



Recommendation ITU-R BT.1368-13
(06/2017)

Planning criteria, including protection ratios, for digital terrestrial television services in the VHF/UHF bands

BT Series
Broadcasting service
(television)



International
Telecommunication
Union
Documents
Document Sharing Hub

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.

Policy on Intellectual Property Right (IPR)

ITU-R policy on IPR is described in the Common Patent Policy for ITU-T/ITU-R/ISO/IEC referenced in Annex 1 of Resolution ITU-R 1. Forms to be used for the submission of patent statements and licensing declarations by patent holders are available from <http://www.itu.int/ITU-R/go/patents/en> where the Guidelines for Implementation of the Common Patent Policy for ITU-T/ITU-R/ISO/IEC and the ITU-R patent information database can also be found.

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

Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

Electronic Publication
Geneva, 2016

© ITU 2016

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without written permission of ITU.

RECOMMENDATION ITU-R BT.1368-13

Planning criteria, including protection ratios, for digital terrestrial television services in the VHF/UHF bands

(1998-1998-2000-2002-2004-2005-2006-2007-2009-2011-2013-2014-2015-2017)

Scope

This Recommendation defines planning criteria for various methods of providing digital terrestrial television services in the VHF/UHF bands.

Keywords

DTTB, ATSC, DVB-T, ISDB-T, DTMB, DTMB-A, planning criteria, protection ratio, overload threshold

The ITU Radiocommunication Assembly,

considering

- a) that systems have been developed for the transmission of digital terrestrial television services (DTTS) in the VHF/UHF bands;
- b) that the VHF/UHF television bands are still occupied by analogue television services;
- c) that the analogue television services will remain in use in some administrations for a considerable period of time;
- d) that the availability of consistent sets of planning criteria agreed by administrations will facilitate the planning of digital terrestrial television services;
- e) that parts of the VHF/UHF television bands are shared with other primary services;
- f) that sharing between digital terrestrial television broadcasting (DTTB) and some other primary services is an evolving situation;
- g) that the protection ratios established for the protection of digital terrestrial television need to be at the threshold of signal failure,

recommends

- 1 that the relevant protection ratios (PRs) and the relevant minimum field strength values given in Annexes 1, 2, 3, 4 and 5 and the additional information given in Annexes 6, 7, 8 and 9 should be used as the basis for frequency planning for digital terrestrial television services.

Introduction

This Recommendation contains the following Annexes:

- Annex 1 – Planning criteria for ATSC digital terrestrial television systems in the VHF/UHF bands
- Annex 2 – Planning criteria for DVB-T digital terrestrial television systems in the VHF/UHF bands
- Annex 3 – Planning criteria for ISDB-T digital terrestrial television systems in the VHF/UHF bands
- Annex 4 – Planning criteria for DTMB digital terrestrial television systems in the VHF/UHF bands
- Annex 5 – Planning criteria for DTMB-A digital terrestrial television systems in the VHF/UHF bands
- Annex 6 – Other planning factors
- Annex 7 – Subjective comparison method (SCM) with a reference interferer for assessment protection ratios for analogue television systems
- Annex 8 – Failure point assessment methods
- Annex 9 – Tropospheric and continuous interference

General

The RF protection ratio is the minimum value of wanted-to-unwanted signal ratio, usually expressed in decibels at the receiver input.

The reference level of the digital signal is defined as the r.m.s. value of the emitted signal power within the channel bandwidth. It should preferably be measured with a thermal power meter. Historically, protection ratio values for wanted digital signals were measured with a -60 dBm receiver input power. Where possible, protection ratios for digital TV systems are derived from measurements using a range of signal levels.

The reference level of the analogue vision-modulated signal is defined as the r.m.s. value of the vision carrier at peaks of the modulation envelope. All protection ratio values for wanted analogue signals are measured with a receiver input power of -39 dBm (70 dB(μ V) at 75Ω).

1 Wanted digital terrestrial television systems

The protection ratios for digital terrestrial television systems apply to both continuous and tropospheric interference. The protection ratios refer to the centre frequency of the wanted digital terrestrial television system.

Because a digital television receiver needs to operate successfully in the presence of high level analogue signals on nearby channels, a high degree of receiver front-end linearity is required.

The protection ratios for digital terrestrial television systems as the interfering system are those for the case where the wanted and unwanted signals are not synchronized and/or do not have a common programme source. Results relevant to single frequency networks (SFN) are yet to be developed and simple aggregate power sum calculations taking into account transmitter sites and propagation for each transmitter in the network may be used as an initial guide.

For the digital terrestrial television system, ATSC, the protection ratios are measured for a $\text{BER} = 3 \times 10^{-6}$ at the input of the MPEG-2 demultiplexer.

For the digital terrestrial television systems (digital video broadcasting-terrestrial (DVB-T) and integrated service digital broadcasting-terrestrial (ISDB-T)) the protection ratios are measured between the inner and outer codes, before Reed-Solomon decoding, for a $\text{BER} = 2 \times 10^{-4}$; this corresponds to a $\text{BER} < 1 \times 10^{-11}$ at the input of the MPEG-2 demultiplexer. For domestic receivers

it may not be possible to measure the BER before Reed-Solomon decoding. The BER for such cases is under study.

For digital television terrestrial multimedia broadcasting (DTMB), the protection ratios are measured at the output of BCH, $BER = 3 \times 10^{-6}$ at the input of demultiplexer.

To reduce the number of measurements and tables, it is proposed that protection ratio measurements for DVB-T systems should preferably be made with the following three modes shown in Table 1. Protection ratio values for the different required operational modes for fixed, portable or mobile reception can be calculated from the given measured values. The tabulated scaling values for varying reception channel qualities from Gaussian, through Ricean, to Rayleigh are provided in Table 50 § 4 of Annex 2.

TABLE 1

Proposed preferable DVB-T mode types for measurements on protection ratios

Modulation	Code rate	$C/N^{(1)}$ (dB)	Bit rate ⁽²⁾ (Mbit/s)
QPSK	2/3	6.9	≈ 7
16-QAM	2/3	13.1	≈ 13
64-QAM	2/3	18.7	≈ 20

⁽¹⁾ The figures are given for a Gaussian channel (including a typical implementation margin) for a $BER < 1 \times 10^{-11}$.

⁽²⁾ For a guard interval of 1/4.

To reduce the number of measurements and tables, it is proposed that protection ratio measurements for DTMB systems should preferably be made with the following 11 modes shown in Table 2.

TABLE 2

Proposed preferable DTMB mode types for measurements on protection ratios

Modulation	Code rate	$C/N^{(1)}$ (dB)	Bit rate ⁽²⁾ (Mbit/s)
4-QAM	0.4	2.5	5.414
16-QAM	0.4	8.0	10.829
64-QAM	0.4	14.0	16.243
4-QAM	0.6	4.5	8.122
16-QAM	0.6	11.0	16.243
64-QAM	0.6	17.0	24.365
4-QAM-NR	0.8	2.5	5.414
4-QAM	0.8	7.0	10.829
16-QAM	0.8	14.0	21.658
32-QAM	0.8	16.0	27.072
64-QAM	0.8	22.0	32.486

⁽¹⁾ The figures are given for a Gaussian channel at BCH output $BER < 3 \times 10^{-6}$.

⁽²⁾ For a guard interval of 1/9 and RF bandwidth 8 MHz.

2 Wanted analogue terrestrial television systems

Measurements of protection ratios for the vision signal of a wanted analogue terrestrial television system should preferably be made with the subjective comparison method with a sine-wave reference interferer described in Annex 7.

The values of protection ratio quoted apply to interference produced by a single source. Except where otherwise stated, the ratios apply to tropospheric, *T*, interference and correspond closely to a slightly annoying impairment condition. They are considered to be acceptable only if the interference occurs for a small percentage of the time, not precisely defined but generally considered to be between 1% and 10%. For substantially non-fading unwanted signals, it is necessary to provide a higher degree of protection and ratios appropriate to continuous, *C*, interference should be used (see Annex 9).

When the wanted signal is an analogue television signal, two or more protection ratio values should be considered, one for the protection ratio of the vision signal and others for the protection ratios of sound signals. The most stringent value should then be used.

Significantly strong wanted input signals can require higher protection ratio values because of non-linear effects in the receiver.

For 625-line systems, the reference impairment levels are those which correspond to co-channel protection ratios of 30 dB and 40 dB, when two-thirds line offset is used, see Recommendation ITU-R BT.655. These conditions approximate to impairment grades 3 (slightly annoying) and 4 (perceptible but not annoying) and apply to tropospheric, *T*, and continuous, *C*, interference, respectively.

Table of Contents

	<i>Page</i>
1 Wanted digital terrestrial television systems	2
2 Wanted analogue terrestrial television systems	4
Annex 1 – Planning criteria for ATSC digital television systems in the VHF/UHF bands.....	18
1 Protection ratios for ATSC wanted digital terrestrial television signals	18
1.1 Protection of an ATSC digital terrestrial television signal interfered with by an ATSC digital terrestrial television signal	18
1.2 Protection of ATSC digital terrestrial television interfered with by analogue terrestrial television	19
2 Protection ratios for wanted analogue terrestrial television signals interfered with by unwanted ATSC digital terrestrial television signals	20
2.1 Protection ratios for 525-line television systems	20
2.2 Protection ratios for 625-line television systems	21
3 Protection ratios for sound signals of wanted analogue terrestrial television signals interfered with by unwanted ATSC digital terrestrial television signals.....	22
3.1 Protection for NTSC sound signals (BTSC MTS system and SAP) interfered with by an ATSC digital television signal (see Note 1)	22
4 Minimum field strengths for ATSC terrestrial digital television	23
Attachment 1 to Annex 1 – Derivation by the figure of merit method	24
Annex 2 – Planning criteria for DVB-T digital television systems in the VHF/UHF bands...	25
1 Protection ratios for DVB-T wanted digital terrestrial television signals	25
1.1 Protection of a DVB-T digital terrestrial television signal interfered with by a digital terrestrial television signal.....	26
1.2 Protection of DVB-T digital terrestrial television interfered with by analogue terrestrial television	29
1.3 Protection of DVB-T digital terrestrial television signal from CW or FM signals	32
1.4 Protection of DVB-T digital terrestrial television signals from T-DAB signals	33
1.5 Protection of DVB-T from wideband signals other than terrestrial broadcasting	34
2 Protection ratios for wanted analogue terrestrial television signals interfered with by unwanted DVB-T digital terrestrial television signals	44
2.1 Protection ratios for 625-line television systems	45

3	Protection ratios for sound signals of wanted analogue terrestrial television signals interfered with by unwanted DVB-T digital terrestrial television signals.....	48
3.1	Protection for FM, AM and NICAM sound signals of analogue television systems interfered with by DVB-T digital terrestrial television signals.....	49
4	Correction factors for different wanted DVB-T system variants and different reception conditions.....	50
5	Protection ratios for a T-DAB signal interfered with by an unwanted digital terrestrial television signal	52
6	Minimum field strengths for DVB-T terrestrial digital television, fixed reception	52
7	Minimum median field strength for mobile DVB-T reception	53
7.1	Required average C/N for mobile reception	53
7.2	Receiver noise figure	55
8	Minimum median field strength for hand held pedestrian indoor, pedestrian outdoor and mobile DVB-H reception.....	55
8.1	Channel models for hand held pedestrian indoor and outdoor reception	55
8.2	Channel model for mobile reception	57
8.3	Required average C/N for hand held indoor and outdoor reception.....	57
8.4	Required average C/N for hand held indoor and outdoor reception.....	58
8.5	Receiver noise figure	59
	Attachment 1 to Annex 2 – Calculation of minimum field strength and minimum median equivalent field strength	60
	Attachment 2 to Annex 2	61
	Attachment 3 to Annex 2	66
	Annex 3 – Planning criteria for ISDB-T digital television system in the VHF/UHF bands....	66
1	Protection ratios for ISDB-T wanted digital terrestrial television signals.....	66
1.1	Protection of an ISDB-T digital terrestrial television signal interfered with by digital television signals	67
1.2	Protection of an ISDB-T digital terrestrial television signal interfered with by analogue terrestrial television signals.....	69
2	Protection ratios for wanted analogue terrestrial television signals interfered with by unwanted ISDB-T digital terrestrial television signals.....	72
2.1	Protection ratios for 525-line television systems.....	72
2.2	Protection ratios for 625-line television systems.....	73

3	Protection ratios for sound signals of wanted analogue terrestrial television systems interfered with by ISDB-T unwanted digital terrestrial television system.....	73
3.1	Protection for NTSC sound signals interfered with by an ISDB-T digital television signal	73
3.2	Protection for FM sound signals of I/PAL and G/PAL analogue television systems interfered with by an ISDB-T digital terrestrial television signal.....	74
4	Protection ratios and overload threshold for a 6 MHz ISDB-T signal interfered with by an LTE base station or user equipment signal	75
5	Minimum field strengths for ISDB-T terrestrial digital television, fixed reception.....	75
6	Minimum median field strength for hand-held pedestrian indoor, pedestrian outdoor and mobile ISDB-T reception.....	76
6.1	Channel models for hand-held pedestrian indoor and outdoor reception.....	76
6.2	Channel model for mobile reception	78
6.3	Required average C/N for hand-held indoor and outdoor reception.....	78
6.4	Required average C/N for mobile reception	79
6.5	Receiver noise figure	79
	Attachment 1 to Annex 3 – Calculation of minimum field strength and minimum median equivalent field strength	80
	Annex 4 – Planning criteria for DTMB digital television systems in the VHF/UHF bands ...	81
1	Protection ratios for DTMB wanted digital terrestrial television signals.....	81
1.1	Protection of a DTMB signal interfered with by a DTMB signal	82
1.2	Protection of DTMB signal interfered with by analogue terrestrial television ..	85
2	Protection ratios for wanted analogue terrestrial television signals interfered with by unwanted DTMB 8 MHz, DTMB 7 MHz and 6 MHz signals.....	90
2.1	Protection of wanted vision signals interfered with by DTMB 8 MHz, DTMB 7 MHz and 6 MHz signal.....	90
3	Minimum field strengths for DTMB fixed reception	95
4	Minimum median field strength for mobile DTMB reception	96
4.1	Required average C/N for mobile reception	96
4.2	Receiver noise figure	99
	Attachment 1 to Annex 4 – Calculation of minimum field strength and minimum median equivalent field strength	100
	Annex 5 – Planning criteria for DTMB-A digital television systems in the VHF/UHF bands	101

1	Protection ratios for DTMB-A wanted digital terrestrial television signals.....	101
1.1	Protection of a DTMB-A signal interfered with by a DTMB-A signal.....	101
1.2	Protection of DTMB-A signal interfered with by analogue terrestrial television	103
2	Protection ratios for wanted analogue terrestrial television signals interfered with by unwanted DTMB-A 8 MHz signals.....	104
2.1	Protection of wanted vision signals interfered with by DTMB-A 8 MHz signal	104
3	Minimum field strengths for DTMB-A fixed reception.....	106
4	Minimum median field strength for mobile DTMB-A reception.....	107
4.1	Required average C/N for mobile reception	107
4.2	Receiver noise figure	108
Attachment 1 to Annex 5 – Calculation of minimum field strength and minimum median equivalent field strength		109
Annex 6 – Other planning factors		110
1	Field strength distribution with location.....	110
2	Reception using portable equipment inside buildings and vehicles	111
2.1	Height loss: L_h	111
2.2	Building entry loss: L_b	111
2.3	Vehicle entry loss: L_v	112
3	Receiving antenna discrimination	112
4	Antennas for portable and mobile receivers	112
4.1	Antennas for portable reception.....	112
4.2	Antennas for hand-held reception.....	113
4.3	Antennas for mobile reception.....	113
Annex 7 – Subjective comparison method (SCM) with a reference interferer for assessment of protection ratios for analogue television systems		114
1	Introduction	114
2	SCM for assessment of protection ratios using a sine-wave reference	114
2.1	General description	114
2.2	Realization of the reference interferer	115
2.3	Test conditions.....	115

2.4	Presentation of the results	116
3	Table of important parameters.....	116
	Annex 8 – Failure point assessment methods	117
1	Background.....	117
2	Subjective failure point (SFP) method for protection ratio measurements	117
	Annex 9 – Tropospheric and continuous interference	117

List of Tables

	<i>Page</i>
Table 1 – Proposed preferable DVB-T mode types for measurements on protection ratios ...	3
Table 2 – Proposed preferable DTMB mode types for measurements on protection ratios	3
Table 3 – Co-channel protection ratios (dB) for a 6 MHz ATSC signal interfered with by a 6 MHz ATSC signal at various signal-to-noise ratios (S/N)	18
Table 4 – Protection ratios (dB) for a 6 MHz ATSC signal (wanted) interfered with by a 6 MHz ATSC signal (unwanted) in the lower ($N - 1$) and upper ($N + 1$) adjacent channels at the given wanted signal average power levels at the receiver input.....	18
Table 5 – Protection ratios (dB) for a 6 MHz ATSC signal (wanted) interfered with by a 6 MHz ATSC signal (unwanted) in multiple adjacent channels, $N \pm 2$ to $N \pm 15$, at the given wanted signal average power levels at the receiver input.....	19
Table 6 – Co-channel protection ratios (dB) for an ATSC 6 MHz signal interfered with by an analogue television signal	19
Table 7 – Protection ratios (dB) for lower adjacent channel ($N - 1$) interference for an ATSC 6 MHz signal interfered with by an analogue television signal including sound.....	20
Table 8 – Protection ratios (dB) for upper adjacent channel ($N + 1$) interference for an ATSC 6 MHz signal interfered with by an analogue television signal	20
Table 9 – Protection ratios (dB) for an ATSC 6 MHz signal interfered with by an M/NTSC signal at other out-of-band channels.....	20
Table 10 – Protection ratios (dB) for a wanted analogue vision signal (NTSC, 6 MHz) interfered with by an unwanted ATSC signal	21
Table 11 – Protection ratios (dB) for a wanted analogue vision signal interfered with by an unwanted ATSC 6 MHz signal.....	21
Table 12 – Protection ratios (dB) for a wanted analogue vision signal interfered with by an ATSC 6 MHz signal (lower adjacent channel).....	22

Table 13 – Protection ratios (dB) for a wanted analogue vision signal interfered with by an ATSC 6 MHz signal (upper adjacent channel).....	22
Table 14 – Derivation by the figure of merit method ATSC 6 MHz system.....	23
Table 15 – Co-channel protection ratios (dB) for a DVB-T signal interfered with by a DVB-T signal.....	26
Table 16 – Co-channel protection ratios (dB) for a DVB-T signal interfered with by a DTMB signal for the case of fixed reception.....	27
Table 17 – Protection ratios (dB) and overload thresholds (dBm) for an 8 MHz 64-QAM code rate 2/3 DVB-T signal interfered with by an 8 MHz DVB-T signal in the adjacent channels and beyond (see Notes 1 to 6)	28
Table 18 – Protection ratios (dB) for a DVB-T 64 QAM code rate 2/3 signal interfered with by a DTMB signal in the lower ($N - 1$) and upper ($N + 1$) adjacent channels	29
Table 19 – Co-channel protection ratios (dB) for DVB-T 7 MHz and 8 MHz signals interfered with by analogue television (non-controlled frequency condition) signals ..	29
Table 20 – Protection ratios (dB) for lower adjacent channel ($N - 1$) interference for DVB-T 7 MHz and 8 MHz signals interfered with by analogue television signals including sound.....	30
Table 21 – Protection ratios (dB) for upper adjacent channel ($N + 1$) interference for DVB-T 7 MHz and 8 MHz signals interfered with by an analogue television signal	31
Table 22 – Protection ratios (dB) for a DVB-T 8 MHz signal interfered with by an overlapping PAL B signal including sound.....	31
Table 23 – Protection ratios (dB) for a DVB-T 7 MHz signal interfered with by an overlapping 7 MHz analogue TV signal including sound.....	31
Table 24 – Protection ratios (dB) for a DVB-T 7 MHz signal interfered with by an overlapping 8 MHz analogue TV signal including sound.....	32
Table 25 – Protection ratios (dB) for a DVB-T 8 MHz signal interfered with by an overlapping 8 MHz analogue TV signal including sound.....	32
Table 26 – Co-channel protection ratios (dB) for a DVB-T 8 MHz 64-QAM code rate 2/3 signal interfered with by a CW or a FM carrier (non-controlled frequency offset)	32
Table 27 – Co-channel protection ratios (dB) for a DVB-T 7 MHz 64-QAM code rate 2/3 signal interfered with by a CW or an FM carrier (non-controlled frequency offset)	33
Table 28 – Co-channel protection ratios (dB) for a DVB-T 7 MHz 64-QAM code rate 2/3 signal interfered with by a CW carrier (controlled frequency offset)	33
Table 29 – Co-channel protection ratios (dB) for a DVB-T 7 MHz and 8 MHz signal interfered with by four T-DAB frequency block signals.....	33

Table 29bis – Co-channel protection ratios (dB) for a DVB-T 7 MHz interfered with by fewer than four T-DAB frequency block signals within a 7 MHz channel.....	34
Table 30 – Protection ratios (dB) for a DVB-T 7 MHz and 8 MHz signal interfered with by a T-DAB signal in the lower ($N - 1$) or upper ($N + 1$) adjacent channels.....	34
Table 31 – Protection ratios for DVB-T 8 MHz 64-QAM code rate 2/3 signal interfered with by emissions of the fixed service.....	34
Table 32 – Protection ratios for DVB-T 8 MHz 64-QAM code rate 2/3 signal interfered with by emissions of CDMA-1X.....	35
Table 33 – Protection ratios for DVB-T 8 MHz 64-QAM code rate 2/3 signal interfered with by emissions of CDMA-3X.....	35
Table 34 – Protection ratios (PR) and overload thresholds (O_{th}) for DVB-T 8 MHz 64-QAM code rate 2/3 signal interfered with by emissions of 5 MHz UMTS base station without transmit power control (TPC Off) (see Notes 1 to 4).....	37
Table 35 – Protection ratios (PR) and overload thresholds for DVB-T 8 MHz 64-QAM code rate 2/3 signal interfered with by emissions of 5 MHz UMTS user equipment with transmit power control (TPC on) (see Notes 1 to 5).....	38
Table 36 – PR values at the 50 th and 90 th percentile and O_{th} values at the 10 th and 50 th percentile for an 8 MHz DVB-T 64-QAM with code rate 2/3 signal interfered with by a 10 MHz LTE BS signal in a Gaussian channel environment for can tuners (see Notes 1 to 5).....	40
Table 37 – PR values at the 50 th and 90 th percentile and O_{th} values at the 10 th and 50 th percentile for an 8 MHz DVB-T 64-QAM with code rate 2/3 signal interfered with by a 10 MHz LTE BS signal in a Gaussian channel environment for silicon tuners (see Notes 1 to 5)	41
Table 38 – Corrected PR values at the 50 th and 90 th percentile and O_{th} values at the 10 th and 50 th percentile for an 8 MHz DVB-T 64-QAM with code rate 2/3 signal interfered with by a 10 MHz LTE user equipment signal in a Gaussian channel environment for can tuners (see Notes 1 to 4)	42
Table 38A – Corrected PR values at the 50 th and 90 th percentile and O_{th} values at the 10 th and 50 th percentile for an 8 MHz DVB-T 64-QAM with code rate 2/3 signal interfered with by a 10 MHz LTE user equipment signal in a Gaussian channel environment for silicon tuners (see Notes 1 to 4).....	43
Table 38B – Recommended PR values and O_{th} values for sharing studies for an 8 MHz DVB-T 64-QAM with code rate 2/3 signal interfered with by a 10 MHz LTE base station or user equipment signal in a Gaussian channel environment for all tuners and traffic loadings (see Notes 1 to 5).....	44
Table 39 Protection ratios (dB) for a wanted analogue vision signal interfered with by an unwanted DVB-T 8 MHz signal.....	45
Table 40 – Protection ratios (dB) for a wanted analogue vision signal interfered with by an unwanted DVB-T 7 MHz signal.....	45

Table 41 – Protection ratios (dB) for a wanted analogue vision signal interfered with by DVB-T 7 MHz and 8 MHz signals (lower adjacent channel)	45
Table 42 – Protection ratios (dB) for a wanted analogue vision signal interfered with by DVB-T 7 MHz and 8 MHz signals (upper adjacent channel)	46
Table 43 – Protection ratios (dB) for a wanted analogue vision signal interfered with by a DVB-T 8 MHz signal (image channel)	46
Table 44 – Protection ratios (dB) for a wanted analogue vision signal interfered with by a DVB-T 7 MHz signal (image channel)	46
Table 45 – Protection ratios (dB) for analogue B, D, D1, G, H, K/PAL vision signals interfered with by a DVB-T 7 MHz signal (overlapping channels)	47
Table 46 – Protection ratios (dB) for analogue B, D, D1, G, H, K/PAL vision signals interfered with by a DVB-T 8 MHz signal (overlapping channels)	48
Table 47 – Co-channel protection (dB) ratios for a wanted sound signal interfered with by DVB-T digital terrestrial television signals	49
Table 48 – Protection ratios (dB) for a wanted FM sound signal interfered with by a DVB-T 7 MHz signal (overlapping channels)	50
Table 49 – Protection ratios (dB) for a wanted AM sound signal interfered with by a DVB-T 8 MHz signal for different frequency offsets (upper adjacent channel)	50
Table 50 – Theoretical correction factors for protection ratios (dB) for different wanted DVB-T system variants relative to 64-QAM 2/3 DVB-T signal and for different reception conditions (interfered with by DVB-T or other services)	51
Table 51 – Protection ratios (dB) for a T-DAB signal interfered with by a DVB-T 8 MHz signal	52
Table 52 – Protection ratios (dB) for a T-DAB signal interfered with by a DVB-T 7 MHz signal	52
Table 53 – Calculation of minimum field strength DVB-T 8 MHz system	52
Table 54 – Required average C/N , speed limits for mobile reception for the non-diversity case	54
Table 55 – Required average C/N , speed limits for mobile reception for the diversity case...	54
Table 56 – Channel profile for measurement of required average C/N for mobile reception of DVB-T reception “typical urban”	55
Table 57 – Doppler spectrum definitions for PI- and PO-channels	56
Table 58 – Definition of PI-channel	56
Table 59 – Definition of PO-channel	57
Table 60 – C/N (dB) for 5% MFER in PI and PO channel	57

Table 61 – DVB-H C/N (dB) in mobile channel for 5% MFER.....	59
Table 62 – Protection ratios (PR) and overload thresholds (O_{th}) for DVB-T 8 MHz 64-QAM code rate 2/3 signal interfered with by emissions of 5 MHz UMTS base station without transmit power control (TPC Off) measured for silicon tuners (see Notes 1 to 3).....	61
Table 63 – Protection ratios (PR) and overload thresholds for DVB-T 8 MHz 64-QAM code rate 2/3 signal interfered with by emissions of 5 MHz UMTS user equipment with transmit power control (TPC On) measured for silicon tuners (see Notes 1 to 4)	62
Table 64 – PR values at the 50 th and 90 th percentile and O_{th} values at the 10 th and 50 th percentile for an 8 MHz DVB-T 64-QAM with code rate 2/3 signal interfered with by a 10 MHz LTE BS signal with 0% traffic load in a Gaussian channel environment for can tuners and silicon tuners (see Notes 1 to 7)	63
Table 65 – PR values at the 50 th and 90 th percentile and O_{th} values at the 10 th and 50 th percentile for an 8 MHz DVB-T 64-QAM with code rate 2/3 signal interfered with by a 10 MHz LTE BS signal with 50% traffic load in a Gaussian channel environment for can tuners and silicon tuners (see Notes 1 to 6).....	64
Table 66 – PR values at the 50 th and 90 th percentile and O_{th} values at the 10 th and 50 th percentile for an 8 MHz DVB-T 64-QAM with code rate 2/3 signal interfered with by a 10 MHz LTE BS signal with 100% traffic load in a Gaussian channel environment for can tuners and silicon tuners (see Notes 1 to 6).....	65
Table 67 – Co-channel protection ratios (dB) for ISDB-T 6 MHz interfered with by ISDB-T 6 MHz	67
Table 67bis – Co-channel protection ratios (dB) for wanted ISDB-T signal interfered with by DVB-T2 digital terrestrial television signal for Ricean Channel (BW=6 MHz).....	67
Table 68 – Co-channel protection ratios (dB) for an ISDB-T 8 MHz signal interfered with by an ISDB-T 8 MHz or a DVB-T 8 MHz signal	68
Table 69 – Protection ratios (dB) for ISDB-T 6 MHz 64-QAM code rate 7/8 signal interfered with by ISDB-T 6 MHz signal in the lower ($N - 1$) and upper ($N + 1$) adjacent channels.....	68
Table 69bis – Adjacent channel protection ratios (dB) for wanted ISDB-T 64-QAM code rate 7/8 signal interfered with by DVB-T2 signal for Ricean channel (BW=6 MHz) ..	68
Table 70 – Protection ratios (dB) for an ISDB-T 8 MHz 64-QAM coding rate 7/8 signal interfered with by an ISDB-T 8 MHz or a DVB-T 8 MHz signal in the lower ($N - 1$) and upper ($N + 1$) adjacent channels	69
Table 71 – Co-channel protection ratios (dB) for ISDB-T 6 MHz interfered with by analogue television.....	69
Table 72 – Co-channel protection ratios (dB) for an ISDB-T 8 MHz signal interfered with by analogue television (non-controlled frequency condition) signals.....	70
Table 73 – Protection ratios (dB) for lower adjacent channel ($N - 1$) interference for ISDB-T 6 MHz interfered with by NTSC signals including sound	70

Table 74 – Protection ratios (dB) for lower adjacent channel ($N - 1$) interference for an ISDB-T 8 MHz signal interfered with by analogue television signals including sound	71
Table 75 – Protection ratios (dB) for upper adjacent channel ($N + 1$) interference for ISDB-T 6 MHz interfered with by NTSC 6 MHz signal	71
Table 76 – Protection ratios (dB) for upper adjacent channel ($N + 1$) interference for an ISDB-T 8 MHz signal interfered with by analogue television signals.....	72
Table 77 – Protection ratios (dB) for analogue vision signal (NTSC, 6 MHz) interfered with by ISDB-T signal.....	72
Table 78 – Protection ratios (dB) for wanted analogue vision signals (I/PAL and G/PAL, 8 MHz) interfered with by an unwanted ISDB-T 8 MHz signal	73
Table 79 – Protection ratios (dB) for wanted analogue vision signals (I/PAL and G/PAL, 8 MHz) interfered with by an wanted ISDB-T 8 MHz signal (lower adjacent channel)	73
Table 80 – Protection ratios (dB) for wanted analogue vision signals (I/PAL and G/PAL, 8 MHz) interfered with by an wanted ISDB-T 8 MHz signal (upper adjacent channel)	73
Table 81 – Sound quality related to the vision protection ratio of grade 3 when NTSC 6 MHz signal interfered with by ISDB-T 6 MHz signal	74
Table 82 – Co-channel protection ratios (dB) for a wanted sound signal interfered with by an ISDB-T digital terrestrial television signal	74
Table 83 – PR and O_{th} values for a 6 MHz ISDB-T 64-QAM with code rate 7/8 signal interfered with by a 10 MHz LTE base station or user equipment signal in a Gaussian channel environment for all tuners and traffic loadings (see Notes 1 to 4).....	75
Table 84 – Calculation of minimum field strengths for ISDB-T 6 MHz system.....	76
Table 85 – Calculation of minimum field strengths for ISDB-T 8 MHz system.....	77
Table 86 – C/N (dB) for 5% ESR in PI and PO channel	78
Table 87 – ISDB-T C/N (dB) in mobile channel for 5% ESR.....	79
Table 88 – Co-channel protection ratios (dB) for a DTMB 8 MHz signal interfered with by a DTMB signal	82
Table 89 – Protection ratios (dB) for a DTMB 8 MHz signal interfered with by a DTMB 8 MHz signal in the lower ($N - 1$) and upper ($N + 1$) adjacent channels	82
Table 90 – Co-channel protection ratios (dB) for a DTMB 7 MHz signal interfered with by a DTMB 7 MHz signal	83
Table 91 – Protection ratios (dB) for a DTMB 7 MHz signal interfered with by a DTMB 7 MHz signal in the lower ($N - 1$) and upper ($N + 1$) adjacent channels	83
Table 92 – Co-channel protection ratios (dB) for a DTMB 6 MHz signal interfered with by a DTMB 6 MHz signal	84

Table 93 – Protection ratios (dB) for a DTMB 6 MHz signal interfered with by a DTMB 6 MHz signal in the lower ($N - 1$) and upper ($N + 1$) adjacent channels	84
Table 94 – Co-channel protection ratios (dB) for DTMB 8 MHz signal interfered with by analogue television (non-controlled frequency condition) signals.....	85
Table 95 – Co-channel protection ratios (dB) for DTMB 7 MHz signal interfered with by analogue television (PAL B) signals	86
Table 96 – Co-channel protection ratios (dB) for DTMB 6 MHz signal interfered with by analogue television (M/NTSC) signals.....	86
Table 97 – Protection ratios (dB) for lower adjacent channel ($N - 1$) interference for DTMB 8 MHz signal interfered with by analogue television signals including sound	87
Table 98 – Protection ratios (dB) for lower adjacent channel ($N - 1$) interference for DTMB 7 MHz signal interfered with by analogue television signals including sound	87
Table 99 – Protection ratios (dB) for lower adjacent channel ($N - 1$) interference for DTMB 6 MHz signal interfered with by analogue television signals including sound	88
Table 100 – Protection ratios (dB) for upper adjacent channel ($N + 1$) interference for DTMB 8 MHz signal interfered with by an analogue television signal	88
Table 101 – Protection ratios (dB) for upper adjacent channel ($N + 1$) interference for DTMB 7 MHz signal interfered with by an analogue television signal	89
Table 102 – Protection ratios (dB) for upper adjacent channel ($N + 1$) interference for DTMB 6 MHz signal interfered with by an analogue television signal	89
Table 103 – Protection ratios (dB) for a wanted analogue vision signal interfered with by an unwanted DTMB 8 MHz signal	90
Table 104 – Protection ratios (dB) for a wanted analogue vision signal interfered with by an unwanted DTMB 7 MHz signal	90
Table 105 – Protection ratios (dB) for a wanted analogue vision signal interfered with by an unwanted DTMB 6 MHz signal	90
Table 106 – Protection ratios (dB) for a wanted analogue vision signal interfered with by DTMB 8 MHz signal (lower adjacent channel)	91
Table 107 – Protection ratios (dB) for a wanted analogue vision signal interfered with by DTMB 7 MHz signal (lower adjacent channel)	91
Table 108 – Protection ratios (dB) for a wanted analogue vision signal interfered with by DTMB 6 MHz signal (lower adjacent channel)	91
Table 109 – Protection ratios (dB) for a wanted analogue vision signal interfered with by DTMB 8 MHz signal (upper adjacent channel)	91
Table 110 – Protection ratios (dB) for a wanted analogue vision signal interfered with by DTMB 7 MHz signal (upper adjacent channel)	92

Table 111 – Protection ratios (dB) for a wanted analogue vision signal interfered with by DTMB 6 MHz signal (upper adjacent channel)	92
Table 112 – Protection ratios (dB) for a wanted analogue vision signal interfered with by a DTMB 8 MHz signal (image channel)	92
Table 113 – Protection ratios (dB) for a wanted analogue vision signal interfered with by a DTMB 7 MHz signal (image channel)	92
Table 114 – Protection ratios (dB) for a wanted analogue vision signal interfered with by a DTMB 6 MHz signal (image channel)	93
Table 115 – Protection ratios (dB) for an analogue vision signal interfered with by a DTMB 8 MHz signal (overlapping channels).....	93
Table 116 – Protection ratios (dB) for an analogue vision signal interfered with by a DTMB 7 MHz signal (overlapping channels).....	94
Table 117 – Protection ratios (dB) for an analogue vision signal interfered with by a DTMB 6 MHz signal (overlapping channels).....	94
Table 118 – Calculation of minimum field strength DTMB 8 MHz system	95
Table 119 – Calculation of minimum field strength DTMB 7 MHz system	96
Table 120 – Calculation of minimum field strength DTMB 6 MHz system	96
Table 121 – Required average C/N for 8 MHz DTMB system, speed limits for mobile reception for the non-diversity case.....	97
Table 122 – Required average C/N for 7 MHz DTMB system, speed limits for mobile reception for the non-diversity case.....	98
Table 123 – Required average C/N for 6 MHz DTMB system, speed limits for mobile reception for the non-diversity case.....	98
Table 124 – Channel profile for measurement of required average C/N for mobile reception of DTMB reception “typical urban”	98
Table 125 – Co-channel protection ratios (dB) for a DTMB-A 8 MHz signal interfered with by a DTMB-A signal	101
Table 126 – Protection ratios (dB) for a DTMB-A 8 MHz signal interfered with by a DTMB-A 8 MHz signal in the lower ($N - 1$) and upper ($N + 1$) adjacent channels	102
Table 127 – Co-channel protection ratios (dB) for DTMB-A 8 MHz signal interfered with by analogue television (non-controlled frequency condition) signals.....	103
Table 128 – Protection ratios (dB) for lower adjacent channel ($N - 1$) interference for DTMB-A 8 MHz signal interfered with by analogue television signals including sound.....	103
Table 129 – Protection ratios (dB) for upper adjacent channel ($N + 1$) interference for DTMB-A 8 MHz signal interfered with by an analogue television signal.....	104

Full document details: ITU-R BT.1368-13 2017

Table 130 – Protection ratios (dB) for a wanted analogue vision signal interfered with by an unwanted DTMB-A 8 MHz signal	104
Table 131 – Protection ratios (dB) for a wanted analogue vision signal interfered with by DTMB-A 8 MHz signal (lower adjacent channel)	105
Table 132 – Protection ratios (dB) for a wanted analogue vision signal interfered with by DTMB-A 8 MHz signal (upper adjacent channel)	105
Table 133 – Protection ratios (dB) for a wanted analogue vision signal interfered with by a DTMB-A 8 MHz signal (image channel).....	105
Table 134 – Protection ratios (dB) for an analogue vision signal interfered with by a DTMB-A 8 MHz signal (overlapping channels).....	106
Table 135 – Calculation of minimum field strength DTMB-A 8 MHz system.....	106
Table 136 – Required average C/N for 8 MHz DTMB-A system, speed limits for mobile reception for the non-diversity case.....	108
Table 137 – Channel profile for measurement of required average C/N for mobile reception of DTMB-A reception “typical urban”	108
Table 138 – Building entry loss variations in the UHF Bands IV/V	112
Table 139 – Antenna gain (dBd) for portable reception	113
Table 140 – Antenna gain (dBd) for hand-held reception	113
Table 141 – Antenna gain (dBd) for mobile reception	113
Table 142 – Basic terms and relations for the SCM	116

List of Tables

	<i>Page</i>
Figure 1 – Required average C/N in a mobile propagation channel	53
Figure 2 – Required average C/N in a mobile propagation channel.....	97
Figure 3 – Required average C/N in a mobile propagation channel	107
Figure 4 – Ratio (dB) of the field strength for a given percentage of the receiving locations to the field strength for 50% of the receiving locations	111
Figure 5 – SCM for assessment of protection ratios.....	115

Annex 1

Planning criteria for ATSC digital television systems in the VHF/UHF bands

1 Protection ratios for ATSC wanted digital terrestrial television signals

Tables 3 to 5 and 6 to 9 show protection ratios for an ATSC digital terrestrial television signal interfered with by an ATSC digital terrestrial television signal, and by an analogue terrestrial television signal, respectively.

1.1 Protection of an ATSC digital terrestrial television signal interfered with by an ATSC digital terrestrial television signal

TABLE 3

Co-channel protection ratios (dB) for a 6 MHz ATSC signal interfered with by a 6 MHz ATSC signal at various signal-to-noise ratios (S/N)

Signal-to-noise ratio (S/N) of wanted signal (dB)	Unwanted signal protection ratio (dB)
	ATSC 6 MHz
16 dB	23
Greater than 16 dB but less than 28 dB	Use equation below ⁽¹⁾
Greater than or equal to 28 dB	15

⁽¹⁾ Protection Ratio (dB) = $15 + 10 \log_{10}\{1/(1-10^{-x/10})\}$
 where $x = S/N - 15.19$ (minimum S/N).

TABLE 4

Protection ratios (dB) for a 6 MHz ATSC signal (wanted) interfered with by a 6 MHz ATSC signal (unwanted) in the lower ($N - 1$) and upper ($N + 1$) adjacent channels at the given wanted signal average power levels at the receiver input

Type of interference	Adjacent channel protection ratio (dB)		
	Weak wanted ATSC signal (−68 dBm)	Moderate wanted ATSC signal (−53 dBm)	Strong wanted ATSC signal (−28 dBm)
Lower adjacent channel interference ($N - 1$)	−28	−28	−20
Upper adjacent channel interference ($N + 1$)	−26	−26	−20

The protection ratios (dB) apply to both continuous and tropospheric interference.

TABLE 5

Protection ratios (dB) for a 6 MHz ATSC signal (wanted) interfered with by a 6 MHz ATSC signal (unwanted) in multiple adjacent channels, $N \pm 2$ to $N \pm 15$, at the given wanted signal average power levels at the receiver input

Type of interference	Multiple adjacent channel protection ratio (dB)		
	Weak wanted ATSC signal (-68 dBm)	Moderate wanted ATSC signal (-53 dBm)	Strong wanted ATSC signal (-28 dBm)
$N \pm 2$	-44	-40	-20
$N \pm 3$	-48	-40	-20
$N \pm 4$	-52	-40	-20
$N \pm 5$	-56	-42	-20
$N \pm 6$ to $N \pm 13$	-57	-45	-20
$N \pm 14$ and $N \pm 15$	-50	-45	-20

1.2 Protection of ATSC digital terrestrial television interfered with by analogue terrestrial television

1.2.1 Protection from co-channel interference

TABLE 6

Co-channel protection ratios (dB) for an ATSC 6 MHz signal interfered with by an analogue television signal

Wanted signal	Unwanted signal (Analogue TV signal including sound carriers)	
	M/NTSC	PAL B
ATSC	2 ⁽¹⁾ 7	9
ATSC with 1/2 rate concatenated trellis coding	1	3
ATSC with 1/4 rate concatenated trellis coding	-2	0

⁽¹⁾ Using a comb filter in the digital television receiver and C/N of 19 dB.

1.2.2 Protection from lower adjacent channel ($N - 1$) interference

TABLE 7

Protection ratios (dB) for lower adjacent channel ($N - 1$) interference for an ATSC 6 MHz signal interfered with by an analogue television signal including sound

Wanted signal	Unwanted signal (Analogue TV signal including sound carriers)
	M/NTSC
ATSC	−48

1.2.3 Protection from upper adjacent channel ($N + 1$) interference

TABLE 8

Protection ratios (dB) for upper adjacent channel ($N + 1$) interference for an ATSC 6 MHz signal interfered with by an analogue television signal

Wanted signal	Unwanted signal (Analogue TV signal including sound carriers)
	M/NTSC
ATSC	−49

1.2.4 Protection from other channel interference

TABLE 9

Protection ratios (dB) for an ATSC 6 MHz signal interfered with by an M/NTSC signal at other out-of-band channels

Wanted signal	Unwanted signal	Unwanted channels	Protection ratio
ATSC	M/NTSC	$N \pm 2$ to $N \pm 8$	−58

2 Protection ratios for wanted analogue terrestrial television signals interfered with by unwanted ATSC digital terrestrial television signals

Table 10 and Tables 11 to 13 show protection ratios for wanted 525-line and 625-line, respectively, analogue television signals interfered with by ATSC digital terrestrial television signals.

2.1 Protection ratios for 525-line television systems

2.1.1 Protection for vision signals interfered with by ATSC digital television

In this section the protection ratios for an analogue wanted signal interfered by an unwanted ATSC digital signal apply only to the interference to the vision and colour carriers.

TABLE 10

Protection ratios (dB) for a wanted analogue vision signal (NTSC, 6 MHz) interfered with by an unwanted ATSC signal

Unwanted digital channel	Tropospheric interference grade 3	Continuous interference grade 4
$N - 1$ (lower)	-16	
N (co-channel)	34	
$N + 1$ (upper)	-17	
$N + 14$ (image)	-33	
$N + 15$ (image)	-31	
$N \pm 2$	-24	
$N \pm 3$	-30	
$N \pm 4$	-25	
$N \pm 7$	-34	
$N \pm 8$	-32	

2.2 Protection ratios for 625-line television systems

2.2.1 Protection of wanted vision signals interfered with by ATSC digital terrestrial television

In this section the protection ratios for an analogue wanted signal interfered by an unwanted digital signal relate only to the interference to the vision signal.

The protection ratio values given are related to an out-of-channel spectrum attenuation of the unwanted DVB-T transmitter of 40 dB.

2.2.1.1 Protection from co-channel interference

TABLE 11

Protection ratios (dB) for a wanted analogue vision signal interfered with by an unwanted ATSC 6 MHz signal

Wanted signal: analogue system	Unwanted signal: ATSC 6 MHz	
	Tropospheric interference	Continuous interference
B/PAL	38	45

2.2.1.2 Protection from lower adjacent channel interference

TABLE 12

Protection ratios (dB) for a wanted analogue vision signal interfered with by an ATSC 6 MHz signal (lower adjacent channel)

Wanted signal: analogue system	Unwanted signal: ATSC 6 MHz signal (lower adjacent channel)	
	Tropospheric interference	Continuous interference
B/PAL	−7	−1

2.2.1.3 Protection from upper adjacent channel interference

TABLE 13

Protection ratios (dB) for a wanted analogue vision signal interfered with by an ATSC 6 MHz signal (upper adjacent channel)

Wanted signal: analogue system	Unwanted signal: ATSC 6 MHz signal (upper adjacent channel)	
	Tropospheric interference	Continuous interference
B/PAL	−7	0

3 Protection ratios for sound signals of wanted analogue terrestrial television signals interfered with by unwanted ATSC digital terrestrial television signals

3.1 Protection for NTSC sound signals (BTSC MTS system and SAP) interfered with by an ATSC digital television signal (see Note 1)

In the case of an unwanted upper adjacent digital channel $N + 1$ the audio signals degrade before the vision signal. The protection ratio value for the interference into the BTSC MTS and SAP sound signals was measured with −12 dB. (Vision protection ratio for $N + 1$ is −17 dB.) The −12 dB sound protection ratio figure is related to the wanted NTSC vision carrier level.

NOTE 1 – BTSC MTS: broadcast television system committee multichannel television sound; SAP: sound audio programme.

4 Minimum field strengths for ATSC terrestrial digital television

TABLE 14

Derivation by the figure of merit method ATSC 6 MHz system*

Planning parameter ⁽¹⁾	Low VHF 54-88 MHz	High VHF 174-216 MHz	UHF 470-806 MHz
Frequency (MHz)	69	194	615
C/N (dB)	19.5 ⁽²⁾	19.5 ⁽²⁾	19.5 ⁽²⁾
k (dB)	-228.6	-228.6	-228.6
B (dB(Hz)) (6 MHz)	67.8	67.8	67.8
G_{1m^2} (dB)	-1.8	7.3	17.2
G_D (dB)	6	8	10
G_I (dB)	8.2	10.2	12.2
Transmission line loss (dB) α_{line}	1.1	1.9	3.3
Antenna 300/75 balun loss (dB) α_{balun}	0.5	0.5	0.5
Receiver noise figure (dB)	5	5	10
T_{rx} (K)	627.1	627.1	2 610
T_{line} (K)	65.0	102.9	154.4
LNA noise figure (dB)	5	5	5
LNA gain (dB)	20	20	20
T_{LNA} (dB)	627.1	627.1	627.1
T_{balun} (K)	31.6	31.6	31.6
T_a (K)	9 972.1	569.1	Negligible
$T_a \alpha_{balun}$ (K)	8 885.1	507.1	Negligible
$T_{line}/\alpha G$ (K)	0.8	1.6	3.3
$T_{rx}/\alpha G$ (K)	8.1	9.7	55.8
T_e (K)	9 552.6	1 176.8	717.8
$10 \log(T_e)$ (dB(K))	39.8	30.7	28.6
G_A (dB)	7.7	9.7	11.7
E_{rx} (dB(μ V/m)) ^{(2), (3)} (TBC)	35	33	39

* The values in the Table were calculated assuming C/N with typical multipath reception impairment and equal partitioning for noise and interference. The receiving system model is a typical receiving installation located near the edge of coverage and consists of an externally mounted antenna, a low noise amplifier (LNA) mounted at the antenna, an interconnecting downlead cable and an ATSC receiver.

⁽¹⁾ For definitions see Attachment 1 to Annex 1.

⁽²⁾ Figures should be adjusted downward (towards better performance) by 6 dB for 1/2 rate concatenated trellis coding or 9 dB for 1/4 rate concatenated trellis coding.

⁽³⁾ For formula see Attachment 1 to Annex 1.

Attachment 1 to Annex 1

Derivation by the figure of merit method

Required field strength

$$\begin{aligned}
 E_{rx} \text{ (dB(V/m))} &= \varphi \text{ (dB(W/m}^2\text{))} + 10 \log(120 \pi) \\
 C/N &= \varphi - G_{lm}^2 + G_A/T_e - k - B_{rf} \\
 E_{rx} \text{ (dB(}\mu\text{V/m))} &= \varphi \text{ (dB(W/m}^2\text{))} + 25.8 \text{ (dB)} + 120 \text{ (dB)} \\
 &= 145.8 + C/N + G_{lm}^2 - G_A/T_e + 10 \log(k) + 10 \log(B_{rf})
 \end{aligned}$$

E_{rx} : required field strength at the receive system antenna

φ : power flux-density at the receive system antenna

C/N : carrier-to-noise ratio

G_{lm}^2 : gain of 1 m²

G_A/T_e : figure of merit of the receive system

k : Boltzmann's constant (J/K)

B_{rf} : system equivalent noise bandwidth.

Receive system figure of merit

(For receiving system model with LNA)

$$G_A/T_e = (G - L)/(\alpha_{balun} T_a + T_{balun} + T_{LNA} + T_{line}/(\alpha_{line} G_{LNA}) + T_{rx}/(\alpha_{line} G_{LNA}))$$

Receiver noise temperature

$$T_{rx} = (10^{NF/10} - 1) \times 290^\circ$$

LNA noise temperature

$$T_{LNA} = (10^{NF/10} - 1) \times 290^\circ$$

Transmission line noise temperature

$$T_{line} = (1 - \alpha_{line}) \times 290^\circ$$

Balun noise temperature

$$T_{balun} = (1 - \alpha_{balun}) \times 290^\circ$$

Antenna noise temperature

$$T_a = 10^{(6.63 - 2.77(\log f))} \times 290^\circ \quad (\text{for dipole antenna})$$

where f is expressed in MHz.

Antenna noise temperature (referred to LNA input)

$$\alpha T_a = T_a(\alpha_{balun})$$

System noise temperature

$$T_e = (\alpha_{balun} T_a + T_{balun} + T_{LNA} + T_{line}/(\alpha_{line} G_{LNA}) + T_{rx}/(\alpha_{line} G_{LNA}))$$

$$T_e \text{ (dB(K))} = 10 \log(\alpha_{balun} T_a + T_{balun} + T_{LNA} + T_{line}/(\alpha_{line} G_{LNA}) + T_{rx}/(\alpha_{line} G_{LNA}))$$

$$\text{or} \quad = 10 \log(T_{balun} + T_{LNA} + T_{line}/(\alpha_{line} G_{LNA}) + T_{rx}/(\alpha_{line} G_{LNA})) + N_{ext}$$

when T_a is not known.

Gain of 1 m²

$$G_{1m^2} = 10 \log(4 \pi / \lambda \lambda^2)$$

Data

- G_I : antenna gain (isotropic) (dB)
- L : transmission line loss (dB)
- α_{line} : transmission line loss (numeric ratio)
- T_a : antenna noise temperature (K)
- T_{rx} : receiver noise temperature (K)
- n_f : noise factor (numeric ratio)
- NF : noise figure (dB)
- T_0 : reference temperature = 290 K
- λ : wavelength of frequency of operation
- G_A : system gain (dB)
- T_e : system noise temperature (K)
- N_{ext} : dB value representing the contribution due to external noise
- k : Boltzmann's constant 1.38×10^{-23} (−228.6 dB) (J/K)
- B : system equivalent noise bandwidth (dB(Hz))
- α_{balun} : antenna 300/75 Balun loss (numeric ratio)
- LNA: low noise amplifier
- T_{LNA} : LNA noise temperature (K)

Annex 2

Planning criteria for DVB-T digital television systems in the VHF/UHF bands

1 Protection ratios for DVB-T wanted digital terrestrial television signals

Tables 15 to 17, 19 to 25, 26 to 28 and 29 to 30 show protection ratios for the DVB-T wanted digital terrestrial television signals interfered with:

- by DVB-T digital terrestrial television signals,
- by analogue terrestrial television signals,
- by a single continuous wave (CW) or FM carrier,
- by terrestrial digital audio broadcasting (T-DAB) signals, respectively.

1.1 Protection of a DVB-T digital terrestrial television signal interfered with by a digital terrestrial television signal

TABLE 15
Co-channel protection ratios (dB) for a DVB-T signal
interfered with by a DVB-T signal

Modulation	Code rate	Gaussian channel	Rice channel	Rayleigh channel
QPSK	1/2	5	6	8
QPSK	2/3	7	8	11
16-QAM	1/2	10	11	13
16-QAM	2/3	13	14	16
16-QAM	3/4	14	15	18
64-QAM	1/2	16	17	19
64-QAM	2/3	19	20	23
64-QAM	3/4	20	21	25

Protection ratios are given for three types of propagation channels (i.e. Gaussian, Ricean and Rayleigh). For fixed and portable reception, the values relevant to the Ricean and Rayleigh channels, respectively, should be adopted.

The same protection ratios should be applied for DVB-T systems with 6, 7 and 8 MHz bandwidth.

Protection ratios are rounded to the nearest integer.

For overlapping channel, in absence of measurement information, and if the overlapping bandwidth between the wanted and unwanted signals is less than 1 MHz, the protection ratio, PR , should be extrapolated from the co-channel ratio figure as follows:

$$PR = CCI + 10 \log_{10}(BO/BW)$$

where:

CCI : co-channel protection ratio

BO : bandwidth (MHz) in which the two DVB-T signals are overlapping

BW : bandwidth (MHz) of the wanted signal

$PR = -30$ dB should be used when the above formula gives $PR < -30$ dB.

However, further studies are needed on this subject.

Co-channel protection ratios (dB) for a DVB-T signal interfered with by a DTMB signal for the case of fixed reception

DVB-T system variant	PR, dB
QPSK 1/2	6
QPSK 2/3	8
QPSK 1/4	9.3
QPSK 5/6	10.5
QPSK 7/8	11.5
16-QAM 1/2	11
16-QAM 2/3	14
16-QAM 3/4	15
16-QAM 5/6	16.9
16-QAM 7/8	17.5
64-QAM 1/2	17
64-QAM 2/3	20
64-QAM 3/4	21
64-QAM 5/6	23.3
64-QAM 7/8	24.3

For overlapping channel the protection ratio, PR, should be extrapolated from the co-channel ratio figure as follows:

$$PR = CCI + 10 \log_{10}((0.855784 * BO + 1.153725) / BW)$$

CCI: co-channel protection ratio

BW : bandwidth (MHz) of the wanted DVB-T signal

$PR = -30$ dB should be used when the above formula gives $PR < -30$ dB.

NOTE – This formula is not valid for adjacent channel protection ratio (< 0.1 MHz overlap).

TABLE 17

Protection ratios (dB) and overload thresholds (dBm) for an 8 MHz 64-QAM code rate 2/3 DVB-T signal interfered with by an 8 MHz DVB-T signal in the adjacent channels and beyond (see Notes 1 to 6)

Δf MHz	PR, dB (90 th percentile)	O _{th} , dBm (10 th percentile)
–80	–54	–4.4
–72	–53	–4.7
–64	–52	–5.6
–56	–51	–5.0
–48	–51	–8.5
–40	–50	–8.5
–32	–49	–9.0
–24	–47	–10.5
–16	–43	–10.4
–8	–30	NR
8	–30	NR
16	–42	–10.7
24	–45	–22.6
32	–49	–12.7
40	–49	–10.6
48	–50	–8.8
56	–51	–8.6
64	–51	–3.1
72	–40	–3.8
80	–53	–3.0

NOTE 1 – The 90th percentile for the protection ratio value corresponds to the protection of 90% of receivers measured, with respect to the given frequency offset and parameter; whereas the 10th percentile for the overload threshold should be used to protect 90% of receivers measured.

NOTE 2 – Δf is the difference between the centre frequency of the unwanted channel and the centre frequency of the wanted channel.

NOTE 3 – NR: O_{th} is not reached. That is at this frequency offset PR is the predominant criterion. Consequently, DVB-T receiver is interfered with by the interfering signal due to insufficient C/I (<PR) before reaching its O_{th}.

NOTE 4 – PR is applicable unless the interfering signal level is above the corresponding O_{th}. If the interfering signal level is above the corresponding O_{th}, the receiver is interfered with by the interfering signal whatever the signal to interference ratio is.

NOTE 5 – At wanted signal level close to receiver sensitivity, noise should be taken into account, e.g. at sensitivity +3 dB, 3 dB should be added to the PR.

NOTE 6 – PR for different system variants and various reception conditions can be obtained using the correction factors in Table 50 in § 4 of this Annex. The overload threshold is assumed to be independent of system variant and reception conditions.

The protection ratio is given in dB and applies to both continuous and tropospheric interference.

The values given apply to the case where wanted and unwanted DVB-T signals have the same channel width. Other combinations of channel width need further studies.

TABLE 18

Protection ratios (dB) for a DVB-T 64 QAM code rate 2/3 signal interfered with by a DTMB signal in the lower ($N - 1$) and upper ($N + 1$) adjacent channels

Reception mode (Note 1)	Channel	
	$N - 1$	$N + 1$
FX	-30	-30

NOTE 1 – PR for different system variants and various reception conditions of the wanted DVB-T signal can be obtained using the correction factors in Table 50 in § 4 of this Annex.

1.2 Protection of DVB-T digital terrestrial television interfered with by analogue terrestrial television

1.2.1 Protection from co-channel interference

TABLE 19

Co-channel protection ratios (dB) for DVB-T 7 MHz and 8 MHz signals interfered with by analogue television (non-controlled frequency condition) signals

Modulation	Code rate	Gaussian channel	Rice channel	Rayleigh channel
QPSK	1/2	-12		-12
QPSK	2/3	-8		-8
QPSK	3/4	-4		
QPSK	5/6	3		
QPSK	7/8	9		
16-QAM	1/2	-8		-8
16-QAM	2/3	-3		3
16-QAM	3/4	0		5
16-QAM	5/6	9		
16-QAM	7/8	16		
64-QAM	1/2	-3		3
64-QAM	2/3	3		6
64-QAM	3/4	9		15
64-QAM	5/6	15		
64-QAM	7/8	20		

NOTE 1 – The PAL/SECAM values are valid for the following sound carrier modes:

- MONO FM with a single sound carrier at –10 dB referred to the vision carrier;
- DUAL FM and FM + NICAM with two sound carriers at –13 dB and –20 dB level;
- AM + NICAM with two sound carriers at respectively –10 dB and –27 dB level.

According to the available measurements, the same protection ratio values are applicable for 2k and 8k modes.

In all Tables except Table 28, the so-called non-controlled conditions are used.

Actual measurements of protection ratio values will reflect the cyclic variation that occurs when the offset between a wanted DVB-T signal and an unwanted analogue signal is varied over a frequency range equivalent to the spacing between carriers of coded orthogonal frequency division multiplex (COFDM) systems. The protection ratios given represent a conservative, but realistic, value that covers the expected offset performance of existing receivers. The adoption of fine offset between COFDM signals and interfering analogue TV signals will permit the achievement of up to 3 dB improvement in protection ratio. The required transmitter frequency stability is similar to that of analogue precision offset, that means a range of some ± 1 Hz.

Protection ratios for DVB-T 6 MHz are missing due to lack of measurement results.

1.2.2 Protection from lower adjacent channel ($N - 1$) interference

TABLE 20

**Protection ratios (dB) for lower adjacent channel ($N - 1$) interference for
DVB-T 7 MHz and 8 MHz signals interfered with by analogue
television signals including sound**

Wanted signal		Unwanted signal					
Constellation	Code rate	PAL B	PAL G, B1	PAL I	PAL D, K	SECAM L	SECAM D, K
QPSK	1/2		–44				
QPSK	2/3	–44	–44				
16-QAM	1/2		–43	–43			
16-QAM	2/3	–42	–42				
16-QAM	3/4		–38				
64-QAM	1/2		–40	–38			
64-QAM	2/3	–35	–35	–34		–35	–37
64-QAM	3/4		–32				

All values applicable for fixed and portable reception conditions.

1.2.3 Protection from upper adjacent channel ($N + 1$) interference

TABLE 21

Protection ratios (dB) for upper adjacent channel ($N + 1$) interference for DVB-T 7 MHz and 8 MHz signals interfered with by an analogue television signal

Wanted signal		Unwanted signal
Constellation	Code rate	PAL/SECAM
QPSK	2/3	−47
16-QAM	2/3	−43
64-QAM	2/3	−38

1.2.4 Protection from overlapping channel interference

TABLE 22

Protection ratios (dB) for a DVB-T 8 MHz signal interfered with by an overlapping PAL B signal including sound

Unwanted signal: PAL B analogue TV system	Wanted signal: DVB-T, 8 MHz, 64-QAM, code rate 2/3												
Δf (MHz)	−9.75	−9.25	−8.75	−8.25	−6.75	−3.95	−3.75	−2.75	−0.75	2.25	3.25	4.75	5.25
PR	−37	−14	−8	−4	−2	1	3	3	3	2	−1	−29	−36

The frequency difference Δf is the vision carrier frequency of the analogue television signal minus the centre frequency of the DVB-T signal.

TABLE 23

Protection ratios (dB) for a DVB-T 7 MHz signal interfered with by an overlapping 7 MHz analogue TV signal including sound

Unwanted signal: 7 MHz analogue TV system	Wanted signal: DVB-T, 7 MHz, 64-QAM, code rate 2/3													
Δf (MHz)	−9.25	−8.75	−8.25	−7.75	−6.25	−3.45	−3.25	−2.25	−1.25	0	1.75	2.75	4.25	4.75
PR	−35	−12	−11	−5	−3	−1	4	1	0	2	−5	−5	−36	−38

The frequency difference Δf is the vision carrier frequency of the analogue television signal minus the centre frequency of the DVB-T signal.

TABLE 24

Protection ratios (dB) for a DVB-T 7 MHz signal interfered with by an overlapping 8 MHz analogue TV signal including sound

Unwanted signal: 8 MHz analogue TV system	Wanted signal: DVB-T, 7 MHz, 64-QAM, code rate 2/3													
Δf (MHz)	-10.25	-9.75	-9.25	-8.75	-7.25	-3.45	-3.25	-2.25	-1.25	0	1.75	2.75	4.25	4.75
PR	-35	-12	-11	-5	-3	-1	4	1	0	2	-5	-5	-36	-38

The frequency difference Δf is the vision carrier frequency of the analogue television signal minus the centre frequency of the DVB-T signal.

TABLE 25

Protection ratios (dB) for a DVB-T 8 MHz signal interfered with by an overlapping 8 MHz analogue TV signal including sound

Unwanted signal: 8 MHz analogue TV system	Wanted signal: DVB-T, 8 MHz, 64-QAM, code rate 2/3													
Δf (MHz)	-10.75	-10.25	-9.75	-9.25	-7.75	-3.45	-3.25	-2.25	-1.25	0	2.25	3.25	4.75	5.25
PR	-35	-12	-11	-5	-3	-1	4	1	0	2	-5	-5	-36	-38

The frequency difference Δf is the vision carrier frequency of the analogue television signal minus the centre frequency of the DVB-T signal.

1.3 Protection of DVB-T digital terrestrial television signal from CW or FM signals

TABLE 26

Co-channel protection ratios (dB) for a DVB-T 8 MHz 64-QAM code rate 2/3 signal interfered with by a CW or a FM carrier (non-controlled frequency offset)

Unwanted signal: CW or FM carrier	Wanted signal: DVB-T, 8 MHz, 64-QAM, code rate 2/3						
Δf (MHz)	-12	-4.5	-3.9	0	3.9	4.5	12
PR	-38	-33	-3	-3	-3	-33	-38

TABLE 27

Co-channel protection ratios (dB) for a DVB-T 7 MHz 64-QAM code rate 2/3 signal interfered with by a CW or an FM carrier (non-controlled frequency offset)

Unwanted signal: CW or FM carrier	Wanted signal: DVB-T, 7 MHz, 64-QAM, code rate 2/3						
Δf (MHz)	-10.5	-4.0	-3.4	0	3.4	4.0	10.5
PR	-38	-33	-3	-3	-3	-33	-38

The given protection ratio Tables can be used for interfering signals with narrow bandwidth e.g. analogue sound carriers or non-broadcast services.

TABLE 28

Co-channel protection ratios (dB) for a DVB-T 7 MHz 64-QAM code rate 2/3 signal interfered with by a CW carrier (controlled frequency offset)

Unwanted signal: CW carrier	Wanted signal: DVB-T, 7 MHz, 64-QAM, code rate 2/3						
Δf (MHz)	-8	-4	-3	0	3	4	8
PR	-48	-41	-8	-9	-6	-39	-48

The given protection ratio Tables can be used for interfering signals with narrow bandwidth e.g. analogue sound carriers or non-broadcast services. It should be noted that the fine structure of the protection ratio versus frequency offset between the OFDM signal and the interfering CW signal exhibits a cyclic variation. The values shown in Table 28 are for the optimum offset.

1.4 Protection of DVB-T digital terrestrial television signals from T-DAB signals

TABLE 29

Co-channel protection ratios (dB) for a DVB-T 7 MHz and 8 MHz signal interfered with by four T-DAB frequency block signals

Wanted signal DVB-T		PR (Note 1)
Constellation	Code rate	
QPSK	1/2	10
QPSK	2/3	12
QPSK	3/4	14
16-QAM	1/2	15
16-QAM	2/3	18
16-QAM	3/4	20
64-QAM	1/2	20

TABLE 29 (*end*)

Wanted signal DVB-T		PR (Note 1)
Constellation	Code rate	
64-QAM	2/3	24
64-QAM	3/4	26
64-QAM	7/8	31

NOTE 1 – The given protection ratios for DVB-T signals represent the worst case of interference from T-DAB (These values are derived from measurements using four T-DAB frequency blocks with equal power levels).

TABLE 29bis

Co-channel protection ratios (dB) for a DVB-T 7 MHz interfered with by fewer than four T-DAB frequency block signals within a 7 MHz channel

Wanted signal DVB-T		PR (Note 1)		
Constellation	Code rate	1 T-DAB	2 T-DAB	3 T-DAB
64-QAM	2/3	13	21	23
64-QAM	3/4	17	23	25

NOTE 1 – These values were derived from measurements in a Gaussian channel. (The measured Subjective Failure Point (SFP) values were increased by 1 dB and rounding up to the nearest integer to derive QEF values). For planning situations involving Ricean channels a further 0.6 dB increase should be applied to these values.

TABLE 30

Protection ratios (dB) for a DVB-T 7 MHz and 8 MHz signal interfered with by a T-DAB signal in the lower ($N - 1$) or upper ($N + 1$) adjacent channels

Channel	$N - 1$	$N + 1$
PR	-30	-30

The protection ratio is given in dB.

1.5 Protection of DVB-T from wideband signals other than terrestrial broadcasting

1.5.1 Protection ratios for DVB-T interfered with by the fixed service (relocatable system)

TABLE 31

Protection ratios for DVB-T 8 MHz 64-QAM code rate 2/3 signal interfered with by emissions of the fixed service

Δf (MHz)	-12	-4.5	-3.75	0	3.75	4.5	12
PR (dB)	-45	-27	1	4	1	-27	-45

Δf : difference between the centre frequencies.