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Planning parameters for hand held reception

Concerning the use of DVB-H and T-DMB in Bands III, IV, V and the 1.5 GHz band

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Introduction

Hand-held reception of TV, Audio, IP datacast[1] and multimedia services is a fairly new broadcasting application, in general.

The definition of hand-held receivers is given in [15] (Broadcasting to Hand-helds: Systems and services considerations):

"Hand-held devices ('handhelds' for short) are personal wireless devices, normally of a very small size, similar to that of a mobile phone or PDA (Personal Digital Assistant), with the capability of receiving audiovisual streams and data services, often with facilities for bidirectional voice/data communication."

Two systems for hand-held reception have been derived from the digital terrestrial broadcasting systems T-DAB and DVB-T. These are T-DMB and DVB-H, respectively.

The hand-held reception requirements are different from those of fixed reception (using a roof top antenna) or portable and mobile reception, in terms of its use and with respect to planning. This means that higher field strengths are needed in order to compensate the low antenna gain, lower receiving antenna height and building penetration loss, real mobility, etc, associated with the use of hand-held devices. These negative aspects can in part be compensated by improvements of the link layer. (For example, in the case of DVB-H, forward error correction leads to an improvement in C/N performance, Doppler performance in mobile channels and an improved tolerance to impulse interference[2]; in addition, it is possible to employ the 4k mode for trading off mobility and SFN[3] cell size.

DAB presently provides two variants for transmitting multimedia to mobile and hand-held terminals: DMB and DAB-IP. It can be assumed that the planning criteria for such DAB based systems are very similar. For this reason only T-DMB, as defined by ETSI TS 102 427 and TS 102 428 [21] is covered in the present document.

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[1] IP datacast: broadcasting data using Internet protocol

[2] MPE-FEC (Forward error correction for multi-protocol encapsulated data) is not mandatory for DVB-H

[3] SFN: Single Frequency Network

Recent frequency planning for digital terrestrial broadcasting systems, as given in the RRC-06[1] frequency plan, is based on the characteristics of T-DAB and DVB-T in Band III, and DVB-T in Bands IV/V. Except for mobile reception, hand-held reception has not been taken into account in the RRC-06 planning process.

The harmonised broadcasting frequency bands are 174-230 MHz (Band III) and 470-862 MHz (Bands IV and V). There are no specific frequency (sub-) bands decided for DVB-H and T-DMB planning. T-DMB using T-DAB channel raster is intended for implementation in Band III or in the 1.5 GHz Band. Bands IV and V are earmarked for DVB-H, but Band III and the 1.5 GHz band are also under consideration.

However, in terms of frequency planning, T-DMB and DVB-H systems are different from T-DAB and DVB-T systems, even if they belong, respectively, to the same technology families. Therefore, it is necessary to review the planning criteria and parameters applicable to the new systems, to check to what extent they may be replaced for T-DAB and/or DVB-T in a frequency-planning context, and to evaluate their differences and their impacts in an implementation within the GE06[2] Plan.

This document provides guidance for network planning and implementation aspects for hand-held reception using DVB-H and T-DMB. It provides in particular the planning parameters of the two systems.

The network aspects, including network structures and spectrum requirements of the two systems, and the implementation aspects of the networks using each of the two systems (taking into account the constraints of the GE06 Agreement and Plans), will be dealt with in a separate document.

1. DVB-H and T-DMB Planning parameters

1.1 Reception modes

1.1.1 Portable reception

In the context of this document, portable reception is defined as the reception at rest (stationary reception) or at very low speed (walking speed). Portable reception will, in practice, take place under a great variety of conditions (outdoor, indoor, ground floor and upper floors). In addition, the hand-held receiver will probably be moved (at walking speed) while being viewed. In this document, portable reception is classified into two classes:

- **Class A**: hand-held portable outdoor reception
  - with external (for example telescopic or wired headsets) or integrated antenna
  - at no less than 1.5 m above ground level, at very low speed or at rest
- **Class B**: hand-held portable indoor reception
  - with external (for example telescopic or wired headsets) or integrated antenna
  - at no less than 1.5 m above ground level, at very low speed or at rest
  - on the ground floor in a room with a window in an external wall.

It is assumed that the portable receiver is not moved during reception and large objects near the receiver are also not moved. This does not mean that the transmission channel is static, rather a

[1] RRC-06: ITU Radiocommunications Regional Conference, held in Geneva from 15 May to 16 June 2006. It has produced an Agreement and associated frequency plans for the digital broadcasting services using DVB-T and T-DAB in parts of ITU Regions 1 and 3, in the frequency bands 174-230 MHz and 470-862 MHz

[2] GE06: The Geneva 06 Agreement, resulting from the RRC-06

slowly time-varying channel is assumed. It is also assumed that extreme cases, such as reception in completely shielded rooms, are disregarded.

For the hand-held reception mode, it is often possible to improve reception by moving the receiver position and/or by having an antenna with higher efficiency.

It is to be expected that there will be significant variation of reception conditions for indoor portable reception, also depending on the floor-level at which reception is required. There will also be considerable variation of building penetration loss from one building to another and considerable variation from one part of a room to another. Also, hand-held receivers could suffer from body-absorption/reflection loss in certain circumstances, e.g. file-downloading applications when the receiver is in a pocket. It is to be expected that "portable coverage" will be mainly aimed at urban and suburban areas.

1.1.2 Mobile reception

In the context of this document, mobile reception is comprised of two classes:

- **Class C**: hand-held reception inside a moving vehicle (car, bus etc.)
  - with the receiver connected to the external antenna of the vehicle.
  - at no less than 1.5 m above ground level, at higher speed.
- **Class D**: hand-held reception inside a moving vehicle (e.g. car, bus, etc.)
  - without connexion of the receiver to the external antenna of the vehicle.
  - with external (for example telescopic or wired headsets) or integrated antenna.
  - at no less than 1.5 m above ground level, at higher speed.

It should be noted that body-absorption/reflection losses could also be of importance in Class D under certain circumstances, for example when the terminal is in a pocket and file downloading is underway. However, the present document does not consider this situation.

It is to be expected that there will be significant variation of reception conditions for mobile reception, depending on the environment of the receiver. There might also be considerable variation of entry loss caused by the varying construction of cars and vehicles.

In both cases, it is assumed that the mobile receiver and/or large objects near the receiver may move during the reception. It is also assumed that extreme cases, such as reception in completely shielded vehicles, are disregarded.

1.2 Systems aspects

1.2.1 DVB-H

1.2.1.1 Transmission Modes

In addition to the native DVB-T 2k and 8k FFT[1] sizes, DVB-H has an additional 4k FFT size mode. As the C/N performance is FFT size independent, the new 4k size will offer the same performance as the other two modes in Gaussian, Rice and Rayleigh channels.

The current DVB-T standard can provide satisfactory mobile performance with 2k modes, but with 8k modes the performance is not always satisfactory. On the network planning side, the short guard

[1] FFT: fast Fourier Transform. The 2k, 4k and 8k variants refer to the number of OFDM subcarriers in the digital signal.

interval associated with the 2k mode effectively prevents its usage in the SFN type of planning, where rather large geographical areas are covered with one frequency. For these reasons, a compromise mode lying between the 2k mode and the 8k mode would allow acceptable mobile performance on the receiver side whilst allowing more flexible network architectures. This was the reason for introducing the new 4k mode.

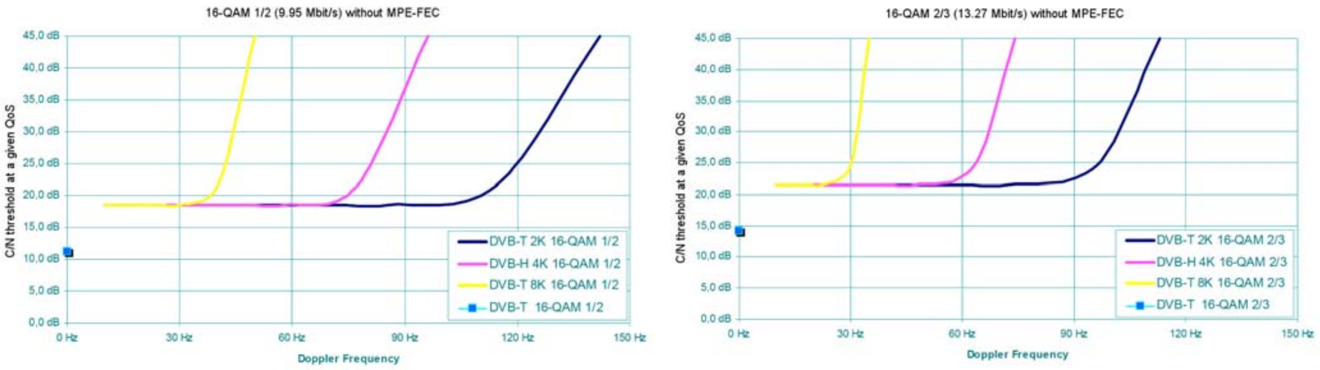

Figure 1.2.1: 4k versus 2k and 8k

Note: The square mark (corresponding to a Doppler Frequency = 0 Hz) indicates the C/N values for a specific static transmission channel, taken as a reference in [8]. This value is not relevant for planning.

Note: As a rule of thumb, if the transmission channel is at 500 MHz, a rough approximation of the corresponding speed in km/h may be obtained by doubling the Doppler frequency, f_d [1].

The 4k mode will provide roughly 2 times better Doppler performance than the 8k mode. By using this rule and performing linear interpolation between the known 2k and 8k modes performance figures of the reference receiver developed in the Motivate project [2], the following figure of the predicted 4k mobile performance can be produced. It shows, for DVB-T-16--QAM-1/2 and -2/3 as examples, how the Doppler performance varies with the FFT size.

Theoretically, in the design of SFNs the acceptable inter-transmitter distance is proportional to the maximum echo delay acceptable by the transmission system, which depends on the guard interval value. For the 4k mode, this distance is 2 times larger than for the 2k mode and half that of the 8k mode.

Table 1.2.1 shows the guard interval lengths in time and how the guard interval values and therefore the size of SFN cells for the 4k mode fall between those of the 2k and 8k modes.

Table 1.2.1: Guard interval lengths for all modes (8 MHz bandwidth)

	2k	4k	8k
1/4	56 µs	112 µs	224 µs
1/8	28 µs	56 µs	112 µs
1/16	14 µs	28 µs	56 µs
1/32	7 µs	14 µs	28 µs

[1] The relation between Speed v and Doppler Frequency f_d is: $v = c\frac{f_d}{F_c}$ where c is the speed of light and F_c is the channel frequency (speeds in m/s and frequencies in Hz). This gives the following relation with more practical units: $v_{[km/h]} = 1080\frac{f_{d[Hz]}}{F_{c[MHz]}}$. It should be noted that this speed corresponds to the worst case of multipath reception in a Rayleigh channel. It always occurs when there is no dominant echo present or in the case of SFN reception.

The remaining impact of the new 4k mode on network planning is minimal, as the 4k mode has similar spectrum mask characteristics and protection ratios as current DVB-T.

The 4k mode used in conjunction with the in-depth interleaver (8k interleaver with 4k and 2k symbols) may have an impact on the impulse interference tolerance as in this case the bits of one symbol are spread over two 4k symbols providing a better time diversity.

1.2.1.2 Minimum C/N requirements

NOTE from ETSI Technical report ETSI TR 102 377 V1.2.1 (2005-11) [1]: The following information for DVB-H is based on early simulations and measurements. It should be considered as preliminary and may change, as more comprehensive information becomes available.

1.2.1.2.1 DVB-H degradation criterion

In DVB-H a suitable degradation criterion is the MPE-FEC[1] frame error rate (MFER), referring to the error rate of the time sliced burst protected with the MPE-FEC. As an erroneous frame will destroy the service reception for the whole interval between the bursts, it is appropriate to fix the degradation point to the frequency of lost frames. Obviously the used burst and IP-parameters will affect the final service quality obtained with certain fixed MFER, but experience has shown that the behaviour is very steep and a very small change in C/N will result in a large change in MFER. MFER is the ratio of the number of erroneous frames (i.e. not recoverable) and total number of received frames. To provide sufficient accuracy, at least 100 frames shall be analysed.

$$\text{MFER[\%]} = \frac{\text{Number of Erroneous Frames x 100}}{\text{Total Number of Frames}}$$

It has been agreed that 5% MFER is used to mark the degradation point of the DVB-H service. Note that the service reception quality at the 5% MFER degradation point may not meet the QoS requirement in all cases. The criterion is nevertheless suitable for measurements, and a small 0.5 dB to 1 dB carrier power increase will improve the reception quality to less than 1% MFER.

1.2.1.2.2 General

In the ETSI guideline [1], the DVB-H C/N-values for Gaussian and static Rayleigh channels are based on theoretical simulated DVB-T values where the measured effect of the MPE-FEC and different degradation point (QEF[2] vs. MFER 5%) has been added. No implementation loss has been included. Therefore, these values are artificial in the context of the present document and may not be used for planning purposes. However, for completeness these figures are given in table 1.2.2.

For the time-variant mobile transmission channel, the ETSI guidelines [1] distinguishes between a “typical” and a “possible” reference receiver. They differ by 1 dB in their C/N values. In the present document the “typical” reference receiver is taken as representative.

The performance is given for the following parameters:

- DVB-H burst bit rate 4 Mbit/s
- MPE-FEC code rate 3/4
- Number of rows in MPE-FEC 1024

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[1] MPE-FEC: multiprotocol encapsulation forward error correction

[2] QEF. Quasi Error free

(The burst size in case MPE-FEC is set directly by the number of rows. With MPE-FEC code rate ¾, 1024 Rows give a burst size of 2 048 kbit = 2 Mbit)

- DVB-T/H bandwidth 7.61 MHz

These parameters will result in approximately 0.5s duration for the time slicing bursts: Burst Duration = Burst size / (Burst bit rate*0.96). The degradation criterion has been set to 5% MFER.

1.2.1.2.3 C/N Performance in a Gaussian channel and in a static Rayleigh channel

The receiver should have the theoretical performance given in Table 1.2.2 when noise (N) is applied together with the wanted carrier (C) in a signal bandwidth of 7.61 MHz. The values are calculated using the theoretical C/N figures given in EN 300 744 [1] and the measured effect of the MPE-FEC. The difference between DVB-T QEF C/N and MFER 5% C/N is assumed to be 1.0 dB in a Gaussian Channel and 1.5 dB in a static Rayleigh channel. An ideal transmitter and receiver are assumed. For a practical receiver, an implementation margin of 2.5 dB should be added to these figures.

Figures for some modulation/code rates are not available for the time being (December 2006).

Table 1.2.2: C/N (dB) in a Gaussian and in a static Rayleigh channel

Modulation	Code rate	Gaussian MPE-FEC CR = 3/4	Static Rayleigh MPE-FEC CR = 3/4
QPSK	1/2	2.5	3.9
QPSK	2/3	4.3	6.9
QPSK	3/4		
16--QAM	1/2	8.3	9.7
16--QAM	2/3	10.4	12.7
16--QAM	3/4		
64--QAM	1/2		
64--QAM	2/3		
64--QAM	3/4		

1.2.1.2.4 C/N performance in Portable and Mobile Channels

The reference receiver model describes the DVB-H receiver performance in an idealized way using two figures, C/N_{min} and F_{d3dB}. C/N_{min} gives the minimum required C/N for MFER 5%. The C/N curve is flat up to high Doppler frequencies, but is not applicable to very low Doppler frequencies F_d < 1/burst duration.

F_{d3dB} gives the Doppler frequency where the C/N requirement has raised 3 dB from the C/N_{min} value. Note that F_{d3dB} is almost equal the F_{dmax}. The schematic behaviour of the reference receiver is shown in figure 1.2.2. The C/N values are given in Table 1.2.3. The implementation margin is already included in these figures.

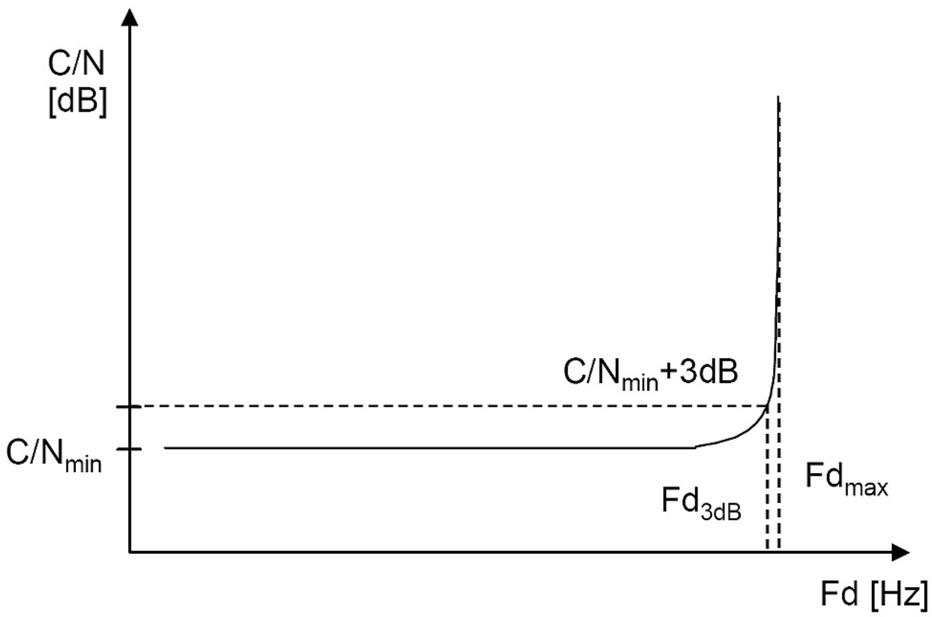

Figure 1.2.2: DVB-H reference receiver C/N behaviour in a Mobile Channel

Using the Typical Urban (TU6) channel model for DVB-H would generally increase the required C/N at lower speed (lower Doppler) corresponding to the portable reception case, compared to the mobile reception case. The reason for this is that the MPE-FEC (time interleaving) is not fully effective due to the low Doppler frequency (at pedestrian speed).

However, measurements within the Wing TV project show that the portable reception channel is less demanding than the TU6 channel model at low Doppler frequencies (see Annex A). Using the portable reception channel model might in fact result in lower C/N values for portable reception than for mobile reception.

Foreseen measurements within the B21C program, based on the portable channel profiles, might therefore call for a later revision of the C/N values currently proposed for portable reception. However since this is still an ongoing process, it has been decided to use the same C/N values for all four reception classes (A-D) for the time being.

For planning of **portable reception** (Class A and B) and **mobile reception** (Class C and D) it is proposed to use the C/N values in table 1.2.3. The values are taken from ETSI implementation guideline TS 102 377 version 1.2.2 [1] for the "typical" reference receiver for mobile reception.

Table 1.2.3: C/N for planning purposes, portable (A, B) and mobile (C, D) reception

Modulation	**Code rate**	**C/N [dB]**	
		Portable (Class A and B)	**Mobile (Class C and D)**
QPSK	1/2	9.5	9.5
QPSK	2/3	12.5	12.5
16--QAM	1/2	15.5	15.5
16--QAM	2/3	18.5	18.5

In Annex A, more comprehensive tables for mobile and portable reception and all MPE-FEC code rates are provided. The table for mobile reception also includes the speed at the maximal Doppler frequency (Fd_{3dB}).

1.2.1.3 Noise figure

The receiver performance is defined according to the reference model shown in figure 1.2.3.

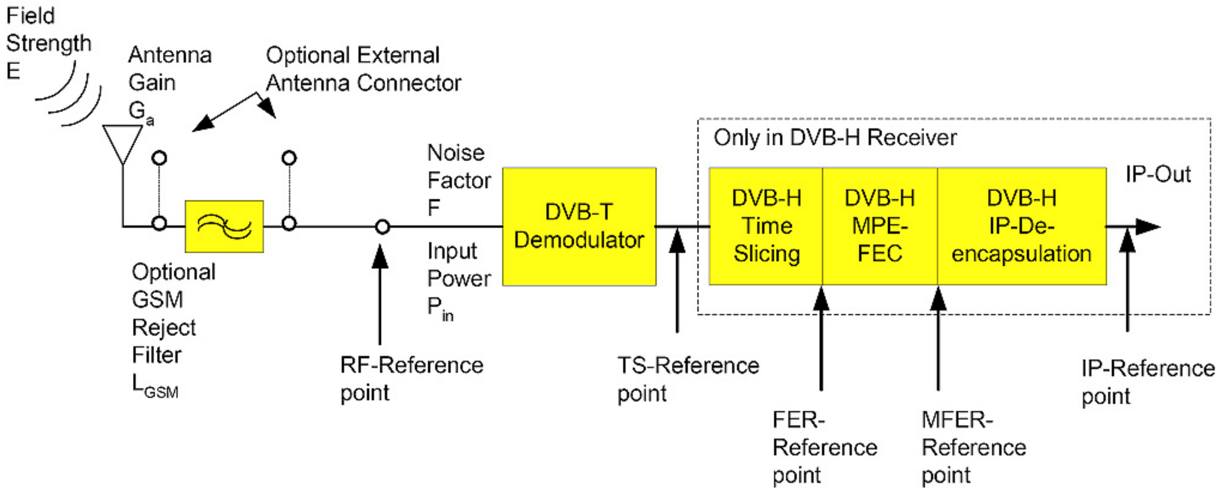

Figure 1.2.3: DVB-H receiver reference model (Extracted from ETSI TR 102 377[1])

All the receiver performance figures are specified at the RF-reference point, which is the input of the receiver. If the DVB-H receiver is combined with a GSM900 mobile handset, in some cases a GSM reject filter must be added in front of the receiver to prevent the high power from the GSM transmitter entering the DVB-H receiver. Typically the insertion loss of the filter L_{GSM} is of the order of 1 dB, raising the overall noise figure to 6 dB at frequencies below 700 MHz. At higher frequencies between 700 and 750 MHz the noise figure will be even higher. However, in the following sections, this value of 6 dB for the noise figure is proposed for planning purposes in all frequency bands, as shown in Table 1.2.4.

Table 1.2.4: Noise figure for DVB-H

	DVB-H in VHF Band III	DVB-H in UHF Band IV/V	DVB-H in Band 1.5 GHz
Noise figure	6 dB	6 dB	6 dB

1.2.2 T-DMB

1.2.2.1 Transmission Modes

The transmission modes, in terms of number of carriers, guard interval and symbol duration are identical to those of the T-DAB system. They are shown in Table 1.2.5 below.

The system provides four transmission mode options that allow for portable and mobile reception in both band III and the 1.5 GHz band. These transmission modes have been designed to cope with Doppler spread and delay spread, for mobile reception in the presence of multi-path echoes.

Table 1.2.5: Characteristics of each transmission mode (T-DAB based)

System Parameter	Transmission Mode			
	I	II	III	IV
Guard interval duration	~246 μs	~62 μs	~31 μs	~123 μs
Useful symbol duration ts	1 ms	250 μs	125 μs	500 μs
Total symbol duration Ts	~1246 μs	~312 μs	~156 μs	~623 μs
No. radiated carriers, N	1536	384	192	768

Nominal maximum transmitter separation for SFN	96 km	24 km	12 km	48 km
Typical frequency	= 375 MHz	= 1.5 GHz	= 3 GHz	= 1.5 GHz

Mode I is most suitable for a terrestrial single-frequency network (SFN) in the VHF Band III because it allows the largest transmitter separations. Mode II will preferably be used for medium-scale SFNs in the 1.5 GHz band. Larger transmitter spacing can be accommodated by inserting artificial delays at the transmitters and by using directive transmitting antennas. Mode III is appropriate for cable, satellite and complementary terrestrial transmission at all frequencies since it can be operated at all frequencies up to 3 GHz for mobile reception, and has the greatest tolerance of phase-noise. Mode IV is also used in the 1.5 GHz band and allows larger transmitter spacing in SFNs. However, it is less resistant to degradation at higher vehicle speeds.

1.2.2.2 Minimum C/N requirements

Since T-DAB uses only one level of error protection (together with deep time interleaving) both in stream mode (SM) and in packet mode (PM), it needs an additional level of error protection for video or data transmission using the MPEG-2 transport stream (TS) or the Internet protocol (IP). This has been implemented in T-DAB by means of the Enhanced Stream Mode and the Enhanced Packet Mode. T-DMB also uses the Enhanced Stream Mode, which, for the same transmission parameters provides coverage for MPEG-2 TS that is about the same as for T-DAB radio services. In view of this, only C/N measurements made for T-DAB are referred to in the following text.

Measurements of the required C/N for T-DAB have been made at the IRT (Institut fur Rundfunktechnik) for both mobile and portable reception using a Typical Urban (TU12) channel model. The required C/N for mobile reception was measured to be 13.5 dB.

For portable reception, i.e. Classes A and B, slow variation of field strength is a major problem and this requires the use of an approximately 3 dB higher minimum C/N value. [17], [18].

Nevertheless, as explained for DVB-H, the portable reception channel is expected to be less demanding than the Typical Urban channel model at low Doppler frequencies. For this reason, it has been decided to use the same C/N values for all reception classes (A-D) for the time being.

Based on the preceding considerations, for planning of **portable reception** (Class A and B) and **mobile reception** (Class C and D) it is proposed to use the C/N values in Table 1.2.6.

Table 1.2.6 Minimum C/N requirements for T-DMB

		T-DMB in VHF Band III	T-DMB in Band 1.5 GHz
D-QPSK 1/2	Class A, B	13.5 dB	13.5dB
	Class C, D	13.5 dB	13.5 dB

In Annex B the IRT measurement results for both mobile and portable reception, using the TU12-channel model, are provided.

1.2.2.3 Noise Figure

The noise figure for Band III is taken to be identical to the T-DAB receiver noise figure cited in the GE06 Agreement [20], as shown in Table 1.2.7. However, the ITU-R Recommendation BT.1368-5 [22] mentions that DVB-T and T-DAB receivers should achieve a noise figure of 5 dB in the near future. The same value is also assumed for T-DMB in the 1.5 GHz Band.

Table 1.2.7: Noise figure for the T-DMB receiver

	T-DMB in VHF Band III	T-DMB in the 1.5 GHz Band
Noise figure	7 dB	7 dB

1.2.3 Diversity receivers

A significant reduction in terms of the required C/N ratio for portable or mobile reception is achieved when using diversity receivers, both for T-DMB and DVB-H. In these receivers, output signals obtained from several antennas are linearly combined using adjustable complex weight factors (MRC, Maximum Ratio Combining), before being decoded using the standard decoding algorithm. This leads to lower minimum field strength values, which allow for the reduction of transmitter powers, or for improvement of the indoor reception for a given transmitter power.

However, the small size of the hand-held receivers does not allow implementing this technique in general. It is more suitable for reception with antennas integrated in a car.

In this document, it is assumed that the planning is made for receivers without diversity reception. However, figures of minimum median equivalent field strength required for diversity receivers could easily be derived from the calculated figures by applying a diversity gain equal to the difference between the C/N without diversity and the C/N with diversity.

1.3 Service planning parameters

1.3.1 Coverage definitions

In defining the coverage area for each reception condition, a three level approach is taken:

Receiving location

- The smallest unit is a receiving location with dimensions of about 0.5 m × 0.5 m. In the case of portable antenna reception, it is assumed that optimal receiving conditions will be found by moving the antenna or by moving the hand-held terminal up to 0.5 m in any direction.
- Such a location is regarded as covered if the required carrier-to-noise and carrier-to-interference values are achieved for 99% of the time.

Small area coverage

- The second level is a "small area" (typically 100 m × 100 m).
- In this small area the percentage of covered location is indicated.
- The coverage of a small area is classified as:
    - ‘Good’, if at least 95% of receiving locations within the area are covered for portable reception and 99% of receiving locations within it are covered for mobile reception.
    - ‘Acceptable’, if at least 70% of receiving locations within the area are covered for portable reception and 90% of receiving locations within it are covered for mobile reception.

Coverage area

- The third level is the coverage area.
    - The coverage area of a transmitter, or a group of transmitters, is made up of the sum of the individual small areas in which a given class of coverage is achieved.

1.3.2 Minimum receiver signal input levels

1.3.2.1 General

To illustrate how the C/N ratio influences the minimum signal input level to the receiver, the latter has been calculated for representative C/N ratios. For other values simple linear interpolation can be applied.

The receiver noise figure is given in sections 1.2.1.3 and 1.2.2.3 for DVB-H and T-DMB respectively. The noise figure is given for all the frequency bands and thus the minimum receiver input signal level is independent of the transmitter frequency. If other noise figures are used in practice, the minimum receiver input signal level will change correspondingly by the same amount.

The minimum receiver input signal levels calculated here are used in section 1.3.3 to derive the minimum power flux densities and corresponding minimum median equivalent field strength values for various frequency bands.

Definitions:

B	: Receiver noise bandwidth [Hz]
C/N	: RF signal to noise ratio required by the system [dB]
F	: Receiver noise figure [dB]
P_n	: Receiver noise input power [dBW]
$P_{s\,min}$	: Minimum receiver signal input power [dBW]
$U_{s\,min}$	: Minimum equivalent receiver input voltage into Z_i [dBμV]
Z_i	: Receiver input impedance (75Ω)

Constants:

k	: Boltzmann's Constant = $1.38 \cdot 10^{-23}$ Ws/K
T_0	: Absolute temperature = 290 K

Formulas used:

$$P_n \text{(in dBW)} = F + 10 \log (k \cdot T_0 \cdot B)$$

$$P_{s\,min} \text{(in dBW)} = P_n + C/N$$

$$U_{s\,min} \text{(in dB}\mu\text{V)} = P_{s\,min} + 120 + 10 \log (Z_i)$$

1.3.2.2 DVB-H with 8 MHz channels

The C/N ratio figures used in the calculation examples, shown in Table 1.3.1, correspond to the following configurations:

C/N = 9.5 dB → QPSK, 1/4 GI (guard interval), 1/2 CR (code rate), MPE-FEC 3/4, portable reception (Classes A and B) and mobile reception (Classes C and D)

C/N = 12.5 dB → QPSK, 1/4 GI, 1/2 CR, MPE-FEC 3/4, portable reception (Classes A and B) and mobile reception (Classes C and D)

C/N = 15.5 dB → 16--QAM, 1/4 GI, 1/2 CR, MPE-FEC 3/4, portable reception (Classes A and B) and mobile reception (Classes C and D)

C/N = 18.5 dB → 16--QAM, 1/4 GI, 1/2 CR, MPE-FEC 3/4, portable reception (Classes A and B) and mobile reception (Classes C and D)

Table 1.3.1: Minimum required input signal level to receiver for 8 MHz versions.

Frequency Band III, IV, V - 8 MHz channels					
Equivalent noise band width	B [Hz]	$7.6*10^6$	$7.6*10^6$	$7.6*10^6$	$7.6*10^6$
Receiver noise figure	F [dB]	6	6	6	6
Receiver noise input power	P_n [dBW]	-129.2	-129.2	-129.2	-129.2
RF signal/noise ratio	**C/N [dB]**	**9.5**	**12.5**	**15.5**	**18.5**
Min. receiver signal input power	$P_{s\ min}$ [dBW]	-119.7	-116.7	-113.7	-110.7
Min. equivalent receiver input voltage, 75Ω	$U_{s\ min}$ [dBμV]	19.1	22.1	25.1	28.1

Note: This table provides a derivation of minimum required signal levels. sections 1.3.3 and 1.3.4 provide information on the minimum median values of signal levels required in practical situations.

For other channel bandwidths B' (5, 6 or 7 MHz), the figures of minimum required signal power and voltage could be derived from Table 1.3.1 by adding the correction factor 10 log (B'/8).

1.3.2.3 T-DMB

The C/N ratio figures used in the calculation examples below correspond to the following configurations:

C/N = 13.5 dB → D-QPSK, 1/4 GI, 1/2 CR, portable reception (Classes A and B) and mobile reception (Classes C and D)

Table 1.3.2: Minimum required input signal level to receiver for 1.712 MHz.

Frequency Band III, 1.712 MHz channels		
Equivalent noise band width	B [Hz]	$1.536*10^6$
Receiver noise figure	F [dB]	7
Receiver noise input power	P_n [dBW]	-135.1
RF signal/noise ratio	C/N [dB]	13.5
Min. receiver signal input power	$P_{s\ min}$ [dBW]	-121.6
Min. equivalent receiver input voltage, 75 Ω	$U_{s\ min}$ [dBμV]	17.1

Note: This table provides a derivation of minimum required signal levels. §§ 1.3.3 and 1.3.4 provide information on the minimum median values of signal levels required in practical situations.

1.3.3 Signal levels for planning

1.3.3.1 General

In § 1.3.2 the minimum signal levels to overcome noise are given as the minimum receiver input power and the corresponding minimum equivalent receiver input voltage. No account is taken of any propagation effects. However, it is necessary to consider these effects when considering reception in a practical environment, especially in a mobile/portable environment.

In defining coverage, it is indicated that due to the very rapid transition from near perfect to no reception at all, it is necessary that the minimum required signal level is achieved at a high percentage of locations. These percentages have been set at 95 for "good" and 70 for "acceptable" portable reception. For mobile reception the percentages defined were 99 and 90, respectively.

The minimum median power flux densities and equivalent field strengths are calculated for:

a) Four different conditions for portable and mobile reception:

1) Hand-held portable outdoor reception = Class A.
2) Hand-held portable indoor reception at ground floor = Class B.
3) Mobile vehicular reception = Class C.
4) Hand-held mobile reception (i.e. terminals are used within a moving vehicle) = Class D.

b) Four frequencies representing Bands III, IV, V and 1.5 GHz:

1) Band III: 200 MHz
2) Band IV: 500 MHz
3) Band V: 800 MHz
4) 1.5 GHz Band: 1500 MHz

c) Representative C/N ratios:

Representative C/N values are used for these examples, as explained in § 1.3.2. Results for other system variants may be obtained by applying the difference of C/N to the minimum median power flux density and the minimum median equivalent field strength, provided that the same channel bandwidth and the same frequency are used.

d) Combinations System/Channel bandwidth/Frequency band

Calculations are made for the following combinations:

DVB-H / 7 MHz / Band III

DVB-H / 8 MHz / Band IV

DVB-H / 8 MHz / Band V

DVB-H / 5 MHz / Band 1.5 GHz

T-DMB / 1.712 MHz / Band III

T-DMB / 1.712 MHz / Band 1.5 GHz

All minimum median equivalent field strength values presented in this clause are for coverage by a single transmitter only, not for Single Frequency Networks.

To calculate the minimum median power flux density or equivalent field strength needed to ensure that the minimum values of signal level can be achieved at the required percentage of locations, the following formulas are used:

ϕ_{min} = $P_{s\,min} - A_a$

E_{min} = $\phi_{min} + 120 + 10 \log_{10} (120\pi) = \phi_{min} + 145.8$

ϕ_{med} = $\phi_{min} + P_{mmn} + C_l + L_h$ (For Classes A and C)

ϕ_{med} = $\phi_{min} + P_{mmn} + C_l + L_h + L_b$ (For Class B)

ϕ_{med} = $\phi_{min} + P_{mmn} + C_l + L_h + L_v$ (For Class D)

E_{med} = $\phi_{med} + 120 + 10 \log_{10} (120\pi) = \phi_{med} + 145.8$

where:

C/N : RF signal to noise ratio required by the system [dB]

ϕ_{min} : Minimum power flux density at receiving place [dBW/m^2]

E_{min} : Equivalent minimum field strength at receiving place [dBμV/m]

L_h : Height loss (10 m a.g.l. - above ground level - to 1.5 m a.g.l.) [dB]

L_b : Building penetration loss [dB]

L_v : Vehicle entry loss [dB]

P_{mmn} : Allowance for man-made noise [dB]

C_l : Location correction factor [dB]

ϕ_{med} : Minimum median power flux density, planning value [dBW/m^2]

E_{med} : Minimum median equivalent field strength, planning value [dBμV/m]

A_a : Effective antenna aperture [dBm^2] [$A_a = G_{iso} + 10\log_{10}(\lambda^2/4\pi)$]. G_{iso} is the antenna gain relative to an isotropic antenna.

$P_{s\,min}$: Minimum receiver input power [dBW]

For calculating the location correction factor C_l a log-normal distribution of the received signal is assumed.

C_l = $\mu * \sigma$

Where:

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

σ : the standard deviation taken as 5.5 dB for outdoor reception. See section 1.3.3.6 for σ values appropriate for indoor reception.

While the matters dealt with in this section are generally applicable, additional special considerations are needed in the case of SFNs where there is more than one wanted signal contribution.

1.3.3.2 Antenna gains

The same figures of antenna gains apply for Class A, B and D reception, as all relate to antenna in a small hand-held terminal. In Class C reception a vehicular built-in antenna is used with a greater gain than for hand-held terminals. The practical standard antenna for vehicle reception is λ/4 monopole which uses the metallic roof as ground plane. The antenna gain for conventional incident wave angles depends on the position of the antenna on the roof. The figures used for planning relate to passive antenna systems.

Generally, no polarization discrimination can be expected from this type of portable or mobile reception antenna and the radiation pattern in the horizontal plane is omni-directional.

Band III:

Different manufacturers provide information about the gain of their antennas in different ways. It is therefore important to distinguish between three antenna types: integrated, external (for example telescopic antennas or the cable of wired headsets) and adapted antennas. The value for the integrated antenna is based on measurements made at the IRT (Institut fur Rundfunktechnik). The external antenna is better matched to the wavelength, therefore the improvement of the antenna gain is assumed to be 4 dB.

Bands IV and V:

The antenna in a small hand-held terminal has to be an integral part of the terminal construction and will therefore be small when compared to the relevant wavelength. If the antenna has to cover the whole wide tuning range of the UHF band, it probably has to be matched with a tuneable matching circuit. The resistive part of antenna impedance (radiation resistance), which is to be matched to the receiver input impedance, will be rather small due to the small size of the antenna (< 1/10). This leads to rather high losses and to a low overall efficiency. Moreover in this type of terminal the ground plane acts as a radiator. However even the size of the radiating ground plane is small when compared to the wavelength, resulting in low radiation efficiency.

Another issue is the influence of the user on the radiation characteristic of the antenna. Depending on the relative position of the user to the hand-held terminal, the human body can act as an absorber or as a reflector.

Current understanding of the overall design problem indicates that a typical antenna gain at the lowest UHF-band frequencies would be in the order of -10 dBi (-12.2 dBd) increasing to -5 dBi (-7.2 dBd) at the upper end of the UHF-band. The nominal antenna gain between these frequencies can be obtained by linear interpolation.

External antennas can improve reception. Hand-held terminals with external antenna gain may dramatically reduce the network complexity/cost requirements, while guaranteeing at the same time the customer satisfaction for the technical service quality.

In the case where GSM 900 is used in a convergence terminal, the usable frequency range is limited to channels below 55 (750 MHz) due to interoperability considerations. If GSM 900 is not used, this limitation does not apply.

1.5 GHz Band:

According to [16], achievable antenna gains at 1.5 GHz are around -4dBd (max gain) for an integrated antenna, with an external antenna typically -1 dBd.

For an adapted antenna, the figure used is 0 dBd, taken from BPN 003 [9]

For planning purposes the values shown in Table 1.3.4 will be used for the different bands and environment classes.

Table 1.3.4: Antenna gain in dBd for the different bands and for the different reception classes.

	Gain (dBd)				
	Band III	**Band IV**	**Band V**	**1.5 GHz Band**	**Classes**
Integrated antenna	-17 dBd	-12	-7	-4	A, B, D
External antenna)(*)	-13 dBd	-8	-3	-1	A, B, D
Adapted antenna	-2.2 dBd	0	0	0	C

(*) Telescopic or wired headsets

1.3.3.3 Man-Made Noise (MMN)

IRT measurements of man-made noise in Band III [13] have shown much higher values than those assessed in the RRC-06 report [6] (8 dB instead of 2 dB in urban areas), affecting Class C (Mobile reception using an adapted antenna). On the other hand the effect of man-made noise in the receiving environment is affected by the negative antenna gain of the hand-helds. The full man-made noise values are only valid for antennas with a gain greater than 0 dBi (-2.2 dBd). For antennas with a gain less than 0 dBi it is important to distinguish between the pure antenna gain and the efficiency of the antenna. The efficiency of the antenna reduces all received signals equally, also the man-made noise. Due to this, the relevant value for calculation purposes is reduced. In Annex C the treatment of man-made noise for negative isotropic antenna gains is further described.

The allowance for man-made noise for Bands IV and V is usually taken to be negligible. However, according to measurement [1], an allowance of 1 dB is specified for Bands IV and V in urban areas for adapted antennas.

For planning purposes, the figures in Tables 1.3.5 and 1.3.6 are used.

Table 1.3.5: Allowance for man-made noise used in the calculation for urban areas

Urban	Band III	Bands IV, V	1.5 GHz Band	Class
Allowance for man-made noise:				
Relevant value for integrated antenna	0 dB	0 dB	0 dB	A, B, D
Relevant value for external antenna (*)	1 dB	0 dB	0 dB	A, B, D
Relevant value for adapted antenna	8 dB	1 dB	0 dB	C

(*) Telescopic or wired headsets

Table 1.3.6: Allowance for man-made noise used in the calculation for rural areas

Rural	Band III	Bands IV, V	1.5 GHz Band	Class
Allowance for man-made noise:				
Relevant value for integrated antenna	0 dB	0 dB	0 dB	A, B, D
Relevant value for external antenna (*)	0 dB	0 dB	0 dB	A, B, D
Relevant value for adapted antenna	5 dB	0 dB	0 dB	C

(*) Telescopic or wired headsets

The difference between the man-made noise values for residential and rural areas in ITU Rec. P. 372-8 is 2-3 dB. It seems reasonable to apply this difference also to the new man-made noise values here. Therefore the rural MMN value for adapted antennas in Band III is assumed to be 5 dB, in Band IV/V 0 dB. The corresponding relevant values for external and integrated antennas are 0 dB in all bands.

It may be noted that there are lower MMN values for rural areas in accordance with NTIA Report 02-390 and document EBU/CPRT 008 Rev 1 -24 May 2004.

1.3.3.4 Height Loss

For portable reception, the antenna height of 10 m above ground level, generally used for planning purposes, is not representative and a correction factor needs to be introduced based on a receiving antenna near ground floor level. For this reason a receiving antenna height of 1.5 m above ground level (outdoor) or above floor level (indoor) has been assumed.

The propagation prediction method of ITU-R Recommendation R.1546 [5] uses a receiving height that corresponds to the height of the surrounding clutter (buildings etc.). To correct the predicted values for a receiving height of 1.5 m above ground level a factor called "height loss" has been introduced.

However, the height loss can also be specified for different types of receiving environments. CEPT document [7] provides the height loss values for some type of environments.

For planning purposes the values in Table 1.3.7 could be used for the different bands and environment classes.

Table 1.3.7: Height loss for the different bands and environment classes.

	Receiving antenna height loss (dB)			
	Band III	**Band IV**	**Band V**	**1.5 GHz Band**
Urban	19	23	24	27
Suburban	12	16	18	21
Rural	12	16	17	19

The height loss values are based on the ITU-R Rec. P.1546 [5].

The height loss may also depend on the distance between the transmitter and the receiver, which makes it variable with the size of the coverage area. Therefore, in this document the figures of minimum median equivalent field strength are calculated at 1.5 m a.g.l. The values of height loss given in this section could be used to derive the minimum median equivalent field strength corresponding to the height of the surrounding clutter (buildings etc.). Further investigations about the height loss are, however, needed.

1.3.3.5 Penetration Loss

Portable reception will take place at outdoor and indoor locations but also within moving objects such as cars or other vehicles. The field strength at indoor locations will be attenuated significantly by an amount depending on the materials and the construction of the building. A large spread of building penetration losses and entry losses for moving objects is to be expected.

For planning purposes, the present document assumes the values shown in Table 1.3.8 for Class B (portable indoor).

Table 1.3.8: Building penetration loss

Band	Class B	
	Median value	Standard deviation
Band III	9 dB	3 dB
Bands IV/V	11 dB	6 dB
1.5 GHz Band	11 dB	6 dB

For Band III, the values are taken from the GE06 Final Acts [6].

For Bands IV and V, the values are taken from the ETSI DVB-H implementation guidelines [1], (where further information on building penetration loss can be found.)

For the 1.5 GHz Band the same values as for Bands IV/V are taken.

For Class D (mobile inside), the values shown in Table 1.3.9 are used in the calculations:

Table 1.3.9: Vehicle (car) penetration loss

Band	Class D	
	Median value	Standard deviation
Band III	8 dB	2 dB
Bands IV/V	8 dB	2 dB
1.5 GHz Band	8 dB	2 dB

These values come from a study presented in [19] which shows in-car penetration losses of 8 dB with an associated standard deviation of 2 – 3 dB, based on measurements at 800 MHz.

Furthermore, it is expected that the value of 8 dB will not be sufficient for estimating penetration loss into trains.

Due to the lack of investigations concerning the car entry loss and its variation with the frequency, the same value is taken for all Bands III, IV/V and 1.5 GHz. Further studies are needed on this subject.

1.3.3.6 Body absorption/reflection loss

Another issue is the influence of the user on the radiation characteristic of the antenna. Depending on the relative position of the user to the hand-held terminal, the human body could act as an absorber or a reflector. This could cause additional loss to the signal. However, due to lack of information on this subject, no account of this loss is taken in the planning parameters.

1.3.3.7 Location percentage

(a) Signal level variations

Field strength variations can be divided into macro-scale and micro-scale variations. The macro-scale variations relate to areas with linear dimensions of 10 m to 100 m or more and are mainly caused by shadowing, reflection and scattering. The micro-scale variations relate to areas with dimensions in the order of a wavelength and are mainly caused by multi-path reflections from nearby objects. The effect of micro-scale fading is normally taken into account by an appropriate C/N value for the transmission channel under consideration. Moreover, as it may be assumed that for portable reception the position of the antenna can be optimized within the order of a wavelength, micro-scale variations will not be too significant for planning purposes.

Macro-scale variations of the field strength are very important for coverage assessment. In general, a high target percentage for coverage would be required to compensate for the rapid failure rate of digital TV signals. Therefore an extra correction is required to the value derived from a field strength prediction that applies to 50% of locations.

(b) Location percentage requirements at outdoor locations (Class A)

ITU-R Recommendation P.1546 [5] gives a standard deviation for wide band signals of 5.5 dB. This value is used here for determining the location correction factor for outdoor locations for all Bands III, IV/V and 1.5 GHz.

Table 1.3.10: Macro-scale variation for portable outdoor reception: Coverage targets and location correction factors

Class A, all bands	
Coverage target	Location correction factor (dB)
> 70%	3
> 95%	9

(c) Location percentage requirements at indoor locations (Class B)

The location correction factor at indoor locations is the combined result of the outdoor variation and the variation factor due to building attenuation. These distributions are expected to be uncorrelated. The standard deviation of the indoor field strength distribution can therefore be calculated by taking the root of the sum of the squares of the individual standard deviations. As a consequence, the location variation of the field strength is increased for indoor reception.

In Band III, where the macro-scale standard deviations are 5.5 dB and 3 dB (§ 1.3.3.5), respectively, the combined value is 6.3 dB.

In Bands IV/V and at 1.5 GHz, where the macro-scale standard deviations are 5.5 dB and 6 dB (§ 1.3.3.5), respectively, the combined value is 8.1 dB.

The resultant location correction factors at indoor locations for the different bands are given in Table 1.3.11.

Table 1.3.11: Macro-scale variation for portable indoor reception: Coverage targets and location correction factors

	Class B	
	Location correction factor (dB)	
Coverage target	Band III	Bands IV/V and 1.5 GHz
> 70%	3	4
> 95%	10	13

(d) Location percentage requirements for mobile vehicular reception (Class C)

The value of standard deviation given in (b) is used here for determining the location variation at outdoor locations for mobile vehicular reception. To cope with a mobile environment, larger values of location correction factors than for portable reception are used.

These location correction factors for Classes C and D and for all bands are given in Table 1.3.12.

Table 1.3.12: Macro-scale variation for mobile vehicular reception: Coverage targets and location correction factors

Class C , all bands	
Coverage target	Location correction factor
> 90%	7 dB
> 99%	13 dB

(e) Location percentage requirements for hand-held reception in a moving vehicle (Class D)

The location correction factor for hand-held reception in a moving vehicle is the combined result of the outdoor variation and the variation factor due to vehicle penetration loss. These distributions are expected to be uncorrelated. The standard deviation of the field strength distribution for hand-held reception in a moving vehicle can therefore be calculated by taking the root of the sum of the squares of the individual standard deviations.

In all bands, the macro-scale standard deviations are 5.5 dB and 2 dB (section 1.3.3.5), respectively; the combined value is 5.9 dB.

The resultant location correction factors for hand-held reception in a moving vehicle (Class D) are given in Table 1.3.13.

Table 1.3.13: Macro-scale variation for hand-held reception in moving vehicle (Class D): Coverage targets and location correction factors

Class D, all bands	
Coverage target	Location correction factor
> 90%	7.6 dB
> 99%	13.7 dB

1.3.3.8 Frequency interpolation in the UHF band (Bands IV and V)

The minimum median field strength Fs_1 for a frequency f_1 using the value of the field strength Fs for the frequency f given in the examples, for Bands IV/V, may be calculated from:

For Classes A, B and D: $Fs_1 = Fs - 5\log_{10}(f_1/f)$

This is due to the combination of two factors:

1. The wavelength variation, which gives a factor of $+20\log_{10}(f_1/f)$
2. The gain variation of the integrated antenna, which gives a factor of $-25\log_{10}(f_1/f)$

For Class C: $Fs_1 = Fs + 20\log_{10}(f_1/f)$

This is due to the wavelength variation, which gives a factor of $+20\log_{10}(f_1/f)$. The gain of the adapted antenna (integrated in the vehicle) is assumed to be the same in the entire UHF band.

1.3.4 Examples of Signal levels for planning

The following sections give the details of calculation for the cases listed in sections 1.3.2 and 1.3.3.

1.3.4.1 DVB-H in Band III

			DVB-H Class A	DVB-H Class B	DVB-H Class C	DVB-H Class D
Frequency	Freq	MHz	200	200	200	200
Minimum C/N required by system	C/N	dB	9.5	9.5	9.5	9.5
System variant			QPSK, 1/4 GI, 1/2 CR , MPE-FEC 3/4			
Bit rate		Mbit/s	3.27	3.27	3.27	3.27
Receiver Noise figure	F	dB	6	6	6	6
Equivalent noise band width	B	MHz	6.66	6.66	6.66	6.66
Receiver noise input power	Pn	dBW	-129.7	-129.7	-129.7	-129.7
Min. receiver signal input power	Ps min	dBW	-120.2	-120.2	-120.2	-120.2
Min. equivalent receiver input voltage, 75 ohm	Umin	dBμV	19	19	19	19
Antenna gain relative to half dipole	Gd	dB	-17	-17	-2.2	-17
Effective antenna aperture	Aa	dBm^2	-22.3	-22.3	-7.5	-22.3
Min Power flux density at receiving location	Φmin	$dB(W)/m^2$	-97.9	-97.9	-112.7	-97.9
Min equivalent field strength at receiving location	Emin	dBμV/m	48	48	33	48
Allowance for man-made noise	Pmmn	dB	0	0	5	0
Penetration loss (building or vehicle)	Lb, Lh	dB		9		8
Standard deviation of the penetration loss		dB		3		2
Diversity gain	Div	dB	0	0	0	0
Location probability		%	70	70	90	90
Distribution factor			0.5244	0.5244	1.2816	1.2816
Standard deviation			5.5	6.3	5.5	5.9
Location correction factor	Cl	dB	2.9	3.3	7.0	7.6
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-95.0	-85.6	-100.7	-82.4
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 70% for Classes A and B and 90% for Classes C and D)	Emed_1.5m	dBμV/m	50.8	60.2	45.1	63.4
Location probability		%	95	95	99	99
Distribution factor			1.6449	1.6449	2.3263	2.3263
Standard deviation			5.5	6.3	5.5	5.9
Location correction factor	Cl	dB	9.0	10.4	12.8	13.7
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-88.9	-78.6	-94.9	-76.2
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 95% for Classes A and B and 99% for Classes C and D)	Emed_1.5m	dBμV/m	56.9	67.2	50.9	69.6

			DVB-H Class A	DVB-H Class B	DVB-H Class C	DVB-H Class D
Frequency	Freq	MHz	200	200	200	200
Minimum C/N required by system	C/N	dB	15.5	15.5	15.5	15.5
System variant			16-QAM, 1/4 GI, 1/2 CR, MPE-FEC 3/4			
Bit rate		Mbit/s	6.53	6.53	6.53	6.53
Receiver Noise figure	F	dB	6	6	6	6
Equivalent noise band width	B	MHz	6.66	6.66	6.66	6.66
Receiver noise input power	Pn	dBW	-129.7	-129.7	-129.7	-129.7
Min. receiver signal input power	Ps min	dBW	-114.2	-114.2	-114.2	-114.2
Min. equivalent receiver input voltage, 75 ohm	Umin	dBμV	25	25	25	25
Antenna gain relative to half dipole	Gd	dB	-17	-17	-2.2	-17
Effective antenna aperture	Aa	dBm^2	-22.3	-22.3	-7.5	-22.3
Min Power flux density at receiving location	Φmin	$dB(W)/m^2$	-91.9	-91.9	-106.7	-91.9
Min equivalent field strength at receiving location	Emin	dBμV/m	54	54	39	54
Allowance for man-made noise	Pmmn	dB	0	0	5	0
Penetration loss (building or vehicle)	Lb, Lh	dB		9		8
Standard deviation of the penetration loss		dB		3		2
Diversity gain	Div	dB	0	0	0	0
Location probability		%	70	70	90	90
Distribution factor			0.5244	0.5244	1.2816	1.2816
Standard deviation			5.5	6.3	5.5	5.9
Location correction factor	Cl	dB	2.9	3.3	7.0	7.6
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-89.0	-79.6	-94.7	-76.4
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 70% for Classes A and B and 90% for Classes C and D)	Emed_1.5m	dBμV/m	56.8	66.2	51.1	69.4
Location probability		%	95	95	99	99
Distribution factor			1.6449	1.6449	2.3263	2.3263
Standard deviation			5.5	6.3	5.5	5.9
Location correction factor	Cl	dB	9.0	10.4	12.8	13.7
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-82.9	-72.6	-88.9	-70.2
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 95% for Classes A and B and 99% for Classes C and D)	Emed_1.5m	dBμV/m	62.9	73.2	56.9	75.6

1.3.4.2 DVB-H in Band IV

			DVB-H Class A	DVB-H Class B	DVB-H Class C	DVB-H Class D
Frequency	Freq	MHz	500	500	500	500
Minimum C/N required by system	C/N	dB	9.5	9.5	9.5	9.5
System variant			QPSK, 1/4 GI, 1/2 CR, MPE-FEC 3/4			
Bit rate		Mbit/s	3.74	3.74	3.74	3.74
Receiver Noise figure	F	dB	6	6	6	6
Equivalent noise band width	B	MHz	7.61	7.61	7.61	7.61
Receiver noise input power	Pn	dBW	-129.2	-129.2	-129.2	-129.2
Min. receiver signal input power	Ps min	dBW	-119.7	-119.7	-119.7	-119.7
Min. equivalent receiver input voltage, 75 ohm	Umin	dBμV	19	19	19	19
Antenna gain relative to half dipole	Gd	dB	-12	-12	0	-12
Effective antenna aperture	Aa	dBm^2	-25.3	-25.3	-13.3	-25.3
Min Power flux density at receiving location	Φmin	$dB(W)/m^2$	-94.4	-94.4	-106.4	-94.4
Min equivalent field strength at receiving location	Emin	dBμV/m	51	51	39	51
Allowance for man-made noise	Pmmn	dB	0	0	0	0
Penetration loss (building or vehicle)	Lb, Lh	dB		11		8
Standard deviation of the penetration loss		dB		6		2
Diversity gain	Div	dB	0	0	0	0
Location probability		%	70	70	90	90
Distribution factor			0.5244	0.5244	1.2816	1.2816
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	2.9	4.2	7.0	7.6
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-91.5	-79.1	-99.3	-78.8
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 70% for Classes A and B and 90% for Classes C and D)	Emed_1.5m	dBμV/m	54.3	66.7	46.5	67.0
Location probability		%	95	95	99	99
Distribution factor			1.6449	1.6449	2.3263	2.3263
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	9.0	13.3	12.8	13.7
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-85.3	-70.1	-93.6	-72.7
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 95% for Classes A and B and 99% for Classes C and D)	Emed_1.5m	dBμV/m	60.5	75.7	52.2	73.1

			DVB-H Class A	DVB-H Class B	DVB-H Class C	DVB-H Class D
Frequency	Freq	MHz	500	500	500	500
Minimum C/N required by system	C/N	dB	15.5	15.5	15.5	15.5
System variant			16-QAM, 1/4 GI, 1/2 CR, MPE-FEC 3/4			
Bit rate		Mbit/s	7.46	7.46	7.46	7.46
Receiver Noise figure	F	dB	6	6	6	6
Equivalent noise band width	B	MHz	7.61	7.61	7.61	7.61
Receiver noise input power	Pn	dBW	-129.2	-129.2	-129.2	-129.2
Min. receiver signal input power	Ps min	dBW	-113.7	-113.7	-113.7	-113.7
Min. equivalent receiver input voltage, 75 ohm	Umin	dBμV	25	25	25	25
Antenna gain relative to half dipole	Gd	dB	-12	-12	0	-12
Effective antenna aperture	Aa	dBm^2	-25.3	-25.3	-13.3	-25.3
Min Power flux density at receiving location	Φmin	$dB(W)/m^2$	-88.4	-88.4	-100.4	-88.4
Min equivalent field strength at receiving location	Emin	dBμV/m	57	57	45	57
Allowance for man-made noise	Pmmn	dB	0	0	0	0
Penetration loss (building or vehicle)	Lb, Lh	dB		11		8
Standard deviation of the penetration loss		dB		6		2
Diversity gain	Div	dB	0	0	0	0
Location probability		%	70	70	90	90
Distribution factor			0.5244	0.5244	1.2816	1.2816
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	2.9	4.2	7.0	7.6
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-85.5	-73.1	-93.3	-72.8
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 70% for Classes A and B and 90% for Classes C and D)	Emed_1.5m	dBμV/m	60.3	72.7	52.5	73.0
Location probability		%	95	95	99	99
Distribution factor			1.6449	1.6449	2.3263	2.3263
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	9.0	13.3	12.8	13.7
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-79.3	-64.1	-87.6	-66.7
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 95% for Classes A and B and 99% for Classes C and D)	Emed_1.5m	dBμV/m	66.5	81.7	58.2	79.1

1.3.4.3 DVB-H in Band V

			DVB-H Class A	DVB-H Class B	DVB-H Class C	DVB-H Class D
Frequency	Freq	MHz	800	800	800	800
Minimum C/N required by system	C/N	dB	9.5	9.5	9.5	9.5
System variant			QPSK, 1/4 GI, 1/2 CR, MPE-FEC 3/4			
Bit rate		Mbit/s	3.74	3.74	3.74	3.74
Receiver Noise figure	F	dB	6	6	6	6
Equivalent noise band width	B	MHz	7.61	7.61	7.61	7.61
Receiver noise input power	Pn	dBW	-129.2	-129.2	-129.2	-129.2
Min. receiver signal input power	Ps min	dBW	-119.7	-119.7	-119.7	-119.7
Min. equivalent receiver input voltage, 75 ohm	Umin	dBμV	19	19	19	19
Antenna gain relative to half dipole	Gd	dB	-7	-7	0	-7
Effective antenna aperture	Aa	dBm^2	-24.4	-24.4	-17.4	-24.4
Min Power flux density at receiving location	Φmin	$dB(W)/m^2$	-95.3	-95.3	-102.3	-95.3
Min equivalent field strength at receiving location	Emin	dBμV/m	50	50	43	50
Allowance for man-made noise	Pmmn	dB	0	0	0	0
Penetration loss (building or vehicle)	Lb, Lh	dB		11		8
Standard deviation of the penetration loss		dB		6		2
Diversity gain	Div	dB	0	0	0	0
Location probability		%	70	70	90	90
Distribution factor			0.5244	0.5244	1.2816	1.2816
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	2.9	4.2	7.0	7.6
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-92.4	-80.1	-95.3	-79.7
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 70% for Classes A and B and 90% for Classes C and D)	Emed_1.5m	dBμV/m	53.4	65.7	50.5	66.1
Location probability		%	95	95	99	99
Distribution factor			1.6449	1.6449	2.3263	2.3263
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	9.0	13.3	12.8	13.7
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-86.3	-71.0	-89.5	-73.6
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 95% for Classes A and B and 99% for Classes C and D)	Emed_1.5m	dBμV/m	59.5	74.8	56.3	72.2

			DVB-H Class A	DVB-H Class B	DVB-H Class C	DVB-H Class D
Frequency	Freq	MHz	800	800	800	800
Minimum C/N required by system	C/N	dB	15.5	15.5	15.5	15.5
System variant			16-QAM, 1/4 GI, 1/2 CR, MPE-FEC 3/4			
Bit rate		Mbit/s	7.46	7.46	7.46	7.46
Receiver Noise figure	F	dB	6	6	6	6
Equivalent noise band width	B	MHz	7.61	7.61	7.61	7.61
Receiver noise input power	Pn	dBW	-129.2	-129.2	-129.2	-129.2
Min. receiver signal input power	Ps min	dBW	-113.7	-113.7	-113.7	-113.7
Min. equivalent receiver input voltage, 75 ohm	Umin	dBµV	25	25	25	25
Antenna gain relative to half dipole	Gd	dB	-7	-7	0	-7
Effective antenna aperture	Aa	dBm^2	-24.4	-24.4	-17.4	-24.4
Min Power flux density at receiving location	Φmin	$dB(W)/m^2$	-89.3	-89.3	-96.3	-89.3
Min equivalent field strength at receiving location	Emin	dBµV/m	56	56	49	56
Allowance for man-made noise	Pmmn	dB	0	0	0	0
Penetration loss (building or vehicle)	Lb, Lh	dB		11		8
Standard deviation of the penetration loss		dB		6		2
Diversity gain	Div	dB	0	0	0	0
Location probability		%	70	70	90	90
Distribution factor			0.5244	0.5244	1.2816	1.2816
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	2.9	4.2	7.0	7.6
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-86.4	-74.1	-89.3	-73.7
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 70% for Classes A and B and 90% for Classes C and D)	Emed_1.5m	dBµV/m	59.4	71.7	56.5	72.1
Location probability		%	95	95	99	99
Distribution factor			1.6449	1.6449	2.3263	2.3263
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	9.0	13.3	12.8	13.7
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-80.3	-65.0	-83.5	-67.6
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 95% for Classes A and B and 99% for Classes C and D)	Emed_1.5m	dBµV/m	65.5	80.8	62.3	78.2

1.3.4.4 DVB-H in the 1.5 GHz Band

			DVB-H Class A	DVB-H Class B	DVB-H Class C	DVB-H Class D
Frequency	Freq	MHz	1500	1500	1500	1500
Minimum C/N required by system	C/N	dB	9.5	9.5	9.5	9.5
System variant			QPSK, 1/4 GI, 1/2 CR, MPE-FEC 3/4			
Bit rate		Mbit/s	2.33	2.33	2.33	2.33
Receiver Noise figure	F	dB	6	6	6	6
Equivalent noise band width	B	MHz	4.758	4.758	4.758	4.758
Receiver noise input power	Pn	dBW	-131.2	-131.2	-131.2	-131.2
Min. receiver signal input power	Ps min	dBW	-121.7	-121.7	-121.7	-121.7
Min. equivalent receiver input voltage, 75 ohm	Umin	dBμV	17	17	17	17
Antenna gain relative to half dipole	Gd	dB	-4	-4	0	-4
Effective antenna aperture	Aa	dBm^2	-26.8	-26.8	-22.8	-26.8
Min Power flux density at receiving location	Φmin	$dB(W)/m^2$	-94.9	-94.9	-98.9	-94.9
Min equivalent field strength at receiving location	Emin	dBμV/m	51	51	47	51
Allowance for man-made noise	Pmmn	dB	0	0	0	0
Penetration loss (building or vehicle)	Lb, Lh	dB		11		8
Standard deviation of the penetration loss		dB		6		2
Diversity gain	Div	dB	0	0	0	0
Location probability		%	70	70	90	90
Distribution factor			0.5244	0.5244	1.2816	1.2816
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	2.9	4.2	7.0	7.6
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-92.0	-79.6	-91.8	-79.3
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 70% for Classes A and B and 90% for Classes C and D)	Emed_1.5m	dBμV/m	53.8	66.2	54.0	66.5
Location probability		%	95	95	99	99
Distribution factor			1.6449	1.6449	2.3263	2.3263
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	9.0	13.3	12.8	13.7
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-85.8	-70.6	-86.1	-73.2
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 95% for Classes A and B and 99% for Classes C and D)	Emed_1.5m	dBμV/m	60.0	75.2	59.7	72.6

			DVB-H Class A	DVB-H Class B	DVB-H Class C	DVB-H Class D
Frequency	Freq	MHz	1500	1500	1500	1500
Minimum C/N required by system	C/N	dB	15.5	15.5	15.5	15.5
System variant			16-QAM, 1/4 GI, 1/2 CR, MPE-FEC 3/4			
Bit rate		Mbit/s	4.66	4.66	4.66	4.66
Receiver Noise figure	F	dB	6	6	6	6
Equivalent noise band width	B	MHz	4.758	4.758	4.758	4.758
Receiver noise input power	Pn	dBW	-131.2	-131.2	-131.2	-131.2
Min. receiver signal input power	Ps min	dBW	-115.7	-115.7	-115.7	-115.7
Min. equivalent receiver input voltage, 75 ohm	Umin	dBμV	23	23	23	23
Antenna gain relative to half dipole	Gd	dB	-4	-4	0	-4
Effective antenna aperture	Aa	dBm^2	-26.8	-26.8	-22.8	-26.8
Min Power flux density at receiving location	Φmin	$dB(W)/m^2$	-88.9	-88.9	-92.9	-88.9
Min equivalent field strength at receiving location	Emin	dBμV/m	57	57	53	57
Allowance for man-made noise	Pmmn	dB	0	0	0	0
Penetration loss (building or vehicle)	Lb, Lh	dB		11		8
Standard deviation of the penetration loss		dB		6		2
Diversity gain	Div	dB	0	0	0	0
Location probability		%	70	70	90	90
Distribution factor			0.5244	0.5244	1.2816	1.2816
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	2.9	4.2	7.0	7.6
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-86.0	-73.6	-85.8	-73.3
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 70% for Classes A and B and 90% for Classes C and D)	Emed_1.5m	dBμV/m	59.8	72.2	60.0	72.5
Location probability		%	95	95	99	99
Distribution factor			1.6449	1.6449	2.3263	2.3263
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	9.0	13.3	12.8	13.7
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-79.8	-64.6	-80.1	-67.2
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 95% for Classes A and B and 99% for Classes C and D)	Emed_1.5m	dBμV/m	66.0	81.2	65.7	78.6

1.3.4.5 T-DMB in Band III

			T-DMB Class A	T-DMB Class B	T-DMB Class C	T-DMB Class D
Frequency	Freq	MHz	200	200	200	200
Minimum C/N required by system	C/N	dB	13.5	13.5	13.5	13.5
System variant			D-QPSK, 1/4 GI, 1/2 CR			
Bit rate		Mbit/s	1.06	1.06	1.06	1.06
Receiver Noise figure	F	dB	7	7	7	7
Equivalent noise band width	B	MHz	1.536	1.536	1.536	1.536
Receiver noise input power	Pn	dBW	-135.1	-135.1	-135.1	-135.1
Min. receiver signal input power	Ps min	dBW	-121.6	-121.6	-121.6	-121.6
Min. equivalent receiver input voltage, 75 ohm	Umin	dBμV	17	17	17	17
Antenna gain relative to half dipole	Gd	dB	-17	-17	-2.2	-17
Effective antenna aperture	Aa	dBm^2	-22.3	-22.3	-7.5	-22.3
Min Power flux density at receiving location	Φmin	$dB(W)/m^2$	-99.3	-99.3	-114.1	-99.3
Min equivalent field strength at receiving location	Emin	dBμV/m	47	47	32	47
Allowance for man-made noise	Pmmn	dB	0	0	5	0
Penetration loss (building or vehicle)	Lb, Lh	dB	0	9	0	8
Standard deviation of the penetration loss		dB		3		2
Diversity gain	Div	dB	0	0	0	0
Location probability		%	70	70	90	90
Distribution factor			0.5244	0.5244	1.2816	1.2816
Standard deviation			5.5	6.3	5.5	5.9
Location correction factor	Cl	dB	2.9	3.3	7.0	7.6
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-96.4	-87.0	-102.0	-83.7
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 70% for Classes A and B and 90% for Classes C and D)	Emed_1.5m	dBμV/m	49.4	58.8	43.8	62.1
Location probability		%	95	95	99	99
Distribution factor			1.6449	1.6449	2.3263	2.3263
Standard deviation			5.5	6.3	5.5	5.9
Location correction factor	Cl	dB	9.0	10.4	12.8	13.7
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-90.2	-79.9	-96.3	-77.6
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 95% for Classes A and B and 99% for Classes C and D)	Emed_1.5m	dBμV/m	55.6	65.9	49.5	68.2

1.3.4.6 T-DMB in the 1.5 GHz Band

			T-DMB Class A	T-DMB Class B	T-DMB Class C	T-DMB Class D
Frequency	Freq	MHz	1500	1500	1500	1500
Minimum C/N required by system	C/N	dB	13.5	13.5	13.5	13.5
System variant			D-QPSK, 1/4 GI, 1/2 CR			
Bit rate		Mbit/s	1.06	1.06	1.06	1.06
Receiver Noise figure	F	dB	7	7	7	7
Equivalent noise band width	B	MHz	1.536	1.536	1.536	1.536
Receiver noise input power	Pn	dBW	-135.1	-135.1	-135.1	-135.1
Min. receiver signal input power	Ps min	dBW	-121.6	-121.6	-121.6	-121.6
Min. equivalent receiver input voltage, 75 ohm	Umin	dBμV	17	17	17	17
Antenna gain relative to half dipole	Gd	dB	-4	-4	0	-4
Effective antenna aperture	Aa	dBm^2	-26.8	-26.8	-22.8	-26.8
Min Power flux density at receiving location	Φmin	$dB(W)/m^2$	-94.8	-94.8	-98.8	-94.8
Min equivalent field strength at receiving location	Emin	dBμV/m	51	51	47	51
Allowance for man-made noise	Pmmn	dB	0	0	0	0
Penetration loss (building or vehicle)	Lb, Lh	dB		11		8
Standard deviation of the penetration loss		dB		6		2
Diversity gain	Div	dB	0	0	0	0
Location probability		%	70	70	90	90
Distribution factor			0.5244	0.5244	1.2816	1.2816
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	2.9	4.2	7.0	7.6
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-91.9	-79.5	-91.7	-79.2
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 70% for Classes A and B and 90% for Classes C and D)	Emed_1.5m	dBμV/m	53.9	66.3	54.1	66.6
Location probability		%	95	95	99	99
Distribution factor			1.6449	1.6449	2.3263	2.3263
Standard deviation			5.5	8.1	5.5	5.9
Location correction factor	Cl	dB	9.0	13.3	12.8	13.7
Minimum median power flux density at 1.5 m a.g.l 50% time and 50% locations	Φmed	$dB(W)/m^2$	-85.7	-70.5	-86.0	-73.1
Minimum median equivalent field strength at 1.5 m a.g.l 50% time and 50% locations (location probability 95% for Classes A and B and 99% for Classes C and D)	Emed_1.5m	dBμV/m	60.1	75.3	59.8	72.7

1.4 Frequency planning parameters

The frequency planning parameters for DVB-H and T-DMB include:

- The protection ratios related to all possible combinations (co-channel, overlapping and adjacent channels/blocks) between the concerned systems (DVB-H and T-DMB) and the other broadcasting systems that may use the same frequency bands.
- The spectrum masks of DVB-H and T-DMB emissions, as these patterns have an influence on the impact of a given emission on the adjacent channels used in the same area.

General Remark:

The values of protection ratios given in the following sections are derived from values related to DVB-T or T-DAB by applying, when relevant, corrections to take into consideration the differences in C/N. However, these derived values need ultimately to be confirmed by laboratory or field measurements. They are made available here in order to give guidance to broadcasters and network operators making their network planning. Moreover, in some cases, mainly for the protection of DVB-H and T-DMB interfered with by analogue television, it is not possible to derive values of protection ratios from those related to DVB-T and T-DAB because of the unknown influence of the additional error correction in DVB-H and T-DMB on their robustness in presence of interfering analogue signals. The corresponding protection ratios need to be defined either through complex simulations or laboratory or field measurements.

1.4.1 Protection Ratios for DVB-H

1.4.1.1 DVB-H interfered with by other broadcasting systems

The following cases are considered:

Wanted signal	Unwanted signal	Table
DVB-H	Co-channel DVB-T or DVB-H	Table 1.4.1
DVB-H	Adjacent channel DVB-T or DVB-H	Table 1.4.2
DVB-H	Co-channel T-DAB or T-DMB	Table 1.4.3
DVB-H	Adjacent channel T-DAB or T-DMB	Table 1.4.4
DVB-H	Co-channel analogue TV	To be defined
DVB-H	Lower channel analogue TV	To be defined
DVB-H	Upper channel analogue TV	To be defined
DVB-H (8 MHz)	Overlapping 7 MHz analogue TV	To be defined
DVB-H (7 MHz)	Overlapping 7 MHz analogue TV	To be defined
DVB-H (8 MHz)	Overlapping 8 MHz analogue TV	To be defined
DVB-H (7 MHz)	Overlapping 8 MHz analogue TV	To be defined

1.4.1.1.1 Co-channel protection ratios for DVB-H interfered with by DVB-T or DVB-H

TABLE 1.4.1: Co-channel protection ratios (dB) for a DVB-H signal interfered with by a DVB-T or a DVB-H signal for different variants of the wanted DVB-H signal (for the case of portable reception (Class A and B) and mobile reception (Class C and D)

Modulation	Code rate	Protection ratio [dB]	
		Portable (Class A and B)	Mobile (Class C and D)
QPSK	1/2	9.5	9.5
QPSK	2/3	12.5	12.5
16--QAM	1/2	15.5	15.5
16--QAM	2/3	18.5	18.5

The same protection ratios should be applied for DVB-H systems with 5, 7 and 8 MHz

1.4.1.1.2 Overlapping and adjacent channels protection ratios for DVB-H interfered with by DVB-T or DVB-H

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

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

CCI : co-channel protection ratio

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

BW : bandwidth (MHz) of the wanted signal

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

For an overlap greater than 1 MHz the CCI protection ratio should be used.

However, further studies are needed on this subject.

For adjacent channel, the figures of Table 1.4.2 below apply.

TABLE 1.4.2: Protection ratios (dB) for a DVB-H signal interfered with by a DVB-T or a DVB-H signal in the lower (*N* - 1) and upper (*N* + 1) adjacent channels

Channel	*N* - 1	*N* + 1
PR	-30	-30

1.4.1.1.3 Co-channel protection ratios for DVB-H interfered with by T-DAB or T-DMB signals

Table 1.4.3: Co-channel protection ratios (dB) for a DVB-H 7 MHz and 8 MHz signal interfered with by a T-DAB or a T-DMB signal

Modulation	**Code rate**	**Protection ratio [dB]**	
		Portable (Class A and B)	Mobile (Class C and D)
QPSK	1/2	14.5	14.5
QPSK	2/3	17.5	17.5

16--QAM	1/2	20.5	20.5
16--QAM	2/3	23.5	23.5

Remark:

GE06 gives PRs for DVB-T interfered with by T-DAB that are around 5 dB higher than the PRs for DVB-T interfered with by DVB-T (the same difference is applied to the different reception modes but it varies with the system variant).

As preliminary figures, subject to further studies, a 5 dB increase to the figures of DVB-H versus DVB-T or DVB-H (Table 1.4.1) has been applied to derive the figures of Table 1.4.3.

1.4.1.1.4 Adjacent channel protection ratios for DVB-H interfered with by T-DAB or T-DMB signals

TABLE 1.4.4: Protection ratios (dB) for a DVB-H 7 MHz and 8 MHz signal interfered with by a T-DAB or T-DMB signal in the lower (N – 1) or upper (N + 1) adjacent channels

Channel	*N* - 1	*N* + 1
PR	-30	-30

1.4.1.1.5 Protection ratios for DVB-H interfered with by Analogue TV

No information is yet available concerning the robustness of the DVB-H signal, with MPE-FEC, in the presence of analogue television interference. Further studies are needed.

1.4.1.2 Other broadcasting systems (except T-DMB) interfered with by DVB-H

It is assumed here that DVB-H, as the unwanted signal, has the same effect as the DVB-T unwanted signal due to the noise-like characteristic of both signals and assuming identical spectrum patterns for both. Therefore, the protection ratios for the cases listed below can be taken from the tables contained in the GE06 Final Acts. The relevant table is indicated for each case.

Wanted signal	Unwanted signal	GE06 Final Acts Table
DVB-T	Co-channel DVB-H	A.3.3-1
DVB-T	Adjacent channel DVB-H	A.3.3-2
T-DAB	DVB-H (8 MHz)	A.3.3-13
T-DAB	DVB-H (7 MHz)	A.3.3-14
Analogue TV	Co-channel DVB-H	A.3.3-23
Analogue TV	Overlapping 7 MHz DVB-H	A.3.3-24
Analogue TV	Overlapping 8 MHz DVB-H	A.3.3-25

1.4.2 Protection Ratios for T-DMB

1.4.2.1 T-DMB interfered with by other broadcasting systems

The following cases are considered:

Wanted signal	Unwanted signal	Table
T-DMB	Co-channel T-DAB or T-DMB	1.4.5
T-DMB	Adjacent block T-DAB or T-DMB	1.4.6
T-DMB	DVB-T or DVB-H (8 MHz)	1.4.7
T-DMB	DVB-T or DVB-H (7 MHz)	1.4.8
T-DMB	Analogue TV – I/PAL	To be defined
T-DMB	Analogue TV – B/PAL	To be defined
T-DMB	Analogue TV – D/SECAM	To be defined
T-DMB	Analogue TV – L/SECAM	To be defined
T-DMB	Analogue TV – B/SECAM, B/PAL (T2)	To be defined
T-DMB	Analogue TV – D/PAL	To be defined
T-DMB	Analogue TV – G/PAL	To be defined
T-DMB	Analogue TV – K1/SECAM	To be defined

1.4.2.1.1 Co-channel protection ratios for T-DMB interfered with by T-DAB or T-DMB

Table 1.4.5: Co-channel protection ratios (dB) for a T-DMB signal interfered with by a T-DAB or a T-DMB

Co-channel	Protection ratio [dB]	
	Portable (Class A and B)	Mobile (Class C and D)
T-DMB wanted / T-DAB or T-DMB unwanted	13.5	13.5

1.4.2.1.2 Adjacent block protection ratios for T-DMB interfered with by T-DAB or T-DMB

No information is available on the adjacent block measured protection ratios for T-DMB. In the absence of measured figures, a unique value of -35 dB could be applied.

Table 1.4.6: Protection ratios (dB) for a T-DMB signal interfered with by a T-DAB or a T-DMB signal in the lower (*N* – 1) and upper (*N* + 1) adjacent blocks

Block	*N* – 1 [dB]	*N* + 1 [dB]
PR	-35	-35

1.4.2.1.3 Protection ratios for T-DMB interfered with by DVB-T or DVB-H

The values given in the tables 1.4.7 and 1.4.8 below are based on the values given in GE06 technical annexes for T-DAB, by applying a correction equal to the difference between the corresponding C/N figures of T-DAB and T-DMB.

Table 1.4.7: Protection ratios (dB) for a T-DMB signal interfered with by a DVB-T or a DVB-H 8 MHz signal

Δf [(1)] (MHz)	−5	−4.2	−4	−3	0	3	4	4.2	5
PR (dB) portable (Class A and B)	-41.6	7.6	8.6	9.6	9.6	9.6	8.6	7.6	-41.6
PR (dB) mobile (Class C and D)	−43	6	7	8	8	8	7	6	−43

(1) *Δf :Centre frequency of the DVB-T or DVB-H signal minus centre frequency of the T-DMB signal.*

Table 1.4.8: Protection ratios (dB) for a T-DMB signal interfered with by a DVB-T or a DVB-H 7 MHz signal

Δf [(1)] (MHz)	−4.5	−3.7	−3.5	−2.5	0	2.5	3.5	3.7	4.5
PR (dB) portable (Class A and B)	-40.4	8.6	9.6	10.6	10.6	10.6	9.6	8.6	-40.4
PR (dB) mobile (Class C and D)	−42	7	8	9	9	9	8	7	−42

(1) *Δf : Centre frequency of the DVB-T or DVB-H signal minus centre frequency of the T-DMB signal.*

1.4.2.1.4 Protection ratios for T-DMB interfered with by analogue television

No information is yet available concerning the robustness of the T-DMB signal in presence of analogue television interference. Definition of protection ratios for this case requires either complex simulation or laboratory or field measurements. Further studies are needed.

1.4.2.2 Other broadcasting systems (except DVB-H) interfered with by T-DMB

It is assumed here that T-DMB, as unwanted signal, has the same effect as the T-DAB unwanted signal due to the noise like characteristic of both signals and assuming identical spectrum patterns for both. Therefore, the protection ratios for the cases listed below can be taken from the tables contained in the GE06 Final Acts, the ITU-R Rec. BT.1368-5 or the ITU-R Rec. BT.655-7. The relevant source is indicated for each case.

Wanted signal	Unwanted signal	Table
DVB-T	Co-channel T-DMB	ITU-R-REC-BT.1368-5 Table 24
DVB-T	Adjacent channel T-DMB	ITU-R-REC-BT.1368-5 Table 25
T-DAB	Co-channel T-DMB	GE06 Final Acts Table A.3.3-13
T-DAB	Adjacent channel T-DMB	GE06 Final Acts Table A.3.3-14
Analogue TV	T-DMB	ITU-R-REC-BT.655-7 Figure 6, Tables 15 and 19

1.4.3 Spectrum mask for DVB-H emission

Taking into account that DVB-H would share frequency bands used by DVB-T, it is proposed to apply the same spectrum pattern (or mask) as it is specified for DVB-T in the GE06 Agreement [20]. Two spectrum masks are specified in Fig. 1.4.1 and the associated Table 1.4.9. The upper curve defines the spectrum mask for the non-critical cases and the lower curve defines the spectrum mask for the sensitive cases.

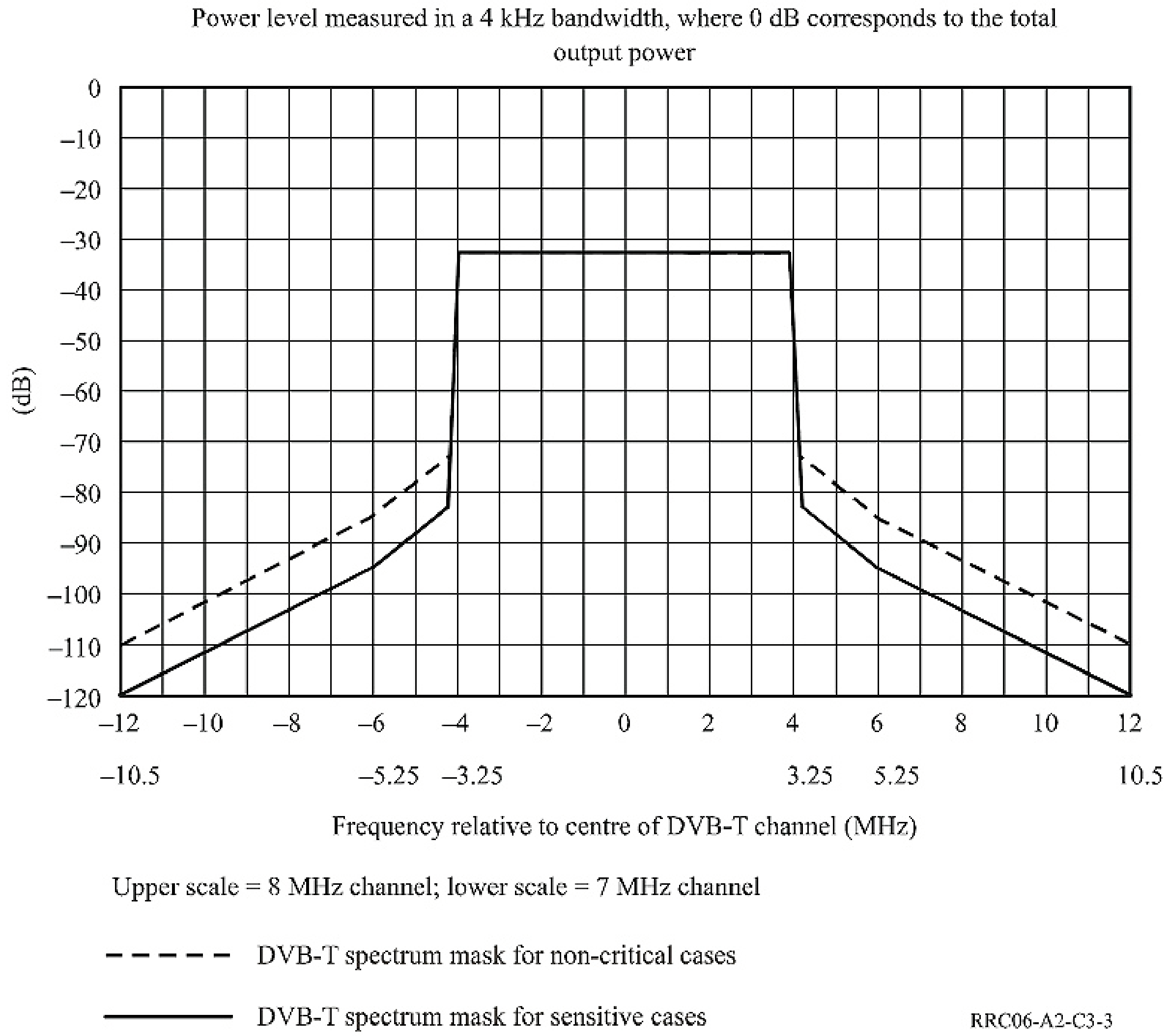

Figure 1.4.1: DVB-T or DVB-H symmetrical spectrum masks for non-critical and sensitive cases

Table 1.4.9: DVB-T or DVB-H symmetrical spectrum masks' table for non-critical and sensitive cases

Breakpoints					
8 MHz channels			**7 MHz channels**		
Relative frequency (MHz)	Non-critical cases Relative level (dB)	Sensitive cases Relative level (dB)	Relative freq.(MHz)	Non-critical cases Relative level (dB)	Sensitive cases Relative level (dB)
-12	-110	-120	-10.5	-110	-120
-6	-85	-95	-5.25	-85	-95
-4.2	-73	-83	-3.7	-73	-83
-3.9	-32.8	-32.8	-3.35	-32.8	-32.8
+3.9	-32.8	-32.8	+3.35	-32.8	-32.8
+4.2	-73	-83	+3.7	-73	-83
+6	-85	-95	+5.25	-85	-95
+12	-110	-120	+10.5	-110	-120

1.4.3 Spectrum mask for T-DMB emission

Taking into account that T-DMB would share frequency bands used by T-DAB, it is proposed to apply the same spectrum patterns (or masks) as are provided for T-DAB in the GE06 Agreement [20]. Two spectrum masks are specified in Fig. 1.4.2 and the associated Table 1.4.10. The upper curve defines the spectrum mask for the non-critical cases and the lower curve defines the spectrum mask for the sensitive cases.

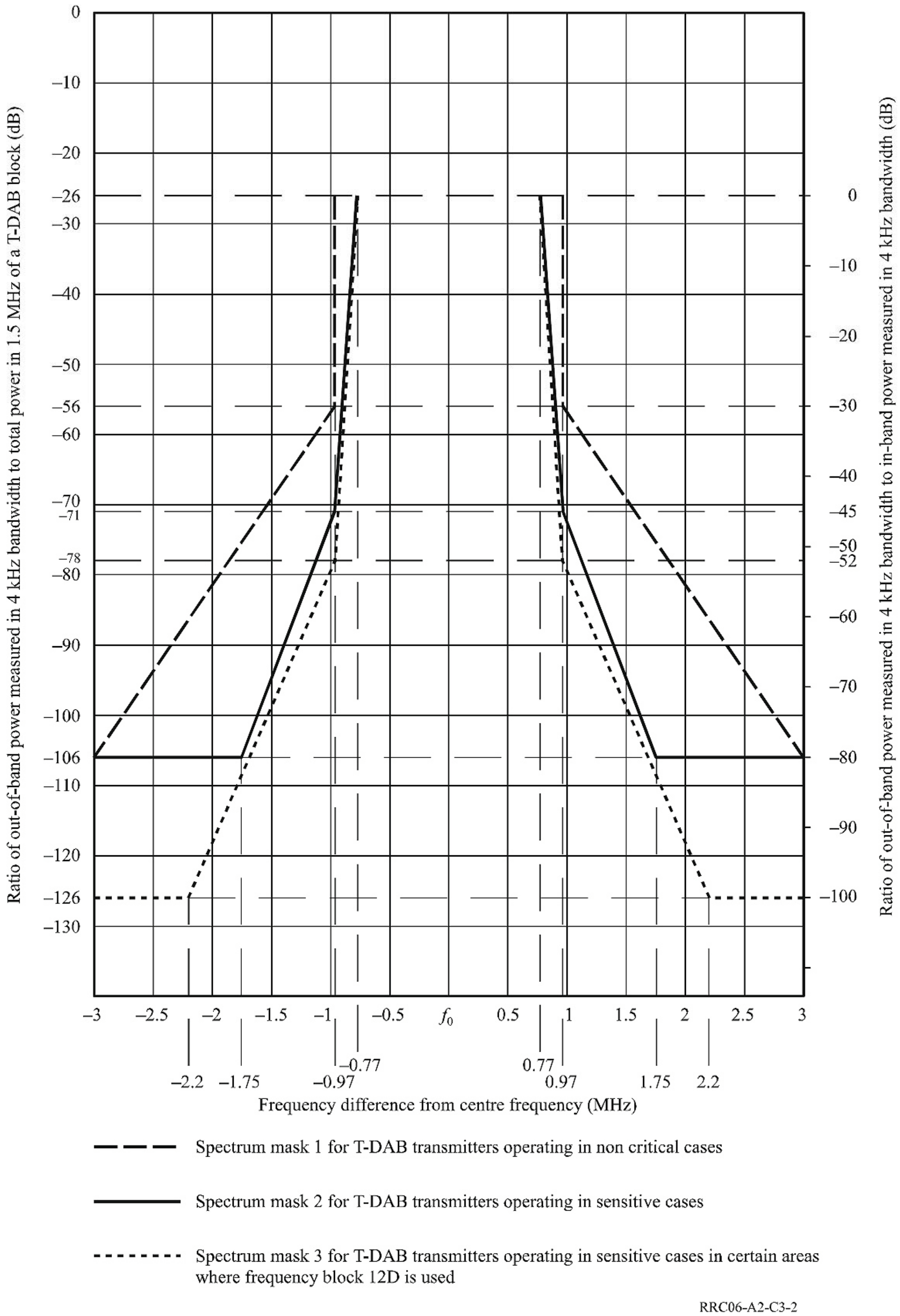

Figure 1.4.2: Out-of-band spectrum masks for a T-DAB or T-DMB transmission signal

Table 1.4.10: Out-of-band spectrum masks' table for a T-DAB or T-DMB transmission signal

	Frequency relative to the centre of the 1.54 MHz channel (MHz)	Relative level (dB)
Spectrum mask for T-DAB or T-DMB transmitters operating in non-critical cases	±0.97	-26
	±0.97	-56
	±3.0	-106
Spectrum mask for T-DAB or T-DMB transmitters operating in sensitive cases	±0.77	-26
	±0.97	-71
	±1.75	-106
	±3.0	-106
Spectrum mask for T-DAB or T-DMB transmitters operating in sensitive cases in certain areas where frequency block 12D is used	±0.77	-26
	±0.97	-78
	±2.2	-126
	±3.0	-126

2. Conclusions

1. The minimum median equivalent field strength required for hand-held reception is in general very high, especially for portable indoors reception (Class B). Planning a network to provide such levels in a more or less large area is technically challenging and costly.

   A summary of the calculated values of minimum median equivalent field strength at 1.5 m a.g.l. is given in Tables 2.1 and 2.2, below.

2. In general, Class C (vehicular reception) is the least demanding and Class B (hand-held portable indoor reception) is the most demanding in terms of minimum median equivalent field strength. This latter is 16 to 24 dB higher for Class B than for Class C, depending on the frequency band. It should be noted that the highest difference between these two classes is calculated in Band IV.

3. Band III is the least demanding in terms of minimum median equivalent field strength for all classes and Band 1.5 GHz is the most demanding. For DVB-H, for instance, the minimum median equivalent field strength in the 1.5 GHz Band is 3 to 9 dB higher than in Band III, depending on the Class of reception. The highest differences are calculated for Class C (vehicular reception) and B (hand-held portable indoors reception).

4. The minimum median equivalent field strength is almost stable throughout the UHF Bands IV and V for the three hand-held Classes A, B and D (for DVB-H). This is due to the rather large variation of the integrated antenna gain with frequency. As shown in § 1.3.3.2, the gain of the hand-held integrated antenna varies by 5 dB between 500 MHz and 800 MHz, which almost compensates the opposite difference in the calculation of minimum field strength due to wavelength variation.

5. Using an external antenna could reduce the very high field strength required for Class B (portable indoor reception). This could be a telescopic antenna plugged directly into the hand-held device, or one fixed to a base station which hosts the hand-held device during the viewing time. It could also be the cable of wired headsets. Such an external antenna could offer about 4 dB better antenna gain than the hand-held integrated antenna. This helps

reduce the large difference quoted above between Class C and B.

It should be noted that many of the hand-held receivers in the countries that started commercial services using T-DMB or DVB-H, have external, mainly telescopic, antennas. This is the case in Korea and Germany, which have started operational T-DMB networks in Band III and the 1.5 GHz Band, respectively, and in Italy, which has started operational DVB-H networks in Band IV.

Table 2.1:Summary of calculated values of Minimum median equivalent field strength at 1.5 m a.g.l, for 50% time and 50% locations for the different hand-held reception Classes

Cases of DVB-H using QPSK1/2 (2.33 to 3.74 Mbit/s) and T-DMB (1.06 Mbit/s)

		VHF		UHF		1.5 GHz	
		DVB-H (7 MHz)	T-DMB (1.712 MHz)	DVB-H (8 MHz)	DVB-H (8 MHz)	DVB-H (5 MHz)	T-DMB (1.712 MHz)
		200 MHz	200 MHz	500 MHz	800 MHz	1.5 GHz	1.5 GHz
		QPSK 1/2	DQPSK	QPSK 1/2	QPSK 1/2	QPSK 1/2	DQPSK
Class C (vehicular reception). Location probability: 99%	[dBuV/m]	51	50	52	56	60	60
Class A (hand-held portable outdoor reception). Location probability: 95%	[dBuV/m]	57	56	60	60	60	60
Class D (hand-held portable reception inside a moving vehicle (e.g. car, bus). Location probability: 99%	[dBuV/m]	70	68	73	72	73	73
Class B (hand-held portable indoor reception). Location probability: 95%	[dBuV/m]	67	66	76	75	75	75

Table 2.2: Summary of calculated values of Minimum median equivalent field strength at 1.5 m a.g.l, for 50% time and 50% locations for the different hand-held reception classes

Case of DVB-H using 16-QAM1/2 (4.66 to 7.46 Mbit/s)

		VHF	UHF		1.5 GHz
		DVB-H (7 MHz)	DVB-H (8 MHz)	DVB-H (8 MHz)	DVB-H (5 MHz)
		200 MHz	500 MHz	800 MHz	1.5 GHz
		16QAM1/2	16QAM1/2	16QAM1/2	16QAM1/2
Class C (vehicular reception). Location probability: 99%	[dBuV/m]	57	58	62	66
Class A (hand-held portable outdoor reception). Location probability: 95%	[dBuV/m]	63	66	66	66
Class D (hand-held portable reception inside a moving vehicle (e.g. car, bus, etc.). Location probability: 99%	[dBuV/m]	76	79	78	79
Class B (hand-held portable indoor reception). Location probability: 95%	[dBuV/m]	73	82	81	81

References:

[1] ETSI Technical report ETSI TR 102 377 V1.2.1 (2005-11) and Draft TR 102 377 V1.2.2 (2006-01): Digital Video Broadcasting (DVB); DVB-H Implementation Guidelines.

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[19] Measurements of the vehicle penetration loss characteristics at 800 MHz. 48th IEEE Vehicular technology Symposium, May 1998.

[20] GE06 Agreement, Geneva, June 2006

[21] ETSI Technical Specification 102 428 V1.1.1 (2005-06): Digital Audio Broadcasting (DAB); DMB video service; User Application Specification.

[22] ITU-R Recommendation BT.1368-5: Planning criteria for digital terrestrial television services in the VHF/UHF bands.

Annex A New channel models for hand held reception and DVB-H receiver C/N-performance in pedestrian and mobile channels (Extract from ITU Document 6E/464-E)

DVB-H Proposed Channel Models

Finland is proposing new channel models for hand held reception. New channel models, better suited especially for portable indoor and portable outdoor (pedestrian) reception conditions, have been under discussion for some time. Lack of suitable measurement data have been prohibiting any practical development on the subject. The Finnish partners of the multinational CELTIC Wing-TV project (http://projects.celtic-initiative.org/WING-TV/) performed in the autumn of 2005 a comprehensive measurement campaign to gather channel data in various indoor, outdoor pedestrian and mobile environments. Based on the data, a set of new channel models was developed. These were then verified both in the laboratory and back in field conditions. Both DVB and IEC are also adopting the new channel models as part of the DVB-H specifications.

Two new channel models are proposed, Pedestrian Indoor (PI) for slowly moving indoor reception and Pedestrian Outdoor (PO) for slowly moving outdoor reception. The models describe the radio channel behaviour in a dense Single Frequency Networks (SFN). These networks differ from traditional cellular or broadcast systems in terms of the impulse response (IR) by the fact that the receiver sees several transmitters and repeaters simultaneously. This also implies that the power delay profile (PDP) differs quite much from the traditional single transmitter case, which has been described by the earlier used channel models. Speed of the movement is expected to be below 3 km/h, which corresponds about 1.5 Hz Doppler at the middle of the UHF-band. This Doppler frequency has been adopted to the new models.

The Pedestrian Indoor and Pedestrian Outdoor models are Tapped Delay Line (TDL) models, with Doppler spectrum, amplitude distribution, power and delay value specified for each tap. Derivation of the tapped delay line models is based on average power delay profiles for each selected channel type. The individual multipath components were extracted from the measurements using 30 dB power cut threshold. The power delay profiles (PDP) were determined from the impulse response data by dividing the data into smaller sets (time-wise) to satisfy the stationary requirement. Then the average PDP of each set was calculated and finally the PDPs from several measurements (from the same environment) were averaged. Accurate 24-tap channel models were formed by visual inspection from these averaged PDPs. One criterion in the selection process was the frequency correlation of the taps. The selected taps should have a low frequency correlation on the bandwidth of the receiver. Reduction to 12 taps was accomplished by using localized delay and power estimation. Special care has been used to maintain possible SFN-structure of the profile. Finally power normalization is made, i.e., the largest tap has value of 0 dB.

The analysis of the Ricean K-factors of the measurements gave evidence that even SFN networks often contain one or several strong signal components with Ricean distributed complex envelope. It seems that the resulting Doppler spectrum is a combination of a lower power Gaussian part and a direct strong peak (pure Doppler). The traditional TU6 does not take this into account as the Doppler spectrum is of Jakes-type. Therefore PI- and PO-models, which have been derived directly from channel measurements, are modelling the Doppler in a more accurate way. Laboratory measurements with real receivers have confirmed that this new Doppler spectrum has a clear effect on the receiver performance and it differs from performance obtained with the Jakes spectrum.

Receiver C/N performance

The Wing-TV project studied the DVB-H receiver performance with the new PI- and PO-channel models. Three state-of-the art receiver implementations were measured in the laboratory and based on the results a Wing-TV reference receiver model was developed:

(http://projects.celtic-initiative.org/WING-TV/deliverables/Wing%20TV-WP3-D3%20Reference%20Receiver.pdf)

This gives the minimum required C/N in PI- and PO-channels. The given performance is based on the best-measured receiver performance added with a margin of 2 dB.

In addition to the new performance figures in PI- and PO-channels the Wing-TV project studied the DVB-H receiver performance in mobile typical urban channel and included the C/N-performance figures in the reference receiver specification.

Channel models for hand held pedestrian indoor and outdoor reception

The pedestrian indoor (PI) and pedestrian outdoor (PO) channel models have been developed for describing the slowly moving hand held reception indoors and outdoors. The channel models are based on measurements in DVB-H Single Frequency Networks and have paths from two different transmitter locations. Definitions of the taps for the channels are given in Table X2 and Table X3. The indicated Doppler frequency of 1.5 Hz is corresponding 3 km/h velocity at middle of UHF-band. The Doppler spectra of various taps are defined in Table A.

Table A1: Doppler spectrum definitions for PI- and PO-channels

Spectrum for the 1st tap	Spectrum for taps 2-12
$0.1G(f;0.08f_D)+\delta(f-0.5f_D)$	$G(f;0.08f_D)$

Where $G(f;\sigma)=\exp\left(\frac{-f^2}{2\sigma^2}\right)$.

Table A2: Definition of PI-channel

Path	Delay (μs)	Power (dB)	Doppler Spectrum	Fd (Hz)	STD Norm.
1	0.0	0.0	See table X1	1.69	0.08
2	0.1	-6.4	Gauss	1.69	0.08
3	0.2	-10.4	Gauss	1.69	0.08
4	0.4	-13.0	Gauss	1.69	0.08
5	0.6	-13.3	Gauss	1.69	0.08
6	0.8	-13.7	Gauss	1.69	0.08
7	1.0	-16.2	Gauss	1.69	0.08
8	1.6	-15.2	Gauss	1.69	0.08
9	8.1	-14.9	Gauss	1.69	0.08
10	8.8	-16.2	Gauss	1.69	0.08
11	9.0	-11.1	Gauss	1.69	0.08
12	9.2	-11.2	Gauss	1.69	0.08

Table A3: Definition of PO-channel

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

Channel model for mobile reception

The channel model for mobile reception is given in Table 45 in chapter 6 of the Annex 2 to Recommendation ITU-R BT.1368-6. This typical urban model is valid for both DVB-T and DVB-H.

Required average C/N for mobile reception

The DVB-H receiver shall have the performance given in Table A4 when noise (N) is applied together with the wanted carrier (C) in a signal bandwidth of 7.61 MHz. Degradation point criteria is 5% MPE-FEC frame error rate (5% MFER). The C/N performance figures are based on the state of the art receivers on the market added with a 2 dB margin.

Table A4: *C/N* (dB) for 5% *MFER* in PI & PO channel

Modulation	Code rate	MPE-FEC code rate	PI	PO
QPSK	1/2	1/2	6,6	7,6
QPSK	1/2	2/3	6,8	7,8
QPSK	1/2	3/4	7,0	8,0
QPSK	1/2	5/6	7,2	8,2
QPSK	1/2	7/8	7,4	8,4
QPSK	2/3	2/3	9,8	10,8
QPSK	2/3	3/4	10,0	11,0
QPSK	2/3	5/6	10,2	11,2
QPSK	2/3	7/8	10,4	11,4
16-QAM	1/2	2/3	12,8	13,8
16-QAM	1/2	3/4	13,0	14,0
16-QAM	1/2	5/6	13,2	14,2
16-QAM	1/2	7/8	13,4	14,4
16-QAM	2/3	2/3	15,8	16,8

Modulation	Code rate	MPE-FEC code rate	PI	PO
16-QAM	2/3	3/4	16,0	17,0
16-QAM	2/3	5/6	16,2	17,2
16-QAM	2/3	7/8	16,4	17,4
64-QAM	1/2	5/6	17,7	18,7
64-QAM	1/2	7/8	17,9	18,9
64-QAM	2/3	2/3	20,6	21,6
64-QAM	2/3	3/4	20,8	21,8
64-QAM	2/3	5/6	21,0	22,0

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

The DVB-H receiver shall have the performance given in Table A5 when noise (*N*) and Doppler shift (*Fd*) is applied together with the wanted carrier (*C*) in mobile channel defined in Table 45. The figures are given for guard interval 1/4. The *C/N* performance is based on the state of the art DVB-H receivers with added 2 dB margin. The Doppler performance is derived from a use case analysis where the target speed with 8k mode at 750 MHz is 130 km/h. This corresponds a Doppler frequency of 100 Hz. The 4k and 2k Doppler performance is obtained by multiplying the 8k performance by 2 and 4. Degradation point criteria is 5% MPE-FEC frame error rate (5% MFER).

Table A5: DVB-H *C/N* (dB) in mobile channel for 5% *MFER*

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

Annex B Comparison of C/N values for mobile and portable T-DAB reception

Introduction

The DAB system was designed for mobile reception. Since then, many different types of portable DAB receivers have become commercially available and therefore, the DAB signal should also be of good quality when received portable outdoors and indoors. For a DAB planning under these conditions, appropriate planning parameters have to be made available. One important parameter is the protection ratio (C/N).

At mobile DAB reception in a multipath environment, the field strength at the reception antenna may fall below the minimum field strength for good reception for a short time (< 384 ms), even at a high mean field strength, while passing a local field strength minimum. The occurring transmission errors are spread over time by the "time interleaving" of the DAB system and are corrected by the Viterbi decoder.

At portable DAB-reception, if the receiver and implicitly his antenna are moved at walking speed, the passing of a local field strength minimum takes sometimes more time than the DAB system interleaving width (384 ms). This is also valid for stationary reception indoor and outdoor near ground level. Because the wave field is fluctuating slowly due to moving reflectors (vehicles, persons, trees swinging in the wind), a field strength minimum at the antenna can last longer than the interleaving time, causing uncorrectable transmission errors.

To guarantee a good reception quality at portable reception, the field strength has to be higher than for mobile reception. This requirement is equivalent to a higher protection ratio C/N.

The measurements described in this paper show the necessary increase in protection ratio for portable reception, compared to the mobile case, and assuming an equal reception quality. The measurements were carried out in the VHF band, with DAB mode I, in two typical transmission channel profiles, typical urban and rural.

Measurements and results

The comparison of the C/N value for mobile and portable reception was done by using a channel simulator set to two typical channel profiles. The first channel profile, called "typical urban" (TU), simulates the propagation within an urban environment and is favourable for the DAB reception. The second channel profile, called "rural area" (RA), simulates the propagation in a rural environment and is unfavourable due to the short delay-time-differences between the several paths and the resulting flat fading. For all other realistic channel profiles, the quality of DAB reception, under the same conditions otherwise, is in between these two extreme cases.

A Rohde & Schwarz DVB-T channel simulator type SFQ was used for the measurements. The DAB-modulation was done over the external I/Q inputs.

The measurements were carried out in the VHF band (225.648 MHz), with DAB mode I at "protection level 3" (PL 3) and with an audio programme having a bit rate of 192 kbit/s. A Φlips DAB 452 receiver was used for reception. This receiver notifies the CRC errors in every audio frame (CIF, 24 ms).

The reception quality was measured for both channel profiles, for various C/N values and at two different simulated speeds, one typical for mobile reception in town (50 km/h) and the other the lowest settable speed at the channel simulator (0.7 km/h). The low speed corresponds to the portable reception, and simulates the slow fluctuation of the field strength at the receiver antenna.

The C/N ratio was set by the addition of white noise at an appropriate level to the RF signal. For every C/N setting, the number of audio frames (CIF) with CRC errors occurring within 25 minutes were recorded, and the CRC-error-ratio as the ratio of audio frames with errors to all audio frames was calculated. The C/N values were chosen in the way that the CRC-error-ratio is in the range between $3*10^{-2}$ and $3*10^{-5}$.

Figure B1 shows the results of the measurements in the urban environment (SFQ channel "TU 12 Path") at a speed of 50 km/h for the simulated mobile reception and at a speed of 0.7 km/h for the simulated portable reception.

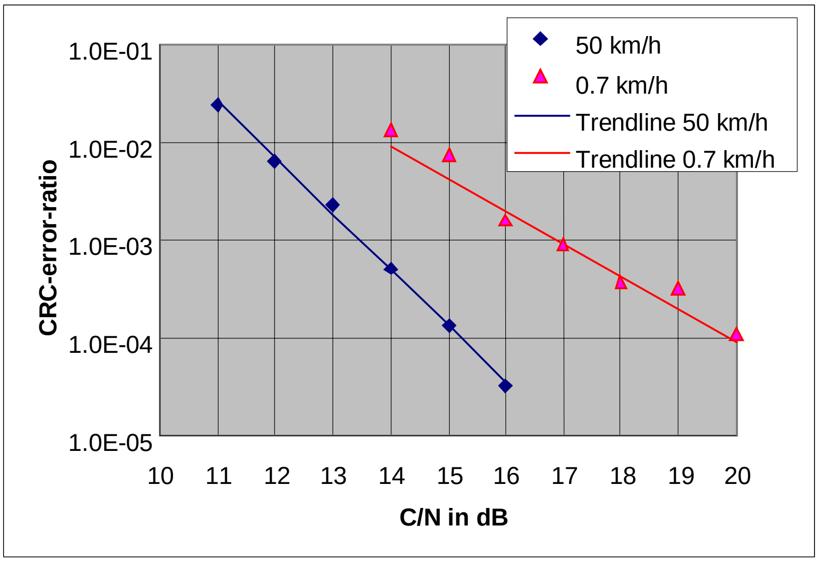

Figure B1: CRC-error-ratio versus C/N in urban environment (TU channel) for mobile (50 km/h) and portable (0.7 km/h) reception

As expected, the CRC-error-ratio decreases with increasing C/N value. In the interval depicted in Figure B1, the logarithm of the CRC-error-ratio is approximately a linear function of the C/N value in dB. The straight line for the portable reception is shifted on the upper end with 2 dB and on the lower end with 5 dB to higher C/N values. The shifting at the threshold for good reception is important, because it shows the increase of the C/N value for portable reception compared to the value for the mobile case.

The threshold for good quality at mobile reception with DAB mode I and protection level PL 3 was established by means of audio tests [1, 2] to be at a CRC-error-ratio of $1.5*10^{-3}$.

According to Figure B1 the C/N value in the mobile TU channel at a CRC-error-ratio of $1.5*10^{-3}$ is 13.3 dB. In the portable TU channel the protection ratio is 16.6 dB. This means that the protection ratio for portable DAB reception in urban environment is 3.3 dB higher than for the mobile case. Related to the protection ratio of 14 dB, proposed in Wiesbaden [3] for the planning of mobile DAB reception, the C/N value for portable reception is 2.6 dB higher.

The C/N values for mobile reception change only marginally for velocities in the range between 20 km/h and far above 100 km/h. Also changes of speed for portable reception in the range of 0 to 1 km/h have only marginal effects on the C/N value for the portable case.

The same measurements were also carried out for rural environments (SFQ channel RA). A comparison was done for the C/N values at mobile reception with 100 km/h and the C/N values at portable reception with 0.7 km/h. The results are shown in Figure B2.

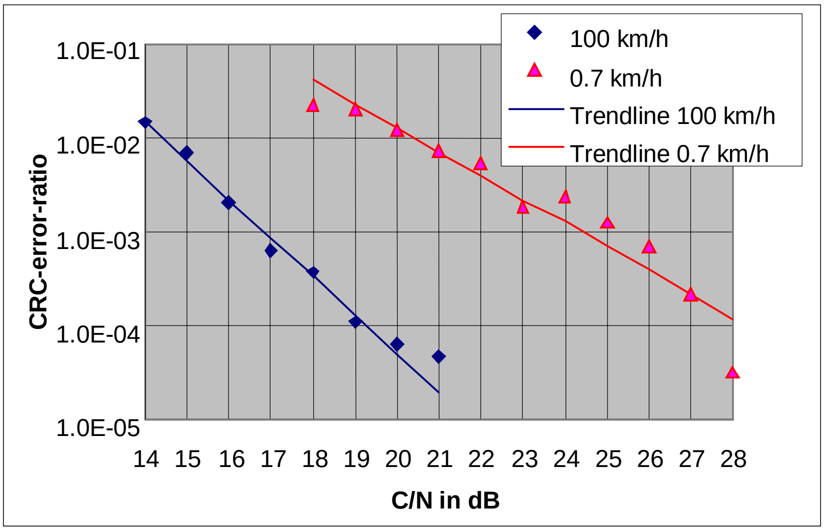

Figure B2: CRC-error-ratio depending on C/N in rural environment (RA channel) for mobile (100 km/h) and portable (0.7 km/h) reception

In the mobile rural (RA) channel the C/N for good reception quality, which means a CRC-error-ratio of $1.5*10^{-3}$, is 16.5 dB. Under the same conditions but for the portable case the C/N value is 24 dB. According to this, the C/N for portable reception is 7.5 dB higher than for the mobile case. Related to the Wiesbaden value (14 dB) the increase is in the range of 2.6 to 10 dB.

Conclusions

The portable reception does not benefit from the advantages of the "time interleaving" in the DAB system. Therefore, a higher C/N is needed. Measurements in the VHF band have shown that related to the proposed Wiesbaden value of 14 dB an increase of 2.6 dB in urban and 10 dB in rural environments is needed. It should be noticed that a coverage planning based on 14 dB does not satisfy the conditions of a good mobile reception in rural areas. A C/N of 16.5 dB would be needed for this purpose.

The C/N for portable DAB-reception is valid for both outdoor and indoor reception.

Measurements at 1.5 GHz were not carried out. But it is expected that the C/N figures in this band have to be increased by the same amount as explained above.

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[2] Berthold E.: „Auswertung von Hörtests zur Beurteilung der DAB-Versorgung", Interner Bericht der RBT, Nürnberg, Juli 2001

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Annex C Effects of negative isotropic antenna gains on the treatment of man-made noise

Introduction

System specifications of current and future broadcast receivers often show negative antenna gains (e.g. for current DMB-receivers the antenna gain is in the range of –15 dBd to –25 dBd). Values less than 0 dBi (–2.2 dBd) do not correspond to antenna gains in the conventional sense.

In contrast to positive antenna gains, which are related to radiation patterns, negative antenna gains are traced back to a lack of efficiency (caused by a mismatch between antenna and receiver). Therefore, a negative antenna gain (in contrast to the positive) induces a modification of the man-made noise allowance value (MMN). The size of reduction of the MMN also depends on the receiver noise figure. The MMN is a usual factor for frequency planning, which indicates the increase of the noise figure caused by noise-like interference.

Fundamentals

External noise figure:

$$Fa = 10\log(fa) \text{ (logarithmic scale)} \rightarrow fa = 10^{\left(\frac{Fa}{10}\right)} \text{ (linear scale)}$$

Receiver noise figure:

$$F = 10\log(f) \text{ (logarithmic scale)} \rightarrow f = 10^{\left(\frac{F}{10}\right)} \text{ (linear scale)}$$

Definition of MMN based on external and receiver noise figure:

$$MMN = 10\log\left(1 + \frac{(fa-1)}{f}\right)$$

$$fa = 1 + 10^{\left(\frac{F}{10}\right)} \cdot \left(10^{\left(\frac{MMN}{10}\right)} - 1\right)$$

This MMN value is valid for all positive antenna gains. It will be the starting point for the calculation of the modified MMN.

Procedure for the calculation of the modified MMN caused by negative antenna gain:

Step 1: Calculation of the external noise figure with given MMN_1:

(MMN_1 is the man-made noise valid for positive antenna gains)

$$fa_1 = 1 + 10^{\left(\frac{F}{10}\right)} \cdot \left(10^{\left(\frac{MMN_1}{10}\right)} - 1\right)$$

Step 2: Decrease of the external noise figure according to the negative antenna gain (antenna gain (*AG*) in dBd)

$Fa_2 = Fa_1 + (AG + 2{,}2)$ (e.g. *AG* = -10 dB → $Fa_2 = Fa_1 - 7{,}8\,dB$)

$$fa_2 = 10^{\left(\frac{10\log(fa_1)+AG+2{,}2}{10}\right)}$$

Step 3: Calculation of the new MMN_2:

(MMN_2 is the man-made noise derived from MMN_1, due to the negative isotropic antenna gain)

$$MMN_2 = 10\log\left(1 + \frac{(fa_2 - 1)}{10^{\left(\frac{F}{10}\right)}}\right)$$

For example: a comparison of the MMN between a typical VHF-antenna with an antenna gain of –2.2 dBd and a handheld antenna with an exemplary antenna gain (*AG*) of –10 dBd.

The receiver noise figure *F* is 7 dB.

For a typical VHF antenna with an antenna gain of –2.2 dBd (0 dBi) the MMN_1 is assumed as 8 dB.

Calculation of the modified MMN_2 caused by negative antenna gain:

Step 1:

$$fa_1 = 1 + 10^{\left(\frac{F}{10}\right)} \cdot \left(10^{\left(\frac{MMN_1}{10}\right)} - 1\right) = 27.6$$

$$Fa_1 = 10\log(fa_1) = 14.4$$

Step 2:

$$Fa_2 = Fa_1 + (AG + 2.2)$$

AG = -10 dB → $Fa_2 = Fa_1 - 7.8\,dB = 6.6$

$$fa_2 = 10^{\left(\frac{10\log(fa_1)+AG+2.2}{10}\right)} = 4.58$$

Step 3:

$$MMN_2 = 10\log\left(1 + \frac{(fa_2 - 1)}{10^{\left(\frac{F}{10}\right)}}\right) = \underline{2.34\text{ dB !}}$$

The modified MMN_2 is decreased by nearly 6 dB compared to the MMN_1 of a typical VHF antenna. Therefore, the modification of the MMN is important for calculations of coverage predictions for the new handheld systems.