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European Standard (Telecommunications series)

Digital Audio Broadcasting (DAB); Distribution interfaces; Digital baseband In-phase and Quadrature (DIQ) interface

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Contents

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Foreword

This European Standard (Telecommunications series) has been produced by the Joint Technical Committee (JTC) of the European Broadcasting Union (EBU), Comité Européen de Normalization Electrotechnique (CENELEC) and the European Telecommunications Standards Institute (ETSI), and is now submitted for the Voting phase of the ETSI standards Two-step Approval Procedure.

NOTE: The EBU/ETSI JTC was established in 1990 to co-ordinate the drafting of standards in the specific field of broadcasting and related fields. Since 1995 the JTC became a tripartite body by the inclusion in the Memorandum of Understanding of CENELEC, which is responsible for the standardization of radio and television receivers. The EBU is a professional association of broadcasting organizations whose work includes 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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EUREKA Project 147 (DAB)**

EUREKA Project 147 was established in 1987, with funding from the EC, to develop a system for the broadcasting of audio and data to fixed, portable or mobile receivers. Their work resulted in the publication of a European standard, ETS 300 401 (see bibliography), for DAB which now has world-wide acceptance. The members of the EUREKA 147 Project are drawn from broadcasting organizations and telecommunication providers together with companies from the professional and consumer electronics industry.

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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

Introduction

The present document is one of a set associated with DAB. ETS 300 401 (see bibliography) describes the transmitted signal; the interface between the broadcaster's transmitters and the listener's receiver. The associated documents, EN 300 797 and ETS 300 799 (see bibliography), describe additional interfaces which can be used by broadcasters or network providers to build DAB networks.

Figure 1 shows a DAB network in outline. For convenience, the network is split into a number of different parts, each managed by a different entity. The different entities are; the Programme/Data provider, the Service Component provider, the Ensemble provider and the Transmission Network provider.

NOTE: A Service Component provider may be generating a full DAB service or a component of a DAB service. For the purposes of the present document, the terms Service provider and Service Component provider are interchangeable.

Programme/Data provider

The Programme/Data provider is the originator of the audio programme or the data being carried within the DAB Service Component. The format for the output of the Programme/Data provider may take many different forms and should be agreed between the Programme/Data provider and the Service Component provider.

Service Component provider

The Service Component provider is producing one or more complete Service Components which may form the complete DAB service, but may not. Data from the Service Component provider will comprise three different parts:

- Service Component data which is to be inserted into the DAB Main Service Channel (MSC);
- Service Information related to the Service Component data which is to be inserted into the Fast Information Channel (FIC);
- Other data, not intended for transmission, including status monitoring or control.

The interface between the Service Component provider and the Ensemble provider is known as the Service Transport Interface (STI) and is defined in EN 300 797 (see bibliography).

Ensemble provider

The Ensemble provider receives a set of service components from one or more Service Component providers. He then formats the FIC, and generates an unambiguous description of the full DAB Ensemble.

The ensemble description is passed to the Transmission Network provider via an interface called the ETI which is defined in ETS 300 799 (see bibliography).

Transmission Network provider

The Transmission Network provider generates the DAB Ensemble and transmits it to the receiver. The output of the Transmission provider is defined by ETS 300 401 (see bibliography). The Transmission Network provider is usually the final recipient of the ETI and is responsible for turning it into the DAB transmission signal using an OFDM generator.

In some cases, as an intermediate step, the Transmission provider may find it convenient to generate a baseband representation of the signal to be transmitted. The baseband representation, known as the DIQ, is a set of digital samples defining the In-phase (I) and Quadrature (Q) components of the final carrier. This interface is defined in the present document and provides a convenient interface between digital processing equipment and radio-frequency modulating equipment.

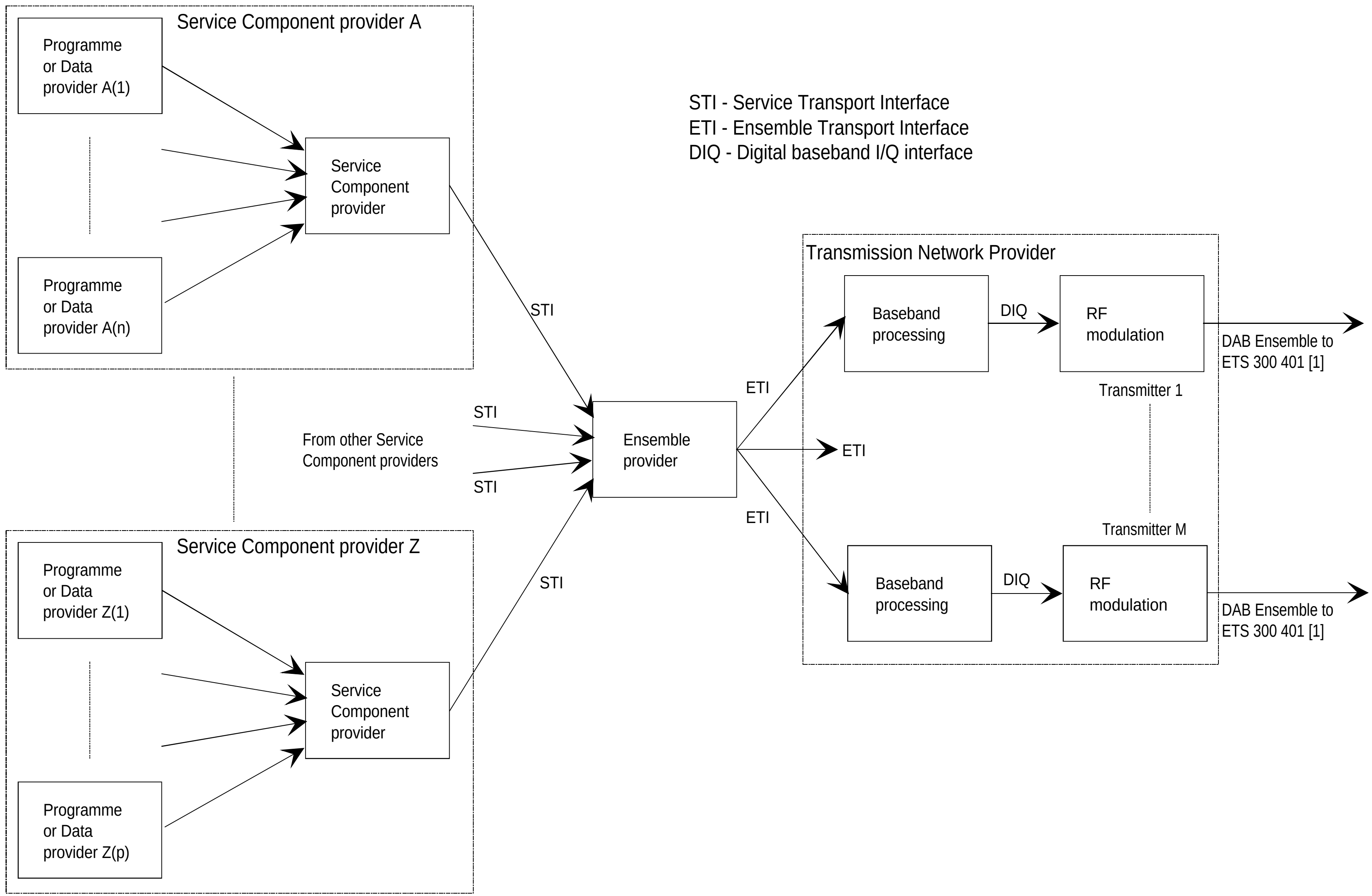


Figure 1: DAB network outline

1 Scope

The present document establishes a standard method for the connection of digital processing equipment (which is producing DAB baseband I/Q signals) and Radio Frequency (RF) modulation equipment in a DAB system. It can also be used to provide access to baseband I/Q signals for test purposes.

ETS 300 401 established a broadcasting standard for a DAB system. Broadcasters who implement DAB networks require standardized interfaces for the connection of different equipment in the DAB chain.

The present document is applicable to DAB channel coding equipment. It describes the characteristics of a suitable interface for the connection of the two major elements of the DAB OFDM generator; the baseband processing equipment and the RF modulator. The interface provides an interconnection between a single source (the baseband processor) and a single destination (the RF modulator).

The present document does not cover the generation of the digital I/Q baseband signals. This is covered in ETS 300 401. The digital baseband I/Q interface is unidirectional and does not cover the provision of status nor control information in the reverse direction (i.e. from the modulator back to the baseband processing section of the equipment).

2 References

References may be made to:

a) specific versions of publications (identified by date of publication, edition number, version number, etc.), in which case, subsequent revisions to the referenced document do not apply; or

b) all versions up to and including the identified version (identified by "up to and including" before the version identity); or

c) all versions subsequent to and including the identified version (identified by "onwards" following the version identity); or

d) publications without mention of a specific version, in which case the latest version applies.

A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] ITU-R BT.656-2 (November 1994): "Interfaces for digital component video signals in 525-line and 625-line television systems".

3 Definitions, abbreviations and symbols

3.1 Definitions

For the purposes of the present document, the definitions of ETS 300 401 (see bibliography) and the following definitions apply:

baseband I/Q: A representation of the DAB transmission signal using I and Q components of the carrier which represent the amplitude of the in-phase and quadrature components of the transmission signal.

baseband processing: When applied to the DIQ interface, this is taken to mean that part of the OFDM generator which receives the ETI signal and produces the DIQ signal.

CIFcount: The Common Interleaved Frame (CIF) counter as defined in ETS 300 401 (see biblography).

COFDM: Coded Orthogonal Frequency Division Multiplex; the combination of channel coding and OFDM as used in the DAB system.

data transfer time: The instant at which data is read by the DIQ receiver.

digital baseband I/Q: A version of the baseband I/Q signal using digital samples to represent the amplitudes of I and Q.

DAB transmission signal: The radio frequency signal radiated from a DAB transmitter.

DAB transmission frame: The transmitted frame, specific to the four transmission modes used by the DAB system, conveying the DAB data.

ensemble: The DAB transmission signal, comprising a set of regularly and closely-spaced orthogonal carriers. The ensemble is the entity which is received and processed by the DAB receiver. In general, it contains programme and data services. Also sometimes used loosely to describe the package of data (or Ensemble Multiplex) representing that signal.

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

OFDM: Orthogonal Frequency Division Multiplex, the modulation method employed by the DAB system.

OFDM generator: The equipment which is the final recipient of the ETI signal and which generates the OFDM signal from it. The OFDM generator is taken to have two major parts - baseband processing, which generates a baseband I/Q signal as an intermediate step, followed by RF modulation.

RF modulator: When applied to the DIQ interface, this is taken to mean that part of the OFDM generator which receives the DIQ signal and produces a DAB transmission signal.

3.2 Abbreviations

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

$\overline{Q}/I$	an alternating signal which identifies a DIQ sample as either an I_n or Q_n sample
CLK	Clock
COFDM	Coded Orthogonal Frequency Division Multiplex
DAB	Digital Audio Broadcasting
DIQ	Digital baseband I/Q interface
ECL	Emitter-Coupled Logic
ETI	Ensemble Transport Interface
FFT	Fast Fourier Transform
FIC	Fast Information Channel
FSYNC	Frame Synchronization
GND	Ground
I(t)	the time variant, In-phase component of the modulated signal
I/Q	In-phase and Quadrature components of the modulated signal
I_n	the n^{th} sample of I(t)
$I_{TII}(t)$	the time variant, In-phase component of the modulated signal during the TII symbol
ITU	International Telecommunications Union
LSb	Least Significant bit
MSb	Most Significant bit
NRZ	Non-Return-to-Zero
OFDM	Orthogonal Frequency Division Multiplex
Q(t)	the time variant, Quadrature component of the modulated signal
Q_n	the nth sample of Q(t)
$Q_{TII}(t)$	the time variant, Quadrature component of the modulated signal during the TII symbol
RF	Radio Frequency
rms	root-mean-square
s(t)	the time variant DAB transmission signal
s_n	the sampled version of the DAB transmission signal
STI	Service Transport Interface
TII	Transmitter Identification Information

3.3 Symbols

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

3.3.1 Numerical ranges

[m.n]	denotes the numerical range m, m + 1, m + 2,..., n, where m and n are positive integers with n > m.

3.3.2 Bit numbering

b_n	denotes bit number *n*. *n* is usually in the range [0..7].

3.3.3 Arithmetic operators

+	Addition
×	Multiplication

3.3.4 Functions

cos x	Cosine of x
sin x	Sine of x
j	Imaginary unit with $j^2 = -1$
σ	rms value

3.3.5 Constants

π	3,141 592 653 59...

4 Conceptual location of the DIQ interface

Figure 2 is a modified version of a diagram taken from ETS 300 401 (see bibliography) and shows the conceptual block diagram of the emission part of the DAB system. The conceptual location of the DIQ is shown on the diagram.

The DIQ interface may also be used directly at the output of the baseband processing part of the OFDM generator, as shown in figure 2, in circumstances where the TII is not required, or is to be added at a later stage.

5 General description of the DIQ signal

5.1 Mathematical definition

The time variant DAB transmission signal, s(t), at a carrier frequency f_c, shall be given as follows:

$$s(t) = I(t)\cos(2\pi f_c t) \quad - \quad Q(t)\sin(2\pi f_c t)$$

where I(t) and Q(t) represent the In-phase and Quadrature, time variant, components of the carrier signal.

The signal carried by the DIQ, s_n, shall be the sampled version of the DAB transmission signal, sampled at the frequency f_s. The sampled values, I_n and Q_n, at time t = (n/f_s) shall be given by the following expression:

$$s_n = I_n(n/f_s) + j\,Q_n(n/f_s)$$

where	n is 0, 1, 2, ...
and	f_s is the sampling frequency.

5.2 Sampling frequency and sample size

The sampling frequency f_s shall be 2 048 kHz.

The DIQ samples shall be 8-bit values.

5.3 Numerical range

In the baseband processing section of the OFDM generator, the I_n and Q_n samples, which will be carried by the DIQ, are generated as the result of an FFT process to obtain a baseband signal. The numerical range at the output of the FFT processing will generally be larger than can be carried by the DIQ and will have a mean value of zero and a standard deviation of σ. The following process shall be used to convert the FFT output range into a range which can be carried by the DIQ interface:

Step 1: Normalize all values at the output of the FFT process with respect to 4σ.

Step 2: Limit the absolute values of the samples to $[1-(1/2^7)]$.

The processed values will then be in the range:

$$\left[-1+\frac{1}{2^7},..,-\frac{1}{2^7}\ ,\ 0\ ,\ +\frac{1}{2^7}\ ,..,1-\frac{1}{2^7}\right]$$

These values are carried by DIQ using two’s complement notation so that the above number range is mapped to the range:

$$[\ 81\ ,..,\ FF\ ,\ 00\ ,\ 01\ ,..,\ 7F\ ]$$

NOTE: When using the above procedure the hexadecimal value 80 is unused.

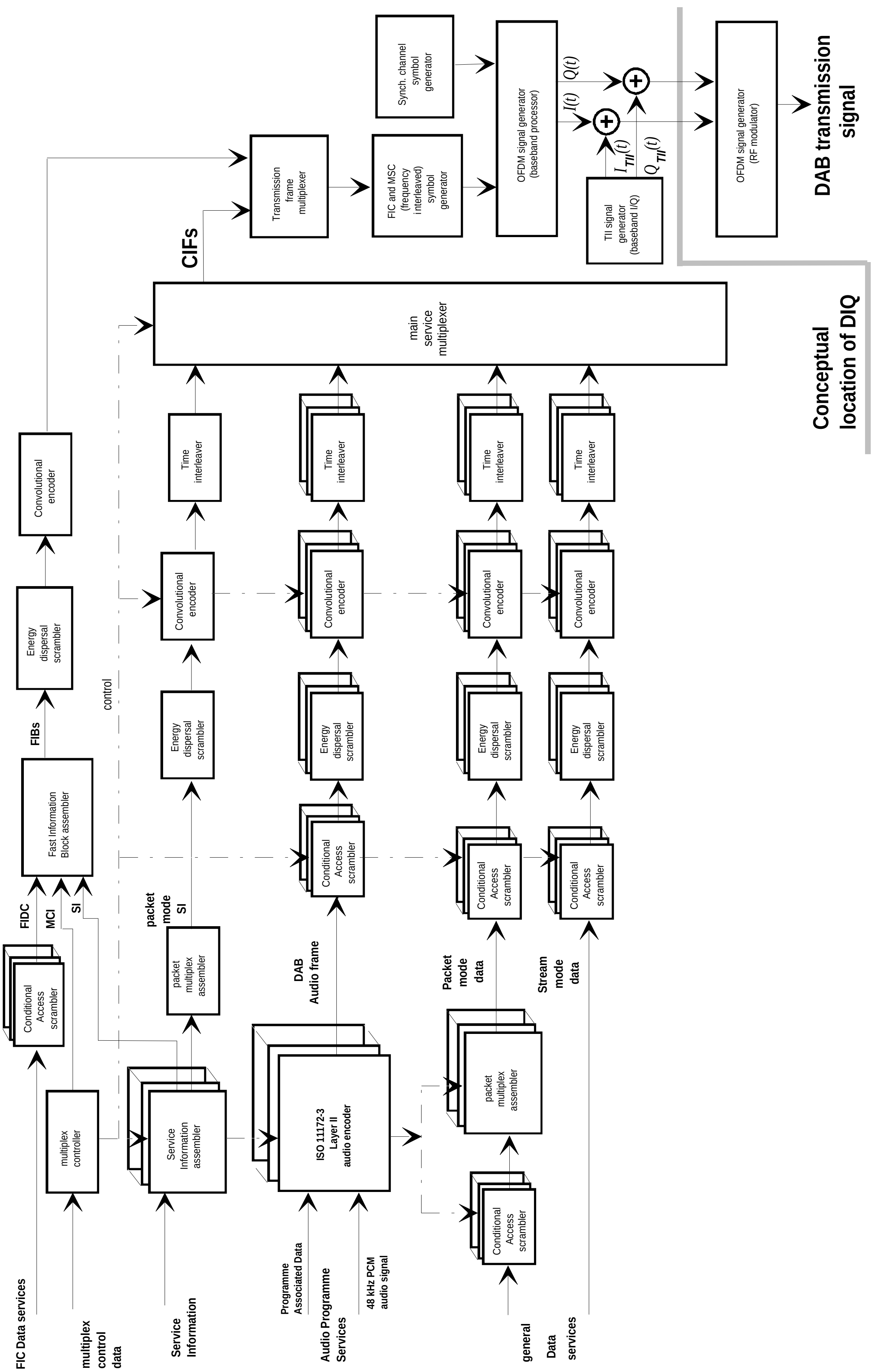


Figure 2: Conceptual DAB emission block diagram showing the location of the DIQ

6 Details of the Digital baseband I/Q interface (DIQ)

6.1 General

The bits of the digital samples that describe the COFDM signal shall be transmitted in parallel by means of eight conductor pairs. Each conductor pair shall carry a multiplexed bit stream comprising alternating bits of the in-phase and quadrature samples. For convenience, the eight bits of the I and Q samples are identified as DATA[0] to DATA[7]. The entire sample is designated as DATA[0..7].

Two additional conductor pairs shall provide a synchronous clock and an I/Q identifier. These are identified as "CLK" and "$\overline{Q}/I$" respectively.

An additional conductor pair can provide a frame synchronization pulse. This is identified as "FSYNC" and shall mark the start of the DAB transmission frame.

All signals on the interface shall be transmitted using balanced conductor pairs. Cable length of up to 50 m may be used without cable equalization.

NOTE 1: Longer cable lengths may be used with suitable equalization (see ITU-R BT.656-2 [1]).

NOTE 2: Special precautions may need to be taken if long cable lengths are planned in areas where high RF fields are present.

The interconnection shall use a twenty-five pin D-subminiature female connector on equipments and a male connector fitted to cables.

6.2 Definition of DIQ signals

6.2.1 The CLK signal

The CLK signal shall have a frequency of twice the sampling frequency f_s (i.e. 4 096 kHz) and shall be generated by the baseband processing equipment. CLK shall be a square wave and the 1-0 transition shall represent the data transfer time.

6.2.2 The DATA signal

DATA[0..7] shall be an 8-bit sample representing the sampled value of I_n and Q_n.

I_n and Q_n shall be output on alternate phases of CLK with I_n appearing before Q_n.

DATA[7] shall be the most significant bit of the sample and DATA[0] shall be the least significant bit.

The numerical format of DATA[0..7] signal shall be two's complement.

DATA[0..7] shall be coded in NRZ form.

DATA[0..7] shall be stable on the 1-0 transition of CLK, see subclause 6.5.

6.2.3 The $\overline{Q}/I$ signal

The $\overline{Q}/I$ signal shall alternate between a logical "1" and a logical "0" on consecutive 0-1 transitions of CLK.

The $\overline{Q}/I$ signal shall be stable on the 1-0 transition of CLK, see subclause 6.5.

The $\overline{Q}/I$ signal shall indicate logical "1" when DATA[0..7] represents I_n. The $\overline{Q}/I$ signal shall indicate logical "0" when DATA[0..7] represents Q_n.

6.2.4 The FSYNC signal

FSYNC shall be a pulse with a period equal to the DAB transmission frame length. FSYNC shall have a minimum pulse width equal to the duration of the null symbol.

The 1-0 transition of FSYNC shall occur on the 0-1 transition of CLK which corresponds to the first DATA[0..7] sample of a DAB transmission frame (which will be the first I_n sample of the null symbol).

The 0-1 transition of FSYNC shall occur on a 0-1 transition of CLK and shall occur before the I_n sample which marks the start of the following DAB transmission frame.

FSYNC, shall be stable on the 1-0 transition of CLK, see subclause 6.5.

NOTE: The width of the FSYNC pulse need not be constant and could be varied, for instance, to indicate the 6-second sequence inherent to the DAB system (cycle length of CIFcount ITU-R BT.656-2 [1]).

6.2.5 Signal direction

DATA[0..7], CLK and $\overline{Q}/I$ shall be generated by the data source and should include TII signal samples, $I_{TII}(t)$ and $Q_{TII}(t)$, as shown in figure 2.

FSYNC, when present, shall be generated by the data source.

Figure 3 shows the flow of signals between data source and receiver.

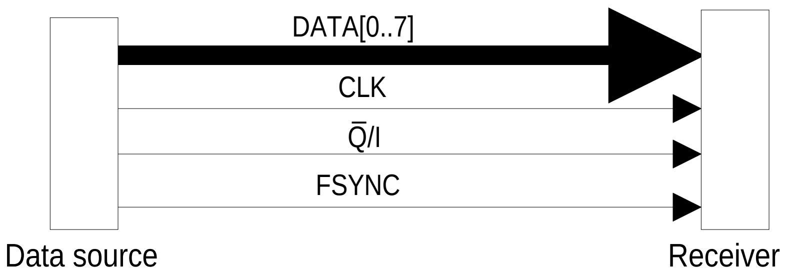


Figure 3: DIQ signal flow

6.3 Electrical characteristics of the DIQ interface

6.3.1 General

The interface shall employ 11-line drivers and 11-line receivers. Each line driver (source) shall have a balanced output and the corresponding line receiver (destination) shall have a balanced input as shown in figure 4.

Line drivers or receivers based on ECL technology should be used.

All digital signal time intervals shall be measured between the half-amplitude points.

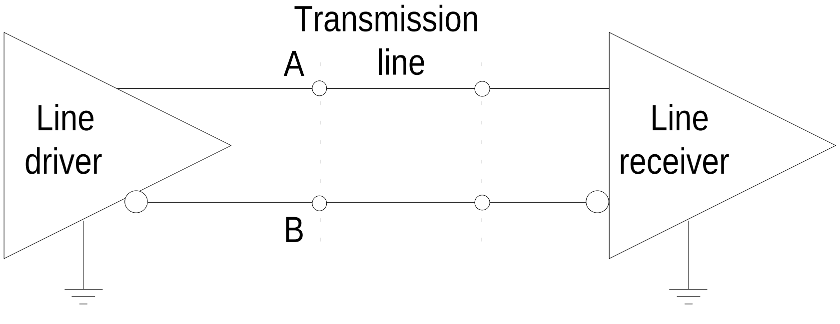


Figure 4: Interconnection between line driver and line receiver

6.3.2 Logic convention

The A terminal of the line driver, see figure 4, shall be positive with respect to the B terminal for a binary "1" and negative for a binary "0".

6.3.3 Line driver characteristics (source)

The output impedance measured between terminals A and B in figure 4 shall be less than 110 Ω.

The common mode voltage shall be in the range -1,29 V ± 15 % on both terminals A and B in figure 4 relative to ground.

The signal amplitude, measured across a 110 Ω resistive load between terminals A and B in figure 4, shall be in the range 0,8 V to 2,0 V peak-to-peak.

The signal rise and fall times shall be measured between the 20 % and 80 % amplitude points, with a 110 Ω resistive load connected between terminals A and B in figure 4. The rise and fall times shall be less than 5 ns, and the difference between the rise and fall times shall not exceed 2 ns.

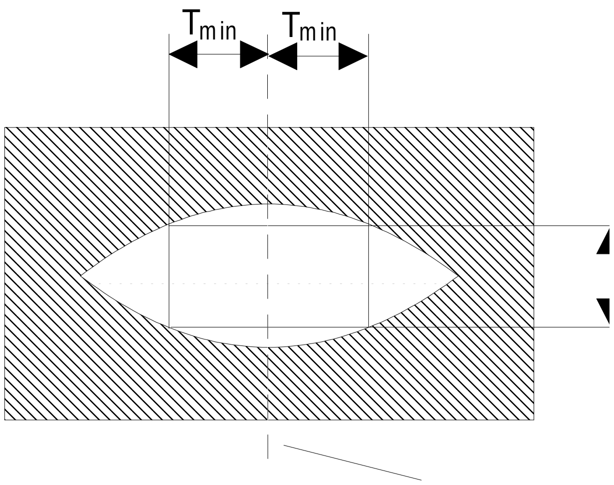
6.3.4 Line receiver characteristics (destination)

The input impedance at the line receiver shall be in the range 110 Ω ± 10 Ω.

The line receiver shall sense correctly the binary data when the input signal is in the range 0,185 V to 2,0 V peak-to-peak. The line receiver shall also sense correctly the binary data when a random data signal produces the conditions represented by the eye diagram in figure 5 at the data detection point.

The line receiver shall sense correctly the binary data in the presence of a common mode signal (on terminals A and B relative to ground) of up to ± 0,5 V, comprising an interfering signal in the frequency range 0 to 15 kHz. The interfering signal shall consist of spot frequencies or band-limited noise.

Data shall be correctly sensed when the differential delay, between CLK and any signal DATA[0..7], $\overline{Q}/I$, or FSYNC, is in the range ±11 ns as shown in figure 5.



NOTE: The width of the window in the eye diagram, within which the data shall be correctly detected, comprises ± 3 ns for clock jitter, ± 3 ns for DATA[0..7], $\overline{Q}/I$ or FSYNC timing and ± 5 ns for differences in delay between pairs of cable.

Figure 5: Idealized eye diagram corresponding to the minimum input signal level (0,185V) (T_{min} = 11 ns, V_{min} = 100 mV)

6.4 Pin allocation of the DIQ signals

The pin allocation for the DIQ signals shall be as given in table 1.

Table 1: Pin allocation for DIQ signals

Pin number	Signal	Pin number	Signal
1	GND	14	GND
2	FSYNC (A)	15	FSYNC (B)
3	$\overline{Q}/I$ (A)	16	$\overline{Q}/I$ (B)
4	CLK (A)	17	CLK (B)
5	DATA[7] (A)	18	DATA[7] (B)
6	DATA[6] (A)	19	DATA[6] (B)
7	DATA[5] (A)	20	DATA[5] (B)
8	DATA[4] (A)	21	DATA[4] (B)
9	DATA[3] (A)	22	DATA[3] (B)
10	DATA[2] (A)	23	DATA[2] (B)
11	DATA[1] (A)	24	DATA[1] (B)
12	DATA[0] (A)	25	DATA[0] (B)
13	Cable shield		

The A and B terminals of the source and receiver should be connected by twisted pair cable.

Shielded cables should be used.

6.5 Timing relationships

The timing relationship between the various signals of DIQ shall be as shown in figure 6.

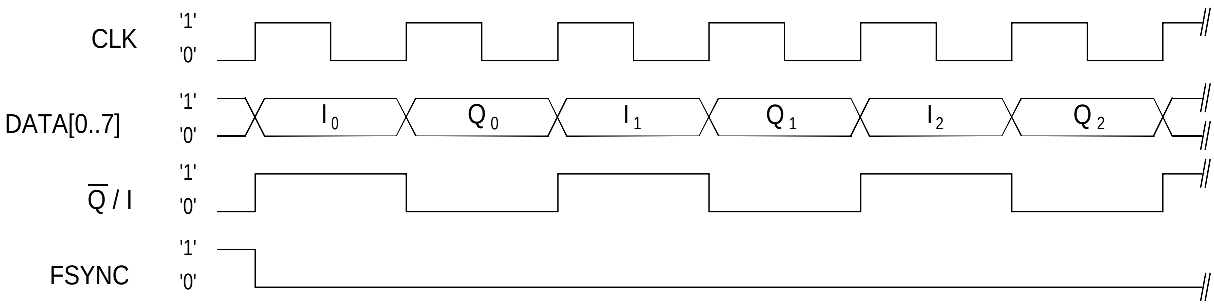


Figure 6: Timing relationship of DIQ signals

The 1-0 transition of the clock signal shall occur midway between the DATA[0..7] and $\overline{Q}/I$ transitions as shown in figure 7.

The relationship between the clock period T, the clock pulse width t_{CLK}, the timing of DATA[0..7] and $\overline{Q}/I$, t_{DIQ}, (all at the sending end respectively) shall be defined as shown in figure 7 where:

- T = 1 / 4 096 kHz = 244 ns;
- t_{CLK} = 1 / (2 × 4 096 kHz) ± 3 ns = 122 ns ± 3 ns;
- t_{DIQ} = 1 / (2 × 4 096 kHz) ± 3 ns = 122 ns ± 3 ns.

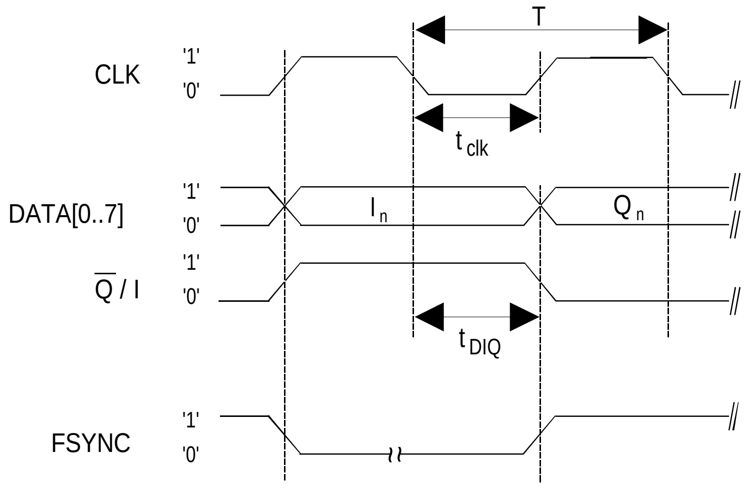


Figure 7: Clock to DATA[0..7], $\overline{Q}$ / I and FSYNC timing

6.6 CLK timing jitter

The variation in the period of the CLK output of the data source, measured between consecutive 1-0 transitions, shall not differ by more than 3 ns from the average period measured over the DAB transmission frame.

NOTE: The jitter specification given above is intended to provide reliable data transfer between data source and receiver. It is not intended to cover situations in which the CLK signal is used as a reference for the centre frequency of the DAB transmission signal. In this latter situation, additional consideration shall be given to the relationship between jitter on the edges of CLK and the required carrier frequency stability.

Annex A (informative): Bibliography

- ETS 300 401: "Digital Audio Broadcasting (DAB); DAB to mobile, portable and fixed receivers".
- prEN 300 797: "Digital Audio Broadcasting (DAB); Distribution interfaces; Service Transport Interface (STI)".
- ETS 300 799: "Digital Audio Broadcasting (DAB); Distribution interfaces; Ensemble Transport Interface (ETI)".
- EUREKA Project 147 (rev 1, November 1995): "Digital Audio Broadcasting System - Definition of the Digital baseband I/Q Interface".
- EIA JESD8-2 (1993): "Standard for Operating Voltages and Interface Levels for Low Voltage Emitter-Coupled Logic (ECL) Integrated Circuits".
- ISO 2110 (1989): "Information technology - Data communication - 25-pole DTE/DCE interface connector and contact number assignments".

History

Document history				
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