

(Draft) Botswana ISDB-T Standard

Technical parameters related to ISDB-T system in Botswana shall be in accordance with the standards summarized in Annex 1. Details of each part of the system are defined in the following sections.

1. Transmission

All technical parameters related to channel coding shall be in accordance with ARIB STD-B31 / ABNT NBR 15601.

8 MHz transmission parameters shall be in accordance with Table 1-1 to 1-5 as follows.

Table 1-1: OFDM-Segment Parameters (8MHz bandwidth system)

Mode		Mode 1		Mode 2		Mode 3	
Segments Bandwidth (Bws)		$8000/14 = 571.428\dots$ kHz					
Spacings between carrier frequencies		$Bws/108 = 5.291\dots$ kHz		$Bws/216 = 2.645\dots$ kHz		$Bws/432 = 1.322\dots$ kHz	
Number of carriers	Total Count	108	108	216	216	432	432
	Data	96	96	192	192	384	384
	SP ^{*1}	9	0	18	0	36	0
	CP ^{*1}	0	1	0	1	0	1
	TMCC ^{*2}	1	5	2	10	4	20
	AC1 ^{*3}	2	2	4	4	8	8
	AC2 ^{*3}	0	4	0	9	0	19
Carrier modulation Scheme		QPSK 16QAM 64QAM	DQPSK	QPSK 16QAM 64QAM	DQPSK	QPSK 16QAM 64QAM	DQPSK
Symbols per frame		204					
Effective symbol Length		189 μ s		378 μ s		756 μ s	
Guard interval		47.25 μ s (1/4), 23.625 μ s (1/8), 11.8125 μ s (1/16), 5.90625 μ s (1/32)		94.5 μ s (1/4), 47.25 μ s (1/8), 23.625 μ s (1/16), 11.8125 μ s (1/32)		189 μ s (1/4), 94.5 μ s (1/8), 47.25 μ s (1/16), 23.625 μ s (1/32)	
Symbol length		236.25 μ s (1/4), 212.625 μ s (1/8), 200.8125 μ s (1/16), 194.90625 μ s (1/32)		472.5 μ s (1/4), 425.25 μ s (1/8), 401.625 μ s (1/16), 389.8125 μ s (1/32)		945 μ s (1/4), 850.5 μ s (1/8), 803.25 μ s (1/16), 779.625 μ s (1/32)	

Frame length	48.195 ms (1/4), 43.3755 ms (1/8), 40.96575ms(1/16), 39.760875ms(1/32)	96.39 ms (1/4), 86.751 ms (1/8), 81.9315 ms (1/16), 79.52175 ms (1/32)	192.78 ms (1/4), 173.502 ms (1/8), 163.863 ms (1/16), 159.0435 ms (1/32)
IFFT sampling Frequency ^{*4}	2048/189 = 10.835978... MHz		
Inner code	Convolutional code (1/2, 2/3, 3/4, 5/6, 7/8)		
Outer code	RS (204,188)		

*1: *SP (Scattered Pilot) and CP (Continual Pilot) are used by the receiver for synchronization and demodulation purposes.*

*2: *TMCC (Transmission and Multiplexing Configuration Control) is control information.*

*3: *AC (Auxiliary Channel) is used to transmit additional information. AC1 is available in an equal number in all segments, while AC2 is available only in differential modulated segments.*

*4: *The IFFT sampling frequency for use with OFDM for digital terrestrial television broadcasting must be as follows:*

IFFT sampling frequency = 10.835978... MHz

Note also that the permissible deviation must be ±0.2 ppm.

Table 1-2: Transmission-signal Parameters(8MHz bandwidth system)

Mode		Mode 1	Mode 2	Mode 3
Number of OFDM segments (Ns)		13		
Bandwidth (Bw)		$Bws \times Ns + Cs = 7.433...MHz$	$Bws \times Ns + Cs = 7.431...MHz$	$Bws \times Ns + Cs = 7.429...MHz$
Number of segments of differential modulations		Nd		
Number of segments of synchronous modulations		Ns ($ns + nd = Ns$)		
Spacings between carrier frequencies(Cs)		$Bws/108 = 5.291... kHz$	$Bws/216 = 2.645... kHz$	$Bws/432 = 1.322... kHz$
Number of carriers	Total Count	$108 \times Ns + 1 = 1405$	$216 \times Ns + 1 = 2809$	$432 \times Ns + 1 = 5617$
	Data	$96 \times Ns = 1248$	$192 \times Ns = 2496$	$384 \times Ns = 4992$
	SP	$9 \times ns$	$18 \times ns$	$36 \times ns$
	CP*1	$nd + 1$	$nd + 1$	$nd + 1$
	TMCC	$ns + 5 \times nd$	$2 \times ns + 10 \times nd$	$4 \times ns + 20 \times nd$
	AC1	$2 \times Ns = 26$	$4 \times Ns = 52$	$8 \times Ns = 104$
	AC2	$4 \times nd$	$9 \times nd$	$19 \times nd$
Carrier modulation Scheme		QPSK, 16QAM, 64QAM, DQPSK		
Symbols per frame		204		
Effective symbol Length		189 μs	378 μs	756 μs
Guard interval		47.25 μs (1/4), 23.625 μs (1/8), 11.8125 μs (1/16), 5.90625 μs (1/32)	94.5 μs (1/4), 47.25 μs (1/8), 23.625 μs (1/16), 11.8125 μs (1/32)	189 μs (1/4), 94.5 μs (1/8), 47.25 μs (1/16), 23.625 μs (1/32)
Symbol length		236.25 μs (1/4), 212.625 μs (1/8), 200.8125 μs (1/16), 194.90625 μs (1/32)	472.5 μs (1/4), 425.25 μs (1/8), 401.625 μs (1/16), 389.8125 μs (1/32)	945 μs (1/4), 850.5 μs (1/8), 803.25 μs (1/16), 779.625 μs (1/32)
Frame length		48.195 ms (1/4), 43.3755 ms (1/8), 40.96575ms(1/16), 39.760875ms(1/32)	96.39 ms (1/4), 86.751 ms (1/8), 81.9315 ms (1/16), 79.52175 ms (1/32)	192.78 ms (1/4), 173.502 ms (1/8), 163.863 ms (1/16), 159.0435 ms (1/32)
Interleaving	Frequency	both inter-segment and intra-segment interleaving		
	Time	l=0 (0Symbol), l=4 (380Symbol), l=8 (760Symbol), l=16 (1520Symbol)	l=0 (0Symbol), l=2 (190Symbol), l=4 (380Symbol), l=8 (760Symbol)	l=0 (0Symbol), l=1 (95Symbol), l=2 (190Symbol), l=4 (380Symbol)
Inner code		Convolutional code (1/2, 2/3, 3/4, 5/6, 7/8)		
Byte Interleave		Convolutional byte interleaving at every 12 byte		
Outer code		RS (204,188)		

*1: The number of CPs represents the sum of those CPs in segments, plus one CP added to the right of the entire bandwidth.

Table 1-3: Data Rate of a Single Segment (8MHz bandwidth system)

Carrier modulation	Convolutional code	Number of TSPs transmitted* ¹ (Mode 1/2/3)	Data rate (kbps) * ²			
			Guard ratio: 1/4	Guard ratio: 1/8	Guard ratio: 1/16	Guard ratio: 1/32
DQPSK QPSK	1/2	12/ 24/ 48	374.47	416.08	440.56	453.91
	2/3	16/ 32/ 64	499.30	554.78	587.41	605.21
	3/4	18/ 36/ 72	561.71	624.13	660.84	680.87
	5/6	20/ 40/ 80	624.13	693.47	734.27	756.52
	7/8	21/ 42/ 84	655.33	728.15	770.98	794.34
16QAM	1/2	24/ 48 / 96	748.95	832.17	881.12	907.82
	2/3	32/ 64 / 128	998.60	1109.56	1174.83	1210.43
	3/4	36/ 72 / 144	1123.43	1248.26	1321.68	1361.74
	5/6	40/ 80 / 160	1248.26	1386.95	1468.54	1513.04
	7/8	42/ 84 / 168	1310.67	1456.30	1541.97	1588.69
64QAM	1/2	36/ 72 / 144	1123.43	1248.26	1321.68	1361.74
	2/3	48/ 96 / 192	1497.91	1664.34	1762.25	1815.65
	3/4	54/ 108 / 216	1685.15	1872.39	1982.53	2042.61
	5/6	60/ 120 / 240	1872.39	2080.43	2202.81	2269.56
	7/8	63/ 126 / 252	1966.01	2184.45	2312.95	2383.04

*1: Represents the number of TSPs transmitted per frame.

*2: Represents the data rate (bits) per segment for transmission parameters.

Data rate (bits): TSPs transmitted × 188 (bytes/TSP) × 8 (bits/byte) × 1/frame length.

Table 1-4: Total Data Rate*¹ (8MHz bandwidth system)

Carrier modulation	Convolutional code	Number of TSPs transmitted* ¹ (Mode 1/2/3)	Data rate (Mbps)			
			Guard ratio: 1/4	Guard ratio: 1/8	Guard ratio: 1/16	Guard ratio: 1/32
DQPSK QPSK	1/2	156 / 312 / 624	4.868	5.409	5.727	5.900
	2/3	208 / 416 / 832	6.490	7.212	7.636	7.867
	3/4	234 / 468 / 936	7.302	8.113	8.590	8.851
	5/6	260 / 520 / 1040	8.113	9.015	9.545	9.834
	7/8	273 / 546 / 1092	8.519	9.465	10.022	10.326
16QAM	1/2	312 / 624 / 1248	9.736	10.818	11.454	11.801
	2/3	416 / 832 / 1664	12.981	14.424	15.272	15.735
	3/4	468 / 936 / 1872	14.604	16.227	17.181	17.702
	5/6	520 / 1040 / 2080	16.227	18.030	19.091	19.669
	7/8	546 / 1092 / 2184	17.038	18.931	20.045	20.653
64QAM	1/2	468 / 936 / 1872	14.604	16.227	17.181	17.702
	2/3	624 / 1248 / 2496	19.472	21.636	22.909	23.603
	3/4	702 / 1404 / 2808	21.907	24.341	25.772	26.553
	5/6	780 / 1560 / 3120	24.341	27.045	28.636	29.504
	7/8	819 / 1638 / 3276	25.558	28.397	30.068	30.979

*1: This table shows an example of the total data rate in which the same parameters are specified for all 13 segments. Note that the total data rate during hierarchical transmission varies depending on the hierarchical parameter configuration. In the case shown above, the data volume transmitted by all 13 segments is equal to the sum of all data volumes transmitted by these segments that can be determined based on Table A-3.

Table 1-5: Channel Table

Channel	Start Frequency (MHz)	End Frequency (MHz)	Center Frequency (MHz)
5	174	182	178
6	182	190	186
7	190	198	194
8	198	206	202
9	206	214	210
10	214	222	218
11	222	230	226
21	470	478	474
22	478	486	482

23	486	494	490
24	494	502	498
25	502	510	506
26	510	518	514
27	518	526	522
28	526	534	530
29	534	542	538
30	542	550	546
31	550	558	554
32	558	566	562
33	566	574	570
34	574	582	578
35	582	590	586
36	590	598	594
37	598	606	602
38	606	614	610
39	614	622	618
40	622	630	626
41	630	638	634
42	638	646	642
43	646	654	650
44	654	662	658
45	662	670	666
46	670	678	674
47	678	686	682
48	686	694	690
49	694	702	698
50	702	710	706
51	710	718	714
52	718	726	722
53	726	734	730
54	734	742	738
55	742	750	746
56	750	758	754
57	758	766	762
58	766	774	770
59	774	782	778
60	782	790	786
61	790	798	794
62	798	806	802
63	806	814	810
64	814	822	818
65	822	830	826
66	830	838	834
67	838	846	842
68	846	854	850
69	854	862	858

NOTE: These channels from ch21 to ch48 are recommended by the report of SADC Sub-Regional GE06 Frequency Coordination Workshop on the Transition to Digital Terrestrial Television (DTT) published on 24th August 2012.

Spectrum mask characteristics should be in accordance with Figure 1-1 and Table 1-6 which are described in ITU-R Recommendation BT.1206-1.

Figure 1-1: Spectrum limit masks for 8 MHz

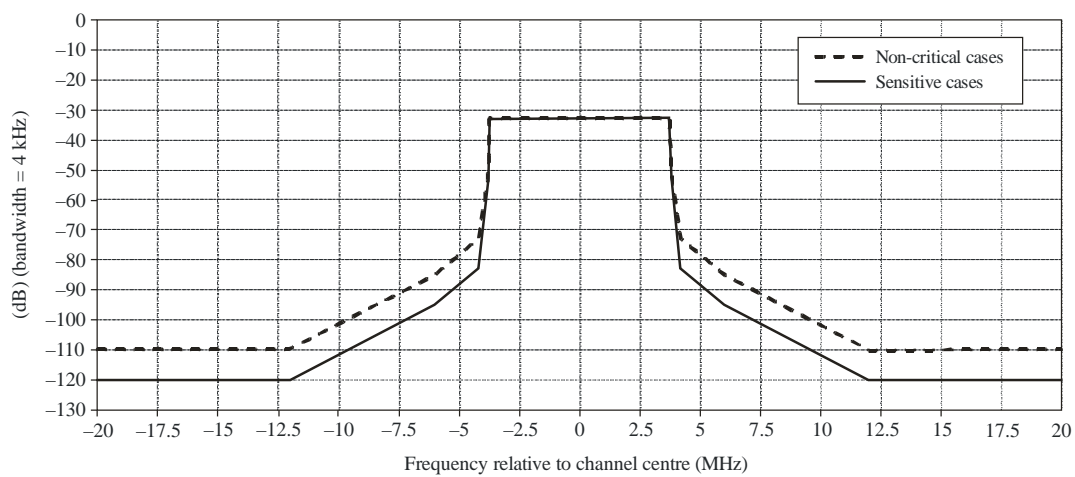


Table 1-6: Break points corresponding to Figure 1-1

Frequency relative to the centre of the 8 MHz channel (MHz)	Relative level in a 4 kHz measurement bandwidth (dB)	
	Non-critical emission mask	Sensitive cases
-20	-110	-120
-12	-110	-120
-6	-85	-95
-4.2	-73	-83
-3.81	-52.7	-52.7
-3.72	-32.7	-32.7
+3.72	-32.7	-32.7
+3.81	-52.7	-52.7
+4.2	-73	-83
+6	-85	-95
+12	-110	-120
+20	-110	-120

2. Video Coding

All technical parameters related to video coding shall be in accordance with ARIB STD-32 Part 1 / ABNT NBR 15602-1. The frame rate of 25 Hz and 50 Hz, and the video format of 576i and 576p shall be supported. The parameters which can be taken are shown in Table 2-1 and Table 2-2.

Table 2-1: Video signal parameters for Full-Seg services

Number of horizontal pixels	Number of vertical pixels	Frame rate [Hz]	Scanning system	Aspect ratio	Profile and level
720	576	25	Interlaced	4:3 16:9	MPEG-2 MP@ML H.264 MPEG-4 AVC HP@L3
720	576	50	Progressive	16:9	MPEG-2 MP@H14L H.264 MPEG-4 AVC HP@L3.1
1280	720	50	Progressive	16:9	MPEG-2 MP@HL H.264 MPEG-4 AVC HP@L4
1920	1080	25	Interlaced	16:9	MPEG-2 MP@HL H.264 MPEG-4 AVC HP@L4
1920	1080	25	Progressive	16:9	MPEG-2 MP@HL H.264 MPEG-4 AVC HP@L4

Table 2-2: Video signal parameters for One-Seg services

Video format	CIF (352 x 288) QVGA (320 x 240 or 320 x 180) SQVGA (160 x 120 or 160 x 90)
Frame rate	5, 10, 12, 15, 24, 25, 30 fps
Aspect ratio	4:3, 16:9
Profile and level	H.264 MPEG-4 AVC BP@L1.3

3. Audio Coding

All technical parameters related to audio coding shall be in accordance with ARIB STD-B32 Part 2 / ABNT NBR 15602-2. With respect to MPEG-4 AAC, ABNT NBR 15602-2 shall be followed.

4. Multiplexing

All technical parameters related to multiplex shall be in accordance with ARIB STD-B32 Part 3 / ABNT NBR 15602-3.

5. Service information

All technical parameters related to Service Information shall be in accordance with ARIB STD-B10 / ABNT NBR 15603.

With respect to Terrestrial delivery system descriptor, section 1 of this document shall be followed.

With respect to Component descriptor and Video decode control descriptor, section 2 of this document shall be followed.

6. Receiver

All technical parameters related to receivers shall be in accordance with ARIB STD-B21 / ABNT NBR 15604 except digital satellite broadcasting, CA module interface, IEEE1394 interface and server-type broadcast receiving function.

6.1. Specifications of DIRD

The Digital Integrated Receiver Decoder (DIRD) must satisfy the following specifications.

6.1.1. Input

Table 6-1: Received frequency and Center frequency (VHF band)

Receiving channel	Received frequency	Center frequency
VHF ch 5	174MHz to 182MHz	178 MHz
VHF ch 6	182MHz to 190MHz	186 MHz
VHF ch 7	190MHz to 198MHz	194 MHz
VHF ch 8	198MHz to 206MHz	202 MHz
VHF ch 9	206MHz to 214MHz	210 MHz
VHF ch 10	214MHz to 222MHz	218 MHz–
VHF ch 11	222MHz to 230MHz	226MHz

Table 6-2: Received frequency and Center frequency (UHF band)

Transmission channel	Received frequency	Center frequency
UHF ch 21	470MHz to 478MHz	474MHz
UHF ch 22	478MHz to 486MHz	482MHz
UHF ch 23	486MHz to 494MHz	490MHz
:	:	:
:	:	:
UHF ch 68	846MHz to 854MHz	850MHz
UHF ch 69	854MHz to 862MHz	858MHz

NOTE: The report of SADC Sub-Regional GE06 Frequency Coordination Workshop on the Transition to Digital Terrestrial Television (DTT), which was published on 24th

August 2012, recommends to use only channels 21 to 48.

6.1.2. First intermediate frequency

- Center frequency (in case of Can Tuner): 36 MHz (frequency reversed)^{*1}
- Local oscillator frequency: At the upper side of the received frequency

**1: In case of Silicon tuner, Low-IF or Zero-IF under 10MHz are almost used now.*

6.1.3. Characteristics of the tuning unit

A tuning unit for receiving 13 segments and a tuning unit for receiving 1 segment located in the central part of the 13 segments must satisfy the following specifications which are in accordance with ITU-R REC. BT.[DTV RX]:

- Maximum input level: 0 dBm or higher.
- Minimum input level: -78.4 dBm or lower (targeted value)

However, when the input level in a one-segment receiver is measured in terms of electric power per segment, the level must be reduced by a factor equivalent to the bandwidth (i.e., one-thirteenth, or -11 dB)

6.1.4. Protection ratios

The results of an interference experiment, which are described in Rec. ITU-R BT.1368-10 (01/2013) Planning criteria, including protection ratios, for digital terrestrial television services in the VHF / UHF bands, are shown in the table below.

Table 6-3: Protection ratios (dB) for an ISDB-T 8 MHz signal

Modulation & Coding Rate	channel	Protection Ratio
Signal interfered with by digital terrestrial television signal		
13segments, 64QAM, 3/4	co-channel	20 dB
13segments, 64QAM, 3/4	lower adjacent channel	-30 dB
13segments, 64QAM, 3/4	upper adjacent channel	-30 dB
Signal interfered with by analogue terrestrial television signal (PAL I)		
13segments, 64QAM, 3/4	co-channel	5 dB
13segments, 64QAM, 3/4	lower adjacent channel	[-32] dB ^{*1}
13segments, 64QAM, 3/4	upper adjacent channel	[-36] dB ^{*1}

**1: The Protection ratios (PR) for lower and upper adjacent channel in coding rate 3/4 are not described in Rec. ITU-R BT.1368-10. But, in case of coding rate 2/3, the protection ratios for the both channels are described in Table 75 and Table77 as*

follows;

64QAM, Coding rate 2/3, lower adjacent channel: PR = -34dB

64QAM, Coding rate 2/3, upper adjacent channel: PR = -38dB

According to the other experimental results, the difference of the protection ratios between coding rate 2/3 and 3/4 is +2dB for each channel. The following values are drawn from the above experimental results;

64QAM, Coding rate 3/4, lower adjacent channel: PR = -34+2dB=-32dB

64QAM, Coding rate 3/4, upper adjacent channel: PR = -38+2dB=-36dB.

6.2. Video decoding process

The receiver shall support the frame rate of 25 Hz and 50 Hz, and the video format of 576i and 576p, in addition to the parameters defined in 6.1.1, ARIB STD-B21, and in 8.1.4 and 8.1.5, ABNT NBR 15604. The parameters which can be taken are shown in Table 2-1 and Table 2-2 of this document.

7. Data broadcasting

There are 2 kinds of Data Broadcasting standards that are already in commercial use at ISDB-T adopted countries. BML is the one which is used especially in Japan, and Ginga (Ginga-NCL and Ginga-J) is the other one which is used especially in Brazil.

About BML Data Broadcasting,

all technical methods and parameters shall be accordance with ARIB STD-B24.

About Ginga Data Broadcasting,

all technical methods and parameters shall be accordance with ABNT NBR 15606.

8. Interactive channel

All technical parameters related to interactive channel shall be in accordance with ARIB STD-B21, -B23,-B 24 / ABNT NBR 15607.

9. EWBS

All technical methods and parameters shall be in accordance with ISDB-T Harmonization Document PART 3: Emergency Warning Broadcasting System (EWBS).

Annex 1

ISDB-T Standards (8 MHz System)

Item	Contents
Transmission	ISDB-T Transmission
Channel Bandwidth	8MHz
Modulation	Segmented OFDM (13 segments/ch)
Mode, guard	Mode: 3 Guard Interval: 1/4, 1/8, 1/16 or 1/32
Carrier Modulation	QPSK, 16QAM, 64QAM
Error Correction (Inner Code)	Convolutional Code (Coding Rate: 1/2, 2/3, 3/4, 5/6 or 7/8)
Error Correction (Outer Code)	(204,188) Reed-Solomon Code
Interleave	Frequency and Time Interleave Time Interleave: 0-0.4 sec
Video Coding	H.264 MPEG4-AVC (ISO/IEC 14496-10)
Audio Coding	MPEG-4 AAC (ISO/IEC 14496-3)
Multiplexing	MPEG-2 Systems (ISO/IEC 13818-1)
Receiver	ISDB-T Receiver
Data Broadcasting	BML / Ginga

(ITU Recommendation)

<http://www.itu.int/en/publications/Pages/default.aspx>

(ISO/IEC standards)

http://www.iso.org/iso/home/store/catalogue_tc/catalogue_tc_browse.htm?commid=45316

(ARIB Standards)

http://www.arib.or.jp/english/html/overview/sb_ej.html

(ABNT Standards)

<http://forumsbtvd.org.br/acervo-online/normas-brasileiras-de-tv-digital/>

(ISDB-T Harmonization Document)

<http://www.dibeg.org/techp/aribstd/harmonization.html>