



Recommendation ITU-R SM.1875-2
(08/2014)

**DVB-T coverage measurements and
verification of planning criteria**

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

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RECOMMENDATION ITU-R SM.1875-2

DVB-T coverage measurements and verification of planning criteria

(2010-2013-2014)

Scope

This Recommendation describes methods for DVB-T coverage measurements and their evaluation.

Keywords

Coverage measurements, DVB-T, monitoring, planning

Abbreviations/Glossary

BER – Bit error ratio

C/N – Carrier-to-noise ratio

C/I – Carrier-to-interference ratio also referred to as protection ratio in this Recommendation

FEC – Forward error correction

DVB-T – Terrestrial Digital Video Broadcasting

GE06 Agreement – Regional Agreement and its annexes together with its associated Plans as drawn up by the Regional Radiocommunication Conference 2006 for the planning of the digital terrestrial broadcasting service in Region 1 (parts of Region 1 situated to the west of meridian 170° E and to the north of parallel 40° S, except the territories of Mongolia) and in the Islamic Republic of Iran, in the frequency bands 174-230 MHz and 470-862 MHz (Geneva, 2006)

MFN – Multi-frequency network

QEF – Quasi-error-free

QoS – Quality of service

RF – Radio frequency

SFN – Single frequency network

Related ITU Recommendations

Recommendations ITU-R BT.419, ITU-R P.1546 and ITU-R P.1812.

NOTE – In every case the latest edition of the Recommendation/Reports in force should be used.

The ITU Radiocommunication Assembly,

considering

a) that the GE06 Agreement defines the receiving conditions, necessary signal-to-noise ratios and minimum field strength values for the reception of DVB-T;

b) that monitoring services have to measure the coverage of DVB-T transmitters and networks to verify compliance with coverage predictions used in the planning process or to assess the receiving condition at a location where interference is reported,

recommends

that the method described in Annex 1 together with corrections described in Annex 2 should be used for DVB-T coverage measurements and verification of planning criteria.

Annex 1

1 Introduction

Monitoring services have to measure the coverage of broadcast networks for different purposes:

- To verify predictions of computerized tools used for the planning of the network.
- To verify compliance with license conditions if part of the broadcast license is that a certain area, percentage of an area or percentage of the population is covered by the broadcast service.
- To assess the receiving conditions at certain locations where interference is reported.

Due to certain circumstances and principles inherent in the reception of digitally modulated systems, the coverage of digital terrestrial television networks has to be measured different from analogue networks.

This Recommendation describes the measurement principles, procedure and necessary equipment for fixed and mobile coverage measurements of DVB-T transmitters and networks. However, much of the information provided is also valid for measurements of other digital terrestrial broadcasting systems.

Measurements of the quality of service (QoS) and measurements to verify technical transmitter parameters are not covered in this Recommendation.

2 Terms and definitions for the purpose of this Recommendation

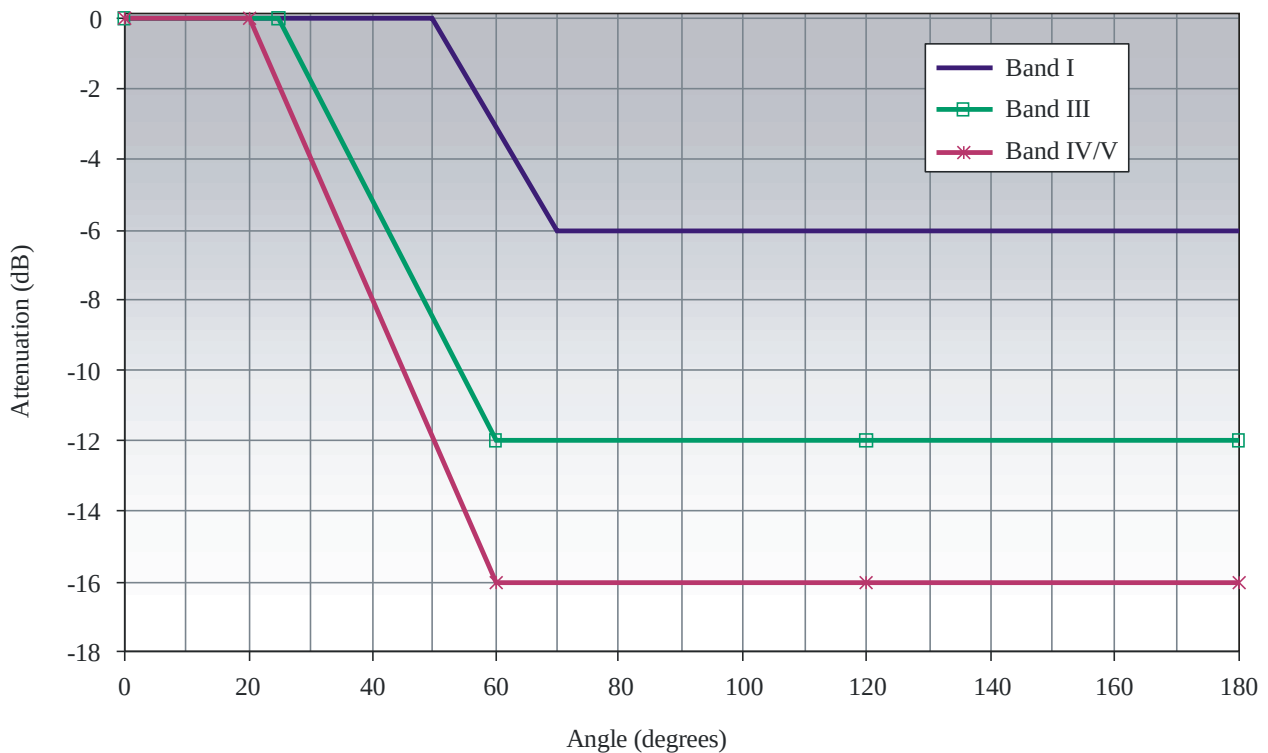
The following terms and definitions are used throughout this Recommendation. In case of generally known terms, their definitions are interpreted and specialized only to coverage issues related to the DVB-T system throughout this Recommendation.

2.1 Antenna diagram for fixed reception

The antenna diagram characterizes the relative output level of an antenna when the signal is received under different angles. Recommendation ITU-R BT.419 defines the directivity of a standard antenna used for fixed broadcast reception as in Fig. 1. To reproduce the actual receiving conditions of a customer installation, measurements for fixed coverage should be made with a measurement antenna having the same directivity.

FIGURE 1

Relative antenna directivity for fixed broadcast reception



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Mobile coverage measurements should be made with omnidirectional measurement antennas. The maximum relative loss in any direction is ± 3 dB.

2.2 Antenna factor

The antenna factor is used to calculate the field strength from the antenna output level. Because it is usually specified in dB, the calculation formula is as follows:

$$E = U + K \quad \text{dB}(\mu\text{V/m})$$

where:

E : electrical field strength at the antenna (dB($\mu\text{V/m}$))

U : measured antenna output voltage (dB(μV))

K : antenna factor (dB(1/m)).

The antenna factor depends on frequency and gain according to the following formula:

$$K = 20 \text{ Log}(f) - G_i - 29.774 \text{ (for 50 Ohm systems)}$$

where:

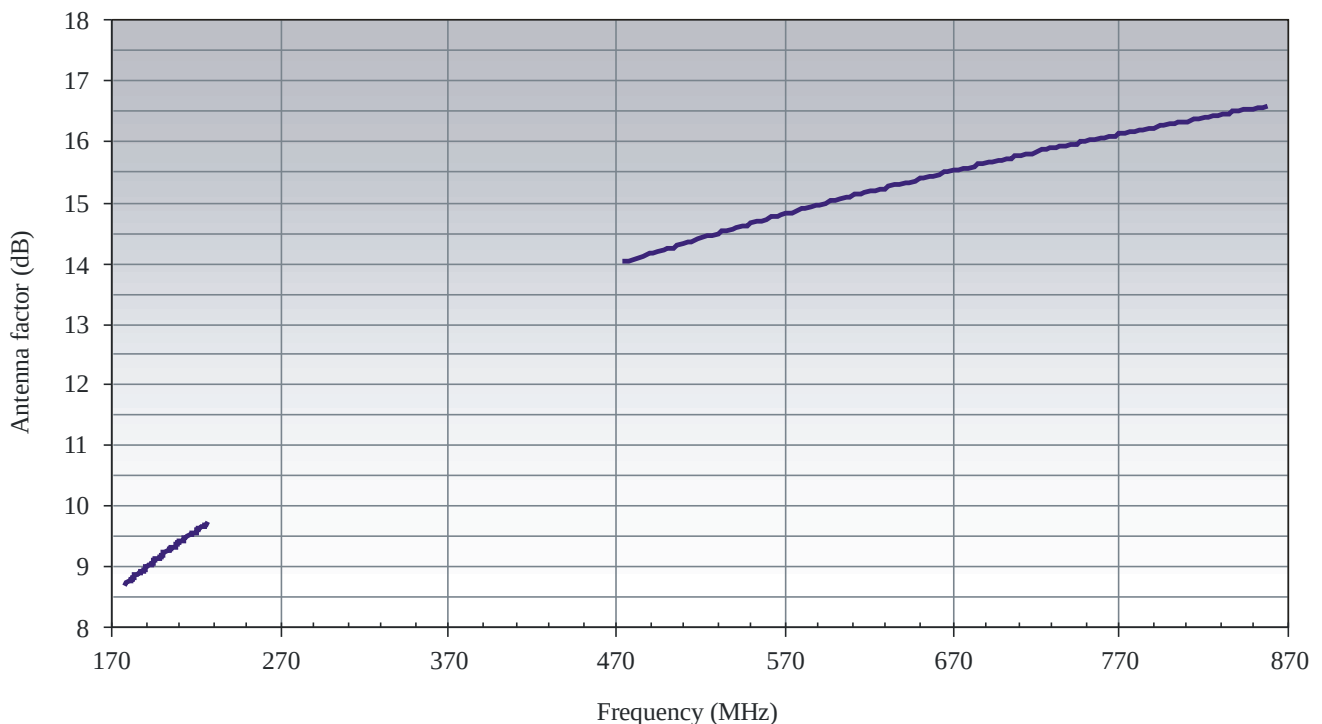
f : frequency (MHz)

G_i : antenna gain relative to an isotropic radiator (dB)

K : antenna factor (dB(1/m)).

Figure 2 shows the antenna factor of the standard antenna used for fixed broadcast reception according to Recommendation ITU-R BT.419 in the direction of the main beam which is the same as the antenna used for measurements of fixed reception.

FIGURE 2

Antenna factor for fixed broadcast reception

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2.3 Assignment area

An assignment area is a coverage area, realized by one or more transmitters where all parameters relevant for the planning process such as transmitter power, antenna height and directivity, are known. The assignment area is limited by interference from sources outside this area.

2.4 Bit error ratio

Generally, the bit error ratio (BER) is the number of false bits divided by the total number of bits transmitted during a given time. It is a measure of the receiving quality of a digital signal. Because DVB-T uses inner and outer error protection, it is possible to determine the BER after the Viterbi and after the Reed-Solomon decoder off the air.

A BER of 10^{-4} after the Viterbi decoder is regarded sufficient for DVB-T reception.

2.5 C/N

See protection ratio.

2.6 The term “covered”

A certain area is regarded as being “covered” by DVB-T, when the median field strength for the particular receiving situation in a specified height above ground (often 10 m) and the protection ratio reach or exceed the values given in the relevant planning documents (e.g. the GE06 Agreement).

The fact of a certain area to be covered or not is a result of the calculation process done with a coverage prediction tool that assumes defined conditions and/or values for:

- the receiving condition (e.g. fixed or portable reception);

- the field strength loss with distance due to topography and morphology;
- the receiver model (e.g. sensitivity and selectivity);
- the receiving antenna (height, gain and directivity);
- the reception channel (Gaussian, Rice or Rayleigh).

Attached to the attribute “covered” is also a certain probability in time and location. Using planning tools, the coverage area is calculated for this probability (e.g. 50% of the time and 50% of the locations).

It can therefore not be assumed that DVB-T reception with a standard receiver is possible at every single location inside the area defined as being covered.

Verification of coverage cannot be done with a standard DVB-T receiver by simply checking whether it works at a certain location. Instead, the technical parameters such as field strength have to be measured, preferably under the same receiving conditions as assumed in the planning tool.

2.7 The term “reception possible”

The DVB-T reception is regarded possible if at a certain location a standard receiver can correct (nearly) all errors in 99% of the time and produce a picture. The BER after the Viterbi decoder should be below $2 \cdot 10^{-4}$.

The actual necessary field strength for a successful DVB-T reception depends on:

- the DVB-T system variant;
- the receiver performance;
- the antenna gain;
- the type of reception channel (Gaussian, Rice or Rayleigh).

Verification of a general reception possibility can be done by measurement of the following parameters:

- median receiving field strength;
- median interfering field strength;
- type of reception channel.

Alternatively, a reception test with a standard DVB-T receiver can be done. Experience from these tests shows that, for portable reception, sometimes higher field strengths than median values given in the relevant agreements are necessary.

2.8 Coverage prediction

Coverage prediction is a procedure to calculate the geographical area inside which reception of the service is possible. It is based on transmitter parameters, terrain and propagation models and is done with computerized tools. The result represents a defined location and time probability.

In the GE06 Agreement, the minimum field strength values for DVB-T to be reached at the coverage border are valid in 10 m height above ground and assume fixed reception with a directional antenna according to Figs 1 and 2. They are medians of the minimum equivalent field strength values and depend on the system variant and the reception channel.

2.9 Crest factor

The crest factor is the ratio between the peak and r.m.s. level value of an RF emission. Usually, it is given in dB and is then the difference between peak and r.m.s. levels (dB).

2.10 Guard interval

To make use of all incoming signal components from co-channel transmissions and reflections that arrive at different times at the receiver, and to prevent interference of two subsequent symbols, each symbol is transmitted longer as would be necessary to decode the signal. The additional time is called guard interval. The actual decoding process inside the receiver can start after the guard interval has passed. The length of the guard interval depends on the system variant and the maximum distance between neighbouring transmitters in a single frequency network (SFN).

2.11 Height loss

This is the field strength difference in 10 m above ground (reference for DVB-T planning) and the receiving field strength at an antenna being closer to the ground (e.g. 1.5 m for portable reception). Its value is statistical.

2.12 Interfering field strength

The interfering field strength is produced by signals from transmitters on the same frequency that are not part of the investigated SFN or transmitter, by signals from neighbour channel transmitters and by signals from transmitters of the investigated SFN that are received outside the guard interval. It is formed by the vector addition of the directly received signal component from the interferer and reflections due to obstructions in the field. It varies with the location of the receiver, and because the reflecting obstacles may not be stationary, it also varies with time. The actual interfering field strength inside a certain area can therefore only be described statistically by a median value and a standard deviation.

Practical measurement of the interfering field strength can be difficult, especially if its level is well below the wanted signal level and both interferer and wanted transmitter are received from the same direction. Possible ways of improving the measurement conditions for the interfering field strength are:

- Use of a measurement antenna with a high directivity to separate wanted and interfering signals by changing the azimuth.
- Measurement of a signal on a different frequency that is emitted from the same location as the interfering transmitter. In this case, corrections for different attenuation loss from the frequency difference and for different transmitter power on the measurement frequency may have to be applied.
- Switch off the wanted transmitter or SFN during the measurement.

When the interfering signal is more than 30 dB below the wanted field strength, its influence on the reception of the wanted transmitter or SFN can be neglected.

2.13 Median

The median is calculated from a total of many samples (e.g. a series of measured field strengths) so that 50% of all samples exceed the median value, the other 50% of the samples are lower. The median is a statistical value and specifies a 50% confidence or probability.

Example: The field strength is measured at 100 locations inside a certain area. The median of all measurement values is 42 dB(μ V/m). This means that the probability of the actual field strength at **any** location in this area being at least 42 dB(μ V/m) is 50%.

The advantage of using the median when specifying field strength statistically is that single values far off do not influence the result as much as the average or mean.

2.14 Minimum median field strength (E_{med})

This is the median field strength based on calculations at a certain percentage of the locations inside a receiving area. In relevant planning texts such as the GE06 Agreement, its values for DVB-T reception are given in 10 m height above ground and for 50% location probability. They are given for each system variant.

Without correction, these values only represent the fixed reception scenario. For portable reception, correction factors have to be applied for the different antenna height, antenna gain, required level of location and time probability, and building penetration loss (where applicable).

Network planning ensures that the minimum wanted field strength is at least theoretically reached for the whole coverage area, depending on radiated transmitter power, transmitter antenna height and topography of the terrain.

2.15 MFN

MFN is the abbreviation for multi-frequency network. This is a network where inside the coverage area, each transmitter works on a different frequency.

2.16 Minimum equivalent signal level

The minimum level at the receiver input necessary to decode the wanted signal is the minimum system-dependant signal-to-noise ratio (S/N) plus the receiver noise figure. The minimum S/N enables the receiver to decode the signal quasi-error-free (QEF). It depends on the system variant and the reception channel. The receiver noise figure assumes a certain receiver performance and is defined to be 7 dB for a standard DVB-T receiver.

2.17 Minimum wanted (equivalent) field strength (E_{min})

This is the minimum field strength of a single wanted signal necessary for a standard receiver to decode the signal QEF, in the absence of any interfering signals. It is the minimum equivalent signal level at the input of the receiver plus antenna factor and is valid for a certain receiving location, i.e. without corrections for location and time probability.

2.18 Network gain

If signals from multiple wanted transmitters inside an SFN can be received within the guard interval, the reception quality can be improved and the minimum wanted field strength from each transmitter can be lower. The network gain, however, is not the sum of the wanted field strengths from all receivable transmitters. It is merely the increased probability to receive a better signal from an additional direction than from a single transmitter alone.

The network gain is the difference of the receiving field strengths inside SFNs and MFNs necessary for the same location probability.

In an SFN, the increased number of transmitters leads to a more homogeneous distribution of the field strength in the coverage area. The standard deviation σ of the field strength values is lower.

Example: The minimum median field strength for a certain system variant according to international agreements E_{med} is 61.3 dB(μ V/m). This, per definition, applies to 50% location probability. In an SFN, the minimum wanted field strength E_{min} for 95% location probability is 66.7 dB(μ V/m), for an MFN it is 70.3 dB(μ V/m). The network gain is then 3.6 dB.