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Report ITU-R BT.2295-4

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Digital terrestrial broadcasting systems

BT Series

Broadcasting service (television)

Foreword

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***Note**: This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.*

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REPORT ITU-R BT.2295-4

Digital terrestrial broadcasting systems

(2013-2015-2017-2020-2022)

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1 Introduction

This Report reviews the general characteristics of the systems for digital terrestrial sound, multimedia and TV broadcasting for fixed, portable and mobile reception. The Report deals with the systems included into ITU-R Recommendations and Reports.

There is an increasing worldwide demand for suitable means of broadcasting high-quality sound, multimedia and TV programmes to vehicular, portable and fixed receivers.

Digital terrestrial broadcasting offers the potential for new and improved services to consumers. Digital terrestrial broadcasting has such advantages as high reliability of service for practically unlimited number of users, free-to-air access, possibility of fixed and mobile reception, etc.

Digital terrestrial broadcasting systems have been implemented in many countries or they are planned to be introduced. It may be necessary for digital terrestrial broadcasting services to coexist with analogue transmissions for a temporary period.

ITU-R Study Group 6 has developed and adopted a set of Recommendations comprising description of various digital terrestrial broadcasting systems – sound, multimedia, TV – that may be used in different frequency bands. These Recommendations are aimed to supply the Administrations with the guidance for the choice of national and regional broadcasting systems providing technical and service requirements to various possible systems.

Recommendation ITU-R BS.1514 describes systems for digital terrestrial sound broadcasting in frequency bands below 30 MHz. Recommendation ITU-R BS.1114 describes systems for digital terrestrial sound broadcasting in frequency range 30-3 000 MHz (VHF and UHF bands). Recommendations ITU-R BT.1833 and ITU-R BT.2016 describe the systems for digital terrestrial multimedia broadcasting in VHF/UHF frequency bands. Recommendations ITU-R BT.1306 and ITU-R BT.1877 describe first and second generation systems for digital terrestrial TV broadcasting.

Recommendations ITU-R BS.1615 and ITU-R BS.1660 provide the technical basis for planning of terrestrial sound broadcasting at frequencies below 30 MHz and in VHF band respectively. Planning criteria for digital terrestrial multimedia broadcasting are given in Recommendation ITU-R BT.2052. Recommendation ITU-R BT.1368 defines planning criteria for various methods of providing digital terrestrial television services in the VHF/UHF bands. Planning criteria for second generation digital television broadcasting systems are given in Recommendation ITU-R BT.2033. Recommendation ITU-R BT.2036 establishes characteristics of a reference television receiving system used as a basis for frequency planning.

The interoperability between digital TV, multimedia and sound broadcasting systems may be desired.

The division of broadcasting systems into sound, multimedia and TV becomes more and more relative in present-day conditions. For example, even digital narrowband sound broadcasting systems are able to transmit video information in frequency bands below 30 MHz. Additionally, digital TV broadcasting systems are used for sound programmes also. Some digital broadcasting systems (for example, ISDB-T, DVB-T2, ATSC 3.0) may be used for TV, multimedia and sound broadcasting, depending on different operating modes.

Availability of receivers in the market, that are capable of receiving all or multiple digital radio systems that are used currently or will be offered in the future, would meet the interests of users at best, in particular for reception during travelling. Availability of such receivers will allow intersystem interoperability of information services in disaster and emergency situations, navigation, safety, etc. This issue is under study of ITU-R Study Group 6 according to ITU-R Question 136-2/6 – Worldwide broadcasting roaming. Recommendation ITU-R BT.2072 provides the requirements for main functionality of consumer receivers for worldwide broadcasting roaming.

Service requirements for digital terrestrial sound broadcasting systems in frequency bands below 30 MHz are outlined in Recommendation ITU-R BS.1348. Service requirements for digital terrestrial sound broadcasting systems in VHF/UHF frequency bands are outlined in Recommendation ITU-R BS.774. Requirements for enhanced multimedia services for digital terrestrial broadcasting in VHF bands are outlined in Recommendation ITU-R BS.1892.

Report ITU-R BS/BT.2384 considers aspects of practice implementation of digital terrestrial sound and multimedia broadcasting.

Digital terrestrial TV broadcasting should fit into existing 6, 7, 8 MHz channels intended for analogue television transmission.

Report ITU-R BT.2382 describes the interference into a digital terrestrial television receiver in general and specifically for such systems as ATSC, DVB-T, DVB-T2.

Report ITU-R BT.2383 analyses characteristics of digital terrestrial television broadcasting systems in frequency bands 470-862 MHz for frequency sharing/interference.

Report ITU-R BT.2389 provides guidelines on measurements for digital terrestrial broadcasting systems.

Report ITU-R BT.2386 discusses various aspects of design and implementation of single frequency networks (SFN) for TV and sound broadcasting.

Report ITU-R BT.2343 describes UHDTV field trials using digital terrestrial television networks.

Modern digital terrestrial broadcasting receivers implement interactivity, broadband access, content delivery from Internet, record of content for further presentation, playback of local content (so-called smart receivers). Modern digital terrestrial broadcasting receivers have programmable functions and allow for software update.

The choice of broadcasting system should depend on specific conditions such as spectrum availability, regulation policy, coverage requirements, structure of existing network, reception conditions, types of required services and cost for customers and broadcasters.

This Report reviews the following systems:

– ATSC, ATSC Mobile DTV, ATSC 3.0 (Recommendations ITU-R BT.1306, ITU-R BT.1368, ITU-R BT.1833, ITU-R BT.2036, ITU-R BT.1877, Reports ITU-R BT.2049, ITU-R BT.2382, ITU-R BT.2383, ITU-R BT.2389);

– DAB (Recommendations ITU-R BS.1114, ITU-R BS.1660, Reports ITU-R BS.1203, ITU-R BT/BS.2384);

– DRM (Recommendations ITU-R BS.1114, ITU-R BS.1514, ITU-R BS.1615, ITU-R BS.1660, ITU-R BS.1661, Reports ITU-R BS.2144, ITU-R BS.2208, ITU-R BS.2214, ITU-R BS.2251, ITU-R BT/BS.2384);

– DTMB, DTMB-A (Recommendations ITU-R BT.1306, ITU-R BT.1368, ITU-R BT.1877, Reports ITU-R BT.2383, ITU-R BT.2386, ITU-R BT.2389);

– DVB-T, DVB-H, DVB-SH (Recommendations ITU-R BT.1306, ITU-R BT.1368, ITU-R BT.1833, ITU-R BT.2016, ITU-R BT.2036, Reports ITU-R BT.2049, ITU-R BT.2382, ITU-R BT.2383, ITU-R BT.2386, ITU-R BT.2389);

– DVB-T2 (Recommendations ITU-R BT.1833, ITU-R BT.1877, ITU-R BT.2016, ITU-R BT.2033, ITU-R BT.2036, Reports ITU-R BT.2049, ITU-R BT.2254, ITU-R BT.2343, ITU-R BT.2382, ITU-R BT.2383, ITU-R BT.2386, ITU-R BT.2389);

– IBOC (Recommendations ITU-R BS.1114, ITU-R BS.1514, ITU-R BS.1615, Reports ITU-R BS.1203, ITU-R BT/BS.2384);

– ISDB-T, ISDB-TSB, ISDB-T multimedia systems (Recommendations ITU-R BS.1114, ITU-R BT.1306, ITU-R BT.1368, ITU-R BS.1660, ITU-R BT.1833, ITU-R BT.2016, ITU-R BT.2052, ITU-R BT.2036, Report ITU-R BT.2049, ITU-R BT.2209, ITU-R BT.2294, ITU-R BT.2343, ITU-R BT.2383, ITU-R BT/BS.2384, ITU-R BT.2389);

– RAVIS (Recommendation ITU-R BS.1114, Reports ITU-R BS.2214, ITU-R BT.2049, ITU-R BS/BT.2384);

– T-DMB, AT-DMB (Recommendations ITU-R BT.1833, ITU-R BT.2016, ITU-R BT.2052, Report ITU-R BT.2049).

– CDR (Recommendation ITU-R BS.1114, Report ITU-R BS.2214);

– System L[1] (Recommendation ITU-R BT.2016, Report ITU-R BT.2049);

– System N (Recommendation ITU-R BT.2016, Report ITU-R BT.2049).

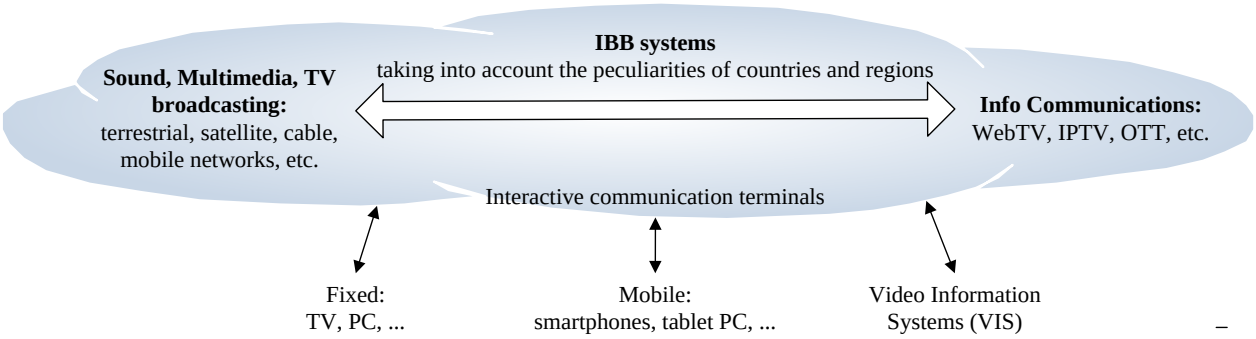
Mobile telecommunication systems with advanced information technologies are under implementation in many countries. In many cases there is a need for interoperability between the mobile telecommunication services and interactive digital broadcasting services.

There are telecommunication systems not explicitly dedicated to broadcasting services, such as Multimedia Broadcast/Multicast Services (MBMS), as shown in Attachment 1, that fulfil the requirements for interoperability between mobile telecommunication services and interactive digital broadcasting services (Report ITU-R BT.2049).

Study Group 6 is carrying out the study of Integrated Broadcast-Broadband (IBB) systems: Report ITU-R BT.2267, Recommendations ITU-R BT.2037, ITU-R BT.2053, ITU-R BT.2075. Such systems integrates both traditional broadcasting (terrestrial, satellite, cable) and broadcasting in mobile networks as well as other types of broadcasting taking into account the peculiarities of countries and regions (see Fig. 1).

FIGURE 1

The media and the means for transmission and reception of information and interactive services of sound, multimedia and television broadcasting



Digital terrestrial broadcasting systems may be efficiently used for public warning, disaster mitigation and relief. These issues and the examples of practical usage of broadcasting for these purposes are considered in the Report ITU-R BT.2299.

[1] This system was developed by 3GPP including the proposal "5G, Release 15 and beyond − LTE+NR SRIT" which is included as Annex 1 of Recommendation ITU-R M.2150-1 − Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2020 (IMT-2020), and has been standardised by ETSI as TS 103 720 − 5G Broadcast System for linear TV and radio services; LTE-based 5G terrestrial broadcast system.

The advances in sound system development reflected in the Reports ITU-R BS.2159 and ITU-R BS.2266 have been led to the principal possibility of the immersive sound usage not only in specially equipped placements but in domestic and even mobile environment by transmission of object-oriented audio content with the aid of digital terrestrial broadcasting systems.

A new Handbook on Digital Terrestrial Television Broadcasting Networks and Systems Implementation was developed by Study Group 6 in 2016.

The aim of the Handbook is to provide assistance in technical and service issues such as networks and systems, audiovisual quality and quality of transmission as well as on other issues of interest for the introduction of digital terrestrial TV broadcasting (from multimedia systems to UHDTV) in different countries. The Handbook takes into account progress and convergence of technologies, different environments for production, primary and secondary distribution of broadcast programs as well as experiences in providing quality of service for Digital Terrestrial Television Broadcasting (DTTB).

In more detail, the Handbook considers:

1) Technical aspects on the introduction of digital terrestrial and multimedia broadcasting.

2) Information on standardized broadcasting systems in digital terrestrial and multimedia broadcasting networks, and some guidance on their implementation.

3) References to normative documents (standards, technical specifications, reports, recommendations and other documents) that are important with respect to baseband (audio, video data) and transmission quality, as well as to DTTB services including interactive TV and access services.

4) The use of DTTB systems in electronic news gathering and contribution of audio-visual content.

The Handbook includes all the digital terrestrial television and multimedia broadcasting systems.

2 General characteristics of digital terrestrial broadcasting systems

Key characteristics of digital terrestrial broadcasting systems are represented in Table 1.

Table 1 can be used for the evaluation of the respective characteristics of the systems and selecting a specific system.

TABLE 1A

Key characteristics of digital terrestrial broadcasting systems

Characteristics	ATSC	ATSC 3.0	CDR	DAB	DRM	DTMB	DTMB-A	DVB-T, DVB-H, DVB-SH
Reception modes: – Fixed – Portable – Portable handheld – Mobile	 + + + +	 + + + +	 + + + +	 + + + +	 + + + +	 + + + +	 + + + +	 + + + +
Net data rates	Depending on modulation code rate: a) 4.23-19.39 Mbit/s b) 4.72-21.62 Mbit/s c) 5.99-27.48 Mbit/s	Depending on modulation and code rate a) 0.93-57.9 Mbit/s b) 1.08-67.5 Mbit/s c) 1.24-77.2 Mbit/s	Depending on modulation, code rate, robustness mode, channel bandwidth: 36 to 712.8 kbit/s	0.576 to 1.728 Mbit/s	Depending on modulation, code rate, robustness mode, channel bandwidth: 1) Modes A, B, C, D – 5-72 kbit/s 2) Mode E – 37-186 kbit/s	Depending on modulation, code and frame header: a) 3.610-24.436 Mbit/s b) 4.211-28.426 Mbit/s c) 4.813-32.486 Mbit/s	Depending on modulation, code and frame header: a) 3.75-38 Mbit/s b) 4.38-44.4 Mbit/s c) 5.0-50.73 Mbit/s	a) 0.42 to 3.447 Mbit/s [3] b) 1.332 to 10.772 Mbit/s [3]; 2.33 to 14.89 Mbit/s [4] c) 1.60 to 12.95 Mbit/s [3]; 2.80 to 23.5 Mbit/s [4] d) 1.868 to 15.103 Mbit/s [3]; 3.27 to 27.71 Mbit/s [4] e) 2.135 to 17.257 Mbit/s [3]; 3.74 to 31.67 Mbit/s [4]
Spectrum efficiency (bit/s/Hz)	0.55-1.48	0.26-10.36	0.37-3.62	0.38-1.1	1) Modes A, B, C, D – 1.1-3.73 kbit/s 2) Mode E – 0.39-1.9 kbit/s	0.64-4.30	0.66-6.52	0.28-2.44 [3] 0.46-1.86 [4]
Single frequency networks		Supported	Supported	Supported	Supported	Supported	Supported	Supported

TABLE 1A (*continued*)

Characteristics	ATSC	ATSC 3.0	CDR	DAB	DRM	DTMB	DTMB-A	DVB-T, DVB-H, DVB-SH
Broadcasting types: – sound – multimedia – TV	 + +	 + + +	 + +	 +	 +	 + +	 + +	 + +
Transmission data/service types	Video, audio, data	Video, audio, data	Video, audio, data	Audio, data	Audio, data	Video, audio, data	Video, audio, data	Video, audio, data
Frequency bands	VHF, UHF	VHF, UHF	VHF	VHF, UHF	LF, MF, HF (Modes A, B, C, D), VHF (Mode E)	VHF, UHF	VHF, UHF	VHF, UHF
Channel bandwidth	a) 6 MHz b) 7 MHz c) 8 MHz	Signalled in 'bootstrap': a) bsr_coefficient=2 for 6 MHz b) bsr_coefficient=5 for 7 MHz c) bsr_coefficent=8 for 8 MHz When channel bonding is used, the channel bandwidth is doubled (e.g., 12, 14, 16 MHz).	a) 100 kHz b) 200 kHz	1.712 MHz	4.5, 5, 9, 10, 18, 20 kHz (Modes A, B, C, D); 100 kHz (Mode E)	a) 6 MHz b) 7 MHz c) 8 MHz	a) 6 MHz b) 7 MHz c) 8 MHz	a) 1.7 MHz [3] b) 5 MHz c) 6 MHz d) 7 MHz e) 8 MHz
Used bandwidth	At –3 dB: a) 5.38 MHz b) 6.00 MHz c) 7.00 MHz	a) 5.508 ~ 5.832 MHz b) 6.426 ~ 6.804 MHz c) 7.345 ~ 7.777 MHz	a) 96.42 kHz 97.22 kHz 96.42 kHz b) 196.8 kHz 196.03 kHz; 196.8 kHz	1.536 MHz	4.4, 4.8, 8.7, 9.8, 17.3, 19.4 kHz (Modes A, B, C, D); 96 kHz (Mode E)	a) 5.67 MHz b) 6.62 MHz c) 7.56 MHz	a) 5.67 MHz b) 6.62 MHz c) 7.56 MHz	a) 1.52 MHz [3] b) 4.75 MHz c) 5.71 MHz d) 6.66 MHz e) 7.61 MHz TDM [3]: a) 1.368 MHz b) 4.27 MHz c) 5.13 MHz d) 5.18 MHz e) 6.838 MHz

TABLE 1A (*continued*)

Characteristics	ATSC	ATSC 3.0	CDR	DAB	DRM	DTMB	DTMB-A	DVB-T, DVB-H, DVB-SH
Number of segments	1	Configurable	1	1	1	1	1	Configurable number of time slices per bandwidth [3]
Number of subcarriers per segment	1	6 529-6 913 (8k mode) 13 057-13 825 (16k mode) 26 113-27 649 (32k mode)	a) 242 122 242 b) 494 246 494	192 384 768 1 536	Mode A: 101 (4.5 kHz), 113 (5 kHz), 205 (9 kHz), 229 (10 kHz), 413 (18 kHz), 461 (20 kHz) Mode B: 91 (4.5 kHz), 103 (5 kHz), 183 (9 kHz), 207 (10 kHz), 367 (18 kHz), 411 (20 kHz) Mode C: 139 (10 kHz), 281 (20 kHz) Mode D: 89 (10 kHz), 179 (20 kHz) Mode E: 213	1 (single-carrier mode) 3 780 (multi-carrier mode)	4 096 (4k mode) 8 192 (8k mode) 32 678 (32k mode)	853 (1k mode) 3 1 705 (2k mode) 3 409 (4k mode) 6 817 (8k mode)

TABLE 1A (*continued*)

Characteristics	ATSC	ATSC 3.0	CDR	DAB	DRM	DTMB	DTMB-A	DVB-T, DVB-H, DVB-SH
Subcarrier spacing	–	a) 843.75 Hz (8k mode) 421.875 Hz (16k mode) 210.9375 Hz (32k mode) b) 984.375 Hz (8k mode) 492.1875 Hz (16k mode) 246.0938 Hz (32k mode) c) 1125 Hz (8k mode) 562.5 Hz (16k mode) 281.25 Hz (32k mode)	398.4375 Hz 796.8750 Hz 398.4375 Hz	a) 8 kHz b) 4 kHz c) 2 kHz d) 1 kHz	750/18 Hz (Mode A), 750/16 Hz (Mode B), 750/11 Hz (Mode C), 750/7 Hz (Mode D), 4000/9 Hz (Mode E)	Multi-carrier mode: a) 1.5 kHz b) 1.75 kHz c) 2.0 kHz	a) 6 MHz bandwidth 4k mode – 1 384 Hz, α = 0.05 [8] 1 424 Hz, α = 0.025 8k mode – 692 Hz, α = 0.05, 712 Hz, α = 0.025 32k mode – 173 Hz, α = 0.05, 178 Hz, α = 0.025 b) 7 MHz bandwidth 4k mode – 1 615 Hz, α = 0.05, 1 662 Hz, α = 0.025 8k mode – 807 Hz, α = 0.05, 831 Hz, α = 0.025 32k mode – 202 Hz, α = 0.05, 208 Hz, α = 0.025 c) 8MHz bandwidth 4k mode – 1 846 Hz, α = 0.05, 1 899 Hz, α = 0.025 8k mode – 923 Hz, α = 0.05, 949 Hz, α = 0.025 32k mode – 231 Hz, α = 0.05, 237 Hz, α = 0.025	a) 1 786 kHz (1k) [3] b) 5 580.322 Hz (1k) [3], 2 790.179 Hz (2k), 1 395.089 Hz (4k), 697.545 Hz (8k) c) 6 696.42 Hz (1k) [3], 3 348.21 Hz (2k), 1 674.11 Hz (4k), 837.05 Hz (8k) d) 7 812 Hz (1k) [3], 3 906 Hz (2k), 1 953 Hz (4k), 976 Hz (8k) e) 8 929 Hz (1k) 3, 4 464 Hz (2k), 2 232 Hz (4k), 1 116 Hz (8k)

TABLE 1A (*continued*)

Characteristics	ATSC	ATSC 3.0	CDR	DAB	DRM	DTMB	DTMB-A	DVB-T, DVB-H, DVB-SH
Active symbol duration	a) 92.9 ns b) 83.3 ns c) 71.4 ns	a) 1 185.185 µs (8k mode) 2 370.370 µs (16k mode) 4 740.741 µs (32k mode) b) 1015.873 µs (8k mode) 2 031.746 µs (16k mode) 4 063.492 µs (32k mode) c) 888.8889 µs (8k mode) 1 777.778 µs (16k mode) 3 555.556 µs (32k mode)	2.804 ms 1.426 ms 2.5786 ms	a) 156 µs b) 312 µs c) 623 µs d) 1 246 µs	24 ms (Mode A), 21.33 ms (Mode B), 14.66 ms (Mode C), 9.33 ms (Mode D), 2.25 ms (Mode E)	a) 0.176 µs (single-carrier mode) 666.67 µs (multi-carrier mode) b) 0.151 µs (single-carrier mode) 571.43 µs (multi-carrier mode) c) 0.132 µs (single-carrier mode) 500 µs (multi-carrier mode)	a) 6 MHz bandwidth 4k mode - 722.4 µs, α = 0.05 [8] 702.17 µs, α = 0.025 8k mode - 1 444.8 µs, α = 0.05, 1 404.34 µs, α = 0.025 32k mode - 5 779.19 µs, α = 0.05, 5 617.37 µs, α = 0.025 b) 7 MHz bandwidth 4k mode - 619.2 µs, α = 0.05, 601.86 µs, α = 0.025 8k mode - 1 238.4 µs, α = 0.05, 1 203.72 µs, α = 0.025 32k mode - 4 953.6 µs, α = 0.05, 4 814.89 µs, α = 0.025 c) 8MHz bandwidth 4k mode - 541.8 µs, α = 0.05, 526.63 µs, α = 0.025 8k mode - 1 083.6 µs, α = 0.05, 1 053.26 µs, α = 0.025 32k mode - 4 334.4 µs, α = 0.05, 4 213.03 µs, α = 0.025	a) 560 µs (1k) [3] b) 179.2 µs (1k) [3], 358.40 µs (2k), 716.80 µs (4k), 1 433.60 µs (8k) c) 149.33 µs (1k) [3], 298.67 µs (2k), 597.33 µs (4k), 1 194.67 µs (8k) d) 2 128 µs (1k) [3], 256 µs (2k), 512 µs (4k), 1 024 µs (8k) e) 112 µs (1k) 3, 224 µs (2k), 448 µs (4k), 896 µs (8k)

TABLE 1A (*continued*)

Characteristics	ATSC	ATSC 3.0	CDR	DAB	DRM	DTMB	DTMB-A	DVB-T, DVB-H, DVB-SH
Guard interval duration/ratio	–	a) 27.778, 55.556, 74.074, 111.111, 148.148, 222.222, 296.296, 351.852, 444.444, 527.778, 592.593, 703.704 µs b) 23.810, 47.619, 63.492, 95.238, 126.984, 190.476, 253.968, 301.587, 380.952, 452.381, 507.937, 603.175 µs c) 20.833, 41.667, 55.556, 83.333, 111.111, 166.667, 222.222, 263.889, 333.333, 395.833, 444.444, 527.778 µs	0.2941 ms 0.1716 ms 0.0686 ms	a) 31µs b) 62 µs c) 123 µs d) 246 µs	1/9 (Mode A), 1/4 (Mode B), 4/11 (Mode C), 11/14 (Mode D), 1/9 (Mode E)	Frame header 1/9, 1/6, 1/4 of frame body: a) 74.07, 104.94, 166.67 µs b) 63.49, 89.95, 142.86 µs c) 55.56, 78.70, 125.00 µs	1/2, 1/4, 1/8, 1/16, 1/32, 1/64	1/32, 1/16, 1/8, 1/4
Frame duration	a) 48.4 ms b) 43.4 ms a) 37.2 ms	50 ms-5s	640 ms	96 ms 48 ms 24 ms	Mode A: 400 ms (15 OFDM symbols) Mode B: 400 ms (15 OFDM symbols) Mode C: 400 ms (20 OFDM symbols) Mode D: 400 ms (24 OFDM symbols) Mode E: 100 ms (40 OFDM symbols)	a) 740.74, 771.60, 833.33 µs b) 634.92, 661.38, 714.29 µs c) 555.56, 578.70, 625.00 µs	a) 6 MHz bandwidth 4k mode – 813, 903, 1 084 µs, $\alpha = 0.05$ [8] 790, 878, 1 053 µs, $\alpha = 0.025$ 8k mode – 1 535, 1 625, 1 806 µs, $\alpha = 0.05$, 1 492, 1 580, 1 755 µs, $\alpha = 0.025$ 32k mode – 5 869, 5 960, 6 140 µs, $\alpha = 0.05$, 5 705, 5 793, 5 968 µs, $\alpha = 0.025$	68 OFDM symbols. One super-frame consists of 4 frames TDM [3]: 476 physical layer slots, each of them comprising 2 176 symbols

TABLE 1A (*continued*)

Characteristics	ATSC	ATSC 3.0	CDR	DAB	DRM	DTMB	DTMB-A	DVB-T, DVB-H, DVB-SH
							b) 7 MHz bandwidth 4k mode – 679, 774, 929 µs, α = 0.05, 677, 752, 903 µs, α = 0.025 8k mode – 1 316, 1 393, 1 548 µs, α = 0.05, 1 279, 1 354, 1 505 µs, α = 0.025 32k mode – 5 031, 5 108, 5 263 µs, α = 0.05, 4 890, 4 965, 5 116 µs, α = 0.025 c) 8MHz bandwidth 4k mode – 610, 677, 813 µs, α = 0.05, 592, 658, 790 µs, α = 0.025 8k mode – 1 151, 1 219, 1 354 µs, α = 0.05, 1 119, 1 185, 1 317 µs, α = 0.025 32k mode – 4 402, 4 470, 4 605 µs, α = 0.05, 4 279, 4 345, 4 467 µs, α = 0.025	
Time/frequency synchronization	Segment sync, pilot carrier; Frame sync	Bootstrap, preamble symbol, scattered pilot, continual pilots, and edge pilots	Guard interval/ Pilot carriers	Null symbol and centre frequency and phase reference symbol	Guard interval/ Pilot carriers	PN sequence as the frame header of signal frame	Super-frame synchronization channel and dual PN-MC symbols of each signal frame	Guard interval/Pilot carriers TDM [3]: Pilot symbols

TABLE 1A (*continued*)

Characteristics	ATSC	ATSC 3.0	CDR	DAB	DRM	DTMB	DTMB-A	DVB-T, DVB-H, DVB-SH
Modulation methods	8-VSB	QPSK, 16-NUC, 64-NUC, 256-NUC, 1024-NUC, 4096-NUC (Non-Uniform constellation)	QPSK, 16-QAM, 64-QAM	4-DQPSK	16-QAM, 64-QAM (Modes A, B, C, D) 4-QAM, 16-QAM (Mode E)	4-QAM-NR, 4-QAM, 16-QAM, 32-QAM, 64-QAM	QPSK, 16-APSK, 64-APSK, 256-APSK	QPSK, 16-QAM, 64-QAM [4], MR-16-QAM [4], MR-64-QAM [4] TDM [3]: QPSK, 8-PSK, 16-APSK
Inner FEC	2/3 trellis, concatenated 1/2 or 1/4 trellis	LDPC code with code rates 2/15, 3/15, 4/15, 5/15, 6/15, 7/15, 8/15, 9/15, 10/15, 11/15, 12/15, 13/15	LDPC code with code rates 1/4,1/3, 1/2,3/4	Convolution code (1/4 to 3/4)	Multilevel punctured convolutional code with mother code rate 1/6 and constraint length 7 (0.25, 0.33, 0.4, 0.41, 0.45, 0.48, 0.5, 0.55, 0.57, 0.58, 0.6, 0.62, 0.67, 0.71, 0.72, 0.78)	LDPC code 0.4 (7 488, 3 008), 0.6 (7 488, 4 512), 0.8 (7 488, 6 016)	LDPC code with block size of 61 440 or 15 360 bits and code rates of 1/2, 2/3, 5/6	a) Convolution code, mother rate 1/2 with 64 states. Puncturing to rate 2/3, 3/4, 5/6, 7/8 4 b) 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 3

TABLE 1A (*end*)

Characteristics	ATSC	ATSC 3.0	CDR	DAB	DRM	DTMB	DTMB-A	DVB-T, DVB-H, DVB-SH
Inner interleaving	Independently encoded streams interleaved in time: a) 12 b) 24 c) 28	Time (convolutional and hybrid), cell interleaving and frequency interleaving	Time interleaving and frequency interleaving	Time interleaving and frequency interleaving	Bit interleaving, cell interleaving	In frequency domain inside one signal frame (multi-carrier mode)	Bit interleaving, bit permutation and time interleaving separately for each service channel	a) Bit interleaving, combined with native or in-depth symbol interleaving [4] b) Frequency interleaving; Time interleaving (Forney with 48 branches QPSK: 320/9 600 ms 16-QAM: 160/4 800 ms) [3]
Outer FEC	RS (207,187, T = 10), concatenated RS (184,164, T = 10)	None, CRC (32-bit), or BCH. BCH (16 200, x, t) or BCH(64800, x, t), there x – depends on LDPC code rate. Error correction capability up to t = 12 errors	–	–	–	BCH (762, 752) derived from BCH (1 023, 1 013)	BCH (30 720, 30 512) for LDPC 1/2 BCH (40 960, 40 752) for LDPC 2/3 BCH (51 200, 50 992) for LDPC 5/6	Outer Code: RS (204, 188, T = 8) [4] IP outer channel code: MPE-FEC RS (255, 191) [3]
Outer interleaving	52 segment convolutional byte interleaved, concatenated 46 segment byte interleaved	Bit (parity, group-wise, block) interleaving	–	–	–	Convolutional interleaving in time domain, number of interleaving branches B = 52, interleaving depth M = 240, 720	Symbol interleaving 240 rows and 4 096 columns	Byte-wise convolutional interleaving, I = 12 [3]
Data randomization/ energy dispersal	16 bit PRBS	16 bit PRBS	12 bit PRBS	16 bit PRBS	16 bit PRBS	PRBS	PRBS	16 bit PRBS
Hierarchical transmission	–	–	–	–	+	–	–	+
Transmission parameter signalling	Mode symbols in frame sync	Bootstrap, Preamble symbol, L1 signalling	Carried by 108 SI symbols placed on the continuous pilots	Phase reference symbol	Control cells	Carried by 36 system information symbol per signal frame	Service channel signalling is carried by control channel in the super frame	TPS pilot carriers

TABLE 1B

Key characteristics of digital terrestrial broadcasting systems

Characteristics	DVB-T2	IBOC	ISDB-T family	RAVIS	T-DMB, AT-DMB	System L	System N
Reception modes: – Fixed – Portable – Portable handheld – Mobile	 + + + +	 + + + +	 + + + +	 + + + +	 + + + +	 + + + +	 + + + +
Net data rates	7.5- 50.5 Mbit/s	Depending on band, modulation, code rate: a) (MF) 20.4 to 40.4 kbit/s b) (VHF Hybrid) 51 to 149 kbit/s c) (VHF all Digital) 51 to 280 kbit/s	n × a) 0.281 to 1.787 Mbit/s b) 0.328 to 2.085 Mbit/s c) 0.374 to 2.383 Mbit/s	Depending on modulation and code rate for different channel bandwidth: a) 100 kHz-75-341 kbit/s b) 200 kHz-155-703 kbit/s c) 250 kHz-196-888 kbit/s	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	Typical bit rates of 4.3 Mbit/s (QPSK, code rate 0.37) to 24.8 Mbit/s (64-QAM, code rate 0.71) with a 200 µs Cyclic Prefix in a 10 MHz channel bandwidth. The provided values are net date rates relating to PMCH capacity and take into account overheads due to signalling/synchronisation and Guard Interval (Cyclic Prefix).	Depending on modulation and code rate for different channel bandwidth, data rates for each modulation order: a) 1.8 to 13.9 Mbit/s (QPSK in 10 MHz channel bandwidth) b) 3.5 to 27.8 Mbit/s (16 QAM in 10MHz channel bandwidth) c) 5.3 to 41.7 Mbit/s (64 QAM in 10MHz channel bandwidth) d) 7 to 55.7 Mbit/s (256 QAM in 10MHz channel bandwidth)

TABLE 1B (*continued*)

Characteristics	DVB-T2	IBOC	ISDB-T family	RAVIS	T-DMB, AT-DMB	System L	System N
Spectrum efficiency (bit/s/Hz)	0.98-6.50	a) (MF) 1.27 – 4.1 b) (VHF Hybrid) 0.15 – 1.76 c) (VHF all Digital) 0.52 – 1.41	0.66-4.17	0.77-3.64	T-DMB: 0.38-1.13 AT-DMB: 0.56-1.88	Typical spectral efficiencies of 0.43 bit/s/Hz (QPSK, code rate 0.37) to 2.48 bit/s/Hz (64-QAM, code rate 0.71) with a 200 µs Cyclic Prefix The provided values are net efficiencies relating to PMCH capacity and take into account overheads due to signalling/synchronisation and Guard Interval (Cyclic Prefix).	From 0.18 bit/s/Hz (QPSK, coding rate 0.12) to 5.56 bit/s/Hz (256 QAM, coding rate 0.93)
Single frequency networks	Supported	Supported	Supported	Supported	Supported	Supported	Supported
Broadcasting types: – sound – multimedia – TV	 + +	 + +	 + + +	 + +	 + + +	 + + +	 + + +
Transmission data/service types	Video, audio, data	Audio, images/ pictures, data (traffic, news, weather, alerts, IoT control/config)	Video, audio, data	Video, audio, still pictures, presentations, traffic data, etc.	Video, audio, data	Video, audio, data	Video, audio, data
Frequency bands	VHF, UHF	MF, VHF	VHF, UHF	VHF bands I, II	VHF, UHF	UHF	UHF
Channel bandwidth	a) 1.7 MHz b) 5 MHz c) 6 MHz d) 7 MHz e) 8 MHz f) 10 MHz [5]	a) (MF) 5, 10, 20, 30 kHz b) (VHF Hybrid) 70, 100 140, 170, 200 kHz c) (VHF All digital) 400 kHz	1/14 × n of a) 6 MHz b) 7 MHz c) 8 MHz n ≥ 1 [1]	a) 100 kHz b) 200 kHz c) 250 kHz	1.712 MHz	a) 1.4 MHz b) 3 MHz c) 5 MHz d) 10 MHz e) 15 MHz f) 20 MHz (9)	a) 5 MHz b) 10 MHz c) 15 MHz d) 20 MHz e) 25 MHz f) 30 MHz g) 35 MHz h) 40 MHz

TABLE 1B (*continued*)

Characteristics	DVB-T2	IBOC	ISDB-T family	RAVIS	T-DMB, AT-DMB	System L	System N
Used bandwidth	a) 1.52 MHz b) 4.75 MHz c) 5.71 MHz d) 6.66 MHz e) 7.61 MHz f) 9.51 MHz [5, 6]	a) (MF) 4.9, 9.8, 18.9, 28.34 kHz b) (VHF Hybrid) 69.4, 97, 138.8, 166.4, 194.0 kHz c) (VHF all-Digital) 397.2 kHz	Subcarrier spacing + 1/14 × n × a) 6 MHz b) 7 MHz c) 8 MHz $n \geq 1$ [1]	a) 96.0 kHz b) 185.6 kHz c) 246.2 kHz	1.536 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) 33.12MHz (30kHz SCS) h) 38.88MHz (15kHz SCS) 38.16 MHz (30 kHz SCS)
Number of segments	Configurable	a) (MF) 1 to 6 b) (VHF Hybrid) 1 to 4 c) (VHF all Digital) 1 to 10	$n \geq 1$ [1]	1	1		

TABLE 1B (*continued*)

Characteristics	DVB-T2	IBOC	ISDB-T family	RAVIS	T-DMB, AT-DMB	System L	System N
Number of subcarriers per segment	853 (1k mode) 1 705 (2k mode) 3 409 (4k mode) 6 817 (8k mode) 13 633 (16k mode) 27 265 (32k mode) 6,7	a) (MF) 25 LP, UP 25 LS, US 25 LT, UT b) (VHF Hybrid) 191 LMP, UMP 76 LPX, UPX c) (VHF All Digital) 191 LPM, UMP 76 LPX, UPX 13 LSP, UXP 76 LSX, USX 190 LSM 191 USM	108 (Mode 1) 216 (Mode 2) 432 (Mode 3)	a) 215 b) 439 c) 553	192 384 768 1 536	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) 1272 (15 kHz SCS) 612 (30 kHz SCS) e) 1596 (15 kHz SCS) 780 (30 kHz SCS) f) 1920 (15 kHz SCS) 936 (30 kHz SCS) g) 2256 (15 kHz SCS) 1104 (30 kHz SCS) h) 2592 (15 kHz SCS) 1272 (30 kHz SCS)
Subcarrier spacing	a) 1 802 Hz (1k mode) 901 Hz (2k mode) 450 Hz (4k mode) 225 Hz	a) 181.7 Hz (MF) b) 363.4 Hz (VHF)	a) 3.968 kHz (Mode 1) [2], 1.984 kHz (Mode 2), 0.992 kHz (Mode 3)	4000/9 Hz	a) 8 kHz b) 4 kHz c) 2 kHz d) 1 kHz	a) 1/2.7 ≈ 0.37 kHz b) 1.25 kHz c) 2.5 kHz d) 7.5 kHz e) 15 kHz	1) 15 kHz 2) 30 kHz

TABLE 1B (*continued*)

Characteristics	DVB-T2	IBOC	ISDB-T family	RAVIS	T-DMB, AT-DMB	System L	System N
	(8k mode) 113 Hz (16k mode) 56 Hz (32k mode) b) 5 580 Hz (1k mode) 2 790 Hz (2k mode) 1 395 Hz (4k mode) 698 Hz (8k mode) 349 Hz (16k mode) 174 Hz (32k mode) c) 6 696 Hz (1k mode) 3 348 Hz (2k mode), 1 674 Hz (4k mode) 837 Hz (8k mode) 419 Hz (16k mode) 209 Hz (32k mode) d) 7 812 Hz (1k mode) 3 906 Hz (2k mode) 1 953 Hz (4k mode) 977 Hz (8k mode) 488 Hz (16k mode) 244 Hz (32k mode)		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)				

TABLE 1B (*continued*)

Characteristics	DVB-T2	IBOC	ISDB-T family	RAVIS	T-DMB, AT-DMB	System L	System N
	e) 8 929 Hz (1k mode) 4 464 Hz (2k mode) 2 232 Hz (4k mode) 1 116 Hz (8k mode) 558 Hz (16k mode) 279 Hz (32k mode) f) 11 161 Hz (1k mode) 5 580 Hz (2k mode) 2 790 Hz (4k mode) 1 395 Hz (8k mode) 698 Hz (16k mode) 349 Hz (32k mode) [5,7]						

TABLE 1B (*continued*)

Characteristics	DVB-T2	IBOC	ISDB-T family	RAVIS	T-DMB, AT-DMB	System L	System N
Active symbol duration	a) 554.99 µs (1k), 1 109.98 µs (2k), 2 219.97 µs (4k), 4 439.94 µs (8k) 8 879.87 µs (16k) 17 759.75 µs (32k) b) 179.2 µs (1k) 358.4 µs (2k), 716.8 µs (4k), 1 433.6 µs (8k), 2 867.2 µs (16k) 5 734.4 µs (32k) c) 149.3 µs (1k) 298.67 µs (2k), 597.33 µs (4k), 1 194.67 µs (8k), 2 389.33 µs (16k) 4 778.67 µs (32k) d) 128 µs (1k) 256 µs (2k), 512 µs (4k), 1 024 µs (8k), 2 048 µs (16k) 4 096 µs (32k) e) 112 µs (1k) 224 µs (2k), 448 µs (4k), 896 µs (8k), 1 792 µs (16k) 3 584 µs (32k) f) 89.6 µs (1k) 179.2 µs (2k) 358.4 µs (4k) 716.8 µs (8k) 1 433.6 µs (16k) 2 867.2 µs (32k) [5,7]	a) 5.504 ms (MF) b) 2.752 ms (VHF)	a) 252 µs (Mode 1) [2], 504 µs (Mode 2), 1 008 µs (Mode 3) b) 216 µs (Mode 1), 432 µs (Mode 2), 864 µs (Mode 3) c) 189 µs (Mode 1), 378 µs (Mode 2), 756 µs (Mode 3)	2.25 ms	a) 156 µs b) 312 µs c) 623 µs d) 1 246 µs	a) 66.6 µs b) 133.3 µs c) 400 µs d) 800 µs e) 2 700 µs	1) 66.6 µs (15 kHz SCS) 2) 33.3 µs (30 kHz SCS)

TABLE 1B (*continued*)

Characteristics	DVB-T2	IBOC	ISDB-T family	RAVIS	T-DMB, AT-DMB	System L	System N
Guard interval duration/ratio	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4	7/128	1/32, 1/16, 1/8, 1/4	1/8	a) 31 µs b) 62 µs c) 123 µs d) 246 µs	a) 16.6 µs b) 33.3 µs c) 100 µs d) 200 µs e) 300 µs	1) 4.7 µs (15 kHz SCS) 2) 2.35 µs (30 kHz SCS)
Frame duration	Flexible with possibility of changing on frame-by-frame basis. Max 250 ms	a) (MF) Sub-frame 185.98 ms Frame 1.486 s b) (VHF) Sub-frame 92.88 ms Frame 1.486 s	204 OFDM symbols	103.78125 ms (41 OFDM symbols)	96 ms 48 ms 24 ms	a) 3 ms b) 1 ms c) 1 ms d) 1 ms e) 1 ms	Slot-based transmission unit: 1) 1 ms (15 kHz SCS) 2) 0.5 ms (30 kHz SCS)
Time/frequency synchronization	P1 symbol/Guard interval/Pilot carriers	Guard interval/ pilot carriers, AM carrier	Pilot carriers	Guard interval/ Pilot carriers	Null symbol and centre frequency and phase reference symbol	Cell Acquisition Sub-frame (CAS) – Primary Synchronization Signal (PSS) and Secondary Synchronization Signal (SSS) / Pilot (Reference Signal) carriers	Synchronization Signal block（SSB） including Primary Synchronization Signal (PSS) and Secondary Synchronization Signal (SSS)
Modulation methods	QPSK, 16-QAM, 64-QAM, 256-QAM with or without constellation rotation specific for each physical layer pipe	a) (MF) BPSK, QPSK, 16-QAM, 64-QAM b) (VHF) BPSK, QPSK	DQPSK, QPSK, 16-QAM, 64-QAM	QPSK, 16-QAM, 64-QAM	T-DMB: DQPSK AT-DMB: DQPSK BPSK over DQPSK QPSK over DQPSK	QPSK, 16-QAM, 64-QAM, 256-QAM	QPSK, 16-QAM, 64-QAM, 256-QAM
Inner FEC	LDPC code with code rates 1/3, 2/5, 1/2, 3/5, 2/3, 3/4	Convolution code 2/9 to 5/6	Convolution code, Mother rate 1/2 with 64 states. Puncturing to rate 2/3, 3/4, 5/6, 7/8	LDPC code with approximate code rates 1/2, 2/3, 3/4	T-DMB: Convolution code (1/4 to 3/4) AT-DMB: Convolution code + Turbo code (1/4 to 1/2)	Turbo code, mother rate 1/3 with rate matching to the available capacity	Polar for control channel, and LDPC for data channel： base graph 1 with mother code 1/3 or base graph 2 with mother code 1/5, rate matching to the available capacity

TABLE 1B (*continued*)

Characteristics	DVB-T2	IBOC	ISDB-T family	RAVIS	T-DMB, AT-DMB	System L	System N
Inner interleaving	Cell, time and frequency 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)	Bit, cell, time and frequency interleaving	Time interleaving and frequency interleaving	None	None
Outer FEC	BCH (16 200, x, t), there x – depends on LDPC code rate. Error correction capability t = 12 errors	RS (96, 88, 4) RS (255, 223, 16) RS (255, 191, 32)	RS (204, 188, T = 8)	BCH (n, k, t); n, k depend on channel bandwidth, LDPC code rate; error correction capability t = 10 errors (for main service channel)	RS (204, 188, T = 8) code for video service and scalable video service	CRC	CRC
Outer interleaving	Bit (parity and column twist) interleaving	Up to 64 code words	Byte-wise convolutional interleaving, I = 12	–	Convolutional interleaving for video service and scalable video service	Code-block bit interleaving	Bit interleaving within a code block. No interleaving between Code-blocks.
Data randomization/ energy dispersal	16 bit PRBS	12 bit PRBS	PRBS	16 bit PRBS	16 bit PRBS		31bit Pseudo Random Sequence
Hierarchical transmission	–	+	+	–	–	+	-
Transmission parameter signalling	Preamble symbol P1	32 bit information sequence provided cyclically	TMCC pilot carriers	4 subcarriers per OFDM symbol, 41 bit per OFDM frame	Phase reference symbol		L1 /L 2 control signalling

TABLE 1B (*end*)

Notes to Tables 1A and 1B:

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 transmissior 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.

3 Available for DVB-SH.

4 Available for DVB-T, DVB-H.

5 The 10 MHz configuration of DVB-T2 is only intended for professional applications and is not expected to be supported by domestic receivers.

6 The values in the DVB-T2 table apply to the normal carrier mode. An extended carrier mode is available for 8k, 16k and 32k modes.

7 A limited sub-set of modes shall be used for DVB-T2 Lite. The mode limitations apply to FFT size, pilot patterns and to the allowed combinations of these parameters and guard interval. The allowed set of FFT sizes for DVB-T2 Lite is restricted to 2k, 4k, 8k and 16k.

8 For DTMB-A system α - the roll off factor.

9 Additional bandwidth values for 6, 7 and 8 MHz were under discussion in 3GPP at the time of publication of the present Report. A foreseen revision of the ETSI TS 103 720 to address these additional bandwidths into L System and consequently the present Annex may address these.

3 Summaries of digital terrestrial broadcasting systems and references to ITU-R Recommendations and Reports

3.1 Summary of ATSC system

3.1.1 Summary of ATSC 1.0/ATSC Mobile DTV

ATSC standards are a set of standards developed by the Advanced Television Systems Committee for digital television transmission over terrestrial, cable, and satellite networks.

ATSC Mobile DTV is an enhancement of the ATSC system to provide multimedia services including video, audio, and interactive data service delivery to small (power efficient) receivers, for fixed, handheld and vehicular environments. The system uses IP-based mechanism with control of time synchronized delivery via buffer modelling for an end-to-end broadcast system including enablement of a return path to facilitate delivery of any type of digital content and service.

Recommendation ITU-R BT.1306-7 (06/2015) provides transmission parameters (Table 1 Part a) and bibliography (Attachment 1 to Annex 1) for ATSC system standard (System A).

Recommendation ITU-R BT.1368-13 (06/2017) provides planning criteria for ATSC system (Annex 1). Planning criteria includes protection ratios (ATSC signal interfered with by ATSC signal, ATSC signal interfered with by analogue TV signal, analogue TV signal and TV sound signal interfered with by ATSC signal) and minimum field strengths.

Recommendation ITU-R BT.2036-1 (06/2016) establishes characteristics (Annexes 1 and 2) for a reference ATSC television receiving system to be used as a basis for frequency planning.

Recommendation ITU-R BT.1833-3 (02/2014) provides general system characteristics (Table 1) for ATSC Mobile DTV (Multimedia system B).

Report ITU-R BT.2049-7 (02/2016) gives summary of broadcasting transport mechanisms (Table 1), transmission parameters (Table 2a), technical performance overview (Table 3a), user requirements (Table 5a) and general description (Annex 7) for ATSC Mobile DTV (Multimedia system B) for mobile reception.

Report ITU-R BT.2382-1 (10/2016) provides the description of interference into a digital terrestrial television (DTT) receiver, i.e., violation of the protection ratio (PR), that can impact the received picture. Field measurement and analysis of various multipath interference scenarios (Annex 3), measurement and analysis of intermodulation in the DTT receiver (Annex 4) for ATSC receiver are given Report ITU-R BT.2383-1 (10/2016) describes the characteristics of DTTB systems in the frequency band 470-862 MHz for frequency sharing/interference analysis. Section 8 gives ATSC reference broadcasting network characteristics, §§ 11 and 12 gives reception modes and system parameters of DTTB systems, including ATSC.

Report ITU-R BT.2389-0 (02/2016) gives the guidelines on measurements for digital terrestrial television broadcasting systems, including ATSC specific (§§ 3.2, 5.2).

More information about the system and standards can be found at http://www.atsc.org/

3.1.2 Summary of ATSC 3.0 system

ATSC 3.0 is a suite of voluntary technical Standards and Recommended Practices that is fundamentally different from, and an operational replacement for, the predecessor ATSC Standard (known as ATSC 1.0), which was essentially limited to video and audio.

The ATSC 3.0 standard is intended to allow substantial improvements in performance, functionality, and efficiency sufficient to warrant implementation of a non-backwards-compatible system. With

higher capacity to deliver dramatically improved quality for video services, robust mobile reception on a wide range of devices, improved efficiency, IP transport, advanced emergency information, personalization features, and interactive capability, the ATSC 3.0 suite of standards provides much more capability than previous generations of terrestrial broadcasting in the same spectrum bandwidth. It also provides a means to integrate broadcast and broadband services and thus can be part of the 5G transmission ecosystem.

The suite including 21 approved standards and four recommended practices is summarized in Table 2.

TABLE 2

ATSC 3.0 Standards

Doc. No.	Title	Description
A/300	ATSC 3.0 System	Description of entire ATSC 3.0 suite
A/321	System Discovery and Signaling	Description of the system discovery and signaling architecture (the bootstrap)
A/322	Physical Layer Protocol	Description of the RF/Transmission of a physical layer waveform
A/323	Dedicated Return Channel	Description of a dedicated return channel (DRC) system for ATSC 3.0
A/324	Scheduler Studio/Transmitter Link	Description of the protocol on the STL and SFN
A/325	PHY Lab Performance Test Plan	Processes used to test the RF performance in a laboratory environments
A/326	ATSC 3.0 Field test plan	General methodology for conducting field tests of ATSC 3.0
A/327	Guidelines for the Physical Layer Protocol	Recommended practices for the ATSC 3.0 physical layer protocol standards
A/330	Link Layer Protocol	Description of ATSC link-layer protocol
A/331	Signaling, Synchronization, Delivery, Error Protection	Description of protocols used for IP-based delivery and synchronization
A/332	Service Announcement	Description of metadata for the Electronic Service Guide
A/333	Service Usage Reporting	Description of collection, storage, and reporting of viewer's service consumption
A/334	Audio Watermark Emission	Identification of ATSC 3.0 broadcast services for redistribution scenarios via information encoded in the audio
A/335	Video Watermark Emission	Identification of ATSC 3.0 broadcast services for redistribution scenarios via information encoded in the video
A/336	Content Recovery in Redistribution Scenarios	Process to retrieve broadcaster content when the broadcast signal is not directly received
A/337	Application Signaling	Signaling and synchronization of Applications
A/338	Companion Device	Communication between ATSC 3.0 and companion devices

TABLE 2 (*end*)

Doc. No.	Title	Description
A/339	Audio Watermark Modification and Erasure	Recommended practices for erasure and modification of audio watermark
A/341	Video – HEVC	Description of video coding based on HEVC (H.265)
A/342 Part 1	Audio Common Elements	Common framework for ATSC 3.0 Next Generation Audio
A/342 Part 2	Audio: AC-4 System	AC-4 Audio system for ATSC 3.0
A/342 Part 3	Audio: MPEG-H System	MPEG-H Audio system for ATSC 3.0
A/343	Captions and Subtitles	Closed captions and subtitle tracks for ATSC 3.0
A/344	Interactive Content	Environment for running broadcaster applications
A/360	Security and Service Protection	Security, conditional access, and digital rights management

3.2 Summary of DAB system

DAB system, also known as the Eureka 147 digital audio broadcasting (DAB) system, has been developed for both satellite and terrestrial broadcasting applications in order to allow a common low-cost receiver to be used. The system has been designed to provide vehicular, portable and fixed reception with low gain omni-directional receive antennas located at 1.5 m above ground. DAB system allows for complementary use of satellite and terrestrial broadcast transmitters resulting in better spectrum efficiency and higher service availability in all receiving situations. It especially offers improved performance in multipath and shadowing environments which are typical of urban reception conditions by the use of on-channel terrestrial repeaters to serve as gap-fillers. DAB system is capable of offering various levels of sound quality up to high quality sound comparable to that obtained from consumer digital recorded media. It can also offer various data services and different levels of conditional access and the capability of dynamically re-arranging the various services contained in the multiplex.

Recommendation ITU-R BS.1114-9 (06/2015) provides performance (Table 1) of DAB system (Digital system A), summary (Annex 1 Part 1) and description (Annex 2) of the system, including spectrum mask and RF performance characteristics in AWGN and Rayleigh channels.

Recommendation ITU-R BS.1660-7 (10/2015) gives the technical basis for planning of terrestrial digital sound broadcasting (T-DAB) in the VHF band (Annex 1), including minimum wanted field strength used for planning, spectrum masks for T-DAB out-of-band emissions, position of frequency blocks in Band III (Wiesbaden 1995 Special Arrangement), T-DAB reference network, protection ratios (T-DAB interfered with by T-DAB, T-DAB interfered with by analogue sound broadcasting, T-DAB interfered with by digital terrestrial television broadcasting, T-DAB interfered with by analogue terrestrial television broadcasting, T-DAB interfered with by services other than broadcasting), and bibliography.

Report ITU-R BS.1203-1 (1994) gives DAB system description (Annex 1-A), system experimental evaluations (1988-1993) (Annex 1-B), applicable propagation/channel characteristics and related experimental results (Annex 1-C), computer simulations of coverage concepts (Annex 1-D), computer simulations of system performance (Annex 1-E).

Report ITU-R BS.2384-0 (07/2015) gives the observation of current and planned DAB implementations (§ 3.1) and social, regulatory and technical factors involved when considering a transition to the DAB or DAB+ systems (Annex 3).

More information about the system and standards can be found at http://www.worlddab.org/

3.3 Summary of DRM system

Digital Radio Mondiale (DRM) system has been developed for terrestrial broadcasting applications in all the frequency bands allocated worldwide for analogue sound broadcasting. It respects the ITU-defined spectrum masks, allowing a smooth transition from analogue to digital broadcasting. The system is designed as a digital-only system. In the bands above 30 MHz, it defines Robustness Mode E (also known as DRM+) to offer audio quality comparable to that obtained from consumer digital recorded media. In addition, DRM system also offers various data services, including images and electronic programme guides, and the capability of dynamically rearranging the various services contained in the multiplex without loss of audio.

Recommendation ITU-R BS.1114-9 (06/2015) provides performance (Table 1) of DRM system Mode E (Digital system G), summary (Annex 1 Part 4) and description (Annex 5) of the system, including simulated system performance.

Recommendation ITU-R BS.1514-2 (03/2011) provides summary description of DRM system for operation below 30 MHz (Modes A, B, C, D) (Annex 1) and summary of DRM system performance below 30 MHz (Annex 4).

Recommendation ITU-R BS.1615-1 (05/2011) provides planning parameters DRM sound broadcasting below 30 MHz including minimum usable field strengths (Annex 1) and RF protection ratios (Annex 2).

Recommendation ITU-R BS.1660-7 (10/2015) gives the technical basis for planning of DRM terrestrial digital sound broadcasting in the VHF band (Annex 3), including minimum wanted field strength used for planning, out-of-band spectrum masks, protection ratios (DRM interfered with by DRM, DRM interfered with by analogue FM in Band II, DRM interfered with by DAB in Band III, DRM interfered with by DVB-T in Band III, analogue FM interfered with by DRM in Band II, DAB interfered with by DRM in Band III), and bibliography.

Recommendation ITU-R BS.1661 (12/2003) sets that IEC Standard 62272-1 should be used for DRM system in the bands below 30 MHz.

Report ITU-R BS.2144 (05/2009) gives planning parameters and coverage for DRM broadcasting at frequencies below 30 MHz, including DRM system aspects, required S/N ratios for DRM reception, minimum usable field-strength values for planning, RF protection ratios, simulcast aspects, examples of SFN and international regulation aspects.

Report ITU-R BS.2208 (10/2010) considers possible use of VHF Band I for digital sound broadcasting using in particular DRM system.

Report ITU-R BS.2214-2 (10/2016) gives planning parameters for DRM broadcasting in VHF bands I, II and III (§ 4), such as minimum median field-strength level, position of DRM frequencies, out-of-band spectrum mask and protection ratios (for DRM, for broadcasting systems interfered with by DRM, for other services interfered with by DRM).

Report ITU-R BS.2251-1 (10/2012) gives some aspects of using DRM broadcasting in the 26 MHz band (25 670-26 100 kHz).

Report ITU-R BS.2384-0 (07/2015) gives the observation of current and planned DRM implementations (§ 3.2) and social, regulatory and technical factors involved when considering a transition to the DRM system (Annex 1).

More information about the system and standards can be found at http://www.drm.org/

3.4 Summary of DTMB and DTMB-A systems

Digital Terrestrial Multimedia Broadcast (DTMB) and Digital Television Terrestrial Multimedia Broadcasting-Advanced (DTMB-A) are the TV standards for mobile and fixed terminals. Besides the basic functions of traditional television services, the DTMB and DTMB-A allow additional services. DTMB and DTMB-A systems are compatible with fixed reception (indoor and outdoor) and mobile digital terrestrial television. Mobile reception is compatible with standard definition digital TV broadcasting, digital audio broadcasting, multimedia broadcasting and data broadcasting service. Fixed reception in addition to the previous services also supports high definition digital TV broadcasting.

Recommendation ITU-R BT.1306-7 (06/2015) provides transmission parameters (Table 1 Parts d) and bibliography (Attachments 4 to Annex 1) for DTMB system standard (System D). Recommendation ITU-R BT.1877-2 (12/2019) provides transmission parameters (Table 3, Annex 3) and bibliography (Attachment 1 to Annex 3) for DTMB-A system.

Recommendation ITU-R BT.1368-13 (06/2017) provides planning criteria for DTMB and DTMB-A systems (Annexes 4, 5). Planning criteria includes protection ratios for DTMB and DTMB-A wanted digital terrestrial television signals, protection ratios for wanted analogue terrestrial television signals interfered with by unwanted DTMB (6, 7, 8 MHz) and DTMB-A (8 MHz) signals, minimum field strengths for DTMB and DTMB-A fixed reception, minimum median field strength for mobile DTMB and DTMB-A reception.

Report ITU-R BT.2383-1 (10/2016) describes the characteristics of DTTB systems in the frequency band 470-862 MHz for frequency sharing/interference analysis. Section 10 gives DTMB reference broadcasting network characteristics, §§ 11 and 12 gives reception modes and system parameters of DTTB systems, including DTMB.

Report ITU-R BT.2386-0 (07/2015) provides the DTTB design and implementation of single frequency networks (SFN), including DTMB case study (Part 4).

Report ITU-R BT.2389-0 (02/2016) gives the guidelines on measurements for digital terrestrial television broadcasting systems, including DTMB specific (§§ 3.5 and 5.5).

3.5 Summary of DVB-T, DVB-H, DVB-SH systems

DVB-T is the standard for the broadcast transmission of digital terrestrial television. The system transmits compressed digital audio, digital video and other data in an MPEG transport stream, using COFDM modulation. DVB-H and DVB-SH systems are end-to-end broadcast systems for delivery of any types of digital content and services using IP-based mechanisms optimized for devices with limitations on computational resources and battery. They consist of a unidirectional broadcast path that may be combined with a bidirectional mobile cellular (2G/3G) interactivity path. The broadcast path of DVB-SH system uses combined or integrated satellite and terrestrial networks. Both DVB-H and DVB-SH are platforms that can be used for enabling the convergence of services from broadcast/media and telecommunications domains (e.g. mobile/cellular).

Recommendation ITU-R BT.1306-7 (06/2015) provides transmission parameters (Table 1 Part b) and bibliography (Appendix 2 to Annex 1) for DVB-T system standard (System B).

Recommendation ITU-R BT.1368-13 (06/2017) provides planning criteria for DVB-T system (Annex 2). Planning criteria includes:

– protection ratios for DVB-T wanted signals (DVB-T signal interfered with by digital terrestrial television signal, DVB-T signal interfered with by analogue terrestrial TV signal, DVB-T signal interfered with by CW or FM signals, DVB-T signal interfered with by T-DAB signals, DVB-T signal interfered with by wideband signals other than terrestrial broadcasting);
– protection ratios for wanted analogue terrestrial TV signals interfered with by unwanted DVB-T signals;
– protection ratios for sound signals of wanted analogue terrestrial television signals interfered with by unwanted DVB-T signals;
– correction factors for different wanted DVB-T system variants and different reception conditions;
– protection ratios for a T-DAB signal interfered with by an unwanted DVB-T signal;
– minimum field strengths for DVB-T signal (fixed reception);
– minimum median field strength for mobile DVB-T reception;
– minimum median field strength for handheld pedestrian indoor, pedestrian outdoor and mobile DVB-H reception.

Recommendation ITU-R BT.2036-1 (06/2016) establishes characteristics (Annexes 1 and 2) for a reference DVB-T television receiving system to be used as a basis for frequency planning.

Recommendation ITU-R BT.1833-3 (02/2014) provides general system characteristics (Table 1) for DVB-H (Multimedia system H) and DVB-SH (Multimedia system I) for mobile reception by handheld receivers.

Recommendation ITU-R BT.2016-1 (01/2013) provides error-correction, data framing, modulation and emission methods for terrestrial multimedia broadcasting for mobile reception using handheld receivers in VHF/UHF bands, particularly for DVB-H (Multimedia system H) and DVB-SH (Multimedia system I). The Recommendation includes the parameters for emission for the systems (Table 1), technical features of the systems (Table 2), description and bibliography for DVB-SH system (Appendix 3 to Annex 1), description and bibliography for DVB-H system (Appendix 4 to Annex 1).

Report ITU-R BS.2049-7 (02/2016) gives summary of broadcasting transport mechanisms (Table 1), transmission parameters (Table 2b), technical performance overview (Table 3b) and user requirements (Table 5b) for DVB-H (Multimedia system H) and DVB-SH (Multimedia system I). Overview of DVB-H standard is given in Annex 3, overview of DVB-SH standard is given in Annex 6.

Report ITU-R BT.2382-1 (10/2016) provides the description of interference into a digital terrestrial television (DTT) receiver, i.e. violation of the protection ratio (PR), that can impact the received picture. The impact of in band and out-of-band emissions of discontinuous interference on DTT reception (Annex 2), field measurement and analysis of various multipath interference scenarios (Annex 3), measurement and analysis of intermodulation in the DTT receiver (Annex 4) for DVB-T receiver are given.

Report ITU-R BT.2383-1 (10/2016) describes the characteristics of DTTB systems in the frequency band 470-862 MHz for frequency sharing/interference analysis. Section 7 gives DVB-T reference broadcasting network characteristics, §§ 11 and 12 gives reception modes and system parameters of DTTB systems, including DVB-T.

Report ITU-R BT.2386-0 (07/2015) provides the DTTB design and implementation of single frequency networks (SFN), including DVB-T system (Part 2).

Report ITU-R BT.2389-0 (02/2016) gives the guidelines on measurements for digital terrestrial television broadcasting systems, including DVB specific (§§ 3.3 and 5.3).

More information about the system and standards can be found at http://www.dvb.org/

3.6 Summary of DVB-T2 system

DVB-T2 is a 2nd generation terrestrial broadcast transmission system developed since 2006. The main purpose was to increase capacity, ruggedness and flexibility to the DVB-T system. The first version was published in 2009.

DVB-T2 Lite profile is designed to make use of the same reliable features we are familiar with from DVB-T2, but by a careful selection of a sub-set of modes, allows for receivers to be implemented using much smaller and more efficient silicon chips. So T2-Lite will efficiently deliver TV and radio to mobile devices such as phones and tablets (for which power consumption is an important issue) and in-car at the same time as providing services to existing fixed receivers.

Recommendation ITU-R BT.1833-3 (02/2014) provides general system characteristics (Table 1) for DVB-T2 Lite profile (Multimedia system T2) for mobile reception by handheld receivers.

Recommendation ITU-R BT.1877-1 (08/2012) provides error-correction, data framing, modulation and emission methods for DVB-T2 system. The Recommendation includes general transmission parameters of the system (Table 1) and references to system standards (Appendix 1 to Annex 1).

Recommendation ITU-R BT.2016-1 (01/2013) provides error-correction, data framing, modulation and emission methods for terrestrial multimedia broadcasting for mobile reception using handheld receivers in VHF/UHF bands, particularly for DVB-T2 Lite profile (Multimedia system T2). The Recommendation includes the parameters for emission for the systems (Table 1), technical features of the systems (Table 2), short description and bibliography for DVB-T2 Lite profile (Appendix 5 to Annex 1).

Recommendation ITU-R BT.2033-1 (02/2015) provides planning criteria, including protection ratios, for DVB-T2 system in the VHF/UHF bands, particularly:

– planning criteria, including protection ratios, for DVB-T2 system in the VHF/UHF bands for 7 and 8 MHz channel bandwidth (Annex 1);
– planning criteria, including protection ratios, for DVB-T2 system in the VHF/UHF bands for 6 MHz channel bandwidth (Annex 2);
– additional test results from UK and Russian Federation (Annex 3);
– other planning factors such as antenna types and antenna discrimination, height loss, etc. (Annex 4);
– subjective failure point description (Annex 5);
– tropospheric and continuous interference (Annex 6).

Recommendation ITU-R BT.2036-1 (06/2016) establishes characteristics (Annexes 1 and 3) for a reference DVB-T2 television receiving system to be used as a basis for frequency planning.

Report ITU-R BT.2049-7 (02/2016) gives summary of broadcasting transport mechanisms (Table 1), transmission parameters (Table 2a), technical performance overview (Table 3a), user requirements (Table 5a) and general description (Annex 8) for DVB-T2 Lite standard for multimedia broadcasting (Multimedia system T2).

Report ITU-R BT.2254-3 (03/2017) gives frequency and network planning aspects of DVB-T2, including system properties, receiver properties, sharing and compatibility, network planning parameters, new planning features (SFN extension, degradation beyond guard interval, MISO, time-frequency slicing, time slicing, physical layer pipes, PAPR reduction techniques, future extension frames), implementation scenarios, transition to DVB-T2 scenarios and references. The Report consider DVB-T2 Lite profile also (Annex 5).

Report ITU-R BT.2343-2 (10/2016) provides the collection of field trials of UHDTV over DTT networks including DVB-T2 networks.

Report ITU-R BT.2382-1 (10/2016) provides the description of interference into a digital terrestrial television (DTT) receiver, i.e., violation of the protection ratio (PR), that can impact the received picture. The impact of in band and out-of-band emissions of discontinuous interference on DTT reception (Annex 2), field measurement and analysis of various multipath interference scenarios (Annex 3), measurement and analysis of intermodulation in the DTT receiver (Annex 4) for DVB-T2 receiver are given.

Report ITU-R BT.2383-1 (10/2016) describes the characteristics of DTTB systems in the frequency band 470-862 MHz for frequency sharing/interference analysis. Section 7 gives DVB-T2 reference broadcasting network characteristics, §§ 11 and 12 gives reception modes and system parameters of DTTB systems, including DVB-T2.

Report ITU-R BT.2386-0 (07/2015) provides the DTTB design and implementation of single frequency networks (SFN), including DVB-T2 system (Part 2).

Report ITU-R BT.2389-0 (02/2016) gives the guidelines on measurements for digital terrestrial television broadcasting systems, including DVB specific (§§ 3.3 and 5.3).

More information about the system and standards can be found at http://www.dvb.org/

3.7 Summary of IBOC system

In-band on-channel (IBOC) digital sound broadcasting (DSB) system was designed to provide vehicular, portable and fixed reception using terrestrial transmitters. Although IBOC system can be implemented in unoccupied spectrum, a significant feature of the system is its ability to offer simulcasting of analogue and digital signals in the existing AM and FM sound broadcasting bands.

The system offers improved performance in multipath environments resulting in greater reliability than is offered by existing analogue AM and FM operations. IBOC system (also called HD Radio system) offers enhanced audio quality comparable to that obtained from consumer digital recorded media, new data-casting services in addition to the enhanced audio programming. In addition, the system allows for allocation of bits between audio and data-casting capacity to maximize the data-casting capabilities.

Recommendation ITU-R BS.1114-9 (06/2015) provides performance (Table 1) of IBOC system in VHF band (Digital system C), summary (Annex 1 Part 3) and description (Annex 4) of the system, including simulated system performance.

Recommendation ITU-R BS.1514-2 (03/2011) provides summary description of IBOC system for operation below 30 MHz (Annex 2) and summary of IBOC system performance below 30 MHz (Annex 5).

Recommendation ITU-R BS.1615-1 (05/2011) provides planning parameters IBOC sound broadcasting below 30 MHz including measured RF protection ratios in the MF band (Annex 3).

Report ITU-R BS.1203-1 (1994) gives IBOC system description (Annex 2).

Report ITU-R BS.2384-0 (07/2015) gives the observation of current and planned HD Radio implementations (§ 3.3). HD Radio system overview, key features and status of implementations are given in Annex 3.

More information about the system and standards can be found at http://www.hdradio.com

3.8 Summary of ISDB-T systems family

The ISDB-T family (ISDB-T, ISDB-TSB, ISDB-T multimedia systems) was designed on the basis of the OFDM band-segmented transmission scheme. One OFDM segment corresponds to 1/13 of the bandwidth of a television channel. The number of segments can be chosen in accordance with the available bandwidth and application; 13 for television service, 1 or 3 for sound service, and 1 or more determined by the available bandwidth for multimedia service. The ISDB-T family of terrestrial broadcasting systems of sound, television, and multimedia has commonality and interoperability.

Recommendation ITU-R BS.1114-9 (06/2015) provides performance (Table 1) of ISDB-TSB system (Digital system F), summary (Annex 1 Part 2) and description (Annex 3) of the system, including RF performance characteristics.

Recommendation ITU-R BT.1306-7 (06/2015) provides transmission parameters (Table 1 Part c) and bibliography (Appendix 3 to Annex 1) for ISDB-T system standard (System C).

Recommendation ITU-R BT.1368-13 (06/2017) provides planning criteria for ISDB-T system (Annex 3). Planning criteria includes:

– protection ratios for ISDB-T wanted signals (ISDB-T signal interfered with by digital terrestrial television signal, ISDB-T signal interfered with by analogue terrestrial TV signal);
– protection ratios for wanted analogue terrestrial TV signals interfered with by unwanted ISDB-T signals;
– protection ratios for sound signals of wanted analogue terrestrial television signals interfered with by unwanted ISDB-T signals;
– protection ratios and overload threshold for a 6 MHz ISDB-T signal interfered with by an LTE base station or user equipment signal;
– minimum field strengths for ISDB-T signal (fixed reception);
– minimum median field strength for handheld pedestrian indoor, pedestrian outdoor and mobile ISDB-T reception.

Recommendation ITU-R BS.1660-7 (10/2015) gives the technical basis for planning of ISDB-TSB terrestrial digital sound broadcasting in the VHF band (Annex 2), including spectrum masks for out-of-band emissions, frequency conditions, minimum usable field strengths, protection of ISDB-TSB (protection ratios for ISDB-TSB interfered with by ISDB-TSB, protection ratios for ISDB-TSB interfered with by analogue television (NTSC), protection ratios for analogue television (NTSC) interfered with by ISDB-TSB, maximum interfering field strength density interfered with by services other than broadcasting).

Recommendation ITU-R BT.1833-3 (02/2014) provides general system characteristics (Table 1) for ISDB-TSB (Multimedia system C) and ISDB-T (Multimedia system F) for mobile reception by handheld receivers.

Recommendation ITU-R BT.2016-1 (01/2013) provides error-correction, data framing, modulation and emission methods for terrestrial multimedia broadcasting for mobile reception using handheld receivers in VHF/UHF bands, particularly for ISDB-T (Multimedia system F). The Recommendation include the parameters for emission for the system (Table 1), technical features of the system (Table 2), description and bibliography for ISDB-T system (Appendix 2 to Annex 1).

Recommendation ITU-R BT.2036-1 (06/2016) establishes characteristics (Annexes 1 and 2) for a reference ISDB-T television receiving system to be used as a basis for frequency planning.

Recommendation ITU-R BT.2052-1 (10/2015) provides planning criteria for ISDB-T multimedia broadcasting (Multimedia System F) in VHF/UHF bands characteristics (Annex 2) including:

– characteristics of reference receiver;
– protection ratios for wanted ISDB-T multimedia broadcasting signals;
– protection ratios for other broadcasting systems interfered with by ISDB-T multimedia broadcasting signal;
– minimum field strength for ISDB-T multimedia broadcasting.

Report ITU-R BT.2049-7 (02/2016) gives summary of broadcasting transport mechanisms (Table 1), transmission parameters (Table 2a), technical performance overview (Table 3a) and user requirements (Table 5a) for ISDB-TSB (Multimedia system C) and ISDB-T multimedia broadcasting (Multimedia system F). Overview of ISDB-T system multimedia broadcasting for mobile reception is given in Annex 1.

Report ITU-R BT.2209-1 (05/2013) provides detailed considerations on receiver characteristics under single frequency network (SFN) conditions for ISDB-T system. It introduces new technical parameters that dominate receiver performances, in addition to the conventional planning parameters: amplitude proportional noise (APN), FFT window setting margin and interpolation filter characteristics used for reference carrier recovery. Using these parameters, the overall receiver characteristics can be expressed by a single parameter called guard interval mask characteristics, which is useful in estimating whether or not the signal is received correctly. The Report also gives a reference receiver characteristic that would be applied in frequency planning and/or network design of ISDB-T based broadcasting systems.

Report ITU-R BT.2294 (11/2013) describes construction technique of DTTB relay station network for ISDB-T system. It provides how to determine relay system between a relay station and its upper node station, and single frequency network (SFN) delay time adjustment design.

Report ITU-R BT.2343-2 (10/2016) provides the collection of field trials of UHDTV over DTT networks including advanced ISDB-T networks.

Report ITU-R BT.2383-1 (10/2016) describes the characteristics of DTTB systems in the frequency band 470-862 MHz for frequency sharing/interference analysis. Section 9 gives ISDB-T reference broadcasting network characteristics, §§ 11 and 12 gives reception modes and system parameters of DTTB systems, including ISDB-T.

Report ITU-R BS.2384-0 (07/2015) gives the observation of current and planned ISDB-Tmm implementations (§ 3.4) and social, regulatory and technical factors involved when considering a transition to the ISDB-Tmm system (Annex 4).

Report ITU-R BT.2389-0 (02/2016) gives the guidelines on measurements for digital terrestrial television broadcasting systems, including ISDB specific (§§ 3.4 and 5.4).

More information about the system and standards can be found at http://www.dibeg.org/

3.9 Summary of RAVIS system

Digital terrestrial sound and multimedia broadcasting system RAVIS have been developed for the purpose of efficiency enhancement of utilization of spectrum bands used now for audio FM broadcasting, i.e., VHF Bands I and II. RAVIS allows to deliver digital data with bit rates from 150 to 900 kbit/s through one 100, 200 or 250 kHz bandwidth radio-frequency channel. Channel capacity provides transmission of video programme with standard TV definition of several audio programmes with various quality from mono or stereo sound to multichannel or object-oriented immersive sound.

RAVIS provides for steady mobile reception (up to 250 km/h) in urban environment, in the districts with difficult topography, in mountainous and dense forested areas, in water areas, that is under conditions characterized by multipath propagation, without direct visibility of transmitting antenna and so forth.

Recommendation ITU-R BS.1114-11 (06/2019) provides performance (Table 1) of RAVIS system (Digital system I), summary (Annex 1 Part 6) and description (Annex 7) of the system, including the system parameters and performance characteristics.

Report ITU-R BS.2214-4 (09/2019) gives planning parameters for RAVIS broadcasting in VHF bands I and II (§ 5), such as minimum field-strength requirements, out-of-band spectrum mask and protection ratios (FM interfered with by RAVIS, RAVIS interfered with by RAVIS, RAVIS interfered with by FM).

Report ITU-R BT.2049-7 (02/2016) gives summary of broadcasting transport mechanisms (Table 1) and general description of RAVIS system (Annex 5), including service requirements for RAVIS use cases, technical aspects of source and channel coding, transmission mechanisms, network architecture, performance simulation and testing, user requirements and references for source coding and multiplexing.

Report ITU-R BS/BT.2384-1 (04/2019) gives the observation of current and planned RAVIS implementations (§ 3.5). RAVIS system overview, key features and status of implementations are given in Annex 5.

More information about the system and standards can be found at http://www.ravis-radio.com/

3.10 Summary of T-DMB, AT-DMB systems

Terrestrial digital multimedia broadcasting (T-DMB) system is the extended system compatible with digital sound broadcasting system T-DAB, which enables video services using T-DAB networks for handheld receivers in a mobile environment. T-DMB provides multimedia services including video, audio, and interactive data.

AT-DMB is the extended system of guaranteeing backward compatibility with T-DMB, which increases channel capacity of T-DMB by applying hierarchical modulation mechanism. AT-DMB provides a scalable video service as well as all kinds of T-DMB services.

Recommendation ITU-R BT.1833-3 (02/2014) provides general system characteristics (Table 1) for T-DMB and AT-DMB (Multimedia system A) for mobile reception by handheld receivers.

Recommendation ITU-R BT.2016-1 (01/2013) provides error-correction, data framing, modulation and emission methods for T-DMB and AT-DMB (Multimedia system A) for mobile reception using handheld receivers in VHF/UHF bands, including parameters for emission (Table 1), technical features (Table 2), description of the systems and bibliography (Appendix 1 to Annex 1).

Recommendation ITU-R BT.2052-1 (10/2015) provides planning criteria for T-DMB and AT-DMB terrestrial multimedia broadcasting systems (Multimedia System A) in VHF/UHF bands characteristics (Annex 1) including:

– characteristics of reference receiver;
– protection ratios for T-DMB/AT-DMB wanted multimedia broadcasting signals;
– minimum field strength for T-DMB/AT-DMB.

Report ITU-R BT.2049-7 (02/2016) gives summary of broadcasting transport mechanisms (Table 1), transmission parameters (Table 2a), technical performance overview (Table 3a), user requirements (Table 5a) and general description (Annex 2) of T-DMB and AT-DMB systems (Multimedia system A).

More information about the systems and standards can be found at http://www.worlddab.org/

3.11 Summary of CDR system

Digital terrestrial sound and multimedia broadcasting system Convergent Digital Radio (CDR), has been developed for smoothly switch-off from the currently analogue FM to digital radio. The system was designed to provide vehicular, portable and fixed reception using terrestrial transmitters. During simulcast stage, CDR can make full use the unoccupied spectrum in currently FM channel, provide several additional digital radio services, the system offers improved performance in multipath environments resulting in greater reliability than is offered by existing analogue FM operations. After switch-off is finished, CDR can provide more high-quality digital audio services (such as CD quality or 5.1 multichannel services) as well as various data services, and the system also can support the nation-wide coverage by using single frequency network (SFN).

CDR flexibly provides several spectrum-occupancy modes for different scenarios, the digital signal bandwidth can be 100 kHz or 200 kHz. During the switch-off stage, the digital signal can be simulcast with analogue FM signal, in this case, the digital signal spectrum is divided into two parts, the spectrum interval is 300 kHz or 200 kHz in which the stereo FM radio or analogue mono FM broadcasting signals can be placed. When the switch-off is finished, the digital signal can be continuous, the signal bandwidth may be 100 kHz or 200 kHz.

Recommendation ITU-R BS.1114-11 (06/2019) provides performance (Table 1) of CDR system (Digital system H), summary (Annex 1 Part 5) and description (Annex 6) of the system, including the system parameters and performance characteristics.

Report ITU-R BS.2214-5 (03/2020) gives planning parameters for CDR broadcasting in VHF bands, such as minimum field-strength requirements.

3.12 Summary of the Multimedia System L

Several 3GPP specifications have been extended or newly developed over several releases to address the use cases and requirements for dedicated broadcast networks. With the completion of Release 16, a comprehensive set of 3GPP specifications is available that fulfils the use cases and requirements for a Broadcast System, including:

– Support of Free-to-Air (FTA) and Receive-Only Mode (ROM) services over 3GPP.
– Network dedicated to linear television and radio broadcast.
– Single Frequency Network (SFN) deployments with Inter-Site Distance (ISD) significantly larger than a typical ISD associated with typical cellular deployments.
– Support for mobility scenarios including speeds of up to 250 km/h to support receivers in cars, with external omni-directional antennas.
– Support for common streaming distribution formats such as Dynamic Streaming over HTTP (DASH), Common Media Application Format (CMAF) and HTTP Live Streaming (HLS).
– Support for IP-based services such as IPTV or ABR multicast.
– Support for different file delivery services such as scheduled delivery or file carousels.

The System L is defined in ETSI TS 103 720.

Recommendation ITU-R BT.2016 provides error-correction, data framing, modulation and emission methods for the System L for mobile reception using handheld receivers in VHF/UHF bands, including parameters for emission (Table 1), technical features (Table 2), description of the systems and bibliography (Appendix 1 to Annex 1).

Report ITU-R BT.2049 gives summary of broadcasting transport mechanisms (Table 1), transmission parameters (Table 2b), technical performance overview (Table 3b), user requirements (Table 5b) and general description (Annex 11) of System L.

3.13 Summary of the Multimedia System N

System N (5G NR MBS (Multicast/Broadcast Services)) will evolve into a universal flexible broadcast technique serving all screens.

– Flexibly achieve dynamic and seamless switching between unicast services and broadcast/multicast services.
– Flexible servicing abilities, excellent bi-direction interaction, accurate push of broadcast and multicast services based on location, suitable for expanding new multimedia broadcast services such as public safety and emergency broadcast.
– Widely adapted to various types of 5G general-purpose terminals, and extensive supporting from major global industry manufacturers.
– Deeply and continuously cover various complex scenarios, with coordinated mixed network based on 5G cellular base stations and existing TV towers.
– Support both unicast and broadcast reception.

Recommendation ITU-R BT.2016 provides error-correction, data framing, modulation and emission methods for the System N for mobile reception using handheld receivers in VHF/UHF bands, including parameters for emission (Table 1), technical features (Table 2), description of the systems and bibliography (Attachment 9 to Annex 1).

Report ITU-R BT.2049 gives summary of broadcasting transport mechanisms (Table 1), transmission parameters (Table 2b), technical performance overview (Table 3b), user requirements (Table 5b) and general description (Annex 12) of System N.

Annex 1

Summary of MBMS system (Multimedia Broadcast/Multicast Services)

There are telecommunication systems, such as Multimedia broadcast/multicast services (MBMS), that fulfil the requirements for interoperability between mobile telecommunication services and interactive digital broadcasting services. The MBMS system is intended to work within services other than broadcasting.

Report ITU-R BT.2049-7 (02/2016) includes Annex 9 that provides:

– MBMS key characteristics;
– MBMS requirements;
– MBMS Broadcast Multicast Service Centre description;
– MBMS user equipment handheld terminal capabilities;
– MBMS service and application types;
– MBMS radio bearer implementation description;
– performance of MBMS for mobile reception;

– specifications of MBMS for mobile reception; and
– informative references.