Draft ETSI EN 300 401 V2.2.1 (2026-02)

EUROPEAN STANDARD

Radio Broadcasting Systems;
Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers

Reference
REN/JTC-DAB-114

Keywords
audio, broadcasting, DAB, data, digital, terrestrial

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Foreword

This draft European Standard (EN) has been produced by Joint Technical Committee (JTC) Broadcast of the European Broadcasting Union (EBU), Comité Européen de Normalisation ELECtrotechnique (CENELEC) and the European Telecommunications Standards Institute (ETSI), and is now submitted for the combined Public Enquiry and Vote phase of the ETSI EN Approval Procedure (ENAP).

NOTE 1: The EBU/ETSI JTC Broadcast was established in 1990 to co-ordinate the drafting of standards in the specific field of broadcasting and related fields. Since 1995 the JTC Broadcast became a tripartite body by including in the Memorandum of Understanding also CENELEC, which is responsible for the standardization of radio and television receivers. The EBU is a professional association of broadcasting organizations whose work includes the co-ordination of its members' activities in the technical, legal, programme-making and programme-exchange domains. The EBU has active members in about 60 countries in the European broadcasting area; its headquarters is in Geneva.

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The Eureka Project 147 was established in 1987, with funding from the European Commission, to develop a system for the broadcasting of audio and data to fixed, portable or mobile receivers. Their work resulted in the publication of European Standard, ETSI ETS 300 401 [i.1], for DAB® (see note) which now has worldwide acceptance.

NOTE 2: DAB® is a registered trademark owned by one of the Eureka Project 147 partners.

The DAB® family of standards is supported by World DAB®, an organization with members drawn from broadcasting organizations and telecommunication providers together with companies from the professional and consumer electronics industry.

With respect to the previous version of ETSI EN 300 401 [i.2] published in January 2017, the present document contains several refinements to the DAB system. These refinements were performed and agreed by the WorldDAB Forum and include the following areas:

- inclusion of new and revised FIGs;
- provision of signalling for indication of services with public prominence;
- addition of the DAB location coding system.

Proposed national transposition dates	
Date of latest announcement of this EN (doa):	3 months after ETSI publication
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	6 months after doa
Date of withdrawal of any conflicting National Standard (dow):	6 months after doa

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

1 Scope

The present document establishes a broadcasting standard for the Digital Audio Broadcasting (DAB) system designed for delivery of high-quality digital audio and video programmes and data services for mobile, portable and fixed reception from terrestrial transmitters in the Very High Frequency (VHF) frequency bands as well as for distribution through cable networks. The DAB system is designed to provide spectrum and power efficient techniques in terrestrial transmitter network planning, known as the Single Frequency Network (SFN) and the gap-filling technique. The DAB system meets the required sharing criteria with other radiocommunication services.

The present document defines the DAB transmission signal. It includes the coding algorithms for multiplexing of audio and video programmes and data services, channel coding and modulation. Provision is also made for transmission of additional data services which may be programme related or not, within the limit of the total system capacity. The present document provides information on the system configuration which includes information about the ensembles, services, service components and linking of them.

The present document describes the nominal characteristics of the emitted DAB signal. The aspects related to the receiver design are outside the scope of the present document.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found in the ETSI docbox.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long-term validity.

The following referenced documents are necessary for the application of the present document.

[1] ETSI TS 103 466: "Digital Audio Broadcasting (DAB); DAB audio coding (MPEG Layer II)".

[2] ETSI TS 102 563: "Digital Audio Broadcasting (DAB); Transport of Advanced Audio Coding (AAC) audio".

[3] ETSI TS 101 756: "Digital Audio Broadcasting (DAB); Registered Tables".

[4] ETSI TS 102 367: "Digital Audio Broadcasting (DAB); Conditional access".

[5] ETSI TS 103 176: "Digital Audio Broadcasting (DAB); Rules of implementation; Service information features".

[6] ETSI EN 301 234: "Digital Audio Broadcasting (DAB); Multimedia Object Transfer (MOT) protocol".

[7] ETSI TS 102 980: "Digital Audio Broadcasting (DAB); Dynamic Label Plus (DL Plus); Application specification".

[8] ETSI ES 201 980: "Digital Radio Mondiale (DRM); System Specification".

[9] ETSI TS 102 386: "Digital Radio Mondiale (DRM); AM signalling system (AMSS)".

[10] IEC 62106: "Radio data system (RDS) - VHF/FM sound broadcasting in the frequency range from 64,0 MHz to 108,0 MHz".

[11] Recommendation ITU-T X.25: "Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit".

[12] ETSI TS 104 089: "Digital Audio Broadcasting (DAB); Emergency Warning System (EWS); Definition and rules of behaviour".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents may be useful in implementing an ETSI deliverable or add to the reader's understanding, but are not required for conformance to the present document.

[i.1] ETSI ETS 300 401 (edition 1) (1995): "Radio Broadcasting Systems; Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers".

[i.2] ETSI EN 300 401 (V2.1.1) (2017): "Radio Broadcasting Systems; Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers".

3 Definition of terms, symbols, abbreviations and conventions

3.1 Terms

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

Access Control System (ACS): particular set of rules for managing entitlement checking and conditional access messages

announcement cluster: group of services which share the same announcement interruption privileges

Capacity Unit (CU): smallest addressable unit (64 bits) of the Common Interleaved Frame (CIF)

Change Event Indication (CEI): set of FIG fields with particular values to indicate a change of database content for certain service information features

Common Interleaved Frame (CIF): serial digital output from the main service multiplexer which is contained in the Main Service Channel part of the transmission frame

Conditional Access (CA): mechanism by which the user access to service components can be restricted

convolutional coding: coding procedure which generates redundancy in the transmitted data stream in order to provide ruggedness against transmission distortions

DAB transmission signal: transmitted radio frequency signal

database key: set of FIG fields that sub-divide a database for certain service information features

data service: service which comprises a non-audio primary service component and optionally additional secondary service components

energy dispersal: operation involving deterministic selective complementing of bits in the logical frame, intended to reduce the possibility that systematic patterns result in unwanted regularity in the transmitted signal

ensemble: transmitted signal, comprising a set of regularly and closely-spaced orthogonal carriers

NOTE: The ensemble is the entity which is received and processed. In general, it contains programme and data services.

Ensemble Identifier (EId): unique 16-bit code, allocated to an ensemble and intended to allow unambiguous world-wide identification of that ensemble

Equal Error Protection (EEP): error protection procedure which ensures a constant protection of the bit stream

Extended Programme Associated Data (X-PAD): extended part of the PAD carried towards the end of the DAB audio frame, immediately before the Scale Factor Cyclic Redundancy Check (CRC)

NOTE: Its length is variable.

Fast Information Block (FIB): data burst of 256 bits

Fast Information Channel (FIC): part of the transmission frame, comprising the Fast Information Blocks, which contains the multiplex configuration information together with optional service Information and data service components

Fast Information Group (FIG): package of data used for one feature in the Fast Information Channel. Eight different types are available to provide a classification of the features

Fixed Programme Associated Data (F-PAD): fixed part of the PAD contained in the last two bytes of the DAB audio frame

logical frame: data burst, contributing to the contents of a sub-channel, during a time interval of 24 ms

EXAMPLE: Data bursts at the output of an audio encoder, a Conditional Access scrambler and a convolutional encoder are referred to as logical frames. The number of bits contained in a specific logical frame depends on the stage in the encoding process and the bit rate associated with the sub-channel.

logical frame count: value of the CIF counter corresponding to the first CIF which carries data from the logical frame

Main Service Channel (MSC): channel which occupies the major part of the transmission frame and which carries all the digital audio service components, together with possible supporting and additional data service components

MSC data group: package of data used for one user application in the Main Service Channel

NOTE: MSC data groups are transported in a series of one or more packets or X-PAD data sub-fields.

Multiplex Configuration Information (MCI): information defining the configuration of the multiplex

NOTE: It contains the current (and in the case of an imminent reconfiguration, the forthcoming) details about the services, service components and sub-channels and the linking between these entities. It is carried in the FIC in order that a receiver may interpret this information in advance of the service components carried in the Main Service Channel. It also includes identification of the ensemble itself.

N: transform length of Fast Fourier Transform (FFT)

null symbol: first Orthogonal Frequency Division Multiplex (OFDM) symbol of the transmission frame

OFDM symbol: transmitted signal for that portion of time when the modulating phase state is held constant on each of the equi-spaced, equal amplitude carriers in the ensemble

NOTE: Each carrier is four-phase differentially modulated from one symbol to another, giving a gross bit rate of two bits per carrier per symbol.

packet mode: mode of data transmission in which data are carried in addressable blocks called packets

NOTE: Packets are used to convey MSC data groups within a sub-channel.

primary service component: first and mandatory component of a service

NOTE: It can be used as a default selection in the receiver.

programme: time-slice of a programme service, corresponding to an entry in a programme schedule

Programme Associated Data (PAD): information which is related to the audio data in terms of contents and synchronization

programme item: time-slice of a programme, for example, a piece of music or a news report

programme service: service which comprises an audio primary service component and optionally additional secondary service components

protection level: level specifying the degree of protection, provided by the convolutional coding, against transmission errors

protection profile: scheme of convolutional coding applied

Reserved for future addition (Rfa): bits that do not change the meaning of other parts of an information entity and so are not evaluated by receivers

NOTE: Rfa bits are always set to zero. If a new requirement is determined and specified in the future, Rfa bits may be replaced by fields with definite functions, but this will have no effect on any existing parts of the information entity.

Reserved for future use (Rfu): bits that change the meaning of other parts of an information entity and so are evaluated by receivers

NOTE: Rfu bits are always set to zero. If a new requirement is determined and specified in the future, Rfu bits may be replaced by fields with definite functions, and associated parts of the information entity may also change meaning.

secondary service component: service component that is additional to the primary service component

service: user-selectable output which can be either a programme service or a data service

service component: part of a service which carries either audio (including PAD) or data

Service Identifier (SId): 16-bit or 32-bit code used to identify a particular service

Service Information (SI): auxiliary information about services, such as service labels and programme type codes

service label: alphanumeric characters associated with a particular service and intended for display in a receiver

Single Frequency Network (SFN): network of DAB transmitters sharing the same radio frequency to achieve a large area coverage

stream mode: mode of data transmission within the Main Service Channel in which data are carried transparently from source to destination

sub-channel: part of the Main Service Channel which is individually convolutionally encoded and comprises an integral number of Capacity Units per Common Interleaved Frame

synchronization channel: part of the transmission frame providing a phase reference

transmission frame: actual transmitted frame, conveying the Synchronization Channel, the Fast Information Channel and the Main Service Channel

transmission mode: specific set of transmission parameters (e.g. number of carriers, OFDM symbol duration)

Unequal Error Protection (UEP): error protection procedure which allows the bit error characteristics to be matched with the bit error sensitivity of the different parts of the bit stream

User Application (UA): data application defined in a separate standard

X-PAD data group: package of data used for one user application in the Extended Programme Associated Data (X-PAD)

3.2 Symbols

3.2.0 General

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

3.2.1 Arithmetic operators

^	Power
/	Integer division with truncation of the result toward zero; for example, 7/4 and -7/-4 are truncated to 1 and -7/4 and 7/-4 are truncated to -1
Q(a/b)	Q(a/b) is the quotient part of the division of a by b (a and b positive integers)
R(a/b)	R(a/b) is the remainder of the division of a by b
mod(a,b) (b positive integer)	$\mathrm{mod}(a,b) = \begin{cases} R(a/b) \text{ if } a \text{ is a positive integer} \\ R((b\text{-}\mathrm{R}(-a/b))/b) \text{ if } a \text{ is a negative integer} \end{cases}$
(mod p)	Modulo p operation

3.2.2 Logical and set operators

max [,...,]	The maximum value in the argument list
min [,...,]	The minimum value in the argument list
$\oplus$	Exclusive or
$\cap$	Set intersection
$\cup$	Set union
\	Set exclusion: {-3, -2, ..., 3} \ {0} is the set of integers {-3, -2, -1, 1, 2, 3}

3.2.3 Functions

sin	Sine
cos	Cosine
exp	Exponential
$e^{(.)}$	Exponential function
$\sqrt{\ }$	Square root
log10	Logarithm to base 10
j	Imaginary unit, $j^2 = -1$
Rect	$\mathrm{Rect}(x) = \begin{cases} 1 \text{ if } 0 \le x < 1 \\ 0 \text{ elsewhere} \end{cases}$
δ	Kronecker symbol $\delta(i,j) = \begin{cases} 1 \text{ if } i = j \\ 0 \text{ if } i \ne j \end{cases}$

3.2.4 Constants

π	3,14159265359...
e	2,71828182846...

3.3 Abbreviations

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

A/D	Audio/Data
ACS	Access Control System
AM	Amplitude Modulation
AMSS	Amplitude Modulation Signalling System
AppTy	Application Type
ASCTy	Audio Service Component Type
ASu	Announcement Support flags
ASw	Announcement Switching flags

AU	Access Unit
C/N	Current/Next
CA	Conditional Access
CAId	Conditional Access Identifier
CAOrg	Conditional Access Organization
CEI	Change Event Indication
CI	Contents Indicator
CIF	Common Interleaved Frame
CRC	Cyclic Redundancy Check
CU	Capacity Unit
d&t	date and time
DAB	Digital Audio Broadcasting
DFT	Discrete Fourier Transform
DG	Data Group
DL	Dynamic Label
D-QPSK	Differential QPSK
DRC	Dynamic Range Control
DRM	Digital Radio Mondiale
DSCTy	Data Service Component Type
EBU	European Broadcasting Union
ECC	Extended Country Code
EEP	Equal Error Protection
EId	Ensemble Identifier
ETS	European Telecommunication Standard
FEC	Forward Error Correction
FFT	Fast Fourier Transform
FI	Frequency Information
FIB	Fast Information Block
FIC	Fast Information Channel
FIG	Fast Information Group
FM	Frequency Modulation
F-PAD	Fixed Programme Associated Data
IEC	International Electrotechnical Commission
ILS	International Linkage Set indicator
LA	Linkage Actuator
LSb	Least Significant bit
LSI	Leap Second Indicator
LSN	Linkage Set Number
LTO	Local Time Offset
MainId	Main Identifier of a transmitter
MCI	Multiplex Configuration Information
MJD	Modified Julian Date
MOT	Multimedia Object Transfer
MPEG	Moving Pictures Expert Group
MSb	Most Significant bit
MSC	Main Service Channel
OE	Other Ensemble
OFDM	Orthogonal Frequency Division Multiplex
P/D	Programme/Data service flag
P/S	Primary/Secondary
PAD	Programme Associated Data
PI	Programme Identification code (RDS)
PRBS	Pseudo-Random Binary Sequence
PTy	Programme Type
QPSK	Quadrature Phase Shift Keying
R&M	Range and Modulation
RDS	Radio Data System
Rfa	Reserved for future addition
Rfu	Reserved for future use
RS	Reed-Solomon
S/D	Static/Dynamic
SC	Service Component

SCId	Service Component Identifier
SCIdS	Service Component Identifier within the Service
SFN	Single Frequency Network
SI	Service Information
SId	Service Identifier
SIV	Service Information Version
SPI	Service and Programme Information
SubChId	Sub-Channel Identifier
SubId	Sub-Identifier of a transmitter
TII	Transmitter Identification Information
TMId	Transport Mechanism Identifier
TPEG	Transport Protocol Expert Group
TTI	Traffic and Travel Information
UA	User Application
UEP	Unequal Error Protection
UTC	Co-ordinated Universal Time
UTF	Unicode Transformation Format
VHF	Very High Frequency
X-PAD	eXtended Programme Associated Data

3.4 Conventions

Unless otherwise stated, the following notation, regarding the order of bits within each step of processing is used:

- in figures, the bit shown in the left hand position is considered to be first;
- in tables, the bit shown in the left hand position is considered to be first;
- in byte fields, the Most Significant bit (MSb) is considered to be first and denoted by the higher number. For example, the MSb of a single byte is denoted "b_7" and the Least Significant bit (LSb) is denoted "b_0";
- in vectors (mathematical expressions), the bit with the lowest index is considered to be first.

NOTE: Due to time-interleaving, this order of bits is not the true transmission order.

4 Basic DAB system description

4.0 General

The DAB system is a rugged, yet highly spectrum- and power-efficient sound, video and data broadcasting system. It uses industry standard audio and video encoding techniques to remove redundancy from the source signals, it then applies closely controlled redundancy to the signal to be transmitted to provide strong error protection. The transmitted information is spread in both the frequency and time domains so that the defects of channel distortions and fades can be eliminated from the recovered signal in the receiver, even when working in conditions of severe multi-path propagation, whether stationary or mobile. Efficient spectrum utilization is achieved by interleaving multiple programme signals and, additionally, by a special feature of frequency re-use, which permits broadcasting networks to be extended, virtually without limit, by operating additional transmitters carrying the same multiplexes on the same radiated frequency. The latter feature is known as the Single Frequency Network (SFN). This can also employ the gap filling technique. In this case, a gap filler transmitter receives and re-transmits the signal on the same frequency without demodulation and remodulation. This provides coverage of shadowed areas (including tunnels), which can arise within the overall coverage area provided by the main broadcast network transmitters. Nevertheless, the relatively low co-channel protection ratio of the DAB system also permits adjacent local coverage areas to be planned, on a continuously extending basis, with as few as four different frequency blocks.