



Report ITU-R BO.2397-1
(09/2022)

Satellite transmissions for UHDTV satellite broadcasting

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REPORT ITU-R BO.2397-1

Satellite transmissions for UHDTV satellite broadcasting

(Question ITU-R 292/4)

(2016-2022)

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Abbreviations/Glossary

AAC	Advanced audio coding
ARIB	Association of Radio Industries and Businesses
APSK	Amplitude and phase shift keying
AWGN	Additive white gaussian noise
BPSK	Binary phase shift keying
BCH code	Bose-Chaudhuri-Hocquenghem code
BER	Bit error rate
BSS	Broadcasting-satellite service
C/N	Carrier to noise ratio
D/C	Down converter
EPG	Electronic Program Guide
FIR	Finite impulse response
HEVC	High efficiency video coding
HPA	High power amplifier
HDR	High dynamic range
HTML	Hyper text markup language
IF	Inter frequency
ISDB-S3	Integrated Services Digital Broadcasting for Satellite, 3rd generation
LCD	Liquid crystal display
LDPC code	Low density parity check code
MPEG	Moving Picture Experts Group
MMT	MPEG Media Transport
OBO	Output back off
OBW	Occupied bandwidth
PAPR	Peak to average power ratio
PN	Pseudo noise
PSK	Phase shift keying
QPSK	Quadrature phase shift keying
RMP	Rights management and protection
TDM	Time division multiplexing
TLV	Type length value
TMCC	Transmission and multiplexing configuration control
TS	Transport stream
TOC	Technical operation centre
TTML	Timed text markup language
TWTA	Traveling Wave Tube Amplifier

UHDTV	Ultra-high definition television
U/C	Up converter

1 Introduction

Ultra-high definition television (UHDTV) is one of the major applications of next-generation satellite broadcasting. New technologies such as amplitude and phase shift keying (APSK), low density parity check code (LDPC), and spectrum shaping by lowering the roll-off factor are required to implement UHDTV services via satellite within the same bandwidth as conventional high definition television.

This Report provides useful information of UHDTV satellite broadcasting including satellite transmission experiments and the latest status of UHDTV satellite broadcasting. Administrations are encouraged to contribute further information on the implementation of the UHDTV services via satellites.

2 Status of ITU-R standardization of UHDTV broadcasting

The ITU-R Recommendations relevant to UHDTV broadcasting are listed below as informative references.

Informative references

Recommendation ITU-R BT.1122 – User requirements for codecs for emission and secondary distribution systems for SDTV, HDTV, UHDTV and HDR-TV

Recommendation ITU-R BS.1196 – Audio coding for digital broadcasting

Recommendation ITU-R BT.1852 – Conditional-access systems for digital broadcasting

Recommendation ITU-R BT.1869 – Multiplexing scheme for variable-length packets in digital multimedia broadcasting systems

Recommendation ITU-R BT.1870 – Video coding for digital television broadcasting emission

Recommendation ITU-R BS.1873 – Serial multichannel audio digital interface for broadcasting studios

Recommendation ITU-R BT.1887 – Carriage of IP packets in MPEG-2 transport stream in multimedia broadcasting

Recommendation ITU-R BT.2020 – Parameter values for ultra-high definition television systems for production and international programme exchange

Recommendation ITU-R BS.2051 – Advanced sound system for programme production

Recommendation ITU-R BT.2073 – Use of the high efficiency video coding (HEVC) standard for UHDTV and HDTV broadcasting

Recommendation ITU-R BT.2074 – Service configuration, media transport protocol, and signalling information for MMT-based broadcasting systems

Recommendation ITU-R BT.2075 – Integrated broadcast-broadband system

Recommendation ITU-R BT.2077 – Real-time serial digital interfaces for UHDTV signals

Recommendation ITU-R BO.2098 – Transmission system for UHDTV satellite broadcasting

Recommendation ITU-R BT.2100 – Image parameter values for high dynamic range television for use in production and international programme exchange

3 Satellite transmissions for UHDTV satellite broadcasting

Annex 1 provides the details on the UHDTV satellite broadcasting system used in Japan including transmission experiments to confirm the feasibility of the system and the latest status of UHDTV satellite broadcasting. The geostationary satellites BSAT-3 and BSAT-4 located at 110 degrees east longitude are used for transmission in the 12 GHz BSS band. The results of the experiments confirmed that all of the combinations of modulation and inner coding rate defined for the ISDB-S3 system are feasible and 16-APSK (7/9) transmission provides an approximately 100 Mbit/s transmission capacity in a 34.5 MHz-bandwidth single satellite transponder.

Annex 2 provides techniques for APSK modulation signals in satellite transmission, which enable transmission capacity for UHDTV to be increased. However, the APSK modulation signals are more susceptible to non-linear characteristics of the RF components in the broadcasting satellite network, therefore there is a trade-off for TWTA operation in a satellite transponder between the output power and the transmission performance. An evaluation formula for the overall performance is considered to analyse the link margin. The results of the transmission experiments show that the evaluation formula is useful to improve the link margin.

Annex 1

UHDTV satellite broadcasting in Japan

1 Introduction

A 4K/8K UHDTV satellite broadcasting system named as ISDB-S3 was standardized as ARIB STD-B44 in Japan in 2014. The system is also specified in Recommendation ITU-R BO.2098.

The key technologies in ISDB-S3 include highly efficient video coding with the HEVC/H.265 standard [1], a flexible multiplexing scheme with the MMT protocol [2], and a larger channel capacity by the new transmission system. The target channel capacity for a single satellite transponder in the BSS band is set to 80-100 Mbit/s [3], which is shown as one of the basic parameters for UHDTV broadcasting using the HEVC standard in ITU-R BT.2073. 16-APSK and LDPC code with a coding rate of 7/9 and a symbol rate of 33.7561 Mbaud by lowering the roll-off factor of 0.03 can provide a capacity of approximately 100 Mbit/s in a satellite transponder with a 34.5 MHz bandwidth.

Satellite transmission experiments were conducted using a 12 GHz band broadcasting satellite in 2015 [4] to demonstrate the feasibility of this system. The geostationary satellite BSAT-3b located at 110 degrees east longitude was used for transmission on the 12 GHz BSS band. The results indicated that all of the combinations of modulation and inner coding rate are feasible and 16-APSK (7/9) provides a 100 Mbit/s transmission capacity in a 34.5 MHz-bandwidth single satellite transponder.

Practical UHDTV satellite broadcasting has been in operation since December 2018 via BSAT-4a after the test broadcasting conducted in 2016-2018 via BSAT-3b satellite.

Section 2 gives the technical specifications for the ISDB-S3 transmission system. Section 3 presents the satellite transmission experiments. The experimental results are summarized with the results obtained from C/N vs. BER measurements in § 3.2. Section 4 introduces the UHDTV satellite broadcasting in Japan.

2 Technical characteristics (ISDB-S3) for transmission system and main parameters used in satellite transmissions

The technical specifications are summarized in Table 1. This system has adopted 0.03 as the roll-off factor for the raised-cosine square-root Nyquist filters implemented in the transmitter and receiver. Lowering the roll-off factor to 0.03 enables the symbol rate to be increased to 33.7561 Mbaud, and this combination also meets the occupied bandwidth (OBW) of 34.5 MHz [5].

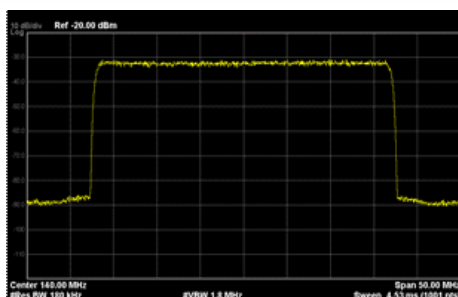
ISDB-S3 does not specify the specific symbol rate. Japan chose 33.7561 Mbaud according to domestic regulation in the experiments. The symbol rate of ISDB-S3 can be set according to the various kinds of satellite transponder bandwidth flexibly.

A transmitter and receiver that satisfied the technical specifications listed in Table 1 were developed. The Finite Impulse Response (FIR) raised-cosine square-root Nyquist filter that achieved a roll-off factor of 0.03 was implemented in the transmitter and receiver, and the numbers of tap coefficients were 678 for the former and 512 for the latter. The centre frequency of the transmitter was 140 MHz, which is the inter frequency (IF) of the 17 GHz feeder link. The spectrum of transmitter output is shown in Fig. 1.

TABLE 1
Technical specifications for the 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, $T = 12$), BCH (65535,65343, $T = 12$) 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.

FIGURE 1
Spectrum of Transmitter Output



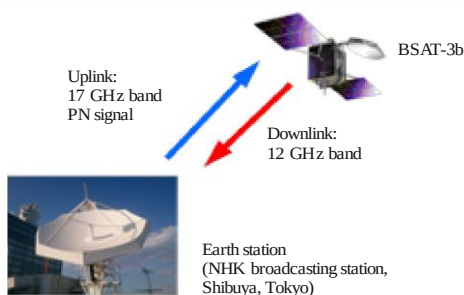
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3 Satellite transmission experiments in the 12 GHz BSS band in Japan

3.1 Measurement system

Figure 2 shows schematic and photographs of the measurement system used in the satellite transmission experiments with the BSAT-3b satellite. The earth station with a 5.5-m transmitting and receiving antenna was located at NHK, Nippon Hoso Kyokai (JAPAN BROADCASTING CORPORATION) Broadcasting Station, Shibuya, Tokyo, Japan. The uplink frequency was in the 17 GHz band and that of the downlink was in the 12 GHz band. Figure 3 shows schematic of the measurement system. The satellite transmission experiments were conducted from 31 August to 14 September 2015.

FIGURE 2
Measurement system



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