For certain problems with DVB-T reception

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Abstract – **This article presents theoretical and experimental results of research of main (basic) parameters (BER, MER, END and PR) of the received digital signals for a certain channel (ch. 40) under the influence of adjacent (upper) PAL-K (AM-VSB) channel (ch. 41) at various problems.**

Keywords – **DVB-T, MER, field strength, simulcast.**

I. Introduction

In modern systems for terrestrial broadcasting are used more and more the methods for digital transmission of information. The transition from analogue to digital methods cannot be done immediately (abruptly) but it is needed some period of time (around 6 months), in order for that transition to be performed.

This time period is famous with the name "*simulcast*" and within it are broadcasted radio and television programs, both in analogue and digital type. Furthermore there are other radio communication systems existing that work in the co-channels or adjacent channels, which import certain interferences and even sometimes lead to impossible receiving.

In the present paper are shown (systematized) the important (significant) problems with reception of DVB-T, basic problems have been studied and some methods for their solving are shown.

II. Problems with DVB-T reception

There are many various and diverse problems (Table I) existing in the reception of DVB-T signals from stationary (set-top-box and TV receivers) and portable (outdoor, indoor: USB, Euroscart, etc.) and mobile (LTE, car) receivers.

The specified parameters and features in the transmission of signals (Table I) directly correspond to the problems specific in a greater or lesser degree for every one of the above mentioned DVB-T receivers. Here are also recorded the problems resulting of the influence of other radio communication systems: WI-FI, wireless Internet [1], etc.

In this paper are presented the results of main (basic) parameters (BER, MER, END, PR) of the received digital signals for a certain channel (ch.40) under the influence of adjacent (upper) PAL-K (AM-VSB) channel (ch.41) at various problems (Table I: № 1; 2; 3; 9; 11; 12), Fig.1.

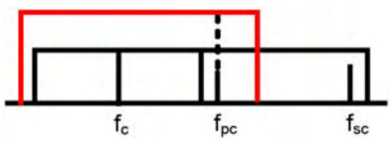

Fig.1. Spectrum of the DVB-T receiver's input signals

TABLE I
PARAMETERS, FEATURES AND REASONS FOR OCCURRENCE OF PROBLEMS WITH DVB-T RECEIVING

№	Parameters	Features / clarifications
1	Selectivity	Radiofrequency: adjacent, co-channel interference; Intermediate frequency: SAW filter
2	Sensitivity	AGC; antenna amplifier (LNA); active antenna, power supply +5V
3	Wave polarization	Vertical: DVB-T; AM-VSB, etc. Horizontal: AM-VSB, FM.
4	Power of radio transmitters	Analog: big Digital: small
5	Signal compression	MPEG-2; MPEG-4
6	HDTV; SDTV; CVBS; R, G, B; Y, C_B, C_R; IEC- female	Connection between STB and TV: base band (non-modulated) signals; remodulators: AM (amplitude modulation)
7	Number of STB (set-top-box)	For every TV without DVB-T tuner
8	Encryption programs	CAM and Smart card
9	Field strength	Rain, snow, fog, trees, buildings, walls (in room)
10	Doppler effects (car velocity), Diffraction, interference	DVB-H, DVB-T receivers for cars
11	BER in Gaussian, Ricean, Rayleigh channel	Directional, omni-directional antenna
12	Current consumption	USB tuner blocking some μC
13	Software conflict (available programs on μC and USB tuner software)	USB tuner software is installed but can not be started and etc.

III. Theoretical positions and quantitative ratios

For the proper and reliable transmission of information in digital DVB-T channel is needed the values of the basic parameters (BER, MER, C/N, END, PR) to be in the boundaries defined by the corresponding standard [2], [3].

The mathematical dependencies between them are derived and given below.

A. Protection Ratio

The influence between the channels (adjacent and co-channel) is studied by inputting a *PR* (protection ratio), which according to [2], [4] is defined as ratio of the power of the received analog and digital signals in the point of reception (the place in which the antenna is installed), i.e.

Protection Ratio [*dB*] = *Wanted Signal level* [*dBm*]
– *Unwanted Signal Level* [*dBm*]. (1)

In our case the desired signal is the digital one and the unwanted - the analogue one, so we can write the upper equation as:

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$$PR[dB] = P_{rD}[dBm] - P_{rA}[dBm] \text{, or} \quad (2)$$

$$PR[dB] = P_{rD}[dB\,\mu W] - P_{rA}[dB\,\mu W] \text{, where} \quad (3)$$

$$P_{rD}[dB\,\mu W] = E_{rD}[dB\,\mu V/m] - A_e[dB] - 145{,}76 \text{,} \quad (4)$$

$$P_{rA}[dB\,\mu W] = E_{rA}[dB\,\mu V/m] - A_e[dB] - 145{,}76 \text{.} \quad (5)$$

In Eqs. (2), (3), (4) and (5):

P_{rD} is received power of the digital signal at Channel 40 (626 MHz) at the receiving antenna;
P_{rA} is received power of the analogue signal at Channel 41 (631.25 MHz) at the receiving antenna;
E_{rD} is the field strength of the digital signal at Channel 40 (626 MHz) at the receiving antenna;;
E_{rA} is the field strength of the analogue signal at Channel 41 (631.25 MHz) at the receiving antenna;
A_e is the effective antenna aperture.

$$P_{rx}[dB\,\mu W] = P_{rx}[dBm] + 60 = P_{rx}[dBW] + 120 \text{,} \quad (6)$$

x=D or A.

From Eq.4 and Eq.5, replacing in Eq.3, we get

$$PR[dB] = E_{rD}[dB\,\mu V/m] - E_{rA}[dB\,\mu V/m], \quad (7)$$

where from [5]

$$E_{rx}[dB\,\mu V/m] = U_x + 6 - (G + \lambda_{dB} + k_\ell) \text{ and} \quad (8)$$

U_x - level of the analogue or digital signal at the receiver input, [$dB\mu V$];
G – antenna gain, [dB];

$$\lambda_{dB} = 20\lg\left(\lambda/\pi\right), [dB/m]; \ \lambda = c/f, [m]; \quad (9)$$

$k_\ell<0$ is transmission line loss, [dB].

B. Modulation error ratio (MER)

The parameter MER encompasses all the parameters that can be determined by means of the constellation diagram. The MER is, therefore, the most important parameters to be monitored in a DVB-T system besides the BER. If the MER is within agreed tolerances, all other parameters are likewise within tolerances [6].

To determine the MER, an error vector is calculated for each I/Q value pair. The length of this vector indicates the offset of the actual position of an I/Q value pair from the ideal position, i.e. the center of the decision field (Fig.2).

To determine the MER, the sum of the squares of all error vectors calculated during one second is formed. The same is done with the ideal vectors of the decision fields. Then the ratio of the two sums is formed. This value is logarithmized, which yields the MER value in dB. The logarithmic ratio can also be expressed in percent.

From [2], [5], [6] and [7] are derived the next equations:

$$MER[dB] = E_{rA} + PR + k_{r-f} - d_A - NF_\Sigma - B_{dB} + 65 \text{, or} \quad (10)$$

$$MER[dB] = E_{rA} + PR + G_a/T_e + k_{r-f} - G_{1m^2} - k_B - B_{dB} - 145{,}76 \text{,} \quad (11)$$

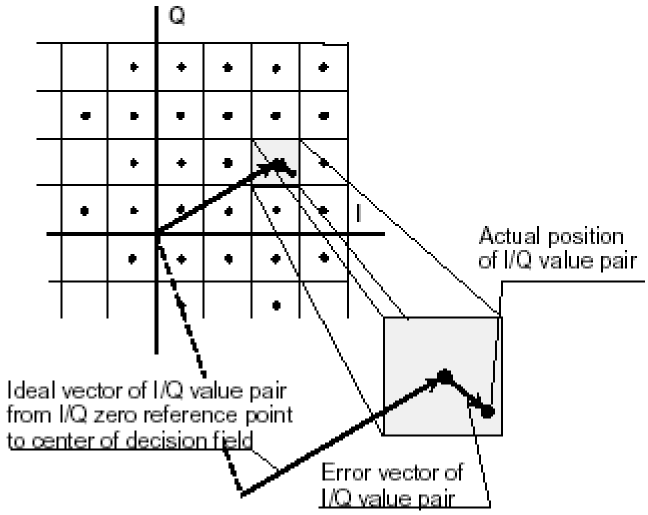


Fig.2. Ideal vector and error vector used in calculating the MER sum parameters

where all parameters are in logarithmic values and their meanings are described in [2], except

$$d_A[dB] = 6 - G - \lambda_{dB} - k_\ell; \quad (12)$$

$$NF_\Sigma[dB] = (N_{rx} + N_{LNA} + N_I) \text{, where} \quad (13)$$

NF_{rx} is receiver noise figure [dB];
NF_{LNA} is antenna amplifier (LNA) noise figure [dB];
NF_I is receiver noise figure due adjacent channel interference [dB].

C. Bit Error Ratio (BER)

The theoretical determination of BER is made through [8]:

$$P_B = \{[erfc(\sqrt{10^{(MER-6,75/10}/7})]/1{,}12\}$$

$$\times\{1-[erfc(\sqrt{10^{(MER-6,75)/10}/7})]/2{,}27\}. \quad (14)$$

D. Equivalent Noise Degradation (END)

The equivalent noise degradation (END) denotes the deviation of the actual SNR from the empirically determined SNR for a BER of 7.10^{-5}. To prevent influences from the test equipment invalidating results, two measurements are required to determine the END:

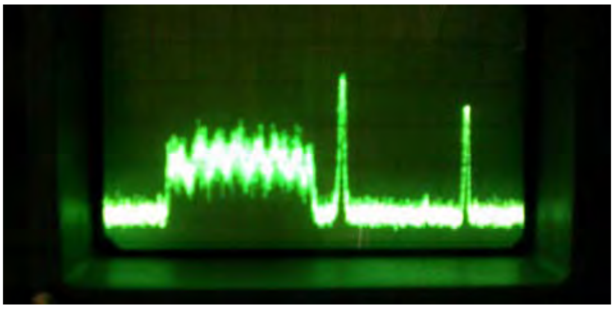
$$END[dB] = MER_1 - MER_2 \text{, where} \quad (15)$$

MER=S/N, [6], [9] and $S/N = C/N + k_{r-f}$ from [6], [8].

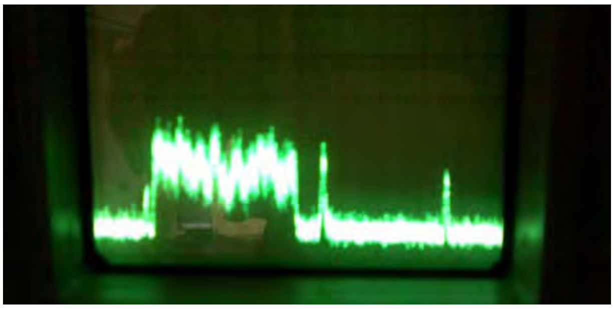
IV. Measurements and Results

The studies are made for different values of the field strength in the reception point with two types of antennas: directional-roof (ATK12/6-12, 21-60) with horizontal (h) and vertical (v) polarizations and indoor omni-directional (rod).

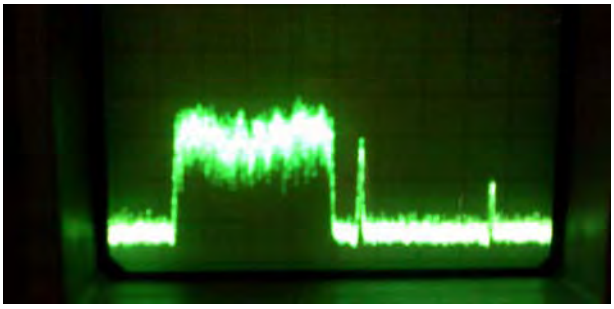
On Fig.3 are presented spectrums of digital and analogue signals for channels 40 and 41 respectively. DVB-T receiver



a) horizontal (h) polarization (directional-roof antenna)



b) omni-directional (rod) antenna



c) vertical (v) polarization (directional-roof antenna)

Fig.3. Spectrums of digital and analogue signals (ch. 40 and ch.41)

is a USB TV tuner with separate (external) power supply. To improve its selectivity, between the antenna and its input a notch filter (*nf*) is connected, and for improving the sensitivity – antenna amplifier (LNA) with adjustable gain G_{LNA} = (10÷30) dB. The input level of the receiver according to ITU-R has been fixed by the adjustable attenuator and amplifier.

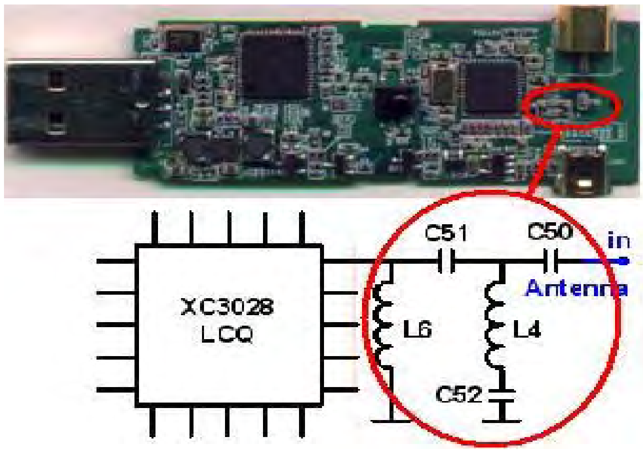
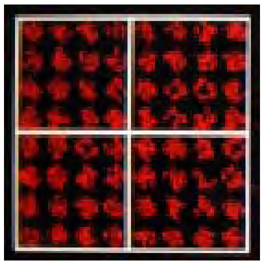


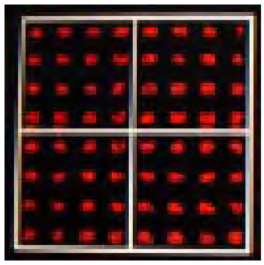
Fig.4. DVB-T USB receiver (in red loop is Input Filter)

On Fig.4 is shown the scheme of the input block, realized with XC 3028, as well as the elements' installation on printed circuit board.

The measurement setup scheme is shown in Fig.5 and the results for constellation are presented on Fig.6. The theoretical and experimental results for MER and BER are presented on Fig.7, Fig.8, Fig.9, Fig.10, Fig.11 and Fig.12, where it is seen that the END ≤ 0,5dB, and in application of *nf* MER increased to values above 18dB, corresponding to the requirements of the ITU-R [2], [3]. However, (for rod and roof antenna - h polarization) BER reaches minimum values to $3{,}83.10^{-3}$. But for the roof antenna - v polarization BER = $1{,}09.10^{-8}$ (experimentally), which guarantees the reception of ch.40, despite the presence of an adjacent upper analog TV channel (ch. 41).



a) without notch filter



b) with notch filter

Fig.6. 64-QAM constellation

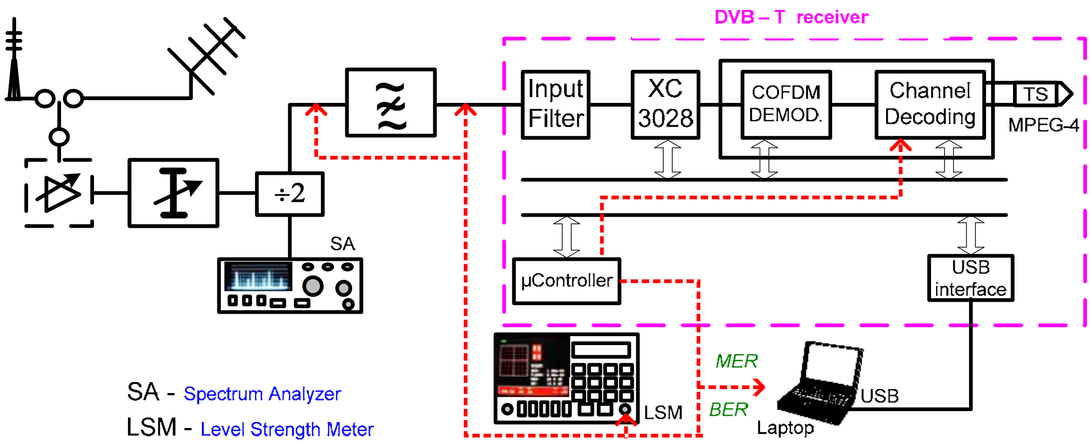


Fig.5. Measurement setup

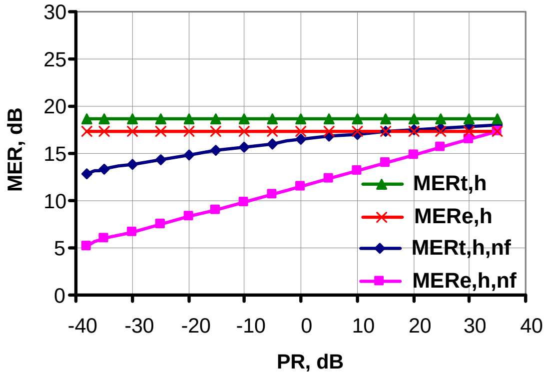


Fig.7. *MER=func (PR)* for roof antenna, (h) polarization

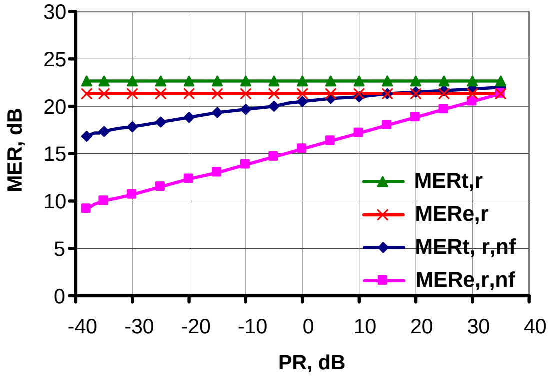


Fig.8. *MER=func (PR)* for rod antenna

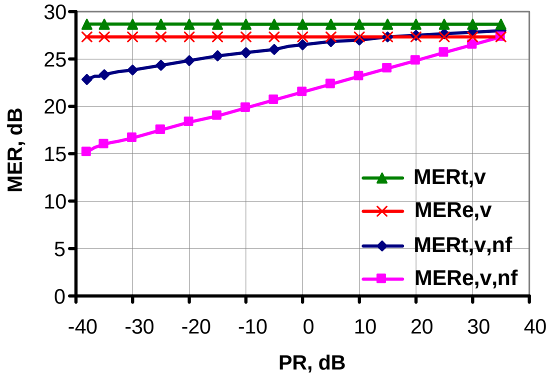


Fig.9. *MER=func (PR)* for roof antenna, (v) polarization

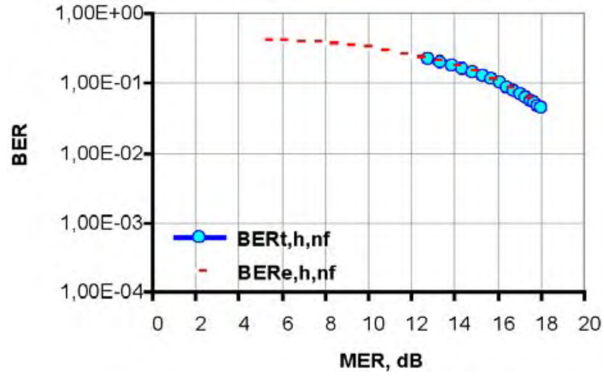


Fig.10. *BER = func (MER)* for roof antenna, (h) polarization

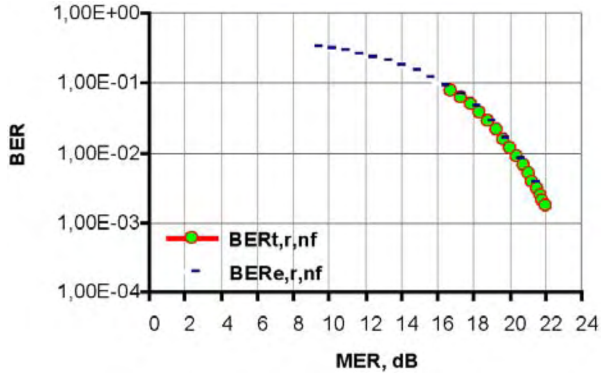


Fig.11. *BER = func (MER)* for rod antenna

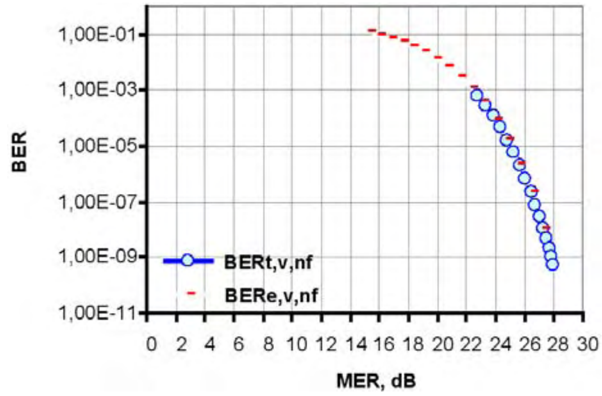


Fig.12. *BER = func (MER)* for roof antenna, (v) polarization

V. Conclusion

From the performed tests it is shown that the application of *nf* makes it possible to improve the reception of the DVB-T channels subjected to the influence of the adjacent AM-VSB channels. Besides, to achieve higher values for MER and low BER it is required for *nf* to have a large slope, and PR>15dB.

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