should be ≥5,5 MHz from the centre frequency of the wanted DAB signal. The output power of the unwanted signal (measured at the DAB receiver input “A”) is increased until the BER is 10^{-4}.

7.7.3.3 Presentation of results

The rejection of unwanted signals is expressed in dB.

The relative level of the maximum permissible unwanted signal is given for both measurements by the equation:

$$R_r = P_{unwanted} - P_{wanted} = P_{unwanted} + 70 \qquad [dB]$$

where R_r is the rejection ratio.

7.7.3.4 Requirements

Minimum requirement: 40 dB for any in-band or out-of-band interfering frequency with an offset ≥5,5 MHz from the centre of the wanted DAB signal.

7.8 RF part – Performance in a Rayleigh channel

7.8.1 General

This is considered a technology provider measurement using specialized equipment in a conducted mode only and hence is expected to be a BER (not OOI) measurement.

7.8.2 Sensitivity

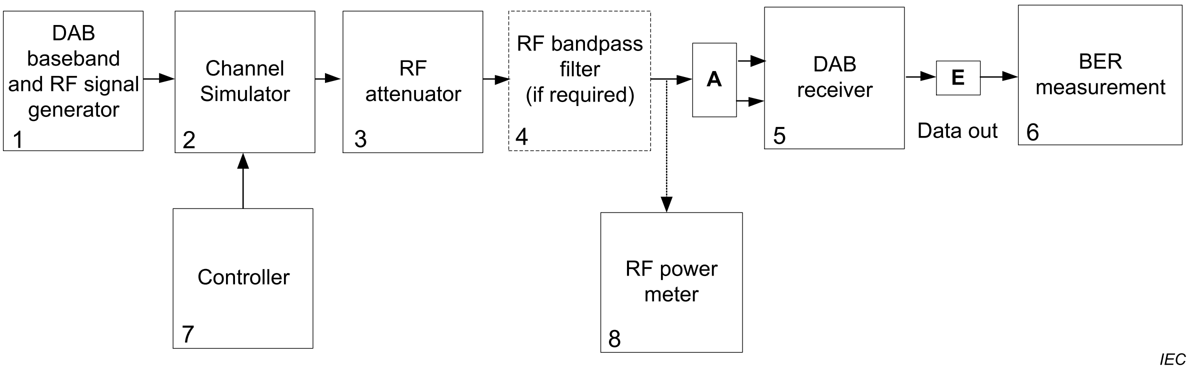
It is recognized that behaviour under mobile conditions is one of the strong features of the DAB system. The objective of this measurement is to provide a reference for the performance of a DAB car receiver in a dynamically changing environment. Typically, such an environment is described by the Rayleigh channel model.

The effects described above model the propagation of electromagnetic waves in realistic terrain and under moving conditions. Included in these models is the Doppler-effect, as well as multi-path reception, plus fast and slow fading. Since many combinations of these effects are possible, there has been an effort to standardize a set of conditions for measurement purposes. These so-called profiles were laid down in the COST 207 document on digital land mobile radio communications. Extracted from that document, certain relevant profiles have been selected. These are given in Annex B.

Based on static conditions, it is possible to compare the behaviour of different receivers. However, since the channel is changing dynamically, it is difficult to test without long-term observation. Therefore, long-term evaluation shall be performed, during which the BER may not drop below 10^{-4}.

7.8.3 Method of measurement – Conducted input signal only

The block diagram of a basic set-up for channel simulation is shown in Figure 9.



Key: The numbers in the corners refer to blocks.

Figure 9 – Block diagram for measuring the performance in a Rayleigh channel

The DAB signal generator is set to one of the centre frequencies given in Table 9 and is modulated by a DAB encoder. A channel simulator is inserted between the DAB signal generator and the variable attenuator. This simulator shall be programmed through its controller with parameters corresponding to the channel profiles mentioned in Annex B. An attenuator is foreseen at the output of the channel simulator. A bandpass filter may also be necessary to filter out spurious signals.

Measurements shall be made in different bands (frequencies) and modes combined with different channel simulation profiles: urban, rural and SFN, according to Table 9. Table 9 includes urban and rural profiles referring to the profiles given in Annex B.

Table 9 – Channel simulation profiles related to frequency band and mode

Measuring frequency MHz	Mode	Channel simulation profiles
225,648	I	Urban at 25 km/h Rural at 120 km/h SFN (VHF) at 60 km/h

The measurement shall be performed in three steps.

a) The power level at the input of the DAB receiver shall be adjusted, using a selective power meter, in such a way that error-free reception is possible i.e. BER ≤ 10^{-4}. All synchronization conditions shall be met, including FIC, phase-reference and null-symbol capturing.

b) The input power to the receiver is reduced by increasing the variable attenuation. During this process, care shall be taken that synchronization is not lost such as caused by attenuator switching transients).

c) The BER measurement is observed or otherwise calculated i.e.

$$BER = \sum_{t=1}^{60} \left(No.\_Bits\_in\_Error \right) \div \sum_{t=1}^{60} \left(Total\_No.\_Bits\_Transmitted \right)$$

where t = time in seconds.

It should be confirmed that the BER has been better than the specified value 10^{-4} for a specified measuring time of 1 min. If this is so, the receiver is qualified for this power level, and the procedure goes back to repeat the second and third phase, to measure the next lower power level.

When the receiver fails to maintain the specified BER of 10^{-4}, the procedure stops and the previous value of input power, at which the BER is less than 10^{-4}, is taken as the result.

7.8.4 Presentation of results

The result of this measurement is presented as the lowest power level in dBm at which the receiver is still able to maintain a BER of 10^{-4} during a one minute observation period, and this for each defined channel simulation profile.

7.8.5 Requirements

The minimum requirement is dependent upon the tuning frequency band, as follows:

Minimum requirement: –92,2 dBm VHF band 3

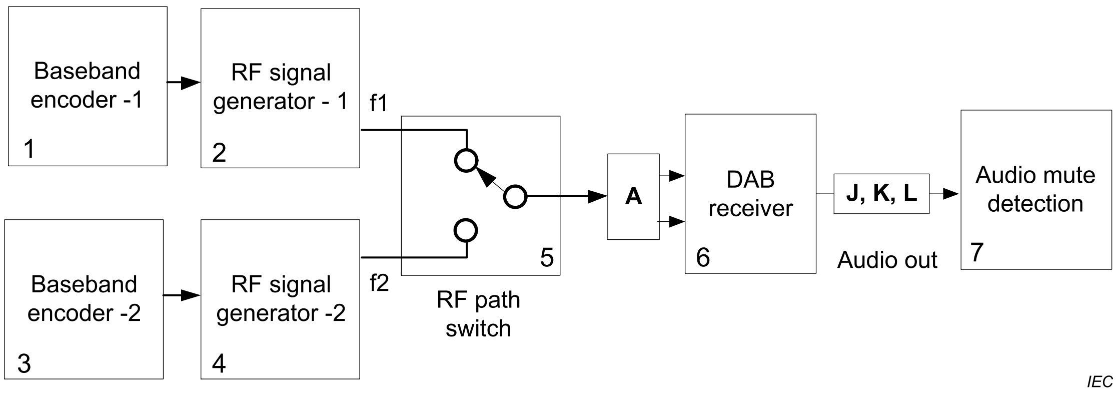
7.9 RF part – Acquisition time after synchronization loss

7.9.1 General

The time of audio mute between switching off the received ensemble and re-synchronizing to the same ensemble at an offset frequency is defined as the acquisition time after synchronization loss.

7.9.2 Method of measurement

Figure 10 shows the block diagram of the measurement set-up.



Key: The numbers in the corners refer to blocks.

Figure 10 – Block diagram for measuring acquisition time after synchronization loss

The DAB signal should be according to 7.1.6.

The frequency $f2$ of RF signal generator 2 shall have an offset to frequency $f1$ of RF signal generator 1 of half a carrier spacing, according to the appropriate DAB transmission mode (500 Hz in the case of mode I, ETSI EN 300 401).

First the signal of RF signal generator 1 is supplied to the RF receiver. After a switch-off time of at least 10 s the signal of RF signal generator 2 is supplied to the DAB receiver and the time it takes for the DAB receiver to resynchronize is measured with the mute detection circuit.

Measurements shall be made five times, separately for all supported DAB transmission modes.

The result is the average value of the measurements.

For DAB receivers without any audio capability, the measurements shall be conducted by monitoring valid data at the output of the channel decoder.

7.9.3 Presentation of results

The acquisition time is expressed in milliseconds and presented separately for each supported transmission mode.

7.9.4 Requirements

Minimum requirement: <3 000 ms for a switch-off time >10 s.

Annex A
(informative)

Recommended centre frequencies

Table A.1 shows the recommended centre frequencies for DAB.

Table A.1 – Recommended centre frequencies for DAB *(1 of 2)*

T-DAB block	T-DAB block	Centre frequency	Lower limit	Upper limit
Number	**Label[a]**	MHz	MHz	MHz
13	5A	174,928	174,160	175,696
14	5B	176,640	175,872	177,408
15	5C	178,352	177,584	179,120
16	5D	180,064	179,296	180,832
17	6A	181,936	181,168	182,704
18	6B	183,648	182,880	184,416
19	6C	185,360	184,592	186,128
20	6D	187,072	186,304	187,840
21	7A	188,928	188,160	189,696
22	7B	190,640	189,872	191,408
23	7C	192,352	191,584	193,120
24	7D	194,064	193,296	194,832
25	8A	195,936	195,168	196,704
26	8B	197,648	196,880	198,416
27	8C	199,360	198,592	200,128
28	8D	201,072	200,304	201,840
29	9A	202,928	202,160	203,696
30	9B	204,640	203,872	205,408
31	9C	206,352	205,584	207,120
32	9D	208,064	207,296	208,832
33	10A	209,936	209,168	210,704
See NOTE 5	10N	210,096	209,328	210,864
34	10B	211,648	210,880	212,416
35	10C	213,360	212,592	214,128
36	10D	215,072	214,304	215,840
37	11A	216,928	216,160	217,696
See NOTE 5	11N	217,088	216,320	217,856
38	11B	218,640	217,872	219,408

Table A.1 *(2 of 2)*

T-DAB block	T-DAB block	Centre frequency	Lower limit	Upper limit
Number	**Label[a]**	MHz	MHz	MHz
39	11C	220,352	219,584	221,120
40	11D	222,064	221,296	222,832
41	12A	223,936	223,168	224,704
See NOTE 5	12N	224,096	223,328	224,864
42	12B	225,648	224,880	226,416
43	12C	227,360	226,592	228,128
44	12D	229,072	228,304	229,840
45	13A	230,784	230,016	231,552
46	13B	232,496	231,728	233,264
47	13C	234,208	233,440	234,976
48	13D	235,776	235,008	236,544
49	13E	237,488	236,720	238,256
50	13F	239,200	238,432	239,968

NOTE 1 This table contains a unified labelling system for all the DAB frequency blocks in Europe.

NOTE 2 To avoid temporary compatibility problems with other services in some countries in exceptional cases, it could be necessary to shift the transmitted centre frequency a few times 16 kHz. Dedicated receivers will comply.

NOTE 3 The table is fully compatible with the existing VHF television channel numbers for Standard Europe B, C (i.e. channels E5 to E12 and the so-called channel 13, which corresponds to a frequency range from 230 MHz to 240 MHz).

NOTE 4 All the frequencies listed in the table comply with the 16 kHz raster as specified in ETSI EN 300 401.

NOTE 5 Offsets to blocks 10A, 11A and 12A will allow these blocks to be used in areas also covered by B/PAL/NICAM television transmitters operating in the lower adjacent channels. The television transmitters also need to be offset downwards in frequency by the maximum allowable amount (approximately 200 kHz). The three additional centre frequencies are:

– 210,096 MHz (10 N);
– 217,088 MHz (11 N);
– 224,096 MHz (12 N).

[a] Frequency block labels consist of two or three characters, which may be convenient for receiver manufacturers and consumers for initial programming of their receivers.

Annex B
(normative)

Characteristics of a Rayleigh channel

NOTE This annex describes the settings of a channel simulator according to Figure 9.

B.1 Simulation of the mobile radio channel

The mobile radio channel is described by highly dispersive multi-path propagation caused by reflection and scattering. The paths between transmitter and mobile receiver can be considered to consist of large reflectors and/or scatterers at some distance to the mobile, giving rise to a number of waves that arrive in the vicinity of the mobile with random amplitudes and delays. Close to the mobile, these paths are further randomized by local reflections/diffractions.

For a moving mobile, the angle of incidence of the received signal at the antenna shall also be taken into account, since it affects the Doppler shift associated with a wave arriving from a particular direction.

Propagation models for the description of the above mobile radio channel have been defined in order to allow practical simulation by means of a hardware simulator. They comprise echo profiles covering the specific reception conditions in conventional networks as well as in single- frequency networks (SFN).

The propagation models are presented below in terms of the time delay, amplitude coefficient and the Doppler spectra associated with each delay path:

a) a discrete number of taps, each determined by its time delay and its average power;
b) the Rayleigh distributed amplitude of each tap, varying according to a Doppler spectrum $S(\tau_{\mathrm{i}}, f)$, where i is the tap index.

B.2 Doppler spectrum types

B.2.1 General

For the modelling of the channel, five types of Doppler spectra are defined. They describe the relation of power density versus Doppler shift, i.e. the influence of the speed of the moving car and the impacts of the surrounding terrain.

The following abbreviations are used:

– $f_{\mathrm{d}} = v/\lambda$ represents the maximum Doppler shift, with vehicle speed v [m/s] and wavelength λ [m].
– $G(A, f_1, f_2)$ is the Gaussian function:

G(magnitude, Doppler shift, standard deviation of Gaussian distribution)

$$G(f) = A \exp\left(\frac{(f - f_1)^2}{2 f_2^2}\right)$$

The defined spectrum types are described in subclauses B.2.2 to B.2.6.

B.2.2 Doppler spectrum: CLASS

CLASS is the classical Doppler spectrum and is to be used for paths with delays up to 0,5 µs, ($\tau_i \leq 0{,}5$ µs).

(CLASS) $$S(\tau_i, f) = \frac{A}{\sqrt{1 - \left(f/f_d\right)^2}} \quad \text{for } f \in \left]-f_d, f_d\right[$$

B.2.3 Doppler spectrum: GAUS1

GAUS1 is the sum of two Gaussian functions and is used for excess delay times in the range of 0,5 µs to 2 µs, (0,5 µs $\leq \tau_i \leq$ 2 µs).

(GAUS1) $$S(\tau_i, f) = G\,(A, -0{,}8\,f_d, 0{,}05\,f_d) + G\,(A_1, +0{,}4\,f_d, 0{,}1\,f_d)$$

where A_1 is 10 dB below A.

B.2.4 Doppler spectrum: GAUS2

GAUS2 is also the sum of two Gaussian functions and is used for paths with delays in excess of 2 µs, ($\tau_i > 2$ µs).

(GAUS2) $$S(\tau_i, f) = G\,(B, +0{,}7\,f_d, 0{,}1\,f_d) + G\,(B_1, -0{,}4\,f_d, 0{,}15\,f_d)$$

where B_1 is 15 dB below B.

B.2.5 Doppler spectrum: GAUSDAB

GAUSDAB is composed of a Gaussian function and is used for special DAB profiles.

(GAUSDAB) $$S(\tau_i, f) = G\,(A, \pm 0{,}7\,f_d, 0{,}1\,f_d)$$

where $+0{,}7\,f_d$ applies to even path numbers and $-0{,}7\,f_d$ for odd, except path 1.

B.2.6 Doppler spectrum: RICE

RICE is the sum of a classical Doppler spectrum and one direct path, so that the total multi-path contribution is equal to that of the direct path. This spectrum is used for the shortest path of the model for propagation in rural areas.

(RICE) $$S(\tau_i, f) = \frac{0{,}41}{2\pi f_d \sqrt{1 - \left(f/f_d\right)^2}} + 0{,}91\,\delta\left(f - 0{,}7\,f_d\right)$$

for $f \in \left]-f_d, f_d\right[$

B.3 Propagation models

B.3.1 General

The multi-path propagation model is based on a transversal filter structure, each tap representing a signal path associated with a certain delay and modulated by the appropriate Doppler spectrum.

Continuous delay power profiles for different types of terrain are specified to describe the models. These continuous profiles are approximated by the discrete parameter settings of hardware fading simulators according to Clause B.4.

The continuous delay power profiles $P(\tau)$ are defined in B.3.2 and B.3.3.

B.3.2 Typical rural (non-hilly) area (RA)

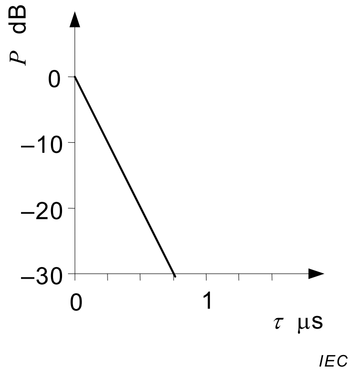


Figure B.1 – Continuous delay power profile $P(\tau)$ for RA

$$P(\tau)=\begin{cases}\exp(-\tau/\tau_m) & \text{for } 0<\tau<0{,}7\\ 0 & \text{elsewhere}\end{cases}$$

$$\tau_m = 0{,}108\ \mu s$$

B.3.3 Typical urban (non-hilly) area (TU)

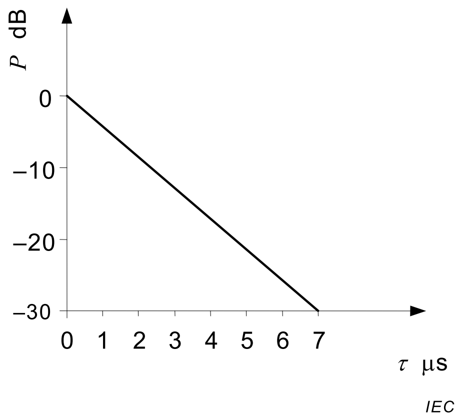


Figure B.2 – Continuous delay power profile $P(\tau)$ for TU

$$P(\tau)=\begin{cases}\exp(-\tau/\tau_m) & \text{for } 0<\tau<7\\ 0 & \text{elsewhere}\end{cases}$$

$$\tau_m = 1\ \mu s$$

B.4 Tap setting for hardware simulators

Hardware multi-tap fading simulators use the propagation model described in Clause B.3. They are equipped with a finite number of taps (3 to 16 taps) which can be set to discrete values of $S\,(\tau_i)$ in both amplitude and delay.

Further, the assignment of a particular Doppler spectrum to each path is possible to simulate the mobile channel, i.e. the moving receiver. The Doppler spectrum requires for complete definition the maximum Doppler shift. This can be chosen directly at the simulator or by selecting the centre frequency and driving speed.

The tap setting below is given for simulators comprising up to 12 taps and for simulators with reduced model settings up to 6 taps.

The delay spread mentioned in the tables below is defined by the equation:

$$S_D^2 = \frac{1}{P_m}\sum_{i=1}^{I}\tau_i^2 P(\tau_i) - \left[\frac{1}{P_m}\sum_{i=1}^{I}\tau_i P(\tau_i)\right]^2$$

where I is the total number of taps and $P_m = \sum_{i=1}^{I} P(\tau_i)$ is the total transmitted power.

Tap settings are shown in Table B.1, Table B.2, Table B.3, Table B.4 and Table B.5.

Table B.1 – Four tap setting for typical rural (non-hilly) area (RA)

Tap **No**	**Delay** µs	**Power** **linear**	**Power** dB	**Doppler** **category**	S_D µs
1	0	1	0	RICE	
2	0,2	0,63	–2	CLASS	0,1 ± 0,02
3	0,4	0,1	–10	CLASS	
4	0,6	0,01	–20	CLASS	

Table B.2 – Six tap setting for typical rural (non-hilly) area (RA)

Tap **No**	**Delay** µs	**Power** **linear**	**Power** dB	**Doppler** **category**	S_D µs
1	0	1	0	RICE	
2	0,1	0,4	–4	CLASS	
3	0,2	0,16	–8	CLASS	0,1 ± 0,02
4	0,3	0,06	–12	CLASS	
5	0,4	0,03	–16	CLASS	
6	0,5	0,01	–20	CLASS	

Table B.3 – Twelve tap setting for typical urban (non-hilly) area (TU)

Tap No	Delay μs	Power linear	Power dB	Doppler category	S_D μs
1	0	0,4	–4	CLASS	
2	0,1	0,5	–3	CLASS	
3	0,3	1	0	CLASS	
4	0,5	0,55	–2,6	CLASS	
5	0,8	0,5	–3	GAUS1	
6	1,1	0,32	–5	GAUS1	1,0 ± 0,1
7	1,3	0.2	–7	GAUS1	
8	1,7	0,32	–5	GAUS1	
9	2,3	0,22	–6,5	GAUS2	
10	3,1	0,14	–8,6	GAUS2	
11	3,2	0,08	–11	GAUS2	
12	5,0	0,1	–10	GAUS2	

Table B.4 – Six tap setting for typical urban (non-hilly) area (TU)

Tap No	Delay μs	Power linear	Power dB	Doppler category	S_D μs
1	0	0,5	–3	CLASS	
2	0,2	1	0	CLASS	
3	0,5	0,63	–2	CLASS	1,0 ± 0,1
4	1,6	0,25	–6	GAUS1	
5	2,3	0,16	–8	GAUS2	
6	5,0	0,1	–10	GAUS2	

Table B.5 – Tap setting for single-frequency networks (SFN) in VHF bands

Tap No	Delay μs	Power linear	Power dB	Doppler category	S_D μs
1	0	0,93	0	CLASS	
2	100	0,046	−13	GAUSDAB	
3	220	0,015	−18	GAUSDAB	
4	290	6×10^{-3}	−22	GAUSDAB	
5	385	3×10^{-3}	−26	GAUSDAB	
6	480	8×10^{-4}	−31	GAUSDAB	
7	600	6×10^{-4}	−32	GAUSDAB	

Annex C
(informative)

Basic characteristics and functionality for accessibility for blind and visually impaired users

A digital radio device shall support speech output for all configuration functions. This applies for menus as well as for service selection. Service label and additional textual information shall be output as audio, e.g. using a build-in text-to-speech engine. The beginning or end of scrollable lists should be acoustically indicated.

For frequently-used functions (like volume, bass, treble) explicitly assigned tactile use elements shall be available. Numeric buttons for selection of channels or station storage are very useful. Multiple functional assignments to buttons should be avoided or, if this is not possible, different usage levels of the same buttons shall be signalled by acoustic hints (tones or speech output). All buttons should easily be identifiable by their form and/or location.

The manual and supporting documentation for a digital radio device shall be available as audio or in braille.

Digital radio data services should be made available to the listener as much as possible. For example, dynamic label information could be read out through a built-in text-to-speech engine. Journaline as the advanced text service for digital radio explicitly supports hinting information for an improved text-to-speech conversion, including options for phonemic metadata descriptions (based on the IPA standard), pause indications, a macro function to insert repeating information, e.g. to make tables usable, and general language indications for whole text pages and individual sections. This functionality can be used for speech output in cars as well as for blind or visually disabled persons.

Additional information is available from various organisations that support accessibility, for example:

http://www.rnib.org.uk/sites/default/files/video_transcript_Making_digital_radios_more_usable.doc

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CISPR 20, *Sound and television broadcast receivers and associated equipment – Immunity characteristics – Limits and methods of measurement*

ISO/IEC 11172-4, *Information technology – Coding of moving pictures and associated audio for digital storage media at up to about 1,5 Mbit/s – Part 4: Compliance testing*

ISO/IEC 13818-4, *Information technology – Part 4: Generic coding of moving pictures and associated audio information – Conformance testing*

ITU-T Recommendation O.151, *Error performance measuring equipment operating at the primary rate and above*

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