International Telecommunication Union

ITU-R

Radiocommunication Sector of ITU

Recommendation ITU-R BO.2098-0

(12/2016)

Transmission system for UHDTV satellite broadcasting

BO Series

Satellite delivery

International Telecommunication Union

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

Policy on Intellectual Property Right (IPR)

ITU-R policy on IPR is described in the Common Patent Policy for ITU-T/ITU-R/ISO/IEC referenced in Annex 1 of Resolution ITU-R 1. Forms to be used for the submission of patent statements and licensing declarations by patent holders are available from http://www.itu.int/ITU-R/go/patents/en where the Guidelines for Implementation of the Common Patent Policy for ITU-T/ITU-R/ISO/IEC and the ITU-R patent information database can also be found.

Series of ITU-R Recommendations

(Also available online at http://www.itu.int/publ/R-REC/en)

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.*

Electronic Publication
Geneva, 2017

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-B44[2] 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)

Table of Contents

Page

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 π/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. π/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			π/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		π/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.

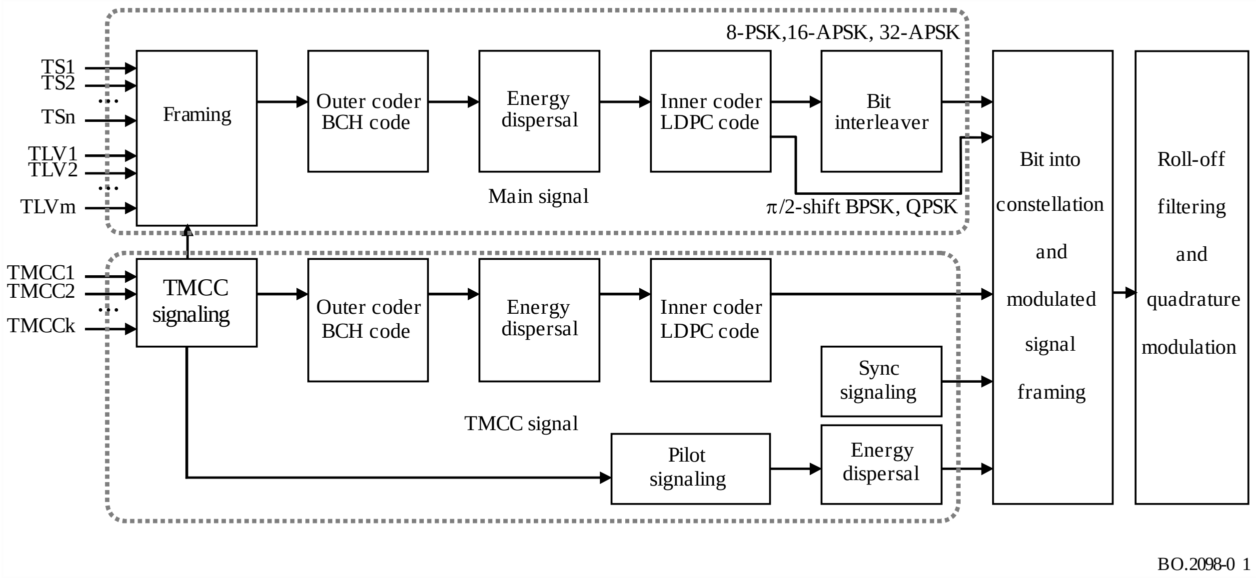
2 Technical specifications of the ISDB-S3 system for UHDTV satellite broadcasting

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,…, TSn, TLV1, TLV2,…, TLVm) as main signals (upper part of Fig. 1), as well as transmission parameters for transmitting each stream (TMCC1, TMCC2, …,TMCCk), 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



2.2 Framing

2.2.1 Main-signal frame configuration

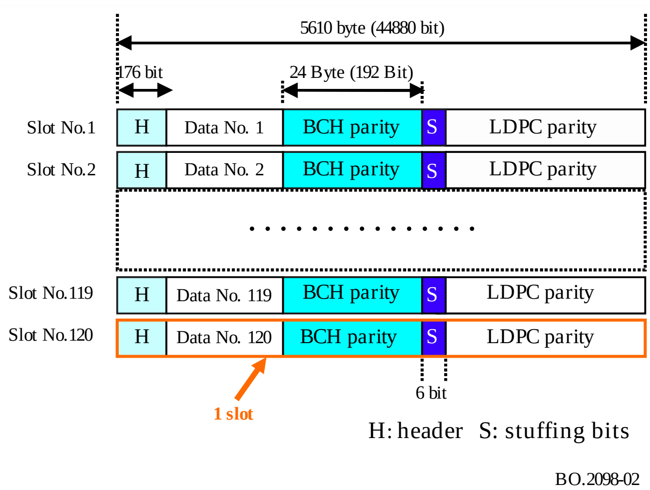
The frame configuration for the main signal is shown in Fig. 2. This multiplexed frame consists of 120 slots, each consisting of a header, data, BCH parity bits, stuffing bits, and LDPC parity bits.

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

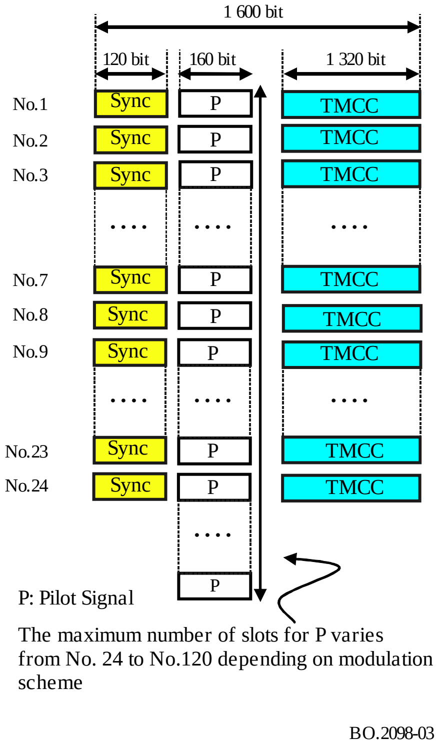


2.2.2 Control-signal frame configuration

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.

FIGURE 3

Frame configuration of control signals

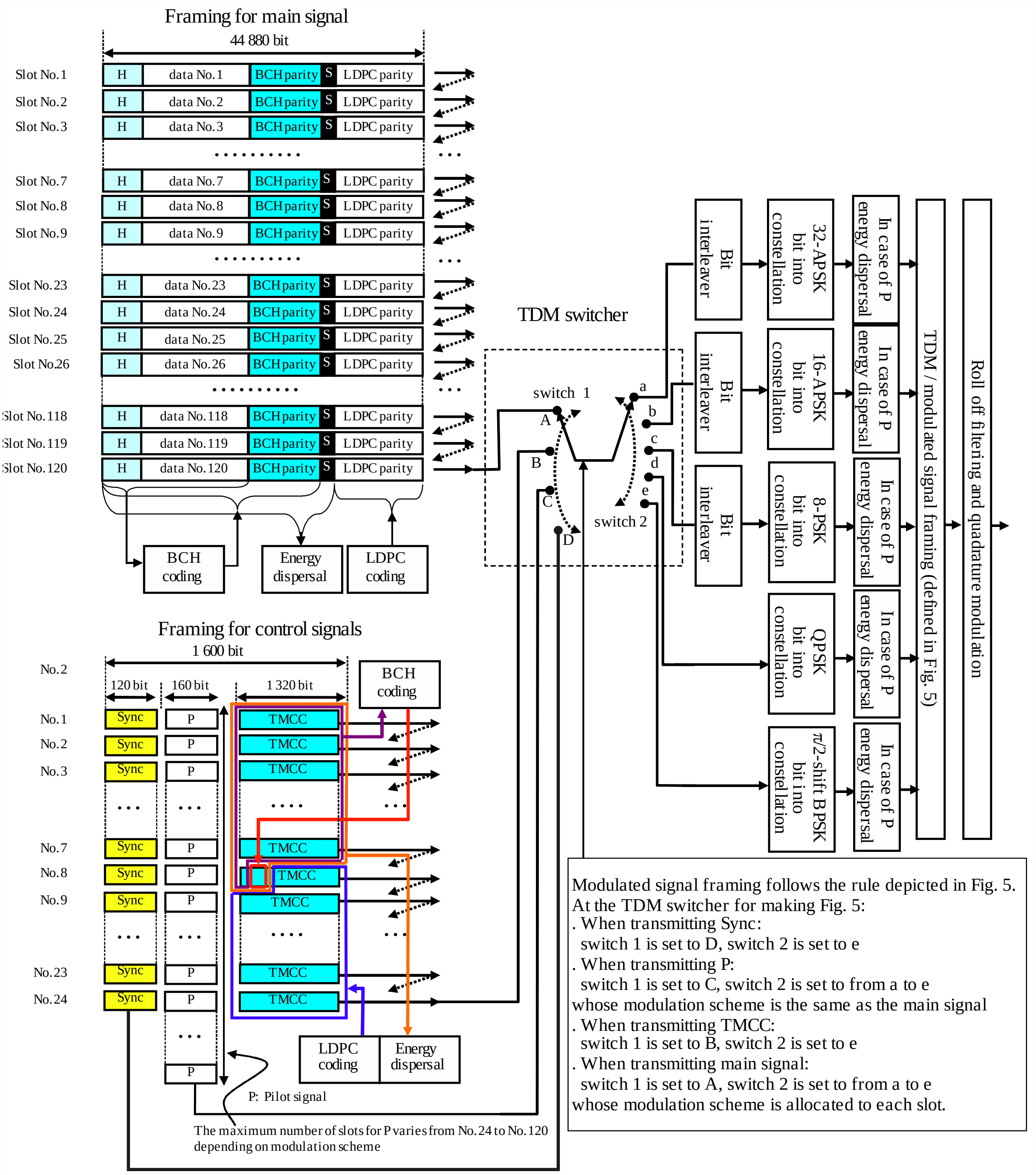


2.3 Modulated-signal frame configuration

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

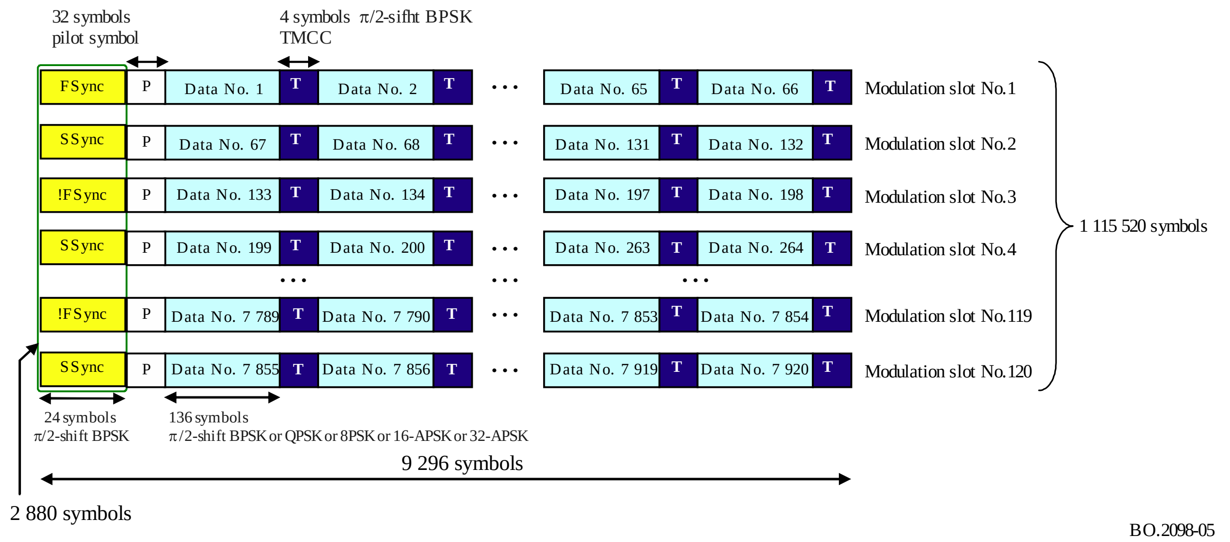
Generation of modulated signal



BO.2098-04

FIGURE 5

Frame configuration of modulated signal



2.4 Forward error correction

2.4.1 Outer-code coding method

The method of outer coding is BCH (65535, 65343) shortened code with correcting capability $T = 12$.

2.4.2 Inner-code coding method

The method of inner coding is LDPC code with a length of 44 880 bits and 11 rates as listed in Table 2.

TABLE 2

Inner-code code rates

Inner coding rate (nominal value)	True value
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

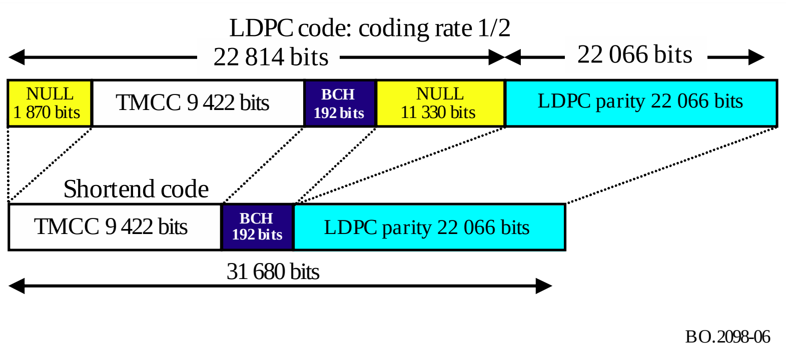
Here, "true value" in the above table is the actual coding rate and "nominal value" approximates the true value by a simple fraction.

2.5 Error correction method for TMCC

The outer coding method used for the main signal is used for the outer code. A shortened version of the LDPC coding (rate 1/2) for the main signal is used for the inner code (see Fig. 6). The LDPC code data consists of NULL data (1870 bits, all zeros), TMCC data (9422 bits), Bose-Chaudhuri-Hocquenghem code (BCH) parity (192 bits), another sequence of NULL data (11330 bits, all zeros) and LDPC parity (22066 bits). After LDPC coding and NULL data deletion, the TMCC data, BCH parity, and LDPC parity are transmitted as TMCC symbols. At the receiver, the ideal symbols for NULL data corresponding to zeros are inserted in the NULL data section, and LDPC decoding is performed at coding rate 1/2.

FIGURE 6

TMCC coding



2.6 Energy dispersal

Energy dispersal is performed for the header, data, BCH data, and stuffing bits.

Energy dispersal is also performed for TMCC and pilot signal.

2.7 Bit Interleaver

In the case of 8-PSK, 16-APSK and 32-APSK, the output from the LDPC coding section is bit interleaved.

2.8 Modulation schemes

The applicable modulation schemes are listed in Table 3, and the constellation diagrams for each modulation scheme are depicted in Fig. 7. Modulation by π/2-shift BPSK uses the following constellation. For odd-numbered symbols including the 1st symbol at the front of the frame, symbol 0 and symbol 1 take on signal points in the 1st and 3rd quadrants, respectively, and for the second symbol and subsequent even-numbered symbols, the above points are rotated by 90° in the counterclockwise direction. The radius ratio γ (=R2/R1) for 16-APSK and those γ1 (=R2/R1) and γ2 (=R3/R1) for 32-APSK are listed in Table 4 and Table 5 according to the inner coding rate. Furthermore, while the radius is taken to be 1 and power is normalized to 1 in modulation schemes (a) to (c), we respectively use $4R_1^2+12R_2^2=16$ and $4R_1^2+12R_2^2+16R_3^2=32$ for modulation schemes (d) and (e), with power normalized to 1.

TABLE 3

Modulation schemes

Modulation Scheme	Application
π/2-shift BPSK	Frame synchronization Slot synchronization TMCC signal Main signal (including pilot signal)
QPSK	Main signal (including pilot signal)
8-PSK	Main signal (including pilot signal)
16-APSK	Main signal (including pilot signal)
32-APSK	Main signal (including pilot signal)

FIGURE 7

Constellation diagrams for each modulation scheme

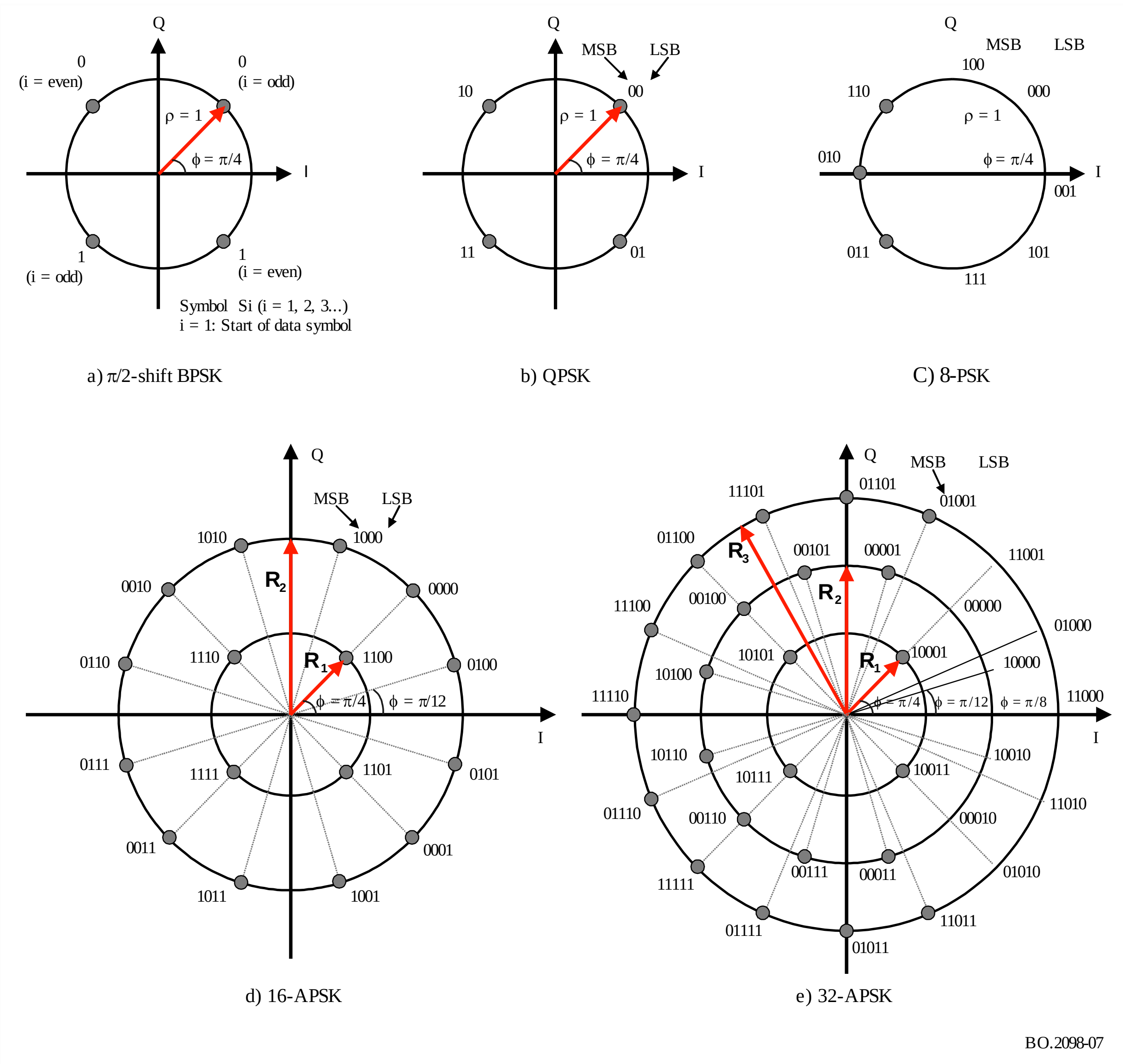


TABLE 4

16-APSK radius ratios

Inner coding rate	Radius ratio γ
1/3	3.09
2/5	2.97
1/2	3.93
3/5	2.87
2/3	2.92
3/4	2.97
7/9	2.87
4/5	2.73
5/6	2.67
7/8	2.76
9/10	2.69

TABLE 5

32-APSK radius ratios

Inner coding rate	Radius ratio γ1	Radius ratio γ2
1/3	3.09	6.53
2/5	2.97	7.17
1/2	3.93	8.03
3/5	2.87	5.61
2/3	2.92	5.68
3/4	2.97	5.57
7/9	2.87	5.33
4/5	2.73	5.05
5/6	2.67	4.80
7/8	2.76	4.82
9/10	2.69	4.66

2.9 Pilot signal

The pilot signal sequentially transmits signal points for the modulation scheme specified for that slot by TMCC. For example, the pilot signal will transmit signal points 00000, 00001, 00010, 00011, …11111 in that order for 32-APSK, signal points 0000, 0001, 0010, 0011, …1111 in that order two times for 16-APSK, signal points 000, 001, 010, 011, …111 in that order four times for 8PSK, and signal points 00, 01, 10, and 11 in that order eight times for QPSK, and signal points 0 and 1 in that order 16 times for π/2-shift BPSK.

2.10 Roll-off factor

The filter characteristics for limiting the band of the carrier wave are set to raised-cosine characteristics, as defined by the following frequency transfer function:

where:

$$\begin{cases} 1 & |F| \le F_n \times (1-\alpha) \\ \sqrt{\dfrac{1}{2}+\dfrac{1}{2}\sin\dfrac{\pi}{2F_n}\left[\dfrac{F_n-|F|}{\alpha}\right]} & F_n(1-\alpha) \le |F| \le F_n(1+\alpha) \\ 0 & |F| \ge F_n(1+\alpha) \end{cases}$$

F_n: Nyquist frequency

α: roll-off factor = 0.03

2.11 TMCC signal

The TMCC signal transmits transmission-related control information on the transmission-stream allocation, the relationship between streams and modulation schemes, etc., for each slot. The size of the area that can be used for transmitting TMCC signals is 9 244 bits per frame. When switching between modulation schemes, etc., the TMCC signal transmits the switching information two frames prior to actual switching. The minimum update interval of the TMCC signal is one frame. The receiver must continuously monitor the TMCC-signal information to ensure that it receives such control information. The bit configuration of the control information in the TMCC signal is shown in Fig. 8.

FIGURE 8

Bit configuration of TMCC signal

Order of change	Transmission mode/ slot information	Stream type/ relative number information	Stream type/ relative number information	Packet format/ relative stream number information	Relative stream number/ slot information	Corresponding table between relative stream ID and transmission stream ID	Transmit/ receive control information	Extension information
8 bits	192 bits	128 bits	896 bits	3 840 bits	480 bits	256 bits	8 bits	3 614 bits

BO.2098-08

2.11.1 Order of change

The order of change is an 8-bit number and incremented by one every time information in the TMCC signal is changed. Its value is reset to “00000000” after “11111111.”.

2.11.2 Transmission mode/slot information

This information indicates the modulation scheme used for the main signal (4 bits), the inner coding rate (4 bits), the number of allocated slots (8 bits), and the satellite output back off (OBO) value (8 bits), whose parameters are defined as the transmission mode. The maximum number of transmission modes is 8. The bit configuration of this information is shown in Fig. 9, and the correspondence between the field values and transmission parameters is given in Tables 6 to 8.

Transmission modes 1-8 are allocated in the order of the modulation schemes and inner coding rates appearing in the transmission frame, beginning with slot 1 (modulation schemes having the most constellation points appear first, and in the case of identical modulation schemes, those with higher code rates appear first).

If the number of modulation schemes to be used is less than 8, then, for any unused transmission mode, the value set for the modulation scheme and code rate is “1111” and the value set for the number of allocated slots and back off is “00000000.”

The number of allocated slots indicates the number of slots, including dummy slots, allocated to the modulation scheme/inner coding rate combination indicated in the immediately preceding fields. The number of slots allocated to each transmission mode must be a multiple of 5, and the total number of slots allocated to transmission modes must equal 120, which is the number of slots for one transmission frame.

FIGURE 9

Bit configuration of transmission mode/slot information

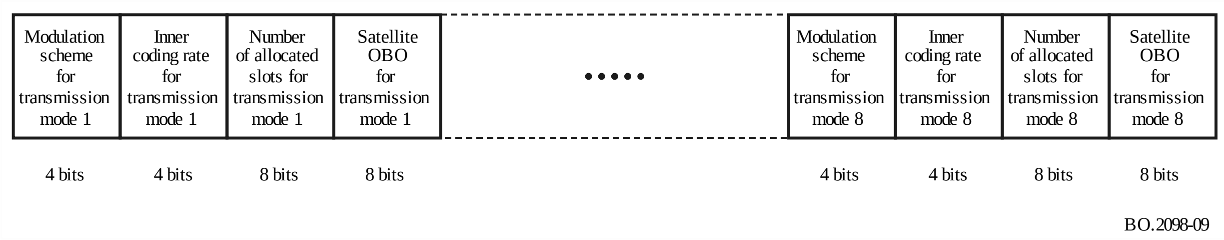


TABLE 6

Modulation schemes for transmission mode

Value	Modulation Scheme
0000	Reserved
0001	π/2 shift BPSK
0010	QPSK
0011	8-PSK
0100	16-APSK
0101	32-APSK
0110 – 1110	Reserved
1111	No scheme allocated

TABLE 7

Inner coding rates for transmission mode

Value	Inner Coding Rate
0000	Reserved
0001	1/3
0010	2/5
0011	1/2
0100	3/5
0101	2/3
0110	3/4
0111	7/9
1000	4/5
1001	5/6
1010	7/8
1011	9/10
1100 – 1110	Reserved
1111	No scheme allocated

TABLE 8

Satellite OBO for transmission mode

Value	Satellite OBO
00000000	0.0 dB
00000001	0.1 dB
00000010	0.2 dB
00000011	0.3 dB
00000100	0.4 dB
00000101	0.5 dB
00000110	0.6 dB
00000111	0.7 dB
. . . .	. . . .
11111010	25.0 dB
11111011	25.1 dB
11111100	25.2 dB
11111101	25.3 dB
11111110	25.4 dB
11111111	25.5 dB

2.11.3 Stream type/relative stream number information

The stream type/relative stream number information (8 bits) indicates the type of packet stream for each of the relative stream numbers from #0 to #15 allocated to the slots in the manner described in § 2.11.6 below. The configuration of the stream type/relative stream information is shown in Fig. 10, and the correspondence between the values and the stream type is given in Table 9.

FIGURE 10

Bit configuration of stream type/relative stream information

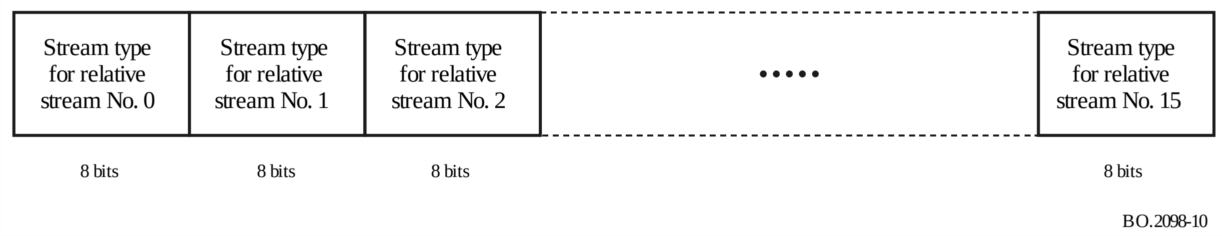


TABLE 9

Stream types

Value	**Stream Type**
00000000	Reserved
00000001	MPEG-2 TS
00000010	TLV
00000011 – 11111110	Reserved
11111111	No type allocated

2.11.4 Packet format/relative stream number information

The packet format/relative stream information indicates the packet format for each of the relative stream numbers from #0 to #15 allocated to the slots in the manner described in § 2.11.6 below. The configuration of packet format/relative stream information is shown in Fig. 11.

“Packet length” (16 bits) refers to the length of each packet in bytes; it is indicated for each of relative streams from #0 to #15.

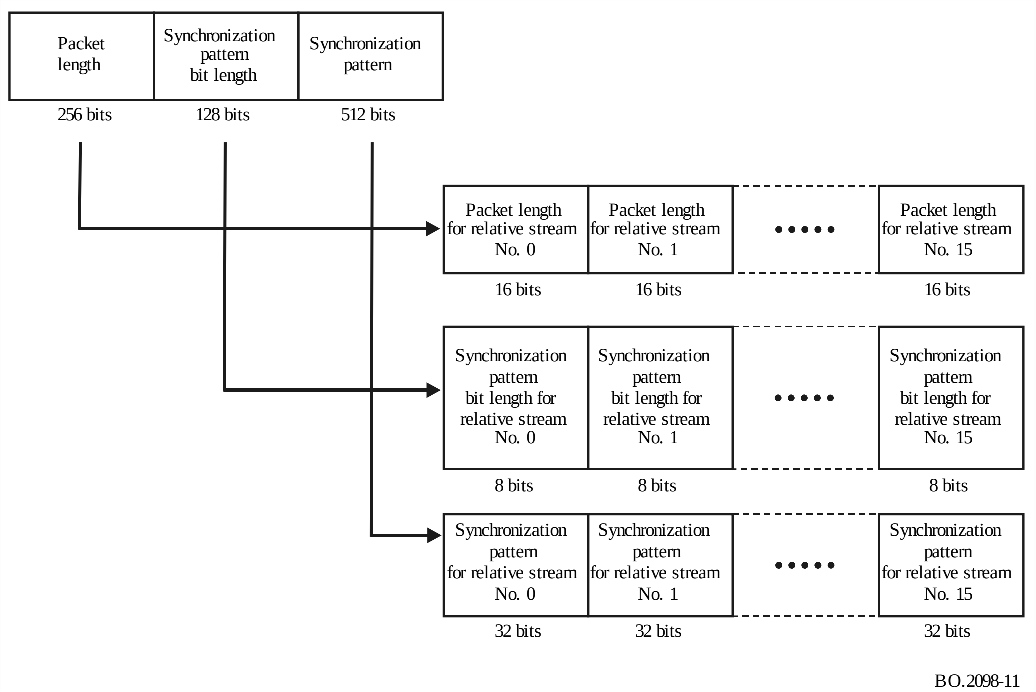
“Synchronization pattern bit length”(8 bits) refers to the length in bits of the synchronization pattern affixed to the front of the packet; it is indicated for each of the relative streams from #0 to #15.

“Synchronization pattern”(32 bits) refers to the pattern affixed to the front of the packet; it is indicated for each of the relative streams from #0 to #15.

If the synchronization pattern bit length happens to be less than 32 bits, the synchronization pattern for that transmission packet is to be written from the front of that field and surplus bits are to be filled with zeros.

FIGURE 11

Bit configuration of packet format/relative stream number information



2.11.5 Pointer/slot information

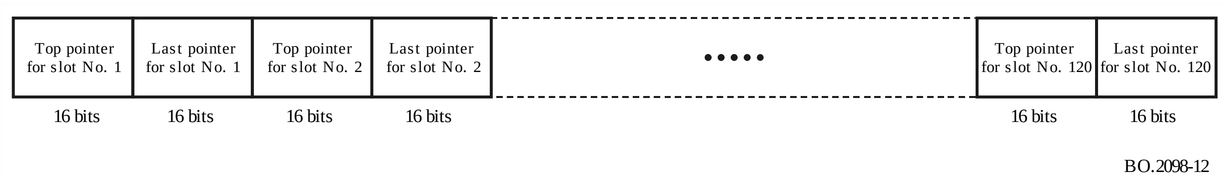
The pointer/slot information indicates the very front (top pointer) of the first packet and the tail end (last pointer) of the final packet in each slot from #1 to #120. The configuration of the pointer/slot information is shown in Fig. 12.

The top pointer (16 bits) indicates the position of the leading byte of the first packet within the slot in terms of the number of bytes from the front of the slot excluding the header. Here, the value 0xFFFF indicates that no leading byte exists.

The last pointer (16 bits) indicates the position of the final byte of the last packet plus 1 within the slot in terms of the number of bytes from the front of the slot excluding the header. Here, the value 0xFFFF indicates that no final byte exists.

FIGURE 12

Bit configuration of pointer/slot information

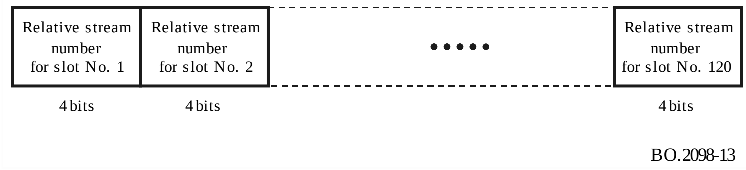


2.11.6 Relative stream number/slot information

The relative stream number/slot information (4 bits) indicates the number of relative streams to be transmitted in each slot in order from slot #1. A maximum of 16 streams can be transmitted within one frame, which means that the relative stream number can be indicated with 4 bits. The same number can also be allocated to dummy slots. The configuration of the relative stream number/slot information is shown in Fig. 13.

FIGURE 13

Bit configuration of relative stream number/slot information

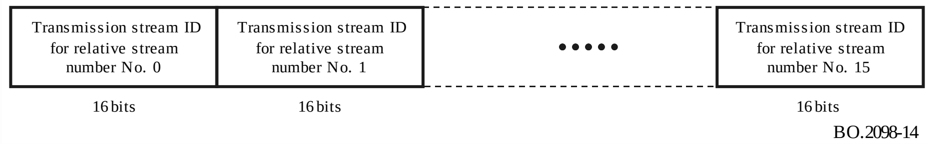


2.11.7 Corresponding table between relative stream number and transmission stream ID

Figure 14 indicates the correspondence between the relative stream numbers and the "transmission stream ID (16 bits)", which is the transport stream ID (TS_ID) in the case of an MPEG-2 TS stream and the TLV stream ID in the case of a TLV stream.

FIGURE 14

Bit configuration of corresponding table between relative stream number and transmission stream ID

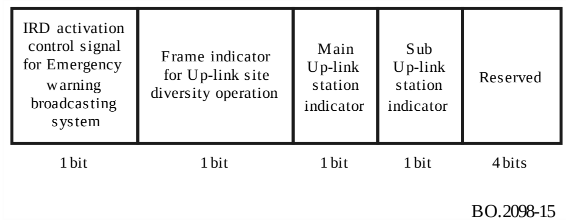


2.11.8 Transmit/receive control information

The transmit/receive control information transmits various control signals, such as one for controlling the startup of the receiver for an emergency warning broadcasting system (EWS) and a control signal for switching the uplink station in the event of fading of the uplink signal by rain attenuation. The configuration of the transmit/receive control information is shown in Fig. 15.

FIGURE 15

Bit configuration of transmit/receive control information

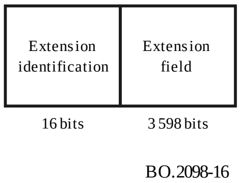


2.11.9 Extension information

Extension information (3 614 bits) is a field reserved for future extensions of the TMCC signal. The configuration of the extension information is shown in Fig. 16. When making an extension to the TMCC signal, the extension identification (16 bits) takes on a value other than the originally prescribed "0000000000000000", and that value indicates that the extension field (3 598 bits) is valid from thereon.

FIGURE 16

Bit configuration of extension information



Annex 2

Comparison table of transmission systems for UHDTV satellite broadcasting

Tables 10 and 11 compare the transmission systems for UHDTV satellite broadcasting. DVB-S2X (broadcasting part is referred to as System E2) described in Recommendation [ITU-R BO.1784] was chosen as a referable system in the ITU-R Recommendation. These tables compare System E2 with the Integrated Services Digital Broadcasting for Satellite, 3rd generation (ISDB-S3) system described in Annex 1, which is indicated as System F.

TABLE 10

Comparison of technical parameters for transmission systems in system E2 in Recommendation ITU-R BO.1784 and in system in Annex 1 to this Recommendation (system F)

a) Function

	System E2	System F
Delivered services	SDTV, HDTV and UHDTV, sound, data and interactive data applications[(1)]	SDTV, HDTV, and UHDTV, and sound, data, and interactive data applications
Input signal format	MPEG-TS/generic stream (e.g. IP)	MPEG-TS, TLV
Multiple input signal capability	Yes: 255 maximum	Yes: 16 maximum
Rain fade survivability	For broadcasting: Variable Coding and Modulation is available in addition to transmitter power and inner code rate.	Hierarchical transmission is available in addition to transmitter power and inner code rate. TMCC provides uplink station indicator for site diversity operation.
Channel bonding	Up to three channels	Yes MMT/TLV enables a bonding of data transmitted in up to 256 channels.
Mobile reception	VL-SNR modes suitable for mobile applications and other services to areas with SNR as low as -10 dB	Not available and for future consideration
Flexible assignment of services bit rate	Available	Available
Common receiver design with other receiver systems	Systems A, B, C, D, E1 and E2 are possible	Systems A, B, C, D, E1, E2 and F are possible
Commonality with other media (i.e. terrestrial, cable, etc.)	MPEG-TS basis GSE, GSE-Lite basis	MPEG-TS and IP basis
Broadcasting station equipment	Available on the market	Available on the market
EWS	–	Yes

TABLE 10 (*continued*)

b) Performance

	System E2	System F
Example of net data rate (transmissible rate without parity)	Symbol rate is not specified. The following net data rates result from an example symbol rate of 27.776 MBd, normal FEC frame length, and no pilots: QPSK 1/2: 27.467 Mbit/s QPSK 3/4: 41.316 Mbit/s 8-PSK 2/3: 55.014 Mbit/s 16-APSK 3/4: 82.404 Mbit/s. ([6]) ([7]) 8-PSK 25/36: 57.278 32-APSK 2/3 L: 91.437 64-APSK 5/6: 137.120 ([7])	Symbol rate is not specified. The following net data rates result from an example symbol rate of 33.7561 MBd. MPEG-TS TLV π/2-shift BPSK 1/2: 16.3842 Mbit/s 16.2971 Mbit/s QPSK 1/2: 32.7684 Mbit/s 32.5941 Mbit/s 8-PSK 3/4: 72.0905 Mbit/s 71.7070 Mbit/s 16-APSK 7/9: 100.4898 Mbit/s 99.9552 Mbit/s 32-APSK 4/5: 131.0736 Mbit/s 130.3764 Mbit/s
Upward extensibility	Yes	Yes
HDTV capability	Yes	Yes
UHDTV capability	Yes	Yes
Selectable conditional access	Yes	Yes

c) Technical characteristics (transmission)

	System E2	System F
Modulation schemes for broadcasting	QPSK/8-PSK/8-APSK-L/16-APSK/16-APSK-L/32-APSK/32-APSK-L/64-APSK/64-APSK-L/([7])	π/2-shift BPSK/QPSK/8-PSK/16-APSK/32-APSK
Symbol rate	Not specified	Not specified
Necessary bandwidth (−3 dB)	Not specified	Not specified
Roll-off factor	0.35, 0.25, 0.2, 0.15, 0.10, 0.05 (raised cosine)	0.03
Outer code	BCH (N, K, T) with parameters different according to the inner coding and frame length configuration	BCH (65535, 65343, T = 12) shortened code T means correctable bits in each code word.
Outer code generator	BCH (N, K, T) with parameters different according to the inner coding and frame length configuration	BCH (65535, 65343, T = 12) shortened code T means correctable bits in each code word.

TABLE 10 (*continued*)

c) Technical characteristics (transmission) (continued)

	System E2	System F
Outer code generator polynomial	Different according to the inner coding and frame length configuration	Polynomials of BCH code are listed below $g_1(x)=1+x+x^3+x^{12}+x^{16}$ $g_2(x)=1+x^2+x^3+x^4+x^8+x^9+x^{11}+x^{12}+x^{16}$ $g_3(x)=1+x^2+x^3+x^7+x^9+x^{10}+x^{11}+x^{13}+x^{16}$ $g_4(x)=1+x+x^3+x^6+x^7+x^{11}+x^{12}+x^{13}+x^{16}$ $g_5(x)=1+x+x^2+x^3+x^5+x^7+x^8+x^9+x^{11}+x^{13}+x^{16}$ $g_6(x)=1+x+x^6+x^7+x^9+x^{10}+x^{12}+x^{13}+x^{16}$ $g_7(x)=1+x+x^2+x^6+x^9+x^{10}+x^{11}+x^{15}+x^{16}$ $g_8(x)=1+x+x^3+x^6+x^8+x^9+x^{12}+x^{15}+x^{16}$ $g_9(x)=1+x+x^4+x^6+x^8+x^{10}+x^{11}+$ $x^{12}+x^{13}+x^{15}+x^{16}$ $g_{10}(x)=1+x+x^2+x^4+x^6+x^8+x^9+$ $x^{10}+x^{11}+x^{15}+x^{16}$ $g_{11}(x)=1+x^6+x^8+x^9+x^{10}+x^{13}+x^{14}+x^{15}+x^{16}$ $g_{12}(x)=1+x+x^2+x^3+x^5+x^6+x^7+$ $x^{10}+x^{11}+x^{15}+x^{16}$
Field generator polynomial	Different according to the inner coding and frame length configuration	$1+x+x^3+x^{12}+x^{16}$
Randomization for energy dispersal	PRBS n Gold sequences derived by the combination of two sequence constructed using the primitive (over GF(2)) polynomials $1+x^7+x^{18}$ and $1+y^5+y^7+y^{10}+y^{18}$ $n \in [0, 262\ 141]$ The n[th] Gold code sequence z_n $n = 0,1,2,\ldots,2^{18}-2$, is then defined as: - $z_n(i) = [x((i+n) \text{ modulo } (2^{18}-1)) + y(i)] \text{ modulo } 2$, $i = 0,\ldots, 2^{18}-2$.	PRBS for slot data: $1+x^{22}+x^{25}$ PRBS for TMCC signal: $1+x^{14}+x^{15}$ PRBS for pilot signal: $1+x^{14}+x^{15}$
Loading sequence into pseudo-random binary sequence (PRBS) register	n= i×10 949, with $i \in [0,6]$ for for broadcasting services, to mitigate interference	Slot data: 1010000000000000000011010 TMCC signal: 100000000001110 Pilot signal: 100000000101100

TABLE 10 (*continued*)

c) Technical characteristics (transmission) (continued)

	System E2[(4)]	System F
Randomization point	Before Modulation/ after bit mapping into Phyisical layer frame and optional pilot insertion	After BCH encoder
Interleaving between inner and outer codes	[(2)]	[(3)]
Inner coding	LDPC Code	LDPC Code
Inner code block length	Normal FEC frame = 64 800 bits Short FEC frame = 16 200 bits Medium FEC frame = 32 400 bits	44 880 bits
Inner coding rate	QPSK: 1/4,1/3,2/5,1/2, 3/5, 2/3, 3/4, 4/5, 5/6,8/9,9/10, 13/45, 9/20, 11/20, 11/45, 4/15, 14/45, 7/15, 8/15, 32/45 8-PSK: 3/5, 2/3, 3/4, 5/6, 8/9, 9/10, 23/36, 25/36, 13/18, 7/15, 8/15, 26/45, 32/45 8-APSK-L: 5/9, 26/45 16-APSK: 2/3, 3/4, 4/5, 5/6, 8/9, 9/10, 26/45, 3/5, 28/45, 23/36, 25/36, 13/18, 7/9, 77/90, 7/15, 8/15, 26/45, 3/5, 32/45 16-APSK-L: 5/9, 8/15, 1/2, 3/5, 2/3 32-APSK: 3/4, 4/5, 5/6, 8/9, 9/10, 2/3, 32/45 64-APSK: 11/15, 7/9, 4/5, 5/6 64-APSK-L: 32/45	1/3,2/5,1/2, 3/5, 2/3, 3/4, 7/9, 4/5, 5/6, 7/8, 9/10
Transmission control	Baseband and physical layer framing structure; optional pilots	TMCC
Frame structure	Normal FEC frame = 64 800 bits Short FEC frame = 16 200 bits Medium FEC frame = 32 400 bits	120 slots/frame
Superframing structure	Yes	No
Packet size (bytes)	188 for MPEG-TS Not specified for GS	188 for MPEG-TS Not specified for TLV
Transport layer	Not specified	Not specified
Satellite downlink frequency range (GHz)	Designed for 11/12 and 17/21, not excluding other satellite frequency ranges	Designed for 11/12 and 17/21, not excluding other satellite frequency ranges

TABLE 10 (*continued*)

d) Technical characteristics (source coding)

		System E2	System F
Video source coding	Syntax	MPEG-4 AVC MPEG-2 generic HEVC ([5]) Not restricted	HEVC[(5)]
	Levels	Level-3 and 4 Not restricted, applicable to all levels	Levels 4.1, 5.1, 5.2, 6.1, and 6.2
	Profiles	Main profile Not restricted, all profiles usable	Main profile for Level 4.1 , main 10 profiles for all levels
Aspect ratios		4:3 16:9 (2.12:1 optionally) Not restricted	16:9
Image supported formats		Recommended for MPEG-2: 720 × 576 704 × 576 544 × 576 480 × 576 352 × 576 352 × 288 Recommended for MPEG-4 AVC: 720 × 480 640 × 480 544 × 480 480 × 480 352 × 480 352 × 240 1 920 × 1 080 1 440 × 1 080 1 280 × 1 080 960 × 1 080 1 280 × 720 960 × 720 640 × 720 Recommended for HEVC ([5]) Not restricted	Level 6.2: 7 680 × 4 320/120/P 7 680 × 4 320/100/P Level 6.1: 7 680 × 4 320/60/P 7 680 × 4 320/50/P Level 5.2: 3 840 × 2 160/120/P 3 840 × 2 160/100/P Level 5.1: 3 840 × 2 160/60/P 3 840 × 2 160/50/P Level 4.1: 1 920 × 1 080/60/P 1 920 × 1 080/50/P 1 920 × 1 080/60/I 1 920 × 1 080/50/I
Frame rates at monitor (per s)		25, 50 or 100, 24, 30, 60 or 120	30 (interlaced), 60, 120 and those divided by 1.001 25 (interlaced), 50, 100

TABLE 10 (*end*)

d) Technical characteristics (source coding)

	System E2	**System F**
Audio source decoding	MPEG-1 Layer I, MPEG-1 Layer II or MPEG-2 Layer II backward-compatible audio MPEG-4 AAC, MPEG-4 ALS	MEPG-4 AAC, MPEG-4 ALS
Service information	Supported	Supported
EPG	Supported	Supported
teletext	Supported	Supported
Subtitling	Supported	Supported
Closed caption	Not specified	Not specified

(1) Also applicable to news gathering, interactive services and other satellite applications.

(2) Although Systems E2 do not use an interleaver between the inner and outer codes, there is a bit interleaver before the symbol mapper (except for QPSK).

(3) Although System F does not use an interleaver between the inner and outer codes, there is a bit interleaver before the symbol mapper (except for π/2-shift BPSK and QPSK).

(4) Not all the inner coding rates are applicable to any FEC frame size.

(5) Recommandation ITU-T H.265 (2013) | ISO/IEC 23008-2:2013: High efficiency video coding.

(6) QPSK and 8-PSK are normative, 16-APSK and 32-APSK are optional for broadcast applications in DVB-S2.

(7) QPSK, 8-PSK, 8-APSK-L, 16-APSK, 16-APSK-L, 32-APSK, and 32-APSK-L are normative for broadcasting, 64-APSK and 64-APSK-L are optional for broadcasting in DVB-S2X. Additionally, 128-APSK, 256-APSK and 256-APSK-L are available in DVB-S2X, that are not applicable for broadcasting. L indicates modes optimized for quasi-linear channels.

TABLE 11

Table to compare characteristics

Modulation and coding		**System E2(5)**		**System F**	
Modulation modes supported individually and on the same carrier		QPSK, 8-PSK, 16-APSK, 32-APSK (6) (7), 8-APSK-L, 16-APSK-L, 32-APSK-L 64-APSK, 64-APSK-L (7)		π/2-shift BPSK, QPSK, 8-PSK, 16-APSK, 32-APSK	
Performance (define quasi-error-free (QEF)) required *C*/*N* (bit/s/Hz))		Spectral efficiency(1)	*C*/*N* for QEF(2)	Spectral efficiency(3)	*C*/*N* for QEF(4)
Modes	Inner code				
π/2 shift BPSK	1/3	Not used		0.32	-4.0
	2/5	Not used		0.39	-3.0
	1/2	Not used		0.48	-1.8
	3/5	Not used		0.58	-0.5
	2/3	Not used		0.64	0.3
	3/4	Not used		0.71	1.0
	7/9	Not used		0.74	1.5
	4/5	Not used		0.77	2.0
	5/6	Not used		0.80	2.5
	7/8	Not used		0.84	2.9
	9/10	Not used		0.86	3.8

TABLE 11 (*continued*)

Modulation and coding		System E2		System F	
QPSK	1/4	0.49	−2.3	Not used	
	13/45	0.57	−2.03	Not used	
	1/3	0.66	−1.2	0.64	−1.0
	2/5	0.79	−0.3	0.77	0.0
	9/20	0.89	0.22	Not used	
	1/2	0.99	1.0	0.97	1.2
	11/20	1.09	1.45	Not used	
	3/5	1.19	2.2	1.16	2.5
	2/3	1.32	3.1	1.29	3.3
	3/4	1.49	4.0	1.42	4.0
	7/9	Not used		1.48	4.5
	4/5	1.59	4.7	1.54	5.0
	5/6	1.65	5.2	1.61	5.5
	7/8	Not used		1.67	5.9
	8/9	1.77	6.2	Not used	
	9/10	1.79	6.4	1.73	6.8
8-APSK-L	5/9	1.65	4.73	Not used	
	26/45	1.71	5.13	Not used	
8-PSK	1/3	Not used		0.97	2.2
	2/5	Not used		1.16	3.1
	1/2	Not used		1.45	4.4
	3/5	1.78	5.5	1.74	5.7
	23/36	1.90	6.12	Not used	
	2/3	1.98	6.6	1.93	6.7
	25/36	2.06	7.02	Not used	

TABLE 11 (*continued*)

Modulation and coding		**System E2**		**System F**	
8-PSK	13/18	2.15	7.49	Not used	
	3/4	2.23	7.9	2.12	7.9
	7/9	Not used		2.22	8.6
	4/5	Not used		2.32	9.1
	5/6	2.48	9.3	2.41	9.7
	7/8	Not used		2.51	10.4
	8/9	2.65	10.7	Not used	
	9/10	2.68	11.0	2.59	11.4
16-APSK-L	1/2	1.97	5.97	Not used	
	8/15	2.10	6.55	Not used	
	5/9	2.19	6.84	Not used	
	3/5	2.37	7.41	Not used	
	2/3	2.64	8.43	Not used	
16-APSK	1/3	Not used		1.29	4.1
	2/5	Not used		1.54	5.1
	1/2	Not used		1.93	6.6
	26/45	2.28	7.51	Not used	
	3/5	2.37	7.80	2.32	8.0
	28/45	2.46	8.10	Not used	
	23/36	2.52	8.38	Not used	
	2/3	2.64	9.0	2.57	9.1
	25/36	2.75	9.27	Not used	

TABLE 11 (*continued*)

Modulation and coding		System E2		System F	
16-APSK	13/18	2.86	9.71	Not used	
	3/4	2.97	10.2	2.83	10.2
	7/9	3.08	10.65	2.96	10.8
	4/5	3.17	11.0	3.09	11.3
	5/6	3.30	11.6	3.22	11.9
	77/90	3.39	11.99	Not used	
	7/8	Not used		3.35	12.5
	8/9	3.52	12.9	Not used	
	9/10	3.57	13.1	3.46	13.5
32-APSK-L	2/3	3.29	11.10	Not used	
32-APSK	1/3	Not used		1.61	6.4
	2/5	Not used		1.93	7.2
	1/2	Not used		2.41	9.2
	3/5	Not used		2.90	10.6
	2/3	Not used		3.22	11.7
	32/45	3.51	11.75	Not used	
	11/15	3.62	12.17	Not used	
	3/4	3.70	12.7	3.54	12.8
	7/9	3.84	13.05	3.70	13.4
	4/5	3.95	13.6	3.86	14.0
	5/6	4.12	14.3	4.02	14.5
	7/8	Not used		4.18	15.3
	8/9	4.40	15.7	Not used	
	9/10	4.46	16.0	4.32	16.3

TABLE 11 (*continued*)

Modulation and coding		**System E2**		**System F**
64-APSK-L	32/45	4.21	13.98	Not used
64-APSK	11/15	4.34	14.81	Not used
	7/9	4.60	15.47	Not used
	4/5	4.74	15.87	Not used
	5/6	4.93	16.55	Not used
Capable of hierarchical modulation control?		Yes		Yes
Symbol rate characteristics		Continuously variable		Continuously variable

TABLE 11 (*end*)

Transport and multiplexing	**System E2**	**System F**
Packet length (bytes)	188 for TS, user definable up to 64 K for GS. Variable length packet streams, unpacketized streams or packet lengths exceeding 64 K are possible, treated as continuous streams	188 for TS, user definable up to 64K for TLV. Variable-length packets such as IPv4, IPv6 packets are encapsulated into TLV packets. Signalling information is also encapsulated into TLV packets.
Transport streams supported	MPEG-2 and generic stream (GS), All-IP	MPEG-2 and TLV
Transport stream correspondence with satellite channels	1 to 255 streams/channel	1 to 16 streams/channel
Support for statistical multiplex of video streams	No limitations within transport stream. No limitations for generic streams	No limitations within transport stream. No limitations for TLV streams.

(1) Defined as the useful bit rate per unit symbol rate without pilots.

(2) These values were derived from computer simulations, 50 LDPC iterations, perfect carrier and synchronization recovery, no phase noise, AWGN channel. FEC frame length is 64 800 bits. The values apply to FER = 10^{-5}, where FER is the ratio, after forward error correction at the receiver, between the number of received normal FEC frames affected by error and the totally received ones. It does not include hardware implementation margin or satellite transponder loss margin.

(3) Defined as the TLV input useful bit rate per symbol rate 33.7561 MBd.

(4) These values were derived from computer simulations, with 50 LDPC fixed-point decoding iterations, perfect carrier and synchronization recovery, no phase noise, and AWGN channel. The FEC frame length is 44 880 bits. The values apply to BER = 10^{-11}, where BER is the ratio after forward error correction (FEC) at the receiver between the transmitted PRBS of $1+ x^{22}+x^{25}$ and the FEC decoded stream. It does not include the hardware implementation margin or satellite transponder loss margin.

(5) The listed modulation and coding configurations refer to the normal FEC frame.

(6) QPSK and 8-PSK are normative, 16-APSK and 32-APSK are optional for broadcast applications in DVB-S2.

(7) QPSK, 8-PSK, 8-APSK-L, 16-APSK, 16-APSK-L, 32-APSK, and 32-APSK-L are normative for broadcasting, 64-APSK and 64-APSK-L are optional for broadcasting in DVB-S2X. Additionally, 128-APSK, 256-APSK and 256-APSK-L are available in DVB-S2X, that are not applicable for broadcast applications. L indicates modes optimized for quasi-linear channels.