DVB-T measurement giudeline

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***Abstract*—This paper deals with guideline of Digital Video Broadcasting DVB-T measurement. It brings a full guide manual for preparation such as this type of measurement. The paper describes all steps, which are necessary to be done before measurement to achieve relevant findings**

***Index Terms*— Antenna, antenna factor, DVB-T, gain.**

I. Introduction

DIGITAL Video Broadcasting (**DVB-T**) is a headline topic nowadays. The process of digitalization in the Czech Republic successfully runs following technical switch-over plan (TPP). [1] A correctly mastered measurement is an important issue in switch-over process that brings a relevant feedback from digitally covered areas. The paper describes some conditions of theoretical coverage simulation, a process of measuring point determination, an antenna calibration, and finding of antenna factor (**AF**). It also brings a useful list of quantitative and subjective evaluation factors characterizing quality of **DVB-T** signal. [5] Finally it describes an extension of traditional method by mobile measurement. The paper is based on [1] and extends findings published in [7].

II. Before You Start

A. Software calculation of coverage area

Software calculation follows [1]. The calculations are performed in simulation software such as RadioLab [6], which is able to create a coverage map of the electromagnetic field intensity **E**. RadioLab is software for analysis and visualization of the spread radio signals above the Earth surface, which can be used in the analysis and design of radio systems for coverage of services such as DVB-T. Simulations are performed to cover a particular area with the setting of the following parameters:

- curve spread of electromagnetic waves are related to
  - 50% places, 50% of the time for a useful signal,
  - 50% capacity, 10% of the time for disturbing signal,
- officiall analysis model: **ITU-R P.1546-2 CA** [2], non-official (more accurate) method **RDK2** [6],
- a minimum level: 66 dBμV/m (determined by calculation [1]),
- distance: 50 km (depended on transmitter's power),
- azimuth step: 1 °,
- coefficient of curvature of the earth surface: 4 / 3,
- receiving antenna height: 10 m (given by [1]).

The output of the simulation software is a map of DVB-T signal coveraged area (Fig.1). For purposes of electromagnetic intensity calculating is used a digital terrain model in the grid of 100 x 100 m with triangular interpolation without consideration of morphology in particular buildings and green.

The setting parameters are based on practical experiences [7]. Regarding of that, non-official calculating method **RDK2** is the most realistic method of simulation calculations.

B. Determination of measuring points

At the first, it is essential to select locations with low levels of electromagnetic field (E ≤ 56 dBμV/m) [1], that is based on outputs from RadioLab (Fig.1).[6] The measurement has to be done at least in 5 measuring points. Measuring points are chosen with regard to a broken topography and buildings in the build-up area and in places that are not in close proximity to obstacles or objects in shadow to transmitters.

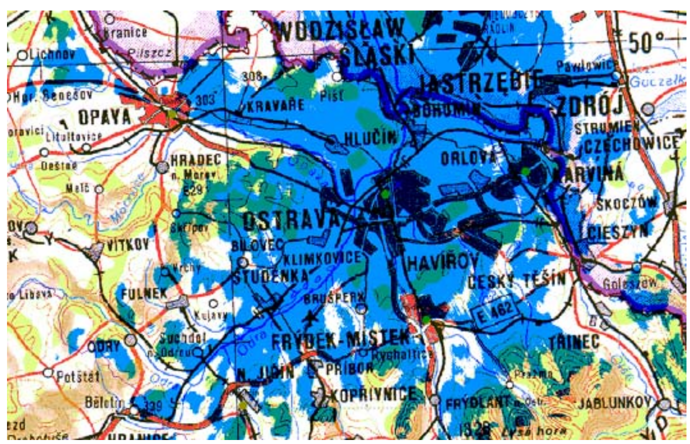

Fig. 1. Software Output from RadioLab – coverage DVB-T multiplex I, Ostrava, 1st of February 2009

C. Procedure for setting the number of measuring points [1]

1) Select at least 5 measurement points so that they represent locations with the worst and the best predicted values of signal in measured area and measure electromagnetic field intensity **E.** Than determine by formula (1) intensity difference [1]:

$$\triangle E = E_{n\max} - E_{n\min} \left[V.m^{-1} \right] \quad (1)$$

Where: ΔE *difference of intensity*
E_{nmax}. *maximal value of the measured intensity,*
E_{nmin}. *minimal value of the measured intensity.*

2) If the found values of **Δ E** referred to paragraph 1 of [1]:
   a. **Δ E ≤ 5 dB**, it is not necessary to increase the number of points,
   b. **Δ E > 5 dB**, it is necessary to choose the number of points as follows:
   - where Δ E 0 to 5 dB, the required number of measuring points at least 5,
   - where Δ E 6 to 10 dB, is the number of measuring points, at least 7,
   - where Δ E 11 to 15 dB, the number needed at least 15 measuring points,
   - where Δ E 16 to 20 dB, is the number of measuring points at least 27.

In the case of Δ E greater than 21 dB must be considered area divided into smaller, self-assessment areas.

Measurement of electric field intensity and a subjective signal quality evaluation are carried out [1]:

a) at a height of 10 m above ground,

b) on the roofs of buildings, where the height exceeds the height of buildings border 10 m above terrain.

However, there still possibility of measurement in a local minimum, resulting from the influence of multi-path signal propagation. Regarding of that, there is necessary to determine the maximum value of the change in the horizontal position of the measuring antenna in the range between 5 m to 10 m.

The sensitivity of measurement sets (noise threshold) must be taken into account. If the difference in values of measured signal and level noise threshold of measuring set is less than 8 dB, measured values should be corrected.[1]

III. Measurement Set

A. Antenna

Receiving antenna for the objective evaluation of the quality of Terrestrial Digital Video Broadcasting signal is a directional antenna with gain of values in Table I.

TABLE I
Required Gain Of Measuring Antenna

TV band	Frequency Range	Antenna Gain
I.	48,5-66 MHz	3,5 dB
III.	174-230 MHz	7 dB
IV.	470-582 MHz	10 dB
V.	582 – 862 MHz	12 dB

Consequently, the maximum permitted loss of coaxial cable in all TV bands is up to 4,5 dB [1].

This quality perfectly matches a Yagi directional antenna (Fig.2).

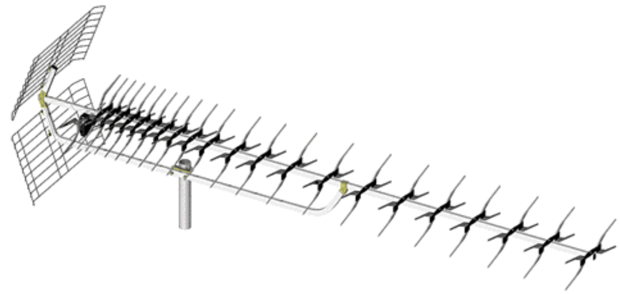

Fig. 2. Yagi antenna

It is essential for a measurement accuracy to know an antenna gain characteristic. If the characteristic is not provided by seller, it is necessary to calibrate antenna by your own. The process of calibration is simply. Antenna is usually used only at few TV channels (frequencies). The easiest way how to calibrate the antenna is to make a half-wave length dipole and compare the receiving power level of a reference signal on the particular frequency with the measuring antenna. The output of calibration is the gain characteristic (Fig.3).

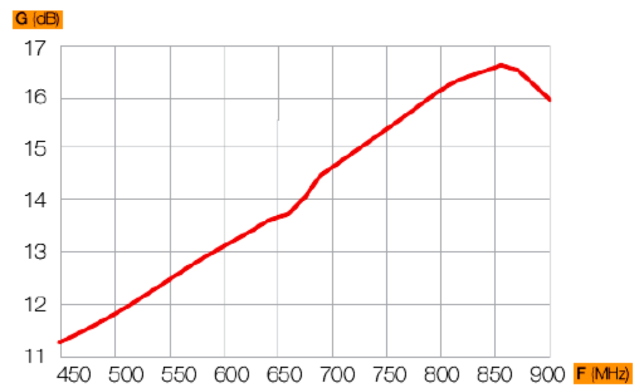

Fig. 3. Gain characteristic of Yagi antenna in IVth and Vth TV band

For further calculations is important to know the antenna factor **AF** for all measured channels [3], [4].

$$AF = \sqrt{\frac{480\pi^2}{Z\lambda^2 Gr}} \left[m^{-1}\right] \qquad (2)$$

Where: Z *is output impedance of antenna (Z = 75 Ω)*
λ *is wave-length*
Gr *antenna gain on the particular frequency/channel*

The values obtained by measuring voltage level on the spectral analyzer have to be calculated according to the following relation (3) to obtain the right value of the electric field.

$$E_{dB\mu V/m} = U_{dB\mu V} + AF_{m^{-1}} + a_k \left[dB\mu Vm^{-1};\ dB\mu V, m^{-1},\ dB\right]$$

(3)

Where*: AF* *is antenna factor,*
$U_{dB\mu V}$ *is measured voltage level,*
a_k *is attenuation on coaxial cable.*

B. Spectral Analyzer

Due to Orthogonal Frequency Division Multiplexing (**OFDM**) modulation, that DVB-T uses, is preferred an integration method of electromagnetic field intensity measurement. It is measured in all signal bandwidth of DVB-T signal. In the event that there is no automatic setting of parameters, measuring device must be set manually to the following parameters (Table.II).

TABLE II
RECOMMENDED SETTING PARAMETERS

resolution bandwidth RBW	7,61 MHz
detector	RMS
trace	C/W or AVG
span	10 MHz
swp	200ms or grater

One of successfully experienced type of spectral analyzer suitable for DVB-T measurement is **SEFRAM 7825TM** (Fig.4). This type of spectral analyzer is a reasonable compromise between number of operation functions, a measurement accuracy and price.

The measurement features of this type of analyzer can be extended to Digital Video Broadcasting – Satellite (**DVB-S**) and Digital Video Broadcasting – Cable (**DVB-C**) measurement modules.

Fig. 4. SEFRAM 7825TM

IV. MEASUREMENT DATA EVALUATION

A correctly evaluated data is the last stage of measurement. Values of quantitative parameters such as input power level, Bit Error Ratio (**BER**) and Modulation Error Ratio (**MER**) are set by [1].

A. Qualitative parameters

In assessing the quality of DVB-T signal according to the possibility of measuring instruments measure one of the parameters defining the objective quality decoded **OFDM** signal.

- BER measurement is carried out before Viterbi decoder, where the measured error transmitted data stream before the correction, or after Viterbi decoder, where the measured error correction isolates errors in the data flow. Usually, for the purpose measuring the quality of DVB-T signal is usually measured BER after Viterbi decoder, where the reference value is **BER** $< 2.10^{-4}$.[1]
- Modulation error MER is a parameter that comprehensively evaluates the quality of received signal strength (distance error signal modulation DVB-T). The recommended value is **MER** $\geq$ **22 dB**.
- The last parameter that is measure is a median value of electromagnetic field **E**. There are four values:
  - o FX fixed reception on fixed antenna
  - o PO mobile reception outside building
  - o PI mobile reception inside building
  - o MO mobile reception

It follows a raw table with referred levels of electromagnetic field intensity for fix reception FX (detailed table for each TV channel in [1]).

TABLE III
MINIMUM VALUE OF THE USEFUL SIGNAL DVB-T

Range of TV Channels	E_{min} (dBµV/m)
5-6	48
7-9	49
10-12	50
21-22	52
23-30	53
31-38	54
39-47	55
48-58	56
59-69	57

Basic technical parameters of the signal OFDM used for DVB-T are:

- o Number of carrier waves
  - in the 2k mode -1705,
  - in the 8k mode - 6817
- o Possible carrier wave modulation
  - QPSK,
  - 16-QAM
  - 64-QAM.
- o Viterbi correction code ratio-1/2, 2/3, 3/4, 5/6, 7/8,
- o Guarded interval - 1/4, 1/8, 1/16, 1/32.

The first (public) multiplex, which in the Czech Republic broadcasts České Radiokomunikace a.s., it used a combination of COFDM: mod 8k, code ratio - 2/3, the guard interval - 1/8, modulation carrier wave of 64-QAM. This combination allows the data rate around 23 Mbit/s, channel bandwidth of 8 MHz. When is used the source signal compression Motion Picture Experts Group 2 (**MPEG2**) allows the transfer of up to 5 standard quality TV programs, several stereo radio stations, and basic data flow for one of Multimedia Home Platform (**MHP**) with passive interactivity such as Electronic Program Guide (**EPG**), weather etc.

Practical measurements show that the minimal level of received signal is about 40 dBµV. Since this level is DVB-T receiver fully sufficient for high quality image. Bit error rate at that minimal level after Viterbi decoding **BER <10^{-3}**, which brings a stable clear picture of television programme.

Digital receiver set-top-boxes and DVB-T also allows to measure and form bar-graph shows a level of error rate BER of received signal. This "measurement" is only informative, inaccurate, and mostly non-linear. Power level at which the receiver "refuses" received signal to demodulate and decode usually around value of **35 dBµV**.

B. *Subjective parameters*

Not only quantitative parameters are evaluative, there also is a subjective classification of DVB-T picture quality. Source [1] gives a clear evaluation list of picture quality. There is a three-level evaluation scale (Table.IV).

TABLE IV
SUBJECTIVE EVALUATION OF DVB-T QUALITY

Q1	poor quality, frequent failures, the receiver is not synchronized
Q3	good quality, single failure
Q5	excellent quality, unobservable defects in the quality of image and sound

Time tracking of video and audio quality to a selected program from the multiplex is measured at least 3 minutes.

If the measurement is done on the roofs of buildings, the area surrounding the measuring point considered to be covered, only if the measured intensity reaches a minimum value (Table.IV) and according to a subjective evaluation of the signal quality is:

- Q5 for the purposes of group reception (STA),
- Q3 for the purposes of single user reception.

V. METHOD EXTENTION

As shown practical experiences, it is everytime not possible to follow [1] into the detail. The density of measurement points (100x100m) is a bit unrealistic to measure point by point. The practise rutine is that firstly it is made a detailed software calculation followed by predicting problematic areas.

Emerging technologies (such as DVB−T/H) are generating a demand for new coverage measurement methods that do more than the traditional procedure [1] mentioned above. These new methods must work in mobile scenarios, i.e. during driving.

The traditional method [1] is extended by continuous mobile measurement that is continuously made at 2 – 3m high above ground. The measurement tools such as Fig. 5 and Fig. 6 are arranged in a car or van that goes through uncertain places find in software calculation.

Fig. 5. R&S® TSM-DVB mobile Diversity Test Receiver [12]

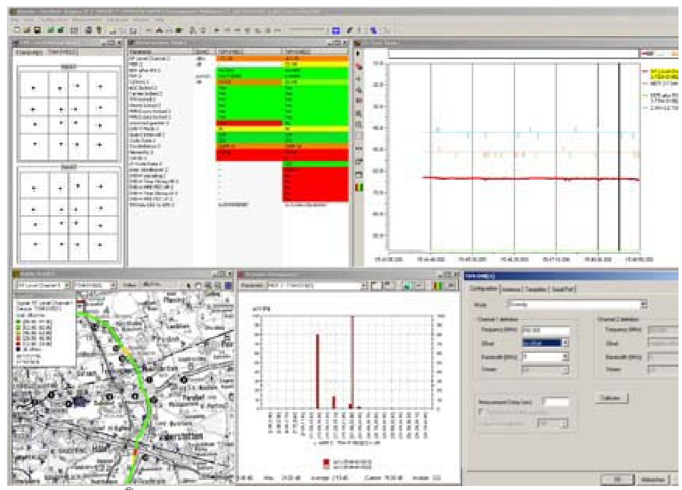

Fig. 6. R&S® TSM-DVB mobile Diversity Test Receiver – a software part [12]

The R&S® ROMES application software (Fig.6) displays all of parameters online and stores them with time and positioning information into a database.

Benefits of this extended method are that it brings reduction of measurement time and measurements cost-saving. Once problematic places are interpret from mobile findings, a regular stationary measurement followed [1] is made.

The extended method is also commonly used by engineers at ČTÚ and České Radiokomunikace a.s.

VI. CONCLUSION

The issue of DVB-T reception is more complex than is for analogue broadcasting. The accuracy of DVB-T signal measurement relies on the use of measuring devices. On the transmitting part, for high quality monitoring is needed to use a wide range of measuring equipment intended for professional measurements, which are able to analyze all the important parameters of the transmitter. While at the receiving side suffices a simple measuring device for measuring the basic parameters as was described above. The list of parameters measured DVB-T signal at the transmitter/receiver side and additionally also at the distribution network, provides technical manual ETSI TR101 290 [10].

There is no universal solution, therefore, becomes necessary measurements in problematic areas to verify the correctness of software calculations.

The above described method was successfully used by authors as they work on a project “Measurement of DVB-T signal coverage on territory of city of Ostrava”. While the measurement team solved the project, they have taken wide experiences with software calculation and in estimation of problematic areas.

The certainty of successfully predicted signal intensity based on the software calculation is more than with 5 dBµV accuracy, and always depends on the particular site. Mainly, the software simulation does not expect coverage places by reflected signal. The advantage of DVB-T signal is that a signal reflection does causes that even the “white” places are covered. Unfortunately this kind of propagation due to [1] can not to be mentioned as covered because of instability of such as this kind of reception.

The above described guideline can be used as a measurement guide such as in problematic areas. Authors find as pointless to mention certain example of measured values due to generality and complexity of issue as measured values strongly depend on particular place.

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