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(07/2016)

Characteristics of a reference receiving system for frequency planning of digital terrestrial television systems

BT Series

Broadcasting service (television)

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RECOMMENDATION ITU-R BT.2036-1

Characteristics of a reference receiving system for frequency planning of digital terrestrial television systems

(Questions ITU-R 114/6 and ITU-R 132-2/6)

(2013-2016)

Scope

This Recommendation defines characteristics of reference receiving systems for various digital terrestrial television systems employed as a basis for frequency planning digital terrestrial television services in the VHF/UHF bands.

The ITU Radiocommunication Assembly,

considering

a) that digital terrestrial television services using a variety of systems are now in widespread use;

b) that the ITU-R has responsibility for international frequency planning and inter-service sharing to ensure equitable and efficient use of the radio spectrum;

c) that the error-correction, data framing, modulation and emission methods for first- and second-generation digital terrestrial television broadcasting (DTTB) systems are defined in Recommendations ITU-R BT.1306 and ITU-R BT.1877, respectively;

d) that the criteria for planning digital terrestrial television services in the VHF/UHF bands are given in Recommendations ITU-R BT.1368 and BT.2033;

e) that frequency planning parameters for Digital video broadcasting - terrestrial (DVB-T) in Region 1 and the Islamic Republic of Iran are defined by the GE06 Agreement which planned Band III (174-230 MHz) for digital sound and television broadcasting and Bands IV/V (470-862 MHz) for digital television broadcasting. The GE06 Agreement gives the framework for television frequency planning coordination among Region 1 countries and the Islamic Republic of Iran;

f) that the International Electrotechnical Commission (IEC) has responsibilities relating to television receiver standards and methods of measurement and definitions;

g) that nominal characteristics of and measurement methods for digital television receivers have been established for the various DTTB systems in the IEC;

h) that while there is a necessary connection between the receiver characteristics required as limit specifications for manufacturing, efficient spectrum use and frequency planning should take account of the complete receiving system and should be based on a representative reference receive system rather than “worst-case” limit specifications,

recommends

1 that the common characteristics of reference television receiving systems given in Annex 1 should be employed as a basis for frequency planning;

2 that the characteristics of reference first-generation television receiving systems given in Annex 2 should be employed as a basis for frequency planning[1];

3 that the characteristics of reference second-generation television receiving systems in Annex 3 should be employed as a basis for frequency planning[1].

Annex 1

Digital terrestrial television common receiving system characteristics for frequency planning

Tables 1 to 5 below provide values for common receiver characteristics applicable to any digital terrestrial television systems in frequency planning.

TABLE 1

Receiver antenna height (m)

Reception mode	Fixed roof top reception	Portable outdoor/ mobile	Portable indoor
Receiver antenna height above ground	10	1.5	1.5

TABLE 2

Receiving antenna directivity

Receiving antenna directivity	See Rec. ITU-R BT.419

TABLE 3

Receiver noise figure (dB)

	Band I	Band III	Bands IV/V
Frequency (MHz)	47-68	174-230	470-862
Receiver noise figure	7 to 10	6 to 10	6 to 7

[1] The definitions, methods of measurement and presentation of results used in the Annex are consistent with relevant IEC standards/specifications.

TABLE 4

Antenna gain (dBd)

	Band I	Band III	Band IV	Band V
Frequency (MHz)	47-68	174-230	470-582	582-862
Fixed roof top reception	4	5 to 7	8 to 10	9 to 12

TABLE 5

Feeder loss (dB)

	Band I	Band III	Band IV	Band V
Frequency (MHz)	47-68	174-230	470-582	582-862
Fixed roof top reception	1	2	3 to 4	4 to 5

Annex 2

Digital terrestrial television first-generation reference receiving system characteristics for frequency planning[2]

1 Introduction

The characteristics of reference first-generation television receiving systems given in this Annex are to be employed as a basis for frequency planning.

1.1 DVB-T reference receiver characteristics

Reference values for the parameters of a DVB-T reference receiving system are defined for three different reception modes[3]:

- Reception mode RM1 for fixed roof top reception.
- Reception mode RM2 for portable outdoor reception or mobile reception.
- Reception mode RM3 for portable indoor reception.

Tables 6 and 7 give the reference DVB-T receiver characteristics for all three RMs for Band III, 7 and 8 MHz channel raster, respectively. Table 8 gives the reference DVB-T receiver characteristics for all three RMs for Bands IV/V.

[2] As DTTB receive system technology is improving rapidly, administrations are invited to study any improvement of the planning parameters which can result from improved receive system characteristics.

[3] Those reception modes are equivalent to the Reference Planning Configurations for fixed roof-top, portable outdoor/mobile and portable indoor reception of the GE06 Agreement.

The reference parameters of the RMs that are given in Tables 6, 7 and 8 are not associated with a particular DVB-T system variant or a real DVB-T network implementation; rather, they stand for a large number of different real implementations.

TABLE 6

Reference DVB-T receiver characteristics in Band III, 7 MHz channel raster

Reception mode	RM1	RM2	RM3
Frequency f_r (MHz)	200	200	200
Equivalent noise bandwidth (MHz)	6.66	6.66	6.66
Receiver noise figure (dB)	7	7	7
Receiver noise input power (dBW)	–128.7	–128.7	–128.7
RF signal/noise ratio Reference *C*/*N* (dB)	21	19	17
Minimum receiver signal input power (dBW)	–107.7	–109.7	–111.7
Min. equivalent receiver input voltage, 75 Ω (dB(μV)	31	29	27
Reference Minimum field strength $(E_{min})_{ref}$ (dB(μV/m)) at f_r = 200 MHz	38.5	43.5	41.5
ACS (dB)	See Note 1 below		

NOTE 1 – Information on the calculation of adjacent channel selectivity (ACS) values for DVB-T receivers can be found in Recommendation ITU-R BT.1368-10.

TABLE 7

Reference DVB-T receiver characteristics in Band III, 8 MHz channel raster

Reception mode	RM1	RM2	RM3
Frequency f_r (MHz)	200	200	200
Equivalent noise bandwidth (MHz)	7.61	7.61	7.61
Receiver noise figure (dB)	7	7	7
Receiver noise input power (dBW)	–128.2	–128.2	–128.2
RF signal/noise ratio Reference *C*/*N* (dB)	21	19	17
Minimum receiver signal input power (dBW)	–107.2	–109.2	–111.2
Min. equivalent receiver input voltage, 75 Ω (dB(μV)	31.5	29.5	27.5

TABLE 7 (*end*)

Reception mode	RM1	RM2	RM3
Reference Minimum field strength $(E_{min})_{ref}$ (dB(μV/m)) at f_r = 200 MHz	39	44	42
ACS (dB)	See Note 1 below		

NOTE 1 – Information on the calculation of ACS values for DVB-T receivers can be found in Recommendation ITU-R BT.1368-10.

TABLE 8

Reference DVB-T receiver characteristics in Band IV/V, 8 MHz channel raster

Reception mode	RM1	RM2	RM3
Frequency f_r (MHz)	650	650	650
Equivalent noise bandwidth (MHz)	7.61	7.61	7.61
Receiver noise figure (dB)	7	7	7
Receiver noise input power (dBW)	–128.2	–128.2	–128.2
RF signal/noise ratio Reference *C*/*N* (dB)	21	19	17
Minimum receiver signal input power (dBW)	–107.2	–109.2	–111.2
Min. equivalent receiver input voltage, 75 Ω (dB(μV)	31.5	29.5	27.5
Reference Minimum field strength $(E_{min})_{ref}$ (dB(μV/m)) at f_r = 650 MHz	47	52	50
ACS (dB)	See Note 1 below		

NOTE 1 – Information on the calculation of ACS values for DVB-T receivers can be found in Recommendation ITU-R BT.1368-10.

The formula for calculating minimum field strength is given in Appendix 1 to Annex 2 of Recommendation ITU-R BT.1368-10. For other frequencies, the reference minimum field strength values in Tables 6 and 7 above shall be adjusted by adding the correction factor defined according to the following rule:

$$(E_{min})_{ref}(f) = (E_{min})_{ref}(f_r) + 20 \log_{10} (f/f_r)$$

where f is the actual frequency and f_r the reference frequency of the relevant band quoted in the Table.

Further planning parameters, including *C*/*N* values, protection ratios and overloading thresholds for particular DVB-T system variants, are given in Recommendation ITU-R BT.1368.

Some parameters concerning the receiving DVB-T system are presented in the following Tables 9 and 10 below. Annex 1 provides common receiver characteristics applicable to any digital terrestrial television systems in frequency planning.

TABLE 9

Antenna gain (dBd)

	Band III	**Band IV**	**Band V**
Frequency (MHz)	174-230	470-582	582-862
Fixed roof top reception	7	10	12
Portable/mobile reception	–2.2	0	0

TABLE 10

Feeder loss (dB)

	Band III	**Band IV**	**Band V**
Frequency (MHz)	174-230	470-582	582-862
Fixed roof top reception	2	3	5

1.2 Reference receiver characteristics for System A (ATSC)

Reference values for the parameters of an advanced television systems committee (ATSC) reference receiving system (System A) with a 6 MHz bandwidth are given in Tables 11 through 15 in the following sections.

The threshold values for the reference receiver in the following sections are intended to assure reliable reception and may differ from the protection criteria for planning and channel allocation in Recommendation ITU-R BT.1368.

1.2.1 RF characteristics

Table 11 tabulates the basic RF performance characteristics.

TABLE 11

RF characteristics for a reference 6 MHz ATSC receiving system

Parameters	**Reference Guideline**
Frequency ranges (MHz)	47-68, 174-216, 470-806
Equivalent noise bandwidth (MHz)	6
Minimum bit error rate (BER) for reception	3×10^{-6}
Maximum receiver sensitivity (dBm)	–83
Minimum receiver overload (dBm)	–5
Minimum *S/N* (dB)	15.19
Minimum noise burst duration performance	165 µs at 10 Hz repetition

1.2.2 Co-channel interference thresholds

Table 12 provides the minimum thresholds for rejection of co-channel interference at a "weak wanted" ATSC signal level (–68 dBm) and a "moderate wanted" ATSC signal level (–53 dBm) at the receiver input. Note that different thresholds are required for interference from ATSC digital television signals as opposed to analogue television interference (National television systems committee (NTSC)).

TABLE 12

Co-channel rejection thresholds for a 6 MHz reference ATSC receiving system interfered with by a 6 MHz ATSC digital signal or an NTSC analogue signal

Type of Interference	Co-channel wanted/unwanted ratio (dB)	
	Weak wanted ATSC signal (–68 dBm)	Moderate wanted ATSC signal (–53 dBm)
ATSC interference into ATSC	+15.5	+15.5
NTSC interference into ATSC	+2.5	+2.5

NOTE – All ATSC values are average power; all NTSC values are peak power.

1.2.3 First adjacent channel interference thresholds

Table 13 tabulates the minimum rejection thresholds for first adjacent channel interference at various "wanted" signal levels at the receiver input. It is noted that protection ratio values are provided in Recommendation ITU-R BT.1368. Protection ratios are measured wanted-to-unwanted signal ratios that include the effects of receiver filtering and the emission spectrum of the transmitted signal, whereas adjacent channel selectivity defines a characteristic that is specific to the receiving system.

TABLE 13

First adjacent channel selectivity thresholds for a reference 6 MHz ATSC receiving system from a 6 MHz interference signal (digital or analogue) in the lower (N – 1) or upper (N + 1) adjacent channels at given wanted signal average power levels at the receiver input

Type of Interference	Adjacent channel wanted/unwanted ratio (dB)		
	Weak wanted (–68 dBm)	Moderate wanted (–53 dBm)	Strong wanted (–28 dBm)
Lower ATSC interference into ATSC (*N – 1)*	–33	–33	–20
Upper ATSC interference into ATSC (*N+1*)	–33	–33	–20
Lower NTSC interference into ATSC (*N – 1)*	–40	–35	–26
Upper NTSC interference into ATSC (*N+1*)	–40	–35	–26

NOTE – All NTSC values are peak power; all ATSC values are average power.

1.2.4 Multiple adjacent channel interference thresholds

Multiple adjacent channel selectivity thresholds for a reference 6 MHz ATSC receiving system from a 6 MHz interference signal (digital or analogue) in the multiple adjacent channels, *N*±2 to *N*±15, at given wanted signal average power levels at the receiver input can be found in Table 5 of Recommendation ITU-R BT.1368.

Multiple interferers on various adjacent channels significantly impact the adjacent channel selectivity thresholds for a reference 6 MHz ATSC receiving system. Combinations of unwanted signals can cause interference on a wanted channel. In particular, if the wanted channel is *N*, signals on channels $N + K$ and $N + 2K$ (or $N – K$ and $N – 2K$), where *K* is an integer between 1 and 10, will combine to cause interference into the wanted channel *N*. The ratio between the wanted signal and the unwanted interference signal pairs at the receiver threshold represents the selectivity threshold needed to ensure reception. Table 13*bis* summarizes the selectivity thresholds for a reference 6 MHz ATSC receiving system in the presence of pairs of interferers of equal signal strength.

TABLE 13*bis*

Selectivity threshold (dB) for a 6 MHz ATSC signal (wanted channel N) with interference from two 6 MHz ATSC signals (unwanted) of equal signal strength in multiple adjacent channels, N+K and N+2K (or N-K and N-2K), where K = 2, 3, ... 10, at given wanted signal average power levels at the receiver input

Type of interference	Ratio of wanted signal level to each unwanted signal at threshold (dB)		
	Very weak wanted ATSC signal (–78 dBm)	Weak wanted ATSC signal (–68 dBm)	Moderate wanted ATSC signal (–53 dBm)
N+1 and *N*+2 (*N*–1 and *N*–2)	–30.0	–31.5	–30.5
N+2 and *N*+4 (*N*–2 and *N*–4)	–38.2	–37.6	–35.1
N+3 and *N*+6 (*N*–3 and *N*–6)	–42.2	–38.8	–35.2
N+4 and *N*+ 8 (*N*–4 and *N*–8)	–41.6	–38.9	–35.8
N+5 and *N*+10 (*N*–5 and *N*–10)	–40.8	–40.8	–37.1
N+6 and *N*+12 (*N*–6 and *N*–12)	–44.3	–42.7	–37.7
N+7 and *N*+14 (*N*–7 and *N*–14)	–47.7	–43.4	–38.1
N+8 and *N*+16 (*N*–8 and *N*–16)	–52.3	–44.2	–39.4
N+9 and *N*+18 (*N*–9 and *N*–18)	–48.8	–43.2	–38.7
N+10 and *N*+20 (*N*–10 and *N*–20)	–50.9	–43.6	–37.3

1.2.5 Channel impulse response thresholds

The 6 MHz ATSC reference receiver is expected to have a channel impulse response in the range of –30 µs (pre-echo) to +40 µs (post-echo), with amplitudes decreasing with displacement. Table 14 describes the magnitude of the channel impulse response profile of the receiver under static or quasi-static conditions in the presence of a single static echo. The receiver should be insensitive to the phase of the single echo. The quasi-static condition introduces a phase shift using a slow Doppler of 0.05 Hz.

TABLE 14

Maximum channel impulse response thresholds for a reference 6 MHz ATSC receiving system in the presence of a single static echo of varying delay

Echo delay (µs)	Amplitude (dB)
–40.0	–15
–30.0	–7
–20.0	–7
–15.0	–5
–10.0	–3
–5.0	–0.5
+5.0	–0.5
+10.0	–1
+15.0	–1
+20.0	–2
+30.0	–3
+40.0	–4
+50.0	–15

In addition to the single static echoes found in Table 14, the reference 6 MHz ATSC receiving system is expected to operate in more difficult dynamic environments. A series of multiple dynamic echo laboratory ensembles and actual field ensembles are defined in the ATSC Recommended Practice, A/74[4].

[4] "ATSC Recommended Practice: Receiver Performance Guidelines", Document A/74:2010, Advanced Television Systems Committee, Washington, DC, 7 April 2010. http://www.atsc.org/cms/standards/a_74-2010.pdf.

1.2.6 Planning factors for ATSC reception

TABLE 15

Planning factors for ATSC reception using System A (ATSC)

Parameters	Symbol	Low VHF	High VHF	UHF
Frequency (MHz)	F	47-68	174-216	470-806
Dipole factor (dBm to dBμV/m)	K_d	–111.8	–120.8	–130.8
Dipole factor adjustment	K_a	0.0	0.0	See Note
Thermal noise (dBm)	N_t	–106.2	–106.2	–106.2
Antenna gain (dBd)	G	4	6	10
Download cable loss (dB)	L	1	2	4
Receiver noise figure (dB)	N_s	10	10	7
Required signal/noise ratio (dB)	S/N	15.19	15.19	15.19
Antenna front-to-back ratio (digital, ATSC)		10	12	14
Antenna front-to-back ratio (analogue, NTSC)		6	6	6

NOTE – The adjustment, K_a = 20 log (615/(channel mid-frequency)), is added to K_d to account for the higher field strengths required at high UHF frequencies and lower field strengths required at lower UHF frequencies.

The defining minimum field strength for ATSC coverage can be derived from the values in Table 15 and the following equation:

$$\text{Field Strength (dB}\mu\text{V/m)} = S/N + N_t + N_s + L - G - K_d - K_a \quad (1)$$

1.3 ISDB-T reference receiving system characteristics

1.3.1 Receiver characteristics

The parameter values of the Terrestrial integrated services digital broadcasting (ISDB-T) reference receiver operating in Band III, Band IV and Band V are given in Table 16.

The values in the Table are applied for the receivers to be used in planning studies.

The receiver characteristics for a single frequency network are specified, an example of which is shown in Fig. 2 in the form of the guard interval mask[5].

[5] See Report ITU-R BT.2209 for detailed definition.

TABLE 16

Reference ISDB-T receiver characteristics for DTTB planning

Parameters		Values		
Equivalent noise bandwidth, *b* (MHz)		5.57	6.5	7.43
Receiver noise figure, *F* (dB)		7	7	7
Receiver noise input voltage (dBμV) for 75Ω and 290K		9.2	9.9	10.5
Reference threshold *C*/*N* (dB)[6]		20.1	20.1	20.1
Minimum receiver input voltage, V_{min} (dBμV)[6]		29.3	30.0	30.6
Receiver overload threshold (dBμV) (all)[7]		109	109	109
Adjacent channel interference immunity (dB)[6, 8] for desired signal range from V_{min} to 64 dBμV (see also Fig. 1)		–35	–35	–35
Amplitude proportional noise (APN) (relative to receiver input signal amplitude) (dB)[9]		–35	–35	–35
Interpolation filter used for carrier recovery (time-domain characteristics (μs))[10]	Flat	–126 to 126	–108 to 108	–94.5 to 94.5
	Transition	–168 to –126 and 126 to 168	–144 to –108 and 108 to 144	–126 to –94.5 and 94.5 to 126
FFT window setting margin (μs)[11]		6	5.1	4.5

[6] The values correspond to a system variant of 64-QAM-FEC 3/4, and the reception environment of a fixed reception. The values are different for other system variants or reception environments. For further detail, see Recommendation ITU-R BT.1368.

[7] The receiver overload threshold (all) is defined as the allowable limit of receiver input voltage.

[8] The value is defined under no SFN environment. Different values may be applied in an actual SFN environment (for further detail, see Report ITU-R BT.2209).

[9] APN is the noise whose amplitude equivalently increases/decreases in proportion to the receiver input signal level, and is expressed by the value relative to input signal level. See Report ITU-R BT.2209 for a detailed definition.

[10] Since the ISDB-T system sends scattered pilot signals (SP) that contain reference carrier information via every three OFDM carriers, the receiver needs to recover other OFDM carriers that are not SP. An interpolation filter is used for this recovery. The values are for the system variant of Mode 3 (8k FFT). The values for Mode 2 (4k FFT) are divided by two and those for Mode 1 (2k FFT) are divided by four. See Report ITU-R BT.2209 for further details.

[11] In SFN environments, the receiver sets up its FFT window at the best position by several measures. Although the adjustment range of the FFT window position is theoretically ±GI/2 (GI denotes guard interval duration), the receiver hardware needs to set some margins against this position. See Report ITU-R BT.2209 for further detail.

FIGURE 1

Desired-to-interference characteristics (64-QAM-FEC 3/4)

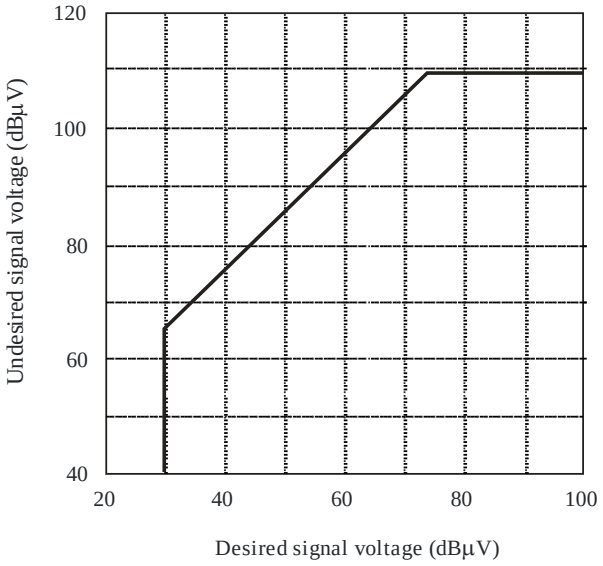

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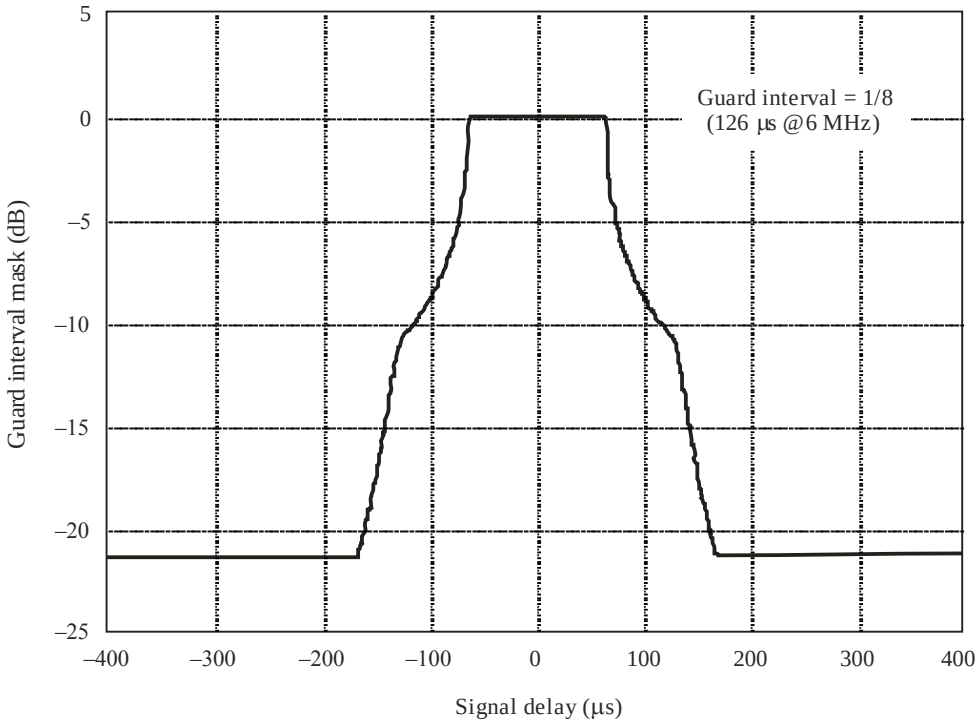
FIGURE 2

Guard interval mask characteristics for 6 MHz (@GI = 1/8, 64-QAM-FEC 3/4)[12]



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[12] The method of deriving the guard interval mask characteristics is described in detail in Report ITU-R BT.2209. The characteristics depend on the system variant employed.

1.3.2 Characteristics of receiving antenna system

The reference receiving antenna gain and cable loss applied in planning studies is given in Annex 1. Values other than those listed in Annex 1 may be applied according to the reception environment.

Annex 3

Digital terrestrial television second-generation reference receiving system characteristics for frequency planning[13]

1 Introduction

The characteristics of reference second-generation television receiving systems given in this Annex are to be employed as a basis for frequency planning.

1.1 DVB-T2 reference receiver characteristics

Reference values for the parameters of a Digital Video Broadcasting-Second Generation Terrestrial (DVB-T2) reference receiving system are defined for four different reception modes. The reception modes are:

- Reception mode RM1 for fixed roof top reception.
- Reception mode RM2a for portable outdoor reception and RM2b mobile reception. The values for mobile reception are to be included at a later stage when further measurements are performed with DVB-T2 for that reception mode.
- Reception mode RM3 for portable indoor reception.

Reference values for the parameters of a DVB-T2 reference receiving system are given in Tables 17 and 18, 7 and 8 MHz channel raster, respectively. Table 19 gives the reference DVB-T receiver characteristics for Bands IV/V.

The reference parameters of the RMs that are given in Tables 17 to 19 are not associated with a particular DVB-T2 system variant or a real DVB-T2 network implementation; rather, they stand for a large number of different real implementations.

[13] As DTTB receive system technology is improving rapidly, administrations are invited to study any improvement of the planning parameters which can result from improved receive system characteristics.

TABLE 17

Reference DVB-T2 receiver characteristics in Band III, 7 MHz channel raster

Reception mode	RM1	RM2a	RM2b	RM3
Frequency f_r (MHz)	200	200	200	200
Equivalent noise bandwidth (MHz)	6.66	6.66	6.66	6.66
Receiver noise figure (dB)	6	6	TBC	6
Receiver noise input power (dBW)	–129.7	–129.7	TBC	–129.7
RF signal/noise ratio Reference *C*/*N* (dB)	20	18	TBC	18
Minimum receiver signal input power (dBW)	–109.7	–111.7	TBC	–111.7
Min. equivalent receiver input voltage, 75 Ω (dB(µV)	29	27	TBC	27
Reference Minimum field strength $(E_{min})_{ref}$ (dB(µV/m)) at f_r = 200 MHz	36.5	41.5	TBC	41.5
ACS (dB)	See Note 1 below			

NOTE 1 – Information on the calculation of ACS values for DVB-T2 receivers can be found in Recommendation ITU-R BT.2033.

TABLE 18

Reference DVB-T2 receiver characteristics in Band III, 8 MHz channel raster

Reception mode	RM1	RM2a	RM2b	RM3
Frequency f_r (MHz)	200	200	200	200
Equivalent noise bandwidth (MHz)	7.77	7.77	7.77	7.77
Receiver noise figure (dB)	6	6	TBC	6
Receiver noise input power (dBW)	–129	–129	TBC	–129
RF signal/noise ratio Reference *C*/*N* (dB)	20	18	TBC	18
Minimum receiver signal input power (dBW)	–109	–111	TBC	–111
Min. equivalent receiver input voltage, 75 Ω (dB(µV)	29.75	27.75	TBC	27.75
Reference Minimum field strength $(E_{min})_{ref}$ (dB(µV/m)) at f_r = 200 MHz	37	42.5	TBC	42.5
ACS (dB)	See Note 1 below			

NOTE 1 – Information on the calculation of ACS values for DVB-T2 receivers can be found in Recommendation ITU-R BT.2033.

TABLE 19

Reference DVB-T2 receiver characteristics in Band IV/V

Reception mode	RM1	RM2a	RM2b	RM3
Frequency f_r (MHz)	650	650	650	650
Equivalent noise bandwidth (MHz)	7.77	7.77	7.77	7.77
Receiver noise figure (dB)	6	6	TBC	6
Receiver noise input power (dBW)	–129	–129	TBC	–129
RF signal/noise ratio Reference *C*/*N* (dB)	20	18	TBC	18
Minimum receiver signal input power (dBW)	–109	–111	TBC	–111
Min. equivalent receiver input voltage, 75 Ω (dB(µV)	29.7	27.7	TBC	27.75
Reference Minimum field strength $(E_{min})_{ref}$ (dB(µV/m)) at f_r = 650 MHz	45.5	50.5	TBC	50.5
ACS (dB)	See Note 1 below			

NOTE 1 – Information on the calculation of ACS values for DVB-T2 receivers can be found in Recommendation ITU-R BT.2033.

The formula for calculating minimum field strength is given in Annex 1 of Report ITU-R BT.2254. For other frequencies, the reference minimum field strength values in Tables 16 and 17 above shall be adjusted by adding the correction factor defined according to the following rule:

$$(E_{min})_{ref}(f) = (E_{min})_{ref}(f_r) + 20 \log_{10} (f/f_r)$$

where f is the actual frequency and f_r the reference frequency of the relevant band quoted in the Table.

Information on frequency and network planning of DVB-T2, including *C*/*N* values, protection ratios and overloading thresholds for particular DVB-T2 system variants, are given in Recommendation ITU-R BT.2033.

Some parameters concerning the receiving DVB-T2 system are presented in the following Tables 18 and 19 below. Annex 1 provides common receiver characteristics applicable to any digital terrestrial television systems in frequency planning.

TABLE 20

Antenna gain (dBd)

	Band III	Band IV	Band V
Frequency (MHz)	174-230	470-582	582-862
Fixed rooftop antenna	7	10	12
Portable/mobile reception	–2.2	0	0

TABLE 21

Feeder loss (dB)

	Band III	**Band IV**	**Band V**	**Reception mode**
Frequency (MHz)	174-230	470-582	582-862	
Fixed roof top antenna	2	3	5	Fixed rooftop