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

BT Series

Broadcasting service (television)

International Telecommunication Union

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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.1368-10

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)

Scope

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

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 and 4 and the additional information given in Annexes 5, 6, 7 and 8 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 – Other planning factors

Annex 6 – Subjective comparison method (SCM) with a reference interferer for assessment protection ratios for analogue television systems

Annex 7 – Failure point assessment methods

Annex 8 – 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(μV) at 75 Ω).

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 BER = 3×10^{-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 BER = 2×10^{-4}; this corresponds to a BER < 1×10^{-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 = 3×10^{-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 < 1×10^{-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 < 3×10^{-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 6.

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 8).

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.

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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) = $15 + 10 \log_{10}\{1/(1\text{-}10^{-x/10})\}$
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 α_{balun} (K)	8 885.1	507.1	Negligible
T_{line}/α G (K)	0.8	1.6	3.3
T_{rx}/α 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(μV/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 Appendix 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 Appendix 1 to Annex 1.

Appendix 1
to Annex 1

Derivation by the figure of merit method

Required field strength

$$E_{rx}\ (\text{dB(V/m)}) = \varphi\ (\text{dB(W/m}^2)) + 10 \log(120\ \pi)$$

$$C/N = \varphi - G_{\text{lm}^2} + G_A/T_e - k - B_{rf}$$

$$E_{rx}\ (\text{dB}(\mu\text{V/m})) = \varphi\ (\text{dB(W/m}^2)) + 25.8\ (\text{dB}) + 120\ (\text{dB})$$

$$= 145.8 + C/N + G_{\text{lm}^2} - G_A/T_e + 10 \log(k) + 10 \log(B_{rf})$$

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 m^2

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

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

LNA noise temperature

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

Transmission line noise temperature

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

Balun noise temperature

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

Antenna noise temperature

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

where f is expressed in MHz.

Antenna noise temperature (referred to LNA input)

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

System noise temperature

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

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

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

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.

TABLE 16

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
QPSK1/2	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

The treatment of overlapping and adjacent channel cases DVB-T vis-à-vis DTMB is based on Recommendation ITU-R BT.1368-6 with correction to the measurements. The protection ratios for the adjacent channels in Table 18 are used.

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

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

where:

CCI: co-channel protection ratio

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

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)

Δ*f* MHz	PR, dB (90th percentile)	O_{th}, dBm (10th 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 – Δ*f* 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 29*bis*

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.

Technical characteristics of the interferer

– Modulation 2-FSK

– Bandwidth: 750 kHz (3 dB)

1.5.2 Protection ratios for DVB-T interfered with by code-division multiple access (CDMA)

It should be noted that the Tables 32 and 33 refer to the situation where one single channel of the CDMA system is interfering with DVB-T.

TABLE 32

Protection ratios for DVB-T 8 MHz 64-QAM code rate 2/3 signal interfered with by emissions of CDMA-1X

Δf (MHz)	–12	–4.5	–3.75	0	3.75	4.5	12
PR (dB)	–38	–20	–3	10	–3	–20	–38

Δf: difference between the centre frequencies.

Characteristics of the interfering signal

– Modulation: QPSK

– Bandwidth: 1.25 MHz (99%)

TABLE 33

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

Δf (MHz)	–12	–4.5	–3.75	0	3.75	4.5	12
PR (dB)	–38	8	13	18	13	8	–38

Δf: difference between the centre frequencies.

Characteristics of the interfering signal

– Modulation: QPSK

– Bandwidth: 4 MHz (99%)

The following section provides protection ratios and overload thresholds for DVB-T systems interfered with by UMTS W-CDMA FDD systems. All measurements to derive these parameters were performed on DVB-T receivers designed for a frequency tuning range from 470 to 862 MHz, all interfering signals were within the frequency range 759 to 862 MHz.

The protection ratio and overload threshold can be significantly different for silicon tuners[1] and can tuners[2]. Silicon tuners are increasingly being used in TV receiver equipment including high-end products such as iDTVs and PVRs.

As silicon and can tuners have different performance characteristics, planners are advised to consider the relative usage volumes of each tuner type and the difference in characteristics during network planning. Compared to can tuners, silicon tuners do not suffer from degradations in PR and O_{th} when the interferer is at the 36 MHz IF frequency or at the 2/IF = 72 MHz image frequency, however some have higher protection ratios at other interferer offsets.

It is likely that a mixture of these types of tuners will exist and their proportion is likely to change with time. This Recommendation provides separate results for each type of tuners. (For further information the technical explanation of the differences can be found in Report "Measurement of protection ratios and overload threshold for TV receivers".)

If the actual distribution is not known the administrations might have to make a choice between the values.

If the actual distribution is known, e.g. X% for can tuners and Y% for silicon tuners, a possible way of weighting the figures would be to apply the following equation for each parameter (protection ratio or overload threshold):

Combined Parameter = (X% /100) / (can tuners parameter) + (Y%/100) / (silicon tuners parameter)[3]

The highest level of protection (to protect both types of tuner) is achieved by taking the higher value for the protection ratio and the lower value for the overload threshold.

The characteristics of the UMTS (W-CDMA FDD) signal used in the measurements are given in Report – Measurement of protection ratios and overload threshold for TV Receivers.

This section includes the case of TPC On (transmit power control) used at the user equipment.

Using statistical analysis the 50^{th} and 90^{th} percentile of all measured protection ratios and the 10^{th} and 50^{th} percentile of all measured overload thresholds for UMTS interference into DVB-T were calculated. They are listed in Tables 34 and 35 for the interfering UMTS base station signal and the UMTS user equipment signal respectively. The PR and O_{th} for the UMTS user equipment signal are relative to the interfering signal maximum r.m.s. The frequency offset is measured between the centre frequencies of wanted and interfering signals.

The 90^{th} (respectively 50^{th}) percentile for the protection ratio value corresponds to the protection of 90% (respectively 50%) of receivers measured.

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1 "Silicon" tuners are IC-based tuners integrating all tuner circuitry into a small package directly to be fitted onto main boards. The tuned circuits may be completely absent or can be integrated onto the silicon. The silicon chip may be protected from external electromagnetic interference by a metallic cover. When integrated onto the silicon there is a compromise in performance when compared with discrete classical layouts. The units measured represent an early generation on the market. This technology is still developing.

2 "Can" tuners are classical super heterodyne tuners housed in a metal enclosure containing discrete components. Classically, there are fixed and tuneable circuits made up from discrete inductors and transistors usually with varactor diode frequency control. The metal enclosure should minimize RF interference and eliminate crosstalk and stray radiation.

3 The values X% and Y% are in the range of 0 to 100 and their sum is equal to 100.

The 10th (respectively 50th) percentile for the overload threshold value corresponds to the protection of 90% (respectively 50%) of receivers measured.

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)

Number of Rx	**Can tuner**				**Silicon tuner**			
	14				**(Note 5)**			
Interferer offset N/(MHz)	**PR, dB 50th percentile**	**PR, dB 90th percentile**	**O_{th}, dBm 10th percentile**	**O_{th}, dB 50th percentile**	**PR, dB 50th percentile**	**PR, dB 90th percentile**	**O_{th}, dBm 10th percentile**	**O_{th}, dBm 50th percentile**
0/(0 MHz)	17.0	18.1	NR	NR				
1/(6.5 MHz)	−32.0	−30.3	−12.4	−8.0				
2/(11.5 MHz)	−43.5	−38.3	−7.7	−3.0				
3/(16.5 MHz)	−44.0	−33.7	−7.8	0.0				
4/(21.5 MHz)	−50.5	−34.9	−13.2	−1.0				
5/(26.5 MHz)	−56.0	−41.9	−15.1	−5.0				
6/(31.5 MHz)	−60.0	−43.8	−13.8	−5.5				
7/(36.5 MHz)	−45.0	−18.1	−23.9	−9.5				
8/(41.5 MHz)	−67.5	−55.1	−12.1	−2.0				
9/(46.5 MHz)	−65.0	−55.5	−12.4	−0.5				
10/(51.5 MHz)	−68.0	−57.2	−12.7	0.0				
11/(56.5 MHz)	−69.5	−60.0	−12.0	0.5				
14/(71.5 MHz)	−50.5	−41.6	−12.8	2.5				

NOTE 1 – 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 2 – 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 3 – 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 4 − 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.

NOTE 5 – Silicon tuners may have a significant difference. A limited number of three silicon tuners has been tested. Therefore no valid statistics can be provided. The values can be found in Table 62 in Appendix 2 to Annex 2 as a guidance and should be used carefully.

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)

	Can tuner				Silicon tuner			
Number of Rx	**14**				**Note 6**			
Interferer offset N/(MHz)	**PR, dB 50th percentile**	**PR, dB 90th percentile**	**O_{th}, dBm 10th percentile**	**O_{th}, dB 50th percentile**	**PR, dB 50th percentile**	**PR, dB 90th percentile**	**O_{th}, dBm 10th percentile**	**O_{th}, dB 50th percentile**
0/(0 MHz)	18.0	19.0	NR	NR				
1/(6.5 MHz)	−18.0	−16.0	−33.8	−13.0				
2/(11.5 MHz)	−37.0	−25.6	−24.7	−4.0				
3/(16.5 MHz)	−42.5	−30.6	−6.8	0.0				
4/(21.5 MHz)	−42.0	−35.9	−13.0	0.0				
5/(26.5 MHz)	−49.5	−37.3	−15.5	−0.5				
6/(31.5 MHz)	−57.5	−41.1	−8.7	−2.5				
7/(36.5 MHz)	−47.0	−18.2	−24.0	−12.0				
8/(41.5 MHz)	−68.0	−53.6	−9.0	0.0				
9/(46.5 MHz)	−66.5	−55.3	−9.0	0.5				
10/(51.5 MHz)	−71.0	−57.6	−9.7	1.5				
11/(56.5 MHz)	−72.0	−58.6	−9.1	1.5				
14/(71.5 MHz)	−50.0	−43.2	−9.5	3.0				

NOTE 1 – 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 2 – 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 3 – 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 4 − 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.

NOTE 5 – DVB-T PR and O_{th} relative to the interfering signal maximum r.m.s. power is applicable to sharing studies when the interfering UMTS user equipment signal power is taken fixed to its maximum value.

NOTE 6 – Silicon tuners may have a significant difference. A limited number of three silicon tuners has been tested. Therefore no valid statistics can be provided. The values can be found in Table 62 in Appendix 2 to Annex 2 as a guidance and should be used carefully.

1.5.3 Protection ratios and overload thresholds for DVB-T interfered with by LTE base station and user equipment signals

This section provides protection ratios and overload thresholds for DVB-T systems interfered with by LTE OFDMA (base station) and SC-FDM (user equipment) systems. All measurements to derive these parameters were performed on DVB-T receivers designed for a frequency tuning range from 470 to 862 MHz, all interfering signals were within the frequency range 759 to 862 MHz and were conducted in the manner described in Report ITU-R BT.2215.

The protection ratio and overload threshold can be significantly different for silicon tuners[4] and can tuners[5]. Silicon tuners are increasingly being used in TV receiver equipment including high-end products such as iDTVs and PVRs.

As silicon and can tuners have different performance characteristics, planners are advised to consider the relative usage volumes of each tuner type and the difference in characteristics during network planning. Compared to can tuners, silicon tuners do not suffer from degradations in PR and O_{th} when the interferer is at the 36 MHz IF frequency or at the 2 IF = 72 MHz image frequency, however some have higher protection ratios at other interferer offsets.

The LTE tests in this report assume a 1 MHz guard band between the wanted channel edge and the LTE interferer channel edge. For the case of larger guard bands where the can tuner image channel may not coincide with N + 9, the can tuner PR and O_{th} performance can be estimated by using the N + 9 performance figures for the frequency offset when the image channel occurs, and the N + 8 performance figures for the nearby frequency offsets that are close but not on image channel frequency offset.

It is likely that a mixture of these types of tuners will exist and their proportion is likely to change with time. This Recommendation provides separate results for each type of tuners. (For further information the technical explanation of the differences can be found in Report ITU-R BT.2215 “Measurement of protection ratios and overload threshold for TV receivers”.)

If the actual distribution is not known the administrations might have to make a choice between the values.

The highest level of protection (to protect both types of tuner) is achieved by taking the higher value for the protection ratio and the lower value for the overload threshold.

The characteristics of the LTE signal used in the measurements are given in Report ITU-R BT.2215 “Measurement of protection ratios and overload threshold for TV receivers”.

Using statistical analysis the 50^{th} and 90^{th} percentile of all measured protection ratios and the 10^{th} and 50^{th} percentile of all measured overload thresholds for LTE interference into DVB-T were calculated.

The 90^{th} (respectively 50^{th}) percentile for the protection ratio value corresponds to the protection of 90% (respectively 50%) of receivers measured.

The 10^{th} (respectively 50^{th}) percentile for the overload threshold value corresponds to the protection of 90% (respectively 50%) of receivers measured.

The sharing between DVB-T and the mobile LTE service is an evolving situation. The design of both the television tuners and the implementation of base stations are evolving in both cases. All parties involved are actively encouraged to improve the performance of their respective equipment so that these tables can be revisited in the near future.

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[4] “Silicon” tuners are IC-based tuners integrating all tuner circuitry into a small package directly to be fitted onto main boards. The tuned circuits may be completely absent or can be integrated onto the silicon. The silicon chip may be protected from external electromagnetic interference by a metallic cover. When integrated onto the silicon there is a compromise in performance when compared with discrete classical layouts. The units measured represent an early generation on the market. This technology is still developing.

[5] “Can” tuners are classical super heterodyne tuners housed in a metal enclosure containing discrete components. Classically, there are fixed and tuneable circuits made up from discrete inductors and transistors usually with varactor diode frequency control. The metal enclosure should minimize RF interference and eliminate crosstalk and stray radiation.

The range of protection ratios and overload thresholds obtained for LTE-BS interferer is listed in Table 36 for can tuners and Table 37 for silicon tuners for the BS traffic load range of 0% to 100%[6].

The current worst-case PR and O_{th} measurements correspond to some silicon tuners tested using an LTE signal with a very low traffic load on the base station. For these tuners, protection ratios for interference signals with 0% traffic load were generally higher than those for higher traffic load. Also on some tuners the overload thresholds for interference signals with 0% traffic load were lower than those for a higher traffic load. All situations of traffic load are provided here as the actual traffic load in the real BS operation is unlikely to be predictable. For further explanation see Report ITU-R BT.2215 "Measurement of protection ratios and overload threshold for TV receivers".

The highest level of protection (to protect broadcasting for all BS traffic load cases) is achieved by taking the highest value for the protection ratio and the lowest value for the overload threshold.

The frequency offset is measured between the centre frequencies of wanted and interfering signals.

TABLE 36

PR values at the 50th and 90th percentile and O_{th} values at the 10th and 50th 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)

Interferer offset N/(MHz)	PR, dB 50th percentile	PR, dB 90th percentile	O_{th}, dBm 10th percentile	O_{th}, dBm 50th percentile
1/(10 MHz)	–46 … –39	–37 … –33	–15 … –13	–11 … –9
2/(18 MHz)	–53 … –46	–50 … –42	–8 … –5	–3 … –2
3/(26 MHz)	–56 … –50	–51 … –41	–15 … –11	–8 … –3
4/(34 MHz)	–62 … –53	–57 … –46	–19 … –10	–12 … –7
5/(42 MHz)	–67 … –64	–63 … –51	–8 … –6	–4 … –3
6/(50 MHz)	–68 … –64	–58 … –53	–6 … –4	–2 … 1
7/(58 MHz)	–71 … –67	–66 … –58	–5 … –2	0 … 2
8/(66 MHz)	–68 … –58	–58 … –51	–5 … –1	1 … 2
9/(74 MHz)	–55 … –47	–46 … –39	–3 … –1	2 … 4

NOTE 1 – 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 2 – 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 3 − 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.

NOTE 4 – For further detail on the different BS traffic load case, see Tables 64, 65 and 66 in Appendix 2 to Annex 2.

NOTE 5 – The LTE BS interference signals used in the measurements had ACLRs of 60 dB or greater for N – 1, and significantly higher ACLRs for N – 2 and beyond.

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[6] The term 0% traffic loading on an LTE BS refers to the situation where the base station is not handling any user traffic but is still transmitting signaling, synchronisation and possibly occasional broadcast data. Early experiments showed that two out of the four TV receivers tested suffered degraded protection ratios when the BS traffic loading was between 0% and 30% but receivers are improving.

TABLE 37

PR values at the 50th and 90th percentile and O_{th} values at the 10th and 50th 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)

Interferer offset N/(MHz)	PR, dB 50th percentile	PR, dB 90th percentile	O_{th}, dBm 10th percentile	O_{th}, dBm 50th percentile
1/(10 MHz)	–41 … –32	–40 … –26	–40 … –13	–31 … –3
2/(18 MHz)	–52 … –40	–47 … –22	–32 … –10	–6 … 1
3/(26 MHz)	–52 … –39	–48 … –25	–39 … –9	–5 … 3
4/(34 MHz)	–55 … –45	–49 … –29	–29 … –8	–5 … 4
5/(42 MHz)	–55 … –50	–51 … –33	–28 … –8	–3 … 5
6/(50 MHz)	–57 … –50	–51 … –35	–26 … –8	–4 … 4
7/(58 MHz)	–57 … –54	–52 … –38	–25 … –8	–4 … 3
8/(66 MHz)	–57 … –55	–52 … –39	–24 … –8	–4 … 3
9/(74 MHz)	–57 … –53	–51 … –41	–23 … –8	3 … 5

NOTE 1 – 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 2 – 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 3 − 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.

NOTE 4 – For further detail on the different BS traffic load case, see Tables 64, 65 and 66 in Appendix 2 to Annex 2.

NOTE 5 – The LTE BS interference signals used in the measurements had ACLRs of 60 dB or greater for N – 1, and significantly higher ACLRs for N – 2 and beyond.

The range of protection ratios and overload thresholds obtained for LTE user equipment (LTE-UE) interferer is listed in Table 38 for can tuners and Table 38A for silicon tuners for time variant and continuous interference.

The current worst case situation corresponds to interference from time varying signals on some silicon tuners where the protection ratios for interference signals with constant average power and no frequency variation were generally lower than those for time varying interference signals such as the pulsed LTE UE waveform. Also the overload thresholds for interference signals with constant average power and no frequency variation were generally higher than those for time varying interference signals such as the pulsed LTE UE waveform. For further explanation, see Report ITU-R BT.2215 “Measurement of protection ratios and overload threshold for TV Receivers”. The highest level of protection (to protect broadcasting in the cases of continuous and time variant interference) is achieved by taking the highest value for the protection ratio and the lowest value for the overload threshold.

The frequency offset is measured between the centre frequencies of wanted and interfering signals.

TABLE 38

Corrected PR values at the 50th and 90th percentile and O_{th} values at the 10th and 50th 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)

Interferer offset N/(MHz)	No. Rx	PR, dB 50th percentile	PR, dB 90th percentile	O_{th}, dBm 10th percentile	O_{th}, dBm 50th percentile
1/(10 MHz)	19	–6	–6 … –5	–21 … –19	–16 … –11
2/(18 MHz)	19	–13	–13	–18 … –4	–6 … –2
3/(26 MHz)	19	–49 … –48	–43 … –40	–31 … –26	–16 … –10
4/(34 MHz)	19	–60 … –57	–58 … –54	–19 … –11	–13 … –9
5/(42 MHz)	19	–65 … –56	–62 … –50	–17 … –7	–9 … –4
6/(50 MHz)	31	–68 … –56	–65 … –48	–18 … –7	–9 … –2
7/(58 MHz)	19	–68 … –57	–67 … –47	–16 … –3	–3 … 2
8/(66 MHz)	31	–69 … –58	–67 … –52	–16 … –3	–4 … 2
9/(74 MHz)	19	–50 … –44	–38 … –33	–9 … –3	–2 … 4

NOTE 1 – 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 2 – 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 3 − 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.

NOTE 4 − Note the PR values in N = 1 and N =2 are corrected based on the assumption that the ACLR’ of the interferer is equal to 25.2 dB (N + 1), 32.2 dB (N + 2). The PR values for all other offsets are based on an ACLR’ of 88 dB. A co-channel PR_0 of 18.7 dB is used. A method to calculate values for other ACLR’ values is given in Appendix 3 to Annex 2. The measurement bandwidth used in the ACLR calculation is 8 MHz for the wanted signal and 10 MHz for the interferer.

TABLE 38A

Corrected PR values at the 50th and 90th percentile and O_{th} values at the 10th and 50th 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)

Interferer offset N/(MHz)	No. Rx High/Low rate	PR, dB 50th percentile	PR, dB 90th percentile	No. Rx High/Low rate	O_{th}, dBm 10th percentile	O_{th}, dBm 50th percentile
1/(10 MHz)	16/16	–6	–6	9/8	–31… –21	–16 … –12
2/(18 MHz)	16/16	–13	–13 … –11	9/7	–21 … –5	1 … 2
3/(26 MHz)	16/16	–51 … –39	–46 … –22	9/7	–21 … –3	1 … 5
4/(34 MHz)	9/9	–52 … –39	–48 … –28	9/7	–21 … –2	1 … 5
5/(42 MHz)	9/9	–56 … –39	–52 … –29	9/7	–20 … –3	2 … 5
6/(50 MHz)	15/20	–53 … –44	–47 … –34	12/16	–34 … –7	–15 … 1
7/(58 MHz)	9/9	–58 … –39	–53 … –28	9/7	–19 … –4	3 … 5
8/(66 MHz)	13/16	–56 … –45	–50 … –35	12/14	–30 … –5	–11 … 4
9/(74 MHz)	22/20	–55 … –45	–48 … –33	13/16	–30 … –8	–11 … 1

NOTE 1 – 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 2 – 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 3 − 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.

NOTE 4 − Note the PR values in N = 1 and N = 2 are corrected based on the assumption that the ACLR' of the interferer is equal to 25.2 dB (N + 1), 32.2 dB (N + 2). The PR values for all other offsets are based on an ACLR' of 88 dB. A co-channel PR_0 of 18.7 dB is used. A method to calculate values for other ACLR' values is given in Appendix 3 to Annex 2. The measurement bandwidth used in the ACLR calculation is 8 MHz for the wanted signal and 10 MHz for the interferer.

Selection of PR and O_{th} for sharing studies

Table 38B illustrates recommended values for PR and O_{th} to be used in sharing studies. By applying these values, 90 per cent of the receivers measured would be protected across all traffic loadings. For the UE, the corrected PR 90th percentiles were used based on the UE ACLR assumptions in Note 4.

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)

Interferer offset N/(MHz)	LTE base station		LTE user equipment	
	PR, dB	**O_{th}, dBm**	**Corrected PR, dB**	**O_{th}, dBm**
Co-channel (AWGN)	18.7	–	18.7	–
Co-channel (LTE)	18	–	19	–
1/(10 MHz)	–26	–40	–5	–31
2/(18 MHz)	–22	–32	–11	–21
3/(26 MHz)	–25	–39	–22	–31
4/(34 MHz)	–29	–29	–28	–21
5/(42 MHz)	–33	–28	–29	–20
6/(50 MHz)	–35	–26	–34	–34
7/(58 MHz)	–38	–25	–28	–19
8/(66 MHz)	–39	–24	–35	–30
9/(74 MHz)	–39	–23	–33	–30

NOTE 1 – 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 2 – 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 3 − 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.

NOTE 4 − Note the UE PR values in N = 1 and N = 2 are corrected based on the assumption that the ACLR' of the interferer is equal to 25.2 dB (N + 1), 32.2 dB (N + 2). The PR values for all other offsets are based on an ACLR' of 88 dB. A co-channel PR_0 of 18.7 dB is used. A method to calculate values for other ACLR values is given in Appendix 3 to Annex 2.

NOTE 5 – The LTE BS interference signals used in the measurements had ACLRs of 60 dB or greater for N – 1, and significantly higher ACLRs for N – 2 and beyond.

2 Protection ratios for wanted analogue terrestrial television signals interfered with by unwanted DVB-T digital terrestrial television signals

Tables 39 to 46 show protection ratios for a wanted 625-line analogue television signal interfered with by a DVB-T digital terrestrial television signal.

2.1 Protection ratios for 625-line television systems

2.1.1 Protection of wanted vision signals interfered with by DVB-T digital terrestrial television signal

In this section the protection ratios for an analogue wanted signal interfered by an unwanted DVB-T 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.

2.1.1.1 Protection from co-channel interference

TABLE 39

Protection ratios (dB) for a wanted analogue vision signal interfered with by an unwanted DVB-T 8 MHz signal

Wanted signal: analogue system	Unwanted signal: DVB-T, 8 MHz	
	Tropospheric interference	Continuous interference
B, D, D1, G, H, K/PAL	34	40
I/PAL	37	41
B, D, K, L/SECAM	35	41

TABLE 40

Protection ratios (dB) for a wanted analogue vision signal interfered with by an unwanted DVB-T 7 MHz signal

Wanted signal: analogue system	Unwanted signal: DVB-T, 7 MHz	
	Tropospheric interference	Continuous interference
B/PAL, B/SECAM	35	41

2.1.1.2 Protection from lower adjacent channel interference

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)

Wanted signal: analogue system	Unwanted signal: DVB-T, 7 or 8 MHz (lower adjacent channel)	
	Tropospheric interference	Continuous interference
B, D, D1, G, H, I, K/PAL	–9	–5
B, D, K, L/SECAM	–5	–1

2.1.1.3 Protection from upper adjacent channel interference

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)

Wanted signal: analogue system	Unwanted signal: DVB-T, 7 or 8 MHz (upper adjacent channel)	
	Tropospheric interference	Continuous interference
PAL and SECAM	–8	–5

2.1.1.4 Protection from image channel interference

TABLE 43

Protection ratios (dB) for a wanted analogue vision signal interfered with by a DVB-T 8 MHz signal (image channel)

Wanted analogue system	Unwanted DVB-T channel	Tropospheric interference	Continuous interference
D1, G/PAL	$N + 9$	–19	–15
I/PAL	$N + 9$		
L/SECAM[(1)]	$N + 9$	–24	–22
D, K/SECAM[(1)]	$N + 8$, $N + 9$	–16	–11
D, K/PAL	$N + 8$, $N + 9$		

(1) Provisional values still under study.

TABLE 44

Protection ratios (dB) for a wanted analogue vision signal interfered with by a DVB-T 7 MHz signal (image channel)

Wanted analogue system	Unwanted DVB-T channel	Tropospheric interference	Continuous interference
B/PAL	$N + 10$, $N + 11$	–22	–18

2.1.1.5 Protection from overlapping interference

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)

Frequency of the centre of the unwanted DVB-T signal minus the vision carrier frequency of the wanted analogue television signal (MHz)		Protection ratio	
		Tropospheric interference	Continuous interference
	–7.75	–16	–11
(N – 1)	–4.75	–9	–5
	–4.25	–3	4
	–3.75	13	21
	–3.25	25	31
	–2.75	30	37
	–1.75	34	40
	–0.75	35	41
(N)	2.25	35	41
	4.25	35	40
	5.25	31	38
	6.25	28	35
	7.25	26	33
	8.25	6	12
(N + 1)	9.25	–8	–5
	12.25	–8	–5

* For all SECAM systems similar values are expected. The values are still under study.

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)

Frequency of the centre of the unwanted DVB-T signal minus the vision carrier frequency of the wanted analogue television signal (MHz)		Protection ratio	
		Tropospheric interference(1)	Continuous interference(1)
	–8.25	–16	–11
(*N* – 1)	–5.25	–9	–5
	–4.75	–4	3
	–4.25	12	20
	–3.75	24	30
	–3.25	29	36
	–2.25	33	39
	–1.25	34	40
(*N*)	2.75	34	40
	4.75	34	39
	5.75	30	37
	6.75	27	34
	7.75	25	32
	8.75	5	11
(*N* + 1)	9.75	–8	–5
	12.75	–8	–5

* For all SECAM systems similar values are expected. The values are still under study.

(1) The values for tropospheric and continuous interference have been arrived at from Table 45 by calculation.

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

Tables 47 to 49 in this Annex show protection ratios for wanted FM, AM and NICAM television sound carriers interfered with by unwanted digital terrestrial television signals.

All protection ratios in this section refer to the level of the wanted television sound carriers. The reference level of the sound carriers is the r.m.s. value of the unmodulated carrier.

The sound quality for tropospheric interference corresponds to grade 3, for continuous interference to grade 4.

The reference (S/Ns) for FM sound signals are:

– 40 dB (approximates to impairment grade 3) – tropospheric case;

– 48 dB (approximates to impairment grade 4) – continuous case.

The reference S/Ns are measured as S/N peak-to-peak weighted, given in Recommendation ITU-R BS.468 and Recommendation ITU-R BS.412.

The reference FM sound signal level corresponds to a maximum frequency deviation of ±50 kHz.

The reference BERs for NICAM digital sound signals are:

– BER = 1×10^{-4} (approximates to impairment grade 3), tropospheric case;

– BER = 1×10^{-5} (approximates to impairment grade 4), continuous case.

In the case of a two-sound carrier transmission, each of the two-sound signals must be considered separately. Multiplex modulated sound signals may require higher protection.

3.1 Protection for FM, AM and NICAM sound signals of analogue television systems interfered with by DVB-T digital terrestrial television signals

TABLE 47

Co-channel protection (dB) ratios for a wanted sound signal interfered with by DVB-T digital terrestrial television signals

Protection ratio related to the wanted sound carrier		**Unwanted signal**	
Wanted sound signal		**DVB-T 7 MHz**	**DVB-T 8 MHz**
FM	Tropospheric case	6	5
	Continuous case	16	15
AM	Tropospheric case	21	20
	Continuous case	24	23
NICAM PAL B/G	Tropospheric case	5	4
	Continuous case	6	5
NICAM System I	Tropospheric case		
	Continuous case		
NICAM System L	Tropospheric case	12	11
	Continuous case	13	12

TABLE 48

Protection ratios (dB) for a wanted FM sound signal interfered with by a DVB-T 7 MHz signal (overlapping channels)

		Frequency of the 3 dB point of DVB-T signal minus sound carrier frequency						
Frequency of the DVB-T signal relative to an FM carrier	**Protection ratio related to the wanted sound carrier**	**–500 kHz**	**–250 kHz**	**–50 kHz**	**0.0 kHz**	**50 kHz**	**250 kHz**	**500 kHz**
DVB-T below FM	Tropospheric case	0	0	0	5	5	6	6
	Continuous case	9	9	9	14	14	15	16
DVB-T above FM	Tropospheric case	5	5	4	3	–9	–22	–32
	Continuous case	15	15	14	12	–6	–16	–27

NOTE 1 – The protection ratio figures are related to an out-of-channel spectrum attenuation of 40 dB.

NOTE 2 – This Table is still under study.

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)

Protection ratio related to the wanted sound carrier	**Centre frequency of the DVB-T signal minus sound carrier frequency**		
	With negative offset	**No offset**	**With positive offset**
	4.250 – 0.166 MHz = 4.084 MHz	**4.250 MHz**	**4.250 + 0.166 MHz = 4.416 MHz**
Tropospheric case	–1	–2	–4
Continuous case	+1	0	–2

4 Correction factors for different wanted DVB-T system variants and different reception conditions

The following Table 50 was developed on the basis of a DVB-T signal interfered with by DVB-T. It is proposed to be used for other types of interferers but further studies are required to confirm the values.

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)

DVB-T system variant	Gaussian channel	Fixed reception	Portable outdoor reception	Portable indoor reception	Mobile reception
QPSK 1/2	−13.5	−12.5	−10.3	−10.3	−7.3
QPSK 2/3	−11.6	−10.5	−8.2	−8.2	−5.2
QPSK 3/4	−10.5	−9.3	−6.9	−6.9	−3.9
QPSK 5/6	−9.4	−8.1	−5.6	−5.6	−2.6
QPSK 7/8	−8.5	−7.1	−4.5	−4.5	−1.5
16-QAM 1/2	−7.8	−6.8	−3.6	−3.6	−1.6
16-QAM 2/3	−5.4	−4.3	−2.0	−2.0	1.0
16-QAM 3/4	−3.9	−2.7	−0.3	−0.3	2.7
16-QAM 5/6	−2.8	−1.5	1.0	1.0	4.0
16-QAM 7/8	−2.3	−0.9	1.7	1.7	4.7
64-QAM 1/2	−2.2	−1.2	1.0	1.0	4.0
64-QAM 2/3	0.0	1.1	3.4	3.4	6.4
64-QAM 3/4	1.6	2.8	5.2	5.2	8.2
64-QAM 5/6	3.0	4.3	6.8	6.8	9.8
64-QAM 7/8	3.9	5.3	7.9	7.9	10.9

As compared to a static transmission channel, the time-variant Rayleigh channel which is relevant for portable DVB-T reception shows a significantly higher need for protection ratios. The average increase in the PR values in a time-variant Rayleigh transmission channel compared to the values in a static Rayleigh transmission channel for all receivers measured is about 5 to 6 dB.

In summary, the PR values in a Gaussian transmission channel are 2 to 3 dB lower than the values in the static Rayleigh transmission channel. Compared to the static Rayleigh transmission channel, the time-variant Rayleigh channel shows 4 dB to 6 dB higher PRs.

5 Protection ratios for a T-DAB signal interfered with by an unwanted digital terrestrial television signal

TABLE 51

Protection ratios (dB) for a T-DAB signal interfered with by a DVB-T 8 MHz signal

64-QAM, code rate 2/3									
Δf (1) (MHz)	–5	–4.2	–4	–3	0	3	4	4.2	5
PR	–50	–1	0	1	1	1	0	–1	–50

(1) Δf: centre frequency of the DVB-T signal minus centre frequency of the T-DAB signal.

TABLE 52

Protection ratios (dB) for a T-DAB signal interfered with by a DVB-T 7 MHz signal

64-QAM, code rate 2/3									
Δf (1) (MHz)	–4.5	–3.7	–3.5	–2.5	0	2.5	3.5	3.7	4.5
PR	–49	0	1	2	2	2	1	0	–49

(1) Δf: centre frequency of the DVB-T signal minus centre frequency of the T-DAB signal.

6 Minimum field strengths for DVB-T terrestrial digital television, fixed reception

The formula for calculating minimum field strength is given in Appendix 1 to Annex 2.

TABLE 53

Calculation of minimum field strength DVB-T 8 MHz system

Frequency (MHz)	200			550			700		
System variant guard interval 1/4	QPSK 2/3	16-QAM 2/3	64-QAM 2/3	QPSK 2/3	16-QAM 2/3	64-QAM 2/3	QPSK 2/3	16-QAM 2/3	64-QAM 2/3
Receiver noise figure, *F* (dB)	5	5	5	7	7	7	7	7	7
Receiver carrier/noise ratio(1) (C/N) (dB)	8	14	20	8	14	20	8	14	20
Feeder loss A_f (dB)	3	3	3	3	3	3	5	5	5
Antenna gain, *G* (dB)	5	5	5	10	10	10	12	12	12
Minimum field strength for fixed reception, E_{min} (dB(μV/m))(2)	27	33	39	33	39	45	35	41	47

(1) For Rice channel.

(2) For formula, see Appendix 1 to Annex 2.

7 Minimum median field strength for mobile DVB-T reception

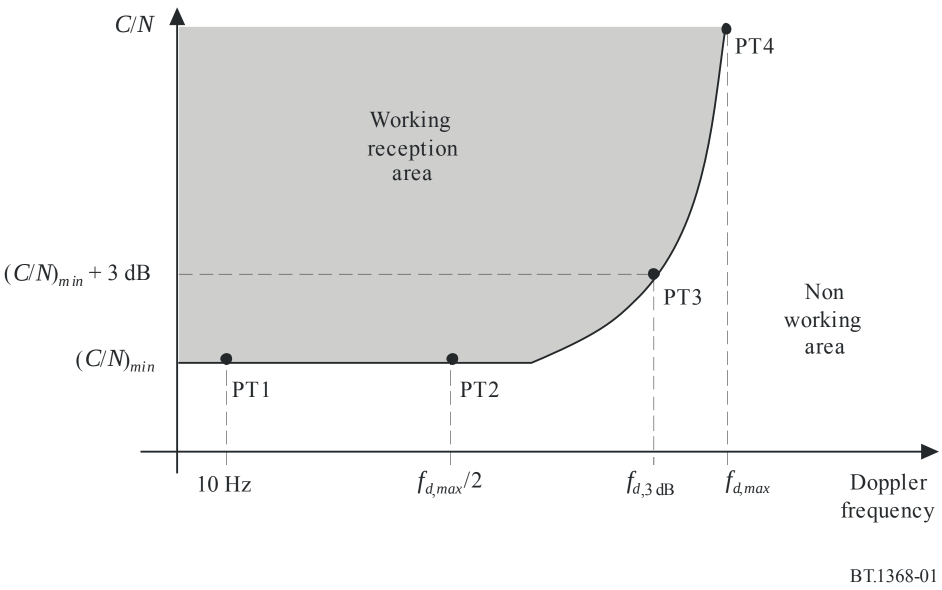
The equations for calculating the minimum median field strength are given in Appendix 1 to this Annex. The input values to the calculation are found in this section and in Annex 4. Mobile reception should be calculated with a location probability of 99%.

7.1 Required average *C*/*N* for mobile reception

For a given DVB-T mode the required average *C*/*N* for a certain quality level is a function of Doppler frequency only, and a graph like the one presented in Fig. 1 can be drawn.

FIGURE 1

Required average *C*/*N* in a mobile propagation channel



The minimum required average *C*/*N* values (C/N_{min}), Doppler frequency for an average *C*/*N* equal to C/N_{min} + 3 dB and the maximum Doppler (speed) limits for mobile reception are given in Tables 54 and 55. The speed limits for C/N_{min} + 3 dB are given for three frequencies (200 MHz, 500 MHz and 800 MHz). The average *C*/*N* value, C/N_{min} + 3 dB, is suitable for calculation of required field strength. Table 54 shows values for the required average *C*/*N* and the speed limits in the non-diversity case. Table 55 contains the corresponding values for the diversity case. The values are based on the typical channel profile "typical urban" shown in Table 56. Quality criteria is the subjective failure point (SFP) corresponding to erroneous seconds ratio, –ESR = 5%, and packet error ratio, PER = 1×10^{-4}.

TABLE 54

Required average *C/N*, speed limits for mobile reception for the non-diversity case

Guard interval = 1/32			2k			Speed at F_d, 3 dB (km/h)			8k			Speed at F_d, 3 dB (km/h)		
Modulation	**Bit rate (Mbit/s)**	**Code rate**	C/N_{min} (dB)	$F_{d,\,max}$ (Hz)	F_d at C/N_{min} + 3 dB	**200 MHz**	**500 MHz**	**800 MHz**	C/N_{min} (dB)	$F_{d,\,max}$ (Hz)	F_d at C/N_{min} + 3 dB	**200 MHz**	**500 MHz**	**800 MHz**
QPSK	6.03	1/2	13.0	318	259	1 398	559	349	13.0	76	65	349	140	87
QPSK	8.04	2/3	16.0	247	224	1 207	483	302	16.0	65	53	286	114	71
16-QAM	12.06	1/2	18.5	224	182	985	394	246	18.5	59	47	254	102	64
16-QAM	16.09	2/3	21.5	176	147	794	318	199	21.5	41	35	191	76	48
64-QAM	18.10	1/2	23.5	141	118	635	254	159	23.5	35	29	159	64	40
64-QAM	24.13	2/3	27.0	82	65	349	140	87	27.0	24	18	95	38	24

TABLE 55

Required average *C/N*, speed limits for mobile reception for the diversity case

Guard interval = 1/32			2k			Speed at F_d, 3 dB (km/h)			8k			Speed at F_d, 3 dB (km/h)		
Modulation	**Bit rate (Mbit/s)**	**Code rate**	C/N_{min} (dB)	$F_{d,\,max}$ (Hz)	F_d at C/N_{min} + 3 dB	**200 MHz**	**500 MHz**	**800 MHz**	C/N_{min} (dB)	$F_{d,\,max}$ (Hz)	F_d at C/N_{min} + 3 dB	**200 MHz**	**500 MHz**	**800 MHz**
QPSK	6.03	1/2	7.0	560	518	2 795	1 118	699	7.0	140	129	699	280	175
QPSK	8.04	2/3	10.0	494	447	2 414	966	604	10.0	129	106	572	229	143
16-QAM	12.06	1/2	12.5	447	365	1 969	788	492	12.5	118	94	508	203	127
16-QAM	16.09	2/3	15.5	353	294	1 588	635	397	15.5	82	71	381	152	95
64-QAM	18.10	1/2	17.5	282	235	1 271	508	318	17.5	71	59	318	127	79
64-QAM	24.13	2/3	21.0	165	129	699	280	175	21.0	47	35	191	76	48

TABLE 56

Channel profile for measurement of required average *C*/*N* for mobile reception of DVB-T reception "typical urban"

Tap number	Delay (μs)	Power (dB)	Doppler category
1	0	–3	Rayleigh
2	0.2	0	Rayleigh
3	0.5	–2	Rayleigh
4	1.6	–6	Rayleigh
5	2.3	–8	Rayleigh
6	5	–10	Rayleigh

The values for the bit rate correspond to the shortest guard interval 1/32 which is the least critical case in terms of Doppler. It is to be expected that when the guard interval increases the maximum speed decreases. For instance with 1/4 guard interval, the maximum Doppler, $F_{d\ max}$, decreases to about 85%.

The performance in a mobile channel depends to large extent on the design of the DVB-T receiver. Improvements may be achieved with receivers particularly designed for mobile reception.

DVB-H uses the DVB-T transmission system as the physical layer and adds extra error correction and time-slicing mechanism on the link layer. The maximum Doppler frequency (speed) in mobile reception will be improved due to the additional time interleaving. *C*/*N* values for DVB-H reception need to be developed.

7.2 Receiver noise figure

Noise figure of 5 dB is for integrated vehicle mobile receivers. A lower noise figure is possible when the antenna is internally matched to the first amplifier stage without a need for a loop through connection.

8 Minimum median field strength for hand held pedestrian indoor, pedestrian outdoor and mobile DVB-H reception

The equations for calculating the minimum median field strength are given in Appendix 1 to this Annex. The input values to the calculation are found in this section and in Annex 4. Mobile reception should be calculated with a location probability of 99%.

8.1 Channel models for hand held pedestrian indoor and outdoor reception

The pedestrian indoor (PI) and pedestrian outdoor (PO) channel models have been developed for describing the slowly moving hand held reception indoors and outdoors. The channel models are based on measurements in DVB-H single frequency networks and have paths from two different transmitter locations. Definitions of the taps for the channels are given in Table 58 and Table 59. The indicated Doppler frequency of 1.5 Hz is corresponding 3 km/h velocity at middle of UHF-band. The Doppler spectra of various taps are defined in Table 57.

TABLE 57

Doppler spectrum definitions for PI- and PO-channels

Spectrum for the 1st tap	Spectrum for taps 2-12
$0.1G(f;0.08f_D)+\delta(f-0.5f_D)$ where: $G(f;\sigma)=\exp\left(\frac{-f^2}{2\sigma^2}\right)$	$G(f;0.08f_D)$

TABLE 58

Definition of PI-channel

Path	Delay (μs)	Power (dB)	Doppler spectrum	Fd (Hz)	STD Norm.
1	0.0	0.0	See Table 2	1.69	0.08
2	0.1	–6.4	Gauss	1.69	0.08
3	0.2	–10.4	Gauss	1.69	0.08
4	0.4	–13.0	Gauss	1.69	0.08
5	0.6	–13.3	Gauss	1.69	0.08
6	0.8	–13.7	Gauss	1.69	0.08
7	1.0	–16.2	Gauss	1.69	0.08
8	1.6	–15.2	Gauss	1.69	0.08
9	8.1	–14.9	Gauss	1.69	0.08
10	8.8	–16.2	Gauss	1.69	0.08
11	9.0	–11.1	Gauss	1.69	0.08
12	9.2	–11.2	Gauss	1.69	0.08

TABLE 59

Definition of PO-channel

Path	Delay (µs)	Power (dB)	Doppler spectrum	Fd (Hz)	STD Norm.
1	0.0	0.0	See Table 2	1.69	0.08
2	0.2	–1.5	Gauss	1.69	0.08
3	0.6	–3.8	Gauss	1.69	0.08
4	1.0	–7.3	Gauss	1.69	0.08
5	1.4	–9.8	Gauss	1.69	0.08
6	1.8	–13.3	Gauss	1.69	0.08
7	2.3	–15.9	Gauss	1.69	0.08
8	3.4	–20.6	Gauss	1.69	0.08
9	4.5	–19.0	Gauss	1.69	0.08
10	5.0	–17.7	Gauss	1.69	0.08
11	5.3	–18.9	Gauss	1.69	0.08
12	5.7	–19.3	Gauss	1.69	0.08

8.2 Channel model for mobile reception

The channel model for mobile reception is given in Table 54. This typical urban model is valid for both DVB-T and DVB-H.

8.3 Required average *C*/*N* for hand held indoor and outdoor reception

The DVB-H receiver shall have the performance given in Table 60 when noise (*N*) is applied together with the wanted carrier (*C*) in a signal bandwidth of 7.61 MHz. Degradation point criteria is 5% MPE-FEC frame error rate (5% MFER). The *C*/*N* performance figures are based on the state of the art receivers on the market added with a 2 dB margin.

TABLE 60

***C*/*N* (dB) for 5% MFER in PI and PO channel**

Modulation	Code rate	MPE-FEC code rate	PI	PO
QPSK	1/2	1/2	6.6	7.6
QPSK	1/2	2/3	6.8	7.8
QPSK	1/2	3/4	7.0	8.0
QPSK	1/2	5/6	7.2	8.2
QPSK	1/2	7/8	7.4	8.4
QPSK	2/3	2/3	9.8	10.8
QPSK	2/3	3/4	10.0	11.0
QPSK	2/3	5/6	10.2	11.2
QPSK	2/3	7/8	10.4	11.4
16-QAM	1/2	2/3	12.8	13.8

TABLE 60 (*end*)

Modulation	**Code rate**	**MPE-FEC code rate**	**PI**	**PO**
16-QAM	1/2	3/4	13.0	14.0
16-QAM	1/2	5/6	13.2	14.2
16-QAM	1/2	7/8	13.4	14.4
16-QAM	2/3	2/3	15.8	16.8
16-QAM	2/3	3/4	16.0	17.0
16-QAM	2/3	5/6	16.2	17.2
16-QAM	2/3	7/8	16.4	17.4
64-QAM	1/2	5/6	17.7	18.7
64-QAM	1/2	7/8	17.9	18.9
64-QAM	2/3	2/3	20.6	21.6
64-QAM	2/3	3/4	20.8	21.8
64-QAM	2/3	5/6	21.0	22.0

8.4 Required average *C*/*N* for hand held indoor and outdoor reception

The DVB-H receiver shall have the performance given in Table 61 when noise (*N*) and Doppler shift (F_d) is applied together with the wanted carrier (*C*) in mobile channel defined in Table 54. The figures are given for guard interval 1/4. The *C*/*N* performance is based on the state of the art DVB-H receivers with added 2 dB margin. The Doppler performance is derived from a use case analysis where the target speed with 8k mode at 750 MHz is 130 km/h. This corresponds to a Doppler frequency of 100 Hz. The 4k and 2k Doppler performance is obtained by multiplying the 8k performance by 2 and 4. Degradation point criteria is 5% MPE-FEC frame error rate (5% MFER).

TABLE 61

DVB-H C/N (dB) in mobile channel for 5% MFER

Guard interval = 1/4			**2k**		**Speed at F_d, 3 dB km/h**		**4k**		**Speed at F_d, 3 dB km/h**		**8k**		**Speed at F_d, 3 dB km/h**	
Modula-tion	**Code rate**	**MPE-FEC CR**	**C/N_{min} dB**	**F_d, 3 dB Hz**	**474 MHz**	**746 MHz**	**C/N_{min} dB**	**F_d, 3 dB Hz**	**474 MHz**	**746 MHz**	**C/N_{min} dB**	**F_d, 3 dB Hz**	**474 MHz**	**746 MHz**
QPSK	1/2	1/2	8.5	400	911	579	8.5	200	456	290	8.5	100	228	145
		2/3	9.0	400	911	579	9.0	200	456	290	9.0	100	228	145
		3/4	9.5	400	911	579	9.5	200	456	290	9.5	100	228	145
		5/6	10.0	400	911	579	10.0	200	456	290	10.0	100	228	145
		7/8	10.5	400	911	579	10.5	200	456	290	10.5	100	228	145
QPSK	2/3	2/3	12.0	400	911	579	12.0	200	456	290	12.0	100	228	145
		3/4	12.5	400	911	579	12.5	200	456	290	12.5	100	228	145
		5/6	13.5	400	911	579	13.5	200	456	290	13.5	100	228	145
		7/8	14.5	400	911	579	14.5	200	456	290	14.5	100	228	145
16-QAM	1/2	2/3	15.0	400	911	579	15.0	200	456	290	15.0	100	228	145
		3/4	15.5	400	911	579	15.5	200	456	290	15.5	100	228	145
		5/6	16.5	400	911	579	16.5	200	456	290	16.5	100	228	145
		7/8	17.5	400	911	579	17.5	200	456	290	17.5	100	228	145
16-QAM	2/3	2/3	18.0	380	866	550	18.0	190	433	275	18.0	95	216	138
		3/4	18.5	380	866	550	18.5	190	433	275	18.5	95	216	138
		5/6	19.5	380	866	550	19.5	190	433	275	19.5	95	216	138
		7/8	20.5	380	866	550	20.5	190	433	275	20.5	95	216	138
64-QAM	1/2	5/6	21.5	200	456	290	21.5	100	228	145	21.5	50	114	73
		7/8	22.5	200	456	290	22.5	100	228	145	22.5	50	114	73
64-QAM	2/3	2/3	25.0	120	273	174	25.0	60	137	87	25.0	30	68	43
		3/4	25.5	120	273	174	25.5	60	137	87	25.5	30	68	43
		5/6	27.0	120	273	174	27.0	60	137	87	27.0	30	68	43

8.5 Receiver noise figure

DVB-H receivers are expected to have a full interoperability with GSM-900 cellular radios and therefore have a GSM-reject filter in front of the DVB-H receiver. The total system noise figure of the receiver and the filter is 6 dB.

Appendix 1
to Annex 2

Calculation of minimum field strength and minimum median equivalent field strength

The minimum field strength and minimum median equivalent field strength values calculated using the following equations:

$$P_n = F + 10 \log (k\, T_0\, B)$$

$$P_{s\,min} = C/N + P_n$$

$$A_a = G + 10 \log (1.64\lambda^2/4\,\pi)$$

$$\varphi_{min} = P_{s\,min} - A_a + L_f$$

$$E_{min} = \varphi_{min} + 120 + 10 \log (120\,\pi) = \varphi_{min} + 145.8$$

$$E_{med} = E_{min} + P_{mmn} + C_l$$ for roof top level fixed reception

$$E_{med} = E_{min} + P_{mmn} + C_l + L_h$$ for portable outdoor and mobile reception

$$E_{med} = E_{min} + P_{mmn} + C_l + L_h + L_b$$ for portable indoor and mobile hand-held reception

$$C_l = \mu \cdot \sigma_t$$

$$\sigma_t = \sqrt{\sigma_b^2 + \sigma_m^2}$$

where:

P_n : receiver noise input power (dBW)

F : receiver noise figure (dB)

k : Boltzmann's constant ($k = 1.38 \times 10^{-23}$ (J/K))

T_0 : absolute temperature ($T_0 = 290$ (K))

B : receiver noise bandwidth ($B = 7.61 \times 10^6$ (Hz))

$P_{s\,min}$: minimum receiver input power (dBW)

C/N : RF S/N at the receiver input required by the system (dB)

A_a : effective antenna aperture (dBm^2)

G : antenna gain related to half dipole (dBd)

λ : wavelength of the signal (m)

φ_{min} : minimum pfd at receiving place (dB(W/m^2))

L_f : feeder loss (dB)

E_{min} : equivalent minimum field strength at receiving place (dB(µV/m))

E_{med} : minimum median equivalent field strength, planning value (dB(µV/m))

P_{mmn} : allowance for man-made noise (dB)

L_h : height loss (reception point at 1.5 m above ground level) (dB)

L_b : building or vehicle entry loss (dB)

C_l : location correction factor (dB)

σ_t : total standard deviation (dB)

σ_m : standard deviation macro-scale (σ_m = 5.5 (dB))

σ_b : standard deviation building entry loss (dB)

μ : distribution factor being 0.52 for 70%, 1.28 for 90%, 1.64 for 95% and 2.33 for 99%.

Appendix 2
to Annex 2

The following Table 62 gives the raw measurement results for silicon tuners for the case of UMTS BS interference. These values are for guidance and should be used carefully.

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)

Interferer offset N/(MHz)	PR, dB			O_{th}, dBm		
(5 MHz Steps)	Si-E	Si-F	Si-B	Si-E	Si-F	Si-B
1/(6.5 MHz)	−47	−39	−44	−8	−6	0
2/(11.5 MHz)	−50	−42	−48	2	−3	4
3/(16.5 MHz)	−51	−45	−48	4	−3	8
4/(21.5 MHz)	−53	−46	−49	4	−2	10
5/(26.5 MHz)	−55	−47	−49	5	−3	10
6/(31.5 MHz)	−57	−48	−49	4	−2	10
7/(36.5 MHz)	−57	−48	−49	4	−2	10
8/(41.5 MHz)	−58	−49	−49	4	−2	10
9/(46.5 MHz)	−57	−50	−49	4	−2	10
10/(51.5 MHz)	−60	−50	−50	5	−3	10
11/(56.5 MHz)	−62	−51	−50	5	−3	10
14/(71.5 MHz)	−59	−53	−53	4	−3	10

NOTE 1 – 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 2 – 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 3 − 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 following Table 63 gives the raw measurement results for silicon tuners for the case of UMTS UE interference. These values are for guidance and should be used carefully.

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)

Interferer offset N/(MHz)	**PR, dB**			**O_{th}, dBm**		
(5 MHz Steps)	**Si-E**	**Si-F**	**Si-B**	**Si-E**	**Si-F**	**Si-B**
1/(6.5 MHz)	−28	−16	−27	NR	NR	−41
2/(11.5 MHz)	−31	−32	−28	NR	−34	−41
3/(16.5 MHz)	−31	−32	−29	NR	−33	−38
4/(21.5 MHz)	−33	−33	−29	NR	−32	−38
5/(26.5 MHz)	−33	−34	−30	1	−31	−39
6/(31.5 MHz)	−35	−35	−30	3	−30	−40
7/(36.5 MHz)	−35	−36	−31	4	−30	−39
8/(41.5 MHz)	−36	−37	−32	4	−31	−39
9/(46.5 MHz)	−37	−38	−33	5	−28	−37
10/(51.5 MHz)	−36	−38	−32	5	−29	−36
11/(56.5 MHz)	−38	−39	−34	6	−28	−36
14/(71.5 MHz)	−41	−41	−34	6	−26	−35

NOTE 1 – 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 2 – 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 3 − 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.

NOTE 4 – The UMTS interference signal out-of-band noise was adjusted to give similar out-of-band noise profile to the mask in 3GPP TS 125.101 8.60; therefore no correction to PR results is required.

The following Table 64 provides the protection ratios and overload thresholds obtained for LTE-BS interferer for the BS with 0% traffic load. Tables 64, 65 and 66 are used to fill in Tables 36 and 37 in Annex 2.

TABLE 64

PR values at the 50th and 90th percentile and O_{th} values at the 10th and 50th 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)

Interferer offset N/(MHz)	Can tuner					Silicon tuner				
	No. Rx (Note 6)	PR, dB 50th percentile	PR, dB 90th percentile	O_{th}, dBm 10th percentile	O_{th}, dBm 50th percentile	No. Rx	PR, dB 50th percentile	PR, dB 90th percentile	O_{th}, dBm 10th percentile	O_{th}, dBm 50th percentile
1/(10 MHz)	10	–45	–36	–13	–10	10	–32	–26	–40	–31
2/(18 MHz)	10	–53	–49	–7	–2	10	–40	–22	–32	–6
3/(26 MHz)	10	–55	–51	–13	–8	10	–39	–25	–39	–5
4/(34 MHz)	10	–62	–57	–10	–7	10	–45	–29	–29	–5
5/(42 MHz)	10	–67	–60	–6	–3	10	–50	–33	–28	–3
6/(50 MHz)	10	–68	–58	–5	1	10	–50	–35	–26	–4
7/(58 MHz)	10	–71	–58	–4	2	10	–55	–38	–25	–4
8/(66 MHz)	10	–59	–58	–3	2	10	–55	–39	–24	–4
9/(74 MHz)	10	–55	–46	–1	4	10	–54	–41	–23	5

NOTE 1 – PR is applicable unless the interfering signal is above the corresponding O_{th}. If the interfering signal level is above the corresponding O_{th}, the receiver will behave in a non-linear way.

NOTE 2 – At wanted signal level close to receiver sensitivity, noise should be taken into account, e.g. at 3 dB above receiver sensitivity threshold, 3 dB should be added to the PR.

NOTE 3 − 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.

NOTE 4 – Using statistical analysis (assuming a Gaussian cumulative distribution) the 50th and 90th percentile of all measured protection ratios and the 10th and 50th percentile of all measured overload thresholds for LTE interference into DVB-T were calculated.

NOTE 5 − The 90th (respectively 50th) percentile for the protection ratio value corresponds to the protection of 90% (respectively 50%) of receivers measured. The 10th (respectively 50th) percentile for the overload threshold value corresponds to the protection of 90% (respectively 50%) of receivers measured.

NOTE 6 − The term 0% traffic loading on an LTE BS refers to the situation where the base station is not handling any user traffic but is still transmitting signalling, synchronization and possibly occasional broadcast data. Experiments showed that two out of the 4 TV receivers tested suffered degraded protection ratios when the BS traffic loading was between 0% and 30%.

NOTE 7 – The LTE BS interference signals used in the measurements had ACLRs of 60 dB or greater for N – 1, and significantly higher ACLRs for N – 2 and beyond.

Table 65 provides the protection ratios and overload thresholds obtained for LTE-BS interferer for the BS with 50% traffic load.

TABLE 65

PR values at the 50th and 90th percentile and O_{th} values at the 10th and 50th 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)

	Can tuner					Silicon tuner				
Interferer Offset N/(MHz)	**No. Rx (Note 6)**	**PR, dB 50th percentile**	**PR, dB 90th percentile**	**O_{th}, dBm 10th percentile**	**O_{th}, dB 50th percentile**	**No. Rx**	**PR, dB 50th percentile**	**PR, dB 90th percentile**	**O_{th}, dBm 10th percentile**	**O_{th}, dBm 50th percentile**
1/(10 MHz)	10	–46	–37	–15	–11	10	–41	–40	–13	–3
2/(18 MHz)	10	–53	–50	–5	–3	10	–52	–47	–10	1
3/(26 MHz)	10	–56	–51	–11	–5	10	–52	–48	–9	3
4/(34 MHz)	10	–53	–46	–19	–12	10	–55	–49	–8	4
5/(42 MHz)	10	–67	–51	–8	–3	10	–55	–51	–8	5
6/(50 MHz)	10	–66	–53	–4	–1	10	–57	–51	–8	4
7/(58 MHz)	10	–70	–58	–2	1	10	–57	–52	–8	3
8/(66 MHz)	10	–58	–51	–1	1	10	–57	–52	–8	3
9/(74 MHz)	10	–52	–42	–3	3	10	–57	–51	–8	4

NOTE 1 – PR is applicable unless the interfering signal is above the corresponding O_{th}. If the interfering signal level is above the corresponding O_{th}, the receiver will behave in a non-linear way.

NOTE 2 – At wanted signal level close to receiver sensitivity, noise should be taken into account, e.g. at 3 dB above receiver sensitivity threshold, 3 dB should be added to the PR.

NOTE 3 − 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.

NOTE 4 – Using statistical analysis (assuming a Gaussian cumulative distribution) the 50th, and 90th percentile of all measured protection ratios and the 10th and 50th percentile of all measured overload thresholds for LTE interference into DVB-T were calculated.

NOTE 5 − The 90th (respectively 50th) percentile for the protection ratio value corresponds to the protection of 90% (respectively 50%) of receivers measured. The 10th (respectively 50th) percentile for the overload threshold value corresponds to the protection of 90% (respectively 50%) of receivers measured.

NOTE 6 – The LTE BS interference signals used in the measurements had ACLRs of 60 dB or greater for N – 1, and significantly higher ACLRs for N – 2 and beyond.

Table 66 provides the protection ratios and overload thresholds obtained for LTE-BS interferer for the BS with 100% traffic load.

TABLE 66

PR values at the 50th and 90th percentile and O_{th} values at the 10th and 50th 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)

	Can tuner					Silicon tuner				
Interferer offset N/(MHz)	**No. Rx**	**PR, dB 50th percen-tile**	**PR, dB 90th percen-tile**	**O_{th}, dBm 10th percen-tile**	**O_{th}, dB 50th percen-tile**	**No. Rx**	**PR, dB 50th percen-tile**	**PR, dB 90th percen-tile**	**O_{th}, dBm 10th percen-tile**	**O_{th}, dBm 50th percen-tile**
1/(10 MHz)	44	–39	–33	–13	–9	24	–39	–34	–13	–7
2/(18 MHz)	44	–46	–42	–8	–3	24	–46	–40	–11	–1
3/(26 MHz)	44	–50	–41	–15	–3	24	–47	–45	–9	2
4/(34 MHz)	32	–58	–53	–15	–10	16	–52	–48	–9	4
5/(42 MHz)	32	–64	–63	–8	–4	16	–53	–49	–10	5
6/(50 MHz)	32	–64	–58	–6	–2	16	–54	–50	–9	4
7/(58 MHz)	32	–67	–66	–5	0	16	–54	–50	–8	3
8/(66 MHz)	32	–68	–53	–5	1	16	–55	–51	–8	3
9/(74 MHz)	44	–47	–39	–3	2	24	–53	–47	–8	3

NOTE 1 – PR is applicable unless the interfering signal is above the corresponding O_{th}. If the interfering signal level is above the corresponding O_{th}, the receiver will behave in a non-linear way.

NOTE 2 – At wanted signal level close to receiver sensitivity, noise should be taken into account, e.g. at 3 dB above receiver sensitivity threshold, 3 dB should be added to the PR.

NOTE 3 − 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.

NOTE 4 – Using statistical analysis (assuming a Gaussian cumulative distribution) the 50th, and 90th percentile of all measured protection ratios and the 10th and 50th percentile of all measured overload thresholds for LTE interference into DVB-T were calculated.

NOTE 5 − The 90th (respectively 50th) percentile for the protection ratio value corresponds to the protection of 90% (respectively 50%) of receivers measured. The 10th (respectively 50th) percentile for the overload threshold value corresponds to the protection of 90% (respectively 50%) of receivers measured.

NOTE 6 – The LTE BS interference signals used in the measurements had ACLRs of 60 dB or greater for N – 1, and significantly higher ACLRs for N – 2 and beyond.

Appendix 3
to Annex 2

The measurements for the LTE user equipment interferer are based on specific ACLR values. This appendix specifies a method which can be used to correct the tabulated PR values in this Recommendation for different UE ACLR assumptions.

The corrected protection ratio is found in two stages: firstly, for a frequency offset Δf the adjacent channel selectivity (ACS) of the DTT receiver is calculated from the protection ratio listed in the table at the offset (PR(Δf)), the co-channel protection ratio PR_0 and the ACLR which is the basis for the PR in the table in the Annex (see Note 4 of Tables 38 and 38A):

$$ACS(\Delta f) = -10\log(10^{-\frac{PR_0 - PR(\Delta f)}{10}} - 10^{-\frac{ACLR}{10}})$$

Secondly, this derived value of the DTT receiver ACS is used to determine the appropriate adjacent channel protection ratios for the interfering terminal that may have different ACLR characteristics.

The corrected protection ratio, $PR'(\Delta f)$, is a function of the ACS and the ACLR of the LTE interferer at (Δf), denoted ACLR':

$$PR'(\Delta f) = PR_0 + 10\log(10^{\frac{-ACS}{10}} + 10^{\frac{-ACLR'}{10}})$$

Note that the ACLR and ACLR' in the equations above are based on power measurements using the channel bandwidth of the LTE interferer (e.g. 10 MHz) and the channel bandwidth of the wanted signal (e.g. 8 MHz) at the appropriate frequency offsets of the interferer.

Annex 3

Planning criteria for ISDB-T[7] digital television system in the VHF/UHF bands

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

Tables 67 to 71 and 72 to 77 show protection ratios for an ISDB-T wanted digital terrestrial television signal interfered with by an ISDB-T digital terrestrial television signal and by an analogue terrestrial television signal, respectively. Tables 68 and 71 also show protection ratios for an ISDB-T wanted digital terrestrial television signal interfered with by a DVB-T digital terrestrial television signal.

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[7] ISDB-T is used in Japan, Brazil and other countries not part of the GE06 Agreement.

1.1 Protection of an ISDB-T digital terrestrial television signal interfered with by digital television signals

TABLE 67

Co-channel protection ratios (dB) for ISDB-T 6 MHz interfered with by ISDB-T 6 MHz

Coding rate	Modulation		
	DQPSK	16-QAM	64-QAM
7/8	10	17	23
5/6	9	16	22
3/4	9	15	21
2/3	8	14	20
1/2	6	12	17

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

Coding rate	Modulation		
	QPSK	16-QAM	64-QAM
1/2	5	10	16
2/3	7	13	19
3/4		14	20

NOTE 1 − The protection ratios described in this Table are only valid for a Gaussian channel, they can be applied for a DVB-T 8 MHz signal interfered with by an ISDB-T 8 MHz signal.

TABLE 69

Protection ratios (dB) for ISDB-T 6 MHz interfered with by ISDB-T 6 MHz in lower adjacent channel (*N* – 1)

Coding rate	Modulation		
	DQPSK	16-QAM	64-QAM
7/8	–28	–27	–24
5/6	–28	–27	–25
3/4	–29	–27	–26
2/3	–29	–28	–26
1/2	–29	–28	–27

TABLE 70

Protection ratios (dB) for ISDB-T 6 MHz interfered with by ISDB-T 6 MHz in upper adjacent channel (*N* + 1)

Coding rate	Modulation		
	DQPSK	**16-QAM**	**64-QAM**
7/8	–29	–28	–27
5/6	–29	–28	–27
3/4	–29	–28	–27
2/3	–30	–29	–27
1/2	–30	–29	–28

TABLE 71

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 in the lower (*N* – 1) and upper (*N* + 1) adjacent channels

Channel	*N* – 1	*N* + 1
Protection ratio	–30	–30

NOTE 1 − The protection ratios described in this Table are only valid for a Gaussian channel, they can be applied for a DVB-T 8 MHz signal interfered with by an ISDB-T 8 MHz signal.

1.2 Protection of an ISDB-T digital terrestrial television signal interfered with by analogue terrestrial television signals

1.2.1 Protection from co-channel interference

TABLE 72

Co-channel protection ratios (dB) for ISDB-T 6 MHz interfered with by analogue television

	Protection ratio									
Modulation	DQPSK					QPSK				
Code rate	1/2	2/3	3/4	5/6	7/8	1/2	2/3	3/4	5/6	7/8
M/NTSC	–5	–3	–1	2	6	–16	–11	–8	0	2
Modulation	16-QAM					64-QAM				
Code rate	1/2	2/3	3/4	5/6	7/8	1/2	2/3	3/4	5/6	7/8
M/NTSC	–11	–5	–1	6	10	–6	–1	5	9	14

NOTE 1 – The sound carrier level is 6 dB lower than NTSC vision carrier level.

NOTE 2 – The values in this Table give the reception threshold. Taking into account the performance variation in domestic receivers, long-term degradation of reception condition, etc., a margin of several dBs should preferably be added in actual frequency planning.

TABLE 73

Co-channel protection ratios (dB) for an ISDB-T 8 MHz signal interfered with by analogue television (non-controlled frequency condition) signals

Wanted signal		**Unwanted signal**
Modulation	**Coding rate**	**I/PAL, G/PAL**
QPSK	1/2	–16
QPSK	2/3	–11
QPSK	3/4	–8
16-QAM	1/2	–11
16-QAM	2/3	–5
16-QAM	3/4	–1
64-QAM	1/2	–6
64-QAM	2/3	–1
64-QAM	3/4	5

1.2.2 Protection from lower adjacent channel (*N* – 1) interference

TABLE 74

Protection ratios (dB) for lower adjacent channel (*N* – 1) interference for ISDB-T 6 MHz interfered with by NTSC signals including sound

Wanted signal		**Unwanted signal**
Modulation	**Coding rate**	**M/NTSC**
DQPSK	1/2	–34
DQPSK	2/3	–34
DQPSK	3/4	–33
16-QAM	1/2	–34
16-QAM	2/3	–33
16-QAM	3/4	–32
64-QAM	2/3	–32
64-QAM	3/4	–31
64-QAM	5/6	–29
64-QAM	7/8	–29

TABLE 75

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

Wanted signal		**Unwanted signal**	
Modulation	**Coding rate**	**I/PAL**	**G/PAL**
QPSK	1/2		–44
QPSK	2/3		–44
QPSK	3/4		
16-QAM	1/2	–43	–43
16-QAM	2/3		–42
16-QAM	3/4		–38
64-QAM	1/2	–38	–40
64-QAM	2/3	–34	–35
64-QAM	3/4		–32

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

TABLE 76

Protection ratios (dB) for upper adjacent channel (*N* + 1) interference for ISDB-T 6 MHz interfered with by NTSC 6 MHz signal

Wanted signal		**Unwanted signal**
Modulation	**Coding rate**	**M/NTSC**
DQPSK	1/2	–35
DQPSK	2/3	–35
DQPSK	3/4	–34
16-QAM	1/2	–35
16-QAM	2/3	–34
16-QAM	3/4	–33
64-QAM	2/3	–33
64-QAM	3/4	–33
64-QAM	5/6	–32
64-QAM	7/8	–31

TABLE 77

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

Wanted signal		Unwanted signal
Modulation	**Coding rate**	**I/PAL, G/PAL**
QPSK	1/2	
QPSK	2/3	–47
QPSK	3/4	
16-QAM	1/2	
16-QAM	2/3	–43
16-QAM	3/4	
64-QAM	1/2	
64-QAM	2/3	–38
64-QAM	3/4	

2 Protection ratios for wanted analogue terrestrial television signals interfered with by unwanted ISDB-T digital terrestrial television signals

Tables 78 and 79 shows protection ratios for a 525-line and a 625-line wanted analogue television signals interfered with by an ISDB-T digital terrestrial television signal, respectively.

The protection ratio values given in Table 78 are related to a spectrum shoulder attenuation of the unwanted digital signal of 38 dB. The protection ratio values given in Tables 79, 80 and 81 are related to an out-of-channel spectrum attenuation of the unwanted digital signal of 40 dB.

Tropospheric and continuous interference correspond to quality impairment grades 3 and 4, respectively. (See Table 105 of Annex 6.)

2.1 Protection ratios for 525-line television systems

2.1.1 Protection for NTSC vision signals interfered with by an ISDB-T digital television signal

TABLE 78

Protection ratios (dB) for analogue vision signal (NTSC, 6 MHz) interfered with by ISDB-T signal

Unwanted digital channel	Tropospheric interference	Continuous interference
N – 1 (lower)	–6	–3
N (co-channel)	39	44
N + 1 (upper)	–6	–3

2.2 Protection ratios for 625-line television systems

2.2.1 Protection for PAL vision signals interfered with by an ISDB-T digital television signal

2.2.1.1 Protection from co-channel interference

TABLE 79

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

Unwanted digital channel	Tropospheric interference	Continuous interference
I/PAL	37	41
G/PAL	34	40

2.2.1.2 Protection from lower adjacent channel interference

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 (lower adjacent channel)

Unwanted digital channel	Tropospheric interference	Continuous interference
I/PAL	–9	–5
G/PAL	–9	–5

2.2.1.3 Protection from upper adjacent channel interference

TABLE 81

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)

Unwanted digital channel	Tropospheric interference	Continuous interference
I/PAL	–8	–5
G/PAL	–8	–5

3 Protection ratios for sound signals of wanted analogue terrestrial television systems interfered with by ISDB-T unwanted digital terrestrial television system

3.1 Protection for NTSC sound signals interfered with by an ISDB-T digital television signal

As shown in Table 82, the sound signal of NTSC broadcasting is robust compared with the vision signal when interfered with by an ISDB-T signal. Therefore protection ratios for NTSC broadcasting are determined by the protection ratios for the vision signal, which are shown in Table 78.

TABLE 82

Sound quality related to the vision protection ratio of grade 3 when NTSC 6 MHz signal interfered with by ISDB-T 6 MHz signal

	Measurement condition (see Note 3)	Sound quality
Co-channel interference	D/U = 39 dB	> grade 4 (S/N = 54 dB)
Upper adjacent channel interference	D/U = –6 dB	> grade 4 (S/N = 53 dB)
Lower adjacent channel interference	D/U = –6 dB	> grade 4 (S/N = 52 dB)

NOTE 1 – The sound carrier level is 6 dB lower than NTSC vision carrier level.

NOTE 2 – The reference FM sound signal level corresponds to a maximum frequency deviation of ±25 kHz.

NOTE 3 – D/U ratio that gives vision quality of grade 3 (corresponding to protection ratio for tropospheric interference).

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

Table 83 shows protection ratios for wanted FM sound signals of I/PAL and G/PAL analogue television systems interfered with by an unwanted ISDB-T digital terrestrial television signal.

All protection ratios in this section refer to the level of the wanted television sound carriers. The reference level of the sound carriers is the r.m.s. value of the unmodulated carrier.

The sound quality for tropospheric interference corresponds to grade 3, for continuous interference to grade 4.

The reference (S/Ns) for FM sound signals are:

– 40 dB (approximates to impairment grade 3) – tropospheric case;

– 48 dB (approximates to impairment grade 4) – continuous case.

The reference S/Ns are measured as S/N peak-to-peak weighted, given in Recommendation ITU-R BS.468 and Recommendation ITU-R BS.412.

TABLE 83

Co-channel protection ratios (dB) for a wanted sound signal interfered with by an ISDB-T digital terrestrial television signal

Protection ratio related to the wanted sound carrier		Unwanted signal
Wanted sound signal		**ISDB-T 8 MHz**
FM (I, G/PAL)	Tropospheric case	5
	Continuous case	15

4 Minimum field strengths for ISDB-T terrestrial digital television, fixed reception

To reduce the number of tables for the minimum field strengths of an ISDB-T system, the derivation of minimum field strengths is made with the typical transmission modes shown in Tables 84 and 85. The minimum field strengths for the different modes of a 6 MHz and an 8 MHz system can be calculated from the given values in Tables 84 and 85, respectively.

5 Minimum median field strength for hand-held pedestrian indoor, pedestrian outdoor and mobile ISDB-T reception

The equations for calculating the minimum median field strength are given in Appendix 1 to this Annex, and the values that were used in the calculation are in this section and Annex 5. To calculate the minimum median field strength for pedestrian indoor, pedestrian outdoor, and mobile ISDB-T reception, the value of the location probability should be determined by the administration that has the transmitting stations on its territory.

5.1 Channel models for hand-held pedestrian indoor and outdoor reception

The pedestrian indoor (PI) and the pedestrian outdoor (PO) channel models are used as channel models for hand-held reception. Definitions of the taps for the channels are given in Tables 58 and 59. The Doppler spectra of various taps are defined in Table 57.

TABLE 84

Calculation of minimum field strengths for ISDB-T 6 MHz system

Frequency (MHz)	Low VHF				High VHF				UHF			
	100				200				600			
System	DQPSK 1/2	QPSK 1/2	16-QAM 3/4	64-QAM 7/8	DQPSK 1/2	QPSK 1/2	16-QAM 3/4	64-QAM 7/8	DQPSK 1/2	QPSK 1/2	16-QAM 3/4	64-QAM 7/8
Noise bandwidth, B (MHz)	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Receiver noise figure, F (dB)	5	5	5	5	5	5	5	5	7	7	7	7
Receiver noise input voltage, U_N (1) (dB(μV))	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	9.1	9.1	9.1	9.1
Receiver carrier/noise ratio (2) (C/N) (dB)	6.2	4.9	14.6	22.0	6.2	4.9	14.6	22.0	6.2	4.9	14.6	22.0
Urban noise (dB)	1	1	1	1	1	1	1	1	0	0	0	0
Minimum receiver input voltage, U_{min} (dB(μV)) (1)	14.3	13.0	22.7	30.1	14.3	13.0	22.7	30.1	15.3	14.0	23.7	31.1
Conversion factor (1) K (dB)	6.4	6.4	6.4	6.4	12.4	12.4	12.4	12.4	21.9	21.9	21.9	21.9

TABLE 84 (*end*)

Frequency (MHz)	**Low VHF**				**High VHF**				**UHF**			
	100				**200**				**600**			
System	DQPSK 1/2	QPSK 1/2	16-QAM 3/4	64-QAM 7/8	DQPSK 1/2	QPSK 1/2	16-QAM 3/4	64-QAM 7/8	DQPSK 1/2	QPSK 1/2	16-QAM 3/4	64-QAM 7/8
Feeder loss, L_f (dB)	3	3	3	3	3	3	3	3	3	3	3	3
Antenna gain, *G* (dB)	3	3	3	3	5	5	5	5	10	10	10	10
Minimum field strength for fixed reception, E_{min} (dB (μV/m))[(1)]	20.7	19.4	29.1	36.5	24.7	23.4	33.1	40.5	30.2	28.9	38.6	46.0

(1) For formula, see Appendix 1 to Annex 3.

(2) For noise bandwidth noted above.

TABLE 85

Calculation of minimum field strengths for ISDB-T 8 MHz system

Frequency (MHz)	**Low VHF**				**High VHF**				**UHF**			
	100				**200**				**600**			
System	DQPSK 1/2	QPSK 1/2	16-QAM 3/4	64-QAM 7/8	DQPSK 1/2	QPSK 1/2	16-QAM 3/4	64-QAM 7/8	DQPSK 1/2	QPSK 1/2	16-QAM 3/4	64-QAM 7/8
Noise bandwidth, *B* (MHz)	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
Receiver noise figure, *F* (dB)	5	5	5	5	5	5	5	5	7	7	7	7
Receiver noise input voltage, U_N[(1)] (dB(μV))	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	10.4	10.4	10.4	10.4
Receiver carrier/noise ratio[(2)] (*C*/*N*) (dB)	6.2	4.9	14.6	22.0	6.2	4.9	14.6	22.0	6.2	4.9	14.6	22.0
Urban noise (dB)	1	1	1	1	1	1	1	1	0	0	0	0
Minimum receiver input voltage, U_{min} (dB(μV))[(1)]	15.5	14.2	23.9	31.3	15.5	14.2	23.9	31.3	16.5	15.2	24.9	32.3
Conversion factor[(1)] *K* (dB)	6.4	6.4	6.4	6.4	12.4	12.4	12.4	12.4	21.9	21.9	21.9	21.9

TABLE 85 (*end*)

Frequency (MHz)	**Low VHF**				**High VHF**				**UHF**			
	100				**200**				**600**			
System	DQPSK 1/2	QPSK 1/2	16-QAM 3/4	64-QAM 7/8	DQPSK 1/2	QPSK 1/2	16-QAM 3/4	64-QAM 7/8	DQPSK 1/2	QPSK 1/2	16-QAM 3/4	64-QAM 7/8
Feeder loss, L_f (dB)	3	3	3	3	3	3	3	3	3	3	3	3
Antenna gain, G (dB)	3	3	3	3	5	5	5	5	10	10	10	10
Minimum field strength for fixed reception, E_{min} (dB(µV/m))[(1)]	21.9	20.6	30.3	37.7	25.9	24.6	34.3	41.7	31.4	30.1	39.8	47.2

(1) For formula, see Appendix 1 to Annex 3.

(2) For noise bandwidth noted above.

5.2 Channel model for mobile reception

The typical urban model is used as the channel model for mobile reception. The channel model for mobile reception is given in Table 56.

5.3 Required average *C*/*N* for hand-held indoor and outdoor reception

The ISDB-T receiver shall have the performance given in Table 86 when noise (*N*) is applied together with the wanted carrier (*C*) in a signal bandwidth of 5.57 MHz. The values for the *C*/*N* ratio in both the non-diversity case and the diversity case are shown in Table 86. Degradation point criterion is an erroneous second ratio (ESR) of 5%.

TABLE 86

***C*/*N* (dB) for 5% ESR in PI and PO channel**

Mode	**Modulation**	**Code rate**	**For the non-diversity case**		**For the diversity case**	
			PI	**PO**	**PI**	**PO**
2 k	QPSK	1/2	10	10.5	5	5
	QPSK	2/3	13	13.5	7.5	7.5
	16-QAM	1/2	15.5	16	11	11
	16-QAM	2/3	19	20	13.5	13.5
	64-QAM	1/2	20.5	20.5	16	16
	64-QAM	2/3	24.5	24.5	19	19
	64-QAM	3/4	27	27	20.5	20.5
4 k	QPSK	1/2	10	10	5	5.5
	QPSK	2/3	13	13	7.5	8
	16-QAM	1/2	15.5	15.5	10.5	11
	16-QAM	2/3	19	19.5	13	13.5
	64-QAM	1/2	20.5	20.5	16	16
	64-QAM	2/3	24.5	25	19	19
	64-QAM	3/4	27	27	20.5	20.5

TABLE 86 (*end*)

Mode	Modulation	Code rate	For the non-diversity case		For the diversity case	
			PI	PO	PI	PO
8 k	QPSK	1/2	10	10	5	5.5
	QPSK	2/3	13.5	13.5	7.5	7.5
	16-QAM	1/2	15.5	16	11	11
	16-QAM	2/3	19.5	19.5	13.5	13.5
	64-QAM	1/2	20.5	21	16	16
	64-QAM	2/3	24.5	24.5	19	19
	64-QAM	3/4	27	27	20.5	21

5.4 Required average *C*/*N* for mobile reception

The ISDB-T receiver shall have the performance given in Table 87 when noise (*N*) and Doppler shift (F_d) is applied together with the wanted carrier (*C*) in the mobile channel based on the channel profile, “TYPICAL URBAN”, which is shown in Table 56. The speed limits for C/N_{min} + 3 dB are given for two frequencies (470 and 770 MHz). The average *C*/*N* value, C/N_{min} + 3 dB, is suitable for calculating the required field strength. The values for the required average *C*/*N* ratio and the speed limits in the non-diversity case are shown in Table 87a), and the corresponding values for the diversity case are shown in Table 87b). The figures are given for a guard interval of 1/8. Degradation point criterion is given by an ESR of 5%.

TABLE 87

ISDB-T *C*/*N* (dB) in mobile channel for 5% ESR

a) Non diversity case

Guard interval = 1/8		2 k		Speed at F_d, 3 dB km/h		4 k		Speed at F_d, 3 dB km/h		8 k		Speed at F_d, 3 dB km/h	
Modula-tion	Code rate	C/N_{min} dB	F_d, 3 dB Hz	470 MHz	770 MHz	C/N_{min} dB	Fd, 3 dB Hz	470 MHz	770 MHz	C/N_{min} dB	F_d, 3 dB Hz	470 MHz	770 MHz
QPSK	1/2	8	360	827	505	8.5	170	391	238	8.5	89	205	125
QPSK	2/3	11.5	310	712	435	12	140	322	196	11.5	74	170	104
16-QAM	1/2	13.5	270	620	379	13.5	130	299	182	14.5	67	154	94
16-QAM	2/3	17.5	200	460	281	17.5	100	230	140	18	50	115	70
64-QAM	1/2	19	180	414	252	19	89	205	125	19.5	42	97	59
64-QAM	2/3	23.5	110	253	154	24	60	138	84	24.5	28	64	39
64-QAM	3/4	26.5	100	230	140	27	49	113	69	27.5	23	53	32

TABLE 87 (*end*)

b) Diversity case

Guard interval = 1/8		**2 k**		**Speed at F_d, 3 dB km/h**		**4 k**		**Speed at F_d, 3 dB km/h**		**8 k**		**Speed at F_d, 3 dB km/h**	
Modulation	**Code rate**	**C/N_{min} dB**	**F_d, 3 dB Hz**	**470 MHz**	**770 MHz**	**C/N_{min} dB**	**F_d, 3 dB Hz**	**470 MHz**	**770 MHz**	**C/N_{min} dB**	**F_d, 3 dB Hz**	**470 MHz**	**770 MHz**
QPSK	1/2	4	420	965	589	4	210	483	295	4	100	230	140
QPSK	2/3	6	390	896	547	6.5	190	437	266	6	96	221	135
16-QAM	1/2	9	350	804	491	9	170	391	238	9.5	85	195	119
16-QAM	2/3	12	280	643	393	12	140	322	196	12	70	161	98
64-QAM	1/2	14.5	230	529	323	14.5	110	253	154	15	57	131	80
64-QAM	2/3	18.5	180	414	252	18	91	209	128	18.5	43	99	60
64-QAM	3/4	20	160	368	224	20	79	182	111	20	38	87	53

The performance in a mobile channel depends to a large extent on the design of the ISDB-T receiver. Using receivers designed for mobile reception may lead to a higher level of performance.

5.5 Receiver noise figure

The values of the noise figure are 5 dB in the VHF band and 7 dB in the UHF band for ISDB-T receivers.

Appendix 1 to Annex 3

Calculation of minimum field strength and minimum median equivalent field strength

The minimum field strength and minimum median equivalent field-strength values were calculated by using the following equations:

$$P_n = F + 10 \log (k\, T_0\, B)$$

$$U_N = P_n + 120 + 10 \log R$$

$$P_{s\,min} = C/N + P_n$$

$$U_{min} = P_{s\,min} + 120 + 10 \log R$$

$$A_a = G + 10 \log (1.64\, \lambda^2/4\, \pi)$$

$$\varphi_{min} = P_{s\,min} - A_a + L_f$$

$$E_{min} = \varphi_{min} + 120 + 10 \log (120\, \pi)$$

$$= \varphi_{min} + 145.8$$

$$= P_{s\,min} - A_a + L_f + 120 + 10 \log (120\,\pi)$$

$$= U_{min} - 10 \log R - G - 10 \log (1.64\,\lambda^2/4\,\pi) + L_f + 10 \log (120\,\pi)$$

$$= U_{min} + 20 \log (2\,\pi/\lambda) - G + L_f$$

$$= U_{min} + K - G + L_f \qquad K = 20 \log (2\,\pi/\lambda)$$

$$E_{med} = E_{min} + P_{mmn} + C_l$$ for rooftop level fixed reception

$$E_{med} = E_{min} + P_{mmn} + C_l + L_h$$ for portable outdoor and mobile reception

$$E_{med} = E_{min} + P_{mmn} + C_l + L_h + L_b$$ for portable indoor and mobile hand-held reception

$$C_l = \mu \cdot \sigma_t$$

$$\sigma_t = \sqrt{\sigma_b^2 + \sigma_m^2}$$

where:

P_n : receiver intrinsic noise power (dBW)

F : receiver noise figure (dB)

k : Boltzmann's constant ($k = 1.38 \times 10^{-23}$ (J/K))

T_0 : absolute temperature ($T_0 = 290$ (K))

B : receiver noise bandwidth ($B = 5.57 \times 10^6$, 6.50×10^6, 7.43×10^6 (Hz))

U_n : receiver noise input voltage (dB(μV))

R : antenna inpedance ($R = 73.1$ (Ω))

$P_{s\,min}$: minimum receiver input power (dBW)

U_{min} : minimum receiver input voltage (dB(μV))

C/N : RF S/N at the receiver input required by the system (dB)

A_a : effective antenna aperture (dBm^2)

G : antenna gain related to half dipole (dBd)

λ : wavelength of signal (m)

φ_{min} : minimum pfd at receiving place (dB(W/m^2))

L_f : feeder loss (dB)

E_{min} : equivalent minimum field strength at receiving place (dB(μV/m))

K : conversion factor (dB)

E_{med} : minimum median equivalent field strength, planning value (dB(μV/m))

P_{mmn} : allowance for man-made noise (dB) (median values of man-made noise power are shown in Recommendation ITU-R P.372-10)

L_h : height loss (reception point at 1.5 m above ground level) (dB)

L_b : building or vehicle entry loss (dB)

C_l : location correction factor (dB)

σ_t : total standard deviation (dB)

σ_m : standard deviation macro-scale (σ_m = 5.5 (dB))

σ_b : standard deviation building entry loss (dB)

μ : distribution factor being 0.52 for 70%, 1.28 for 90%, 1.64 for 95% and 2.33 for 99%.

Annex 4

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

1 Protection ratios for DTMB wanted digital terrestrial television signals

Tables 88 to 90, 91 to 93 show protection ratios for the DTMB wanted signals interfered with:

– by DTMB signals;

– by analogue terrestrial television signals;

respectively.

1.1 Protection of a DTMB signal interfered with by a DTMB signal

TABLE 88

Co-channel protection ratios (dB) for a DTMB 8 MHz signal interfered with by a DTMB signal

Modulation	Code rate	Gaussian channel	Ricean channel	Rayleigh channel
4-QAM	0.4	3	4	5
16-QAM	0.4	9	10	11
64-QAM	0.4	15	16	17
4-QAM	0.6	5	6	8
16-QAM	0.6	12	13	15
64-QAM	0.6	17	18	20
4-QAM-NR	0.8	3	4	5
4-QAM	0.8	7	8	13
16-QAM	0.8	14	15	19
32-QAM	0.8	16	17	21
64-QAM	0.8	22	23	29

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.

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

Modulation	Code rate	Gaussian channel	Ricean channel	Rayleigh channel
4-QAM	0.4	−36	−35	−33
16-QAM	0.4	−31	−30	−29
64-QAM	0.4	−27	−26	−24
4-QAM	0.6	−33	−33	−31
16-QAM	0.6	−30	−28	−27
64-QAM	0.6	−23	−23	−22
4-QAM-NR	0.8	−36	−35	−33
4-QAM	0.8	−30	−30	−27
16-QAM	0.8	−28	−27	−24
32-QAM	0.8	−25	−24	−22
64-QAM	0.8	−20	−20	−17

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 DTMB signals have the same channel width. Other combinations of channel width need further studies.

It is known from measurements of existing receivers that they permit lower protection ratios.

But for planning purposes it is an advantage to have this value.

1.2 Protection of DTMB signal interfered with by analogue terrestrial television

1.2.1 Protection from co-channel interference

TABLE 90

Co-channel protection ratios (dB) for DTMB 8 MHz signal interfered with by analogue television (non-controlled frequency condition) signals

Modulation	Code rate	Gaussian channel	Ricean channel	Rayleigh channel
4-QAM	0.4	−8	−7	−6
16-QAM	0.4	−6	−5	−3
64-QAM	0.4	−4	0	2
4-QAM	0.6	−5	−4	−3
16-QAM	0.6	−4	−2	3
64QAM	0.6	2	5	10
4-QAM−NR	0.8	−8	−7	−6
4-QAM	0.8	−1	0	1
16-QAM	0.8	2	3	5
32-QAM	0.8	4	5	7
64-QAM	0.8	13	14	20

According to the available measurements, the same protection ratio values are applicable for single- and multi-carrier modes.

1.2.2 Protection from lower adjacent channel (*N* – 1) interference

TABLE 91

Protection ratios (dB) for lower adjacent channel (*N* – 1) interference for DTMB 8 MHz signal interfered with by analogue television signals including sound

Wanted signal		Unwanted signal PAL-D		
Constellation	Code rate	Gaussian channel	Ricean channel	Rayleigh channel
4-QAM	0.4	−46	−45	−41
16-QAM	0.4	−46	−45	−41
64-QAM	0.4	−46	−45	−41
4-QAM	0.6	−46	−45	−41
16-QAM	0.6	−46	−45	−41
64-QAM	0.6	−42	−42	−40
4-QAM-NR	0.8	−46	−45	−41
4-QAM	0.8	−46	−45	−41
16-QAM	0.8	−44	−43	−38
32-QAM	0.8	−39	−39	−33
64-QAM	0.8	−39	−37	−30

All values are applicable for fixed and portable reception conditions.

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

TABLE 92

Protection ratios (dB) for upper adjacent channel (*N* + 1) interference for DTMB 8 MHz signal interfered with by an analogue television signal

Wanted signal		Unwanted signal PAL-D (dB)		
Constellation	**Code rate**	**Gaussian channel**	**Ricean channel**	**Rayleigh channel**
4QAM	0.4	−53	−52	−51
16QAM	0.4	−51	−50	−49
64QAM	0.4	−47	−46	−45
4QAM	0.6	−53	−52	−51
16QAM	0.6	−49	−48	−46
64QAM	0.6	−43	−43	−40
4QAM-NR	0.8	−53	−52	−51
4QAM	0.8	−50	−49	−43
16QAM	0.8	−45	−44	−40
32QAM	0.8	−43	−42	−37
64QAM	0.8	−38	−36	−30

2 Protection ratios for wanted analogue terrestrial television signals interfered with by unwanted DTMB 8 MHz signals

Tables 93 to 96 show protection ratios for a wanted analogue television signal interfered with by a DTMB signal.

2.1 Protection of wanted vision signals interfered with by DTMB 8 MHz signal

In this section, the protection ratios for an analogue wanted signal compatible fully compatible with Chinese Standard GB3174-1995 interfered by an unwanted DTMB signal relate only to the interference to the vision signal.

2.1.1 Protection from co-channel interference

TABLE 93

Protection ratios (dB) for a wanted analogue vision signal interfered with by an unwanted DTMB 8 MHz signal

Wanted signal: analogue system	Unwanted signal: DTMB, 8 MHz	
	Tropospheric interference	**Continuous interference**
PAL-D	34	40
D/SECAM	34	40

2.1.2 Protection from lower adjacent channel interference

TABLE 94

Protection ratios (dB) for a wanted analogue vision signal interfered with by DTMB 8 MHz signal (lower adjacent channel)

Wanted signal: analogue system	Unwanted signal: DTMB 8 MHz (lower adjacent channel)	
	Tropospheric interference	Continuous interference
PAL-D	−9	−5
D/SECAM	−13	−9

2.1.3 Protection from upper adjacent channel interference

TABLE 95

Protection ratios (dB) for a wanted analogue vision signal interfered with by DTMB 8 MHz signal (upper adjacent channel)

Wanted signal: analogue system	Unwanted signal: DTMB 8 MHz (upper adjacent channel)	
	Tropospheric interference	Continuous interference
PAL-D	−8	−5
D/SECAM	−15	−12

2.1.4 Protection from image channel interference

TABLE 96

Protection ratios (dB) for a wanted analogue vision signal interfered with by a DTMB 8 MHz signal (image channel)

Wanted signal: analogue system	Unwanted signal: DTMB 8 MHz (N + 9 channel)	
	Tropospheric interference	Continuous interference
PAL-D	−19	−15
D/SECAM	−16	−11

2.1.5 Protection from adjacent and overlapping channel interference

TABLE 97

Protection ratios (dB) for an analogue vision signal interfered with by a DTMB signal (overlapping channels)

Centre frequency of the unwanted DTMB signal minus the vision carrier frequency of the wanted analogue television signal (MHz)		Protection ratio	
		Tropospheric interference	Continuous interference
	−8.25	−20	−15
(N − 1)	−5.25	−13	−9
	−4.75	−11	−4
	−4.25	5	13
	−3.75	24	30
	−3.25	29	36
	−2.25	33	39
	−1.25	34	40
(N)	2.75	34	40
	4.75	34	40
	5.75	30	37
	6.75	27	34
	7.75	25	32
	8.75	5	11
(N + 1)	10.75	−15	−12
	12.75	−15	−12

3 Minimum field strengths for DTMB fixed reception

The formula for calculating minimum field strength is given in Appendix 1.

TABLE 98

Calculation of minimum field strength DTMB 8 MHz system

Frequency (MHz)	65			200			500			700		
Receiver noise figure, F (dB)	5	5	5	5	5	5	7	7	7	7	7	7
Receiver carrier/noise ratio(1) (C/N) (dB)	8	14	20	8	14	20	8	14	20	8	14	20
Feeder loss Af (dB)	1	1	1	3	3	3	3	3	3	5	5	5
Antenna gain, G (dB)	3	3	3	5	5	5	10	10	10	12	12	12
Minimum field strength for fixed reception, Emin (dB(μV/m))(1)	17	23	29	27	33	39	33	39	45	35	41	47

(1) For formula, see Appendix 1.

4 Minimum median field strength for mobile DTMB reception

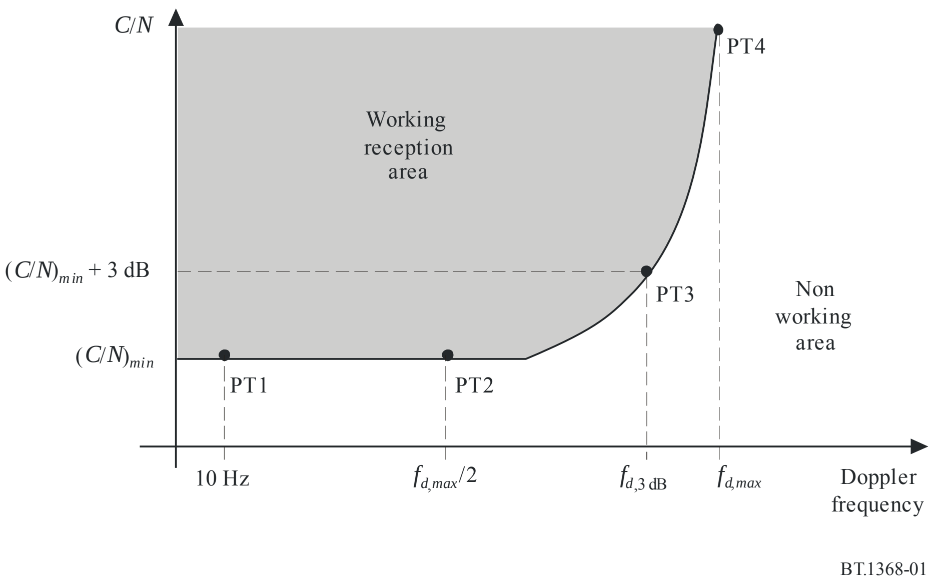
The equations for calculating the minimum median field strength are given in Appendix 1 to this Annex. The input values to the calculation are found in this section and in Appendix 1. Mobile reception should be calculated with a location probability of 99%.

4.1 Required average *C*/*N* for mobile reception

For a given DTMB mode the required average *C*/*N* for a certain quality level is a function of Doppler frequency only, and a graph like the one presented in Figure 1.

FIGURE 1

Required average *C*/*N* in a mobile propagation channel



The minimum required average *C*/*N* values (C/N_{min}), Doppler frequency for an average *C*/*N* equal to C/N_{min} + 3 dB and the maximum Doppler (speed) limits for mobile reception without diversity are given in Table 100. The speed limits for C/N_{min} + 3 dB are given for four frequencies (65 MHz, 200 MHz, 500 MHz and 700 MHz). The average C/N value, C/N_{min} + 3 dB, is suitable for calculation of required field strength. The values are based on the typical channel profile "typical urban" shown in Table 99. Quality criterion is the subjective failure point (SFP) corresponding to erroneous seconds ratio, –ESR = 5% with 5 minutes.

TABLE 99

Required average C/N, speed limits for mobile reception for the non-diversity case

Modulation	Code rate	Bit rate (Mbit/s)	C/N_{min} (dB) at C_f = 762 MHz, F_d = 70 Hz	F_d at C/N_{min} + 3 dB (Hz)	Speed at F_d, 3 dB (km/h)			
					65 MHz	200 MHz	500 MHz	700 MHz
4-QAM	0.4	5.414	6	162	2 692	875	350	250
16-QAM	0.4	10.829	12	134	2 226	724	290	207
4-QAM	0.6	8.122	10	148	2 459	799	320	228
16-QAM	0.6	16.243	17	116	1 927	626	251	179
4-QAM-NR	0.8	5.414	6	162	2 692	875	350	250
4-QAM	0.8	10.829	14	123	2 044	664	266	190

TABLE 100

Channel profile for measurement of required average *C/N* for mobile reception of DTMB reception "typical urban"

Tap number	Delay (μs)	Power (dB)	Doppler category
1	0	–3	Ricean
2	0.2	0	Ricean
3	0.5	–2	Ricean
4	1.6	–6	Ricean
5	2.3	–8	Ricean
6	5	–10	Ricean

The performance in a mobile channel depends to large extent on the design of the DTMB receiver. Improvements may be achieved with receivers particularly designed for mobile reception.

4.2 Receiver noise figure

Noise figure of 7 dB is for integrated vehicle mobile receivers.

Appendix 1
to Annex 4

Calculation of minimum field strength and minimum median equivalent field strength

The minimum field strength and minimum median equivalent field strength values calculated using the following equations:

$P_n = F + 10 \log (k\, T_0\, B)$

$P_{s\,min} = C/N + P_n$

$A_a = G + 10 \log (1.64\lambda^2/4\,\pi)$

$\varphi_{min} = P_{s\,min} - A_a + L_f$

$E_{min} = \varphi_{min} + 120 + 10 \log (120\,\pi)$

$= \varphi_{min} + 145.8$

$E_{med} = E_{min} + P_{mmn} + C_l$ for roof top level fixed reception

$E_{med} = E_{min} + P_{mmn} + C_l + L_h$ for portable outdoor and mobile reception

$E_{med} = E_{min} + P_{mmn} + C_l + L_h + L_b$ for portable indoor and mobile hand-held reception

$C_l = \mu \cdot \sigma_t$

$\sigma_t = \sqrt{\sigma_b^2 + \sigma_m^2}$

where

P_n : receiver noise input power (dBW)

F : receiver noise figure (dB)

k : Boltzmann's constant ($k = 1.38 \times 10^{-23}$ (J/K))

T_0 : reference temperature expressed in absolute temperature ($T_0 = 290$ (K))

B : receiver noise bandwidth ($B = 7.56 \times 10^6$ (Hz))

$P_{s\,min}$: minimum receiver input power (dBW)

C/N : RF S/N at the receiver input required by the system (dB)

A_a : effective antenna aperture (dBm^2)

G : antenna gain related to half dipole (dBd)

λ : wavelength of the signal (m)

φ_{min} : minimum pfd at receiving place (dB(W/m^2))

L_f : feeder loss (dB)

E_{min} : equivalent minimum field strength at receiving place (dB(μV/m))

E_{med} : minimum median equivalent field strength, planning value (dB(μV/m))

P_{mmn} : allowance for man-made noise (dB)

L_h : height loss (reception point at 1.5 m above ground level) (dB)

L_b : building or vehicle entry loss (dB)

C_1 : location correction factor (dB)

σ_t : total standard deviation (dB)

σ_m : standard deviation macro-scale (σ_m = 5.5 (dB))

σ_b : standard deviation building entry loss (dB)

μ : distribution factor being 0.52 for 70%, 1.28 for 90%, 1.64 for 95% and 2.33 for 99%.

Annex 5

Other planning factors

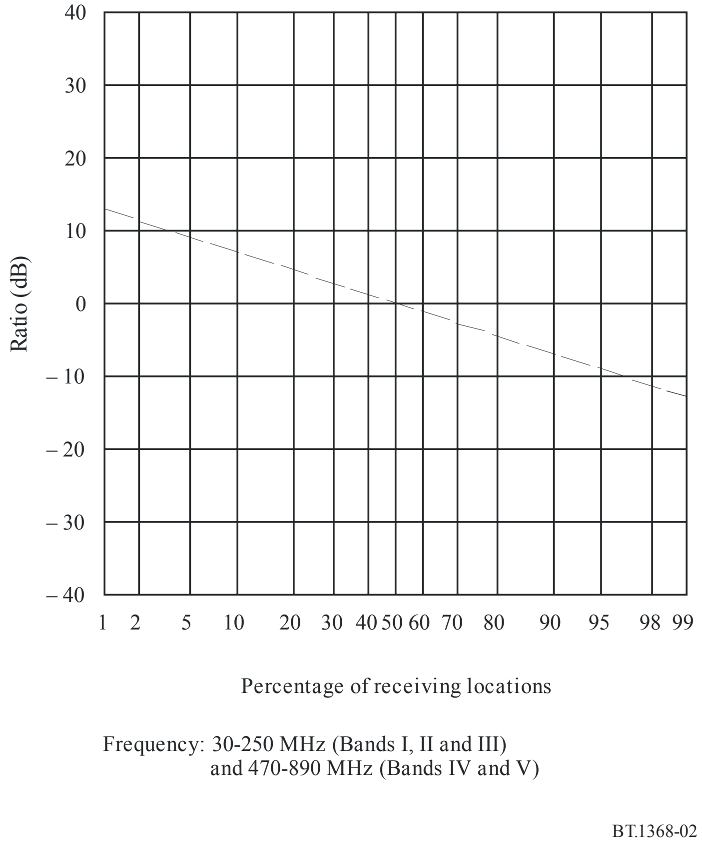
1 Field strength distribution with location

It is to be expected that the distributions of field strength with location for digital television signals will not be the same as those applicable to analogue television signals. Recommendation ITU-R P.1546 includes the standard deviation for the analogue and for the digital case in Tables 1, 2 and 3 for 100 MHz, 600 MHz and 2 000 MHz, respectively.

The results of propagation studies for digital systems are given in Fig. 2 for the VHF and UHF bands. The figure corresponds to a standard deviation of 5.5 dB. These results may also be used to derive propagation prediction curves for location percentages other than 50%. Refer to Recommendation ITU-R P.1546 for the location percentages other than 50% for analogue and digital systems, where the digital system bandwidth is greater than 1.5 MHz.

FIGURE 2

Ratio (dB) of the field strength for a given percentage of the receiving locations to the field strength for 50% of the receiving locations



2 Reception using portable equipment inside buildings and vehicles

2.1 Height loss: L_h

For land paths, the curves in Recommendation ITU-R P.1546 give field-strength values for a receiving antenna height above ground equal to the *representative height* of ground cover around the receiving antenna location. Subject to a minimum height value of 10 m, examples of reference heights are 20 m for an urban area, 30 m for a dense urban area and 10 m for a suburban area. (For sea paths, the notional value is 10 m.)

If the receiving antenna height is different from the representative height, a correction is applied to the field strength taken from the curves of Recommendation ITU-R P.1546 according to a procedure given in the Recommendation.

2.2 Building entry loss: L_b

Losses due to penetration into a building depend significantly on the building material, angle of incidence and frequency. Consideration should also be given as to whether reception is in an interior room or in one located near an exterior wall. The building entry loss is defined as the difference (dB) between the mean field strength inside a building at a given height above ground level and the mean field strength outside the same building at the same height above ground level. Whilst no single comprehensive formula is available for computing building entry loss, useful statistical information based on measured losses in several types of building, at frequencies from about 500 MHz to 5 GHz, are given in Recommendation ITU-R P.679. Once inside the building, propagation loss due to walls and floors are dealt with in Recommendation ITU-R P.1238.

A large spread of building entry losses have been measured. Table 101 gives three classes of the relative possibilities to achieve indoor reception and the corresponding mean and standard deviation values of the building entry losses, for the same outdoor field strength, based on UHF measurements.

TABLE 101

Building entry loss variations in the UHF Bands IV/V

Classification of the relative possibilities to achieve indoor reception	Mean building entry loss (dB)	Standard deviation (dB)
High	7	5
Medium	11	6
Low	15	7

Examples of buildings with different relative possibilities to achieve indoor reception:

High:

– suburban residential building without metallized glass windows,

– room with a window on the exterior wall in an apartment in an urban environment.

Medium:

– exterior rooms in an urban environment with metallized glass windows,

– inner rooms in an apartment in an urban environment.

Low:

– inner rooms in office buildings.

If more precise values based on local measurements are available, these could be used as a basis for planning a specific service.

2.3 Vehicle entry loss: L_v

For reception with a hand-held device inside a vehicle, the vehicle body loss should be taken into account. A typical vehicle entry loss for the UHF Bands IV/V, based on cellular radio experience, is 6 dB.

3 Receiving antenna discrimination

Information concerning the directivity and polarization discrimination of domestic receiving antennas is given in Recommendation ITU-R BT.419.

4 Antennas for portable and mobile receivers

4.1 Antennas for portable reception

A spread in antenna gain has been measured for different types of antenna. The following antenna gain values are typical:

TABLE 102

Antenna gain (dBd) for portable reception

Band	Gain (dBd)
VHF Band III	–2
UHF Band IV	0
UHF Band V	0

No polarization discrimination is expected.

4.2 Antennas for hand-held reception

The antenna in a small hand-held terminal has to be an integral part of the terminal construction and will therefore be small when compared to the wavelength. Current understanding of the design problem indicates that the worst-case antenna gain is in the lowest part of the UHF band. The antenna gain for three frequencies in the UHF band is given in Table 103. Nominal antenna gain between these frequencies can be obtained by linear interpolation.

TABLE 103

Antenna gain (dBd) for hand-held reception

Frequency (MHz)	Gain (dBd)
474	–12
698	–9
858	–7

Generally, no polarization discrimination is expected from this type of portable reception antenna and the radiation pattern in the horizontal plane is omnidirectional.

4.3 Antennas for mobile reception

The practical standard antenna for vehicle reception is l/4 monopole, which uses the metallic roof as a ground plane. The antenna gain for conventional incident wave angles depends on the position of the antenna on the roof. For passive antenna systems the values in Table 104 can be expected.

TABLE 104

Antenna gain (dBd) for mobile reception

Band	Gain (dBd)
VHF Band III	–5
UHF Band IV	–2
UHF Band V	–1

The polarization discrimination is theoretically about 4 to 10 dB depending on the roof position of the antenna.

Annex 6

Subjective comparison method (SCM) with a reference interferer for assessment of protection ratios for analogue television systems

1 Introduction

Subjective methods for assessment of impairment grades involve extensive tests, are time consuming, require large numbers of observers and consider the full impairment grade range.

For assessing protection ratios only two fixed impairment types are necessary, approximately grade 3 for tropospheric and grade 4 for continuous, see Table 105.

This Annex gives a method of assessing protection ratios for wanted analogue TV systems based on the subjective comparison of the impairment of an interferer with that of a reference interferer. Usable and reliable results are produced with only a small number of observers and one still picture.

This subjective comparison method is appropriate for the evaluation of interference from any unwanted digital or analogue transmission system into a wanted analogue television channel. The application of a defined fixed reference interferer results in a reproducible set of figures with a low deviation (approximately ±1 dB standard deviation). Only a small number of observers – three to five experts or non-experts – is necessary.

There are two reference interferers which may be used:

– sine-wave interference

– Gaussian-noise interferer.

Tests have shown that for unwanted digital television systems a noise reference interferer can improve the assessment decision by the observer. The use of noise reference interferer shows the same results as the defined sine-wave interferer. The disadvantage is that a more complicated test arrangement may be necessary. Further tests are necessary, especially by fixing the equivalent noise reference.

(For the time being the sine-wave reference interferer should be used until an agreement on a common test procedure and an agreement on a harmonized unified noise reference figure has been obtained.)

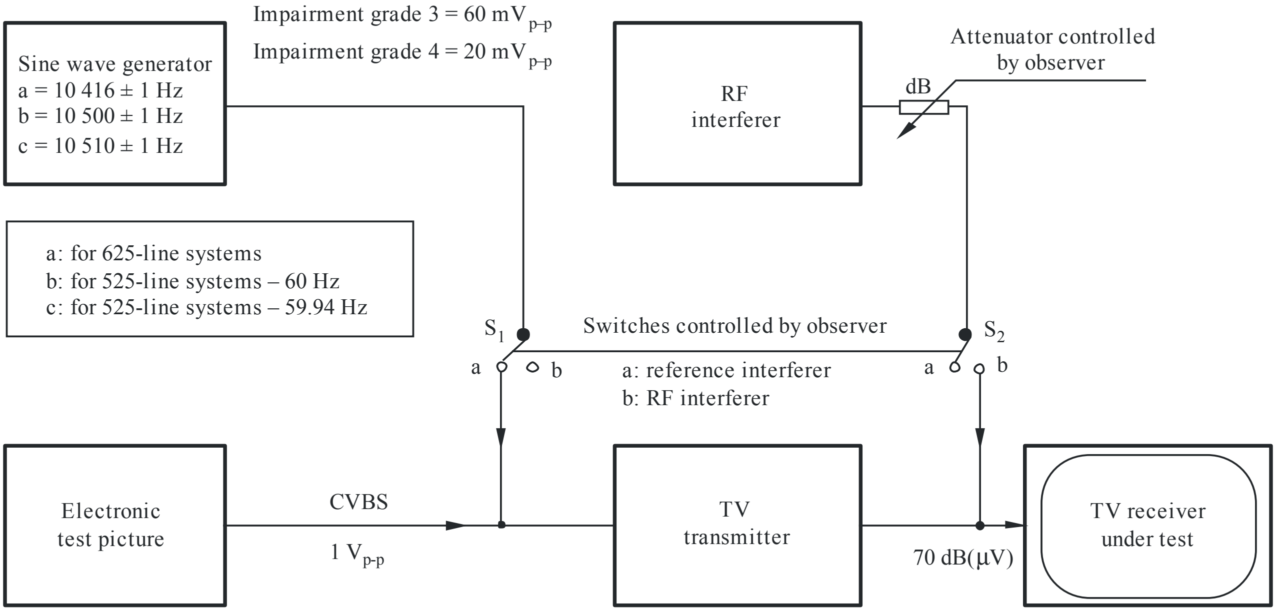
2 SCM for assessment of protection ratios using a sine-wave reference

2.1 General description

Figure 3 shows the test arrangement for the subjective comparison method with sine-wave interferer. The lower three blocks are the main signal path, the wanted video source, the television transmitter and the TV receiver under test. The reference video interferer is a simple sine-wave signal. The amplitude of the sine-wave generator is switchable between tropospheric interference and continuous interference. The unwanted RF interferer is added to the wanted signal path. The amplitude and frequency of the interferer are calculated from the RF reference interferer given in Recommendation ITU-R BT.655, Annex 1, § 2.3.

FIGURE 3

SCM for assessment of protection ratios



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The intensity of the RF interferer can be changed with an attenuator controlled by the observer. The RF interferer is adjusted to produce the same impairment grade as the reference interferer by comparing the interfered pictures on the TV screen.

The RF protection ratio is the difference between the wanted and the unwanted signal levels at the receiver input. The test arrangement can be adjusted in such a way that the value in dB shown at the attenuation box gives, directly, the protection ratio.

2.2 Realization of the reference interferer

For 625-line systems the reference impairment levels are those which correspond to co-channel protection ratios of 30 dB and 40 dB with a frequency offset between the wanted and unwanted vision carriers close to two-thirds of the line frequency but adjusted for maximum impairment. The precise frequency difference is 10 416 Hz. These conditions approximate impairment grades 3 (slightly annoying) and 4 (perceptible, but not annoying) and apply to tropospheric (1% of time) and continuous interference (50% of time), respectively. The impairment grade of the given video baseband reference interferer is independent of the analogue television system and independent of the RF modulation parameters such as modulation polarity, residual carrier, etc.

The RF reference interferer can be realized as a simple sine-wave signal at baseband frequency as shown in Fig. 3. The sine-wave reference interferer has a fixed frequency of 10 416 Hz for 625-line systems or 10 500 Hz for 525-line systems –60 Hz and 10 510 Hz for 525-line systems –59.94 Hz, an amplitude of either 60 $mV_{p\text{-}p}$ or 20 $mV_{p\text{-}p}$ referring to a black-to-white level of 700 $mV_{p\text{-}p}$ or a CVBS level of 1 $V_{p\text{-}p}$. These amplitudes correspond to the RF protection ratios of 30 dB and 40 dB respectively (2/3 line offset). The frequency stability of the sine-wave generator must be within ±1 Hz.

2.3 Test conditions

Wanted video signal: only an electronic test picture is required (e.g. FuBK, Philips or others).

Viewing conditions: as given in Recommendation ITU-R BT.500.

Viewing distance: five times the picture height.

Test receiver: up to five different domestic sets, not older than five years, for co-channel measurements a professional receiver can be used.

Receiver input signal: –39 dBm (70 dB(μV) at 75 Ω).

Observers: five observers, experts or non-experts, are necessary. For initial tests less than five observers are possible. Each single test should be made with one observer only. Observers should be introduced to the method of assessment.

2.4 Presentation of the results

The results should be presented together with the following information:

– mean and standard deviation of the statistical distribution of the protection ratio values;
– test configuration, test picture, type of picture source;
– number of observers;
– reference interferer type;
– the spectrum of the unwanted signal (RF interferer), including the out-of-channel range;
– the used RF level for the wanted signal at the receiver input (for domestic receivers an input voltage of –39 dBm (70 dB(μV) at 75 Ω should be used);
– when domestic sets are used, type, display size and year of production.

3 Table of important parameters

TABLE 105

Basic terms and relations for the SCM

Quality impairment	Grade 3	Grade 4
Interference type	Tropospheric	Continuous
Time allowance	1% to 5% of time	50% of time
Subjective impairment	Slightly annoying	Perceptible, but not annoying
Reference interferer (mV_{p-p})	60	20
RF protection ratio (dB)	30	40

Annex 7

Failure point assessment methods

1 Background

Initial studies of the protection ratios for the DVB-T system were based on a target BER of 2×10^{-4} measured between the inner and outer codes, before Reed-Solomon decoding. For the case of a noise-like interferer, this has been taken to correspond to a quasi-error-free (QEF) picture quality with the BER < 1×10^{-11} at the input of the MPEG-2 demultiplexer.

2 Subjective failure point (SFP) method for protection ratio measurements

For domestic receivers it may not be possible to measure the BER and therefore a new method called the SFP method has been proposed for protection ratio measurements in a unified manner. The quality criterion for protection ratio measurements is to find a limit for a just error-free picture at the TV screen. The RF protection ratio for the wanted DVB-T signal is a value of wanted-to-unwanted signal ratio at the receiver input, determined by the SFP method, and rounded to the next higher integer value.

The SFP method corresponds to the picture quality where no more than one error is visible in the picture for an average observation time of 20 s. The adjustment of the wanted and unwanted signal levels for the SFP method is to be carried out in small steps, usually in steps of 0.1 dB. For a "noise-like" interferer the difference in a value of wanted-to-unwanted signal ratio between the QEF method with a BER of 2×10^{-4} and the SFP method is less than 1 dB. Historically, protection ratio values for wanted digital TV signals are measured with a receiver input power of −60 dBm. Where possible, protection ratios for digital TV systems are derived from measurements using a range of signal levels.

It is proposed that the SFP method should be adopted for assessment of all DTTB systems. (For the digital system ISDB-T this method will be studied in Japan.)

Annex 8

Tropospheric and continuous interference

When using the protection ratios in planning, it is necessary to determine whether, in particular circumstances, the interference should be considered as tropospheric or continuous. This can be done by comparing the nuisance fields for the two conditions, the nuisance field being defined as the field strength of the interfering transmitter (at its pertinent e.r.p.) enlarged by the relevant protection ratio.

Thus, the nuisance field for continuous interference:

$$E_C = E(50, 50) + P + A_C$$

and the nuisance field for tropospheric interference:

$$E_T = E(50, t) + P + A_T$$

where:

$E(50, t)$: field strength (dB(μV/m)) of the interfering transmitter, normalized to 1 kW, and exceeded during t% of the time

P: e.r.p. (dB(1 kW)) of the interfering transmitter

A: protection ratio (dB)

C and T: continuous and tropospheric interference, respectively.

The protection ratio for continuous interference is applicable when the resulting nuisance field is stronger than that resulting from tropospheric interference, that is, when $E_C > E_T$.

This means that A_C should be used in all cases when:

$$E(50, 50) + A_C > E(50, t) + A_T$$