International Telecommunication Union

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Recommendation ITU-R BS.1660-7
(10/2015)

Technical basis for planning of terrestrial digital sound broadcasting in the VHF band

BS Series
Broadcasting service (sound)

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

Electronic Publication
Geneva, 2015

RECOMMENDATION ITU-R BS.1660-7*

Technical basis for planning of terrestrial digital sound broadcasting in the VHF band

(Question ITU-R 56/6)

(2003-2005-2005-2006-2011-2012-2015)

Scope

This Recommendation describes the planning criteria, which could be used for planning of terrestrial digital sound broadcasting in the VHF band, for Digital Systems A, F and G of Recommendation ITU-R BS.1114.

The ITU Radiocommunication Assembly,

considering

a) Recommendations ITU-R BS.774 and ITU-R BS.1114;

b) ITU-R Digital Sound Broadcasting Handbook – Terrestrial and satellite digital sound broadcasting to vehicular, portable and fixed receivers in the VHF/UHF bands,

recommends

1 that the planning criteria as described in Annex 1 for Digital System A and Annex 2 for Digital System F and Annex 3 for Digital System G could be used for planning of terrestrial digital sound broadcasting in the VHF band.

Annex 1

Technical basis for planning of terrestrial digital sound broadcasting System A (T-DAB) in the VHF band

1 General

This Recommendation contains relevant T-DAB system parameters and network concepts, including a description of single frequency networks (SFNs).

The receiving antenna, which is assumed to be representative for mobile and portable reception, has a height of 1.5 m above ground level, omnidirectional with a gain slightly lower than a dipole.

The field strength prediction method relies on curves for 50% locations, 50% time for the wanted signal and 50% locations, 1% time for the unwanted signal.

For the calculation of tropospheric (1% time) and continuous (50% time) interference, see Recommendation ITU-R BT.655.

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* The Administration of the Syrian Arab Republic is not in a position to accept the content of this Recommendation, nor for it to be used as a technical basis for the planning of sound broadcasting in the VHF band, at the forthcoming Regional Radiocommunication Conferences planning of the digital terrestrial broadcasting service in parts of Regions 1 and 3.

The required location percentage for T-DAB services is 99%. Therefore, taking a standard deviation of 5.5 dB, an increase of 13 dB (2.33 × 5.5 dB) shall be applied to the field strength values (50% locations) in order to obtain the 99% location values required for planning a T-DAB service.

The propagation curves used for planning relate to a receiving antenna height of 10 m above ground, whereas a T-DAB service will be planned primarily for mobile reception, i.e., with an effective receiving antenna height of about 1.5 m. An allowance of 10 dB is necessary to convert the minimum required T-DAB field strength at a vehicle antenna height of 1.5 m to the equivalent value at 10 m.

2 Minimum wanted field strength used for planning

Table 1 contains values for VHF Band III with the inclusion of a correction of 13 dB for location percentage and of 10 dB for height gain. The below given minimum median equivalent field strength represents the minimum wanted field strength used for planning.

The values shown in Table 1 are applied to mobile reception.

TABLE 1

Minimum median equivalent field strength (dB(μV/m))
at an antenna height of 10 m

Frequency band	Band III
Minimum equivalent field strength (dB(μV/m))	35
Location percentage correction factor (50% to 99%) (dB)	+13
Antenna height gain correction (dB)	+10
Minimum median equivalent field strength for planning (dB(μV/m))	58

3 Unwanted emissions

3.1 Spectrum masks for T-DAB out-of-band emissions

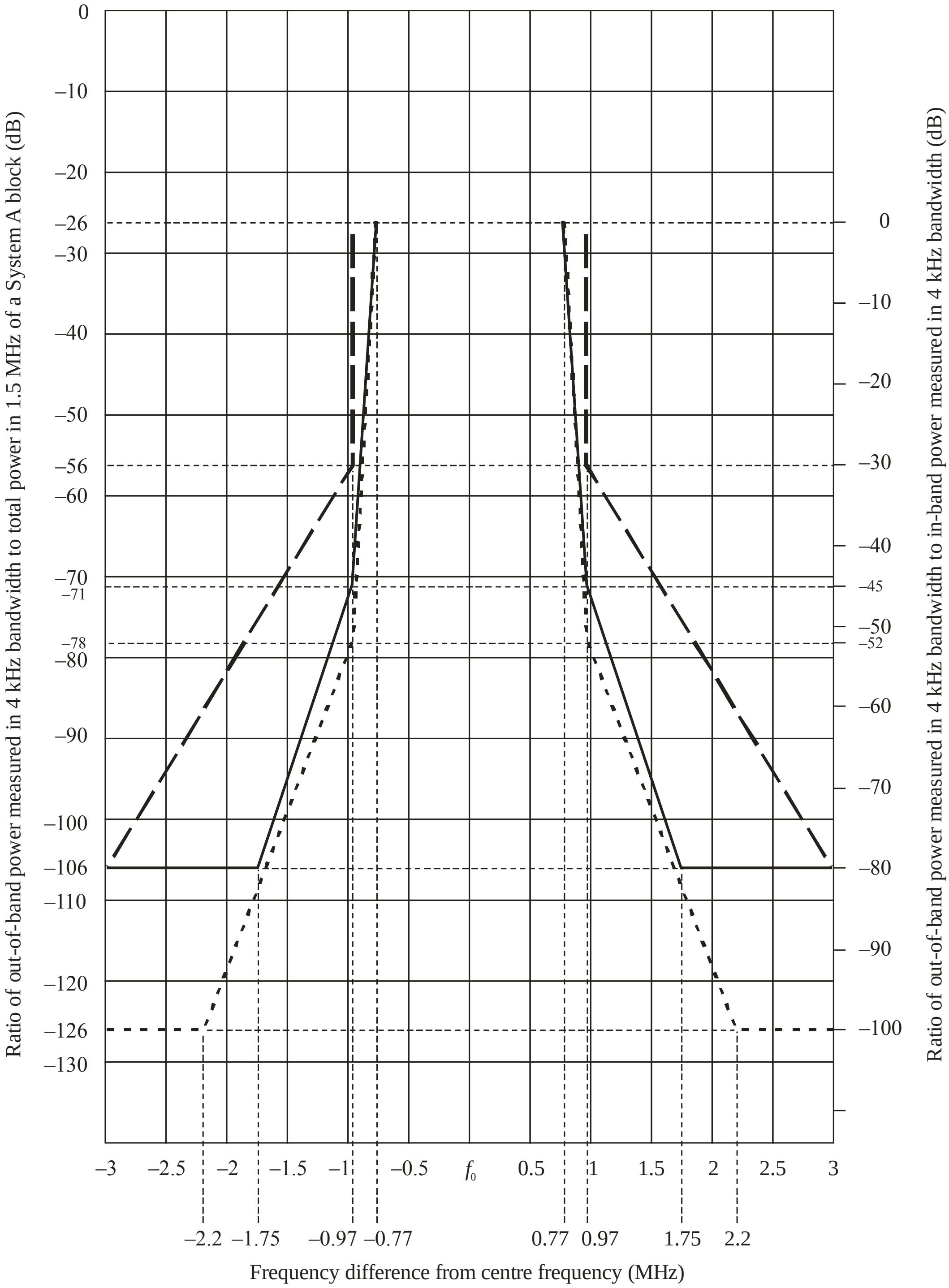
The out-of-band radiated signal in any 4 kHz band should be constrained by one of the masks defined in Fig. 1.

The solid line mask should apply to VHF transmitters operating in critical cases. The dashed line mask should apply to VHF transmitters operating in uncritical cases or in the 1.5 GHz band and the dotted line mask should apply to VHF transmitters operating in certain areas where frequency block 12D is used.

The level of the signal at frequencies outside the normal 1.536 MHz bandwidth can be reduced by applying an appropriate filtering.

FIGURE 1

Out-of-band spectrum masks for a transmission signal of System A



Spectrum mask for VHF System A transmitters operating in uncritical cases or in the 1.5 GHz band

Spectrum mask for VHF System A transmitters operating in critical cases

Spectrum mask for VHF System A transmitters operating in certain areas where frequency block 12D is used

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Out-of-band spectrum table for a transmission signal of System A

	Frequency relative to the centre of the 1.54 MHz channel (MHz)	Relative level (dB)
Spectrum mask for VHF System A transmitters operating in uncritical cases or in the 1.5 GHz band	±0.97	–26
	±0.97	–56
	±3.0	–106
Spectrum mask for VHF System A transmitters operating in critical cases	±0.77	–26
	±0.97	–71
	±1.75	–106
	±3.0	–106
Spectrum mask for VHF System A transmitters operating in certain areas where frequency block 12D is used	±0.77	–26
	±0.97	–78
	±2.2	–126
	±3.0	–126

Appendix 1
to Annex 1

Planning criteria as used by a group of countries in the Wiesbaden 1995 Special Arrangement

1 Position of frequency blocks in Band III

Table 2 shows a harmonized channelling plan. This is based on tuning increments of 16 kHz and guardbands of 176 kHz between adjacent T-DAB frequency blocks.

Within each 7 MHz television channel, four T-DAB frequency blocks are accommodated.

In order to enhance compatibility with the sound carrier(s) in 7 MHz TV systems, the guardbands for T-DAB frequency blocks A in Channel N and D in Channel N-1 are 320 kHz or 336 kHz. The position of T-DAB frequency blocks within Channel 12 is shown as an example in Fig. 2.

TABLE 2

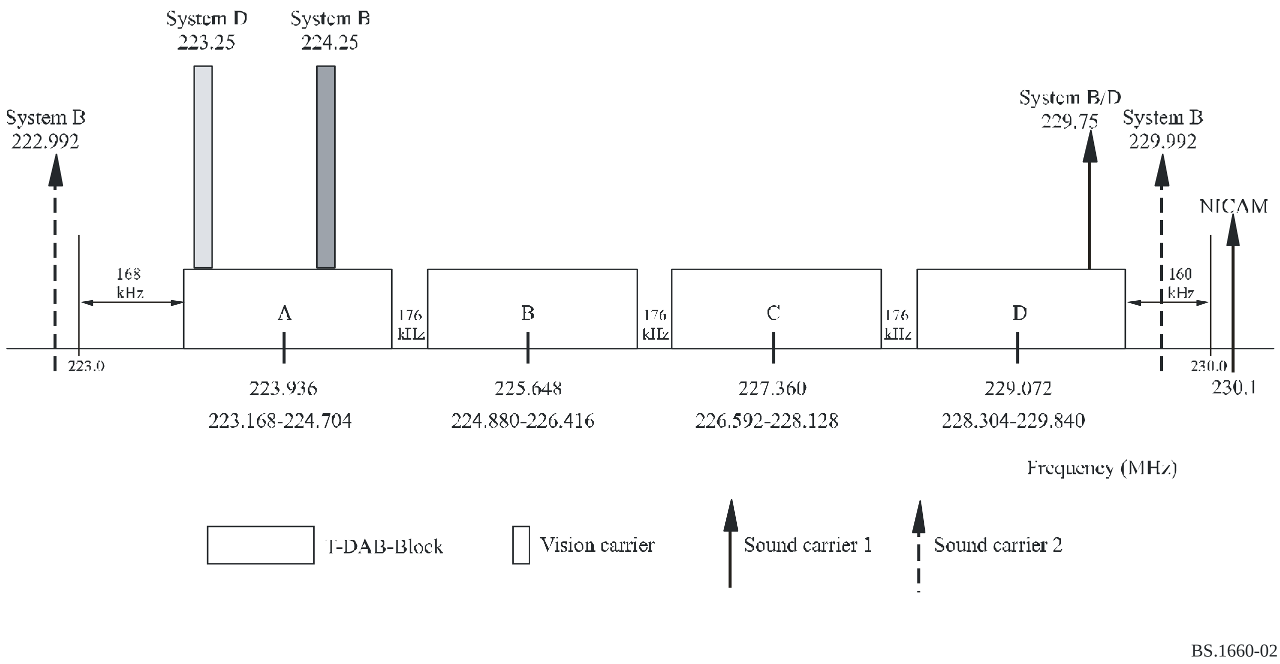
T-DAB frequency blocks

T-DAB block number	Centre frequency (MHz)	Frequency range (MHz)	Lower guardband(1) (kHz)	Upper guardband(1) (kHz)
5A	174.928	174.160-175.696	–	176
5B	176.640	175.872-177.408	176	176
5C	178.352	177.584-179.120	176	176
5D	180.064	179.296-180.832	176	336
6A	181.936	181.168-182.704	336	176
6B	183.648	182.880-184.416	176	176
6C	185.360	184.592-186.128	176	176
6D	187.072	186.304-187.840	176	320
7A	188.928	188.160-189.696	320	176
7B	190.640	189.872-191.408	176	176
7C	192.352	191.584-193.120	176	176
7D	194.064	193.296-194.832	176	336
8A	195.936	195.168-196.704	336	176
8B	197.648	196.880-198.416	176	176
8C	199.360	198.592-200.128	176	176
8D	201.072	200.304-201.840	176	320
9A	202.928	202.160-203.696	320	176
9B	204.640	203.872-205.408	176	176
9C	206.352	205.584-207.120	176	176
9D	208.064	207.296-208.832	176	336
10A	209.936	209.168-210.704	336	176
10B	211.648	210.880-212.416	176	176
10C	213.360	212.592-214.128	176	176
10D	215.072	214.304-215.840	176	320
11A	216.928	216.160-217.696	320	176
11B	218.640	217.872-219.408	176	176
11C	220.352	219.584-221.120	176	176
11D	222.064	221.296-222.832	176	336
12A	223.936	223.168-224.704	336	176
12B	225.648	224.880-226.416	176	176
12C	227.360	226.592-228.128	176	176
12D	229.072	228.304-229.840	176	–

(1) In arriving at these values, it has been assumed that the T-DAB transmitting and receiving equipment must allow for the use of adjacent T-DAB frequency blocks in adjacent areas, i.e., using a 176 kHz guardband.

FIGURE 2

Position of T-DAB blocks in channel 12



2 T-DAB reference network

Reference networks are used for the planning of allotments.

The characteristics of the reference networks represent a reasonable compromise between the density of the transmitters required to support the desired coverage and the potential to reuse the same frequency block with other programme content in other areas.

A reference network is a tool for developing appropriate values for separation distances and for estimating how much interference a typical SFN might produce at a given distance.

2.1 T-DAB transmitter network structures

T-DAB stations or networks consist of one of three basic models or combinations thereof:

– a single transmitter;

– an SFN using non-directional transmitting antennas, also referred to as an “open network”;

– an SFN using directional transmitting antennas along the periphery of the coverage area, also referred to as a “closed network”.

2.2 Definitions

The reference point is the point on the boundary of a reference network from which outgoing interference is calculated, see also Fig. 4. Incoming interference is calculated at the same point.

In the following text, two distances are defined; see also Fig. 3.

– The separation distance is the distance required between the borders (or peripheries) of two coverage areas served by either T-DAB services or by two different services. There will often be two separation distances, one for each service, because of different field strengths to be protected or because of different protection ratios for the two services. In such cases the longer of these two distances shall be used.

– The transmitter distance is the distance between adjacent transmitter sites in an SFN.

FIGURE 3

Definition of distances for different network structures (SFN, single transmitter)

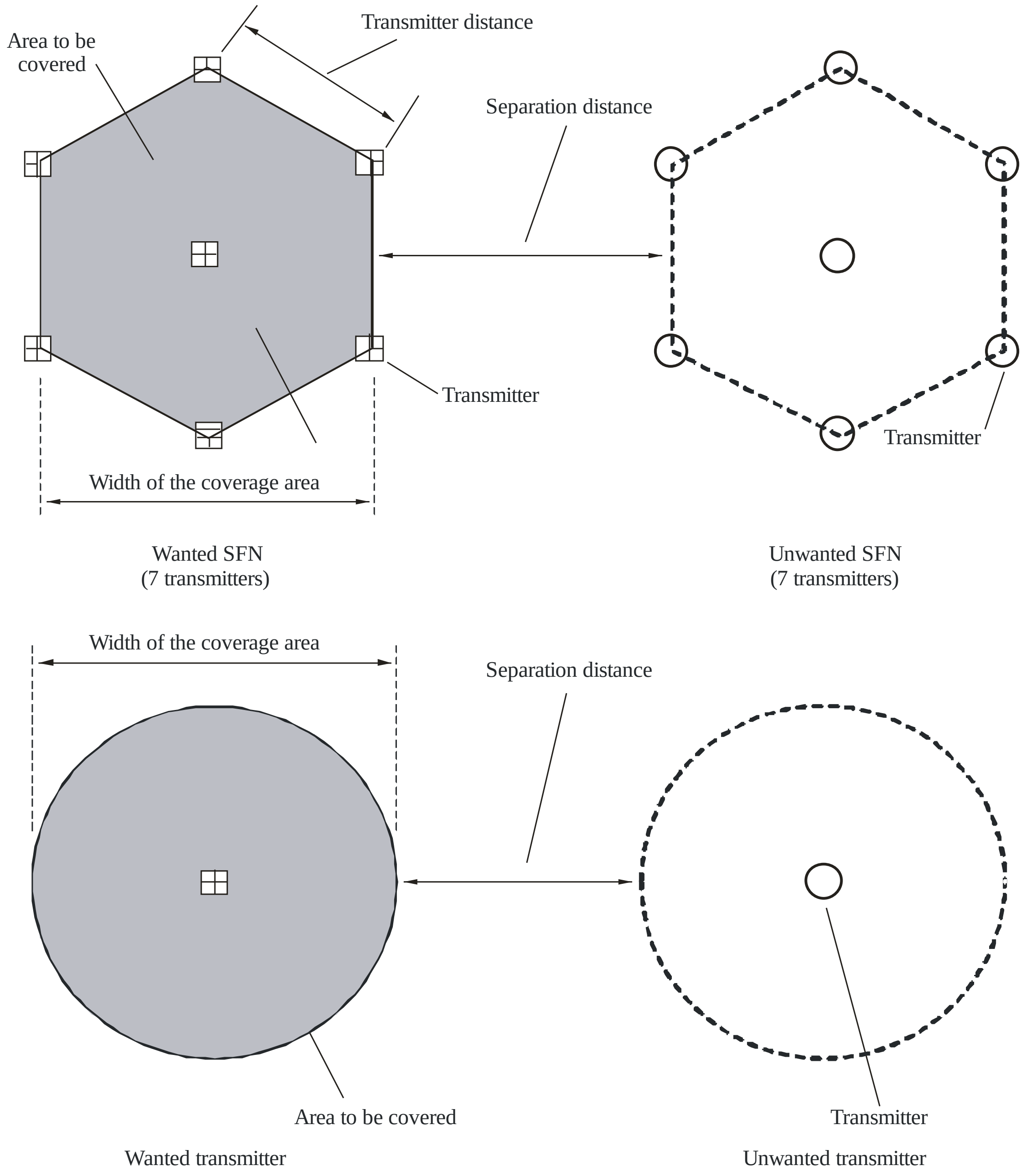


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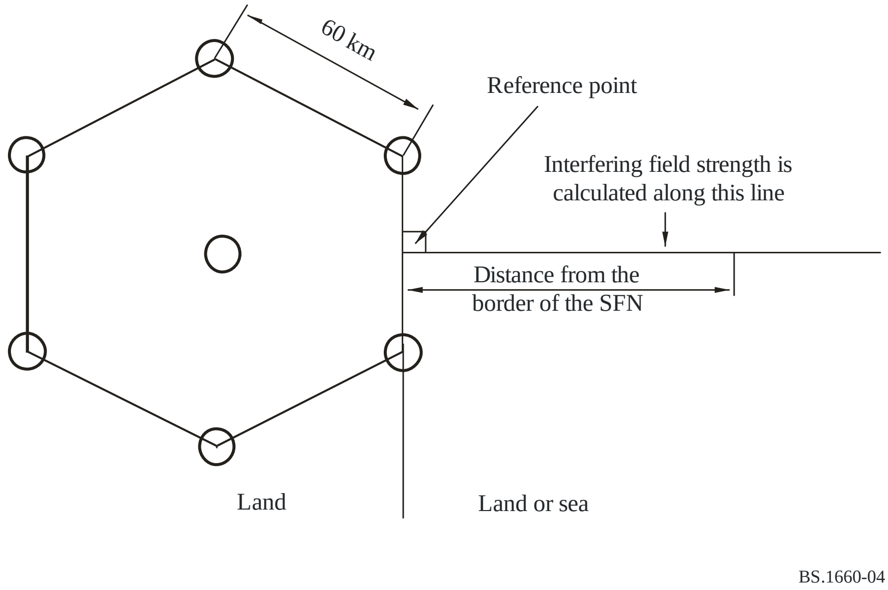
FIGURE 4

Information related to the interfering field strength calculation for the reference network



2.3 T-DAB reference SFN

In interfering field strength calculations the contributions from all transmitters of the reference network are added using the power sum method. In the case of mixed land-sea paths, field strengths are first calculated individually for an all-land path and an all-sea path, each of the same distance as the mixed path concerned. A linear interpolation is then performed between the field strengths for all-land and all-sea paths at the required distance from the border of the SFN according to the following formula:

$$E_M = E_L + \frac{d_S}{d_T}(E_S - E_L)$$

where:

- E_M: field strength for a mixed land-sea path
- E_L: field strength for an all-land path
- E_S: field strength for an all-sea path
- d_S: length of the sea path
- d_T: length of the total path.

All field strengths are in dB(μV/m).

In all-sea path calculations it is assumed that the reference network and its coverage area are on land and that the sea starts from the edge of the coverage area. For land paths a terrain roughness of 50 m is assumed.

2.3.1 Reference network structure

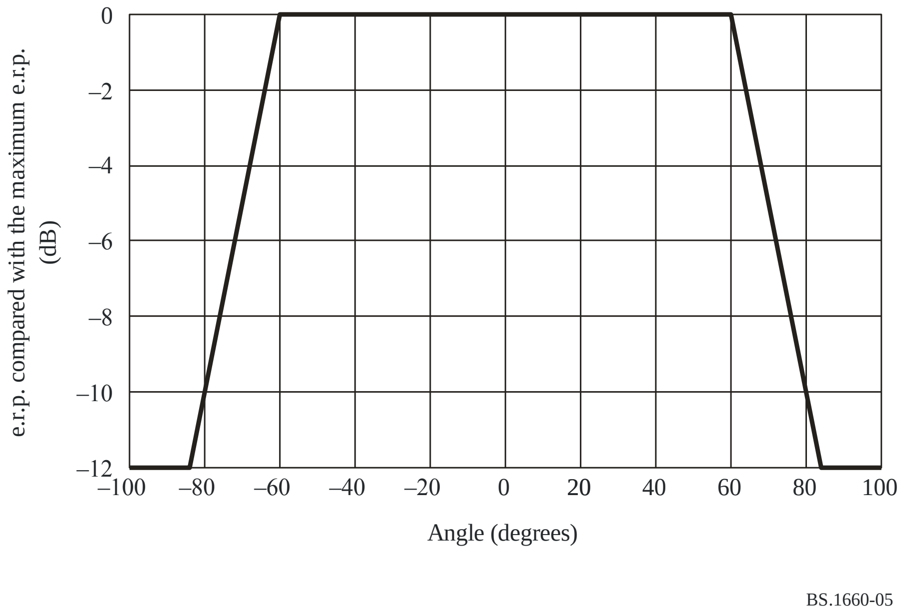
The reference network suitable for the frequency allotment process is defined as follows (see also Fig. 4):

– Hexagonal structure: closed
– Transmitter distance: 60 km
– Transmitting antenna height: 150 m

– Central transmitter effective radiated power (e.r.p.): 100 W
– Radiation pattern of the central transmitter: omnidirectional
– Peripheral transmitter e.r.p.: 1 kW
– Radiation pattern of peripheral transmitters: see Fig. 5
– Main lobe of directional antennas: in the direction of the central transmitter.

FIGURE 5

Radiation pattern of the peripheral transmitters



When using the field strength prediction method described in this Appendix, the reference network produces the required coverage inside the network. The effective wanted field strength on the border of the reference network is about 3 dB higher than the minimum field strength for planning. This makes it possible to allow 3 dB more interference at the edge of the network.

Thus the maximum interfering field strength from another co-channel T-DAB service on the border of the reference network is:

$$E_I^{Max} = E_W^{Min} - PR - PC + 3$$

where:

E_I^{Max}: maximum interfering field strength on the border of the reference network

E_W^{Min}: minimum median wanted field strength for planning

PR: protection ratio, in this case 10 dB

PC: propagation correction 18 dB (50% to 99% location correction factor).

The additional 3 dB margin is not allowed for the other services because during the frequency block allotment procedure each source of interference is considered separately and their power sum is not calculated.

Thus the maximum interfering field strength from any other service on the border of the reference network is:

$$E_I^{Max} = E_W^{Min} - PR - PC$$

where:

E_I^{Max}: maximum interfering field strength on the border of the reference network

E_W^{Min}: minimum median wanted field strength for planning

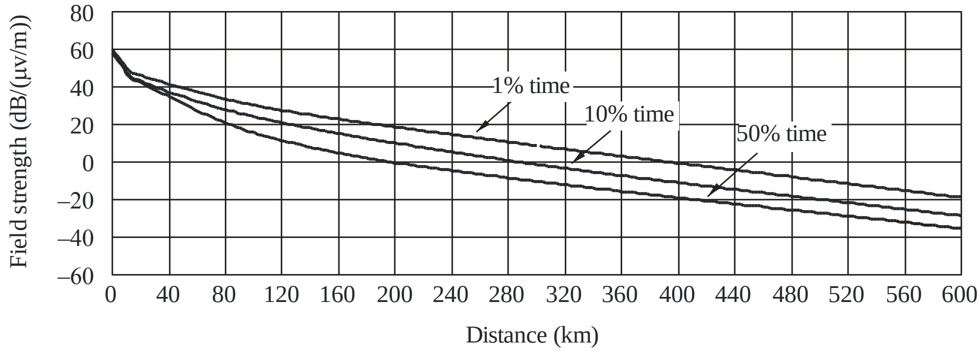
PR: protection ratio, depending on service under consideration

PC: propagation correction 18 dB.

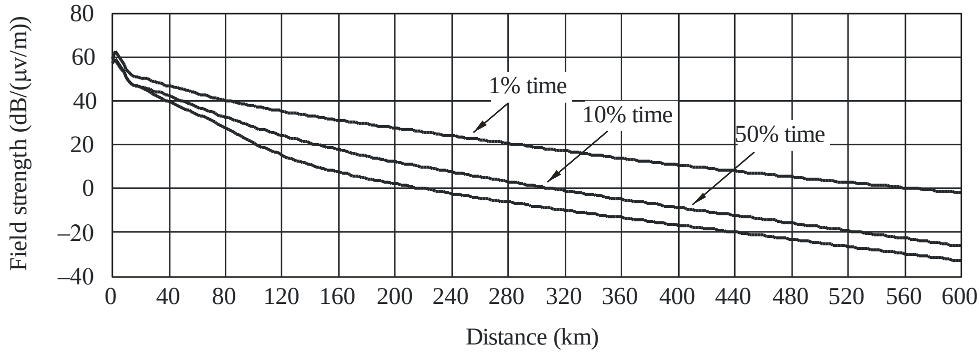
The interfering field strengths for land, cold sea and warm sea paths produced by a reference network are shown in Figs 6a, 6b and 6c. Separation distances for Band III are 81, 142 and 173 km for land, cold sea and warm sea paths respectively.

FIGURE 6

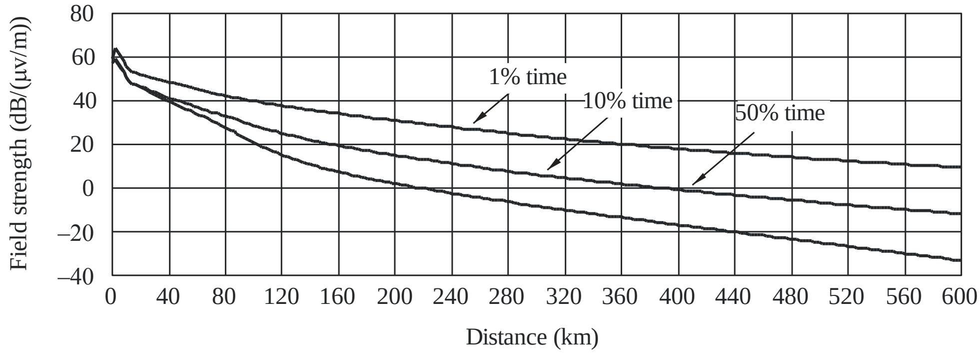
Interfering field strength produced by the reference network



a) Field strength variation with distance: land



b) Field strength variation with distance: cold sea



c) Field strength variation with distance: warm sea

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Where the field strength is calculated within 1 km of the transmitter site location, receiving antenna discrimination should not be taken into account.

2.3.2 Nominal transmitter location for the calculation of potential T-DAB interference to the aeronautical mobile service

The centre of the reference network shall be used as the nominal location for the network to calculate interference to an aeronautical reception test point. In this case the power used for calculations is 33.8 dBW in Band III.

3 Protection of T-DAB

3.1 T-DAB interfered with by T-DAB

The T-DAB co-block protection ratio is 10 dB.

Table 3 shows the values for the maximum permissible interfering field strength used for planning.

TABLE 3

Maximum permissible interfering field strength (T-DAB to T-DAB)

Frequency band	Minimum wanted field strength (dB(μV/m)) (50% locations, 10 m height)	Protection ratio T-DAB interfered with by T-DAB (dB)	Propagation correction (dB)	Maximum permissible interfering field strength (dB(μV/m))
BAND III	58	10	18	30[(1)]

(1) In the case of an SFN, this figure shall be increased by 3 dB.

The standard deviation of a location variation of T-DAB signal is 5.5 dB. The field strength values for wanted and unwanted signals are assumed to be uncorrelated. To protect wanted T-DAB signals for 99% of locations against interference from another T-DAB transmission, a propagation correction of $2.33 \times 5.5 \times \sqrt{2} = 18$ dB as well as the T-DAB protection ratio (T-DAB to T-DAB) of 10 dB shall be taken into account.

$$E_I^{Max} = E_W^{Min} - PR - PC + 3$$

where:

E_I^{Max}: maximum permissible interfering field strength

E_W^{Min}: minimum median equivalent field strength

PR: protection ratio

PC: propagation correction.

3.2 T-DAB interfered with by analogue sound broadcasting

Wideband FM sound mono		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
S1	58.0	10.0

Δ*f* (MHz)	–1.3	–1.2	–1.1	–1.0	–0.9	–0.8	–0.8	–0.7	–0.6	–0.5	–0.4
PR (dB)	–45.1	–43.9	–38.4	–37.5	–28.9	–12.9	–4.9	–1.0	2.1	3.5	4.3
Δ*f* (MHz)	–0.3	–0.2	–0.1	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7
PR (dB)	4.1	4.4	4.1	4.0	4.1	4.4	4.1	4.3	3.5	2.1	–1.0
Δ*f* (MHz)	0.8	0.8	0.9	1.0	1.1	1.2	1.3				
PR (dB)	–4.9	–12.9	–28.9	–37.5	–38.4	–43.9	–45.1				

Wideband FM sound stereo		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
S2	58.0	10.0

Δ*f* (MHz)	–1.3	–1.2	–1.1	–1.0	–0.9	–0.8	–0.8	–0.7	–0.6	–0.5	–0.4
PR (dB)	–45.1	–43.9	–38.4	–37.5	–28.9	–12.9	–4.9	–1.0	2.1	3.5	4.3
Δ*f* (MHz)	–0.3	–0.2	–0.1	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7
PR (dB)	4.1	4.4	4.1	4.0	4.1	4.4	4.1	4.3	3.5	2.1	–1.0
Δ*f* (MHz)	0.8	0.8	0.9	1.0	1.1	1.2	1.3				
PR (dB)	–4.9	–12.9	–28.9	–37.5	–38.4	–43.9	–45.1				

3.3 T-DAB interfered with by digital terrestrial television broadcasting

Protection ratios for a T-DAB system interfered with by a DVB-T 8 MHz system									
Δ*f* [(1)] (MHz)	–5	–4.2	–4	–3	0	3	4	4.2	5
PR (dB) mobile and portable receiving environment	–43	6	7	8	8	8	7	6	–43
PR (dB) Gaussian channel	–50	–1	0	1	1	1	0	–1	–50

[(1)] Δ*f*: centre frequency of the DVB-T signal minus centre frequency of the T-DAB signal.

Protection ratios for a T-DAB system interfered with by a DVB-T 7 MHz system									
Δ*f* [(1)] (MHz)	–4.5	–3.7	–3.5	–2.5	0	2.5	3.5	3.7	4.5
PR (dB) mobile and portable receiving environment	–42	7	8	9	9	9	8	7	–42
PR (dB) Gaussian channel	–49	0	1	2	2	2	1	0	–49

[(1)] Δ*f*: centre frequency of the DVB-T signal minus centre frequency of the T-DAB signal.

3.4 T-DAB interfered with by analogue terrestrial television broadcasting

I/PAL (Band III)		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
T1	58.0	10.0

Δ*f* (MHz)	–8.0	–7.5	–7.0	–6.5	–6.0	–5.5	–5.0	–4.5	–4.0	–3.5	–3.0
PR (dB)	–42.0	–23.5	–10.0	–3.0	–2.0	–3.0	–24.0	–21.0	–23.0	–31.0	–31.5
Δ*f* (MHz)	–2.5	–2.0	–1.5	–1.0	–0.9	–0.8	–0.7	–0.6	0.0	0.6	0.7
PR (dB)	–30.0	–28.5	–25.0	–19.5	–17.5	–11.0	–7.0	–1.5	–1.5	–4.0	–5.5
Δ*f* (MHz)	0.8	0.9	1.0	2.0	3.0						
PR (dB)	–13.5	–17.0	–20.0	–33.0	–47.5						

B/PAL (Band III)		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
T2	58.0	10.0

Δ*f* (MHz)	–7.0	–6.5	–6.0	–5.5	–5.0	–4.5	–4.0	–3.5	–3.0	–2.5	–2.0
PR (dB)	–47.0	–18.0	–5.0	–3.0	–5.0	–20.0	–22.0	–31.5	–31.5	–29.0	–26.5
Δ*f* (MHz)	–1.5	–1.0	–0.9	–0.8	–0.7	–0.6	0.0	0.6	0.7	0.8	0.9
PR (dB)	–23.0	–18.5	–16.0	–9.0	–5.0	–3.0	–0.5	–3.0	–4.0	–12.0	–16.0
Δ*f* (MHz)	1.0	2.0									
PR (dB)	–19.5	–45.3									

D/SECAM, K/SECAM (Band III)		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
T3	58.0	10.0

Δ*f* (MHz)	–8.0	–7.5	–7.0	–6.5	–6.0	–5.5	–5.0	–4.5	–4.0	–3.5	–3.0
PR (dB)	–47.0	–42.5	–3.0	–2.5	–3.0	–37.5	–21.5	–18.5	–20.5	–26.5	–33.5
Δ*f* (MHz)	–2.5	–2.0	–1.5	–1.0	–0.9	–0.8	–0.7	–0.6	0.0	0.6	0.7
PR (dB)	–31.5	–29.0	–26.5	–18.5	–16.5	–9.0	–6.0	–3.0	–2.5	–4.0	–4.5
Δ*f* (MHz)	0.8	0.9	1.0	2.0							
PR (dB)	–12.0	–22.0	–25.0	–46.0							

L/SECAM (Band III)		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
T4	58.0	10.0

Δ*f* (MHz)	–8.0	–7.5	–7.0	–6.5	–6.0	–5.5	–5.0	–4.5	–4.0	–3.5	–3.0
PR (dB)	–46.5	–42.5	–15.5	–13.0	–15.0	–26.5	–18.5	–17.0	–18.0	–23.0	–31.5
Δ*f* (MHz)	–2.5	–2.0	–1.5	–1.0	–0.9	–0.8	–0.7	–0.6	0.0	0.6	0.7
PR (dB)	–30.5	–27.5	–24.5	–18.0	–16.5	–8.0	–5.0	–1.5	1.5	–2.0	–3.5
Δ*f* (MHz)	0.8	0.9	1.0	2.0	3.0						
PR (dB)	–12.5	–18.5	–19.0	–31.0	–46.8						

B/SECAM (Band III). B/PAL (T2) data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
T5	58.0	10.0

Δ*f* (MHz)	–7.0	–6.5	–6.0	–5.5	–5.0	–4.5	–4.0	–3.5	–3.0	–2.5	–2.0
PR (dB)	–47.0	–18.0	–5.0	–3.0	–5.0	–20.0	–22.0	–31.5	–31.5	–29.0	–26.5
Δ*f* (MHz)	–1.5	–1.0	–0.9	–0.8	–0.7	–0.6	0.0	0.6	0.7	0.8	0.9
PR (dB)	–23.0	–18.5	–16.0	–9.0	–5.0	–3.0	–0.5	–3.0	–4.0	–12.0	–16.0
Δ*f* (MHz)	1.0	2.0									
PR (dB)	–19.5	–45.3									

D/PAL (Band III)		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
T6	58.0	10.0

Δ*f* (MHz)	–8.0	–7.5	–7.0	–6.5	–6.0	–5.5	–5.0	–4.5	–4.0	–3.5	–3.0
PR (dB)	–47.0	–42.5	–3.0	–2.5	–3.0	–37.5	–21.5	–20.0	–22.0	–31.5	–31.5
Δ*f* (MHz)	–2.5	–2.0	–1.5	–1.0	–0.9	–0.8	–0.7	–0.6	0.0	0.6	0.7
PR (dB)	–29.0	–26.5	–23.0	–18.5	–16.0	–9.0	–5.0	–3.0	–0.5	–3.0	–4.0
Δ*f* (MHz)	0.8	0.9	1.0	2.0							
PR (dB)	–12.0	–16.0	–19.0	–45.3							

B/PAL (FM+Nicam) (Band III)		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
T7	58.0	10.0

Δ*f* (MHz)	–7.0	–6.5	–6.0	–5.5	–5.0	–4.5	–4.0	–3.5	–3.0	–2.5	–2.0
PR (dB)	–47.0	–18.0	–5.0	–3.0	–5.0	–20.0	–22.0	–31.5	–31.5	–29.0	–26.5
Δ*f* (MHz)	–1.5	–1.0	–0.9	–0.8	–0.7	–0.6	0.0	0.6	0.7	0.8	0.9
PR (dB)	–23.0	–18.5	–16.0	–9.0	–5.0	–3.0	–0.5	–3.0	–4.0	–12.0	–16.0
Δ*f* (MHz)	1.0	2.0									
PR (dB)	–19.5	–45.3									

3.5 T-DAB interfered with by services other than broadcasting

The maximum interfering field strength (FS) to avoid interference is calculated as follows:

$$Maximum\ allowable\ FS = (FS_{T\text{-}DAB} - PR - 18) \qquad \text{dB(μV/m)}$$

As examples the following Table (non-exhaustive list) contains the protection ratio values used for calculations.

The service information is shown as follows, for example:

Aeronautical safety service 1		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
AL	58.0	10 000

where:

AL: service identifier

58.0: T-DAB field strength to be protected (dB(μV/m)) for Band III

10 000: other service transmit antenna height (m).

The columns in the Table relating to the above example have the following meaning:

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–66.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–66.0

where:

Δ*f*: frequency difference (MHz), i.e., interfering other service centre frequency minus centre frequency of interfered-with T-DAB block (in the case of an interfering TV signal the vision carrier frequency has to be taken instead of the centre frequency of the TV channel)

PR: required protection ratio (dB).

Table 4 serves to identify services other than broadcasting:

TABLE 4

Service identifier	Radio Regulations provision No.	Service
AL	1.34	aeronautical mobile (OR)
CA	1.20	fixed
DA	1.34	aeronautical mobile (OR)
DB	1.34	aeronautical mobile (OR)
IA	1.20	fixed
MA	1.26	land mobile
ME	1.34	aeronautical mobile (OR)
MF	1.34	aeronautical mobile (OR)
MG	1.34	aeronautical mobile (OR)
MI	1.28	maritime mobile
MJ	1.28	maritime mobile
MK	1.28	maritime mobile
ML	1.20	fixed
MT	1.20	fixed
MU	1.24	mobile
M1	1.24	mobile
M2	1.24	mobile
RA	1.24	mobile
R1	1.26	land mobile
R3	1.24	mobile
R4	1.24	mobile
XA	1.26	land mobile
XB	1.20	fixed
XE	1.34	aeronautical mobile (OR)
XM	1.26	land mobile
YB	1.26	land mobile
YC	1.34	aeronautical mobile (OR)
YD	1.34	aeronautical mobile (OR)
YE	1.28	maritime mobile
YH	1.26	land mobile
YT	1.34	aeronautical mobile (OR)
YW	1.34	aeronautical mobile (OR)

Aeronautical safety service 1		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
AL	58.0	10 000

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–66.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–66.0

Service used in Czech Republic. No information, continuous wave (CW) interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
CA	58.0	10.0

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Aeronautical safety service 2		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
DA	58.0	10 000

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–66.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–66.0

Aeronautical safety service (Germany), DB. The centre frequency is 235 MHz and the first channel is at 231 MHz. The values used are the same as those for the ME service		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
DB	58.0	10 000

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Italian service. No information, CW interference data used (224.25 MHz)		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
IA	58.0	10.0

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Land mobile service (173-174 MHz). No information, CW interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
MA	58.0	10.0

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Military air-ground-air system, analogue minimum separation distance is 1 km. Frequency range is 230 MHz to just above 240 MHz, but channel frequencies are not identical in all countries. No information, CW interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
ME	58.0	10 000

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Military air-ground-air system, digital (230-243 MHz). No information, CW interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
MF	58.0	10 000

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Military air-ground-air system, frequency hopping (230-243 MHz). No information, CW interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
MG	58.0	10 000

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Mobile navy service, analogue (230-243 MHz). No information, CW interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
MI	58.0	10.0

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Mobile navy service, digital (230-243 MHz). No information, CW interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
MJ	58.0	10.0

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Mobile navy service, frequency hopping (230-243 MHz). No information, CW interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
MK	58.0	10.0

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Military fixed services (230-243 MHz). No information, CW interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
ML	58.0	10.0

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Military mobile and fixed (tactical) services. No information, CW interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
MT	58.0	10.0

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Mobile radio – low power devices S2 data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
MU	58.0	10.0

Δ*f* (MHz)	–2.0	–1.9	–1.8	–1.7	–1.6	–1.5	–1.4	–1.3	–1.2	–1.1	–1.0
PR (dB)	–48.0	–47.9	–47.1	–46.7	–46.4	–46.0	–45.4	–45.1	–43.9	–38.4	–37.5
Δ*f* (MHz)	–0.9	–0.8	–0.8	–0.7	–0.6	–0.5	–0.4	–0.3	–0.2	–0.1	0.0
PR (dB)	–28.9	–12.9	–4.9	–1.0	2.1	3.5	4.3	4.1	4.4	4.1	4.0
Δ*f* (MHz)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.8	0.9	1.0
PR (dB)	4.1	4.4	4.1	4.3	3.5	2.1	–1.0	–4.9	–12.9	–28.9	–37.5
Δ*f* (MHz)	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	
PR (dB)	–38.4	–43.9	–45.1	–45.4	–46.0	–46.4	–46.7	–47.1	–47.9	–48.0	

Mobile services – narrow-band (12.5 kHz) FM system. No information, CW interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
M1	58.0	10.0

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Mobile services – narrow-band (12.5 kHz) FM system. No information, CW interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
M2	58.0	10.0

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Mobile services – narrow-band (12.5 kHz) FM system. No information, CW interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
RA	58.0	10.0

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Medical telemetry in Denmark (223-225 MHz). No interference to T-DAB (10 mW e.r.p.)		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
R1	58.0	10.0

Δ*f* (MHz)	–0.8	0.0	0.8								
PR (dB)	–66.0	–66.0	–66.0								

Mobile service – remote control (223-225 MHz). No information, CW interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
R3	58.0	10.0

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.94
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Mobile service – remote control (223-225 MHz). No information, CW interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
R4	58.0	10.0

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Professional mobile radio (PMR) (5 kHz channel spacing). No information, CW interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
XA	58.0	10.0

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Finnish alarm system (230-231 MHz). No information, CW interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
XB	58.0	10.0

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Military air-ground-air system (aeronautical frequencies). No information		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
XE	58.0	10.0

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Radio microphones (VHF). No information, CW interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
XM	58.0	10.0

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Video link		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
YB	58.0	10.0

Δ*f* (MHz)	–8.0	–7.5	–7.0	–6.5	–6.0	–5.5	–5.0	–4.5	–4.0	–3.5	–3.0
PR (dB)	–42.0	–23.5	–10.0	–3.0	–2.0	–3.0	–24.0	–21.0	–23.0	–31.0	–31.5
Δ*f* (MHz)	–2.5	–2.0	–1.5	–1.0	–0.9	–0.8	–0.7	–0.6	0.0	0.6	0.7
PR (dB)	–30.0	–28.5	–25.0	–19.5	–17.5	–11.0	–7.0	–1.5	–1.5	–4.0	–5.5
Δ*f* (MHz)	0.8	0.9	1.0	2.0	3.0						
PR (dB)	–13.5	–17.0	–20.0	–33.0	–47.5						

Military air-ground-air system, frequency hopping (230-243 MHz). No information, CW interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
YC	58.0	10 000

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Military air-ground-air system, frequency hopping (230-243 MHz). No information, CW interference data used		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
YD	58.0	10 000

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Mobile navy (aircraft) service (230-243 MHz). New type		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
YE	58.0	10 000

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–66.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–66.0

Audio link special		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
YH	58.0	10 000

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–66.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–66.0

Military air-ground-air system, frequency hopping (230-243 MHz). No information, CW interference data used (as YC)		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
YT	58.0	10 000

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Military air-ground-air system, frequency hopping (230-243 MHz). No information, CW interference data used (as YC)		
Service identifier	**Field strength to be protected for Band III (dB(μV/m))**	**Transmit antenna height (m)**
YW	58.0	10 000

Δ*f* (MHz)	–0.9	–0.8	–0.6	–0.4	–0.2	0.0	0.2	0.4	0.6	0.8	0.9
PR (dB)	–60.0	–6.6	2.7	3.2	4.1	6.5	4.1	3.2	2.7	–6.6	–60.0

Where no information concerning protection ratios for T-DAB interfered with by other services has been supplied to the Planning Meeting, the administrations concerned should develop appropriate sharing criteria by mutual agreement or use the relevant ITU-R Recommendations when available.

Bibliography

ETSI Specification EN 300 401 – Radio broadcasting systems; Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers.

Annex 2

Technical basis for planning of terrestrial digital sound broadcasting System F (ISDB-T_{SB}) in the VHF band

1 General

This Annex describes planning criteria for Digital System F (ISDB-T_{SB}) in the VHF band. System F can be assigned to a 6 MHz, 7 MHz, or 8 MHz television channel raster. Segment bandwidth is defined to be a fourteenth of the channel bandwidth, therefore that is 429 kHz (6/14 MHz), 500 kHz (7/14 MHz) or 571 kHz (8/14 MHz). However, the segment bandwidth should be selected in compliance with the frequency situation in each country.

2 Spectrum masks for out-of-band emissions

The radiated signal spectrum should be constrained by the spectrum mask. Table 5 defines the breakpoints of the spectrum mask for *n*-segment transmission for 6/14 MHz, 7/14 MHz, and 8/14 MHz segment system. The spectrum mask is defined as the relative value to the mean power of each frequency. Figure 7 shows the spectrum mask for 3-segment transmission in 6/14 MHz segment system.

TABLE 5

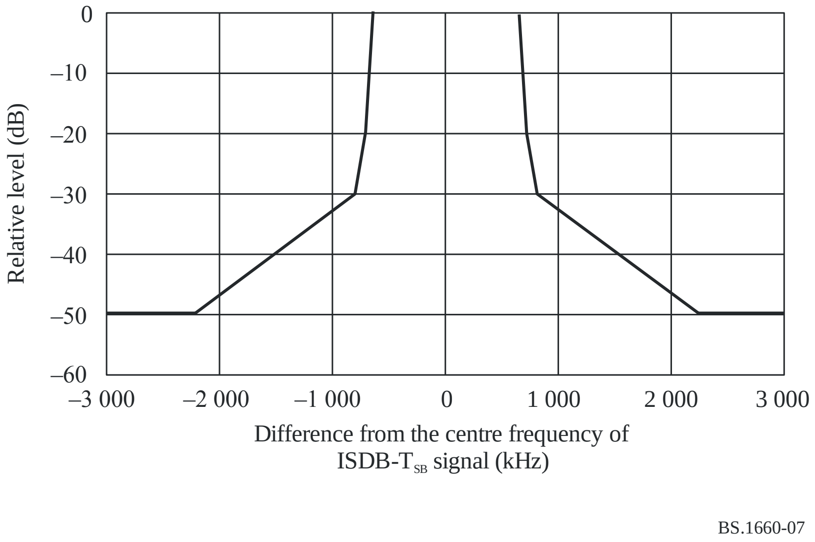
Breakpoints of the spectrum mask
(segment bandwidth (BW) = 6/14, 7/14, or 8/14 MHz)

Difference from the centre frequency of the terrestrial digital sound signal	Relative level (dB)
$\pm\left(\frac{BW\times n}{2}+\frac{BW}{216}\right)$ MHz	0
$\pm\left(\frac{BW\times n}{2}+\frac{BW}{216}+\frac{BW}{6}\right)$ MHz	–20
$\pm\left(\frac{BW\times n}{2}+\frac{BW}{216}+\frac{BW}{3}\right)$ MHz	–30
$\pm\left(\frac{BW\times n}{2}+\frac{BW}{216}+\frac{11\times BW}{3}\right)$ MHz	–50

n: Number of consecutive segments.

FIGURE 7

Spectrum mask for ISDB-T$_{SB}$ transmission signal
(BW = 6/14 MHz, *n* = 3)



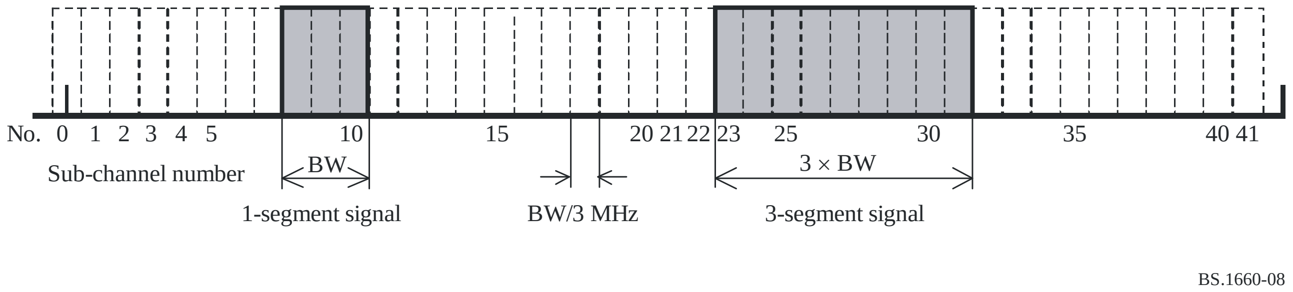
3 Frequency condition

3.1 Definition of sub-channel

In order to indicate the frequency position of the ISDB-T$_{SB}$ signal each segment is numbered using a sub-channel number 0 through 41. The sub-channel is defined as one third of the BW (see Fig. 8). For example, the frequency positions of 1-segment and 3-segment signal shown in Fig. 8 are defined as the 9th and 27th sub-channels respectively in the analogue television channel.

FIGURE 8

Definition of sub-channel

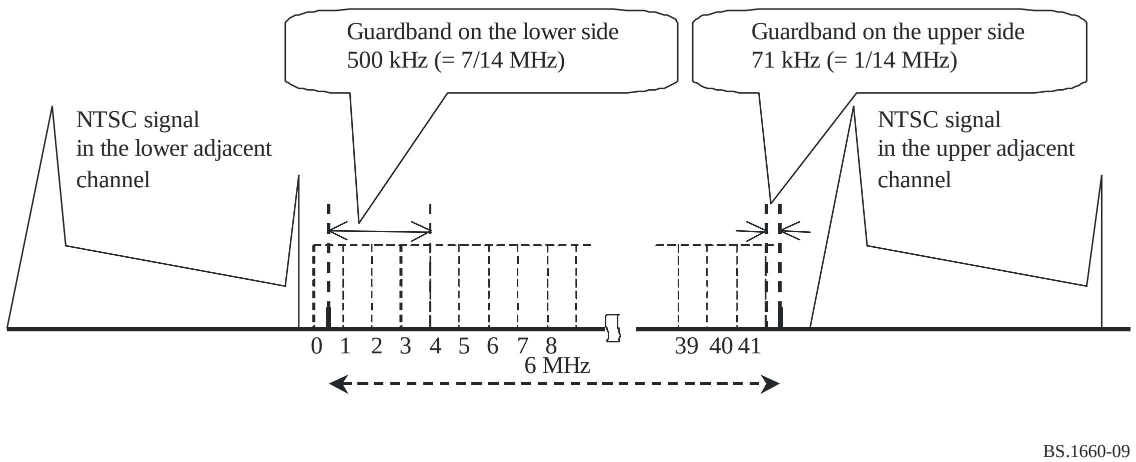


3.2 Guardbands

From the results of subjective evaluation on NTSC interfered with by ISDB-T_{SB}, guardbands are determined at both sides of the NTSC signal. As shown in Fig. 9, the guardbands are 500 kHz (= 7/14 MHz) on the lower side within the channel and 71 kHz (= 1/14 MHz) on the upper side. Accordingly, the sub-channels that can be used for digital sound broadcasting are from sub-channel Nos. 4 to 41. Within a 6 MHz television channel, a maximum of 12 segments can be allocated, excluding the guardbands.

FIGURE 9

Guardbands to coexist with adjacent analogue television signal



4 Minimum usable field strength

Link budgets for the three cases of fixed reception, portable reception and mobile reception at the frequencies of 100 MHz and 200 MHz are presented in Table 6. Required field strengths for the 1-segment and the 3-segment are described in the 22nd row and the 24th row respectively. The values are for the case of 6/14 MHz segment system, and can be converted for the case of 7/14 MHz or 8/14 MHz segment system according to the bandwidth.

TABLE 6

Link budgets for ISDB-T$_{SB}$

(a) 100 MHz

	Element	Mobile reception			Portable reception			Fixed reception		
	Frequency (MHz)	100			100			100		
	Modulation scheme	QPSK	QPSK	16-QAM	QPSK	QPSK	16-QAM	QPSK	QPSK	16-QAM
	Coding rate of the inner code	1/2	2/3	1/2	1/2	2/3	1/2	1/2	2/3	1/2
1	Required *C*/*N* (QEF after error correction) (dB)	4.9	6.6	11.5	4.9	6.6	11.5	4.9	6.6	11.5
2	Implementation degradation (dB)	2	2	2	2	2	2	2	2	2
3	Interference margin (dB)	2	2	2	2	2	2	2	2	2
4	Multipath margin (dB)	–	–	–	1	1	1	1	1	1
5	Fading margin (temporary fluctuation correction) (dB)	9.4	9.4	8.1	–	–	–	–	–	–
6	Receiver required *C*/*N* (dB)	18.3	20	23.6	9.9	11.6	16.5	9.9	11.6	16.5
7	Receiver noise figure, *NF* (dB)	5	5	5	5	5	5	5	5	5
8	Noise bandwidth (1-segment), *B* (kHz)	429	429	429	429	429	429	429	429	429
9	Receiver intrinsic noise power, N_r (dBm)	–112.7	–112.7	–112.7	–112.7	–112.7	–112.7	–112.7	–112.7	–112.7
10	External noise power at the receiver input terminal, N_0 (dBm)	–98.1	–98.1	–98.1	–98.1	–98.1	–98.1	–99.1	–99.1	–99.1
11	Total receiver noise power N_t (dBm)	–98.0	–98.0	–98.0	–98.0	–98.0	–98.0	–98.9	–98.9	–98.9
12	Feeder loss, *L* (dB)	1	1	1	1	1	1	2	2	2
13	Minimum usable receiver input power (dBm)	–79.7	–78.0	–74.4	–88.1	–86.4	–81.5	–89.0	–87.3	–82.4
14	Receiver antenna gain, G_r (dBi)	–0.85	–0.85	–0.85	–0.85	–0.85	–0.85	–0.85	–0.85	–0.85
15	Effective antenna aperture (dB/m^2)	–2.3	–2.3	–2.3	–2.3	–2.3	–2.3	–2.3	–2.3	–2.3
16	Minimum usable field strength, E_{min} (dB(μV/m))	39.4	41.1	44.7	31.0	32.7	37.6	31.1	32.8	37.7
17	Time-rate correction (dB)	0.0	0.0	0.0	0.0	0.0	0.0	4.3	4.3	4.3

TABLE 6 (*continued*)

	Element	Mobile reception			Portable reception			Fixed reception		
18	Location rate correction (dB)	12.8	12.8	12.8	2.9	2.9	2.9	–	–	–
19	Wall penetration loss value (dB)	–	–	–	10.1	10.1	10.1	–	–	–
20	Required field strength (1-segment) at antenna, *E*(dB(μV/m))	52.2	53.9	57.5	44.0	45.7	50.6	35.4	37.1	42.0
	Assumed antenna height, h_2 (m)	1.5	1.5	1.5	1.5	1.5	1.5	4.0	4.0	4.0
21	Height correction to 10 m (dB)	10.0	10.0	10.0	10.0	10.0	10.0	7.0	7.0	7.0
22	Required field strength (1-segment, h_2 = 10 m), *E*(dB(μV/m))	62.2	63.9	67.5	54.0	55.7	60.6	42.4	44.1	49.0
23	Conversion from 1-segment to 3-segment (dB)	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
24	Required field strength (3-segment, h_2 = 10 m), *E*(dB(μV/m))	67.0	68.7	72.3	58.8	60.5	65.4	47.2	48.9	53.8

(b) 200 MHz

	Element	Mobile reception			Portable reception			Fixed reception		
	Frequency (MHz)	200			200			200		
	Modulation scheme	DQPSK	16-QAM	64-QAM	DQPSK	16-QAM	64-QAM	DQPSK	16-QAM	64-QAM
	Coding rate of the inner code	1/2	1/2	7/8	1/2	1/2	7/8	1/2	1/2	7/8
1	Required *C*/*N* (QEF after error correction) (dB)	6.2	11.5	22.0	6.2	11.5	22.0	6.2	11.5	22.0
2	Implementation degradation (dB)	2.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0
3	Interference margin (dB)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
4	Multipath margin (dB)	–	–	–	1.0	1.0	1.0	1.0	1.0	1.0
5	Fading margin (temporary fluctuation correction) (dB)	9.5	8.1	(1)	–	–	–	–	–	–
6	Receiver required *C*/*N* (dB)	19.7	23.6	(1)	11.2	16.5	28.0	11.2	16.5	28.0
7	Receiver noise figure, *NF* (dB)	5	5	–	5	5	5	5	5	5
8	Noise bandwidth (1-segment), *B* (kHz)	429	429	–	429	429	429	429	429	429

TABLE 6 (*continued*)

	Element	**Mobile reception**			**Portable reception**			**Fixed reception**		
9	Receiver intrinsic noise power, N_r (dBm)	–112.7	–112.7	–	–112.7	–112.7	–112.7	–112.7	–112.7	–112.7
10	External noise power at the receiver input terminal, N_0 (dBm)	–107.4	–107.4	–	–107.4	–107.4	–107.4	–107.4	–107.4	–107.4
11	Total receiver noise power, N_t (dBm)	–106.3	–106.3	–	–106.3	–106.3	–106.3	–106.3	–106.3	–106.3
12	Feeder loss, L (dB)	2.0	2.0	–	2.0	2.0	2.0	2.0	2.0	2.0
13	Minimum usable receiver input power (dBm)	–86.6	–82.7	–	–95.1	–89.8	–78.3	–95.1	–89.8	–78.3
14	Receiver antenna gain, G_r (dBi)	–0.85	–0.85	–	–0.85	–0.85	–0.85	–0.85	–0.85	–0.85
15	Effective antenna aperture (dB/m^2)	–8.3	–8.3	–	–8.3	–8.3	–8.3	–8.3	–8.3	–8.3
16	Minimum usable field strength, E_{min} (dB(μV/m))	39.5	43.4		31.0	36.3	47.8	31.0	36.3	47.8
17	Time-rate correction (dB)	0.0	0.0	–	0.0	0.0	0.0	6.2	6.2	6.2
18	Location rate correction (dB)	12.8	12.8	–	2.9	2.9	2.9	–	–	–
19	Wall penetration loss value (dB)	–	–	–	10.1	10.1	10.1	–	–	–
20	Required field strength (1-segment) at antenna, E(dB(μV/m))	52.3	56.2		44.0	49.3	60.8	37.2	42.5	54.0
	Assumed antenna height, h_2 (m)	1.5	1.5	–	1.5	1.5	1.5	4	4	4
21	Height correction to 10 m (dB)	12	12	–	12	12	12	10	10	10
22	Required field strength (1-segment, h_2 = 10 m), E(dB(μV/m))	64.3	68.2	–	56.0	61.3	72.8	47.2	52.5	64.0

TABLE 6 (*end*)

	Element	Mobile reception			Portable reception			Fixed reception		
23	Conversion from 1-segment to 3-segment (dB)	4.8	4.8	–	4.8	4.8	4.8	4.8	4.8	4.8
24	Required field strength (3-segment, h_2 = 10 m), E(dB(μV/m))	69.1	73.0		60.8	66.1	77.6	52.0	57.3	68.8

(1) Not usable in fading environment.

1) Required *C*/*N*

The required *C*/*N* for modulation schemes and coding rates are shown in Table 7.

TABLE 7

Required *C*/*N*

Modulation	Coding rate for convolutional coding				
	1/2	2/3	3/4	5/6	7/8
DQPSK	6.2 dB	7.7 dB	8.7 dB	9.6 dB	10.4 dB
QPSK	4.9 dB	6.6 dB	7.5 dB	8.5 dB	9.1 dB
16-QAM	11.5 dB	13.5 dB	14.6 dB	15.6 dB	16.2 dB
64-QAM	16.5 dB	18.7 dB	20.1 dB	21.3 dB	22.0 dB

2) Implementation degradation

The amount of equivalent *C*/*N* degradation expected in equipment implementation.

3) Interference margin

The margin for the equivalent *C*/*N* degradation caused by interference from analogue broadcasting, etc.

NOTE 1 – Long-distance propagation over sea paths or other environments may cause interference in some circumstances. Although it is not practical to include such special cases in the calculation of link budgets, attention should be paid to this type of interference.

4) Multipath margin for portable reception or fixed reception

The margin for the equivalent *C*/*N* degradation caused by multipath interference.

5) Fading margin for mobile reception

The margin for the equivalent *C*/*N* degradation caused by temporary fluctuation in the field strength.

The *C*/*N* required in the fading channel is shown in Table 8. Fading margins are shown in Table 9.

TABLE 8

Required *C*/*N*
(Mode 3, Guard 1/16, and GSM typical urban fading model)

			Maximum Doppler frequency (f_D)(1)		
Modulation	**Coding rate**	**Gaussian noise (dB)**	2 Hz	7 Hz	20 Hz
DQPSK	1/2	6.2	15.7 dB	11.4 dB	9.9 dB
QPSK	1/2	4.9	14.3 dB	10.8 dB	10.4 dB
16-QAM	1/2	11.5	19.6 dB	17.4 dB	19.1 dB
64-QAM	1/2	16.5	24.9 dB	22.9 dB	>35 dB

(1) When velocity of vehicle is 100 km/h, maximum Doppler frequency is up to 20 Hz in the VHF high channel (170-220 MHz).

TABLE 9

Fading margins
(Temporary field-strength fluctuation margin)

Modulation	**Coding rate**	**VHF (up to f_D = 20 Hz) (dB)**
DQPSK	1/2	9.5
QPSK	1/2	9.4
16-QAM	1/2	8.1
64-QAM	1/2	–

6) Receiver required *C*/*N*

= (1: required *C*/*N*) + (2: implementation degradation) + (3: interference margin) + (4: multipath margin) + (5: fading margin).

7) Receiver noise figure, *NF*

= 5 dB.

8) Noise bandwidth, *B*

= 1-segment signal transmission bandwidth.

9) Receiver thermal noise power, N_r

= 10 × log (*k T B*) + *NF*

$k = 1.38 \times 10^{-23}$ (the Boltzmann constant), T = 290 K.

10) External noise power, N_0

The external noise power (lossless antenna) in the 1-segment bandwidth based on the median values of man-made noise power for business (curve A) category in Recommendation ITU-R P.372 at each of the frequencies of 100 MHz and 200 MHz is as follows:

N_0 = –96.3 dBm – (12: feeder loss) + G_{cor} for 100 MHz,

N_0 = –104.6 dBm – (12: feeder loss) + G_{cor} for 200 MHz,

$G_{cor} = G_r (G_r < 0), 0 (G_r > 0)$.

NOTE 1 – G_{cor} is a correction factor for the received external noise power by a receiving antenna. A receiving antenna with a minus gain ($G_r < 0$) receives both desired signals and external noise with the minus gain ($G_{cor} = G_r$). On the other hand, a receiving antenna with a plus gain ($G_r > 0$) receives desired signals in the direction of the main beam with the plus gain but receives external noise omnidirectionally without a gain ($G_{cor} = 0$).

11) Total received noise power, N_t

= the power sum of (9: receiver intrinsic noise power) and (10: external noise power at the receiver input terminal)

= $10 \times \log (10^{(N_r/10)} + 10^{(N_0/10)})$.

12) Feeder loss, *L*

L = 1 dB at 100 MHz for mobile and portable reception

L = 2 dB at 100 MHz for fixed reception

L = 2 dB at 200 MHz for mobile, portable and fixed reception.

13) Minimum usable receiver input power

= (6: receiver required C/N) + (11: total receiver noise power)

= $C/N + N_t$

14) Receiver antenna gain, G_r

= –0.85 dBi, assuming a $\lambda/4$ monopole antenna.

15) Effective antenna aperture

= $10 \times \log (\lambda^2/4\pi)$ + (14: receiving antenna gain) (dBi).

16) Minimum usable field strength, E_{min}

= (12: feeder loss) + (13: minimum receiver input power) – (15: effective antenna aperture) + 115.8 (power flux-density (dBm/m^2) to field strength (dB(μV/m)) conversion).

17) Time-rate correction

For fixed reception, the time-rate correction value is determined by Recommendation ITU-R P.1546. The value from 50% to 1% is 4.3 dB at 100 MHz and 6.2 dB at 200 MHz, respectively. The propagation condition is as follows:

Path:	Land paths
Transmitting/base antenna height:	250 m
Distance:	70 km.

18) Location rate correction

According to Recommendation ITU-R P.1546, standard deviation of location variation σ is 5.5 dB for digital broadcasting signal.

In the case of mobile reception, the location correction value from 50% to 99%[1] is 12.9 dB (2.33 σ).

[1] Different percentages may be used according to the service criteria in each country.

In the case of portable reception, the location correction value from 50% to 70%[1] is 2.9 dB (0.53 σ).

19) Wall penetration loss

For indoor reception, the signal loss due to passing through walls is considered. The average penetration loss is 8 dB with a standard deviation of 4 dB. Assuming the location rate of 70% (0.53 σ) for portable receivers, the value is as follows.

= 8 dB + 0.53 × 4 dB = 10.1 dB.

20) Required field strength at antenna

= (16: minimum field strength, E_{min}) + (17: time rate correction) + (18: location rate correction) + (19: wall penetration loss).

21) Height correction

According to Recommendation ITU-R P.1546, the height correction values are derived as shown in Table 10.

TABLE 10

Height correction values

(a) Suburban, 100 MHz

	4 m above ground level (dB)	**1.5 m above ground level (dB)**
Difference in field strength from height of 10 m above ground level	–7	–10

(b) Suburban, 200 MHz

	4 m above ground level (dB)	**1.5 m above ground level (dB)**
Difference in field strength from height of 10 m above ground level	–10	–12

22) Required field strength at receiving height of 10 m above ground level

= (20: required field strength at antenna) + (21: reception height correction).

23) Conversion from 1-segment signal to 3-segment signal

noise bandwidth conversion value

= 10 × log (3/1) = 4.8 dB.

24) Required field strength (h_2 = 10 m) for 3-segment signal

= (22: required field strength (h_2 = 10 m)) + (23: conversion from 1-segment signal to 3-segment signal).

5 Protection of ISDB-T_{SB}

5.1 ISDB-T_{SB} interfered with by ISDB-T_{SB}

5.1.1 Required *D*/*U* in fixed reception

The *D*/*U* between 1-segment ISDB-T_{SB} signals are measured at a BER of 2×10^{-4} after decoding the inner code, and are shown for each guardband in Table 11. The guardband means a frequency spacing between spectrum edges.

In the case where the spectra overlap each other, interference is considered as co-channel interference.

TABLE 11

Required *D*/*U* (dB) between 1-segment ISDB-T_{SB} signals (fixed reception)

Modulation	Coding rate	Co-channel	Guardband (MHz)							
			0/7	1/7	2/7	3/7	4/7	5/7	6/7	7/7 or above
DQPSK	1/2	4	–15	–21	–25	–28	–29	–36	–41	–42
16-QAM	1/2	11	–6	–12	–21	–24	–26	–33	–38	–39
64-QAM	7/8	22	–4	–10	–10	–11	–13	–19	–23	–24

5.1.2 Required *D*/*U* in mobile reception

In mobile reception, the standard deviation of a location variation of digital broadcasting signal is 5.5 dB according to Recommendation ITU-R P.1546. The field-strength values for wanted and unwanted signals are assumed to be uncorrelated. To protect wanted ISDB-T_{SB} signals for 99% of locations against interference from other ISDB-T_{SB} transmissions, a propagation correction is 18 dB ($\approx 2.33 \times 5.5 \times 1.414$). The *D*/*U* including the total margins are listed in Table 12.

TABLE 12

Required *D*/*U* (dB) between 1-segment ISDB-T_{SB} signals (mobile reception)

Modulation	Coding rate	Co-channel	Guardband (MHz)							
			0/7	1/7	2/7	3/7	4/7	5/7	6/7	7/7 or above
DQPSK	1/2	22	3	–3	–7	–10	–11	–18	–23	–24
16-QAM	1/2	29	12	6	–3	–6	–8	–15	–20	–21

5.1.3 Resultant protection ratios for ISDB-T_{SB} interfered with by ISDB-T_{SB}

The protection ratios are defined as the highest values taken from Tables 11 and 12 to apply to every reception condition. The resultant protection ratios are shown in Table 13.

TABLE 13

Protection ratios for ISDB-T$_{SB}$ interfered with by ISDB-T$_{SB}$

Desired signal	**Interference**		**Protection ratio**
	Interference signal	**Frequency difference**	
ISDB-T$_{SB}$ (1-segment)	ISDB-T$_{SB}$ (1-segment)	Co-channel	29 dB
		Adjacent	Table 14
	ISDB-T$_{SB}$ (3-segment)	Co-channel	24 dB
		Adjacent	Table 14
ISDB-T$_{SB}$ (3-segment)	ISDB-T$_{SB}$ (1-segment)	Co-channel	34 dB
		Adjacent	Table 14
	ISDB-T$_{SB}$ (3-segment)	Co-channel	29 dB
		Adjacent	Table 14

TE 1 – For protection ratios for ISDB-T$_{SB}$, fading margin for mobile reception is taken into account. The values in the Table include the fading margin of 18 dB.

TABLE 14

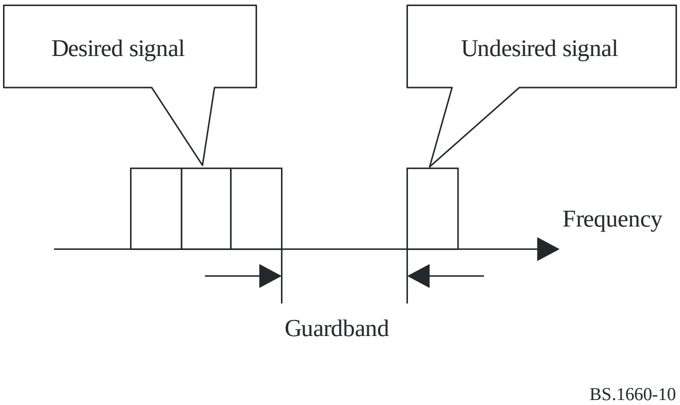
Protection ratios (dB) depending on guardbands

Desired signal	**Interference signal**	**Guardband (MHz)**							
		0/7	1/7	2/7	3/7	4/7	5/7	6/7	7/7 or above
ISDB-T$_{SB}$ (1-segment)	ISDB-T$_{SB}$ (1-segment)	12	6	–3	–6	–8	–15	–20	–21
	ISDB-T$_{SB}$ (3-segment)	7	1	–8	–11	–13	–20	–25	–26
ISDB-T$_{SB}$ (3-segment)	ISDB-T$_{SB}$ (1-segment)	17	11	2	–1	–3	–10	–15	–16
	ISDB-T$_{SB}$ (3-segment)	12	6	–3	–6	–8	–15	–20	–21

TE 1 – The values in the Table include the fading margin of 18 dB. The guardband between ISDB-T$_{SB}$ signals is as shown in Fig. 10.

FIGURE 10

Guardband and arrangement of the signals



5.2 ISDB-T$_{SB}$ interfered with by analogue television (NTSC)

5.2.1 Required *D*/*U* in fixed reception

The *D*/*U* required for 1-segment ISDB-T$_{SB}$ signal interfered with by NTSC are listed in Table 15. The *D*/*U* are measured at the BER of 2×10^{-4} after decoding the inner code. The guardbands between ISDB-T$_{SB}$ signal and NTSC signal in adjacent channel interference are as shown in Fig. 9.

TABLE 15

Required *D*/*U* for 1-segment ISDB-T$_{SB}$ interfered with by analogue television (NTSC) (fixed reception)

Modulation	Coding rate	Interference		
		Co-channel (dB)	Lower-adjacent channel (dB)	Upper-adjacent channel (dB)
DQPSK	1/2	2	–57	–60
16-QAM	1/2	5	–54	–56
64-QAM	7/8	29	–38	–38

5.2.2 Required *D*/*U* in mobile reception

In mobile reception, both the desired signal and interference signal experience field-strength fluctuation due to Rayleigh fading. The standard deviation of a location variation of digital broadcasting signal is 5.5 dB and that of analogue broadcasting signal is 8.3 dB according to Recommendation ITU-R P.1546. The field-strength values for wanted and unwanted signals are assumed to be uncorrelated. To protect wanted ISDB-T$_{SB}$ signals for 99% of locations against interference from NTSC signals, the propagation correction is 23 dB.

The *D*/*U* including a margin required for mobile reception are listed in Table 16.

TABLE 16

Required *D*/*U* for 1-segment ISDB-T$_{SB}$ interfered with by analogue television (NTSC) (mobile reception)

Modulation	**Coding rate**	**Interference**		
		Co-channel (dB)	**Lower-adjacent channel (dB)**	**Upper-adjacent channel (dB)**
DQPSK	1/2	25	–34	–37
16-QAM	1/2	28	–31	–33

5.2.3 Resultant protection ratios for ISDB-T$_{SB}$ interfered with by analogue television (NTSC)

The protection ratios are defined as the highest values taken from Tables 15 and 16 to apply to every reception condition. For the 3-segment transmission, it is necessary to correct the protection ratios by 5 dB (≈ 4.8 dB = 10 × log (3/1)). The resultant protection ratios are shown in Table 17.

TABLE 17

Protection ratios for ISDB-T$_{SB}$ interfered with by analogue television (NTSC)

Desired signal	**Interference**		**Protection ratio (dB)**
	Interference signal	**Frequency difference**	
ISDB-T$_{SB}$ (1-segment)	NTSC	Co-channel	29
		Lower-adjacent	–31
		Upper-adjacent	–33
ISDB-T$_{SB}$ (3-segment)		Co-channel	34
		Lower-adjacent	–26
		Upper-adjacent	–28

TE 1 – For protection ratios for ISDB-T$_{SB}$, fading margin for mobile reception is taken into account. The values in the Table include the fading margin of 23 dB.

5.3 Analogue television (NTSC) interfered with by ISDB-T$_{SB}$

Protection ratios are defined as *D*/*U* at which subjective evaluations resulted in an impairment score of 4 (5-grade impairment scale). The evaluation experiments were conducted according to the double-stimulus impairment scale method described in Recommendation ITU-R BT.500.

In the case of adjacent interference, the guardbands between NTSC signal and ISDB-T$_{SB}$ signal are as shown in Fig. 9. For the 3-segment transmission, it is necessary to correct the protection ratios by 5 dB (≈ 4.8 dB = 10 × log (3/1)). The resultant protection ratios are shown in Table 18.

TABLE 18

Protection ratios for analogue television (NTSC) interfered with by ISDB-T_{SB}

Desired signal	Interference		Protection ratio (dB)
	Interference signal	Frequency difference	
NTSC	ISDB-T_{SB} (1-segment)	Co-channel	57
		Lower-adjacent	11
		Upper-adjacent	11
		Image channel	–9
	ISDB-T_{SB} (3-segment)	Co-channel	52
		Lower-adjacent	6
		Upper-adjacent	6
		Image channel	–14

5.4 ISDB-T_{SB} interfered with by services other than broadcasting

The maximum interfering field-strength density below 108 MHz to avoid interference by services other than broadcasting is shown as follows:

TABLE 19

Maximum interfering field strength density interfered with by services other than broadcasting

Parameter	Value	Unit
Maximum interfering field-strength density	4.6	dB(μV/(m • 100 kHz))

NOTE 1 – For derivation, see Appendix 1 to Annex 2.

Appendix 1
to Annex 2

Derivation of maximum interfering field strength density interfered with by services other than broadcasting

Parameter	Symbol	Value	Unit
Frequency	f	108	MHz
Bandwidth	B	429×10^3	Hz
Receiver antenna gain	Gr	–0.85	dBi
Feeder loss	L	1	dB
NF	NF	5	dB
Receiver intrinsic noise power	Nr	–112.7	dBm
Median value of man-made noise power as described in § 5 of Recommendation ITU-R P.372-10	F_{am}	20.5	dB
External noise power to the receiver input power	N_0	–99.0	dBm
Total receiver noise power	N_t	–98.8	dBm
Effective antenna aperture	A_{eff}	–3.0	dB • m^2
Total noise field strength	E_t	21.0	dB(µV/m)
Maximum interfering field strength (in 429 kHz)	E_i	11.0	dB(µV/m)
Maximum interfering field strength density	E_{is}	4.6	dB(µV/(m • 100 kHz))

Receiver intrinsic noise power

$$N_r = 10 \times \log (k\,T\,B) + NF + 30 \qquad \text{(dBm)}$$

Median value of man-made noise power as described in § 5 of Recommendation ITU-R P.372-9

$$F_{am} = c - d \times \log f \qquad \text{(dB)}$$

(c = 76.8 and d =27.7 for the city area)

External noise power to the receiver input power

$$N_o = 10 \times \log (k\,T\,B) - L + 30 + F_{am} + G_{cor} \qquad \text{(dBm)}$$

$$G_{cor} = G_r\,(G_r < 0),\ 0\ (G_r > 0)^2$$

2 G_{cor} is a correction factor for the received external noise power by a receiving antenna. A receiving antenna with a minus gain ($G_r < 0$) receives both desired signals and external noise with the minus gain ($G_{cor} = G_r$). On the other hand, a receiving antenna with a plus gain ($G_r > 0$) receives desired signals in the direction of the main beam with the plus gain but receives external noise omnidirectionally without a gain ($G_{cor} = 0$).

Total receiver noise power

$$N_t = 10 \times \log \left(10^{(N_r/10)} + 10^{(N_0/10)}\right) \qquad \text{(dBm)}$$

Effective antenna aperture

$$A_{eff} = 10 \times \log(\lambda^2/4\pi) + G_r \ (\text{dB} \cdot \text{m}^2)$$

Total noise field strength

$$E_t = L + N_t - A_{eff} + 115.8 \ (\text{dB}(\mu\text{V/m}))$$

Maximum interfering field strength

$$E_i = E_t + I/N \ (\text{dB}(\mu\text{V/m}))$$

Data

k: Boltzmann's constant = 1.38×10^{-23} J/K

T: Absolute temperature = 290 K

I/*N*: *I*/*N* for inter-service sharing = –10 (dB).

Annex 3

Technical basis for planning of terrestrial digital sound broadcasting System G (DRM) in the VHF bands

1 General

This Annex contains relevant DRM system parameters and network concepts for planning broadcasting networks with DRM in all VHF bands, considering 254 MHz as the international top boundary of the VHF broadcasting spectrum[3].

To calculate the relevant planning parameter minimum median field strength and protection ratios, the receiver and transmitter characteristics, system parameters, and transmission aspects as a common basis for concrete DRM transmission network planning are first determined.

[3] ITU Radio Regulations for Region 1, Footnote **5.252**: in Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe, the bands 230-238 MHz and 246-254 MHz are allocated to the broadcasting service on a primary basis, subject to agreement obtained under RR No. **9.21**.

2 Reception modes

2.1 Fixed reception

Fixed reception (FX) is defined as reception where a receiving antenna mounted at roof level is used. It is assumed that near-optimal reception conditions (within a relatively small volume on the roof) are found when the antenna is installed. In calculating the field-strength levels for fixed antenna reception, a receiving antenna height of 10 m above ground level is considered to be representative for the broadcasting service.

A location probability of 70% is assumed to obtain a good reception situation.

2.2 Portable reception

In general, portable reception means a reception where a portable receiver is used outdoors or indoors at no less than 1.5 m above ground level. A location probability of 95% in a suburban area is assumed to obtain a good reception situation.

Two receiving locations will be distinguished:

– **Indoor reception** is defined by a portable receiver with stationary power supply and a built-in (folded) antenna or with a plug for an external antenna. The receiver is used indoors at no less than 1.5 m above floor level in rooms on the ground floor and with a window in an external wall. It is assumed that optimal receiving conditions will be found by moving the antenna up to 0.5 m in any direction and the portable receiver is not moved during reception and large objects near the receiver are also not moved.

– **Outdoor reception** is defined as reception by a portable receiver with battery supply and an attached or built-in antenna which is used outdoors at no less than 1.5 m above ground level.

Within these receiving locations, two opposed receiving conditions will additionally be distinguished due to the great variability of portable reception situations with different receiver-/antenna-types and also different reception conditions that are applied for further considerations:

– **Portable outdoor reception (PO) and portable indoor reception (PI)**: This situation models the reception situation in a suburban area with good reception conditions for both situations indoors and outdoors, respectively, and a receiver with an omnidirectional VHF antenna pattern.

– **Portable outdoor handheld reception (PO-H) and portable indoor handheld reception (PI-H)**: This situation models the reception situation in an urban area with bad reception conditions and a receiver with an external antenna (for example, telescopic antennas or the cable of wired headsets).

2.3 Mobile reception

Mobile reception (MO) is defined as reception in a rural area with hilly terrain by a receiver in motion also at high speed with a matched antenna situated at no less than 1.5 m above ground level or floor level.

3 Correction factors for field-strength predictions

The wanted field-strength level values predicted with Recommendation ITU-R P.1546-4 refer always to the median value at a receiving location with a receiving antenna in 10 m height above ground level. Otherwise the wanted field-strength values are predicted at the average construction or vegetation height at the receiving location. To take into account the given different receiving modes and circumstances in network planning, correction factors have to be included to carry the minimum field-strength level over to the median minimum field-strength level for predictions with Recommendation ITU-R P.1546-4.

3.1 Reference frequencies

The planning parameters and correction factors in this document are calculated for the reference frequencies given in Table 20.

TABLE 20

Reference frequencies for calculations

VHF band (frequency range)	I (47-68 MHz)	II (87.5-108 MHz)	III (174-230 MHz)
Reference frequency (MHz)	65	100	200

3.2 Antenna gain

The antenna gain G_D (dBd) refers to a half-wave dipole and is given for the different receiving modes in Table 21.

TABLE 21

Antenna gains G_D

Frequency (MHz)		65	100	200
Antenna gain G_D	for fixed reception (FX) (dBd)	0	0	0
	for portable and mobile reception (PO, PI, MO) (dBd)	−2.2	−2.2	−2.2
	for portable handheld reception (PO-H, PI-H) (dBd)	−22.76	−19.02	−13.00

3.3 Feeder loss

The feeder loss L_f expresses the signal attenuation from the receiving antenna to the receiver's RF input. The feeder loss L_f is given with 2 dB for 10 m cable length. Herewith the frequency-dependent cable attenuation per unit length L'_f can be calculated and is given in Table 22.

TABLE 22

Feeder loss L'_f per unit length

Frequency (MHz)	65	100	200
Feeder loss L'_f per unit length (dB/m)	0.11	0.14	0.2

The cable length l for the different reception modes are given in Table 23 and the herewith calculated feeder losses L_f for different frequencies and reception modes are given in Table 24.

TABLE 23

Cable length l for reception modes

Reception mode	Fixed reception (FX)	Portable reception (PO, PI, PO-H, PI-H)	Mobile reception (MO)
Cable length l (m)	10	0	2

TABLE 24

Feeder loss L_f for different reception modes

Frequency (MHz)		65	100	200
Feeder loss L_f	for fixed reception (FX) (dB)	1.1	1.4	2.0
	for portable reception (PO, PI, PO-H, PI-H) (dB)	0.0	0.0	0.0
	for mobile reception (MO) (dB)	0.22	0.28	0.4

3.4 Height loss correction factor

For portable and mobile reception, a receiving antenna height of 1.5 m is assumed. The propagation prediction method usually provides field-strength values at 10 metres. To correct the predicted value from 10 metres to 1.5 m above ground level, a height loss factor L_h (dB) has to be applied as given in Table 25.

TABLE 25

Height loss correction factor L_h for different reception modes

Frequency (MHz)		65	100	200
Height loss correction factor L_h	for fixed reception (FX) (dB)	0	0	0
	for portable and mobile reception (PO, PI, MO) (dB)	8	10	12
	for portable handheld reception (PO-H, PI-H) (dB)	15	17	19

3.5 Building penetration loss

The ratio 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 expressed in (dB) is the mean building penetration loss. The mean building penetration losses L_b and standard deviations σ_b are given in Table 26.

TABLE 26

Building penetration loss L_b and standard deviation σ_b

Frequency (MHz)	65	100	200
Mean building penetration loss L_b (dB)	8	9	9
Standard deviation of the building penetration loss σ_b (dB)	3	3	3

3.6 Allowance for man-made noise

The allowance for man-made noise, MMN (dB), takes into account the effect of man-made noise received by the antenna on the system performance. The system equivalent noise figure F_s (dB) to be used for coverage calculations is calculated from the receiver noise figure F_r (dB) and MMN (dB).

Recommendation ITU-R P.372-8 gives the legal values to calculate the allowance of man-made noise in different areas and frequencies with the definitions of the antenna noise figure, its mean values $F_{a,med}$ and the values of decile variations (10% and 90%) measured in different regions. For all reception modes the residential area (Curve B) is assumed.

Taking into account a receiver noise figure F_r of 7 dB for DRM, the MMN can be computed for fixed, portable and mobile reception. The results are shown in Table 27.

TABLE 27

Allowance for man-made noise for fixed, portable and mobile reception

Frequency (MHz)	65	100	200
Allowance for man-made noise (dB) for fixed (FX), portable (PO, PI) and mobile (MO) reception (F_r = 7 dB)	15.38	10.43	3.62

The value of the decile location variations (10% and 90%) in residential area is given by 5.8 dB. Therefore the standard deviation of MMN for fixed, portable and mobile reception σ_{MMN} = 4.53 dB, see Table 28.

TABLE 28

Standard deviation of MMN σ_{MMN} for fixed, portable and mobile reception

Frequency (MHz)	65	100	200
Standard deviation of MMN σ_{MMN} (dB) for fixed (FX), portable (PO, PI) and mobile (MO) reception	4.53	4.53	4.53

Due to a very low antenna gain for portable handheld reception the MMN for this reception mode is negligible and therefore assumed to be 0 (dB), see Table 29.

TABLE 29

Allowance for man-made noise for portable handheld reception

Frequency (MHz)	65	100	200
Allowance for man-made noise (dB) for portable handheld reception (PO-H, PI-H)	0	0	0

3.7 Implementation loss factor

Implementation loss of the non-ideal receiver is considered in the calculation of the minimum receiver input power level with an additional implementation loss factor L_i of 3 dB, see Table 30.

TABLE 30

Implementation loss factor L_i

Frequency (MHz)	65	100	200
Implementation loss factor L_i (dB)	3	3	3

3.8 Correction factors for location variability

The field-strength level $E(p)$ (dB(μV/m)), used for coverage and interference predictions in the different reception modes, which will be exceeded for p (%) of locations for a land receiving/mobile antenna location, is given by:

$$E(p) \text{ (dB(μV/m))} = E_{med} \text{ (dB(μV/m))} + C_l(p) \text{ (dB)} \qquad \text{for } 50\% \leq p \leq 99\% \tag{1}$$

where:

$C_l(p)$: location correction factor

E_{med} (dB(μV/m)): field-strength value for 50% of locations and 50% of time.

The location correction factor $C_l(p)$ (dB) depends on the so-called combined standard deviation σ_c (dB) of the wanted field-strength level that sums the single standard deviations of all relevant signal parts that have to be taken into account and the so-called distribution factor $\mu(p)$, namely:

$$C_l(p) \text{ (dB)} = \mu(p) \cdot \sigma_c \text{ (dB)} \tag{2}$$

3.8.1 Distribution factor

The distribution factors $\mu(p)$ of the different location probabilities taking into account the different receiving modes (see § 2) are given in Table 31.

TABLE 31

Distribution factor μ

Percentage of receiving locations p (%)	70	95	99
Reception mode	Fixed (FX)	Portable (PO, PI, PO-H, PI-H)	Mobile (MO)
Distribution factor μ	0.524	1.645	2.326

3.8.2 Combined standard deviation

Since the statistics of the received wanted field-strength level for macro-scale, the statistics of the MMN σ_{MMN} (dB), and the statistics of the building attenuation can be assumed to be statistically uncorrelated, the combined standard deviation σ_c (dB) is calculated by:

$$\sigma_c \text{ (dB)} = \sqrt{\sigma_m^2 + \sigma_b^2 + \sigma_{MMN}^2} \quad (3)$$

The values of the standard deviation σ_m (dB) of the wanted field-strength level are dependent on frequency and environment, and empirical studies have shown a considerable spread. Representative values and the equation to calculate the standard deviation σ_m (dB) of the wanted field-strength level are given by Recommendation ITU-R P.1546-4. The calculation of the standard deviation σ_m (dB) of the wanted field-strength level values take into account only the effects of slow fading, but not the effects of fast fading. For DRM it had be ensured that the determination of the minimum C/N value of DRM consider the effects of the fast fading, therefore no additional correction margin is needed here.

The following fixed values are given by Recommendation ITU-R P.1546-4:

Broadcasting, analogue (i.e. FM at 100 MHz): σ_m = 8.3 dB

Broadcasting, digital (more than 1 MHz bandwidth, i.e., DAB at 200 MHz): σ_m = 5.5 dB

The computed standard deviations σ_m (dB) with the equations given by Recommendation ITU-R P.1546-4 for DRM in urban and suburban areas as well as in rural areas are given in Table 32.

TABLE 32

Standard deviation for DRM $\sigma_{m,DRM}$

Frequency (MHz)		65	100	200
Standard deviation for DRM $\sigma_{m,DRM}$	in urban and suburban areas (dB)	3.56	3.80	4.19
	in rural areas (dB)	2.86	3.10	3.49

To calculate the combined standard deviation σ_c (dB) for the different reception modes more or less parts of the given particular standard deviations have to be taken into account. The values for the standard deviation of building penetration loss are given in § 3.5, those for the standard deviation of MMN are given in § 3.6, and those for the standard deviation of the field strength σ_m (dB) are given in Table 32.

The results of the calculations of the combined standard deviation σ_c (dB) for the respective reception modes are given in Table 33.

TABLE 33

Combined standard deviation σ_c for the different reception modes

Frequency (MHz)		65	100	200
Combined standard deviation σ_c for reception mode	fixed (FX) and portable outdoor (PO) (dB)	5.76	5.91	6.17
	portable handheld outdoor (PO-H) (dB)	3.56	3.80	4.19
	mobile (MO) (dB)	5.36	5.49	5.72
	portable indoor (PI) (dB)	6.49	6.63	6.86
	portable handheld indoor (PI-H) (dB)	4.65	4.84	5.15

3.8.3 Combined location correction factor for protection ratios

The needed protection of a wanted signal against an interfering signal is given as the basic protection ratio PR_{basic} (dB) for 50% of location probability. In the case of higher location probability as given for all reception modes, a so-called combined location correction factor CF in (dB) is used as a margin that has to be added to the basic protection ratio PR_{basic}, valid for the wanted field-strength level and the nuisance field-strength level, to the protection ratio $PR(p)$ corresponding to the needed percentage p (%) of locations for the wanted service.

$$PR(p) \text{ (dB)} = PR_{basic} \text{ (dB)} + CF(p) \text{ (dB)} \qquad \text{for } 50\% \le p \le 99\% \tag{4}$$

with:

$$CF(p) \text{ (dB)} = \mu(p)\sqrt{\sigma_w^2 + \sigma_n^2} \text{ (dB)} \tag{5}$$

where σ_w and σ_n, both in (dB), denote the standard deviation of location variation for the wanted signal for the nuisance signal, respectively. The values for σ_w and σ_n are given in § 3.8.2 for the different broadcasting systems as σ_m.

3.9 Polarization discrimination

For the planning procedures of digital sound broadcasting systems in the VHF bands no polarization discrimination will be taken into account for all reception modes.

4 DRM system parameters for field-strength predictions

The description of the DRM system parameters refers to Mode E of the DRM system.

4.1 Modes and code rates for calculations

Several of the derived parameters depend on the characteristic of the transmitted DRM signal. To limit the amount of tests, two typical parameters sets were chosen as basic sets, see Table 34:

– **DRM with 4-QAM** as a high protected signal with a lower data rate which is suited for a robust audio signal with a low data rate data service.

– **DRM with 16-QAM** as a low protected signal with a high data rate which is suited for several audio signals or for an audio signal with a high data rate data service.

TABLE 34

MSC code rates for calculations

MSC mode	11 – 4-QAM	00 – 16-QAM
MSC protection level	1	2
MSC code rate *R*	1/3	1/2
SDC mode	1	1
SDC code rate *R*	0.25	0.25
Bit rate approximately	49.7 kbit/s	149.1 kbit/s

4.2 Propagation-related OFDM parameters

The propagation-related OFDM parameters of DRM are given in Table 35.

TABLE 35

OFDM parameters

Elementary time period *T*	83 1/3 μs
Duration of useful (orthogonal) part $T_u = 27 \cdot T$	2.25 ms
Duration of guard interval $T_g = 3 \cdot T$	0.25 ms
Duration of symbol $T_s = T_u + T_g$	2.5 ms
T_g/T_u	1/9
Duration of transmission frame T_f	100 ms
Number of symbols per frame N_s	40
Channel bandwidth *B*	96 kHz
Carrier spacing $1/T_u$	444 4/9 Hz
Carrier number space	$K_{min} = -106$; $K_{max} = 106$
Unused carriers	none

4.3 Single frequency operation capability

DRM transmitter can be operating in single-frequency networks (SFN). The maximum transmitter distance that has to go below to prevent self-interference depends on the length of the OFDM guard interval. Since the length T_g of the DRM guard interval is 0.25 ms, the maximum echo delay, and therefore the maximum transmitter distance, yields 75 km.

5 Minimum receiver input power level

For having cost effective DRM receiver solutions the receiver noise figure *F* is assumed to be $F_r = 7$ dB.

With $B = 100$ kHz and $T = 290$ K, the thermal receiver noise input power level for DRM Mode E yields $P_n = -146.98$ (dBW).

The DRM standard gives a required $(C/N)_{min}$ to achieve an average coded bit error ratio $\text{BER} = 1 \cdot 10^{-4}$ (bit) after the channel decoder for different channel models. Effects of the narrow-band system, such as fast fading, are included in the channel models and therefore in calculated values of the $(C/N)_{min}$.

Three channel models have been allocated to the given reception modes that give the respective required $(C/N)_{min}$, see Table 36.

TABLE 36

$(C/N)_{min}$ with different channel models

		$(C/N)_{min}$ (dB) for	
Reception mode	**Channel model**	**4-QAM, R = 1/3**	**16-QAM, R = 1/2**
Fixed reception (FX)	Channel 7 (AWGN)	1.3	7.9
Portable reception (PO, PI, PO-H, PI-H)	Channel 8 (urban@60 km/h)	7.3	15.4
Mobile reception (MO)	Channel 11 (hilly terrain)	5.5	12.8

Based on the above given values and including the implementation loss factor, the minimum receiver input power level at the receiving location has been calculated for both 16-QAM and 4-QAM, see Tables 37 and 38.

TABLE 37

Minimum receiver input power level $P_{s, min}$ for 4-QAM, R = 1/3

Reception mode		Fixed	Portable	Mobile
Receiver noise figure	F_r (dB)	7	7	7
Receiver noise input power level	P_n (dBW)	−146.98	−146.98	−146.98
Representative minimum C/N ratio	$(C/N)_{min}$ (dB)	1.3	7.3	5.5
Implementation loss factor	L_i (dB)	3	3	3
Minimum receiver input power level	$P_{s, min}$ (dBW)	−142.68	−136.68	−138.48

TABLE 38

Minimum receiver input power level $P_{s, min}$ for 16-QAM, R = 1/2

Reception mode		Fixed	Portable	Mobile
Receiver noise figure	F_r (dB)	7	7	7
Receiver noise input power level	P_n (dBW)	−146.98	−146.98	−146.98
Representative minimum C/N ratio	$(C/N)_{min}$ (dB)	7.9	15.4	12.8
Implementation loss factor	L_i (dB)	3	3	3
Minimum receiver input power level	$P_{s, min}$ (dBW)	−136.08	−128.58	−131.18

6 Minimum wanted field strength used for planning

6.1 Calculation of minimum median field-strength level

The calculation of the minimum median field-strength level at 10 m above ground level for 50% of time and for 50% of locations is given by the following steps 1 to 5:

1) Determine the receiver noise input power level P_n

$$P_n \text{ (dBW)} = F \text{ (dB)} + 10 \log_{10} (k \cdot T_0 \cdot B) \tag{6}$$

with:

F: receiver noise figure (dB)

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

T_0: absolute temperature (K)

B: receiver noise bandwidth (Hz).

2) Determine the minimum receiver input power level $P_{s,\,min}$

$$P_{s,\,min} \text{ (dBW)} = (C/N)_{min} \text{ (dB)} + P_n \text{ (dBW)} \tag{7}$$

with:

$(C/N)_{min}$: minimum carrier-to-noise ratio at the DRM decoder input in (dB).

3) Determine the minimum power flux-density (i.e., the magnitude of the Poynting vector) at receiving place φ_{min}

$$\varphi_{min} \text{ (dBW/m}^2\text{)} = P_{s,\,min} \text{ (dBW)} - A_a \text{ (dBm}^2\text{)} + L_f \text{ (dB)} \tag{8}$$

with:

L_f: feeder loss (dB)

A_a: effective antenna aperture (dBm^2).

$$A_a \text{ (dBm}^2\text{)} = 10 \cdot \log\left(\frac{1.64}{4\pi}\left(\frac{300}{f \text{ (MHz)}}\right)^2\right) + G_D \text{ (dB)} \tag{9}$$

4) Determine the minimum RMS field-strength level at the location of the receiving antenna E_{min}

$$E_{min} \text{ (dB(µV/m))} = \varphi_{min} \text{ (dBW/m}^2\text{)} + 10\log_{10}(Z_{F0}) \text{ (dBΩ)} + 20\log_{10}\left(\frac{1V}{1\mu V}\right) \tag{10}$$

with:

$$Z_{F0} = \sqrt{\frac{\mu_0}{\varepsilon_0}} \approx 120\pi \text{ (Ω)} \qquad \text{the characteristic impedance in free space} \tag{11}$$

resulting in:

$$E_{min}(\text{dB}\mu\text{V/m}) = \varphi_{min}(\text{dBW/m}^2) + 145.8 \ \ (\text{dB}\Omega) \quad (12)$$

5) Determine the minimum median RMS field-strength level E_{med}

For the different receiving scenarios the minimum median RMS field strength is calculated as follows:

for fixed reception: $E_{med} = E_{min} + P_{mmn} + Cl$ (13)

for portable outdoor and mobile reception: $E_{med} = E_{min} + P_{mmn} + C_l + L_h$ (14)

for portable indoor reception: $E_{med} = E_{min} + P_{mmn} + C_l + L_h + L_b$ (15)

Based on these equations, the minimum median field-strength level for the respective reception modes have been calculated for both 16-QAM and 4-QAM, for VHF Bands I, II and III, see Tables 39 to 44.

6.2 Minimum median field-strength level for VHF Band I

TABLE 39

Minimum median field-strength level E_{med} for 4-QAM, R = 1/3 in VHF Band I

DRM modulation		4-QAM. R = 1/3					
Receiving situation		FX	PI	PI-H	PO	PO-H	MO
Minimum receiver input power level	$P_{s,\,min}$ (dBW)	−142.68	−136.68	−136.68	−136.68	−136.68	−138.48
Antenna gain	G_D (dBd)	0.00	−2.20	−22.76	−2.20	−22.76	−2.20
Effective antenna aperture	A_a (dBm²)	4.44	2.24	−18.32	2.24	−18.32	2.24
Feeder-loss	L_c (dB)	1.10	0.00	0.00	0.00	0.00	0.22
Minimum power flux-density at receiving place	φ_{min} (dBW/m²)	−146.02	−138.92	−118.36	−138.92	−118.36	−140.50
Minimum field-strength level at receiving antenna	E_{min} (dB(μV/m))	−0.25	6.85	27.41	6.85	27.41	5.27
Allowance for man-made noise	P_{mmn} (dB)	15.38	15.38	0.00	15.38	0.00	15.38
Antenna height loss	L_h (dB)	0.00	8.00	15.00	8.00	15.00	8.00
Building penetration loss	L_b (dB)	0.00	8.00	8.00	0.00	0.00	0.00
Location probability	%	*70*	*95*	*95*	*95*	*95*	*99*
Distribution factor	μ	*0.52*	*1.64*	*1.64*	*1.64*	*1.64*	*2.33*
Standard deviation of DRM field strength	σ_m (dB)	*3.56*	*3.56*	*3.56*	*3.56*	*3.56*	*2.86*
Standard deviation of MMN	σ_{MMN} (dB)	*4.53*	*4.53*	*0.00*	*4.53*	*0.00*	*4.53*
Standard deviation of building penetration loss	σ_b (dB)	*0.00*	*3.00*	*3.00*	*0.00*	*0.00*	*0.00*
Location correction factor	C_l (dB)	3.02	10.68	7.65	9.47	5.85	12.46
Minimum median field-strength level	**E_{med} (dB(μV/m))**	**18.15**	**48.91**	**58.06**	**39.71**	**48.26**	**41.11**

TABLE 40

Minimum median field-strength level E_{med} for 16-QAM, R = 1/2 in VHF Band I

DRM modulation		16-QAM. R = 1/2					
Receiving situation		FX	PI	PI-H	PO	PO-H	MO
Minimum receiver input power level	$P_{s, min}$ (dBW)	−136.08	−128.58	−128.58	−128.58	−128.58	−131.18
Antenna gain	G_D (dBd)	0.00	−2.20	−22.76	−2.20	−22.76	−2.20
Effective antenna aperture	A_a (dBm^2)	4.44	2.24	−18.32	2.24	−18.32	2.24
Feeder-loss	L_c (dB)	1.10	0.00	0.00	0.00	0.00	0.22
Minimum power flux-density at receiving place	φ_{min} (dBW/m^2)	−139.42	−130.82	−110.26	−130.82	−110.26	−133.20
Minimum field-strength level at receiving antenna	E_{min} (dB(μV/m))	6.35	14.95	35.51	14.95	35.51	12.57
Allowance for man-made noise	P_{mmn} (dB)	15.38	15.38	0.00	15.38	0.00	15.38
Antenna height loss	L_h (dB)	0.00	8.00	15.00	8.00	15.00	8.00
Building penetration loss	L_b (dB)	0.00	8.00	8.00	0.00	0.00	0.00
Location probability	%	*70*	*95*	*95*	*95*	*95*	*99*
Distribution factor	μ	*0.52*	*1.64*	*1.64*	*1.64*	*1.64*	*2.33*
Standard deviation of DRM field strength	σ_m (dB)	*3.56*	*3.56*	*3.56*	*3.56*	*3.56*	*2.86*
Standard deviation of MMN	σ_{MMN} (dB)	*4.53*	*4.53*	*0.00*	*4.53*	*0.00*	*4.53*
Standard deviation of building penetration loss	σ_b (dB)	*0.00*	*3.00*	*3.00*	*0.00*	*0.00*	*0.00*
Location correction factor	C_l (dB)	3.02	10.68	7.65	9.47	5.85	12.46
Minimum median field-strength level	**E_{med} (dB(μV/m))**	**24.75**	**57.01**	**66.16**	**47.81**	**56.36**	**48.41**

6.3 Minimum median field-strength level for VHF Band II

TABLE 41

Minimum median field-strength level E_{med} for 4-QAM, R = 1/3 in VHF Band II

DRM modulation		4-QAM. R = 1/3					
Receiving situation		FX	PI	PI-H	PO	PO-H	MO
Minimum receiver input power level	$P_{s, min}$ (dBW)	−142.68	−136.68	−136.68	−136.68	−136.68	−138.48
Antenna gain	G_D (dBd)	0.00	−2.20	−19.02	−2.20	−19.02	−2.20
Effective antenna aperture	A_a (dBm^2)	0.70	−1.50	−18.32	−1.50	−18.32	−1.50
Feeder-loss	L_c (dB)	1.40	0.00	0.00	0.00	0.00	0.28
Minimum power flux-density at receiving place	φ_{min} (dBW/m^2)	−141.97	−135.17	−118.35	−135.17	−118.35	−136.69
Minimum field-strength level at receiving antenna	E_{min} (dB(μV/m))	3.79	10.59	27.41	10.59	27.41	9.07
Allowance for man-made noise	P_{mmn} (dB)	10.43	10.43	0.00	10.43	0.00	10.43
Antenna height loss	L_h (dB)	0.00	10.00	17.00	10.00	17.00	10.00
Building penetration loss	L_b (dB)	0.00	9.00	9.00	0.00	0.00	0.00
Location probability	%	*70*	*95*	*95*	*95*	*95*	*99*
Distribution factor	μ	*0.52*	*1.64*	*1.64*	*1.64*	*1.64*	*2.33*
Standard deviation of DRM field strength	σ_m (dB)	*3.80*	*3.80*	*3.80*	*3.80*	*3.80*	*3.10*
Standard deviation of MMN	σ_{MMN} (dB)	*4.53*	*4.53*	*0.00*	*4.53*	*0.00*	*4.53*
Standard deviation of building penetration loss	σ_b (dB)	*0.00*	*3.00*	*3.00*	*0.00*	*0.00*	*0.00*
Location correction factor	C_l (dB)	3.10	10.91	7.96	9.73	6.25	12.77
Minimum median field-strength level	**E_{med} (dB(μV/m))**	**17.32**	**50.92**	**61.37**	**40.74**	**50.66**	**42.27**

TABLE 42

Minimum median field-strength level E_{med} for 16-QAM, R = 1/2 in VHF Band II

DRM modulation		16-QAM R = 1/2					
Receiving situation		FX	PI	PI-H	PO	PO-H	MO
Minimum receiver input power level	$P_{s, min}$ (dBW)	−136.08	−128.58	−128.58	−128.58	−128.58	−131.18
Antenna gain	G_D (dBd)	0.00	−2.20	−19.02	−2.20	−19.02	−2.20
Effective antenna aperture	A_a (dBm^2)	0.70	−1.50	−18.32	−1.50	−18.32	−1.50
Feeder-loss	L_c (dB)	1.40	0.00	0.00	0.00	0.00	0.28
Minimum power flux-density at receiving place	φ_{min} (dBW/m^2)	−135.37	−127.07	−110.25	−127.07	−110.25	−129.39
Minimum field-strength level at receiving antenna	E_{min} (dB(μV/m))	10.39	18.69	35.51	18.69	35.51	16.37
Allowance for man-made noise	P_{mmn} (dB)	10.43	10.43	0.00	10.43	0.00	10.43
Antenna height loss	L_h (dB)	0.00	10.00	17.00	10.00	17.00	10.00
Building penetration loss	L_b (dB)	0.00	9.00	9.00	0.00	0.00	0.00
Location probability	%	*70*	*95*	*95*	*95*	*95*	*99*
Distribution factor	μ	*0.52*	*1.64*	*1.64*	*1.64*	*1.64*	*2.33*
Standard deviation of DRM field strength	σ_m (dB)	*3.80*	*3.80*	*3.80*	*3.80*	*3.80*	*3.10*
Standard deviation of MMN	σ_{MMN} (dB)	*4.53*	*4.53*	*0.00*	*4.53*	*0.00*	*4.53*
Standard deviation of building penetration loss	σ_b (dB)	*0.00*	*3.00*	*3.00*	*0.00*	*0.00*	*0.00*
Location correction factor	C_l (dB)	3.10	10.91	7.96	9.73	6.25	12.77
Minimum median field-strength level	**E_{med} (dB(μV/m))**	**23.92**	**59.02**	**69.47**	**48.84**	**58.76**	**49.57**

6.4 Minimum median field-strength level for VHF Band III

TABLE 43

Minimum median field-strength level E_{med} for 4-QAM, R = 1/3 in VHF Band III

DRM modulation		4-QAM. R = 1/3					
Receiving situation		FX	PI	PI-H	PO	PO-H	MO
Minimum receiver input power level	$P_{s,\,min}$ (dBW)	−142.68	−136.68	−136.68	−136.68	−136.68	−138.48
Antenna gain	G_D (dBd)	0.00	−2.20	−13.00	−2.20	−13.00	−2.20
Effective antenna aperture	A_a (dBm^2)	−5.32	−7.52	−18.32	−7.52	−18.32	−7.52
Feeder-loss	L_c (dB)	2.00	0.00	0.00	0.00	0.00	0.40
Minimum power flux-density at receiving place	φ_{min} (dBW/m^2)	−135.35	−129.15	−118.35	−129.15	−118.35	−130.55
Minimum field-strength level at receiving antenna	E_{min} (dB(μV/m))	10.41	16.61	27.41	16.61	27.41	15.21
Allowance for man-made noise	P_{mmn} (dB)	3.62	3.62	0.00	3.62	0.00	3.62
Antenna height loss	L_h (dB)	0.00	12.00	19.00	12.00	19.00	12.00
Building penetration loss	L_b (dB)	0.00	9.00	9.00	0.00	0.00	0.00
Location probability	%	*70*	*95*	*95*	*95*	*95*	*99*
Distribution factor	μ	*0.52*	*1.64*	*1.64*	*1.64*	*1.64*	*2.33*
Standard deviation of DRM field strength	σ_m (dB)	*4.19*	*4.19*	*4.19*	*4.19*	*4.19*	*3.49*
Standard deviation of MMN	σ_{MMN} (dB)	*4.53*	*4.53*	*0.00*	*4.53*	*0.00*	*4.53*
Standard deviation of building penetration loss	σ_b (dB)	*0.00*	*3.00*	*3.00*	*0.00*	*0.00*	*0.00*
Location correction factor	C_l (dB)	3.24	11.29	8.48	10.15	6.89	13.31
Minimum median field-strength level	**E_{med} (dB(μV/m))**	**17.26**	**52.52**	**63.89**	**42.38**	**53.30**	**44.13**

TABLE 44

Minimum median field-strength level E_{med} for 16-QAM, R = 1/2 in VHF Band III

DRM modulation		16-QAM. R = 1/2					
Receiving situation		FX	PI	PI-H	PO	PO-H	MO
Minimum receiver input power level	$P_{s, min}$ (dBW)	−136.08	−128.58	−128.58	−128.58	−128.58	−131.18
Antenna gain	G_D (dBd)	0.00	−2.20	−13.00	−2.20	−13.00	−2.20
Effective antenna aperture	A_a (dBm^2)	−5.32	−7.52	−18.32	−7.52	−18.32	−7.52
Feeder-loss	L_c (dB)	2.00	0.00	0.00	0.00	0.00	0.40
Minimum power flux-density at receiving place	φ_{min} (dBW/m^2)	−128.75	−121.05	−110.25	−121.05	−110.25	−123.25
Minimum field-strength level at receiving antenna	E_{min} (dB(μV/m))	17.01	24.71	35.51	24.71	35.51	22.51
Allowance for man-made noise	P_{mmn} (dB)	3.62	3.62	0.00	3.62	0.00	3.62
Antenna height loss	L_h (dB)	0.00	12.00	19.00	12.00	19.00	12.00
Building penetration loss	L_b (dB)	0.00	9.00	9.00	0.00	0.00	0.00
Location probability	%	*70*	*95*	*95*	*95*	*95*	*99*
Distribution factor	μ	*0.52*	*1.64*	*1.64*	*1.64*	*1.64*	*2.33*
Standard deviation of DRM field strength	σ_m (dB)	*4.19*	*4.19*	*4.19*	*4.19*	*4.19*	*3.49*
Standard deviation of MMN	σ_{MMN}(dB)	*4.53*	*4.53*	*0.00*	*4.53*	*0.00*	*4.53*
Standard deviation of building penetration loss	σ_b (dB)	*0.00*	*3.00*	*3.00*	*0.00*	*0.00*	*0.00*
Location correction factor	C_l (dB)	3.24	11.29	8.48	10.15	6.89	13.31
Minimum median field-strength level	**E_{med} (dB(μV/m))**	**23.86**	**60.62**	**71.99**	**50.48**	**61.40**	**51.43**

7 Position of DRM frequencies

The DRM system is designed to be used at any frequency with variable channelization constraints and propagation conditions throughout these bands.

For VHF Band I and VHF Band II the DRM centre frequencies are positioned in 100 kHz distance according to the FM frequency grid in VHF Band II. The nominal carrier frequencies are, in principle, integral multiples of 100 kHz. The DRM system is designed to be used with this raster.

For VHF Band III, the DRM centre frequencies are positioned in 100 kHz distance beginning by 174.05 MHz and integral multiples of 100 kHz up to the end of VHF Band III.

8 Unwanted emissions

8.1 Out-of-band spectrum mask

The power density spectrum at the transmitter output is important to determine the adjacent channel interference.

8.1.1 VHF Band I and VHF Band II

An out-of-band spectrum mask for DRM in VHF Band I and VHF Band II, respectively, is given in Figure 11 and Table 45, together with the vertices of the symmetric out-of-band spectrum mask for

FM transmitters[4] as minimum transmitter requirement, defined for a resolution bandwidth (RBW) of 1 kHz.

FIGURE 11

Out-of-band spectrum masks for FM in VHF Band II and DRM in VHF Bands I and II

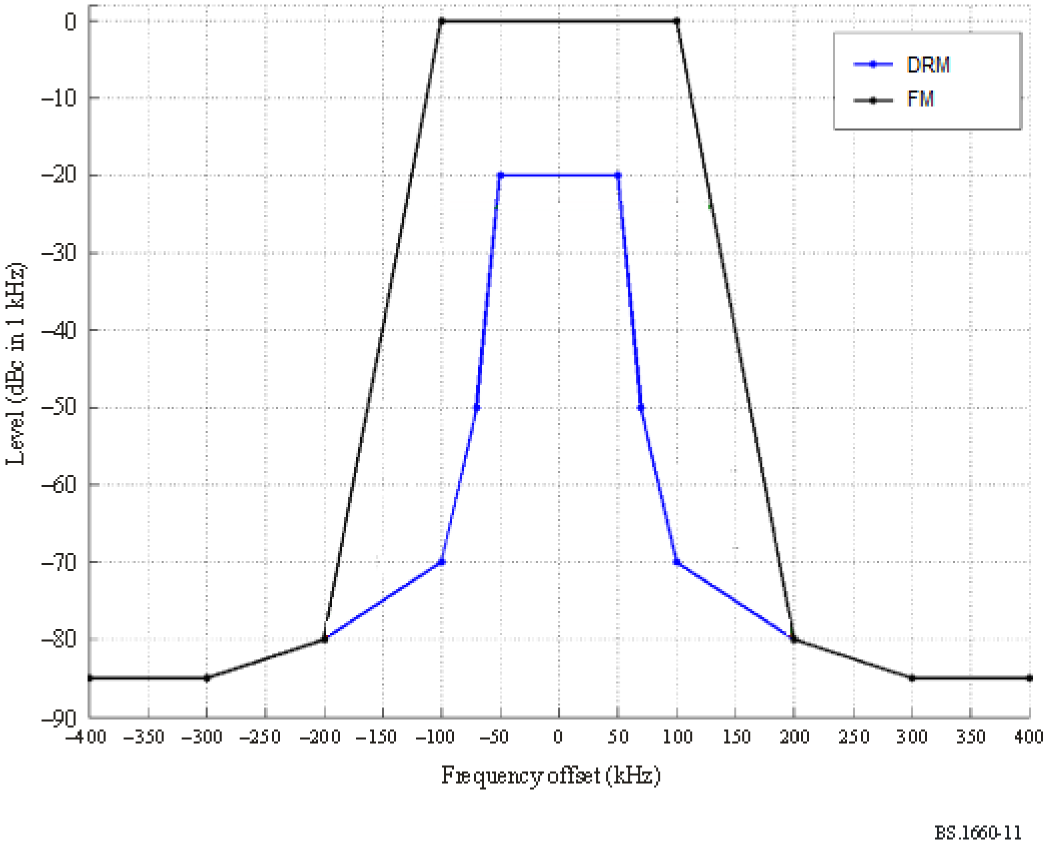


TABLE 45

Out-of-band spectrum masks for FM in VHF Band II and DRM in VHF Bands I and II

Spectrum mask (100 kHz channel)/ relative level for FM		Spectrum mask (100 kHz channel)/ relative level for DRM	
Frequency offset (kHz)	**Level (dBc)/(1 kHz)**	**Frequency offset (kHz)**	**Level (dBc)/(1 kHz)**
0	0	0	−20
±50	0	±50	−20
±70	0	±70	−50
±100	0	±100	−70
±200	−80	±200	−80
±300	−85	±300	−85
±400	−85	±400	−85

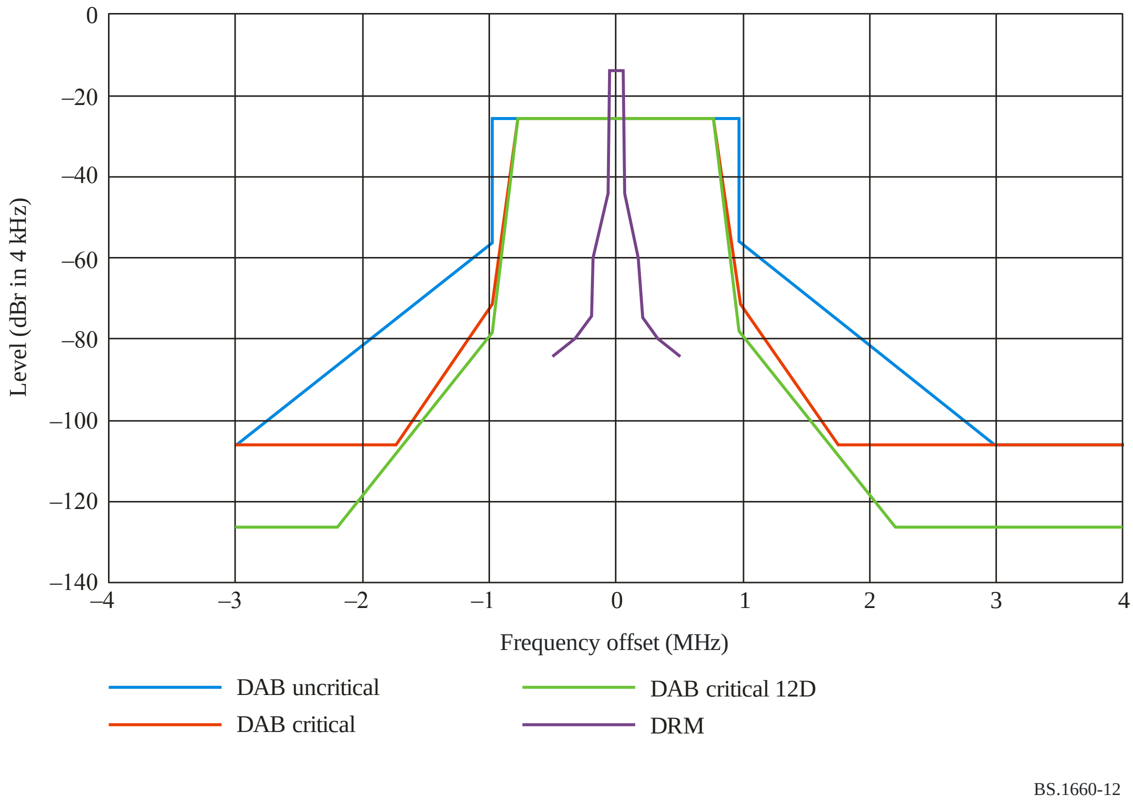
4 Given in ETSI EN 302 018-2; Electromagnetic compatibility and Radio spectrum Matters (ERM); Transmitting equipment for the Frequency Modulated (FM) sound broadcasting service.

8.1.2 VHF Band III

An out-of-band spectrum mask for DRM in VHF Band III is given in Fig. 12 and Table 46, together with the vertices of the symmetric out-of-band spectrum masks for DAB transmitters[5] as minimum transmitter requirement, defined for a resolution bandwidth (RBW) of 4 kHz. Thus the value of −14 dBr results for DRM.

FIGURE 12

Out-of-band spectrum masks for DAB and DRM in VHF Band III



5 Given in Recommendation ITU-R BS.1660-3 – Technical basis for planning of terrestrial digital sound broadcasting in the VHF band.

TABLE 46

Out-of-band spectrum masks for DAB and DRM in VHF Band III

Spectrum mask (1.54 MHz channel)/ relative level for DAB (in 4 kHz)			
Frequency offset (MHz)	**Level (dBc) (uncritical cases)**	**Level (dBc) (critical cases)**	**Level (dBc) (critical cases/12D)**
±0.77	–	–26	–26
< ±0.97	–26	–	–
±0.97	–56	–71	–78
±1.75	–	–106	–
±2.2	–	–	–126
±3.0	–106	–106	–126

Spectrum mask (100 kHz channel)/ relative level for DRM (in 4 kHz)	
Frequency offset (kHz)	**Level (dBc)**
0	–14
±50	–14
±60	–44
±181.25	–59
±200	–74
±300	–79
±500	–84

8.2 Protection ratios

The minimum acceptable ratio between a wanted signal and interfering signals to protect the reception of the wanted signal is defined as the protection ratio *PR* (dB). The values of protection ratios are given as:

– **Basic protection ratio** PR_{basic} for a wanted signal interfered with by an unwanted signal at 50% location probability.

– **Combined location correction factor** *CF* (dB) as a margin that has to be added to the basic protection ratio for a wanted signal interfered with by an unwanted signal for the calculation of protection ratios at location probability greater than 50%. The equation for the calculation is given in § 3.8.3.

– **Corresponding protection ratio** *PR*(*p*) for a wanted digital signal interfered with by an unwanted signal at location probability greater than 50%, taking into account the respective location probability of the corresponding reception modes that have higher protection requirements due to the higher location probability to be protected, and the combined location correction factor *CF* (dB) which is therefore required.

8.2.1 Protection ratios for DRM

8.2.1.1 DRM interfered with by DRM

The basic protection ratio PR_{basic} for DRM is valid for all VHF bands, see Table 47. For the standard deviation of DRM differs in the respective VHF bands the corresponding protection ratios *PR*(*p*), see Table 48 for 4-QAM and Table 49 for 16-QAM, are different in the respective VHF bands.

TABLE 47

Basic protection ratios PR_{basic} for DRM interfered with by DRM

Frequency offset (kHz)		0	±100	±200
DRM (4-QAM, R = 1/3)	PR_{basic} (dB)	4	−16	−40
DRM (16-QAM, R = 1/2)	PR_{basic} (dB)	10	−10	−34

TABLE 48

Corresponding protection ratios $PR(p)$ to reception modes for DRM (4-QAM. R = 1/3) interfered with by DRM

Reference frequency band		65 MHz VHF Band I		
Frequency offset (kHz)		0	±100	±200
Fixed reception (FX)	$PR(p)$ (dB)	6.64	−13.36	−37.36
Portable reception (PO, PI, PO-H, PI-H)	$PR(p)$ (dB)	12.27	−7.73	−31.73
Mobile reception (MO)	$PR(p)$ (dB)	13.40	−6.60	−30.60

Reference frequency band		100 MHz VHF Band II		
Frequency offset (kHz)		0	±100	±200
Fixed reception (FX)	$PR(p)$ (dB)	6.82	−13.18	−37.18
Portable reception (PO, PI, PO-H, PI-H)	$PR(p)$ (dB)	12.84	−7.16	−31.16
Mobile reception (MO)	$PR(p)$ (dB)	14.20	−5.80	−29.80

Reference frequency band		200 MHz VHF Band III		
Frequency offset (kHz)		0	±100	±200
Fixed reception (FX)	$PR(p)$ (dB)	7.11	−12.89	−36.89
Portable reception (PO, PI, PO-H, PI-H)	$PR(p)$ (dB)	13.75	−6.25	−30.25
Mobile reception (MO)	$PR(p)$ (dB)	15.49	−4.51	−28.51

TABLE 49

Corresponding protection ratios *PR*(*p*) to reception modes for DRM (16-QAM. *R* = 1/2) interfered with by DRM

Reference frequency band		65 MHz VHF Band I		
Frequency offset (kHz)		0	±100	±200
Fixed reception (FX)	*PR*(*p*) (dB)	12.64	−7.36	−31.36
Portable reception (PO, PI, PO-H, PI-H)	*PR*(*p*) (dB)	18.27	−1.73	−25.73
Mobile reception (MO)	*PR*(*p*) (dB)	19.40	−0.60	−24.60

Reference frequency band		100 MHz VHF Band II		
Frequency offset (kHz)		0	±100	±200
Fixed reception (FX)	*PR*(*p*) (dB)	12.82	−7.18	−31.18
Portable reception (PO, PI, PO-H, PI-H)	*PR*(*p*) (dB)	18.84	−1.16	−25.16
Mobile reception (MO)	*PR*(*p*) (dB)	20.20	0.20	−23.80

Reference frequency band		200 MHz VHF Band III		
Frequency offset (kHz)		0	±100	±200
Fixed reception (FX)	*PR*(*p*) (dB)	13.11	−6.89	−30.89
Portable reception (PO, PI, PO-H, PI-H)	*PR*(*p*) (dB)	19.75	−0.25	−24.25
Mobile reception (MO)	*PR*(*p*) (dB)	21.49	1.49	−22.51

8.2.1.2 DRM interfered with by FM in VHF Band II

The basic protection ratio PR_{basic} for DRM interfered with by FM in VHF Band II is given in Table 50. The values for the corresponding protection ratios *PR*(*p*), are given in Table 51 for 4-QAM and in Table 52 for 16-QAM, respectively.

TABLE 50

Basic protection ratios PR_{basic} for DRM interfered with by FM

Frequency offset (kHz)		0	±100	±200
DRM (4-QAM. *R* = 1/3) interfered with by FM (stereo)	PR_{basic} (dB)	11	−13	−54
DRM (16-QAM. *R* = 1/2) interfered with by FM (stereo)	PR_{basic} (dB)	18	−9	−49

TABLE 51

Corresponding protection ratios *PR*(*p*) to reception modes for DRM (4-QAM. *R* = 1/3) interfered with by FM stereo

Frequency offset (kHz)		0	±100	±200
Fixed reception (FX)	PR(p) (dB)	15.79	−8.21	−49.21
Portable reception (PO, PI, PO-H, PI-H)	PR(p) (dB)	26.02	2.02	−38.98
Mobile reception (MO)	*PR*(*p*) (dB)	31.61	7.61	−33.39

TABLE 52

Corresponding protection ratios *PR*(*p*) to reception modes for DRM (16-QAM. *R* = 1/2) interfered with by FM stereo

Frequency offset (kHz)		0	±100	±200
Fixed reception (FX)	PR(p) (dB)	22.79	−4.21	−44.21
Portable reception (PO, PI, PO-H, PI-H)	PR(p) (dB)	33.02	6.02	−33.98
Mobile reception (MO)	*PR*(*p*) (dB)	38.61	11.61	−28.39

8.2.1.3 DRM interfered with by DAB in VHF Band III

The basic protection ratio PR_{basic} for DRM interfered with by DAB in VHF Band III is given in Table 53. The values for the corresponding protection ratios *PR*(*p*), are given in Table 54 for 4-QAM and in Table 55 for 16-QAM, respectively.

TABLE 53

Basic protection ratios PR_{basic} of DRM interfered with by DAB

Frequency offset (kHz)		0	±100	±200
Basic protection ratio for DRM (4-QAM. R = 1/3)	PRbasic (dB)	−7	−36	−40
Basic protection ratio for DRM (16-QAM. *R* = 1/2)	PR_{basic} (dB)	−2	−18	−40

TABLE 54

Corresponding protection ratios *PR*(*p*) to reception modes for DRM (4-QAM. *R* = 1/3) interfered with by DAB

Frequency offset (kHz)		0	±100	±200
Fixed reception (FX)	*PR*(*p*) (dB)	−3.37	−32.37	−50.37
Portable reception (PO, PI, PO-H, PI-H)	*PR*(*p*) (dB)	4.37	−24.63	−42.63
Mobile reception (MO)	*PR*(*p*) (dB)	8.16	−20.84	−38.84

TABLE 55

Corresponding protection ratios *PR*(*p*) to reception modes for DRM (16-QAM. *R* = 1/2) interfered with by DAB

Frequency offset (kHz)		0	±100	±200
Fixed reception (FX)	*PR*(*p*) (dB)	1.63	−14.37	−45.37
Portable reception (PO, PI, PO-H, PI-H)	*PR*(*p*) (dB)	9.37	−6.63	−37.63
Mobile reception (MO)	*PR*(*p*) (dB)	13.16	−2.84	−33.84

8.2.1.4 DRM interfered with by DVB-T in VHF Band III

Since the impact mechanism of DAB into DRM is the same as that of DVB-T, it is proposed that the same protection ratios for DRM interfered with by DVB-T in VHF Band III can be assumed as for DRM interfered with by DAB in VHF Band III.

To correct for the lower power spectral density of a DVB-T signal of same field strength compared to a DAB signal, the following correction factors should be applied to the e.r.p. of the interfering signals prior to calculating its field strength:

6.4 dB for a 7 MHz DVB-T signal;

6.9 dB for an 8 MHz DVB-T signal.

8.2.2 Protection ratios for broadcasting systems interfered with by DRM

8.2.2.1 Protection ratios for FM in VHF Band II

The FM signal parameters are given in Recommendation ITU-R BS.412-9. In Annex 5 of Recommendation ITU-R BS.412-9, it is indicated that interferences can be caused by intermodulation of strong FM signals in a frequency offset greater than 400 kHz. This cross-modulation effect from a high interfering signal level in a range up to 1 MHz distance has also to be taken into account when planning OFDM systems into VHF Band II. Therefore not only the protection ratios PR_{basic} in the range of 0 kHz to ±400 kHz are given in Table 56, but also those for ±500 kHz and ±1 000 kHz. The values for 600 kHz to 900 kHz can be interpolated therefrom.

TABLE 56

Basic protection ratios PR_{basic} for FM interfered with by DRM

Frequency offset (kHz)		0	±100	±200	±300	±400	±500	±1 000
Basic protection ratio for FM (stereo)	PR_{basic} (dB)	49	30	3	−8	−11	−13	−21

8.2.2.2 Protection ratios for DAB in VHF band III

The DAB signal parameters are given in Recommendation ITU-R BS.1660-3. T-DAB planning should be able to deal with mobile reception with a location probability of 99%, and with portable indoor reception with a location probability of 95%, respectively[6]. In addition, the values for fixed reception with a location probability of 70% are given.

The basic protection ratio PR_{basic} for DAB interfered with by DRM in VHF Band III is given in Table 57. The values for the corresponding protection ratios $PR(p)$, are given in Table 58.

TABLE 57

Basic protection ratios PR_{basic} for DAB interfered with by DRM

Frequency offset (kHz)		0	±100	±200
Basic protection ratio for T-DAB	PR_{basic} (dB)	10	−40	−40

TABLE 58

Corresponding protection ratios $PR(p)$ to reception modes for DAB interfered with by DRM

Frequency offset (kHz)		0	±100	±200
DAB fixed reception	PR(p) (dB)	13.63	−36.37	−36.37
DAB portable reception	PR(p) (dB)	21.37	−28.63	−28.63
DAB mobile reception	PR(p) (dB)	25.16	−24.84	−24.84

Bibliography

ETSI EN 201 980; Digital Radio Mondiale (DRM); System Specification.

6 Final Acts of the Regional Radiocommunication Conference for planning of the digital terrestrial broadcasting service in parts of Regions 1 and 3, in the frequency bands 174-230 MHz and 470-862 MHz (RRC-06).