DEUTSCHE TV-PLATTFORM

Minimum requirements for DVB-T2 receiving antennas

for portable indoor and portable outdoor reception

based on

Minimum requirements
for DVB-T receiving antennas
for portable indoor and portable outdoor reception Deutsche TV Platform

Version 1.2 / as of: 07.11 2008

Version: 1.0

Date: 30.05.2016

Deutsche TV-Plattform e.V. c/o ZVEI
Lyoner Straße 9
D-60528 Frankfurt/M.
Email: mail@tv-plattform.de

Contents

1. General properties

Application:	portable indoor / portable outdoor (stationary reception)
Polarization:	useable for horizontal and vertical polarization (linear and/or circular)
Frequency Range:	470-790 MHz (470-694 MHz) During migration from DVB-T to DVB-T2 all frequencies up to 790 MHz are used. After DVB-T switch off the frequency range is limited to 694 MHz, the frequencies above will be used by LTE.
Construction types:	passive / active
Impedance:	75Ω
Cable:	recommended 3 meters
Receiver interface:	recommended IEC connector, male, as defined in IEC 61169-2 [1]
Feature passive type:	DC isolation (short-circuit resistance)
Feature active type:	remote power supply by a receiver via RF cable (5V / max. 50mA) and / or external power supply Negative DC-Feeding to the receiver not permitted.
Return loss:	> 6 dB (including cable)

2. Antenna gain and figure of merit

Planning tools for DVB-T2 assume for the entire receiving system (consisting of an antenna, connector cable and receiver) limiting parameters for the antenna gain of the receiving antenna and the noise figure of the receiver. This ensures a sufficiently high signal-to-noise ratio C/N for the received DVB-T2 signal.

For passive antennas the antenna gain is the typical used parameter “gain”. Measuring active antennas in the same way as passive ones does not result in the antenna gain. But rather the results of these measurements have to be transformed to an equivalent passive antenna gain (see for example [2]).

The parameter for the **antenna gain** can be transformed to the **figure of merit** by knowing the receiver’s noise figure.

According to “Minimum requirements for DVB-T2 devices in Germany” [3] the receiver’s noise figure shall be better than **6 dB** for DVB-T2 (for DVB-T the noise figure was 8 dB).

According to ITU-Report BT.2254 [4] the antennas shall perform the following values:

Gain (passive antennas)	0 dBd = +2,2 dBi
Equivalent passive antenna gain (active antennas and receiver’s noise figure of 6 dB)	0 dBd = +2,2 dBi
Figure of merit of the receiving system	-28,4 dB(1/K)

For the above mentioned parameters the following transformation factors can be used:

Figure of merit [dB(1/K)] → equiv. passive gain [dBi]	+30,6 dB
Figure of merit [dB(1/K)] → equiv. passive gain [dBd]	+28,4 dB
Gain [dBi] → Gain [dBd]	-2,2

3. Requirements for amplification of active antennas

A characteristic parameter for the quality of an amplifiers is the OIP (Output Intercept Point). This is important as very high amplification is often combined with unwanted intermodulation. Active antennas consist of a receiving element and an integrated amplifier, both parts cannot be separated. Therefore standalone measuring the OIP of the amplifier is not possible. The OIP3 of the built-in amplifier should be better than 15 dBm.

Limiting the total amplification of an antenna device is not only necessary because of preventing unwanted intermodulation. Besides the output voltage of the antenna shall not exceed maximum input voltage of the receiver (see [2]). The maximum level of the output voltage compared with the voltage of a passive dipole antenna should be less than 22 dBd.

4. Characteristic of the receiving antenna, Filter

Antennas should fulfill the following minimum requirements:

- The (equivalent passive) antenna gain or the figure of merit should not fall below the minimum required value (as mentioned in Chapter 2) for the complete frequency range.
- The maximum permissible level fluctuations ("ripples") caused by the receiving antenna within a **channel bandwidth of 8 MHz** should not exceed 4 dB.
- The maximum permissible level fluctuations ("ripples") caused by the receiving antenna within **the entire frequency range** should not exceed 12 dB.

In 2016 the frequencies above 790 MHz are used by LTE and GSM. As mentioned in chapter 1 after DVB-T switch off frequencies above 694 MHz will also be used by LTE. The active antennas should provide a filter for masking LTE und GSM signals.

5. Measuring methods for antenna gain and figure of merit

The measurement of gain, the equivalent passive antenna gain or the figure of merit is performed for the entire frequency range in the preferential direction which is visible or specified by the manufacturer and in the intended polarization plane.

For all measuring methods the following instructions for the alignment of the cable of the antenna receiving should be observed:

- The RF cable is aligned horizontally backwards for one meter.
- If remote power supply via a receiver is possible for an active antenna, this method has to be chosen. Optimally the power supply is realized directly via the receiver in use. If this is not possible, the power supply is implemented via a power supply input connector at the end of the RF cable from the antenna.
- If the antenna's power supply can be realized only by means of an external power-supply unit or a 220V cable, then this cable has to be aligned horizontally backwards for one meter parallel to the RF cable.

5.1 Measuring the gain of passive antennas

There are several methods for determining the gain of passive antennas. A substitution method, for example, may be used. The receiver input voltage of the antenna under test is compared with the input voltage of a reference dipole antenna in an electromagnetic field with very few reflections. The difference between the two input voltages is the antenna gain. It is necessary to apply a height scan and average the results.

Another possibility to determine the antenna gain is the method of Schwarzbeck ("quasi-free-space calibration", [5]). A transmitting antenna and the antenna under test are mounted on vertically adjustable masts. At different heights of the masts the input voltage of the antenna under test is logged. The reflections between the transmitting and receiving antenna are eliminated by averaging. The antenna gain can be determined by comparing the averaged input voltages to free space loss.

5.2 Measuring the equivalent passive antenna gain of active antennas

5.2.1 Basics

Measuring the gain of active antennas is more complex. The gain of an active antenna is not the amplification of the antenna compared to a half wave dipole, but the noise of the antenna must be taken into account. The result is called “equivalent passive antenna gain”. A publication by BBC [2] describes determining the equivalent passive antenna gain for a receiving system with an active antenna.

Two parts of measurements has to be taken:

- The total gain (system power) of the active antenna is measured as described in chapter 5.1.
- The noise power of the antenna is measured and the equivalent passive antenna gain is determined according to [2].

For measuring the noise power, the active antenna is placed in a shielded room or anechoic chamber and the emitted noise power at the antenna connector is measured with a test receiver. First the test receiver for measuring the noise power is calibrated with a noise source. The output voltages of the noise source are known. For frequencies over the whole frequency range the input voltages of the test receiver are logged. Then the input voltages of the antenna under test are measured and compared with the results of the noise source. The equivalent passive antenna gain can be calculated by applying the formulas in chapter 5.2.2.

5.2.2 Formulas

According to [2] the **equivalent passive antenna gain** is given by:

$$G_{equ} = G_t + 10 * \log (T_p/T_a)$$

$$G_{equ} = G_t + 10 * \log ((T_{Rec} + T_{pass.ant}) / (T_{Rec} + T_{act.ant})) \qquad (1)$$

with:
G_{equ} = Equivalent passive antenna gain
G_t = Total gain of the active antenna
T_p = Noise temperature of the total passive system
T_a = Noise temperature of the total active system
T_{Rec} = Noise temperature of the receiver
$T_{pass.ant}$ = Noise temperature of the passive antenna
$T_{act.ant}$ = Noise temperature of the active antenna

The **noise temperature of the receiver** is calculated as:

$T_{Rec} = (F-1)*T_0$ (2)

The receiver's noise figure is assumed to be 6 dB (F = 4,0).

The **noise temperature of the passive antenna** is:

$T_{pass.ant} = T_0$ (3)

The **noise temperature of the active antenna** is given by:

$T_{act.ant} = P/(k*B)$ (4)

with: P = Noise power of the active antenna

k = Boltzmann's constant ($1{,}38*10^{-23}$ W/(Hz*K))

B = Bandwidth (7,71 MHz for extended carrier mode)

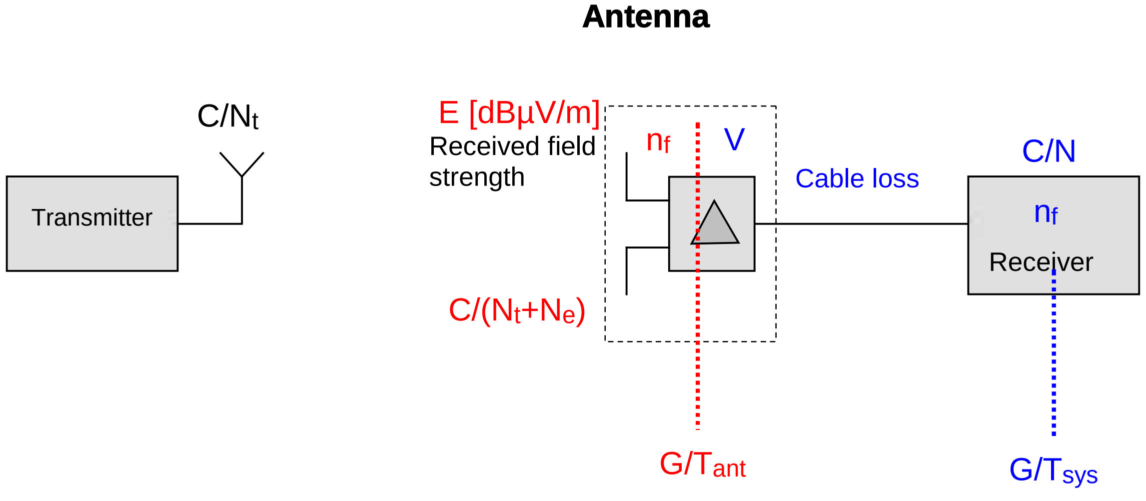
Using formulas (2) to (4) in equation (1), the equivalent passive antenna gain G_{equ} can be determined by measuring the total gain of the active antenna G_t and measuring the noise power P of the antenna.

5.3 Determination of the figure of merit of a DVB-T/T2 receiving system

5.3.1 Definition

The figure of merit is an evaluation criterion for the entire DVB-T receiving system. In this context, for all system components the environment is considered. For a minimum required C/N defined by modulation parameters, it is possible to deduce to the required figure of merit of a receiving system from the expected field strength E for any location (see ETSI TR 101 190). For each receiving frequency the figure of merit is a function of the minimum required signal-to-noise ratio and of the received field strength:

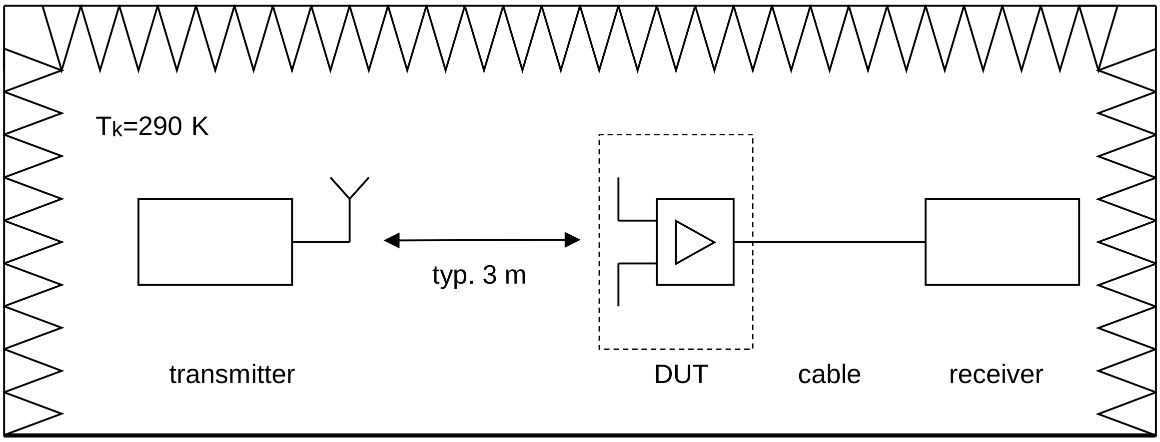
$G/T = f\ (C/N_{min},.E)$.



5.3.2 Assumptions/Requirements

- Digital system
- TV test receiver (e.g. Rohde&Schwarz ETL with Option B300) with n_f = 8dB typ.
- TV test transmitter (e.g. Rohde&Schwarz BTC with Option K516)
- Cable length = 3m
- 75ϑ impedance
- Signal bandwidth 8MHz
- Anechoic chamber suitable for the measuring frequencies
- (typical values: Shielding > 100dB; suppression of reflection > 20dB)

5.3.3 Schematic test setup



The transmitting antenna is aligned towards the antenna under test (height, polarization).

5.3.4 Formulas

linear:

C_{lin} = S * G * A_{wi}

A_{wi} = ⇐² / (4*⇔)

N_{lin} = k * T * B

$(C/N)_{lin}$ = G/T * S * A_{wi}/(k*B)

logarithmic:

(1) C/N = m + PFD + 10*log(A_{wi}) – 10*log(k*B)

PFD = E – 10*log(120*⇔) – 120

(2) PFD = E – 145.8 in (1)

$$m = C/N - E + 10 \cdot \log(k \cdot B) - 10 \cdot \log(A_{wi}) + 145.8$$

$$m = C/N - E + K(f)$$

S	=	Power density [W/m^2]
PFD	=	Power flux density [dBW/m^2]
m	=	Figure of merit [dB/K]
E	=	Field strength at the point of reception [dB⇑V/m]
B	=	Bandwidth [Hz] (7 MHz for VHF, 8 MHz for UHF)
k	=	Boltzmann's constant = 1.38*10^{-23} W /(Hz*K)
C/N	=	Receiver's signal-to-noise ratio [dB]
$(C/N)_{lin}$	=	Receiver's signal-to-noise ratio [linear]
A_{wi}	=	Effective antenna aperture of the isotropic radiator [m^2]
G	=	Gain of the antenna [dBi]
T_{sys}	=	System noise temperature [K]
T_{ant}	=	Equivalent antenna noise temperature [K]
T_k	=	Noise temperature in the anechoic chamber [K]
N_t	=	Transmitter noise [K]
N_{tr}	=	Test-Receiver noise [K]
N_{rec}	=	DVB-T2 Receiver noise [K]
N_e	=	Noise of the environment
f	=	Test frequency [Hz]
K(f)	=	10*log (k*B) – 10*log (A_{wi}) + 145.8 = Constant for test frequency (Frequency dependence of the effective antenna aperture)

5.3.5 Measuring the figure of merit m as a function of the field strength E

For measuring purposes, a DVB-T test transmitter (e.g. Rohde&Schwarz BTC) is used. The test signal is generated with the following settings:

DVB-T2 Variant	FFT	Constellation	LDPC Code Rate	GI	Pilot Pattern	nTi/Lf	Data Rate [mbps]
G1	16K	64 QAM	1/2	19/128	PP2	3/119	18,32
G2	16K	64 QAM	3/5	19/128	PP2	3/119	22,01
G8	32K	64 QAM	2/3	1/16	PP4	3/62	27,60

For more Details see the “Minimum Requirements DVB-T2 HD Germany” on the Website of the Deutsche TV-Plattform “http://www.tv-plattform.de/de/dvb-t2-hd-einfuehrung”.

The received field strength at the site of the antenna can be determined as a function of the set transmission level by means of a reference measurement with a field probe. It must be kept in mind that the result for the figure of merit will be determined in the range of constant figure of merit. In this case an increase in the field strength E of 1dB results in an increase in the signal-to-noise ratio C/N of 1dB.

Correction of the figure of merit with the receiver noise figure of 6 dB:

$T_x = (N_x-1) * T_0$

$T_{meas} = T_{ant} + (T_{cable} + T_{tr})/G_{ant}$

$G/T_{meas} = G_{ant}/T_{meas}$

⇨ $G/T_{sys} = G_{ant} / ((G/T_{meas})^{-1} * (T_{rec} - T_{tr})/G_{ant})$

⇨ $m_{sys} = m_{mes} + C_{Fac}$

Table with the correction factor:

Gain [dB]	10	11	12	13	14	15	16	17
C_{Fac}. [dB]	0,59	0,50	0,41	0,34	0,28	0,23	0,19	0,15
Gain [dB]	18	19	20	21	22	23	24	25
C_{Fac} [dB]	0,12	0,10	0,08	0,06	0,05	0,04	0,03	0,03

6. References

[1] “Radio-frequency connectors”, IEC 61169-2, 2/2007

[2] “Specifying UHF active antennas and calculating system performance”, BBC R&D White Paper WHP066, July 2003

[3] “Minimum Requirements for DVB-T2 Devices in Germany”, Deutsche TV-Plattform, 4. June 2015

[4] “Frequency and network planning aspects of DVB-T2”, ITU-R BT.2254, 11/2014

[5] “Bikonische Breitband-UHF-Meßantenne UBA 9116”, Schwarzbeck, 1991

7. Document History

Date	**Modification**	**Edition**
22.03.2007	Final version 1.0 of Minimum requirements for DVB-T receiving antennas for portable in-door and portable outdoor reception Deutsche TV Platform (Basic Reference Dokument)	1.0
December 2007	Publication of version 1.0	1.0
14.10.2008	Final version 1.1	1.1
07.11.2008	Final version 1.2	1.2
November 2008	Publication of version 1.2	1.2
30.05.2016	Final version 1.0 of Minimum Requirements for DVB-T2 receiving antennas for portable indoor and portable outdoor reception, based on Version 1.2 of Minimum require-ments for DVB-T receiving antennas	1.0
06.06.2016	Publication of Version 1.0	1.0