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| **Recommendation ITU-R BT.1306-7**  **(06/2015)** |
| **Error‑correction, data framing, modulation and emission methods for digital  terrestrial television broadcasting** |
| **BT Series**  **Broadcasting service**  **(television)** |

Foreword

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

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

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| Series of ITU-R Recommendations  (Also available online at <http://www.itu.int/publ/R-REC/en>) | |
| **Series** | Title |
| **BO** | Satellite delivery |
| **BR** | Recording for production, archival and play-out; film for television |
| **BS** | Broadcasting service (sound) |
| BT | Broadcasting service (television) |
| **F** | Fixed service |
| **M** | Mobile, radiodetermination, amateur and related satellite services |
| **P** | Radiowave propagation |
| **RA** | Radio astronomy |
| **RS** | Remote sensing systems |
| **S** | Fixed-satellite service |
| **SA** | Space applications and meteorology |
| **SF** | Frequency sharing and coordination between fixed-satellite and fixed service systems |
| **SM** | Spectrum management |
| **SNG** | Satellite news gathering |
| **TF** | Time signals and frequency standards emissions |
| **V** | Vocabulary and related subjects |

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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.1306-7

Error‑correction, data framing, modulation and emission methods  
for digital terrestrial television broadcasting

(Question ITU-R 132-2/6)

(1997-2000-2005-2006-2009-03/2011-12/2011-2015)

Scope

This Recommendation defines error-correction, data framing, modulation and emission methods for the existing digital terrestrial television broadcasting systems.

The ITU Radiocommunication Assembly,

considering

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

*b)* that DTTB should fit into existing 6, 7, 8 MHz channels intended for analogue television transmission;

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

*d)* that it may be necessary for DTTB services to coexist with existing analogue television transmissions for a temporary period;

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

*f)* that commonalities with alternative media, such as cable and satellite, could be advantageous at the level of outer coding scheme;

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

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

*j)* that both single carrier and multi-carrier modulation methods may be introduced;

*k)* that it is desirable that there be maximum commonality of characteristics between systems;

*l)* that it is desirable that there be maximum commonality between digital terrestrial television transmissions that are required to coexist with existing analogue television transmissions and those that are not;

*m)* that with the rapid evolution of digital technologies, digital terrestrial TV systems, proposed at different times, open new attractive possibilities and services;

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

recommends

**1** that administrations wishing to introduce DTTB should use one of the families of error correction, framing, modulation and emission methods outlined in Annex 1.

Annex 1

Table 1a) provides data for single carrier systems, Table 1b) provides data about multi-carrier systems, and Table 1c) provides data about multi-carrier systems with RF band segmentation, Table 1d) provides data about the combined single- and multi-carrier systems, and Table 1e) provides data about Time-domain synchronized multi-carrier system or TDS multi-carrier systems. Specifications for Systems A, B, C, D and E are found in Attachments 1, 2, 3, 4 and 5.

Selection guidelines for Systems A, B, C, D and E are described in Attachment 6 to Annex 1.

TABLE 1

Parameters for DTTB transmission systems

a)  Single carrier systems

|  | Parameters | 6 MHz | 7 MHz | 8 MHz |
| --- | --- | --- | --- | --- |
| 1 | Used bandwidth | 5.38 MHz (–3 dB) | 6.00 MHz (–3 dB) | 7.00 MHz (–3 dB) |
| 2 | Number of radiated carriers | 1 | 1 | 1 |
| 3 | Modulation method | 8-VSB | 8-VSB | 8-VSB |
| 4 | Spectrum shaping function | Root raised cosine roll‑off  *R* = 5.8% | Root raised cosine roll‑off  *R* = 8.3% | Root raised cosine roll‑off  *R* = 7.1% |
| 5 | Channel occupancy(17) | See Recommendation ITU-R BT.1206 | – | – |
| 6 | Active symbol duration | 92.9 ns | 83.3 ns | 71.4 ns |
| 7 | Overall symbol or segment duration | 77.3 μs (segment) | 69.3 μs (segment) | 59.4 μs (segment) |
| 8 | Transmission frame duration | 48.4 ms | 43.4 ms | 37.2 ms |
| 9 | Channel equalization |  |  |  |
| 10 | Inner interleaving | 12 (independently encoded streams interleaved in time) | 24 (independently encoded streams interleaved in time) | 28 (independently encoded streams interleaved in time) |
|  | Inner channel | *R* = 2/3 trellis, concatenated *R* = 1/2 or *R* = 1/4 trellis | *R* = 2/3 trellis, concatenated *R* = 1/2 or *R* = 1/4 trellis | *R* = 2/3 trellis, concatenated *R* = 1/2 or *R* = 1/4 trellis |
| 11 | Outer channel Reed‑Solomon (RS) code | RS (207,187, *T* = 10), concatenated RS (184,164, *T* = 10) | RS (207,187, *T* = 10), concatenated RS (184,164, *T* = 10) | RS (207,187, *T* = 10), concatenated RS (184,164, *T* = 10) |
| 12 | Outer interleaving | 52 segment convolutional byte interleaved, concatenated  46 segment byte interleaved | 52 segment convolutional byte interleaved, concatenated  46 segment byte interleaved | 52 segment convolutional byte interleaved, concatenated  46 segment byte interleaved |
| 13 | Data randomization/ Energy dispersal | 16 bit PRBS | 16 bit PRBS | 16 bit PRBS |

TABLE 1 (*continued*)

a)  Single carrier systems (*end*)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Parameters | 6 MHz | 7 MHz | 8 MHz |
| 14 | Time/frequency synchronization | Segment sync, pilot carrier | Segment sync, pilot carrier | Segment sync, pilot carrier |
| 15 | Frame synchronization | Frame sync | Frame sync | Frame sync |
| 16 | Data equalization | Frame sync, PN.511 and 3 × PN.63 | Frame sync, PN.511 and 3 × PN.63 | Frame sync, PN.511 and 3 × PN.63 |
| 17 | Transmission mode identification | Mode symbols in frame sync | Mode symbols in frame sync | Mode symbols in frame sync |
| 18 | Net data rate | Depending on modulation code rate 4.23-19.39 Mbit/s | Depending on modulation code rate 4.72-21.62 Mbit/s | Depending on modulation code rate 5.99-27.48 Mbit/s |
| 19 | Carrier-to-noise ratio in an additive white Gaussian noise (AWGN) channel | Depending on channel code, 15.19 dB,  9.2 dB, 6.2 dB(1), (2) | Depending on channel code, 15.19 dB,  9.2 dB, 6.2 dB(2) | Depending on channel code, 15.19 dB,  9.2 dB, 6.2 dB(2) |

b)  Multi-carrier systems

|  | Parameters | 6 MHz multi-carrier (OFDM) | 7 MHz multi-carrier (OFDM) | 8 MHz multi-carrier (OFDM) |
| --- | --- | --- | --- | --- |
| 1 | Used bandwidth | 5.71 MHz | 6.66 MHz | 7.61 MHz |
| 2 | Number of radiated carriers | 1 705 (2k mode)(3) 3 409 (4k mode) 6 817 (8k mode) | 1 705 (2k mode)(3) 3 409 (4k mode) 6 817 (8k mode) | 1 705 (2k mode)(3) 3 409 (4k mode) 6 817 (8k mode) |
| 3 | Modulation mode | Constant coding and modulation (CCM) | Constant coding and modulation (CCM) | Constant coding and modulation (CCM) |
| 4 | Modulation method | QPSK, 16-QAM, 64‑QAM, MR‑16-QAM,  MR‑64‑QAM(4) | QPSK, 16-QAM, 64‑QAM, MR‑16-QAM,  MR-64-QAM(4) | QPSK, 16-QAM, 64‑QAM, MR-16-QAM,  MR-64-QAM(4) |
| 5 | Channel occupancy(17) | See Recommendation ITU-R SM.1541 | See Recommendations ITU-R BT.1206 or ITU-R SM.1541 | See Recommendations ITU-R BT.1206 or  ITU-R SM.1541 |
| 6 | Active symbol duration | 298.67 μs (2k mode) 597.33 µs (4k mode) 1 194.67 μs (8k mode) | 256 μs (2k mode) 512 µs (4k mode) 1 024 μs (8k mode) | 224 µs (2k mode) 448 µs (4k mode) 896 μs (8k mode) |
| 7 | Carrier spacing | 3 348.21 Hz (2k mode) 1 674.11 Hz (4k mode) 837.05 Hz (8k mode) | 3 906 Hz (2k mode) 1 953 Hz (4k mode) 976 Hz (8k mode) | 4 464 Hz (2k mode) 2 232 Hz (4k mode) 1 116 Hz (8k mode) |

TABLE 1 (*continued*)

b)  Multi-carrier systems (*continued*)

|  | Parameters | 6 MHz multi-carrier (OFDM) | 7 MHz multi-carrier (OFDM) | 8 MHz multi-carrier (OFDM) |
| --- | --- | --- | --- | --- |
| 8 | Guard interval duration | 1/32, 1/16, 1/8, 1/4 of active symbol duration 9.33, 18.67, 37.33, 74.67 μs (2k mode) 18.67, 37.33, 74.67, 149.33 (4k mode) 37.33, 74.67, 149.33, 298.67 μs (8k mode) | 1/32, 1/16, 1/8, 1/4 of active symbol duration 8, 16, 32, 64 μs  (2k mode) 16, 32, 64, 128 μs (4k mode) 32, 64, 128, 256 μs  (8k mode) | 1/32, 1/16, 1/8, 1/4 of active symbol duration 7, 14, 28, 56 μs  (2k mode) 14, 28, 56, 112 μs (4k mode) 28, 56, 112, 224 μs  (8k mode) |
| 9 | Overall symbol duration | 308.00, 317.33, 336.00, 373.33 μs (2k mode) 616.00, 634.67, 672.00, 746.67 µs (4k mode) 1 232.00, 1 269.33, 1 344.00, 1 493.33 μs (8k mode) | 264, 272, 288, 320 μs  (2k mode) 528, 544, 576, 640 µs (4k mode) 1 048, 1 088, 1 152, 1 280 μs (8k mode) | 231, 238, 252, 280 μs  (2k mode) 462, 476, 504, 560 µs (4k mode) 924, 952, 1 008, 1 120 μs (8k mode) |
| 10 | Transmission frame duration | 68 OFDM symbols. One super frame consists of 4 frames | 68 OFDM symbols. One super-frame consists of 4 frames | 68 OFDM symbols. One super-frame consists of 4 frames |
| 11 | Inner channel code | Convolutional code, mother rate 1/2 with 64 states. Puncturing to rate 2/3, 3/4, 5/6, 7/8 | Convolutional code, mother rate 1/2 with 64 states. Puncturing to rate 2/3, 3/4, 5/6, 7/8 | Convolutional code, mother rate 1/2 with 64 states. Puncturing to rate 2/3, 3/4, 5/6, 7/8 |
| 12 | Inner interleaving | Bit interleaving, combined with native or in-depth(5) symbol interleaving | Bit interleaving, combined with native or in-depth(5) symbol interleaving | Bit interleaving, combined with native or in-depth(5) symbol interleaving |
| 13 | Outer channel Reed-Solomon (RS) code | RS (204,188, *T* = 8) | RS (204,188, *T* = 8) | RS (204,188, *T* = 8) |
| 14 | Outer interleaving | Bytewise convolutional interleaving, *I* = 12 | Bytewise convolutional interleaving, *I* = 12 | Bytewise convolutional interleaving, *I* = 12 |
| 15 | Data randomization/ energy dispersal | PRBS | PRBS | PRBS |
| 16 | Time/frequency synchronization | Pilot carriers(6) | Pilot carriers(6) | Pilot carriers(6) |
| 17 | IP outer channel code Reed-Solomon (RS) code | MPE-FEC RS (255,191)(7) | MPE-FEC RS (255,191)(7) | MPE-FEC RS (255,191)(7) |
| 18 | Receiver power consumption reduction | Time-slicing(8) | Time-slicing(8) | Time-slicing(8) |

TABLE 1 (*continued*)

b)  Multi-carrier systems(*end*)

|  | Parameters | 6 MHz multi-carrier (OFDM) | 7 MHz multi-carrier (OFDM) | 8 MHz multi-carrier (OFDM) |
| --- | --- | --- | --- | --- |
| 19 | Transmission parameter signalling (TPS)(9) | Carried by TPS pilot carriers | Carried by TPS pilot carriers | Carried by TPS pilot carriers |
| 20 | System transport stream format | MPEG-2 TS | MPEG-2 TS | MPEG-2 TS |
| 21 | Net data rate | Depending on modulation, code rate and guard interval (3.69-23.5 Mbit/s for non‑hierarchical modes)(10) | Depending on modulation, code rate and guard interval (4.35-27.71 Mbit/s for non‑hierarchical modes)(10) | Depending on modulation, code rate and guard interval (4.98-31.67 Mbit/s for non‑hierarchical modes)(10) |
| 22 | Carrier-to-noise ratio in an AWGN channel | Depending on modulation and channel code. 3.1-20.1 dB(11) | Depending on modulation and channel code. 3.1-20.1 dB(11) | Depending on modulation and channel code. 3.1-20.1 dB(11) |

c)  Multi-carrier systems with radio-frequency band segmentation(12)

|  | Parameters | 6 MHz multi-carrier (segmented OFDM) | 7 MHz multi-carrier (segmented OFDM) | 8 MHz multi-carrier (segmented OFDM) |
| --- | --- | --- | --- | --- |
| 1 | Numbers of segments (Ns) | 13(13) | 13(13) | 13(13) |
| 2 | Segment bandwidth (Bws) | 6 000/14 = 428.57 kHz | 7 000/14 = 500 kHz | 8 000/14 = 571.428 kHz |
| 3 | Used bandwidth (Bw) | Bw × Ns + Cs 5.575 MHz (Mode 1) 5.573 MHz (Mode 2) 5.572 MHz (Mode 3) | Bw × Ns + Cs  6.504 MHz (Mode 1) 6.502 MHz (Mode 2) 6.501 MHz (Mode 3) | Bw × Ns + Cs  7.434 MHz (Mode 1) 7.431 MHz (Mode 2) 7.430 MHz (Mode 3) |
| 4 | Number of radiated carriers | 1 405 (Mode 1) 2 809 (Mode 2) 5 617 (Mode 3) | 1 405 (Mode 1) 2 809 (Mode 2) 5 617 (Mode 3) | 1 405 (Mode 1) 2 809 (Mode 2) 5 617 (Mode 3) |
| 5 | Modulation method | DQPSK, QPSK, 16‑QAM, 64‑QAM | DQPSK, QPSK, 16‑QAM, 64‑QAM | DQPSK, QPSK,  16‑QAM, 64‑QAM |
| 6 | Channel occupancy(17) | See Recommendations ITU-R BT.1206 or ITU-R SM.1541 | See Recommendations ITU-R BT.1206 or ITU-R SM.1541 | See Recommendations ITU-R BT.1206 or ITU‑R SM.1541 |
| 7 | Active symbol duration | 252 μs (Mode 1) 504 μs (Mode 2) 1 008 μs (Mode 3) | 216 μs (Mode 1) 432 μs (Mode 2) 864 μs (Mode 3) | 189 μs (Mode 1) 378 μs (Mode 2) 756 μs (Mode 3) |
| 8 | Carrier spacing (Cs) | Bws/108 = 3.968 kHz (Mode 1) Bws/216 = 1.984 kHz (Mode 2) Bws/432 = 0.992 kHz (Mode 3) | Bws/108 = 4.629 kHz (Mode 1) Bws/216 = 2.314 kHz (Mode 2) Bws/432 = 1.157 kHz (Mode 3) | Bws/108 = 5.291 kHz (Mode 1) Bws/216 = 2.645 kHz (Mode 2) Bws/432 = 1.322 kHz (Mode 3) |

TABLE 1 (*continued*)

c)  Multi-carrier systems with radio-frequency band segmentation(12) (*continued*)

|  | Parameters | | 6 MHz multi-carrier (segmented OFDM) | | 7 MHz multi-carrier (segmented OFDM) | | 8 MHz multi-carrier (segmented OFDM) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 9 | Guard interval duration | | 1/4, 1/8, 1/16, 1/32 of active symbol duration 63, 31.5, 15.75, 7.875 μs (Mode 1) 126, 63, 31.5, 15.75 μs (Mode 2) 252, 126, 63, 31.5 μs (Mode 3) | | 1/4, 1/8, 1/16, 1/32 of active symbol duration 54, 27, 13.5, 6.75 μs (Mode 1) 108, 54, 27, 13.5 μs (Mode 2) 216, 108, 54, 27 μs (Mode 3) | | 1/4, 1/8, 1/16, 1/32 of active symbol duration 47.25, 23.625, 11.8125, 5.90625 μs (Mode 1) 94.5, 47.25, 23.625, 11.8125 μs (Mode 2) 189, 94.5, 47.25, 23.625 μs (Mode 3) |
| 10 | Overall symbol duration | | 315, 283.5, 267.75, 259.875 μs (Mode 1) 630, 567, 535.5, 519.75 μs (Mode 2) 1 260, 1 134, 1 071, 1 039.5 μs (Mode 3) | | 270, 243, 229.5,  222.75 μs (Mode 1) 540, 486, 459, 445.5 μs (Mode 2) 1 080, 972, 918, 891 μs (Mode 3) | | 236.25, 212.625, 200.8125, 194.90625 μs (Mode 1) 472.5, 425.25, 401.625, 389.8125 μs (Mode 2) 945, 850.5, 803.25, 779.625 μs (Mode 3) |
| 11 | Transmission frame duration | | 204 OFDM symbols | | 204 OFDM symbols | | 204 OFDM symbols |
| 12 | Inner channel code | | Convolutional code, mother rate 1/2 with 64 states. Puncturing to rate 2/3, 3/4, 5/6, 7/8 | | Convolutional code, mother rate 1/2 with 64 states. Puncturing to rate 2/3, 3/4, 5/6, 7/8 | | Convolutional code, mother rate 1/2 with 64 states. Puncturing to rate 2/3, 3/4, 5/6, 7/8 |
| 13 | Inner interleaving | | Intra and inter segments interleaving (frequency interleaving). Symbolwise convolutional interleaving 0, 380, 760, 1 520 symbols (Mode 1) 0, 190, 380, 760 symbols (Mode 2) 0, 95, 190, 380 symbols (Mode 3) (time interleaving) | | Intra and inter segments interleaving (frequency interleaving). Symbolwise convolutional interleaving 0, 380, 760, 1 520 symbols (Mode 1) 0, 190, 380, 760 symbols (Mode 2) 0, 95, 190, 380 symbols (Mode 3) (time interleaving) | | Intra and inter segments interleaving (frequency interleaving). Symbolwise convolutional interleaving 0, 380, 760, 1 520 symbols (Mode 1) 0, 190, 380, 760 symbols (Mode 2) 0, 95, 190, 380 symbols (Mode 3) (time interleaving) |
| 14 | Outer channel code | | RS (204,188, *T* = 8) | | RS (204,188, *T* = 8) | | RS (204,188, *T* = 8) |
| 15 | Outer interleaving | | Bytewise convolutional interleaving, *I* = 12 | | Bytewise convolutional interleaving, *I* = 12 | | Bytewise convolutional interleaving, *I* = 12 |
| 16 | Data randomization/ energy dispersal | | PRBS | | PRBS | | PRBS |
| 17 | Time/frequency synchronization | | Pilot carriers | | Pilot carriers | | Pilot carriers |
| 18 | | Transmission and multiplexing configuration | | Carried by TMCC pilot carriers | | Carried by TMCC pilot carriers | Carried by TMCC pilot carriers |

TABLE 1 (*continued*)

c)  Multi-carrier systems with radio-frequency band segmentation(12) (*end*)

|  | Parameters | 6 MHz multi-carrier (segmented OFDM) | 7 MHz multi-carrier (segmented OFDM) | 8 MHz multi-carrier (segmented OFDM) |
| --- | --- | --- | --- | --- |
| 19 | Net data rate | Depending on number of segments, modulation, code rate, hierarchical structure and guard interval 3.65-23.2 Mbit/s | Depending on number of segments, modulation, code rate, hierarchical structure and guard interval 4.26-27.1 Mbit/s | Depending on number of segments, modulation, code rate, hierarchical structure and guard interval 4.87-31.0 Mbit/s |
| 20 | Carrier-to-noise ratio in an AWGN channel | Depending on modulation and channel code 5.0-23 dB(14) | Depending on modulation and channel code 5.0-23 dB(14) | Depending on modulation and channel code 5.0-23 dB(14) |

d)  Single- and multi-carrier combined systems

|  | Parameters | 6 MHz | 7 MHz | 8 MHz |
| --- | --- | --- | --- | --- |
| 1 | Used bandwidth | 5.67 MHz | 6.62 MHz | 7.56 MHz |
| 2 | Number of radiated carriers | 1 (single-carrier mode) 3 780 (multi-carrier mode) | 1 (single-carrier mode) 3 780 (multi-carrier mode) | 1 (single-carrier mode) 3 780 (multi-carrier mode) |
| 3 | Modulation mode | Constant coding and modulation (CCM) | Constant coding and modulation (CCM) | Constant coding and modulation (CCM) |
| 4 | Modulation method | 4-QAM-NR, 4-QAM, 16-QAM, 32‑QAM, 64‑QAM | 4-QAM-NR, 4-QAM, 16-QAM, 32‑QAM, 64‑QAM | 4-QAM-NR, 4-QAM, 16-QAM, 32‑QAM, 64‑QAM |
| 5 | Channel occupancy(17) | See Recommendation ITU‑R BT.1206 | See Recommendation ITU‑R BT.1206 | See Recommendation ITU‑R BT.1206 |
| 6 | Active symbol duration | 0.176 μs (single-carrier mode) 666.67 s (multi-carrier mode) | 0.151 μs (single-carrier mode) 571.43 s (multi-carrier mode) | 0.132 μs (single-carrier mode) 500 μs (multi-carrier mode) |
| 7 | Carrier spacing | 5.67 MHz (single-carrier mode) 1.5 kHz (multi-carrier mode) | 6.62 MHz (single-carrier mode) 1.75 kHz (multi-carrier mode) | 7.56 MHz (single-carrier mode) 2.0 kHz (multi-carrier mode) |
| 8 | Frame header duration | 1/9, 1/6, 1/4 of frame body of the signal frame duration 74.07, 104.94, 166.67 μs | 1/9, 1/6, 1/4 of frame body of the signal frame duration 63.49, 89.95, 142.86 μs | 1/9, 1/6, 1/4 of frame body of the signal frame duration 55.56, 78.70, 125.00 μs |
| 9 | Overall signal frame duration | 740.74, 771.60, 833.33 μs | 634.92, 661.38, 714.29 μs | 555.56, 578.70, 625.00 μs |
| 10 | Transmission frame duration | Day-frame of 24 hours, minute-frame of 60 s, super-frame of 166.7 ms, and signal-frames of 740.74, 771.60, 833.33 μs | Day-frame of 24 hours, minute-frame of 60 s, super-frame of 142.8 ms, and signal-frames of 634.92, 661.38, 714.29 μs | Day-frame of 24 hours, minute-frame of 60 s, super-frame of 125 ms,  and signal-frames of 555.56, 578.70, 625.00 μs |
| 11 | Inner channel LDPC code | 0.4 (7 488, 3 008),  0.6 (7 488, 4 512),  0.8 (7 488, 6 016) | 0.4 (7 488, 3 008),  0.6 (7 488, 4 512),  0.8 (7 488, 6 016) | 0.4 (7 488, 3 008),  0.6 (7 488, 4 512),  0.8 (7 488, 6 016) |
| 12 | Inner interleaving in frequency domain | Inside one signal frame (multi-carrier mode) | Inside one signal frame (multi-carrier mode) | Inside one signal frame (multi-carrier mode) |

TABLE 1 (*continued*)

d)  Single- and multi-carrier combined systems (*end*)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Parameters | 6 MHz | 7 MHz | 8 MHz |
| 13 | Outer channel BCH code | BCH (762, 752) derived from BCH (1 023, 1 013) | BCH (762, 752) derived from BCH (1 023, 1 013) | BCH (762, 752) derived from BCH (1 023, 1 013) |
| 14 | Outer convolutional interleaving in time domain | Number of interleaving branches B = 52, interleaving depth  M = 240, 720 | Number of interleaving branches B = 52, interleaving depth  M = 240, 720 | Number of interleaving branches B = 52, interleaving depth  M = 240, 720 |
| 15 | Data randomization/ energy dispersal | PRBS | PRBS | PRBS |
| 16 | Time/frequency synchronization | PN sequence as the frame header of signal frame(15) | PN sequence as the frame header of signal frame(15) | PN sequence as the frame header of signal frame(15) |
| 17 | System information | Carried by 36 system information symbol per signal frame | Carried by 36 system information symbol per signal frame | Carried by 36 system information symbol per signal frame |
| 18 | System transport stream format | MPEG-2 TS | MPEG-2 TS | MPEG-2 TS |
| 19 | Net data rate | Depending on modulation, code and frame header (3.610-24.436 Mbit/s) | Depending on modulation, code and frame header (4.211-28.426 Mbit/s) | Depending on modulation, code and frame header (4.813-32.486 Mbit/s) |
| 20 | Carrier-to-noise ratio in an AWGN channel | Depending on modulation and channel code. 2.5-22.0 dB(16) | Depending on modulation and channel code. 2.5-22.0 dB(16) | Depending on modulation and channel code. 2.5-22.0 dB(16) |

e)  TDS Multi-carrier systems

| No. | Parameters | | 6 MHz multi-carrier (OFDM) | 7 MHz multi-carrier (OFDM) | 8 MHz multi-carrier (OFDM) |
| --- | --- | --- | --- | --- | --- |
| 1 | Used bandwidth | | 5.67 MHz with the roll off factor of 0.05, 5.83 MHz with the roll off factor of 0.025 | 6.62 MHz with the roll off factor of 0.05, 6.81 MHz with the roll off factor of 0.025 | 7.56 MHz with the roll off factor of 0.05, 7.78 MHz with the roll off factor of 0.025 |
| 2 | Number of radiated carriers | 4k mode | 4 096 | 4 096 | 4 096 |
| 8k mode | 8 192 | 8 192 | 8 192 |
| 32k mode | 32 678 | 32 678 | 32 678 |
| 3 | Modulation modes | | Constant coding and modulation (CCM)/ variable coding and modulation (VCM) | | |
| 4 | Modulation method | | QPSK, 16-APSK, 64‑APSK, 256-/APSK specific for each Service Channel | | |
| 5 | Channel occupancy(17) | | See Recommendation ITU-R BT.1206 | | |

TABLE 1 (*continued*)

e)  TDS Multi-carrier systems (*continued*)

| No. | Parameters | | 6 MHz multi-carrier (OFDM) | 7 MHz multi-carrier (OFDM) | 8 MHz multi-carrier (OFDM) |
| --- | --- | --- | --- | --- | --- |
| 6 | Active symbol duration | 4k mode | 722.40 μs with the roll off factor of 0.05, 702.17 μs with the roll off factor of 0.025 | 619.20 μs with the roll off factor of 0.05, 601.86 μs with the roll off factor of 0.025 | 541.80 μs with the roll off factor of 0.05, 526.63 μs with the roll off factor of 0.025 |
| 8k mode | 1444.80 μs with the roll off factor of 0.05, 1404.34 μs with the roll off factor of 0.025 | 1238.40 μs with the roll off factor of 0.05, 1203.72 μs with the roll off factor of 0.025 | 1083.60 μs with the roll off factor of 0.05, 1053.26 μs with the roll off factor of 0.025 |
| 32k mode | 5779.19 μs with the roll off factor of 0.05, 5617.37 μs with the roll off factor of 0.025 | 4953.60 μs with the roll off factor of 0.05, 4814.89 μs with the roll off factor of 0.025 | 4334.40 μs with the roll off factor of 0.05, 4213.03 μs with the roll off factor of 0.025 |
| 7 | Carrier spacing | 4k mode | 1 384 Hz with the roll off factor of 0.05, 1 424 Hz with the roll off factor of 0.025 | 1 615 Hz with the roll off factor of 0.05, 1 662 Hz with the roll off factor of 0.025 | 1 846 Hz with the roll off factor of 0.05, 1 899 Hz with the roll off factor of 0.025 |
| 8k mode | 692 Hz with the roll off factor of 0.05, 712 Hz with the roll off factor of 0.025 | 807 Hz with the roll off factor of 0.05, 831 Hz with the roll off factor of 0.025 | 923 Hz with the roll off factor of 0.05, 949 Hz with the roll off factor of 0.025 |
| 32k mode | 173 Hz with the roll off factor of 0.05, 178 Hz with the roll off factor of 0.025 | 202 Hz with the roll off factor of 0.05, 208 Hz with the roll off factor of 0.025 | 231 Hz with the roll off factor of 0.05, 237 Hz with the roll off factor of 0.025 |
| 8 | Guard interval duration | 4k mode  (1/8, 1/4, 1/2) | 90.3, 181, 361 μs with the roll off factor of 0.05.  87.8, 176, 351 μs with the roll off factor of 0.025 | 77.4, 155, 310 μs with the roll off factor of 0.05.  75.2, 150, 301 μs with the roll off factor of 0.025 | 67.7, 135, 271 μs with the roll off factor of 0.05.  65.8, 132, 263 μs with the roll off factor of 0.025 |
| 8k mode  (1/16, 1/8, 1/4) | 90.3, 181, 361 μs with the roll off factor of 0.05.  87.8, 176, 351 μs with the roll off factor of 0.025 | 77.4, 155, 310 μs with the roll off factor of 0.05.  75.2, 150, 301 μs with the roll off factor of 0.025 | 67.7, 135, 271 μs with the roll off factor of 0.05.  65.8, 132, 263 μs with the roll off factor of 0.025 |
| 32k mode  (1/64, 1/32, 1/16) | 90.3, 181, 361 μs with the roll off factor of 0.05.  87.8, 176, 351 μs with the roll off factor of 0.025 | 77.4, 155, 310 μs with the roll off factor of 0.05.  75.2, 150, 301 μs with the roll off factor of 0.025 | 67.7, 135, 271 μs with the roll off factor of 0.05.  65.8, 132, 263 μs with the roll off factor of 0.025 |

TABLE 1 (*continued*)

e)  TDS Multi-carrier systems (*continued*)

| No. | Parameters | | 6 MHz multi-carrier (OFDM) | 7 MHz multi-carrier (OFDM) | 8 MHz multi-carrier (OFDM) |
| --- | --- | --- | --- | --- | --- |
| 9 | Overall symbol duration | 4k mode | 813, 903, 1 084 μs with the roll off factor of 0.05.  790, 878, 1 053 μs with the roll off factor of 0.025 | 679, 774, 929 μs with the roll off factor of 0.05.  677, 752, 903 μs with the roll off factor of 0.025 | 610, 677, 813 μs with the roll off factor of 0.05.  592, 658, 790 μs with the roll off factor of 0.025 |
| 8k mode | 1 535, 1 625, 1 806 μs with the roll off factor of 0.05.  1 492, 1 580, 1 755 μs with the roll off factor of 0.025 | 1 316, 1 393, 1 548 μs with the roll off factor of 0.05.  1 279, 1 354, 1 505 μs with the roll off factor of 0.025 | 1 151, 1 219, 1 354 μs with the roll off factor of 0.05.  1 119, 1 185, 1 317 μs with the roll off factor of 0.025 |
| 32k mode | 5 869, 5 960, 6 140 μs with the roll off factor of 0.05.  5 705, 5 793, 5 968 μs with the roll off factor of 0.025 | 5 031, 5 108, 5 263 μs with the roll off factor of 0.05.  4 890, 4 965, 5 116 μs with the roll off factor of 0.025 | 4 402, 4 470, 4 605 μs with the roll off factor of 0.05.  4 279, 4 345, 4 467 μs with the roll off factor of 0.025 |
| 10 | Super frame duration | | Super frame starts with super-frame synchronization channel and a control channel for service channel signalling. Each super-frame has configurable number of data signal frames, with maximum duration of 250 μs | | |
| 11 | Input stream format | | Transport streams (TS) | | |
| 12 | Channel coding | | LDPC/BCH code with block size of 61 440 or 15 360 bits and code rates of 1/2, 2/3, 5/6 | | |
| 13 | Interleaving | | Bit interleaving, bit permutation and time interleaving separately for each service channel | | |
| 14 | Service Channel | | Support for multiple service channels. Modulation, coding and time interleaving depth selectable separately for each service channel | | |
| 15 | Data randomization/ energy dispersal | |  | | |
| Initial scan | | Fast scan process with special super-frame synchronization channel | | |
| 16 | Time/frequency synchronization | | Super-frame synchronization channel and dual PN-MC symbols of each signal frame | | |
| 17 | Multiple input single output (MISO) | | An optional 2 × 1 MISO configuration with Alamouti coding in the space-frequency domain | | |
| 18 | Receiver power consumption reduction | | Service channels are organized in both time and frequency domains. When receiving a single service channel only the service channel signalling and relevant slices are received and processed | | |
| 19 | Service channel signalling | | Service channel signalling is carried by control channel in the super frame. The signal frame size for the control channel is 4096, and the PM-MC symbol length is 1024, modulated with QPSK and coded with punctured 2/3 15360 LDPC for OFDM. | | |
| 20 | Peak-to-average power ratio (PAPR) | | Special active constellation extension (ACE) for APSK constellation as options | | |
| 21 | Extension Frame | | A super frame can include extension frame. The extension frame can be used as NULL signals or for uplink services | | |

TABLE 1 (*end*)

e)  TDS Multi-carrier systems (*end*)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | Parameters | 6 MHz multi-carrier (OFDM) | 7 MHz multi-carrier (OFDM) | 8 MHz multi-carrier (OFDM) |
| 22 | Payload | 3.75-37 Mbit/s with the roll off factor of 0.05, 3.86-38 Mbit/s with the roll off factor of 0.025, depending on FFT-size, modulation, code rate, guard interval | 4.38-43.1 Mbit/s with the roll off factor of 0.05, 4.5-44.4 Mbit/s with the roll off factor of 0.025, depending on FFT-size, modulation, code rate, guard interval | 5.0-49.31 Mbit/s with the roll off factor of 0.05, 5.14‑50.73 Mbit/s with the roll off factor of 0.025, depending on FFT-size, modulation, code rate, guard interval |
| 23 | Carrier-to-noise ratio over AWGN channel | Depending on modulation and channel code. 0.62-21.08 dB @ BER=1E-5, for the 7.56 MHz system bandwidth | | |
| APSK: amplitude and phase shift keying  BCH: Bose – Chandhuri – Hocquenghem multiple error correction binary block code  LDPC: low-density parity check  MPE-FEC: multi-protocol encapsulation-forward error correction  NR: nordstrom robinson  OFDM: orthogonal frequency division multiplex  PN-MC: multi-carrier PN-sequence  PRBS: pseudo-random binary sequence  QPSK: quaternary phase shift keying  TMCC: transmission and multiplexing configuration control  VSB: vestigial side band.  (1) Measured value. After RS decoding, error rate 3 × 10−6.  (2) The *C*/*N* ratios are 9.2 dB for 1/2 rate concatenated trellis coding and 6.2 dB for 1/4 rate concatenated trellis coding.  (3) The 2k mode can be used for single transmitter operation, for single frequency gap-fillers and for small single frequency network. The 8k mode can be used for the same network structures and also for large single frequency network. The 4k mode offers an additional trade-off between transmission cell size and mobile reception capabilities, providing an additional degree of flexibility for network planning of handheld and mobile coverage.  (4) 16-QAM, 64-QAM, MR-16-QAM and MR-64-QAM (MR-QAM: non-uniform QAM constellations), may be used for hierarchical transmission schemes. In this case two layers of modulation carry two different MPEG-2 transport streams. The two layers may have different code rates and can be decoded independently.  (5) In-depth symbol interleaver for the 2k and 4k modes for further improving their robustness in mobile environment and impulse noise conditions.  (6) Pilot carriers are continual pilots, carried by 45 (2k mode) or 177 (8k mode) carriers on all OFDM symbols, and scattered pilots, spread in time and frequency.  (7) For improvement in *C*/*N* performance and Doppler performance in mobile channels.  (8) In order to reduce the average power consumption of the terminal and enabling seamless frequency handover.  (9) TPS pilots carry information on modulation, code rate and other transmission parameters.  (10) The choice of modulation, code rate and guard interval depends on service requirements and planning environment.  (11) Simulated with perfect channel estimation, non-hierarchical modes. Error rate before RS decoding  2 × 10–4, error rate after RS decoding 1 × 10–11.  (12) Radio-frequency band segmentation allows use of appropriate modulation and error correction scheme segment by segment, and reception of a centre segment with narrow-band receivers.  (13) Multi-carrier systems with radio-frequency band segmentation uses 13 segments for television services while any number of segments may be used for other services such as sound services.  (14) Error rate before RS decoding 2 × 10–4, error rate after RS decoding 1 × 10–11.  (15) The signal frame consists of frame header (FH) and frame body (FB). FH uses pseudo-random binary sequence and single-carrier modulation as both the guard interval and the training sequence for the synchronization as well as channel estimation. FB has 3 744 data and 36 information symbols and could be modulated using either the single-carrier or multi-carrier scheme.  (16)  Error rate after BCH decoding 3 × 10−6.  (17) The parameter “Channel occupancy” is related to spectrum limit mask. Recommendation ITU-R SM.1541 provides out-of-band domain emission limits regarded as generic spectrum limit masks, which include digital terrestrial television broadcasting systems. Recommendation ITU-R BT.1206 provides specific spectrum limit masks for digital terrestrial television broadcasting systems for specific environments to enhance compatibility with other radiocommunication services. | | | | |

Attachment 1  
to Annex 1  
  
System A Standard

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Attachment 2  
to Annex 1  
  
System B Standard

Bibliography

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ETSI EN 301 192. Digital Video Broadcasting (DVB); DVB specification for data broadcasting.

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Attachment 3  
to Annex 1  
  
System C Standard

Bibliography

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ABNT ABNT NBR 15603 (Part 1-3). Digital terrestrial television – Multiplexing and service information (SI).

ABNT ABNT NBR 15604. Digital terrestrial television – Receivers.

ABNT ABNT NBR 15605. Digital terrestrial television – Security issues.

ABNT ABNT NBR 15606 (Part 1-5). Digital terrestrial television – Data coding and transmission specification.

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ARIB ARIB STD-B24. Data coding and transmission specification for digital broadcasting.

ARIB ARIB STD-B25. Conditional access system specifications for digital broadcasting.

ARIB ARIB STD-B31. Transmission system for digital terrestrial television broadcasting.

ARIB ARIB STD-B32. Video coding. Audio coding and multiplexing specifications for digital broadcasting.

Attachment 4  
to Annex 1  
  
System D Standard

Bibliography

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Attachment 5  
to Annex 1  
  
System E Standard

Bibliography

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Attachment 6  
to Annex 1  
  
System selection guideline

The process of selecting a suitable system may be thought of as an iterative one involving three phases:

– Phase I: an initial assessment of which system is most likely to meet the broadcaster’s main requirements taking into account the prevailing technical/regulatory environment.

– Phase II: a more detailed assessment of the “weighted” differences in performance.

– Phase III: an overall assessment of the commercial and operational factor impacting the system choice.

Given below is a fuller description of these three phases.

Phase I: Initial assessment

As a starting point, Table 2 may be used to assess which of the systems would best meet a particular broadcasting requirement.

TABLE 2

Guideline for the initial selection

|  |  |  |
| --- | --- | --- |
| Requirements | | Suitable systems |
| Maximum data rate in a Gaussian channel for a given *C*/*N* threshold | Required | A, D or E |
| Not required | A, B, C, D or E |
| Maximum ruggedness against multipath interference (1) | Required | B, C, D or E |
| Not required | A, B, C, D or E |
| Single frequency networks (SFNs) | Required | B, C, D or E |
| Not required | A, B, C, D or E |
| Mobile reception (1), (2) | Required | B, C, D or E |
| Not required | A, B, C, D or E |
| Simultaneous transmission of different quality levels  (hierarchical transmission) | Of primary importance | C |
| Required | B or C |
| Not required | A, B, C, D or E |
| Independent decoding of data sub-blocks (for example, to facilitate sound broadcasting) | Required | C |
| Not required | A, B, C, D or E |
| Maximum coverage from central transmitter at a given power in a Gaussian environment (3) | Required | A, D or E |
| Not required | A, B, C, D or E |
| Maximum ruggedness against impulse interference (4) | Required | A, C, D or E |
| Not required | A, B, C, D or E |
| *Notes relating to Table 2*:  (1) Tradable against bandwidth efficiency and other system parameters.  (2) It may not be possible to provide HDTV reception in this mode.  (3) For all systems in situations with coverage holes, gap filler transmitters will be required.  (4) Systems B and C in 8K mode are applied for this comparison. | | |

Phase II: Assessment of the weighted differences in performance

After an initial assessment has been made on the basis of Table 2, a more thorough selection process will require comparative evaluation of the performance of the candidate systems. This is the case because the choice of selection parameters itself is not a simple “black or white” selection. In any given situation, any particular criterion will be of greater or lesser significance in the broadcasting environment under study which means that there has to be a means to identify a balance between small differences in performance and more important or less important selection parameters. In other words, it is clear that a small difference between systems against a critical parameter is likely to influence the choice more than large differences against relatively less important selection criteria.

The following methodology is recommended for this phase of system assessment:

*Step 1:* requires the identification of performance parameters that are relevant to the circumstances of the administration or broadcaster wishing to choose a DTTB system. These parameters might include the inherent performance capabilities of the digital system in itself, its compatibility with existing analogue services and the need for interoperability with other image communications or broadcasting services.

*Step 2:* requires the assignment of “weights” to the parameters in order of importance or criticality to the environment in which the digital TV service is to be introduced. This weighting might be a simple multiplier such as 1 for “normal” and 2 for “important”.

*Step 3:* involves the accumulation of test data from (preferably both) laboratory and field trials. This data can be gathered direct by the parties involved in the evaluation or may be obtained from others who have undertaken trials or evaluations. It is expected that Radiocommunication Study Group 6 (formerly Study Group 11) will, in the near future, prepare a report providing full technical evidence on the different DTTB systems, which may be used where adequate test data is not available from other reliable sources.

*Step 4:* then requires the matching of test data with performance parameters and the determination of a “rating” against each parameter. The overall rating is used to choose a system that best matches the requirements. A tabular structure that uses a simple numerical rating and weighting scale has been found useful by some administrations. It is taken as a “given” that all candidate systems are able to provide a viable DTTB service. Accordingly, the differences between systems will be relatively small. It is desirable to avoid unnecessary exaggeration of the differences but, at the same time, take care to ensure that the selection process is matched to the needs of the intended service. A simple and compact numerical rating scale can be one way to achieve these goals.

The following scales are examples that might be useful:

|  |  |
| --- | --- |
| Performance | Rating |
| Satisfactory | 1 |
| Better | 2 |
| Best | 3 |

In this scale a 0 (or null) value is given for a system that does not provide satisfactory performance against a given parameter or for a parameter that is unable to be evaluated.

|  |  |
| --- | --- |
| Importance | Weighting |
| Normal | 1 |
| Significant | 2 |
| Critical | 3 |

The following is an example of a tabular structure that might be used for comparative assessment of various systems.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| No. | Criterion | System performance | | | | | Weighting | System rating | | | | |
| A | B | C | D | E | A | B | C | D | E |
| 1 | Characteristics of transmitted signals |  |  |  |  |  |  |  |  |  |  |  |
| A | Robustness of signal |  |  |  |  |  |  |  |  |  |  |  |
|  | Immunity of electrical interference |  |  |  |  |  |  |  |  |  |  |  |
|  | Efficiency of transmitted signal |  |  |  |  |  |  |  |  |  |  |  |
|  | Effective coverage |  |  |  |  |  |  |  |  |  |  |  |
|  | Reception using indoor antenna |  |  |  |  |  |  |  |  |  |  |  |
|  | Adjacent channel performance |  |  |  |  |  |  |  |  |  |  |  |
|  | Co-channel performance |  |  |  |  |  |  |  |  |  |  |  |
| B | Resilience to distortions |  |  |  |  |  |  |  |  |  |  |  |
|  | Resilience to multipath distortions |  |  |  |  |  |  |  |  |  |  |  |
|  | Mobile reception |  |  |  |  |  |  |  |  |  |  |  |
|  | Portable reception |  |  |  |  |  |  |  |  |  |  |  |

Phase III: Assessment of commercial and operational aspects

The final phase is an assessment of the commercial and operational aspects to ascertain which of the systems is indeed the best solution overall. Such an assessment will take into account the required timescales to service implementation, cost and availability of equipment, interoperability within an evolving broadcasting environment, etc.

Compatible receiver

In the cases where it is necessary to receive more than one modulation system option, compatible receivers will be needed. The cost of such receivers, taking into account the progress in digital technologies, should not be significantly more than receivers for a single modulation system, but the advantages of such receivers could be important. They may open the door to attractive additional possibilities and services for the consumer and broadcaster as indicated by Table 2. Studies continue on this matter.