



Recommendation ITU-R BO.2098-0
(12/2016)

**Transmission system for UHDTV
satellite broadcasting**

**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)
BT	Broadcasting service (television)
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.2098-0

Transmission system for UHDTV satellite broadcasting

(Question ITU-R 292/4)

(2016)

Scope

UHDTV broadcasting requires transmission capacity that goes beyond conventional HDTV broadcasting. This Recommendation defines a transmission system for UHDTV satellite broadcasting.

Keywords

UHDTV, satellite broadcasting, transmission capacity, ISDB-S3

Abbreviations/Glossary

APSK	Amplitude and Phase Shift Keying
AWGN	Additive White Gaussian Noise
BPSK	Binary Phase Shift Keying
BCH code	Bose-Chaudhuri-Hocquenghem code
C/N	Carrier to Noise Ratio
EWS	Emergency Warning System
FEC	Forward Error Correction
GF	Galois Field
IF-loopback	Inter Frequency-loopback
IP	Internet Protocol
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
ISDB-S	Integrated Services Digital Broadcasting for Satellite
ISDB-S3	Integrated Services Digital Broadcasting for Satellite, 3rd generation
LDPC code	Low Density Parity Check code
LSB	Least Significant Bit
MPEG	Moving Picture Experts Group
MMT	MPEG Media Transport
MSB	Most Significant Bit
OBO	Output Back Off
PSK	Phase Shift Keying
PRBS	Pseudo-Random Binary Sequence
QPSK	Quadrature Phase Shift Keying
TDM	Time Division Multiplexing

TLV	Type Length Value
TMCC	Transmission and Multiplexing Configuration Control
TS	Transport Stream
TS_ID	Transport Stream Identifier
TWTA	Traveling Wave Tube Amplifier
UHDTV	Ultra-High Definition Television

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
Recommendation ITU-R BO/BT.1774-2	Use of satellite and terrestrial broadcast infrastructures for public warning, disaster mitigation, and relief
Recommendation ITU-R BO.1784-0	Digital satellite broadcasting system with flexible configuration (television, sound and data)
Recommendation ITU-R BT.2020-2	Parameter values for ultra-high definition television systems for production and international programme exchange
Recommendation ITU-R BT.2073-0	Use of the high efficiency video coding (HEVC) standard for UHDTV and HDTV broadcasting
Recommendation ITU-R BT.2100-0	Image parameter values for high dynamic range television for use in production and international programme exchange
Report ITU-R BO.2397-0	Satellite transmission for UHDTV satellite broadcasting

The ITU Radiocommunication Assembly,

considering

- a) that ultra-high definition television (UHDTV)¹ broadcasting is expected to be a major media service in the near future;
- b) that an increase in the transmission capacity is required to achieve UHDTV satellite broadcasting in a single satellite transponder;
- c) that the recent progress in digital technology allows a very low roll-off factor, highly bandwidth efficient forward error correction (FEC), and modulation schemes such as low density parity check (LDPC) code and amplitude and phase shift keying (APSK);
- d) that rain attenuation, which differs due to climatic zones, needs to be taken into account in satellite broadcasting systems;
- e) that it is appropriate for a system to be robust against satellite transponder nonlinearity;

¹ UHDTV is defined in Recommendation ITU-R BT.2020.

- f) that it is preferable for a system to accommodate both Moving Picture Expert Group (MPEG) transport stream packets and IP packets;
- g) that it is also desirable for a system to allow flexible transmission and multiplexing configurations;
- h) that it is desirable for a broadcasting system to support an emergency warning system (EWS), in particular for use in earthquake-prone regions,

recognizing

- a) that the digital multiprogramme television systems for use by satellites are described in Recommendations ITU-R BO.1408 and ITU-R BO.1516;
- b) that the digital satellite broadcasting system with flexible configurations (television, sound and data) is described in Recommendations ITU-R BO.1784;
- c) that bit rates for UHDTV and HDTV broadcasting emissions using the high efficiency video coding (HEVC) standard are described in Recommendation ITU-R BT.2073;
- d) that the use of satellite and terrestrial broadcasting infrastructures for public warnings, disaster mitigation, and relief is described in Recommendations ITU-R BO/BT.1774,

recommends

that the ISDB-S3 system specified in ARIB STD-B44² should be used for UHDTV satellite broadcasting (see Note 1 and Note 2).

NOTE 1 – A description of the recommended system (System F) is summarized in Annex 1, while Annex 2 provides a comparison table of transmission systems for UHDTV satellite broadcasting.

NOTE 2 – The symbol rate specified in ARIB STD-B44 is an example. The symbol rate of ISDB-S3 can be set flexibly according to the various kinds of satellite transponder bandwidth.

² ARIB STD-B44 (http://www.arib.or.jp/english/html/overview/doc/6-STD-B44v2_0-E1.pdf)

Annex 1

Technical characteristics of the ISDB-S3 system for UHDTV satellite broadcasting (referred to as System F)

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1 Summary of the ISDB-S3 system for UHDTV satellite broadcasting

The ISDB-S3 system was developed in Japan for UHDTV satellite broadcasting. The technical features of this system are listed below.

- UHDTV home reception: considering that 45-cm dish antennas are widely used in Japan, this system provides about 100 Mbit/s through a 34.5 MHz satellite transponder using 16-APSK with an inner coding rate of 7/9 and achieves service availability of 99.5%;
- Large transmission capacity: The use of a roll-off factor of 0.03, LDPC code, and APSK modulation increases transmission capacity;
- Rain fade survivability: Hierarchical transmission, in which multiple signals with different modulation schemes and inner coding rates are transmitted in a TDM manner, enables signals to be received under strong rain fading conditions;
- Stable reception even at low C/N: Periodic transmission of a $\pi/2$ shift binary phase shift keying (BPSK) phase reference burst signal provides carrier phase recovery robustness under

0.0 dB of C/N. Moreover, utilization of the phase reference burst signal as a payload of TMCC contributes to improving the transmission capacity;

- Robustness against satellite transponder nonlinearity: The use of a pilot signal provides optimal LDPC decoding even in the presence of nonlinear effects;
- Transmission of variable length packets: The use of type-length-value (TLV) as an input signal format enables IP packets like IPv4 or IPv6 to be sent through satellite channels;
- Functional transmission control: The use of 9422-bit Transmission and Multiplexing Configuration Control (TMCC) assignment provides versatile transmission control. Transmission and Multiplexing Configuration Control can send various transmission control signals, including those for controlling the modulation scheme, coding rate, and input signal format (MPEG-2 TS or TLV), as well as those for identifying and managing multiple input signals, starting the Emergency Warning System (EWS), and informing the satellite-transponder operating point.

The technical specifications for ISDB-S3 are listed in Table 1. This system uses LDPC code as an inner code because this code has excellent error correction. $\pi/2$ -shift BPSK, QPSK, and 8PSK are mainly used for the saturated Traveling Wave Tube Amplifier (TWTA) in the satellite transponder. 16-APSK and 32-APSK are supported as ways of increasing the channel capacity. In addition, a pilot signal has been introduced to enable optimal LDPC decoding even in the presence of nonlinear effects, especially when considering that deterioration can easily occur in APSK due to the nonlinear characteristics of TWTA. Furthermore, a roll-off factor of 0.03 is used to achieve steep filter characteristics and enable the use of an even higher symbol rate. This system supports multiple Time Division Multiplexing (TDM) combinations of modulations and inner coding rates and can offer wide ranges of transmission capacity and service availability. Moreover, TMCC can convey signals for identifying the boundaries of the TLV packets, which can be used to send variable-length IP packets.

TABLE 1
Technical specifications of ISDB-S3 system

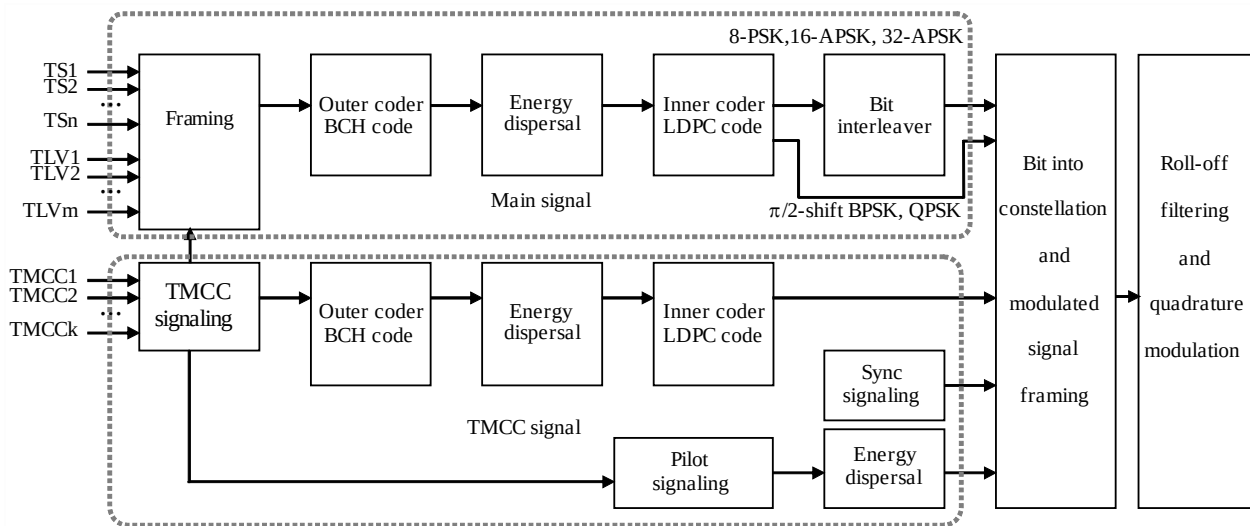
Item		Description
Input signal format		MPEG-2 TS, TLV
Modulation scheme		$\pi/2$ -shift BPSK, QPSK, 8-PSK, 16-APSK, and 32-APSK
Transmission control		TMCC
Forward error correction	Inner code	LDPC code(code length: 44880)
	Coding rate	1/3 (41/120), 2/5 (49/120), 1/2 (61/120), 3/5 (73/120), 2/3 (81/120), 3/4 (89/120), 7/9 (93/120), 4/5 (97/120), 5/6 (101/120), 7/8 (105/120), 9/10 (109/120) (nominal value (true value))
	Outer code	BCH (65535, 65343, $T = 12$) shortened code
TMCC	Modulation scheme	$\pi/2$ -shift BPSK
	Inner code	LDPC (31680,9614) LDPC (44880, 22184) shortened code
	Outer code	BCH (9614,9422), BCH (65535,65343) shortened code
	Control unit	Transmission control in units of slots
TDM frame structure		120 slots per frame
Symbol rate		Not specified. The symbol rate of ISDB-S3 can be set according to the various kinds of satellite transponder bandwidth flexibly.
Roll-off factor		0.03
Nonlinear compensation signal		Pilot signal, which can transmit unique word sequence by using same modulation scheme as that for input signal. Averaged pilot signal was used on receiver side for reference point of LDPC decoding.

2 Technical specifications of the ISDB-S3 system for UHDTV satellite broadcasting

2.1 Block definition

The general configuration of ISDB-S3 is shown in Fig. 1. The system handles MPEG-2 transport stream (TS) and type-length-value (TLV) streams (TS1, TS2,..., TS_n, TLV1, TLV2,..., TLV_m) as main signals (upper part of Fig. 1), as well as transmission parameters for transmitting each stream (TMCC1, TMCC2, ..., TMCC_k), and it generates a TMCC signal on the basis of those transmission parameters (lower part of Fig. 1). Frames are configured on the basis of the TMCC signal, and the main signal and TMCC signal are processed in frame units. Each frame has 120 slots, and each slot is of the same length as the LDPC code. After the frame configuration, the main signal is processed in steps that include outer-code coding, energy dispersal, and inner-code coding, and in the case of the 8-PSK, 16-APSK, or 32-APSK modulation scheme, bit interleaving. With the exception of bit interleaving, the TMCC signal is also processed in a similar manner. In addition to these signals, a synchronization signal (for frame synchronization and slot synchronization) and an energy-dispersed pilot signal, whose modulation scheme is the same as that of the main signal, are generated. The above signals are then mapped to the designated constellation and the modulation framing is processed in a TDM manner.

FIGURE 1
General configuration of the ISDB-S3 system



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2.2 Framing

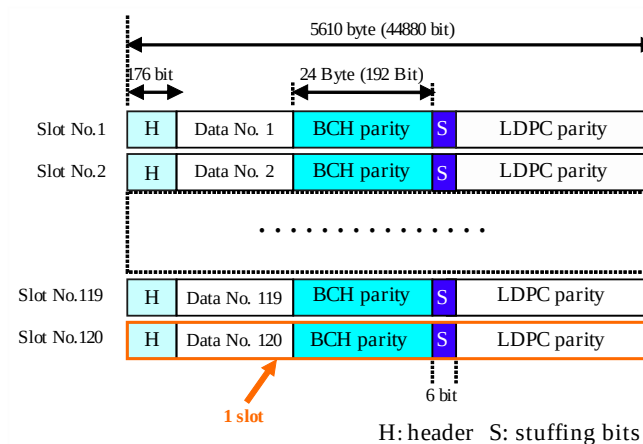
2.2.1 Main-signal frame configuration

The frame configuration for the main signal is shown in Fig. 2. This multiplexed frame consists of 120 slots, each consisting of a header, data, BCH parity bits, stuffing bits, and LDPC parity bits.

Here, MPEG-2 TS or TLV packets are arranged in the data area, and in the case of MPEG-2 TS packets, 187-byte packets, excluding the synchronization byte (0x47) at the front of each packet, are sequentially arranged in the data area of each slot.

The BCH parity bits are calculated for the header and data and positioned after the data area. The BCH parity area is followed by six stuffing bits (0x3F), and after performing energy dispersal on the header, data, BCH parity bits, and stuffing bits, the LDPC parity bits are calculated and placed after the stuffing bits.

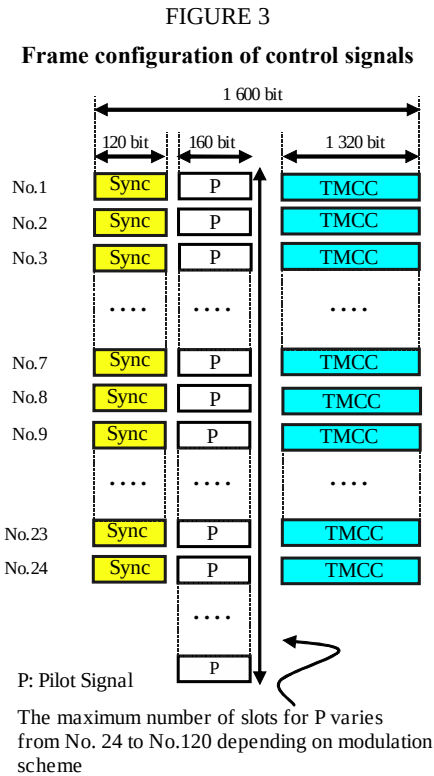
FIGURE 2
Frame configuration of main signal



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2.2.2 Control-signal frame configuration

The frame configuration for control signals is shown in Fig. 3. This multiplexed frame consists of 2 880 bits of synchronization signals, 3 840~19 200 bits of pilot signals and 31 680 bits of TMCC signals.

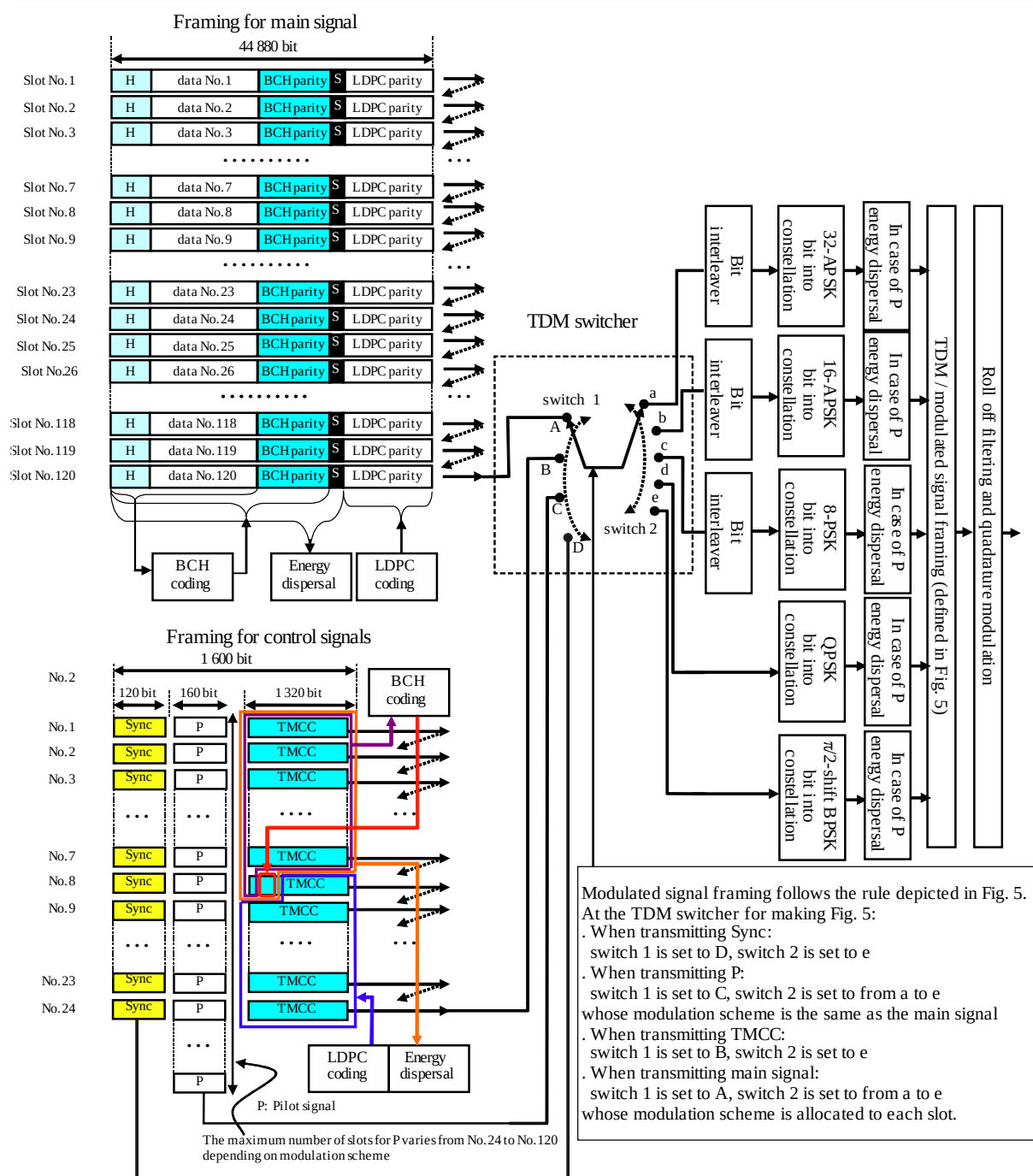


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2.3 Modulated-signal frame configuration

A block diagram showing the generation of a modulated signal from the above frame-configured multiplexed signals is shown in Fig. 4, and the frame configuration of the modulated signal is shown in Fig. 5.

FIGURE 4
Generation of modulated signal



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