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BT Series: Broadcasting service (television)

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

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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.2036-5

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

(Questions ITU-R 114/6 and ITU-R 132-3/6)

(2013-2016-2018-2019-2021-2023)

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.

Keywords

Digital terrestrial television, receiver characteristics, radio frequency, frequency planning, VHF, UHF, protection ratio, adjacent channel selectivity

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 given 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 Annex 1 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 Definitions

Adjacent channel selectivity (ACS): it is a measure of the receiver ability to receive a wanted signal at its assigned channel frequency in the presence of an unwanted adjacent channel signal at a given frequency offset from the centre frequency of the assigned channel. It is most often defined as the ratio of the receiver filter attenuation on the adjacent channel frequency to the receiver filter attenuation on the assigned channel frequency.

Radio frequency protection ratio (PR): it is the minimum value of the wanted-to-unwanted signal ratio, usually expressed in decibels, at the receiver input, determined under specified conditions such that a specified reception quality of the wanted signal is achieved at the receiver output (see RR (2004), Art. 1 § 1.170). Usually, PR is specified as a function of the frequency offset between the wanted and interfering signals over a wide frequency range.

[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.

1.2 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.

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
Minimum 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 below		

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

[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.

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
Minimum 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 = 200 MHz	39	44	42
ACS (dB)	See Note below		

NOTE – 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
Minimum 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 below		

NOTE – 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 Attachment 1 to Annex 2 to Recommendation ITU-R BT.1368. 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

1.3 System A (ATSC) reference receiver characteristics[4]

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 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.

1.3.1 RF characteristics

Table 11 tabulates the basic RF performance characteristics.

[4] System A is defined as the first-generation digital terrestrial television broadcasting system specified in the ATSC Digital Television Standard, A/53-2007, informally referred to as ATSC-1.0.

TABLE 11

RF characteristics for a reference 6 MHz ATSC receiving system

Parameter	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

1.3.2 Co-channel protection

Table 12 provides the minimum ratios for protection 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 ratios are required for interference from ATSC digital television signals as opposed to analogue television interference (National television systems committee (NTSC)).

TABLE 12

Co-channel protection ratios 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.

1.3.3 First adjacent channel protection ratios

Table 13 tabulates the minimum protection ratios for first adjacent channel interference at various "wanted" signal levels at the receiver input. It is noted that that the DTV into DTV protection ratio values provided in Recommendation ITU-R BT.1368 are −28 and −26 dB, for lower and upper adjacent channel interferences respectively. These protection ratios were based on asymmetric transmitter splatter in the first adjacent channel. For this Recommendation, −27 dB is used and a 6 dB margin is added to reach −33 dB. The margin is added to allow for improvement in DTV transmitter technology.

TABLE 13

First adjacent channel protection ratios 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.

1.3.4 Multiple adjacent channel protection ratios

Multiple adjacent channel protection ratios 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 protection ratios 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 input represents the protection ratio needed to ensure reception. Table 14 summarizes the protection ratios for a reference 6 MHz ATSC receiving system in the presence of pairs of interferers of equal signal strength.

TABLE 14

Protection ratios (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* + 2*K* (or *N* − *K* and *N* − 2*K*), 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 level (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

1.3.5 Adjacent channel selectivity

Adjacent channel selectivity (ACS) is expressed in dB and can be calculated according to Recommendation ITU-R BT.1368 as follows:

$$ACS\ (\text{dB}) = -10 \log\left(10^{-\frac{ACIR\ (\text{dB})}{10}} - 10^{-\frac{ACLR\ (\text{dB})}{10}}\right) \quad (1)$$

where:

ACIR: adjacent channel interference ratio

ACLR: adjacent channel leakage power ratio of the unwanted signal.

Note that:

$$ACIR\ (\text{dB}) = PR_{co-ch}(\text{dB}) - PR_{adj-ch}(\text{dB})$$

where:

$PR_{co\text{-}ch}$ (dB): receiver co-channel protection ratio

$PR_{adj\text{-}ch}$ (dB): receiver adjacent channel protection ratio.

1.3.6 Channel impulse response

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 15 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 15

Maximum magnitude of the channel impulse response profile 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 15, 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[5].

[5] "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

1.3.7 Planning factors for ATSC reception

TABLE 16

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 dB(μV/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 16 and the following equation:

$$Field\ Strength\ (\mathrm{dB}(\mu\mathrm{V/m})) = S/N + N_t + N_s + L - G - K_d - K_a \quad (2)$$

1.4 ISDB-T reference receiving system characteristics

1.4.1 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 17.

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[6].

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

TABLE 17

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 75 Ω and 290 *K*		9.2	9.9	10.5
Reference *C*/*N* (dB) (1)		20.1	20.1	20.1
Minimum receiver input voltage, V_{min} (dBμV) (1)		29.3	30.0	30.6
Receiver overload threshold (dBμV) (all) (2)		109	109	109
Amplitude proportional noise (APN) (relative to receiver input signal amplitude) (dB) (3)		−35	−35	−35
Interpolation filter used for carrier recovery (time-domain characteristics (μs)) (4)	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) (5)		6	5.1	4.5

(1) 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.

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

(3) 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.

(4) 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.

(5) 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.

TABLE 18

Strong signal interference immunity(1) of reference ISDB-T receiver for DTTB planning

Parameters	Value (2)		
Nominal channel bandwidth	6 MHz	7 MHz	8 MHz
1st adjacent channel	−30 dB(3)	−30 dB(3)	−30 dB(3)
2nd adjacent channel	−45 dB	−45 dB	−45 dB
3rd adjacent channel	−50 dB	−50 dB	−50 dB
4th and higher adjacent channels	−55 dB	−55 dB	−55 dB

(1) Strong signal interference immunity is the receiver ability to receive the wanted signal in the presence of strong unwanted signal, expressed in the ratio of wanted signal level to unwanted signal level.

(2) The values are defined for the leakage spectrum of unwanted signal satisfying the spectrum limit mask for critical emission specified in Recommendation ITU-R BT.1206. The values for other system variants than 64QAM FEC-3/4 are provided in Report ITU-R BT.2209.

(3) The value of −35 dB is applied for unwanted signal without leakage spectrum.

FIGURE 1

Wanted to interference characteristics for 1st adjacent channel without unwanted signal leakage spectrum for system variant of 64-QAM FEC 3/4

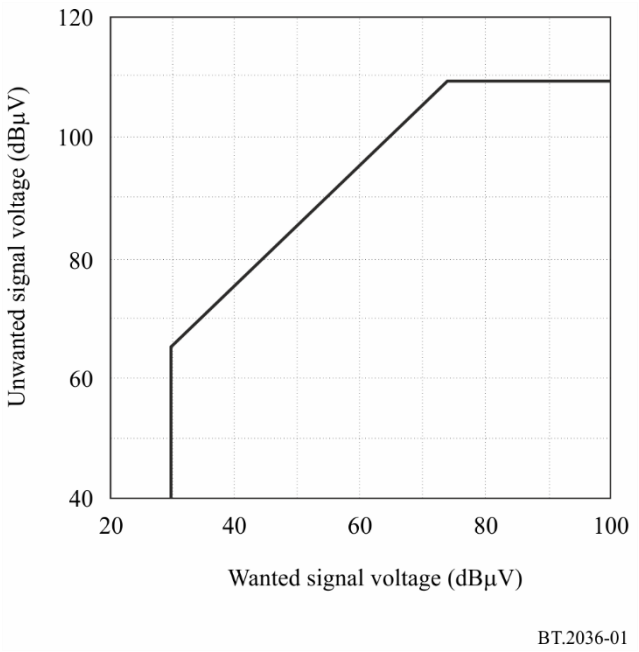
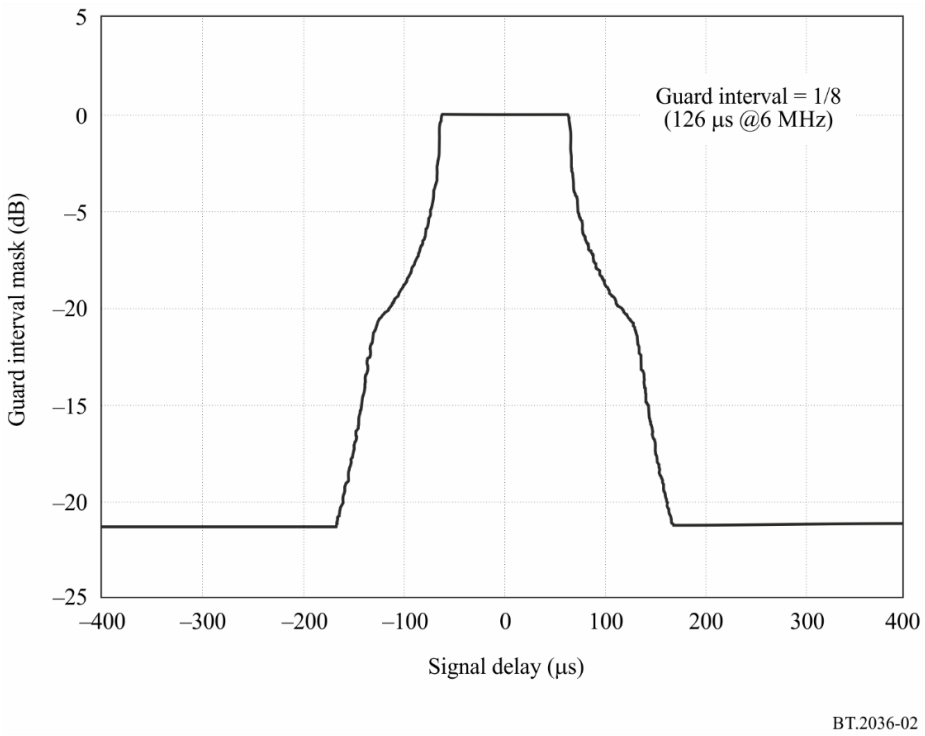


FIGURE 2

Guard interval mask characteristics for 6 MHz (at GI = 1/8, 64-QAM-FEC 3/4)[7]



1.4.2 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.

1.5 DTMB reference receiving system characteristics

1.5.1 Receiver characteristics

Reference values for the parameters of a DTMB reference receiving system are defined for three different reception modes:

– Reception mode RM1 requires *C*/*N* of 8 dB, which can be used in mobile reception with QPSK constellation mapping and code rate of 0.4.

– Reception mode RM2 requires *C*/*N* of 14 dB, which can be used in fixed roof top reception with 64 QAM constellation mapping and code rate of 0.4.

– Reception mode RM3 requires *C*/*N* of 20 dB, which can be used in indoor reception with 64 QAM constellation mapping and code rate of 0.6.

Table 19 gives the reference DTMB receiver characteristics for all three RMs for Band III, 8 MHz channel raster, respectively. Table 20 gives the reference DTMB receiver characteristics for all three RMs for Bands IV/V.

The reference parameters of the RMs that are given in Tables 19 and 20 are not associated with a particular DTMB system variant or a real DTMB network implementation; rather, they stand for a large number of different real implementations.

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[7] 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.

TABLE 19

Reference DTMB 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)	7.56	7.56	7.56
Receiver noise figure (dB)	5	5	5
Receiver noise input power (dBW)	−128.23	−128.23	−128.23
RF signal/noise ratio Reference *C*/*N* (dB)	8	14	20
Minimum receiver signal input power (dBW)	−120.23	−114.23	−108.23
Minimum equivalent receiver input voltage, 75 Ω (dBμV)	18.47	24.47	30.47
Reference minimum field strength $(E_{min})_{ref}$ (dB(μV/m)) at f_r = 200 MHz	27	33	39

TABLE 20

Reference DTMB receiver characteristics in Band IV/V, 8 MHz channel raster

Reception mode	RM1	RM2	RM3
Frequency f_r (MHz)	700	700	700
Equivalent noise bandwidth (MHz)	7.56	7.56	7.56
Receiver noise figure (dB)	7	7	7
Receiver noise input power (dBW)	−128.23	−128.23	−128.23
RF signal/noise ratio reference *C*/*N* (dB)	8	14	20
Minimum receiver signal input power (dBW)	−120.23	−114.23	−108.23
Minimum equivalent receiver input voltage, 75 Ω (dBμV)	18.47	24.47	30.47
Reference Minimum field strength $(E_{min})_{ref}$ (dB(μV/m)) at f_r = 650 MHz	35	41	47

The formula for calculating minimum field strength is given in Attachment 1 to Annex 2 to Recommendation ITU-R BT.1368. For other frequencies, the reference minimum field strength values in Tables 19 and 20 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, quoted in Tables 19 and 20, is the reference frequency of the relevant band.

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

1.5.2 Characteristics of receiving antenna system

The reference receiving antenna gain and cable loss applied in planning studies are given in Tables 21 and 22 below.

TABLE 21

Antenna gain (dBd)

	Band III	**Band IV**	**Band V**
Frequency (MHz)	174-230	470-582	582-862
Fixed roof top reception	5	10	12
Portable/mobile reception	−2.2	0	0

TABLE 22

Feeder loss (dB)

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

Annex 3

Digital terrestrial television second-generation reference receiving system characteristics for frequency planning[8]

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 23 and 24, 7 and 8 MHz channel raster, respectively. Table 25 gives the reference DVB-T receiver characteristics for Bands IV/V.

[8] 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.

The reference parameters of the RMs that are given in Tables 23 to 25 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.

TABLE 23

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
Minimum 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 below			

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

TABLE 24

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
Minimum 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 below			

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

TABLE 25

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
Minimum 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 below			

NOTE – 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 17 and 18 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 26 and 27 below. Annex 1 provides common receiver characteristics applicable to any digital terrestrial television systems in frequency planning.

TABLE 26

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 27

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

1.2 ATSC 3.0 reference receiver characteristics[9]

Reference receiver characteristics for an ATSC 3.0 receiver are provided in Table 28 for three different reception modes: Urban Indoor, Suburban Indoor and Quasi-Open/Rural.[10] The ATSC 3.0 parameters are as follows: 16QAM, 2/15 LDPC code, 8K FFT.

TABLE 28

Reference ATSC 3.0 receiver characteristics, 8 MHz channel

Reception mode	Urban Indoor	Suburban Indoor	Quasi-Open/Rural
Frequency f_r (MHz)	700	700	700
Equivalent noise bandwidth (MHz)	7.78	7.78	7.78
Receiver noise figure (dB)	7	7	7
Receiver noise input power (dBW)	−128	−128	–128
RF signal/noise ratio reference C/N (dB)	1.0	1.0	1.0
Minimum receiver signal input power (dBW)	−127	−127	–127
Reference minimum field strength $(E_{min})_{ref}$ (dB(μV/m)) at f_r = 700 MHz	46.1	44.1	44.1

Reference receiver characteristics for an ATSC 3.0 receiver are provided in Table 29 below for the use of an external outdoor antenna mounted at a height of 10 metres, using a Ricean channel model. The ATSC 3.0 parameters are as follows: 64 QAM, 11/15 LDPC code, 32K FFT.

9 ATSC 3.0 is specified in the ATSC Digital Television Standard, A/300-2019 and its constituent standards.

10 The reception modes are consistent with the Hata propagation-loss model, as described in ETSI TR 143 030 V9.0.0, Annex B, and elsewhere. Quasi-Open/Rural reception is analogous to reception mode RM2 in Section 1.2 of this document, and Indoor reception is analogous to reception mode RM3.

TABLE 29

Reference ATSC 3.0 receiver characteristics, 6 MHz channel, outdoor antenna

Channel centre frequency (MHz)	69	195	605
Channel bandwidth (MHz)	6	6	6
Receiver noise figure (dB)	7.0	7.0	7.0
Equivalent noise at the antenna input (dBm)	−89.7	−99.8	−102.6
Minimum *C*/*N* (dB)	16.9	16.9	16.9
Minimum antenna input power (dBm)	−72.8	−82.9	−85.7
Minimum required field strength at antenna (dBuV/m)	39.0	38.0	44.9
Minimum required field strength at antenna with margin (dB(µV/m))	41.9	40.8	47.8

Reference receiver characteristics for an ATSC 3.0 receiver are provided in Table 30 below for automotive reception, using a Rayleigh channel model. The ATSC 3.0 parameters are as follows: 16 QAM, 5/15 LDPC code, 16K FFT. The downlead loss is assumed to be that of 10 feet (3.0 m) of RG-59 coaxial cable.

TABLE 30

Reference ATSC 3.0 receiver characteristics, 6 MHz channel, automotive reception

Channel centre frequency (MHz)	69	195	605
Channel bandwidth (MHz)	6	6	6
Antenna gain (dB)	−4.0	−2.0	0.0
Receiver noise figure (dB)	7.0	7.0	7.0
Equivalent noise at the antenna input (dBm)	−88.8	−95.8	−97.9
Minimum *C*/*N* (dB)	7.8	7.8	7.8
Minimum antenna input power (dBm)	−81.0	−88.0	−90.1
Minimum required field strength at antenna (dB(µV/m))	30.8	32.8	40.6