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Digitalna videoradiodifuzija (DVB) – Struktura okvirov, kodiranje kanalov in modulacija za satelitske storitve na 11/12 GHz

Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for 11/12 GHz satellite services

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ETSI Secretariat

Postal address
F-06921 Sophia Antipolis Cedex - FRANCE

Office address
650 Route des Lucioles - Sophia Antipolis
Valbonne - FRANCE
Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16
Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

X.400
c= fr; a=atlas; p=etsi; s=secretariat

Internet
secretariat@etsi.fr
http://www.etsi.fr

Contents

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Foreword

This second edition, previously as an ETS now an EN, contains changes of an entirely editorial nature as follows:

1) add the DVB logo to the front page of the deliverable;

2) change the title from: "Digital broadcasting systems for television, sound and data services; etc." to "Digital Video Broadcast (DVB); etc.";

3) add in the foreword the DVB acknowledgement.

This European Standard (Telecommunications series) has been produced by the Joint Technical Committee (JTC) of the European Broadcasting Union (EBU), Comité Européen de Normalisation ELECtrotechnique (CENELEC) and the European Telecommunications Standards Institute (ETSI).

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 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 *.

* European Broadcasting Union

Case Postale 67

CH-1218 GRAND SACONNEX (Geneva)

Switzerland

Tel: +41 22 717 21 11

Fax: +41 22 717 24 81

Digital Video Broadcasting (DVB) Project

Founded in September 1993, the DVB Project is a market-led consortium of public and private sector organizations in the television industry. Its aim is to establish the framework for the introduction of MPEG-2 based digital television services. Now comprising over 200 organizations from more than 25 countries around the world, DVB fosters market-led systems, which meet the real needs, and economic circumstances, of the consumer electronics and the broadcast industry.

Proposed national transposition dates	
Date of adoption:	15 August 1994
Date of latest announcement of this EN (doa):	30 November 1997
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	31 May 1998
Date of withdrawal of any conflicting National Standard (dow):	31 May 1998

1 Scope

The present document describes the modulation and channel coding system (denoted the "System" for the purposes of the present document) for satellite digital multi-programme Television (TV)/High Definition Television (HDTV) services to be used for primary and secondary distribution in Fixed Satellite Service (FSS) and Broadcast Satellite Service (BSS) bands. The System is intended to provide Direct-To-Home (DTH) services for consumer Integrated Receiver Decoder (IRD), as well as collective antenna systems (Satellite Master Antenna Television (SMATV)) and cable television head-end stations, with a likelihood of remodulation, see EN 300 429 (bibliography).

The System uses Quaternary Phase Shift Keying (QPSK) modulation and concatenated error protection strategy based on a convolutional code and a shortened Reed-Solomon (RS) code.

The System is suitable for use on different satellite transponder bandwidths.

Compatibility with Moving Pictures Experts Group-2 (MPEG-2) coded TV services (see ISO/IEC DIS 13818-1 [1]), with a transmission structure synchronous with the packet multiplex, is provided. Exploitation of the multiplex flexibility allows the use of the transmission capacity for a variety of TV service configurations, including sound and data services. All service components are Time Division Multiplexed (TDM) on a single digital carrier.

The present document:

- gives a general description of the System for satellite digital TV transmission;
- specifies the digitally modulated signal in order to allow compatibility between pieces of equipment developed by different manufacturers. This is achieved by describing in detail the signal processing principles at the modulator side, while the processing at the receive side is left open to different implementation solutions. However, it is necessary in the present document to refer to certain aspects of reception;
- identifies the global performance requirements and features of the System, in order to meet the service quality targets.

2 Normative 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] ISO/IEC DIS 13818-1 (June 1994): "Coding of moving pictures and associated audio".

[2] Forney, G.D. IEEE Trans. Comm. Tech., COM-19, pp. 772-781, (October 1971): "Burst-correcting codes for the classic bursty channel".

[3] Intelsat Earth Station Standards (IESS) No. 308, revision 6 (26 October 1990): "Performance characteristics for Immediate Data Rate (IDR) digital carriers".

3 Symbols and abbreviations

3.1 Symbols

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

α	Roll-off factor
C/N	Signal-to-noise ratio
d_{free}	Convolutional code free distance
E_b/N_0	Ratio between the energy per useful bit and twice the noise power spectral density
f_N	Nyquist frequency
G_1,G_2	Convolutional code generators
g(x)	RS code generator polynomial
I	Interleaving depth [bytes]
I, Q	In-phase, Quadrature phase components of the modulated signal
j	Branch index of the interleaver
K	Convolutional code constraint length
M	Convolutional interleaver branch depth for j = 1, M = N/I
N	Error protected frame length (bytes)
p(x)	RS field generator polynomial
r_m	In-band ripple (dB)
R_s	Symbol rate corresponding to the bilateral Nyquist bandwidth of the modulated signal
R_u	Useful bit rate after MPEG-2 [1] transport multiplexer
R_u'	Bit rate after RS outer coder
T	Number of bytes which can be corrected in RS error protected packet
T_s	Symbol period
X,Y	Di-bit stream after rate 1/2 convolutional coding

3.2 Abbreviations

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

AWGN	Additive White Gaussian Noise
BB	BaseBand
BER	Bit Error Ratio
BSS	Broadcast Satellite Service
BW	BandWidth
DTH	Direct To Home
FDM	Frequency Division Multiplex
FEC	Forward Error Correction
FIFO	First-In, First-Out shift register
FIR	Finite Impulse Response
FSS	Fixed Satellite Service
HEX	Hexadecimal notation
HDTV	High Definition Television
IF	Intermediate Frequency
IMUX	Input Multiplexer - Filter
IRD	Integrated Receiver Decoder
MPEG	Moving Pictures Experts Group
MSB	Most Significant Bit
MUX	Multiplex
OBO	Output Back Off
OCT	Octal notation
OMUX	Output Multiplexer - Filter
P	Puncturing
PDH	Plesiochronous Digital Hierarchy
PSK	Phase Shift Keying
PRBS	Pseudo Random Binary Sequence

QEF	Quasi-Error-Free
QPSK	Quaternary PSK
R	Randomized sequence
RF	Radio Frequency
RS	Reed-Solomon
SMATV	Satellite Master Antenna Television
TBD	To Be Defined
TDM	Time Division Multiplex
TV	Television
TWTA	Travelling Wave Tube Amplifier

4 Transmission system

4.1 System definition

The System is defined as the functional block of equipment performing the adaptation of the baseband TV signals, from the output of the MPEG-2 transport multiplexer (see ISO/IEC DIS 13818-1 [1]), to the satellite channel characteristics. The following processes shall be applied to the data stream (see figure 1):

- transport multiplex adaptation and randomization for energy dispersal;
- outer coding (i.e. Reed-Solomon);
- convolutional interleaving;
- inner coding (i.e. punctured convolutional code);
- baseband shaping for modulation;
- modulation.

The System functional description is given in annex B.

DTH services via satellite are particularly affected by power limitations, therefore, ruggedness against noise and interference, shall be the main design objective, rather than spectrum efficiency. To achieve a very high power efficiency without excessively penalizing the spectrum efficiency, the System shall use QPSK modulation and the concatenation of convolutional and RS codes. The convolutional code is able to be configured flexibly, allowing the optimization of the system performance for a given satellite transponder bandwidth (see annex C).

Although the System is optimized for single carrier per transponder Time Division Multiplex (TDM), it is able to be used for multi-carrier Frequency Division Multiplex (FDM) type applications.

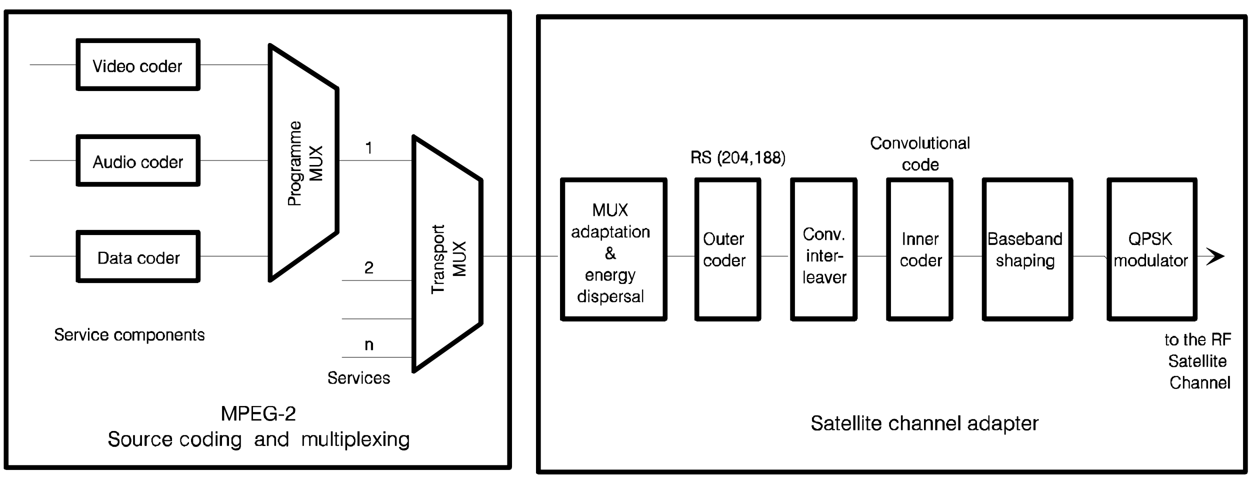

Figure 1: Functional block diagram of the System

The System is directly compatible with MPEG-2 coded TV signals (see ISO/IEC DIS 13818-1 [1]). The modem transmission frame is synchronous with the MPEG-2 multiplex transport packets.

If the received signal is above C/N and C/I threshold, the Forward Error Correction (FEC) technique adopted in the System is designed to provide a "Quasi Error Free" (QEF) quality target. The QEF means less than one uncorrected error-event per transmission hour, corresponding to Bit Error Ratio (BER) = 10^{-10} to 10^{-11} at the input of the MPEG-2 demultiplexer.

4.2 Adaptation to satellite transponder characteristics

Transmissions of digital multi-programme TV services will use satellites in both the FSS and the BSS bands. The choice of transponder bandwidth is a function of the satellite used and the data rates required by the service.

The symbol rate shall be matched to given transponder characteristics. Examples based on computer simulations for a hypothetical satellite chain, not including interference effects, are given in annex C.

4.3 Interfacing

The System, as defined in the present document, shall be delimited by the following interfaces given in table 1:

Table 1: System interfaces

Location	Interface	Interface type	Connection
Transmit station	Input	MPEG-2 [1] transport multiplex	from MPEG-2 multiplexer
	Output	70/140 MHz IF	to RF devices
Receive installation	Output	MPEG-2 transport multiplex	to MPEG-2 demultiplexer
	Input	TBD	from RF devices (indoor unit)

4.4 Channel coding

4.4.1 Transport multiplex adaptation and randomization for energy dispersal

The System input stream shall be organized in fixed length packets (see figure 3), following the MPEG-2 transport multiplexer (see ISO/IEC DIS 13818-1 [1]). The total packet length of the MPEG-2 transport Multiplex (MUX) packet is 188 bytes. This includes 1 sync-word byte (i.e. 47_{HEX}). The processing order at the transmitting side shall always start from the MSB (i.e. "0") of the sync word-byte (i.e. 01000111).

In order to comply with ITU Radio Regulations and to ensure adequate binary transitions, the data of the input MPEG-2 multiplex shall be randomized in accordance with the configuration depicted in figure 2.

The polynomial for the Pseudo Random Binary Sequence (PRBS) generator shall be:

$$1 + X^{14} + X^{15}$$

Loading of the sequence "100101010000000" into the PRBS registers, as indicated in figure 2, shall be initiated at the start of every eight transport packets. To provide an initialization signal for the descrambler, the MPEG-2 sync byte of the first transport packet in a group of eight packets is bit-wise inverted from 47_{HEX} to $B8_{HEX}$. This process is referred to as the "Transport Multiplex Adaptation".

The first bit at the output of the PRBS generator shall be applied to the first bit (i.e. MSB) of the first byte following the inverted MPEG-2 sync byte (i.e. $B8_{HEX}$). To aid other synchronization functions, during the MPEG-2 sync bytes of the subsequent 7 transport packets, the PRBS generation shall continue, but its output shall be disabled, leaving these bytes unrandomized. Thus, the period of the PRBS sequence shall be 1 503 bytes.

The randomization process shall be active also when the modulator input bit-stream is non-existent, or when it is non-compliant with the MPEG-2 transport stream format (i.e. 1 sync byte + 187 packet bytes). This is to avoid the emission of an unmodulated carrier from the modulator.