



Recommendation ITU-R BO.1784-1
(12/2016)

**Digital satellite broadcasting system with
flexible configuration
(television, sound and data)**

BO Series
Satellite delivery



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Series	Title
BO	Satellite delivery
BR	Recording for production, archival and play-out; film for television
BS	Broadcasting service (sound)
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F	Fixed service
M	Mobile, radiodetermination, amateur and related satellite services
P	Radiowave propagation
RA	Radio astronomy
RS	Remote sensing systems
S	Fixed-satellite service
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management
SNG	Satellite news gathering
TF	Time signals and frequency standards emissions
V	Vocabulary and related subjects

Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

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RECOMMENDATION ITU-R BO.1784-1

**Digital satellite broadcasting system with flexible configuration
(television, sound and data)**

(Question ITU-R 285/4)

(2007-2016)

Scope

This Recommendation is intended for the digital broadcasting-satellite service (BSS), when high flexibility in the system configuration and broadcasting interactivity is of importance allowing for a wide-ranging trade-off between operation under minimal C/N levels or maximum transmission capacity.

Keywords

HDTV, UHDTV, satellite, broadcasting, channel bonding, DVB-S2, DVB-S2X

Abbreviations/Glossary

AAC	Advanced Audio Coding
ACM	Adaptive Coding and Modulation
ALS	Audio Lossless coding
APSK	Amplitude and Phase Shift Keying
ATM	Asynchronous Transfer Mode
AVC	Advanced Video Coding
AWGN	Additive White Gaussian Noise
BB	BaseBand
BCH code	Bose-Chaudhuri-Hocquenghem code
BPSK	Binary Phase Shift Keying
BSS	Broadcasting-Satellite Service
CCM	Constant Coding and Modulation
C/N	Carrier to Noise Ratio
CRC	Cyclic Redundancy Check
DSNG	Digital Satellite News Gathering
DTH	Direct To Home
DVB	Digital Video Broadcasting project
DVB S	DVB System for satellite broadcasting
DVB S2	Second generation DVB System for satellite broadcasting and unicasting
DVB S2X	Extensions of the second generation DVB System for satellite broadcasting and unicasting
FEC	Forward Error Correction

FPGA	Field Programmable Gate Array
GF	Galois Field
GS	Generic Stream
GSE	Generic Stream Encapsulation
HDTV	High Definition Television
HEVC	High Efficiency Video Coding
IBO	Input Back Off
IP	Internet Protocol
IRD	Integrated Receiver Decoder
LDPC	Low Density Parity Check
LNB	Low Noise Block
MPEG	Moving Picture Experts Group
OBO	Output Back Off
PL	Physical Layer
PSK	Phase Shift Keying
PRBS	Pseudo-Random Binary Sequence
QAM	Quadrature Amplitude Modulation
QEF	Quasi Error Free
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RS	Reed Solomon
SDTV	Standard Definition Television
SNR	Signal to Noise Ratio
SOF	Start of Frame
TS	Transport Stream
TV	Television
TWTA	Traveling Wave Tube Amplifier
UHDTV	Ultra-High Definition Television
VCM	Variable Coding and Modulation
VL-SNR	Very Low - Signal to Noise Ratio
VSAT	Very Small Aperture Terminal

Related ITU Recommendations, Reports

Recommendation ITU R BO.1408-1	Transmission system for advanced multimedia services provided by integrated services digital broadcasting in a broadcasting-satellite channel
Recommendation ITU R BO.1516-1	Digital multiprogramme television systems for use by satellites operating in the 11/12 GHz frequency range

The ITU Radiocommunication Assembly,

considering

- a) that the digital multiprogramme television systems for use by satellites have been developed in Recommendations ITU-R BO.1408 and ITU-R BO.1516, which are referred to as the current systems;
- b) that recent developments in the field of channel coding and modulation have produced new techniques with performances approaching the Shannon limit;
- c) that these new digital techniques would offer better spectrum and/or power efficiency, in comparison to the current systems, whilst maintaining the possibility to be flexibly configured to cope with the specific satellite bandwidth and power resources;
- d) that the recommended system makes use of such techniques and thus allows for a wide-ranging trade-off between operation under minimal C/N levels or maximum transmission capacity, achieving appreciable gain over DVB-S (System A in Recommendation ITU-R BO.1516) depending on the selected DVB-S2 mode;
- e) that the recommended system was developed to cover not only broadcasting, but also interactivity and contribution applications, such as contribution TV links and digital satellite news gathering (DSNG);
- f) that a system covering all these application areas while keeping the single-chip decoder at reasonable complexity levels, would enable the reuse of the development for the mass market products for contribution or niche applications;
- g) that the new adaptive coding and modulation (ACM) technique offered by the recommended system would allow a more efficient spectrum utilization for unicast applications in connection with a return path, through the optimization of the transmission parameters (i.e. modulation and coding) for each individual user, dependent on path conditions;
- h) that the recommended system accommodates any input stream format, including single or multiple Motion Picture Experts Group (MPEG) Transport Streams (characterized by 188-byte packets), IP as well as asynchronous transfer mode (ATM) packets and continuous bit-streams;
- i) that the recommended system would be capable to handle the variety of advanced audiovisual formats currently available and under definition;
- j) that new extensions to the recommended system offers improved performance and features for its core applications, including Direct to Home (DTH) broadcasting of Ultra-High Definition Television (UHDTV), and also provides an extended operational range to cover emerging markets such as mobile applications,

further considering

- a) that an ITU system Recommendation helps the market in establishing services based on standardized systems, thus avoiding the proliferation of proprietary developments, which is of benefit to both the end users and the industry in general;
- b) that, in spite of the success of the current systems, a new specification to enable delivery of a significantly higher data rate in a given transponder bandwidth than the current systems are able to do, is appreciated by many satellite broadcasters, operators and manufacturers around the world;
- c) that the requirement to offer high-definition television (HDTV) and UHDTV services will force broadcasters to look for more efficient methods of carrying these services within the existing transponders;

d) that the inherent flexibility of the recommended system and of its extensions would provide means to alleviate the influence of the atmospheric attenuations at the higher broadcasting-satellite service (BSS) bands, which are intended to be used for HDTV services and beyond,

recommends

1 that the DVB-S2 system specified in ETSI EN 302 307-1 V 1.4.1 (see Attachment 1) may be considered as a suitable system for the development of a system for satellite broadcasting with flexible configuration;¹

2 that the DVB-S2X system specified in ETSI EN 302 307-2 V1.1.1 (see Attachment 2) may be considered as a suitable system for the development of a system for satellite broadcasting with improved performance and features.¹

NOTE 1 – A description of the recommended system DVB-S2 (System E1) is provided in Annex 1, a description of the extensions DVB-S2X to the recommended system (System E2) is provided in Annex 2, while Annex 3 contains comparison tables which list the recommended systems (Systems E1 and E2) along with the systems contained in Recommendation ITU-R BO.1516 (Systems A, B, C, D).

Annex 1

Main characteristics of the DVB-S2 system (referred to as System E1)

DVB-S2 is the second-generation specification for satellite broadband applications developed by the DVB (Digital Video Broadcasting) Project in 2003 and became ETSI standard EN 302 307 in 2004.

EN 302 307 specifies framing structure, channel coding and modulation for different types of satellite applications:

- broadcasting of standard definition and high-definition TV (SDTV and HDTV);
- interactivity (including Internet access) for satellite broadcasting applications (for integrated receivers-decoders (IRDs) and personal computers);
- contribution applications, such as digital TV contribution, distribution and news gathering;
- data content distribution and internet trunking.

To be able to cover all the application areas while still keeping the single-chip decoder at reasonable complexity levels, DVB-S2 is structured as a *tool-kit*, thus enabling the use of mass market products also for contribution or niche applications.

The DVB-S2 system has been specified around three concepts: best transmission performance, approaching Shannon limit, total flexibility and reasonable receiver complexity.

To achieve the best performance-complexity trade-off, achieving an appreciable capacity gain over DVB-S for conventional broadcast applications, DVB-S2 benefits from more recent developments in channel coding and modulation: low-density parity check (LDPC) codes are adopted combined with quadrature phase shift keying (QPSK), 8-PSK, 16-APSK (amplitude and phase shift keying) and 32-APSK modulations, for the system to properly work on the non-linear satellite channel.

¹ The word “shall” in this ETSI standard should be considered as “should” in this ITU-R Recommendation.

Framing structure allows maximum flexibility for a versatile system and synchronization also in worst-case configurations (low signal-to-noise ratios, SNR).

For interactive point-to-point applications such as IP unicasting in connection with a return path, the adoption of the ACM functionality allows to optimize the transmission parameters for each individual user on a frame-by-frame basis, dependant on path conditions, under closed-loop control via the return channel (connecting the receiver to the DVB-S2 uplink station via terrestrial or satellite links, signalling the receiver reception condition). This results in a further increase of the spectrum utilization efficiency of DVB-S2 over DVB-S, allowing the optimization of the space segment design, thus making possible a drastic reduction of the cost of satellite-based IP services.

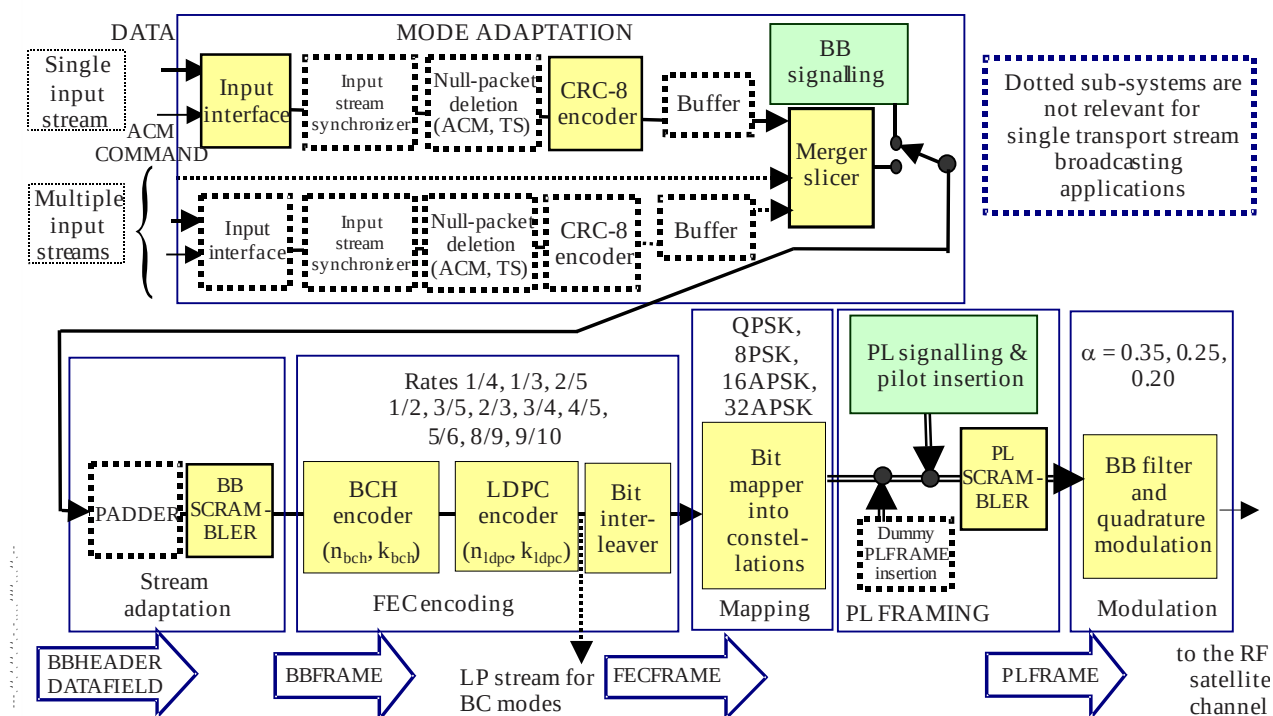
DVB-S2 is so flexible that it can cope with any existing satellite transponder characteristics, with a large variety of spectrum efficiencies and associated SNR requirements. Furthermore it is designed to handle the variety of advanced audio-video formats currently under definition by the international bodies. DVB-S2 accommodates any input stream format, including single or multiple MPEG Transport Streams (characterized by 188-byte packets), IP as well as ATM packets and continuous bit-streams.

The DVB-S2 system structure

The DVB-S2 system is composed of a sequence of functional blocks, as described in Fig. 1. Signal generation is based on two levels of framing structures:

- BBFRAME at baseband (BB) level, carrying a variety of signalling bits, to configure the receiver flexibly according to the application scenario;
- PLFRAME at physical layer (PL) level, carrying few highly-protected signalling bits, to provide robust synchronization and signalling at the physical layer.

FIGURE 1
Functional block diagram of the DVB-S2 system



BO.1784-01

Depending on the application, DVB-S2 input sequences may be single or multiple MPEG transport streams (TS), single or multiple generic streams, either packetized or continuous. The block identified as *Mode Adaptation* provides input stream interfacing², input stream synchronization³ (optional), null-packet deletion⁴ (for ACM and transport stream input format only), CRC-8 coding for error detection at packet level in the receiver (for packetized input streams only), merging of input streams (for multiple input stream modes only) and slicing into data fields. A baseband header is then appended in front of the data field, to notify the receiver of the input stream format and Mode Adaptation type to notify the receiver of the input stream format and Mode Adaptation type: single or multiple input streams, generic or transport stream, constant coding and modulation (CCM) or ACM, and many other configuration details. Thanks to the forward error correction (FEC) protection (covering both the header and the data payload) and the wide length of the FEC frame, the baseband header can in fact contain many signalling bits without losing transmission efficiency or ruggedness against noise. It should be noted that the MPEG multiplex transport packets may be asynchronously mapped to the baseband frames.

Stream Adaptation is then applied, to provide padding in case the user data available for transmission are not sufficient to completely fill a BBFRAME, and baseband scrambling.

Forward error correction (FEC) encoding carries out the concatenation of BCH (Bose-Chaudhuri-Hocquenghem) outer code and low density parity check (LDPC) inner codes (rates 1/4, 1/3, 2/5, 1/2, 3/5, 2/3, 3/4, 4/5, 5/6, 8/9, 9/10). Depending on the application area, the FEC coded blocks (FEC frames) can have a length of 64 800 or 16 200 bits. When variable coding and modulation (VCM) or ACM are used, FEC and modulation mode are constant within a frame but may be changed in different frames; furthermore, the transmitted signal can contain a mix of normal and short code blocks.

Mapping can be chosen among QPSK, 8-PSK, 16-APSK and 32-APSK constellations (see Fig. 2), depending on the application area. QPSK and 8-PSK are typically proposed for broadcast applications, since they are virtually constant envelope modulations and can be used in non-linear satellite transponders driven near saturation. The 16-APSK and 32-APSK modes, mainly targeted to contribution applications, can also be used for broadcasting, but these require a higher level of available C/N and the adoption of advanced pre-distortion methods in the uplink station to minimize the effect of transponder non-linearity. Whilst these modes are not as power efficient as the other modes, the spectrum efficiency is much greater. The 16-APSK and 32-APSK constellations have been optimized to operate over a non-linear transponder by placing the points on circles. Nevertheless their performances on a linear channel are comparable with those of 16-QAM and 32-QAM respectively.

By selecting the modulation constellation and code rates, spectrum efficiencies from 0.5 to 4.5 bits per symbol are available and can be chosen dependant on the capabilities and restrictions of the satellite transponder used.

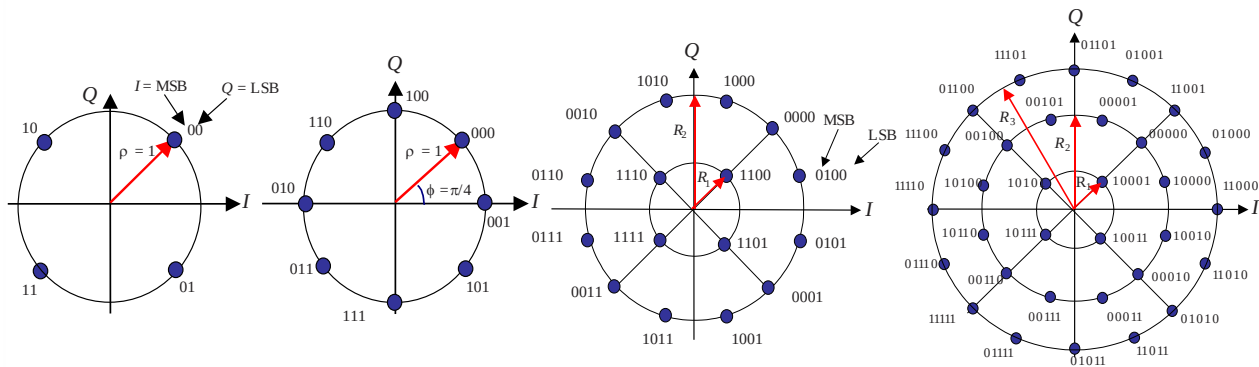
² Input sequences may be single or multiple TSs, single or multiple generic streams (packetized or continuous).

³ Data processing in DVB-S2 may produce variable transmission delay. This block allows to guarantee constant-bit-rate and constant end-to-end transmission delay for packetized input stream.

⁴ To reduce the information rate and increase the error protection in the modulator. The process allows null-packets reinsertion in the receiver in the exact place where they originally were.

FIGURE 2

The four possible DVB-S2 constellations before physical layer scrambling

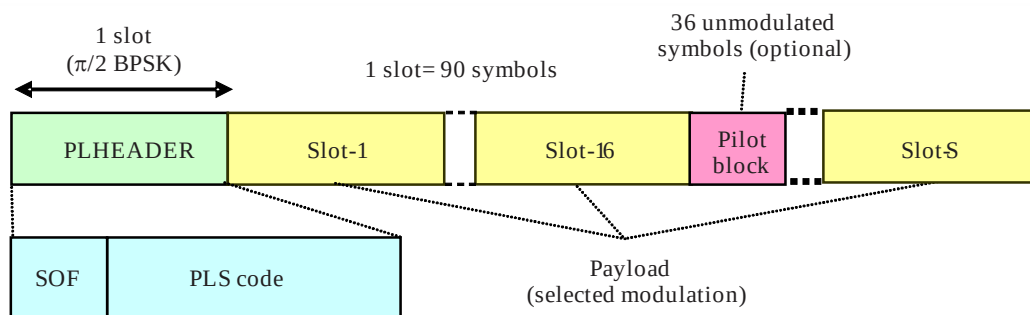


BO.1784-02

Physical layer framing has been designed to provide robust synchronization and signalling at the physical layer. Thus a receiver may synchronize (carrier and phase recovery, frame synchronization) and detect the modulation and coding parameters before demodulation and FEC decoding. The DVB-S2 physical layer signal is composed of a regular sequence of frames (see Fig. 3): within a frame, the modulation and coding scheme is homogeneous, but may change (in the adaptive coding and modulation configuration) in adjacent frames. Every frame is composed of a payload of 64 800 bits in the “normal frame” configuration, 16 200 bits in the “short frame” one, corresponding to an FEC code block. A header of 90 binary modulation symbols precedes the payload, containing synchronization and signalling information, to allow a receiver to synchronize (carrier and phase recovery, frame synchronization) and detect the modulation and coding parameters before demodulation and FEC decoding.

FIGURE 3

PL frame scheme



BO.1784-03

The first 26 binary symbols (the sequence 18D2E82_{HEX}) of the PL header identify the start of the PL frame (SOF, Start Of Frame), the remaining 64 symbols are used for signalling the system configuration. Since the PL header is the first entity to be decoded by the receiver, it could not be protected by the FEC scheme (i.e. BCH and LDPC). On the other hand, it had to be perfectly decodable under the worst-case link conditions (SNR of about -2.5 dB). Therefore, to minimally affect the global spectrum efficiency, the signalling information at this level has been reduced to 7 bits, 5 of which are used to indicate the modulation and coding configuration (MODCOD field), 1 for frame length (64 800 or 16 200 bits), 1 for presence/absence of pilots to facilitate receiver synchronization (as explained below). These bits are then highly protected by an interleaved first-order Reed-Muller block code with parameter rates (64, 7, $t = 32$), suitable for soft-decision correlation decoding.