

BS EN 62002-1:2008

Incorporating corrigendum July 2008



BSI Standards Publication

Mobile and portable DVB-T/H radio access

Part 1: Interface specification

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW

raising standards worldwide™

Full document details: BS EN 62002-1:2008



National foreword

This British Standard is the UK implementation of EN 62002-1:2008. It is identical to IEC 62002-1:2008, incorporating corrigendum July 2008. It supersedes BS EN 62002-1:2006 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EPL/100, Audio, video and multimedia systems and equipment.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© BSI 2011

ISBN 978 0 580 64220 3

ICS 33.170

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 March 2010

Amendments/corrigenda issued since publication

Date	Text affected
30 November 2011	Implementation of IEC corrigendum July 2008: replacement of table 10

**Mobile and portable DVB-T/H radio access -
Part 1: Interface specification
(IEC 62002-1:2008 + corrigendum 2008)**

Accès radio DVB-T/H
vers les mobiles et les portables -
Partie 1: Spécification de l'interface
(CEI 62002-1:2008 + corrigendum 2008)

Mobiler und tragbarer Funkzugang
zu DVB-T/H -
Teil 1: Festlegung der Schnittstelle
(IEC 62002-1:2008 + Corrigendum 2008)

This European Standard was approved by CENELEC on 2008-06-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in two official versions (English and German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 100/1289/CDV, future edition 2 of IEC 62002-1, prepared by IEC TC 100, Audio, video and multimedia systems and equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 62002-1 on 2008-06-01.

This European Standard supersedes EN 62002-1:2006.

The main changes with respect to EN 62002-1:2006 are listed below.

- DVB-H has been included as a part of the main specification;
- all the performance figures have been revised as new simulation results have been made available as well as new reference receivers for DVB-H have been developed;
- DVB-H now includes all the different MPE-FEC code rates;
- new portable indoor and portable outdoor channel models have been included as well as performance figures for those;
- a new 2x TU-6 mobile SFN test channel has been included;
- a new L4 linearity pattern has been added;
- dedicated performance figures for DVB-H for S1, S2, L1 to L4 interference patterns have been included;
- a new GSM-interference measurement method has been added.

The following dates were fixed:

- | | | |
|--|-------|------------|
| – latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2009-03-01 |
| – latest date by which the national standards conflicting with the EN have to be withdrawn | (dow) | 2011-06-01 |

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 62002-1:2008 was approved by CENELEC as a European Standard without any modification.

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
-	-	Digital cellular telecommunications system (Phase 2+) (GSM): Mobile Station (MS) conformance specification; Part 1: Conformance specification	ETSI EN 300 607-1	- ¹⁾
-	-	Digital Video Broadcasting (DVB): Framing structure, channel coding and modulation for digital terrestrial television	ETSI EN 300 744	2007
-	-	Digital Video Broadcasting (DVB); Transmission System for Handheld Terminals (DVB-H)	ETSI EN 302 304	2004
-	-	Radio Equipment and Systems (RES); ElectroMagnetic Compatibility (EMC) for European digital cellular telecommunications system (GSM 900 MHz and DCS 1 800 MHz); Part 1: Mobile and portable radio and ancillary equipment	ETSI ETS 300 342-1	- ¹⁾
-	-	Digital Video Broadcasting (DVB); Implementation guidelines for DVB terrestrial services; Transmission aspects	ETSI TR 101 190	- ¹⁾
IEC 60169-2	- ¹⁾	Radio-frequency connectors - Part 2: Coaxial unmatched connector	HD 134.2 S2	1984 ²⁾
CISPR 13 (mod)	- ¹⁾	Sound and television broadcast receivers and associated equipment - Radio disturbance characteristics - Limits and methods of measurement	EN 55013	2001 ²⁾
CISPR 20	- ¹⁾	Sound and television broadcast receivers and associated equipment - Immunity characteristics - Limits and methods of measurement	EN 55020	2007 ²⁾
ITU-R BT.1701-1	- ¹⁾	Characteristics of radiated signals of conventional analogue television systems	-	-

¹⁾ Undated reference.

²⁾ Valid edition at date of issue.

CONTENTS

1	Scope	8
2	Normative references	8
3	Abbreviations	9
4	Terminal categories	11
5	Definition of receiving conditions	12
5.1	Portable reception	12
5.2	Mobile reception	12
6	Frequencies and channel bandwidths	13
6.1	Channel frequencies	13
6.2	Supported frequency ranges	13
6.3	Supported bandwidths	14
7	DVB-T/H modes	14
7.1	Supported DVB-T/H modes	14
7.2	Change of modulation parameters	14
7.3	Tuning procedure	14
8	Transmitter performance	15
8.1	Transmitter noise-like impairments	15
8.1.1	Noise-like processes	15
8.2	Further transmitter impairments	16
8.2.1	Group delay errors	16
8.2.2	Phase noise in OFDM systems	17
8.2.3	OFDM clock frequency	17
8.3	Spectrum masks	17
8.3.1	DVB-T signals (general)	17
8.3.2	DVB-T signals (critical cases)	18
8.3.3	DVB-T signals (DVB-T in adjacent channel)	18
9	Receiver antenna characteristics	18
9.1	Antennas for terminal category a	18
9.2	Antennas for terminal category b1	18
9.3	Antennas for terminal category b2 and c	19
9.4	External antennas	20
9.4.1	General	20
9.4.2	External antennas for terminal category b2 and c	20
9.4.3	External antenna connector	20
10	Receiver performance	21
10.1	Reference model	21
10.2	Noise model	22
10.3	Degradation criteria	24
10.4	Diversity receivers	25
10.5	DVB-H receivers	26
10.6	Channel models	27
10.6.1	DVB-T Rayleigh channel (P_1)	27
10.6.2	Portable indoor (PI) and outdoor (PO) channels	27
10.6.3	Mobile reception	29

10.7	<i>C/N</i> performance	34
10.7.1	<i>C/N</i> performance in Gaussian channel	34
10.7.2	<i>C/N</i> performance in DVB-T Rayleigh channel (P_1)	34
10.7.3	<i>C/N</i> Performance in portable indoor (PI) and portable outdoor (PO) channels.....	35
10.7.4	DVB-T <i>C/N</i> performance in mobile channels for terminal class a	36
10.7.5	DVB-H <i>C/N</i> performance in mobile channels	37
10.8	Receiver minimum and maximum signal input levels	38
10.8.1	Noise floor	38
10.8.2	Minimum input levels (sensitivity)	39
10.8.3	Total maximum power for wanted and unwanted signals.....	39
10.8.4	Maximum input levels for wanted and unwanted signals	39
10.9	Immunity to analogue and/or digital signals in other channels	40
10.9.1	General	40
10.9.2	Interfering signal definitions	41
10.9.3	Selectivity patterns	42
10.9.4	Linearity patterns	42
10.9.5	Immunity to pattern S1	43
10.9.6	Immunity to pattern S2	44
10.9.7	Immunity to pattern L1.....	45
10.9.8	Immunity to pattern L2.....	46
10.9.9	Immunity to pattern L3.....	47
10.9.10	Immunity to pattern L4.....	48
10.10	Immunity to co-channel interference from analogue TV signals.....	49
10.11	Guard interval utilization	49
10.11.1	Performance with echo within guard interval.....	49
10.11.2	Performance with echo outside guard interval	50
10.12	Tolerance to impulse interference.....	52
10.12.1	General	52
10.12.2	Test patterns	52
10.13	EMC characteristics.....	54
10.13.1	Terminal category c.....	54
10.13.2	Terminal category a and b.....	54
11	Interoperability with other radio systems.....	54
11.1	Cellular radios	54
11.1.1	General	54
11.1.2	Cellular radio uplink wanted signal interference to DVB-T/H receiver.....	56
11.1.3	Cellular radio uplink unwanted signal interference to DVB-T/H receiver	57
11.2	DVB-RCT	58
Annex A (informative)	Active external antennas and system noise floor	59
Annex B (informative)	An example of <i>C/N</i> -performance with a practical transmitter	63
Annex C (informative)	Multipath reception in a DVB-T system.....	64
Bibliography		68
Figure 1 – Reference model.....		22
Figure 2 – Noise model		23
Figure 3 – Antenna diversity receiver		26

Figure 4 – Receiver behaviour in a mobile channel	30
Figure 5 – DVB-H reference receiver C/N behaviour in mobile channel	31
Figure 6 – Mobile SFN synchronisation test channel for weak long echo	32
Figure 7 – Mobile SFN synchronisation test channel for strong long echo	33
Figure 8 – Mobile SFN synchronisation test channel for strong short echo	33
Figure 9 – PAL interfering signals	41
Figure 10 – SECAM L interfering signal	42
Figure 11 – Pattern S1 in case of $N+1$ or $N-1$	43
Figure 12 – Pattern S2 in case of $N + 1$ or $N - 1$	44
Figure 13 – Pattern L1	45
Figure 14 – Pattern L2	46
Figure 15 – Pattern L3	47
Figure 16 – Pattern L4	49
Figure 17 – Echo outside guard interval mask.....	50
Figure 18 – Mask for echo outside GI for $GI = 1/4$	52
Figure 19 – Definition of the impulse interference test pattern.....	53
Figure 20 – Terminal architectures.....	55
Figure 21 – Frequency bands	56
Figure 22 – GSM Tx block diagram	57
Figure 23 – Tx PA-noise mask in DVB-T/H receiver input.....	58
Figure A.1 – System noise floor versus receiver noise figure for different levels of man-made-noise F_a relative to T_0	62
Figure C.1 – Theoretical limits of out of guard delay	64
Figure C.2 – DVB-T model – Splitting of the signal power into contributing and interfering components	65
Figure C.3 – Theoretical echo power profile for 8k, 64QAM, 2/3.....	67
Table 1 – Supported frequency ranges	14
Table 2 – Conversion of MER to END	16
Table 3 – Typical antenna gain for terminal category b2 and c.....	19
Table 4 – Specification for optional antenna supply	21
Table 5 – Modulation versus implementation margin	23
Table 6 – Delta values between picture failure point and reference BER	25
Table 7 – Approximation of the DVB-T specified Rayleigh channel.....	27
Table 8 – Doppler spectrum definitions for PI and PO channels	28
Table 9 – Definition of PI channel	28
Table 10 – Definition of PO channel.....	28
Table 11 – Typical urban profile (TU6) constitution	29
Table 12 – Mobile SFN synchronisation test channel for weak long echo	31
Table 13 – Mobile SFN synchronisation test channel for strong long echo	32
Table 14 – Mobile SFN synchronisation test channel for strong short echo	33
Table 15 – DVB-T C/N (dB) for reference BER in Gaussian channel	34
Table 16 – DVB-H C/N (dB) for 5% $MFER$ in Gaussian channel.....	34
Table 17 – C/N (dB) for reference BER in DVB-T Rayleigh channel (P_1)	35

Table 18 – C/N (dB) for 5 % $MFER$ in portable channel.....	35
Table 19 – C/N (dB) for 5 % ESR in PI and PO channel	35
Table 20 – C/N (dB) for 5 % $MFER$ in PI and PO channel	36
Table 21 – C/N (dB) for 5 % ESR in mobile channels for single antenna receiver	37
Table 22 – C/N (dB) for ESR 5 % in mobile channels for diversity receiver	37
Table 23 – DVB-H C/N (dB) in mobile channel for 5 % $MFER$	38
Table 24 – Maximum input levels for terminal category a and b1.....	40
Table 25 – Maximum input levels for terminal category b2 and c.....	40
Table 26 – Immunity to pattern S1 for DVB-T	43
Table 27 – Immunity to pattern S1 for DVB-H.....	43
Table 28 – Immunity to pattern S2 for DVB-T	44
Table 29 – Immunity to pattern S2 for DVB-H.....	45
Table 30 – Immunity to pattern L1 for DVB-T	45
Table 31 – Immunity to pattern L1 for DVB-H.....	46
Table 32 – Immunity to pattern L2 for DVB-T	46
Table 33 – Immunity to pattern L2 for DVB-H.....	47
Table 34 – Immunity to pattern L3 for DVB-T	47
Table 35 – Immunity to pattern L3 for DVB-H.....	48
Table 36 – Immunity to Pattern L4 for DVB-T	48
Table 37 – Immunity to Pattern L4 for DVB-H.....	48
Table 38 – Immunity to co-channel interference from analogue signals for DVB-T	49
Table 39 – Immunity to co-channel interference from analogue signals for DVB-H	49
Table 40 – C/N for echo within guard interval	50
Table 41 – Timing of the corner point T_c	51
Table 42 – Definition of the value Δ	51
Table 43 – Definition of the inflection point	51
Table 44 – Impulse interference test patterns	53
Table 45 – Cellular interferer frequency ranges.....	56
Table A.1 – Noise floor values	61
Table B.1 – C/N (dB) for reference BER	63

MOBILE AND PORTABLE DVB-T/H RADIO ACCESS –

Part 1: Interface specification

1 Scope

This part of IEC 62002 is a radio access specification for mobile, portable and hand-held portable devices capable of receiving DVB-T/H services. It includes informative system aspects as well as specifications for minimum RF-performance. It covers terminals in three main classes, namely integrated car terminals, portable digital TV sets and hand-held portable convergence terminals. Interoperability with integrated cellular radios is also considered. The specification covers the following areas.

- Frequency ranges
- Supported modes
- Definition of receiving conditions
- Definition of the receiver RF-reference model
- Definition of degradation criteria
- Antenna characteristics
- Channel models
- C/N -performance with different channels
- Minimum and maximum input levels
- Immunity to interfering signals
- Definition of an ensemble of interference patterns
- Tolerance to impulse interference
- SFN-performance
- Transmitter minimum performance
- Interoperability of cellular radios
- EMC aspects

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CISPR 13, *Sound and television broadcast receivers and associated equipment – Radio disturbance characteristics – Limits and methods of measurement*

CISPR 20, *Sound and television broadcast receivers and associated equipment – Immunity characteristics – Limits and methods of measurement*

IEC 60169-2, *Radio-frequency connectors – Part 2: Coaxial unmatched connector*

ETSI EN 300 744:2007, *Digital Video Broadcasting (DVB); Framing structure, Channel coding and modulation for digital terrestrial television, V1.5.2*

ETSI ETS 300 342-1, *Radio Equipment and Systems (RES); ElectroMagnetic Compatibility (EMC) for European digital cellular telecommunications system (GSM 900 MHz and DCS 1 800 MHz); Part 1: Mobile and portable radio and ancillary equipment*

ETSI EN 300 607-1, *Digital cellular telecommunications system (Phase 2+) (GSM) – Mobile Station (MS) conformance specification – Part 1: Conformance specification*

ETSI EN 302 304:2004, *Digital Video Broadcasting (DVB); Transmission System for Handheld Terminals (DVB-H), V1.1.1*

ETSI TR 101 190 V1.2.2, *Digital Video Broadcasting (DVB); Implementation guidelines for DVB terrestrial services; Transmission aspects*

ITU-R BT.1701-1, *Characteristics of radiated signals of conventional analogue television systems*

3 Abbreviations

For the purposes of this document, the following abbreviations apply.

λ	Lambda, wavelength ($\lambda = c/f$)
A2	German analogue TV-stereo system
A_A	Coupling between antennas
AGC	Automatic gain control
A_{GSM}	Stop band attenuation of the GSM reject filter
B	Bandwidth
BER	Bit error ratio
C	Carrier power [In band carrier power including any echoes]
c	Speed of light $c = 3,0 \times 10^8$ m/s
C_i	Power contribution from the i -th signal
C_t	Total useful carrier power
C/N	Carrier to noise ratio
C/N_{min}	Minimum C/N
CPE	Common phase error
CR	Code rate
dB	Decibel
dBc	dB compared to carrier power C
dBd	Antenna gain in dB compared to reference dipole (0 dBd = –2,14 dBi)
dBi	Antenna gain in dB compared to isotropic antenna (0 dBi = 2,14 dBd)
dB(mW)	Power in dB compared to 1 mW
DVB, DVB-T	Digital video broadcasting, terrestrial digital video broadcasting
DVB-H	Digital video broadcasting to hand-held terminals
DVB-RCT	DVB terrestrial return channel
E	Field strength V/m
$E(\text{dB}\mu\text{V/m})$	Field strength in dB compared to 1 μV
EDGE	Enhanced data rates for GSM/Global evolution

EMC	Electromagnetic compatibility
<i>END</i>	Equivalent noise degradation
<i>ENF</i>	Equivalent noise floor
<i>ESR</i>	Erroneous second ratio
<i>F</i>	Frequency in Hz
<i>f</i> (MHz)	Frequency in MHz
<i>F_c</i>	Centre frequency
<i>F</i>	Noise factor
<i>F_d</i> , <i>F_d</i>	Doppler frequency
<i>F_d</i> _{3dB}	Doppler frequency with minimum <i>C/N</i> requirement raised by 3 dB
<i>FER</i>	Frame error rate
<i>G</i>	Gain
<i>G_a</i>	Antenna gain
<i>GI</i>	Guard interval
GPRS	General packet radio service
GSM	Global system for mobile communications
<i>I</i>	Interfering power
<i>Im</i>	Implementation margin
<i>ICI</i>	Intercarrier interference
J	joule
<i>k</i>	Boltzmann's constant $k = 1,38 \times 10^{-26}$ J/K
K	kelvin
L1, L2, L3, L4	Linearity patterns
<i>L_{GSM}</i>	Insertion loss of the GSM reject filter
LNA	Low noise amplifier
<i>MER</i>	Modulation error ratio
<i>MFER</i>	MPE-FEC frame error rate
MHz	Megahertz
MPE-FEC	Multi Protocol Encapsulation Forward Error Correction
MPEG-2	Motion pictures expert group, video compression standard
<i>N</i> , <i>m</i> , <i>N</i>	Channel indexes
<i>NF</i>	Noise figure in dB
NICAM	Additional sound carrier for analogue TV, modulated with a near instantaneous companded audio multiplex.
PA	Power amplifier
PAL, PAL B, PAL G, PAL I, PAL I1	Phase alternation line, TV-systems using PAL
<i>PER</i>	Packet error ratio
<i>P_{in}</i>	Input power W
<i>P_{in}</i> (dB(mW))	Input power dB compared to 1 mW
<i>P_{max}</i>	Maximum power

$P_{\min}$	Minimum power
ppm	Parts per million
PSI/SI	Program specific information, service information
P_{TX}	Transmission power
P_x	Excess noise power dBc
QAM16, QAM64	Quadrature amplitude modulation, 16-level and 64-level versions
QEF	Quasi error free
QoS	Quality of service
QPSK	Quaternary phase shift keying
R_{DQEF}	Minimum level of performance
RF	Radio frequency
RS	Reed Solomon
Rx	Receiver
S1,S2	Selectivity patterns
SECAM, SECAM L	Sequential à mémoire, TV-system using SECAM
SFN	Single frequency network
SFP	Subjective failure point
T	Temperature in kelvin
T_c	Corner point
T_e	Total duration of the gating pulses
T_i	Time of arrival for the i -th signal
TPS	Transmission Parameter Signalling
TS	Transport stream
T_g	Guard interval duration
T_u	Active symbol duration
Tx	Transmitter
UHF	Ultra high frequency
UMTS	Universal mobile telecommunications system
VHF	Very high frequency
W	watt
WCDMA	Wide-band code division multiple access
W_i	Weighting coefficient for the i -th component

4 Terminal categories

In this standard three different terminal categories are considered. The requirements are covering all categories unless otherwise stated.

The terminal categories are:

- a) Integrated car terminals

This category covers DVB-T/H terminals installed in a car and where the antenna is integral with the car.

b) Portable digital TV sets

This category covers terminals, which are intended for receiving normal DVB-T MPEG-2 based digital TV services indoors and outdoors with terminal attached antennas. This category is divided into two subcategories.

- 1) The receiver screen size is typically greater than 25 cm and the receiver may be battery or mains powered. Typically, the terminal is stationary during the reception. An example of the antenna construction may be an adjustable telescope or wide-band design, either active or passive, attached to the receiver.
- 2) Pocketable digital TV-receiver. The terminal is battery operated and can be moved during use. Usually the antenna is integral with the terminal.

c) Hand-held portable convergence terminals

This category covers small battery powered hand-held convergence terminals with built in cellular radio like GSM, GPRS or UMTS. The terminals have the functionality of a mobile phone and can receive IP-based services using DVB-H over DVB-T physical layer. The DVB-T antenna and the cellular antenna are both integral with the terminal.

5 Definition of receiving conditions

5.1 Portable reception

This is when a portable receiver (terminal category b1) with an attached or integral antenna is used indoors or outdoors at a minimum height of 1,5 m above floor or ground level. It is assumed that the receiving antenna is omni-directional. It is also assumed that the antenna and any nearby large objects are stationary. Extreme cases, such as reception in completely shielded rooms, are disregarded. [1]¹⁾

As a special case of portable reception a small hand-held portable receiver (terminal category b2 or c) is used indoors or outdoors at a minimum height of 1,0 m above floor or ground level. It is assumed that the receiving antenna is omni-directional. It is also assumed that the channel conditions can change due to slow movements (≤ 3 km/h) of the antenna and any nearby large objects. Extreme cases, such as reception in completely shielded rooms, are disregarded.

The main difference between portable and hand-held portable reception is the antenna gain of the terminal.

5.2 Mobile reception

This applies to the use of integrated car terminals (terminal category a) with speeds higher than 3 km/h. It is assumed that the receiving antenna is omni directional with a minimum height above ground level of 1,5 m. Other vehicles such as buses or high-speed trains could be considered as special cases.

A small hand-held portable receiver (terminal category b2 or c) used within a car or train could also be considered as a case of mobile reception. [2]

¹⁾ Figures in square brackets refer to the Bibliography.

6 Frequencies and channel bandwidths

6.1 Channel frequencies

The channel frequencies of bands III, IV and V are given below 6 MHz, 7 MHz and 8 MHz channel rasters are used in various countries. The centre frequencies f_c of the incoming DVB-T RF-signals are the following.

VHF III

For countries using 8 MHz channel raster

$$f_c = 178 \text{ MHz} + (N-6) \times 8 \text{ MHz} + f_{\text{offset}}$$

$$N = \{6, \dots, 12\} \text{ (VHF channel number)}$$

For countries using 7 MHz channel raster

$$f_c = 177,5 \text{ MHz} + (N-5) \times 7 \text{ MHz} + f_{\text{offset}}$$

$$N = \{5, \dots, 12\} \text{ (VHF channel number)}$$

For countries using 6 MHz channel raster

$$f_c = 177,0 \text{ MHz} + (N-7) \times 6 \text{ MHz} + f_{\text{offset}}$$

$$N = \{7, \dots, 13\} \text{ (VHF channel number)}$$

In some countries offsets may be used:

Preferred offset is $\pm n \times 1/6 \text{ MHz}$. $n = \{1, 2, \dots\}$

UHF IV and V

For countries using 8 MHz channel raster

$$f_c = 474 \text{ MHz} + (N-21) \times 8 \text{ MHz} + f_{\text{offset}}$$

$$n = \{21, \dots, 69\} \text{ (UHF channel number)}$$

For countries using 7 MHz channel raster

$$f_c = 529,5 \text{ MHz} + (N-28) \times 7 \text{ MHz} + f_{\text{offset}}$$

$$n = \{28, \dots, 67\} \text{ (UHF channel number)}$$

For countries using 6 MHz channel raster

$$f_c = 473,0 \text{ MHz} + (N-14) \times 6 \text{ MHz} + f_{\text{offset}}$$

$$n = \{14, \dots, 83\} \text{ (UHF channel number)}$$

In some countries offsets may be used:

Preferred offset is $\pm n \times 1/6 \text{ MHz}$. $n = \{1, 2, \dots\}$

In the UK $n = 1$.

The error in the centre frequency (f_c) of the transmitted RF-signal should not exceed 500 Hz in MFN. In SFN the error in the centre frequency (f_c) of the transmitted RF-signal should not exceed 1 Hz.

6.2 Supported frequency ranges

The receivers in terminal categories a and b1 shall be able to receive all channels in the VHF band III and UHF bands IV and V. VHF III can be left out in market areas, where it is not used. The receivers in terminal category b2 shall be able to receive all channels in UHF bands IV and V, VHF III is an option depending on the market area needs. The receivers in terminal category c shall be able to receive all channels in UHF band IV and V, provided that the terminal does not support GSM 900.

In case GSM 900 is used in a convergence terminal (category c), the usable frequency range is limited to channel 55 [746 MHz] due to the interoperability considerations. Supported frequency ranges are shown in Table 1.

Table 1 – Supported frequency ranges

Terminal category		VHF III	UHF IV	UHF V
a	Integrated car terminals	Yes, in areas where VHF is in use for DVB-T.	Yes	Yes
b1	Portable digital TV-sets	Yes, in areas where VHF is in use for DVB-T.	Yes	Yes
b2	Pocketable TV-sets	Optional	Yes	Yes
c	Convergence terminals	No	Yes	Yes / up to ch 55 See text above

6.3 Supported bandwidths

The receiver should support the 6 MHz, 7 MHz and 8 MHz bandwidths according to the market area needs. 5 MHz variant of DVB-H exists, but is not covered in this specification.

7 DVB-T/H modes

7.1 Supported DVB-T/H modes

The receiver shall be capable of correctly demodulating all modes specified in ETSI EN 300 744, except the code rates 5/6 and 7/8. The front end shall therefore be able to work with any combination of

- constellation (QPSK, 16-QAM, 64-QAM, hierarchical 16-QAM, hierarchical 64-QAM),
- code rate (1/2, 2/3, 3/4),
- guard interval (1/4, 1/8, 1/16 or 1/32),
- transmission mode (2k or 8k),
- where applicable α (1, 2 or 4).

Receivers in terminal category c should be capable of correctly demodulating the modes specified in EN 300 744, Annex F, additional features for DVB hand-held terminals (DVB-H). Optionally, receivers in other terminal categories can also support DVB-H. The front end in this case should therefore also be able to support

- 4k transmission mode,
- in depth interleavers usable in 2k and 4k modes.

During channel search, the receiver shall automatically detect which mode is being used. The receiver, when fed with one of the hierarchical modes (16-QAM or 64-QAM) specified in ETSI EN 300 744, shall be capable of correctly demodulating whichever of the high or low priority streams is selected by the user.

7.2 Change of modulation parameters

Dynamic change of modulation parameters during the transmission (signalled in the TPS-data) does not have to be supported by the receiver. If this happens, then a new channel search may be required in order to detect which mode is being used.

7.3 Tuning procedure

The receiver shall be able to provide a channel search. It shall also be able to receive information regarding tuning parameters found in PSI/SI.

8 Transmitter performance

8.1 Transmitter noise-like impairments

8.1.1 Noise-like processes

Many of the impairments introduced by transmitters are said to be 'noise-like', because their effect is equivalent to the addition of white Gaussian noise. This equivalence enables the overall 'noise' power to be calculated by summing the 'noise' powers introduced by the individual impairments. It is then approximately true that the total equivalent noise degradation (*END*), as defined in the following paragraph, equals the sum of the contributing *END*s.

The impairments considered to be noise-like are the following.

- Finite precision in the OFDM modulator and other digital processing stages.
- High-frequency phase noise introduced by local oscillators and timing references; that is, those phase noise components occurring at offset frequencies greater than half the OFDM carrier spacing.
- Thermal noise.
- Intermodulation products resulting from non-linearity in the transmitter chain.
- Amplitude errors. (Work carried out by the Digital Television Group (DTG) has confirmed this to be a noise-like impairment.)

Impairments that cannot be considered as being equivalent to the addition of white Gaussian noise are the following.

- Group delay errors.
- Low-frequency phase noise.

These "further transmitter impairments" are considered in 8.2.

A transmission chain should be designed such that its *END* does not exceed 0,5 dB.

A typical signal analyser makes a measurement of the noise remaining in the channel once the OFDM signal has been stripped away. The result is expressed as an *ENF* or a modulation error ratio (*MER*). (When measured in dB, *ENF* and *MER* are numerically identical but of opposite sign: *ENF* equals the ratio of noise power to OFDM carrier power, while *MER* is effectively the ratio of carrier power to noise power.) The *MER* is converted into *END* by means of the following formula:

$$1/END = 1 - \{(C/N)_{\text{ref}} / MER\},$$

where $(C/N)_{\text{ref}}$ is the carrier-to-noise ratio at which the monitoring receiver gives the reference *BER*. The quantities here are all expressed in linear terms. Expressing them in more convenient dB gives Table 2:

Table 2 – Conversion of *MER* to *END*

<i>MER</i> – (<i>C/N</i>) _{ref} dB	<i>END</i> dB
12	0,283
13	0,223
14	0,176
15	0,140
16	0,110
17	0,088
18	0,069
19	0,055
20	0,044
23	0,022
26	0,011

(*C/N*)_{ref} also has to be determined: it is the carrier-to-noise ratio at which the monitoring receiver gives the reference *BER*. For the 64QAM 2/3 mode, this may be taken as 19 dB: the theoretical figure is 16,7 dB, to which must be added the implementation margin for the channel equaliser within the receiver. Slight errors (within 0,5 dB) are unimportant.

MER measurements do not take into account amplitude response errors: they look for ‘real’ noise appearing on the OFDM signal, not the ‘virtual’ noise introduced by response errors. The ‘calibrated’ test transmitter is likely to be nearly ‘perfect’ in this respect, but an allowance should be made. Reference [10] provides the following formula for the 64 QAM 2/3 mode:

$$END \text{ (dB)} = 0,021 \times (\text{amplitude response ripple, dB pk-pk})^2$$

As an example, suppose the *MER* of the test transmitter is 39 dB, and it possesses an amplitude response ripple of 0,5 dB peak-to-peak. The (*C/N*)_{ref} of the receiver is 19 dB. The *END* of the test transmitter is made up of two contributions:

$$\begin{aligned} MER - (C/N)_{\text{ref}} &= 39 \text{ dB} - 19 \text{ dB} = 20 \text{ dB} \\ END_1 &= 0,044 \text{ dB (from Table 2)} \end{aligned}$$

The contribution from the amplitude response ripple is given by:

$$\begin{aligned} END_2 &= 0,021 \times (0,5)^2 \text{ dB} \\ &= 0,005 \text{ dB} \end{aligned}$$

The total *END* (*END*₁ + *END*₂) of the test transmitter is therefore 0,049 dB.

8.2 Further transmitter impairments

8.2.1 Group delay errors

At the input to antenna feeder, the delay of any OFDM-carrier relative to that of any other should not exceed 500 ns.

This value may be measured by exciting the first analogue up-converter with a frequency sweep waveform and examining the group delay response into the input to antenna feeder. Note that most of the group delay errors are likely to be introduced by any high-power filters and combiners.

8.2.2 Phase noise in OFDM systems

Phase noise is introduced by local oscillators and timing references within the transmission chain. If a noisy oscillator signal is viewed on a spectrum analyser, the phase noise appears as sidebands symmetrically disposed about the oscillator centre frequency. Away from the centre frequency, the sideband density generally falls off rapidly. Oscillator phase noise degrades the signal because, in the frequency conversion process, the noise is transferred from the oscillator to each of the carriers within the OFDM ensemble.

Phase noise is specified by quoting $L(f)$, the single sideband phase noise power in a 1 Hz bandwidth at a frequency f from the centre frequency. The unit of $L(f)$ is dBc/Hz, the “c” signifying that the reference is the total power of the oscillator. Oscillator manufacturers normally provide plots of $L(f)$ versus f .

At the receiver demodulator, the phase noise has two different effects. Low-frequency noise gives rise to common phase error (*CPE*) – “common” because each of the OFDM carriers suffers the same phase error. In principle, this error can be measured and removed by the demodulator. High-frequency noise introduces intercarrier interference (*ICI*). The noise from one carrier becomes superimposed upon the neighbouring carriers within the ensemble, and cannot be removed by the demodulator. Because *CPE* and *ICI* are different in their effect, they must be specified differently.

ICI may be calculated approximately by integrating $L(f)$ for all values of f above half the OFDM carrier spacing and for all carriers within the ensemble. (An accurate calculation makes use of weighting functions; see, for instance, [11].) The result is a contribution to the system noise floor, or *ENF*, which may be measured in the way described in section 11.7.2 of [6]. As *ICI* is genuinely “noise-like”, the *END* may be calculated by reference to Table 2.

An approximate value of *CPE* is given by integrating $L(f)$ for all values of f below half the OFDM carrier spacing and for a single carrier within the ensemble. (Again, an accurate calculation makes use of weighting functions.) The result is expressed in dB relative to 1 radian², or dB(rad²). The actual effect of *CPE* depends strongly on the receiver design. For a transmission to be compliant with all possible receiver designs, it is recommended that the total *CPE* for all values of f greater than 10 Hz should not exceed –40 dB(rad²).

Where the phase noise spectrum is known, the *ICI* and *CPE* components may be calculated by reference to [12].

8.2.3 OFDM clock frequency

The error in the clock frequency of the transmitted OFDM signal should not exceed 3×10^{-6} .

8.3 Spectrum masks

The spectrum masks specified in this subclause are designed to prevent interference between digital terrestrial TV transmissions, analogue terrestrial TV transmissions and other transmissions. Transmissions conforming to these masks will not necessarily be acceptable in other respects. For example, the amount of transmitter non-linearity implied by subclause 8.3.1 could give rise to an excessive *END*. Receiver manufacturers should note that transmissions outside bands IV and V could cause interference if the receivers are not suitably designed; GSM (900 MHz) and Tetra (380 MHz to 470 MHz) are such transmissions. The masks may be changed in a future edition of this standard.

8.3.1 DVB-T signals (general)

All DVB-T emissions shall at least meet the spectrum mask requirements defined by ETSI EN 300 744 chapter 4.8.2 for system B/G/I/K/L environments.

8.3.2 DVB-T signals (critical cases)

Where the DVB-T transmission is at the edge of the UHF band, or adjacent to sensitive non-broadcast applications, a second spectrum mask with higher out-of-channel attenuation shall be used. The requirements are given in ETSI EN 300 744 chapter 4.8.2.

8.3.3 DVB-T signals (DVB-T in adjacent channel)

At sites where a DVB-T transmission is present in the adjacent channel, additional restrictions on the transmitted sideband energy may be necessary. Work has shown that, if the two transmissions are to be received with a level difference of 25 dB, the total sideband power in the adjacent channel should not exceed -60 dBc. (This interference level corresponds to an *END* of 0,1 dB for the 64QAM 2/3 modulation mode.)

9 Receiver antenna characteristics

9.1 Antennas for terminal category a

The practical standard antenna for car reception is $\lambda/4$ monopole which use the metallic roof as ground plane.

The antenna gain for conventional incident wave angles depends on the position of the antenna on the roof. For passive antenna systems the following values can be expected:

VHF III	-3 dBi
UHF IV	0 dBi
UHF V	1 dBi

The polarisation discrimination is theoretically about 4 dB to 10 dB depending on the roof position of the antenna, centre of roof giving higher figures.

The horizontal polarisation of the transmitted signal will be influenced by the environment in the propagation path. According to these unpredictable effects, the polarisation discrimination will be less than the theoretical values, but reliable statements can not be made.

The philosophy of the car industry is to integrate the antennas into the windows resulting lower antenna gain. However, the use of diversity system combined with active antennas will enhance the performance significantly.

The dimensioning of the diversity system and the amplifiers should compensate the lower gain and the notches in the radiation pattern of the single screen antennas to achieve a similar reception quality compared with the single roof monopoles mentioned above. The diversity system also partially compensates polarisation discrimination effects.

9.2 Antennas for terminal category b1

In Chester 97 [1], it is assumed that the antenna of a portable receiver intended for indoor or outdoor reception is omni-directional and that the gain relative to $\lambda/2$ dipole is 0 dBd for a UHF antenna and $-2,1$ dBd for a VHF III antenna. To achieve these gains it is probably assumed that the rod type antenna length is adjusted to be optimum for each reception frequency.

However, an individual adjustment of the antenna length to the current frequency is not practicable. As consequence of it, a fixed length must be chosen. An acceptable value could be 100 mm to 150 mm. This corresponds to a $\lambda/4$ rod antenna for UHF IV / V.

For a passive version of an attached antenna the following gain values are typically:

VHF III	–6 dBi
UHF IV	–1 dBi
UHF V	0 dBi

The preferential direction for the best reception differs because of the use for portable reception. In addition to this reason, the position of the antenna at the receiver could be variable.

No polarisation discrimination can be expected in VHF III.

In UHF IV / V a polarisation discrimination up to 6 dB is possible.

9.3 Antennas for terminal category b2 and c

The antenna solution in a small hand-held terminal has to be an integral part of the terminal construction and will therefore be small when compared to the wavelength. If the antenna has to cover the whole wide tuning range, it probably has to be matched with a tunable 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 ($< 1/10 \lambda$). This leads to rather high losses and to a low overall efficiency. Moreover, in this type of terminal the ground plane does not function any more, but acts as a radiator. However, even the size of the radiating ground plane is small when compared to the wavelength resulting 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 could act as an absorber or a reflector.

Current understanding of the design problem indicates that the typical antenna gain at the lowest UHF-band frequencies would be in the order of –10 dBi increasing to –5 dBi at the end of UHF-band. Nominal antenna gain between these frequencies can be obtained by linear interpolation.

In case GSM 900 is used in a convergence terminal (category c), the usable frequency range is limited to channel 55 [746 MHz] due to the interoperability considerations. In case GSM 900 is not used, this limitation does not apply.

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

Typical gain of the antenna is presented in Table 3.

Table 3 – Typical antenna gain for terminal category b2 and c

Frequency MHz	Gain dBi
474 [channel 21]	–10
698 [channel 49]	–7
858 [channel 69]	–5

9.4 External antennas

9.4.1 General

External active or passive antennas may be used. More information about external active antennas is found in Annex A.

9.4.2 External antennas for terminal category b2 and c

Urban indoor reception is often affected by high levels of building penetration losses. Therefore, in some cases it might be difficult to guarantee the appropriate reception quality using low gain integrated antennas as explained in the subclause 9.3. In these cases, the following solutions could be foreseen.

- Use of an external antenna instead of integrated antenna.
- Use of wired headsets as the external antenna.
- Provision of an antenna connector, to facilitate the use of a user-connected external antenna.
- In case that only integrated antenna is available, the use of indoor / in-vehicle gap fillers.

The achievable antenna gain in case of external antenna depends on the specific implementation. The expected range of values is between –3 dBi and +3 dBi, an improvement of about 7 dB with respect to an integrated antenna.

9.4.3 External antenna connector

External antenna connector may be provided in all terminal categories. For terminal category b1, the connector shall be IEC female in accordance with IEC 60169-2. The input impedance of this shall be 75 Ω .

The input connector for terminal category b1 can, as an optional feature, provide a supply of DC-power. This supply would be used for powering external equipment such as masthead amplifiers, distribution amplifiers and active indoor antennas. It must be switchable, and must be able to recover from the large inrush currents taken by high value capacitors within the external equipment. A specification for such a supply is given in Table 4.