



Recommendation ITU-R BT.2016-3
(12/2022)

**Error-correction, data framing, modulation
and emission methods for terrestrial
multimedia broadcasting for mobile
reception using handheld receivers
in VHF/UHF bands**

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Broadcasting service
(television)



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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 BT.2016-3

Error-correction, data framing, modulation and emission methods for terrestrial multimedia broadcasting for mobile reception using handheld receivers in VHF/UHF bands

(2012-2013-2020-2022)

Scope

This Recommendation defines error-correction, data framing, modulation and emission methods for terrestrial multimedia broadcasting for mobile reception using handheld receivers in the VHF/UHF bands.

Keywords

Error correction, data framing, modulation characteristics, emission methods, terrestrial multimedia broadcasting, mobile reception, handheld

The ITU Radiocommunication Assembly,

considering

- a) that digital multimedia broadcasting systems have been implemented in many countries or are planned to be introduced, using the inherent capability of digital broadcasting systems;
- b) that terrestrial emission systems for mobile reception using handheld receivers require specific technical characteristics due to peculiar propagation characteristics;
- c) that the interoperability between multimedia and digital television and sound broadcasting systems could offer the possibility for the reuse of the existing broadcast infrastructure for multimedia services;
- d) that Recommendations ITU-R BT.1306 and ITU-R BT.1877 specify error-correction, data framing, modulation and emission methods for digital terrestrial television broadcasting;
- e) that Recommendation ITU-R BS.1114 specifies error-correction, data framing, modulation and emission methods as well as higher-layer systems characteristics for digital terrestrial sound broadcasting;
- f) that Recommendation ITU-R BT.1833 and Report ITU-R BT.2049 describe end user requirements and higher-layer systems characteristics for multimedia broadcasting systems for mobile reception using handheld receivers,

recommends

that administrations wishing to introduce terrestrial multimedia broadcasting for mobile reception using handheld receivers in the VHF/UHF bands should use one or several (depending on the multimedia broadcasting market) of the systems comprising error-correction, framing, modulation and emission methods outlined in Annex 1.

NOTE – Tables 1A, 1B, 2A and 2B of Annex 1 can be used to evaluate the respective characteristics of the systems in selecting a specific system.

Annex 1

Tables 1A and 1B provide data about emission systems for terrestrial multimedia broadcasting for mobile reception using handheld receivers in the VHF/UHF bands. Supplemental information for the systems can be found in Attachments 1, 2 and 3.

Tables 2A and 2B provide technical features of each system described in Tables 1A and 1B that concern several aspects relevant to implementation and deployment.

TABLE 1A
Parameters for emission systems

	Parameters	Multimedia System A	Multimedia System F	Multimedia System I	Multimedia System H	Multimedia System T2
1	Channel bandwidths	1.712 MHz	$1/14 \times n$ of a) 6 MHz b) 7 MHz c) 8 MHz $n \geq 1$ ⁽¹⁾	a) 1.7 MHz b) 5 MHz c) 6 MHz d) 7 MHz e) 8 MHz	a) 5 MHz b) 6 MHz c) 7 MHz d) 8 MHz	a) 1.7 MHz b) 5 MHz c) 6 MHz d) 7 MHz e) 8 MHz
2	Used bandwidth	1.536 MHz	“Subcarrier spacing” (see item 5) + $1/14 \times n \times$ a) 6 MHz b) 7 MHz c) 8 MHz $n \geq 1$ ⁽¹⁾	a) 1.52 MHz b) 4.75 MHz c) 5.71 MHz d) 6.66 MHz 7.61 MHz	a) 4.75 MHz b) 5.71 MHz c) 6.66 MHz d) 7.61 MHz	a) 1.52 MHz b) 4.75 MHz c) 5.71 MHz d) 6.66 MHz e) 7.61 MHz
3	Number of segments	1	$n \geq 1$ ⁽¹⁾		Configurable number of time slices per bandwidth	Configurable
4	Number of subcarriers per segment	192 384 768 1 536	108 (Mode 1) 216 (Mode 2) 432 (Mode 3)	853 (1k mode) 1 705 (2k mode) 3 409 (4k mode) 6 817 (8k mode)	1 705 (2k mode) 3 409 (4k mode) 6 817 (8k mode)	1 705 (2k mode) 3 409 (4k mode) 6 817 (8k mode) 13 633 (16k mode)

TABLE 1A (continued)

	Parameters	Multimedia System A	Multimedia System F	Multimedia System I	Multimedia System H	Multimedia System T2
5	Subcarrier spacing	a) 8 kHz b) 4 kHz c) 2 kHz d) 1 kHz	a) 3.968 kHz (Mode 1) ⁽²⁾ , 1.984 kHz (Mode 2), 0.992 kHz (Mode 3) b) 4.629 kHz (Mode 1), 2.314 kHz (Mode 2), 1.157 kHz (Mode 3) c) 5.291 kHz (Mode 1), 2.645 kHz (Mode 2), 1.322 kHz (Mode 3)	a) 1 786 kHz (1k) b) 5 580.322 Hz (1k) 2 790.179 Hz (2k) 1 395.089 Hz (4k) 697.545 Hz (8k) c) 6 696.42 Hz (1k), 3 348.21 Hz (2k), 1 674.11 Hz (4k), 837.05 Hz (8k) d) 7 812 Hz (1k), 3 906 Hz (2k), 1 953 Hz (4k), 976 Hz (8k) e) 8 929 Hz (1k), 4 464 Hz (2k), 2 232 Hz (4k), 1 116 Hz (8k)	a) 2 790.179 Hz (2k), 1 395.089 Hz (4k), 697.545 Hz (8k) b) 3 348.21 Hz (2k), 1 674.11 Hz (4k), 837.05 Hz (8k) c) 3 906 Hz (2k), 1 953 Hz (4k), 976 Hz (8k) d) 4 464 Hz (2k), 2 232 Hz (4k), 1 116 Hz (8k)	a) 901 Hz (2k mode), 450 Hz (4k mode), 225 Hz (8k mode), 113 Hz (16k mode) b) 2 790 Hz (2k mode), 1 395 Hz (4k mode), 698 Hz (8k mode), 349 Hz (16k mode) c) 3 348 Hz (2k mode), 1 674 Hz (4k mode), 837 Hz (8k mode), 419 Hz (16k mode) d) 3 906 Hz (2k mode), 1 953 Hz (4k mode), 977 Hz (8k mode), 488 Hz (16k mode) e) 4 464 Hz (2k mode), 2 232 Hz (4k mode), 1 116 Hz (8k mode), 558 Hz (16k mode)

TABLE 1A (continued)

	Parameters	Multimedia System A	Multimedia System F	Multimedia System I	Multimedia System H	Multimedia System T2
6	Active symbol duration	a) 156 μ s b) 312 μ s c) 623 μ s d) 1 246 μ s	a) 252 μ s (Mode 1) ⁽²⁾ , 504 μ s (Mode 2), 1 008 μ s (Mode 3) b) 216 μ s (Mode 1), 432 μ s (Mode 2), 864 μ s (Mode 3) c) 189 μ s (Mode 1), 378 μ s (Mode 2), 756 μ s (Mode 3)	a) 560 μ s (1k) b) 179.2 μ s (1k), 358.40 μ s (2k), 716.80 μ s (4k), 1 433.60 μ s (8k) c) 149.33 μ s (1k), 298.67 μ s (2k), 597.33 μ s (4k), 1 194.67 μ s (8k) d) 2 128 μ s (1k), 256 μ s (2k), 512 μ s (4k), 1 024 μ s (8k) e) 112 μ s (1k), 224 μ s (2k), 448 μ s (4k), 896 μ s (8k)	a) 358.40 μ s (2k), 716.80 μ s (4k), 1 433.60 μ s (8k) b) 298.67 μ s (2k), 597.33 μ s (4k), 1 194.67 μ s (8k) c) 256 μ s (2k), 512 μ s (4k), 1 024 μ s (8k) d) 224 μ s (2k), 448 μ s (4k), 896 μ s (8k)	a) 1 109.98 μ s (2k) 2 219.97 μ s (4k) 4 439.94 μ s (8k) b) 358.4 μ s (2k) 716.8 μ s (4k) 1 433.6 μ s (8k) 2 867.2 μ s (16k) c) 298.67 μ s (2k) 597.33 μ s (4k) 1 194.67 μ s (8k) 2 389.33 μ s (16k) d) 256 μ s (2k) 512 μ s (4k) 1 024 μ s (8k) 2 048 μ s (16k) e) 224 μ s (2k) 448 μ s (4k) 896 μ s (8k) 1 792 μ s (16k)
7	Guard interval duration or guard interval ratio	a) 31 μ s b) 62 μ s c) 123 μ s d) 246 μ s	1/32, 1/16, 1/8, 1/4 of “active symbol duration” (see item 6)	1/32, 1/16, 1/8, 1/4 of active symbol duration	1/32, 1/16, 1/8, 1/4 of active symbol duration	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4 of active symbol duration
8	Transmission unit (frame) duration	96 ms 48 ms 24 ms	204 OFDM symbols (Symbol duration = guard interval duration + active symbol duration)	68 OFDM symbols. One super-frame consists of 4 frames	68 OFDM symbols. One super-frame consists of 4 frames	Flexible with possibility of changing on frame-by- frame basis. Max 250 ms
9	Time/frequency synchronization	Null symbol and centre frequency and phase reference symbol	Pilot carriers	Pilot carriers	Guard interval/pilot carriers	P1 symbol/guard interval/pilot carriers

TABLE 1A (continued)

	Parameters	Multimedia System A	Multimedia System F	Multimedia System I	Multimedia System H	Multimedia System T2
10	Modulation methods	T-DMB: COFDM-DQPSK AT-DMB: COFDM-DQPSK COFDM-BPSK over DQPSK COFDM-QPSK over DQPSK	DQPSK, QPSK, 16-QAM, 64-QAM	QPSK, 16-QAM	QPSK, 16-QAM, 64-QAM, MR-16-QAM, MR-64-QAM	QPSK, 16-QAM, 64-QAM with or without constellation rotation specific for each physical layer pipe
11	Inner channel coding	T-DMB: Convolutional code (1/4 to 3/4) AT-DMB: Convolutional code + Turbo code (1/4 to 1/2)	Convolution code, Mother rate 1/2 with 64 states. Puncturing to rate 2/3, 3/4, 5/6, 7/8	Turbo Code from 3GPP2 with mother information block size of 12 282 bits. Rates obtained by puncturing: 1/5, 2/9, 1/4, 2/7, 1/3, 2/5, 1/2, 2/3	Convolutional code, mother rate 1/2 with 64 states. Puncturing to rate 2/3, 3/4, 5/6, 7/8	LDPC code with code rates 1/3, 2/5, 1/2, 3/5, 2/3, 3/4
12	Inner interleaving	Time interleaving and frequency interleaving	Frequency interleaving: Intra and inter segments interleaving Time interleaving: Symbol-wise convolutional interleaving 0, 380, 760, 1 520, 3 040 symbols (Mode 1) ⁽²⁾ 0, 190, 380, 760, 1 520 symbols (Mode 2) 0, 95, 190, 380, 760 symbols (Mode 3)	– Frequency interleaving – Time interleaving: Forney with 48 branches QPSK: 320/9 600 ms 16-QAM: 160/4 800 ms	Bit interleaving, combined with native or in-depth symbol interleaving	Cell, time and frequency interleaving
13	Outer channel coding	RS (204, 188, T = 8) code for video service and scalable video service	RS (204, 188, T = 8)		Outer Code: RS (204, 188, T = 8) IP outer channel code: MPE-FEC RS (255,191)	BCH (16 200, x , t), there x – depends on LDPC code rate. Error correction capability $t = 12$ errors

TABLE 1A (end)

	Parameters	Multimedia System A	Multimedia System F	Multimedia System I	Multimedia System H	Multimedia System T2
14	Outer interleaving	Convolutional interleaving for video service and scalable video service	Byte-wise convolutional interleaving, I = 12	Byte-wise convolutional interleaving, I = 12		Bit (parity and column twist) interleaving
15	Net data rates	- T-DMB: 0.576 to 1.728 Mbit/s - AT-DMB: 0.864 to 2.304 Mbit/s at BPSK over DQPSK - AT-DMB: 1.152 to 2.88 Mbit/s at QPSK over DQPSK	$n \times$ a) 0.281 to 1.787 Mbit/s b) 0.328 to 2.085 Mbit/s c) 0.374 to 2.383 Mbit/s	At MPEG-TS level and starting from the lower code rate with GI 1/4 to the higher rate with GI 1/32: a) 0,42 to 3.447 Mbit/s b) 1.332 to 10,772 Mbit/s c) 1.60 to 12.95 Mbit/s d) 1.868 to 15.103 Mbit/s e) 2.135 to 17.257 Mbit/s	Depends on MPE-FEC rate. For MPE-FEC rate 3/4: a) 2.33-14.89 Mbit/s b) 2.80-17.87 Mbit/s c) 3.27-20.84 Mbit/s d) 3.74-23.82 Mbit/s	Max available input bit-rate in case of Transport stream is 4 Mbit/s
Reference		Attachment 1	Attachment 2	Attachment 3	Attachment 4	Attachment 5

⁽¹⁾ The number of segments “ n ” is determined by the available bandwidth.

⁽²⁾ Modes 1, 2 and 3 can be selected by the scale of the single frequency network (SFN) and the types of service reception such as fixed or mobile. Mode 1 can be used for single transmission operation, or for small single frequency network. This mode is suitable for mobile reception. Mode 3 can be used for large single frequency network. This mode is suitable for fixed reception. Mode 2 offers an additional trade-off between transmission area size and mobile reception capabilities. The mode should be selected by taking the applied radio frequency, the scale of SFN, and the type of service reception into consideration.

TABLE 1B

Parameters for emission systems

	Parameters	System R	System S	System L	System N
1	Channel bandwidths	a) 100 kHz b) 200 kHz c) 250 kHz	a) 6 MHz b) 7 MHz c) 8 MHz	a) 1.4 MHz b) 3 MHz c) 5 MHz d) 10 MHz e) 15 MHz f) 20 MHz	a) 5 MHz b) 10 MHz c) 15 MHz d) 20 MHz e) 25 MHz f) 30 MHz g) 35 MHz h) 40 MHz
2	Used bandwidth	a) 96.0 kHz b) 185.6 kHz c) 246.2 kHz	a) 5.832 MHz 5.751 MHz, 5.670 MHz, 5.589 MHz, 5.508 MHz ⁽³⁾ b) 6.804 MHz, 6.710 MHz, 6.615 MHz, 6.521 MHz, 6.426 MHz c) 7.777 MHz, 7.669 MHz, 7.561 MHz, 7.453 MHz, 7.345 MHz	a) 1.08 MHz b) 2.7 MHz c) 4.5 MHz d) 9 MHz e) 13.5 MHz f) 18 MHz	a) 4.5 MHz (15 kHz SCS) b) 9.36 MHz (15 kHz SCS) 8.64 MHz (30 kHz SCS) c) 14.22 MHz (15 kHz SCS) 13.68 MHz (30 kHz SCS) d) 19.08 MHz (15 kHz SCS) 18.36 MHz (30 kHz SCS) e) 23.94 MHz (15 kHz SCS) 23.4 MHz (30 kHz SCS) f) 28.8 MHz (15 kHz SCS) 28.08 MHz (30 kHz SCS) g) 33.84 MHz (15 kHz SCS) 33.12 MHz (30 kHz SCS) h) 38.88 MHz (15 kHz SCS) 38.16 MHz (30 kHz SCS)
3	Number of segments	1	Configurable		

TABLE 1B (continued)

	Parameters	System R	System S	System L	System N
4	Number of subcarriers per segment	215 (100 kHz) 439 (200 kHz) 553 (250 kHz)	(8k mode) ⁽³⁾ 6 913 6 817 6 721 6 625 6 529 (16k mode) 13 825 13 633 13 441 13 249 13 057 (32k mode) ⁽⁴⁾ 27 649 27 265 26 881 26 497 26 113	a) 2 916 (0.37 kHz) 864 (1.25 kHz) 432 (2.5 kHz) 144 (7.5 kHz) 72 (15 kHz) b) 7 290 (0.37 kHz) 2 160 (1.25 kHz) 1 080 (2.5 kHz) 360 (7.5 kHz) 180 (15 kHz) c) 12 150 (0.37 kHz) 3 600 (1.25 kHz) 1 800 (2.5 kHz) 600 (7.5 kHz) 300 (15 kHz) d) 24 300 (0.37 kHz) 7 200 (1.25 kHz) 3 600 (2.5 kHz) 1 200 (7.5 kHz) 600 (15 kHz) e) 36 450 (0.37 kHz) 10 800 (1.25 kHz) 5 400 (2.5 kHz) 1 800 (7.5 kHz) 900 (15 kHz) f) 48 600 (0.37 kHz) 14 400 (1.25 kHz) 7 200 (2.5 kHz) 2 400 (7.5 kHz) 1 200 (15 kHz)	a) 300 (15 kHz SCS) b) 624 (15 kHz SCS) 288 (30 kHz SCS) c) 948 (15 kHz SCS) 456 (30 kHz SCS) d) 1 272 (15 kHz SCS) 612 (30 kHz SCS) e) 1 596 (15 kHz SCS) 780 (30 kHz SCS) f) 1 920 (15 kHz SCS) 936 (30 kHz SCS) g) 2 256 (15 kHz SCS) 1 104 (30 kHz SCS) h) 2 592 (15 kHz SCS) 1 272 (30 kHz SCS)

TABLE 1B (continued)

	Parameters	System R	System S	System L	System N
5	Subcarrier spacing	4 000/9 Hz	a) 843.75 Hz (8k) 421.875 Hz (16k) 210.9375 Hz (32k) b) 984.375 Hz (8k) 492.1875 Hz (16k) 246.09375 Hz (32k) c) 1 125 Hz (8k) 562.5 Hz (16k) 281.25 Hz (32k)	1) $1/2.7 \approx 0.37$ kHz 2) 1.25 kHz 3) 2.5 kHz 4) 7.5 kHz 5) 15 kHz	1) 15 kHz 2) 30 kHz
6	Active symbol duration	2.25 ms	a) 1 185.185 μ s (8k) 2 370.370 μ s (16k) 4 740.740 μ s (32k) b) 1 015.873 μ s (8k) 2 031.746 μ s (16k) 4 063.492 μ s (32k) c) 888.889 μ s (8k) 1 777.778 μ s (16k) 3 555.556 μ s (32k)	1) 66.6 μ s 2) 133.3 μ s 3) 400 μ s 4) 800 μ s 5) 2 700 μ s	1) 66.6 μ s (15 kHz SCS) 2) 33.3 μ s (30 kHz SCS)
7	Guard interval duration or guard interval ratio	1/8 of active symbol duration	192, 384, 512, 768, 1 024, 1 536, 2 048, 2 432, 3 072, 3 648, 4 096, 4 864 sample duration ⁽⁵⁾	1) 16.6 μ s 2) 33.3 μ s 3) 100 μ s 4) 200 μ s 5) 300 μ s	1) 4.7 μ s (15 kHz SCS) 2) 2.35 μ s (30 kHz SCS)