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Error-correction, data framing, modulation and emission methods for second generation of digital terrestrial television broadcasting systems

BT Series

Broadcasting service (television)

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RECOMMENDATION ITU-R BT.1877

Error-correction, data framing, modulation and emission methods for second generation of digital terrestrial television broadcasting systems

(Question ITU-R 31/6)

(2010)

Scope

This Recommendation defines error-correction, data framing, modulation and emission methods for the second generation of digital terrestrial television broadcasting transmission systems[1] (referred to, outside ITU-R, as a DVB-T2 system). These systems have been developed such that they are compatible with the provisions of the GE06 Agreement. This Recommendation is intended for the digital terrestrial broadcasting transmission system, 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[2].

The ITU Radiocommunication Assembly,

considering

a) that the digital terrestrial television systems for use in broadcasting systems have been developed in Recommendation ITU-R BT.1306, which are referred to as the current systems;

b) that digital terrestrial television broadcasting (DTTB) is being introduced in the VHF/UHF bands by some administrations from 1997;

c) that it may be desirable to support the simultaneous transmission of a hierarchy of nested quality levels (including high definition television (HDTV), extended definition TV (EDTV)) and standard definition TV (SDTV) within a single channel;

d) that many types of interference, including co-channel and adjacent channel, ignition noise, multipath and other signal distortions exist in the VHF/UHF bands;

e) that it is necessary that the frame synchronization be capable of robustness in channels subject to transmission errors;

f) that it is desirable that the frame structure be adapted to different bit rate channels;

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[1] The second generation of digital terrestrial television broadcasting transmission systems in this Recommendation is meant as systems offering higher bit rate capacity per Hz and better power efficiency in comparison to the systems described in Recommendation ITU-R BT.1306, and there is no general requirement for backward compatibility with first-generation systems.

[2] For the first-generation systems information on planning parameters, protection ratios, etc. is already contained in relevant ITU-R Recommendations. For the second-generation systems, there is a need to study and include such information in the relevant ITU-R Recommendations.

g) that recent developments in the field of channel coding and modulation have produced new techniques with performances approaching the Shannon limit;

h) 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 broadcasting bandwidth and power resources;

j) 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;

k) that the recommended system would be capable to handle the variety of advanced audiovisual formats currently available and under definition;

l) that the selection of a modulation option needs to be based on specific conditions such as spectrum resource, policy, coverage requirements, existing network structure, reception conditions, type of service required, cost to the consumer and broadcasters,

recommends

1 that administrations wishing to introduce the second generation of DTTB systems may use the system outlined in Annex 1.

Annex 1

Table 1 provides data about the second-generation multi-carrier system with multiple physical layer pipes (PLP). Specifications and implementation guidelines for this system (referred to, outside ITU-R, as a DVB-T2 system) are found in Appendix 1.

TABLE 1

Parameters for the second generation of DTTB transmission system

Second-generation multi-carrier system with multiple physical layer pipes (PLP)[1]

No.	Parameters	1.7 MHz multi-carrier (OFDM)[2]	5 MHz multi-carrier (OFDM)[2]	6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)	10 MHz multi-carrier (OFDM)[2]
1	Used bandwidth	1.54 MHz in normal mode	4.76 MHz in normal mode 4.82 MHz in extended mode (8k mode) 4.86 MHz in extended mode (16k and 32k mode)	5.71 MHz in normal mode 5.79 MHz in extended mode (8k mode) 5.83 MHz in extended mode (16k and 32k mode)	6.66 MHz in normal mode 6.75 MHz in extended mode (8k mode) 6.80 MHz in extended mode (16k and 32k mode)	7.61 MHz in normal mode 7.72 MHz in extended mode (8k mode) 7.77 MHz in extended mode (16k and 32k mode)	9.51 MHz in normal mode 9.65 MHz in extended mode (8k mode) 9.71 MHz in extended mode (16k and 32k mode)
2	Number of radiated carriers						
	1k mode	853	853	853	853	853	853
	2k mode	1 705	1 705	1 705	1 705	1 705	1 705
	4k mode	3 409	3 409	3 409	3 409	3 409	3 409
	8k mode	6 817 (8k mode)	6 817 (8k mode) 6 913 (8k extended mode)	6 817 (normal mode) 6 913 (extended mode)	6 817 (normal mode) 6 913 (extended mode)	6 817 (normal mode) 6 913 (extended mode)	6 817 (8k mode) 6 913 (8k extended mode)
	16k mode		13 633 (16k mode) 13 921 (16k extended mode)	13 633 (normal mode) 13 921 (extended mode)	13 633 (normal mode) 13 921 (extended mode)	13 633 (normal mode) 13 921 (extended mode)	13 633 (16k mode) 13 921 (16k extended mode)
	32k mode		27 265 (32k mode) 27 841 (32k extended mode)	27 265 (normal mode) 27 841 (extended mode)	27 265 (normal mode) 27 841 (extended mode)	27 265 (normal mode) 27 841 (extended mode)	27 265 (32k mode) 27 841 (32k extended mode)
3	Modulation modes	Constant coding and modulation (CCM)/variable coding and modulation (VCM)					

TABLE 1 (*continued*)

No.	Parameters	1.7 MHz multi-carrier (OFDM)[2]	5 MHz multi-carrier (OFDM)[2]	6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)	10 MHz multi-carrier (OFDM)[2]
4	Modulation method	QPSK, 16-QAM, 64-QAM, 256-QAM specific for each physical layer pipe					
5	Channel occupancy	To be defined [2]			See Rec. ITU-R BT.1206		To be defined [2]
6	Active symbol duration						
	1k mode	554.99 µs	179.2 µs	149.33 µs	128 µs	112 µs	89.60 µs
	2k mode	1 109.98 µs	358.4 µs	298.67 µs	256 µs	224 µs	179.20 µs
	4k mode	2 219.97 µs	716.8 µs	597.33 µs	512 µs	448 µs	358.40 µs
	8k mode	4 439.94 µs	1 433.6 µs	1 194.67 µs	1 024 µs	896 µs	716.8 µs
	16k mode		2 867.2 µs	2 389.33 µs	2 048 µs	1 792 µs	1 433.6 µs
	32k mode		5 734.40 µs	4 778.67 µs	4 096 µs	3 584 µs	2 867.2 µs
7	Carrier spacing						
	1k mode	1 801.91 Hz	5 580.63 Hz	6 696.75 Hz	7 812.88 Hz	8 929 Hz	11 161.25 Hz
	2k mode	900.86 Hz	2 790 Hz	3 348 Hz	3 906 Hz	4 464 Hz	5 580.00 Hz
	4k mode	450.43 Hz	1 395 Hz	1 674 Hz	1 953 Hz	2 232 Hz	2 790.00 Hz
	8k mode	225.21 Hz	697.50 Hz	837 Hz	976 Hz	1 116 Hz	1 395.00 Hz
	16k mode		348.75 Hz	418.5 Hz	488.25 Hz	558 Hz	697.50 Hz
	32k mode		174.38 Hz	209.25 Hz	244.125 Hz	279 Hz	348.75 Hz

TABLE 1 (*continued*)

No.	Parameters	1.7 MHz multi-carrier (OFDM)[2]	5 MHz multi-carrier (OFDM)[2]	6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)	10 MHz multi-carrier (OFDM)[2]
8	Guard interval duration [3]	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4 of active symbol duration	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4 of active symbol duration	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4 of active symbol duration	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4 of active symbol duration	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4 of active symbol duration	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4 of active symbol duration
	1k mode	34.69, 69.37, 138.75 µs	11.2, 22.4, 44.8 µs	9.3, 18.6, 37.3 µs	8, 16, 32 µs	7, 14, 28 µs	5.6, 11.2, 22.4 µs
	2k mode	34.69, 69.37, 138.75, 277.50 µs	11.2, 22.4, 44.8, 89.6 µs	9.3, 18.6, 37.3, 74.6 µs	8, 16, 32, 64 µs	7, 14, 28, 56 µs	5.6, 11.2, 22.4, 44.8 µs
	4k mode	69.37, 138.75, 277.50, 554.99 µs	22.4, 44.8, 89.6, 179.2 µs	18.6, 37.3, 74.6, 149.3 µs	16, 32, 64, 128 µs	14, 28, 56, 112 µs	11.2, 22.4, 44.8, 89.6 µs
	8k mode	34.69, 138.75, 277.50, 329.53, 554.99, 659.05, 1 109.98 µs	11.2, 44.8, 89.6, 106.4, 179.2, 212.8, 358.4 µs	9.3, 37.3, 74.6, 88.6, 149.3, 177.3, 298.6 µs	8, 32, 64, 75.9, 128, 152, 256 µs	7, 28, 56, 66.5, 112, 133, 224 µs	5.6, 22.4, 44.8, 53.2, 89.6, 106.4, 179.2 µs
	16k mode		22.4, 89.6, 179.2, 212.8, 358.4, 425.6, 716.8 µs	18.6, 74.6, 149.3, 177.3, 298.6, 354.6, 597.3 µs	16, 64, 128, 152, 256, 304, 512 µs	14, 56, 112, 133, 224, 266, 448 µs	11.2, 44.8, 89.6, 106.4, 179.2, 212.8, 358.4 µs
	32k mode		44.8, 179.2, 358.4, 425.6, 716.8, 851.2 µs	37.33, 149.33, 298.67, 354.67, 597.33, 709.33 µs	32, 128, 256, 304, 512, 608 µs	28, 112, 224, 266, 448, 532 µs	22.4, 89.6, 179.2, 212.8, 358.4, 425.6 µs
9	Overall symbol duration						
	1k mode	589.68-4578.69 µs	190.4, 201.6, 224 µs	158.6, 168, 186.6 µs	136, 144, 160 µs	119, 126, 140 µs	95.20-112.00 µs
	2k mode	1 144.67-1 387.48 µs	369.6, 381, 403, 448 µs	308, 317, 336, 373.3 µs	264, 272, 288, 320 µs	231, 238, 252, 280 µs	184.80-224.00 µs
	4k mode	2 289.34-2 774.96 µs	739, 762, 806, 896 µs	616, 635, 672, 746.6 µs	527.9, 544, 576, 640 µs	462, 476, 504, 560 µs	369.60-448.00 µs
	8k mode	4 474.63-5 549.92 µs	1 444.8, 1 478.4, 1 523.2, 1 540, 1 612.8, 1 646.4, 1 792 µs	1 204, 1 232, 1 269.3, 1 283.3, 1 344, 1 372, 1 493.3 µs	1 032, 1 056, 1 088, 1 100, 1 152, 1 176, 1 280 µs	903, 924, 952, 962.5, 1 008, 1 29, 1 120 µs	722.4, 739.2, 761.6, 770, 806.4, 823, 896 µs
	16k mode		2 889, 2 956.8, 3 046.4, 3 080, 3 225.6, 3 292.8, 3 584 µs	2 408, 2 464, 2 538.6, 2 566.6, 2 686, 2 744, 2 986.6 µs	2 064, 2 112, 2 176, 2 200, 2 304, 2 352, 2 560 µs	1 806, 1 848, 1 904, 1 925, 2 016, 2 058, 2 240 µs	1 444.8, 1 478.4, 1 523.2, 1 540, 1 612.8, 1 646.4, 1 792 µs
	32k mode		5 779.20-6 585.60 µs	4 816-5 488 µs	4 128-4 704 µs	3 612, 3 696, 3 808, 3 850, 4 032, 4 116 µs	2 889.6, 2 956.8, 3 046.4, 3 080, 3 225.6, 3 292.8 µs

TABLE 1 (*continued*)

No.	Parameters	1.7 MHz multi-carrier (OFDM)[2]	5 MHz multi-carrier (OFDM)[2]	6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)	10 MHz multi-carrier (OFDM)[2]
10	Transmission frame duration[6]	Frame starts with preamble and has a configurable number of symbols, with maximum duration of 250 ms. Minimum number of data symbols is 3 (32k mode) or 7 (other modes). Super-frame length is configurable, maximum 256 frames, 64 s					
11	Input stream format[4]	Either transport streams (TS) or generic streams (GS)					
12	System stream format	BB format[5]	BB format				
13	Mode adaptation code	CRC-8					
14	Channel coding	LDPC/BCH code with block size of 64 800 or 16 200 bits and code rates 1/2, 3/5, 2/3, 3/4, 4/5, 5/6[1]					
15	Interleaving	Bit, cell and time interleaving separately for each physical layer pipe. Common frequency interleaving[1]					
16	Constellation rotation	Optional, 29 (QPSK), 16.8 (16-QAM), 8.6 (64-QAM) degrees or atn (1/16) (256-QAM)					
17	Physical layer pipes (PLP)	Mode A with single PLP and mode B with multiple PLPs. Modulation, coding and time interleaving depth selectable separately for each PLP[1] [7]					
18	Data randomization/ energy dispersal Initial scan	PRBS Fast scan process with special preamble symbol P1					
19	Time/frequency synchronization	Preamble symbols P1 and P2. Scattered pilot carriers with 8 different pilot patterns available. Continual pilots					
20	MISO	An optional 2 × 1 Multiple Input Single Output (MISO) with Alamouti coding					
21	Receiver power consumption reduction	Physical layer pipes are organized as subslices in the frame. When receiving a single PLP only the preamble and relevant subslices are received and processed					
22	Layer 1 signalling	L1 signalling is carried by P2 symbols in the preamble. L1 pre-signalling is modulated with BPSK and coded with 1/4 16k LDPC. L1 post-signalling has configurable modulation and 1/2 16k LDPC coding. Option for in-band signalling within the PLP					
23	Layer 1 signalling	Either within the data PLPs or with special common PLP at the beginning of the frame					

TABLE 1 (*end*)

No.	Parameters	1.7 MHz multi-carrier (OFDM)[2]	5 MHz multi-carrier (OFDM)[2]	6 MHz multi-carrier (OFDM)	7 MHz multi-carrier (OFDM)	8 MHz multi-carrier (OFDM)	10 MHz multi-carrier (OFDM)[2]
24	PAPR (Peak-to-Average Power Ratio)	Active Constellation Extension (ACE) and Tone Reservation (TR) as options					
25	Future Extension Frames (FEF)	A super frame can include one or several FEF-parts. These can be used for future extensions of the system					
26	Net data rate			4.01-37.8 Mbit/s, depending on FFT-size, modulation, code rate, guard interval, pilot pattern, MISO, FEF, PAPR	4.68-44.1 Mbit/s, depending on FFT-size, modulation, code rate, guard interval, pilot pattern, MISO, FEF, PAPR	5.35-50.4 Mbit/s, depending on FFT-size, modulation, code rate, guard interval, pilot pattern, MISO, FEF, PAPR	
27	Carrier-to-noise ratio in an AWGN channel			Depending on modulation and channel code. 0.8-21.8 dB[8]			

BCH: Bose – Chandhuri – Hocquenghem multiple error correction binary block code

LDPC: Low density parity check

OFDM: Orthogonal frequency division multiplex

PRBS: Pseudo-random binary sequence

QAM: Quadrature amplitude modulation

QSPK: Quaternary phase shift keying.

Notes relating to Table 1

(1) Possibility for one or multiple physical layer pipes (PLP), each having its own specific modulation, coding and time interleaving depth, thus enabling service-specific robustness.

(2) Spectrum-shaping limits for digital terrestrial television systems using 5 MHz, 6 MHz and 10 MHz channels needs to be defined. The 1.7, 5 and 10 MHz channel variants are not normally used for TV-broadcasting purposes in the VHF III or UHF IV/V bands. The 7 and 8 MHz variants of the system are compatible with the GE06 Agreement with respect to spectrum usage. The 1.7 MHz variant is compatible with T-DAB frequency planning.

(3) All the fractions are not available for all FFT-modes.

(4) As defined in EN 302 755 (DVB-T2 standard), system support following input stream formats: GSE (Generic Stream Encapsulated format), GFPS (Generic Fixed-length Packetized Stream format), GCS (Generic Continuous Stream format) and MPEG-TS.

(5) Base band format, used in this second-generation broadcasting system.

(6) Values correspond to maximum frame length in OFDM symbols excluding P1 symbols. For 1k mode the maximum length is defined for guard interval duration of 1/16, 1/8 and 1/4. For 4k and 2k modes the maximum length is defined for 1/32, 1/16, 1/8 and 1/4. In the case of 32k mode non-applicable only 1/4 guard interval. For more information see EN 302 755 (DVB-T2 standard). Number of OFDM symbols for 1.7 MHz, 5 MHz, 6 MHz, 7 MHz, 10 MHz is to be defined.

(7) The system has a future option to spread the PLP subslices over multiple RF-channels within the frame. Time interleaving is applied over all these. Single profile receivers based on the first release of the specification do not support this.

(8) Simulated in Gaussian channels with BER 1×10^{-4} before BCH coding. The expected implementation loss due to real channel estimation needs to be added to the figures. This will be significantly less than the corresponding figure for first-generation multi-carrier systems due to better optimization of the boosting and pattern densities for second-generation multi-carrier systems.

Appendix 1
to Annex 1

System standard

ETSI EN 302 755. Digital Video Broadcasting (DVB); Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2).

ETSI TR 102 831. Digital Video Broadcasting (DVB); Implementation guidelines for a second generation digital terrestrial television broadcasting system (DVB-T2).