



Subject: Document 11/22

Study Group 11

DRAFT REVISION OF RECOMMENDATION ITU-R BT.1368

PLANNING CRITERIA FOR DIGITAL TERRESTRIAL TELEVISION SERVICES IN THE VHF/UHT BANDS

Summary

In Document 11C/TEMP 5 is attached a draft revision of Recommendation ITU-R BT.1368 which is proposed for adoption by SG 11 by correspondence (Section 10.2.2 of Resolution ITU R-1-2) and further approval by Member States Consultation (Section 10.3 of Resolution ITU-R 1.2)

In the draft revision of Recommendation ITU-R BT.1368 a complete change of the structure was made:

Parts where no digital terrestrial television system is mentioned were moved to Recommendation ITU-R BT.655.

All parts with digital terrestrial television systems as wanted or as unwanted signal are within the new Recommendation ITU-R BT.1368.

New is a general introduction part in Recommendation ITU-R BT.1368.

In ANNEX 1 - For wanted digital terrestrial systems interfered with by other digital systems, nearly all tables are updated and different new text is inserted.

ANNEX 2 - For wanted digital terrestrial television systems interfered with by an analogue broadcast systems only small changes are made.

ANNEX 3 - For interferences into sound signals a new ANNEX is created, tables and values are taken from the source Document 11/BL/23.

ANNEX 4 - Minimum field strength, new values and modified tables are inserted.

ANNEX 5 - Is former ANNEX 4 and it is unchanged.

ANNEX 6 - SCM method, one sentence was added.

ANNEX 7 - Concerning T-DAB, the tables are taken from the unchanged source Document 11/BL/23.

(NOTE: The document has not been revision marked because of too extensive changes. A revision-marked copy is available in BRSGD).

Source: 11C/TEMP/5

Working Party 11C

DRAFT REVISION OF RECOMMENDATION ITU-R BT.1368

PLANNING CRITERIA FOR DIGITAL TERRESTRIAL TELEVISION SERVICES IN THE VHF/UHF BANDS

(Question 121-1/11)

The ITU Radiocommunication Assembly,

considering

- a) that systems are being developed for the transmission of digital terrestrial television services in the VHF/UHF bands;
- b) that the VHF/UHF television bands are already occupied by analogue television services;
- c) that the analogue television services will remain in use for a considerable period of time;
- d) that the availability of consistent sets of planning criteria agreed by administrations will facilitate the introduction of digital terrestrial television services,

recommends

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

Introduction:

This Recommendation ITU-R BT.1368 contains the following five Annexes:

Annex 1 - Protection ratios for wanted digital terrestrial television systems

Annex 2 - Protection ratios for wanted analogue terrestrial television systems interfered with by unwanted digital terrestrial television systems

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

Annex 4 - Minimum field strengths for digital terrestrial television systems

Annex 5 - Other planning factors

Annex 6 - Subjective comparison method for protection ratio tests for wanted analogue terrestrial television systems

Annex 7 - Protection ratios for wanted terrestrial digital audio broadcasting interfered with by unwanted digital terrestrial television systems

General

The radio frequency(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 be preferably measured by thermal power meter.

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.

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 synchronised or do not have a common programme source. Results relevant to single frequency networks (SFN) are yet to be developed.

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

For digital terrestrial television system DVB-T the protection ratios are measured between the inner and outer codes, before Reed Solomon decoding, for a $BER = 2 \times 10^{-4}$; this corresponds to a $BER < 10^{-11}$ at the input of the MPEG-2 demultiplexer. For domestic receivers it may not be possible to measure the BER for some Reed-Solomon decoding . BER for such a case is under study.

To reduce the number of measurements and tables, it is proposed that protection ratio measurements for DVB-T systems should preferable be made with the following three modes. Protection ratio values for the different required operational modes for fixed, portable or mobile reception can be calculated from the given measured values. A formula for calculation is still under study.

TABLE 1

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

Modulation	Code rate	C/N ¹⁾	Bit rate ²⁾
QPSK	2/3	8 dB	≈7 Mbit/s
16-QAM	2/3	13 dB	≈12 Mbit/s
64-QAM	2/3	17 dB	≈20 Mbit/s

¹⁾ $BER < 10^{-11}$ at the input of MPEG-2 demultiplexer for a Gaussian channel with no allowance for implementation margin; typical implementation margins of 2 dB have been measured.

²⁾ For a guard interval of 1/4.

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. Values applicable to limit of perceptibility, *LP*, are given for information only.

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 third 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.

ANNEX 1

Protection ratios for wanted digital terrestrial television systems

The Tables in Annex 1 show protection ratios for different wanted digital terrestrial television systems interfered with by digital terrestrial television systems, by analogue terrestrial television systems, by single a single CW and FM carrier and by T-DAB signals, respectively. All protection ratio values in Annex 1 are based upon measurements made with non-consumer receivers.

1 Protection of digital terrestrial television interfered with by digital terrestrial television

TABLE 1
Co-channel protection ratios (dB) for ATSC interfered with by ATSC

Wanted signal	Unwanted signal
	ATSC 6 MHz
ATSC 6 MHz	15 19*

*Based on equally partitioned noise and interference.

TABLE 2
Protection ratios (dB) for ATSC interfered with by ATSC in lower adjacent channel (N-1)

Wanted signal	Unwanted signal
	ATSC 6 MHz
ATSC 6 MHz	-42 ¹⁾ -27 ²⁾

The protection ratios are given in dB and apply to both continuous and tropospheric interference.

- 1) Measured using a digital terrestrial television system ATSC interferer with negligible out-of-band emissions.
- 2) Calculated using a co-channel protection ratio of 19.5 dB and a digital terrestrial television system ATSC interferer with out-of-band emissions measured in a 500 kHz bandwidth relative to the average ATSC transmitted power attenuated by:
 - (46 + 7.5Δf) dB for $0 \leq \Delta f < 3$ MHz
 - (61 + 2.5Δf) dB for $3 \text{ MHz} \leq \Delta f < 6$ MHz
 - 76 dB for $\Delta f \geq 6$ MHz

TABLE 3
**Protection ratios (dB) for ATSC interfered with by
 ATSC in upper channel (N+1)**

Wanted signal	Unwanted signal
	ATSC 6 MHz
ATSC 6 MHz	-43 ¹⁾ -27 ²⁾

The protection ratios are given in dB and apply to both continuous and tropospheric interference.

- 1) Measured using a digital terrestrial television systems ATSC interferer with negligible out-of-band emissions.
- 2) Calculated using co-channel protection ratio of 19.5 dB and a digital terrestrial television systems ATSC interferer with out-of-band emissions measured in a 500 kHz bandwidth relative to the average digital terrestrial television systems transmitted power attenuated by:
 - (46 + 7.5Δf) dB for $0 \leq \Delta f < 3$ MHz
 - (61 + 2.5Δf) dB for $3 \text{ MHz} \leq \Delta f < 6$ MHz
 - 76 dB for $\Delta f \geq 6$ MHz

TABLE 4
**Protection ratio (dB) for ATSC 6 MHz interfered with by
 ATSC 6 MHz in the image channel**

Wanted signal	Unwanted signal
	ATSC
ATSC	-63

TABLE 5
**Protection ratio (dB) for ATSC 6 MHz interfered with by other
 ATSC 6 MHz out-of-band channels**

Wanted signal	Unwanted signal	Unwanted channels	Protection ratio
ATSC	ATSC	N±2 to N±8	-58

TABLE 6
Co-channel protection ratios (dB) for DVB-T interfered with by DVB-T

Modulation	Code rate	Gaussian channel	Rice channel	Rayleigh channel
QPSK	1/2	5	7	8
QPSK	2/3			
16 QAM	2/3			
16 QAM	3/4	14	16	20
64 QAM	2/3	19	20	22

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 adjacent and image channel interference a protection ratio of -30 dB is assumed to be appropriate. Since this assumption is based on only one measurement further studies are required.

For overlapping channel , in absence of measurement information the protection ratio should be extrapolated from the co-channel ratio figure as follows.

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

PR(CCI) is the co-channel protection ratio

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

BW is the bandwidth (in MHz) of the wanted signal

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

2 Protection of digital terrestrial television interfered with by analogue terrestrial television

2.1 Protection from co-channel interference

TABLE 7

Co-channel protection ratios (dB) for ATSC interfered with by analogue television

Wanted signal	Unwanted signal Analogue TV system including sound carriers	
	M/NTSC	PAL B
ATSC 6 MHz	2 7*)	9

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

TABLE 8

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

Constellation	Protection Ratio														
	QPSK					16QAM					64QAM				
Code Rate	1/2	2/3	3/4	5/6	7/8	1/2	2/3	3/4	5/6	7/8	1/2	2/3	3/4	5/6	7/8
PAL/SECAM*	-12	-8	-4	3	9	-8	-3	3	9	16	-3	3	10	17	24

*With teletext and sound carriers

NOTES:

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 -13 dB and -20 dB level;

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

In all tables the so-called non-controlled conditions are used. Introducing precisely controlled frequency offsets between the analogue and digital signals, significant lower co-channel required signal to interference ratios have been measured. Further studies of using controlled offset for DVB-T are necessary.

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

2.2 Protection from lower adjacent channel (N-1) interference

TABLE 9

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

Wanted signal	Unwanted signal Analogue TV system including sound carriers
	M/NTSC
ATSC 6 MHz	-48

TABLE 10

Protection ratios (dB) for lower adjacent channel (N-1) interference for DVB-T 7 and 8 MHz 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	2/3	-44					
16QAM	1/2			-43			
16QAM	2/3	-42					
64QAM	1/2			-38			
64QAM	2/3	-35		-34			

2.3 Protection from upper adjacent channel (N+1) interference

TABLE 11

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

Wanted signal	Unwanted signal Analogue TV system including sound carriers
	M/NTSC
ATSC 6 MHz	-49

TABLE 12

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

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

2.4 Protection from image channel interference

TABLE 13

Protection ratios (dB) for ATSC 6 MHz interfered with by an analogue television signal (including sound) in the image channel

Wanted signal	Unwanted signal
	NTSC M
ATSC	-58

TABLE 14

Protection ratios (dB) for DVB-T 7 and 8 MHz interfered with by an analogue television signal (including sound) in the image channel

Wanted signal		Unwanted signal					
	Code rate	PAL B	PAL G,B1	PAL I	PAL D,K	SECAM L	SECAM D,K
QPSK	2/3			-58*			
16QAM	1/2			-58			
16QAM	2/3			-48*			
64QAM	1/2			-50			
64QAM	2/3			-46			

* calculated values

Note: the protection ratios in this table will depend on the intermediate frequency of the receiver.

2.5 Protection from overlapping channel interference

TABLE 15

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

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 of the analogue television signal minus the centre frequency of the DVB-T signal.

TABLE 16

Protection ratios (dB) for DVB-T 7 MHz interfered with by an overlapping PAL B1, D signal including sound

DVB-T 7 MHz 64 QAM Code rate 2/3													
Δf (MHz) for PAL B1	-9.25	-	-	-	-	-	-	-	-	-	2.75	4.25	4.75
		8.75	8.25	7.75	6.25	3.45	3.25	2.25	1.25	1.75			
Δf (MHz) for PAL D	-10.25	-	-	-	-	-	-	-	-	-	2.75	4.25	4.75
		9.75	9.25	8.75	7.25	3.45	3.25	2.25	1.25	1.75			
PR	-37	-14	-8	-4	-2	1	3	3	3	2	-1	-29	-36

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

2.6 Protection from other channel interference

TABLE 17

Protection ratios (dB) for ATSC 6 MHz interfered with by M/NTSC 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

2.7 Protection from CW and FM signals.

TABLE 18

Co-channel protection ratios (dB) for DVB-T 7 and 8 MHz 64QAM Code rate 2/3 interfered with by CW or a FM carrier.

64 QAM Code rate 2/3							
$\Delta f(\text{MHz})$ for DVB-T 7 MHz	-10.5	-4	-3.4	0	3.4	4	10.5
$\Delta f(\text{MHz})$ for DVB-T 8 MHz	-12	-4.5	-3.9	0	3.9	4.5	12
PR	-38	-33	-3	-3	-3	-33	-38

The given protection ratio tables can be used for interfering signals with narrow band width e.g. analogue sound carriers or non broadcast services.

TABLE 19

Co-channel protection ratios (dB) for DVB-T 7 and 8 MHz 16QAM Code rate 1/2 interfered with by CW or a FM carrier.

16 QAM Code rate 1/2							
$\Delta f(\text{MHz})$ for DVB-T 7 MHz	-10.5	-4	-3.4	0	3.4	4	10.5
$\Delta f(\text{MHz})$ for DVB-T 8 MHz	-12	-4.5	-3.9	0	3.9	4.5	12
PR	-46	-40	-6	-6	-6	-40	-46

The given protection ratio tables can be used for interfering signals with narrow band width e.g. analogue sound carriers or non broadcast services.

2.8 Protection from T-DAB signals

TABLE 20

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

64 QAM Code rate 2/3									
$\Delta f =$ Centre frequency of T-DAB minus Centre frequency of DVB-T									
$\Delta f(\text{MHz})$	-5	-4.2	-4	-3	0	3	4	4.2	5
PR	-30	-6	-5	28	29	28	-5	-6	-30

TABLE 21

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

64 QAM Code rate 2/3									
$\Delta f =$ Centre frequency of T-DAB minus Centre frequency of DVB-T									
Δf (MHz)	-4.5	-3.7	-3.5	-2.5	0	2.5	3.5	3.7	4.5
PR	-30	-6	-5	28	29	28	-5	-6	-30

ANNEX 2

**Protection ratios for wanted terrestrial analogue television systems
interfered with by unwanted digital terrestrial television systems**

The Tables in Annex 2 show protection ratios for different wanted 525- and 625-line analogue television systems interfered with by digital terrestrial television systems.

Protection ratio for 525-line television systems

1 Protection for vision and sound signals interfered with by digital television

1.1 Protection for vision signals interfered with by digital television (ATSC)

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

TABLE 22

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

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

Protection ratios for 625-line television systems

2 Protection of wanted vision signals interfered with by 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.

2.1 Protection from co-channel interference

TABLE 23

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

Wanted analogue system	Tropospheric interference	Continuous interference	Interference grade 4.5
B, D, G, H, K/PAL	34	40	
I/PAL	37	41	45
B, D, K, L/SECAM*	34 to 37	41	

*) Provisional values still under study

TABLE 24

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

Wanted analogue system	Tropospheric interference	Continuous interference	Interference grade 4.5
B/PAL	35	41	
B/SECAM*	34 to 37	41	

*) Provisional values still under study

TABLE 25

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

Wanted analogue system	Tropospheric interference	Continuous interference	Interference grade 4.5
B/PAL	38	45	51

2.2 Protection from lower adjacent channel interference

TABLE 26

Protection ratios for a wanted analogue vision signal interfered with by an unwanted lower adjacent DVB-T 7 MHz and 8 MHz system

Wanted analogue system	Tropospheric interference	Continuous interference	Interference grade 4.5
B, D, G, H, I, K/PAL	-9	-5	0
B, D, K, L/SECAM	-9	-5	

TABLE 27

Protection ratios for a wanted analogue vision signal interfered with by an unwanted lower adjacent ATSC 6 MHz system

Wanted analogue system	Tropospheric interference	Continuous interference	Interference grade 4.5
B/PAL	-7	-1	5

2.3 Protection from upper adjacent channel interference

TABLE 28

Protection ratios for a wanted analogue vision signal interfered with by an unwanted upper adjacent DVB-T 7 MHz and 8 MHz system

Wanted analogue system	Tropospheric interference	Continuous interference	Interference grade 4.5
B, D, G, H, I, K/PAL	-9	-5	
L/SECAM*	-1	-1	
B, D, K/SECAM	-9	-5	

*) Provisional values still under study

TABLE 29

Protection ratios for a wanted analogue vision signal interfered with by an unwanted upper adjacent ATSC 6 MHz system

Wanted analogue system	Tropospheric interference	Continuous interference	Interference grade 4.5
B/PAL	-7	0	5

2.4 Protection from image channel interference

TABLE 30

Protection ratios for a wanted analogue vision signals interfered with by an unwanted image channel DVB-T 8 MHz systems

Wanted analogue system	Unwanted DVB-T channel	Tropospheric interference	Continuous interference	Interference grade 4.5
G/PAL	N+9	-19	-15	
I/PAL	N+9			
L/SECAM*		-25	-22	
D, K/SECAM*	N+8	-16	-11	
D, K/SECAM*	N+9	-16	-11	
D, K/PAL	N+8			
D, K/PAL	N+9			

*) Provisional values still under study

TABLE 31

Protection ratios for a wanted analogue vision signal interfered with by an unwanted image DVB-T 7 MHz system

Wanted analogue system	Unwanted DVB-T channel	Tropospheric interference	Continuous interference	Interference grade 4.5
B/PAL	N+10	-22	-18	
B/PAL	N+11	-21	-18	
B/SECAM				

2.5 Protection from overlapping interference

TABLE 32

Protection ratios for analogue B, D, G, H, K/PAL vision signals^{*)} interfered with by an unwanted overlapping DVB-T 7 MHz system

Frequency of the centre of unwanted DVB-T minus vision carrier frequency of wanted analogue television signal (MHz)	Protection ratio in dB	
	Tropospheric interference	Continuous interference
-7.75	-16	-11
(N-1) -4.75	-9	-5
-4.25	-4	3
-3.75	13	20
-3.25	23	30
-2.75	30	37
-1.75	34	41
-0.75	35	41
(N) 2.25	35	41
4.25	35	41
5.25	31	38
6.25	26	33
7.25	21	30
8.25	4	9
(N+1) 9.25	-9	-5
12.25	-9	-5

^{*)} For all SECAM systems similar values are expected. The values are still under study.

TABLE 33

Protection ratios for analogue B, D, G, H, K/PAL vision signals^{*)} interfered with by an unwanted overlapping DVB-T 8 MHz system

Frequency of the centre of unwanted DVB-T minus vision carrier frequency of wanted analogue television signal (MHz)	Protection ratio in dB	
	Tropospheric interference**	Continuous interference**
-8.25	-16	-11
(N-1) -5.25	-9	-5
-4.75	-5	2
-4.25	12	19
-3.75	22	29
-3.25	29	36
-2.25	33	40
-1.25	34	40
(N) 2.75	34	40
4.75	34	40
5.75	30	37
6.75	25	32
7.75	20	29
8.75	3	8
(N+1) 9.75	-9	-5
12.75	-9	-5

^{*)} For all SECAM systems similar values are expected. The values are still under study.

^{**)} The values for tropospheric and continuous interference have been arrived at from TABLE 32 by calculation.

ANNEX 3

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

The Tables in Annex 3 show protection ratios for wanted FM, AM and NICAM television sound carriers interfered with by unwanted digital terrestrial television systems.

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 signal-to-noise ratios for AM and FM sound signals are:

- 40 dB (approximates to impairment grade 3) – tropospheric case;
- 48 dB (approximates to impairment grade 4) – continuous case

The reference signal-to-noise ratios 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 bit-error rates for NICAM digital sound signals are:

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

1 Protection for NTSC sound signals (BTSC and SAP) interfered with by digital television (ATSC)

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 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.

2 Protection for FM, AM and NICAM sound signals of the analogue television systems interfered with by digital terrestrial television system

TABLE 34

Co-channel protection ratios for a wanted sound signal interfered with by digital terrestrial television

Protection ratio (dB) related to the wanted sound carrier		Unwanted signal	
		DVB-T 7 MHz	DVB-T 8 MHz
Wanted sound signal			
FM	Tropospheric case	6	5
	Continuous case	16	15
AM	Tropospheric case		
	Continuous case		
NICAM PAL B/G	Tropospheric case	5	4
	Continuous case	6	5
NICAM System I	Tropospheric case		
	Continuous case		

TABLE 35

Protection ratios for a wanted FM sound signal interfered with by an overlapping DVB-T 7 MHz signal

Protection ratio (dB) related to the wanted sound carrier	Frequency of the 3 dB edge of DVB-T minus sound carrier frequency	-500	-250	-50	0.0	50	250	500
		kHz	kHz	kHz	kHz	kHz	kHz	kHz
Tropospheric case	Upper edge	0	0	0	5	5	6	6
Continuous case	Upper edge	9	9	9	14	14	15	16
Tropospheric case	Lower edge	5	5	4	3	-9	-22	-32
Continuous case	Lower edge	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 - The protection ratio figures for other television systems in use have to be added.

NOTE 3 - This Table is still under study.

ANNEX 4

Minimum field strengths for terrestrial digital television

Three methods are given for the calculation of minimum field strength values. Each of these methods may be used to give the identical minimum field strength values for a given set of parameters.

TABLE 36
Derivation by the "voltage method"

System: DVB-T 8 MHz

frequency (MHz)	65			200			550			700		
system variant	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	QPSK 2/3	16-QAM 2/3	64-QAM 2/3
noise bandwidth, B (MHz)							7.5	7.5	7.5	7.5	7.5	7.5
receiver noise figure, F (dB)							5	5	5	5	5	5
receiver noise voltage, $U_n^{21)}$ (dB (μ V))							8.4	8.4	8.4	8.4	8.4	8.4
receiver carrier/noise ratio ²²⁾ (C/N) (dB)												
urban noise (dB)							0	0	0	0	0	0
minimum receiver input voltage, U_{Min} (dB (μ V)) ¹⁾												
conversion factor ¹⁾ k (dB)							20.5	20.5		24.5	24.5	
feeder loss, A_f (dB)							3	3		5	5	
antenna gain, G (dB)							10	10		12	12	
minimum field strength for fixed reception, E_{min} (dB (μ V/m)) ²¹⁾												
¹⁾ Formula see Appendix 1. ²⁾ For noise bandwidth noted above.												

TABLE 37
Derivation by the "power method"

frequency (MHz)	65			200			500			700		
system variant	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	QPSK 2/3	16- QAM 2/3	64- QAM 2/3
equivalent noise bandwidth, B (MHz)												
receiver noise figure, F (dB)												
receiver noise power $P_n^{1)}$ (dBW)												
receiver carrier/noise ratio ³⁾²⁾ (C/N) (dB)												
urban noise (dB)												
wave length (m)												
feeder loss (dB)												
antenna gain G (dB)												
effective antenna aperture (dB) ⁻¹⁾												
power flux-density pfd ¹⁾ (dBW)												
conversion pfd/ field strength (dB)												
minimum field strength (dB (μ V/m)) ⁻¹⁾												
¹⁾ Formula see Appendix 1. ²⁾ For noise bandwidth noted above.												

TABLE 38
Derivation by the "Figure of merit method"

System: ATSC 6 MHz¹⁾

Planning parameter	Low VHF 54 - 88 MHz	High VHF 174 - 216 MHz	UHF 470 - 806 MHz
Frequency (MHz)	69	194	615
C/N (dB)	19.5	19.5	19.5
K (dB)	-228.6	-228.6	-228.6
B (dB) (6 MHz)	67.78	67.78	67.78
G _i (1m ²) (dB)	-1.77	7.25	17.23
G _{dipole} (dB)	6	8	10
G _{isotropic} (dB)	8.15	10.15	12.15
Line loss (dB)	1.05	1.81	3.29
α (numeric)	0.786	0.659	0.468
Balun 300/75 loss (dB)	0.5	0.5	0.5
α _{balun} (numeric)	0.891	0.891	0.891
Receiver noise figure (dB)	5	5	10
T _{rx}	627.1	627.1	2610
T _{line}	62.1	98.9	154.3
LNA noise figure (dB)	5	5	5
LNA gain (dB)	20	20	20
T _{LNA}	627.1	627.1	627.1
T _{balun}	31.6	31.6	31.6
T _a	9972.1	569.1	Neg
α _{balun} T _a	8885.1	507.1	Neg
T _{line} /α G	0.79	1.5	3.3
T _{rx} /α G	7.98	9.52	55.8
T _e	9552.6	1176.8	717.8
10log(T _e)	39.8	30.71	28.56
G _A (dB)	7.65	9.65	11.65
E _{reqd} (dBμV/m) ²⁾	35	33	39

¹⁾ 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.

²⁾ Formula see Appendix 4

APPENDIX 1

(to Annex 4)

	Formulae	in dB
Derivation by the "voltage method"	$P = \frac{U^2}{R}$	
Thermal noise power	kTB	10 log (kTB)
Receiver noise input power	n kTB	10 log (kTB) + F
Thermal noise voltage	$U_T = \sqrt{kTBR}$	
Receiver noise input voltage	$U_N = \sqrt{nkTBR}$	10 log (kTB) + F + 10 log (R)
Minimum receiver input voltage	$U_{\min} = U_N \sqrt{C/N}$	$U_N + \frac{C}{N}$

Relationship between voltage and field strength

$$U = \sqrt{PrR} = \sqrt{\phi AR} = \sqrt{\frac{E^2}{120\pi} 1.64 g_o \frac{\lambda^2}{4\pi} R}$$

Therefore
$$U = E \sqrt{\frac{\lambda^2}{480\pi^2} R 1.64 g_o}$$

Conversion factor
$$K = \frac{E}{U} = \sqrt{\frac{480\pi^2}{1.64 g_o \lambda^2 R}}$$

$$K[dB] = 10 \log 480 \pi^2$$

$$- 20 \log \lambda - 10 \log R - 10 \log 1.64$$

$$- G_D + L$$

Conversion factor
$$K_o = \frac{E}{U} = \sqrt{\frac{4\pi^2}{g_o \lambda^2}}$$

$$K_o[dB] = 20 \log (2\pi / \lambda)$$

$$- G_D + L$$

$$E_{\min} = U_{\min} + K_o$$

(with R = 73 Ohms)

Minimum field strength

APPENDIX 2
(to Annex 4)

	Formulae	in dB
Derivation by the "power method"		
Thermal noise	kTB	$10 \log (kTB)$
Receiver noise input power	$P_N = n kTB$	$10 \log (kTB) + F$
Minimum receiver input power	$P_r = P_N \frac{C}{N}$	$P_r = P_N + \frac{C}{N}$
Relationship between power flux-density (ϕ) and power	$P_r = \phi A$	$P_r = \phi + A$
	$\phi = \frac{P_r}{A}$	$\phi = P_r - A$
Relationship between power flux-density and field strength	$E = \sqrt{120\pi\phi}$	$E (dBV / m) = \phi + 10 \log 120\pi$ $E (dB\mu V / m) = \phi + 145.76$

APPENDIX 3

(to Annex 4)

Data

k	Boltzman constant = 1.38×10^{-23}
T ₀ :	290° K
F:	receiver noise figure (dB)
n:	receiver noise figure (factor)
B:	equivalent noise bandwidth (Hz)
C/N:	radio-frequency signal/noise ratio (dB)
f:	frequency (Hz)
G _D :	antenna gain related to half-wave dipole (dB)
L:	cable loss (dB)
φ:	power flux-density
g _o :	gain of receiving antenna system (factor)
A:	effective antenna aperture

Formulae used

thermal noise:	$kT_0 B$
receiver noise temperature:	$T_r = T_0 (10^{F/10} - 1)$
g _o :	$10^{(G_D - L)/10}$
n:	$10^{F/10}$
A:	$\frac{1.64 g_o \lambda^2}{4\pi}$
φ:	$\frac{E^2}{120\pi}$

APPENDIX 4

(to Annex 4)

Derivation by the "Figure of merit method"

Required field strength

$$E_{RX}(\text{dBV/m}) = \Phi(\text{dBW/m}^2) + 10\log(120\pi)$$

$$C/N = \Phi - G_{1m^2} + G_A/T_e - k - B_{rf}$$

$$\begin{aligned} E_{RX}(\text{dB}\mu\text{V/m}) &= \Phi(\text{dBW/m}^2) + 25.8 (\text{dB}) + 120 (\text{dB}) \\ &= 145.8 + C/N + G_{1m^2} - G_A/T_e + 10\log(k) + 10\log(B_{rf}) \end{aligned}$$

E_{RX} required field strength at the receive system antenna

Φ power flux density at the receive system antenna

C/N carrier to noise ratio

G_{1m^2} gain of 1 metre squared

G_A/T_e figure of merit of the receive system

k Boltzmann's constant

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

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

LNA noise temperature

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

Transmission line noise temperature

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

Balun noise temperature

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

Antenna noise temperature

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

reference ITU-R Reports 258-5 and 670-1

Antenna noise temperature (referred to LNA input)

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

System noise temperature

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

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

or $= 10 \log(T_{\text{balun}} + T_{\text{LNA}} + T_{\text{line}} / \alpha_{\text{line}} G_{\text{LNA}} + T_{\text{rx}} / \alpha_{\text{line}} G_{\text{LNA}}) + N_{\text{ext}}$
when T_a is not known

Gain of 1 metre squared

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

Data

G	Antenna gain (isotropic) (dB)
L	Transmission line loss (dB)
α_{line}	Transmission line loss (numeric ratio)
T_a	Antenna noise temperature ($^{\circ}$ K)
T_{rx}	Receiver noise temperature ($^{\circ}$ K)
nf	Noise factor (numeric ratio)

NF	Noise figure (dB)
T_o	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 $1.38 \cdot 10^{-23}$ (-228.6 dB)
B	System equivalent noise bandwidth (dB Hz)
α_{balun}	Antenna 300/75 Balun loss (numeric ratio)
LNA	Low Noise Amplifier
TLNA	LNA noise temperature (°K)

ANNEX 5

Other planning factors

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 and given in Figures 5 and 12 of Recommendation ITU-R PN.370.

The results of propagation studies for digital systems are given in Figure 1 for the VHF and UHF bands. These results may also be used to derive propagation prediction curves for location percentages other than 50%. Refer to Figures 5 and 12 of Recommendation ITU-R P.370-7 for the location percentages other than 50% for analogue and digital systems, where the digital system bandwidth is greater than 1.5 MHz.

Reception using portable television equipment

The methods given in Annex 3 may be used to derive the minimum field strength required in the vicinity of a receiving antenna. By convention, field strength predictions are made for a receiving antenna height of 10 m above ground or roof-top level. In the case of reception using a portable receiver, an estimate will be needed of the difference in field strength between that at 10 m or roof-top level and that at the place where the portable receiver is situated. Representative values, including both indoor and outdoor operation, have yet been developed. Recommendation ITU-R P.370-7 notes that by using Equation (5), a correction to the predicted field strengths can be made for various receiving antenna heights ranging from 1.5 to 40 m above ground.

An approximation for the indoor field strength relative to the ground floor outdoor field strength for the VHF and UHF bands in suburban areas is given by:

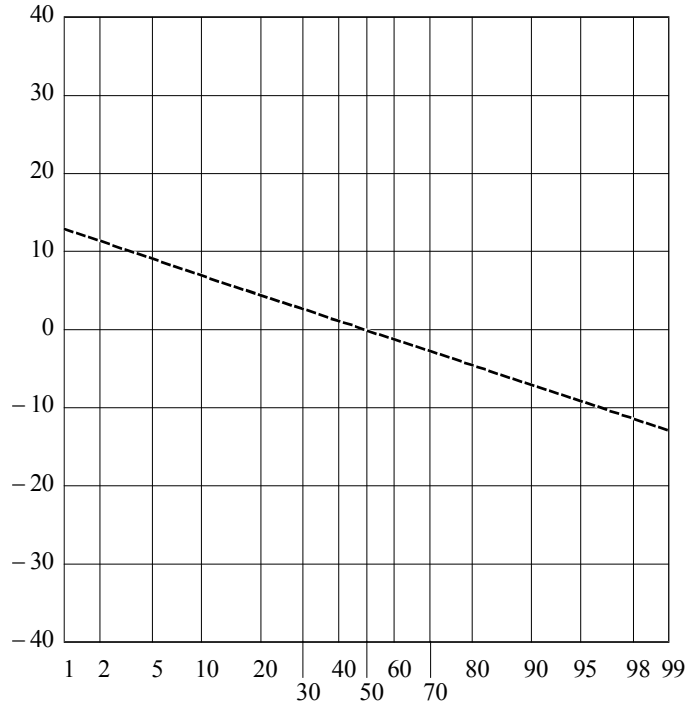
$$FS(\text{indoor}) = FS(\text{outdoor at ground level}) + 2N - 10$$

where N is the number of the floor where the indoor receiver is located and for N ranging from 0 to 2.

Receiving antenna discrimination

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

Frequency: 30 to 250 MHz (Bands I, II and III) and 470 to 890 MHz (Bands IV and V)



D19

Percentage of receiving locations

FIGURE 1

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

ANNEX 6

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

1 Introduction

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.

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 three fixed impairment types are necessary, approximately grade 3 for tropospheric, grade 4 for continuous and grade 4.5 for steady interference, see Table 39. The 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 - are necessary.

There are two reference interferers which may be used:

- sine-wave interference
(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 harmonised unified noise reference figure have been obtained)
- 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.

2 The subjective comparison method (SCM) of assessing protection ratios using sine-wave reference

2.1 General description

Figure 1 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, continuous interference and steady interferences type. 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.

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.

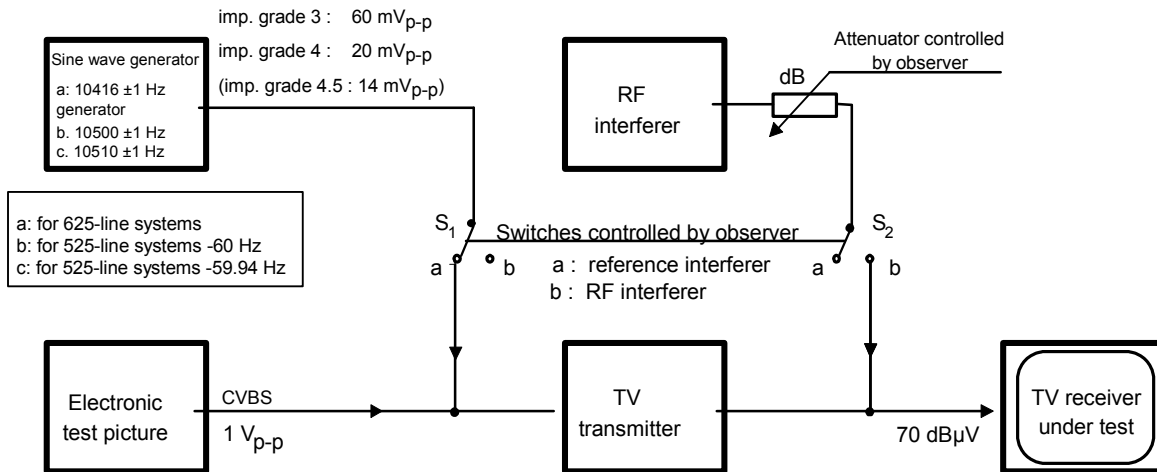


FIGURE 2

Subjective comparison method (SCM) for assessment of protection ratios

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 kHz. 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 from the analogue television system and independent from the RF modulation parameters like modulation polarity, residual carrier etc.

The RF reference interferer can be realized as a simple sine-wave signal at baseband frequency as shown in Figure 1. The sine-wave reference interferer has a fixed frequency of 10.416 kHz for 625-line systems or 10.500 kHz for 525-line systems -60 Hz and 10.510 kHz for 525-line systems -59.94 Hz, an amplitude of either 60 mV_{p-p} or 20 mV_{p-p} referring to a black-to-white level of 700 mV_{p-p} or a CVBS level of 1 V_{p-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: 70 dB μ V at 75 Ohms.

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 70 dB μ V should be used);
- when domestic sets are used, type, display size and year of production.

3 Table of important parameters

TABLE 39

Basic terms and relations for the SCM method

Quality impairment	Grade 3	Grade 4	Grade 4.5*
Interference type	tropospheric	continuous	steady
Time allowance	1% to 5% of time	50% of time	100% of time
Subjective impairment	slightly annoying	perceptible, but not annoying	just perceptible limit
Reference interferer	60 mV _{P-P}	20 mV _{P-P}	14 mV _{P-P}
RF protection ratio	30 dB	40 dB	43 dB

* Protection ratio for steady interference is not yet defined.

ANNEX 7

**Protection ratios for T-DAB interfered with by
an unwanted digital terrestrial television system**

1 T-DAB interfered with by DVB-T

TABLE 40

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

64 QAM Code rate 2/3									
$\Delta f =$ Centre frequency of DVB-T minus Centre frequency of T-DAB									
Δf (MHz)	-5	-4.2	-4	-3	0	3	4	4.2	5
PR	-50	-1	0	1	1	1	0	-1	-50

TABLE 41

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

64 QAM Code rate 2/3									
$\Delta f =$ Centre frequency of DVB-T minus Centre frequency of T-DAB									
Δf (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
