

Mobile and portable DVB-T/H radio access —

Part 1: Interface specification

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National foreword

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Foreword

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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 QoS criteria
- Antenna characteristics
- Channel models
- *C/* -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 300 744:2004, *Digital Video Broadcasting (DVB); Framing structure, Channel coding and modulation for digital terrestrial television, V1.5.1*

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*

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
END	Equivalent noise degradation
ENF	Equivalent noise floor
ESR	Erroneous second ratio

F	Frequency in Hz
f (MHz)	Frequency in MHz
f_c	Centre frequency
F	Noise factor
f_d, F_d	Doppler frequency
$F_{d_{3dB}}$	Doppler frequency with minimum C/N requirement raised by 3dB
FER	Frame error rate
G	Gain
G_a	Antenna gain
GI	Guard interval
GPRS	General packet radio service
GSM	Global system for mobile communications
I	Interfering power
ICI	Intercarrier interference
J	joule
K	Boltzmann's constant $k = 1,38 \times 10^{-26}$ J/K
K	kelvin
L1, L2, L3	Linearity patterns
L_{GSM}	Insertion loss of the GSM reject filter
LNA	Low noise amplifier
MER	Modulation error ratio
$MFER$	MPE-FEC frame error rate
MHz	Megahertz
MPEG-2	Motion pictures expert group, video compression standard
N, m, N	Channel indexes
NF	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
PER	Packet error ratio
P_{in}	Input power W
P_{in} (dB(mW))	Input power dB compared to 1 mW
P_{max}	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
RF	Radiofrequency
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 kelvins
T_c	Corner point
T_e	Total duration of the gating pulses
t_i	Time of arrival for the i -th signal
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 specification three different terminal categories are considered. The requirements cover all categories unless otherwise stated.

The terminal categories are:

a) Integrated car terminals

This category covers DVB-T 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 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]

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 used in various countries. The centre frequencies f_c of the incoming DVB-T RF signals are as follows.

¹⁾ Figures in square brackets refer to the Bibliography.

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 the case where GSM 900 is used in a convergence terminal (category c), the usable frequency range is limited to channel 49 (698 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 49 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. DVB-T modes

7 DVB-T modes

7.1 Supported DVB-T 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). The front end 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 *END*, as defined in the following paragraph, equals the sum of the contributing *ENDs*.

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 Trade 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 an *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, whilst *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 16,5 dB, to which must be added the implementation margin for the channel equalizer 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 *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 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. In order 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 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 specification.

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.