Improving the reception of class DVB-T receivers

Oleg Borisov Panagiev[1]

Abstract - **This paper presents some early results from experimental measurements in the service area of the DVB-T (8K) network. The aim of this study has been to determine the degradation suffered by digital signals in presence of analog PAL-K adjacent channel broadcasting. The result of this study is a circuit solution and curve that estimates protection ratios between analog and digital received power levels.**

Keywords – **DVB-T, PAL-K, receiver, adjacent cannel interference, BER.**

I. INTRODUCTION

Recently digital terrestrial TV using the DVB-T standard [1] is gaining more and more interest in Europe and other parts of the world. This fact leads to a simulcast environment during a period of several years, depending on different countries and estimations, in which analog and digital services will be sharing the same spectrum frequency bands. During the transitional period due to the coexistence of both technologies, minimizing the digital service quality degradation caused from analog transmitters (and vice versa) in the same coverage areas will be one of the main factors to consider when planning digital services.

At the same time manufacturers offer DVB-T receivers with different application: domestic, portable, notebook, PC (Fig.1), built-in TV. Some are with low adjacent channel selectivity and lower sensitivity. This in many cases leads to poor or impossible to receive digital signals in the presence of a adjacent (upper) channel, low level of the received signal and others [2], [3].

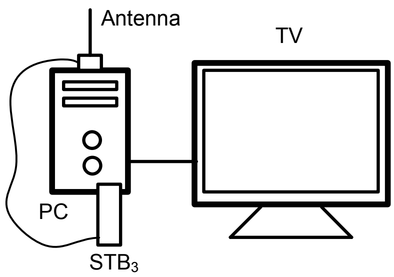


Fig.1. DVB-T reception with personal computer (PC) -TV tuner

In this paper are presented the results of theoretical and experimental investigations carried out to study the relationship between BER and protection ratio (S/N respectively) for portable reception in an urban environment inside the coverage of a Single Frequency Network (SFN). Two types of portable reception have been defined by the European Standards Institute (ETSI): Class A and Class B portable reception [4]. Class B portable reception is defined as indoor (inside a building) reception whereas Class A is defined for outdoor reception using an omnidirectional antenna located at least at 1.5 meters above ground level [5]. The results presented here apply to both cases.

II. EXPERIMENTAL AIMS AND TASKS

The formulation of the aims and the tasks is made on the basis of trials on several (different) DVB-T receivers. Further those would be called for shorter set-top-box (STB). Two of them are for connecting to a TV receiver (television set): one (STB1) is connected through an additional Euroscart-Euroscart or Euroscart-Chinch cable; the other one is connected directly to Eurocscart of the TV receiver (television set), whereby it is supplied through an adapter. The infrared (IR) receiver is a separate module, and its connection with the DVB-T receiver is through a cable, which allows controlling the DVB-T receiver even though it is behind the TV receiver. The third STB3 is connected to a PC through a USB port. The dialog with it is fulfilled via the display (monitor) of the PC, as for the functioning of the DVB-T receiver we have to install certain software (sold in a CD together with the DVB-T receiver).

The three DVB-T receivers were connected respectively to a TV and a PC, then set and every digital TV channel that is broadcasted in the region of the city of Sofia was chosen. The signals were received by three different antennas:

1) Active antenna with G=45dB;
2) Yagi with G=18dB;
3) Whip

Each one of the antennas was successively connected to STB1, STB2 and STB3 and the levels of the signals with the respectively carrier frequency were measured by STB in % as well as with a level strength meter (LM) in dBμV. The results of the measurement are given in Table I.

Note: Antennas 1) and 2) are with a direct visibility to the transmitter centers (Kopitoto and the old TV tower).

After the measurements were done was established that STB1 and STB2 receive all digital channels without any problems, qua the strength and quality indicators are with evidence ≥50% independently of the antenna type. However, STB3 had a problem receiving on ch. 40 and ch. 52, although the conditions for receiving were the same as for STB1 and STB2.

TABLE I

Antenna	1)			2)			3)		
Channel	Strength	Quality	Level	Strength	Quality	Level	Strength	Quality	Level
	%	%	dBμV	%	%	dBμV	%	%	dBμV
40	61	99	91,2	63	99	68,1	60	99	58
41	-	-	96,8	-	-	74	-	-	63,8

[1]Oleg B. Panagiev is with the Technical University of Sofia, Bulgaria, E-mail: olcomol@yahoo.com

On the base of those results were formulated the aims and tasks of this research:

a) To be established the reason for not receiving ch.40 and ch.52;

b) To eliminate the problems with receiving ch.40 and ch.52, i.e. to be provided their receiving with STB3 and other similar to it [2], [3].

To accomplish those aims were made a number of measurements according to the standards [1], [4], [6] and the results were analyzed. As a result of that was made a conclusion, that such a problem could appear at a low selectivity at adjacent channel and by an interference of analog signal (PAL-K), when it is transmitted in higher adjacent channel (by measurements with a spectrum analyzer, was established, that such channels are available: ch.41 and ch.53 at standards G and K), (Fig.2).

To increase the selectivity at a adjacent channel (without changing anything in the STB3) was made the decision for creating a band filter with a certain slope and frequency band, which would be formed in a different module. Its assembly must be outside STB3 and to be applicable to different STBs with similar parameters.

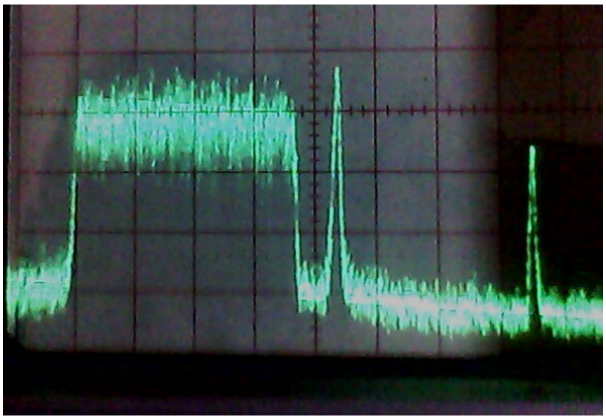


Fig.2. Spectrum of ch.40and ch.41

The first task was to design a BPF and simulate the influence of its parameters onto *S/N* and *BER*, respectively QoS (Quality of signal).

The second task is to be made an actual BPF to be assembled between the antenna and STB3.

The third task is to be checked the receiving of ch.40 and ch.52 (strength and quality) and to be made an analysis for the application of the proposed solution.

III. CIRCUIT SOLUTIONS AND RESULTS

For researching the influence of the parameters of Band Pass Filter (BPF) on improving the quality of receiving for the aforenamed channels, as well as for optimal choosing of suitable scheme solution (Table II) was used an Ansoft Designer VS 2.0 [7]. A large number of simulations were made to determine the scheme solution and the number of links in filter, which give the necessary values of Protection ratio (*PR*), [1], [4], [6], [8]. The theoretical and experimental researches were made with five values for *PR*, where in dB, is the degradation in Power received between digital TV signal (P_{rD}) and analog TV signal (P_{rA}) and is given by the following formula [9]:

$$PR[dB] = P_{rD}[dBW] - P_{rA}[dBW] \quad (1)$$

Eq.1 could be written as follows, having in mind the connections between power and voltage [10] by impedance 75Ω:

$$PR[dB] = U_{rD}[dB\mu V] - U_{rA}[dB\mu V]\,. \quad (2)$$

The practical determination of *PR* is made due to Eq.2 for ch.40 and measured levels of two signals (digital and analog) via spectrum analyzer (SA) Promax AE-476 (Fig.3), according the requirements of [7].

Note: During the simulation was established that the solutions of the placed aims for ch.40 are also valid for ch.52, but at corresponding values of constructive elements (coils and capacitors) and frequency parameters of band pass filter.

The dependence of deterioration of the signal-to-noise ratio (*ΔS/N*) from the amendment of *PR* is shown on Fig.4. The resultant ratio signal-to-noise (S/N_I) at a presence of interference from the analog channel in the digital one are calculated through the following formula:

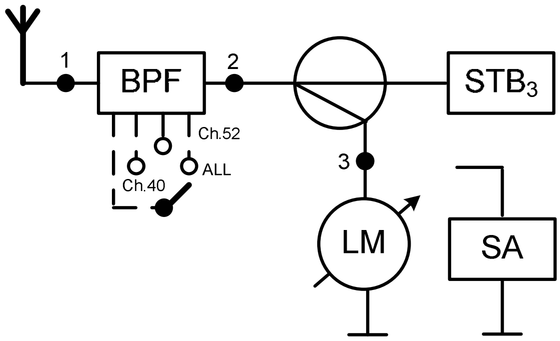


Fig.3. Measurement setup

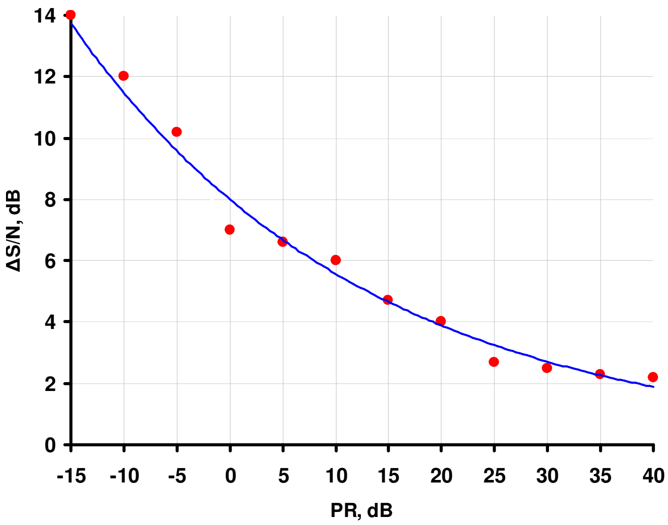
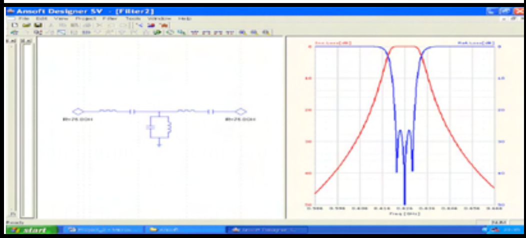
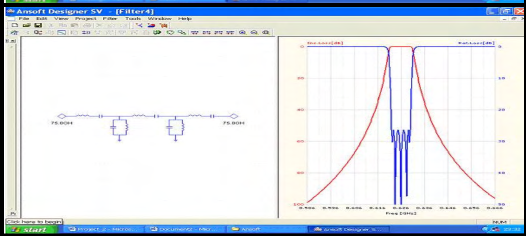
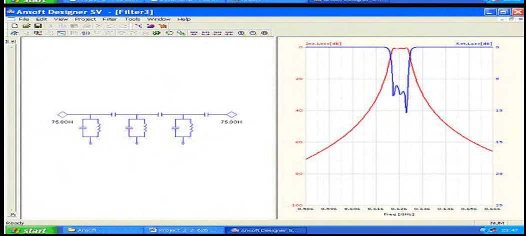
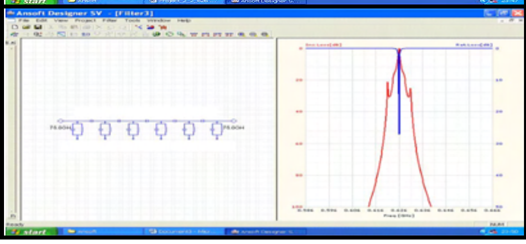


Fig.4. Δ*S/N*[dB] =func (*PR* [dB])

$$S/N_I\,[dB] = S/N[dB] - \Delta S/N[dB]\,, \quad (3)$$

TABLE II

№	BPF	PR	BER					
			Experimental			Theoretical		
		dB	1)	2)	3)	1)*	2)*	3)*
1	no	-6	0,0297955	0,0153234	0,0787797	0,0150099	0,0076909	0,0402155
2		1	0,0024338	0,0006898	0,0153234	0,0012177	0,000345	0,0076909
3		12	6,967E-05	8,322E-06	0,0015181	3,484E-05	4,161E-06	0,0007593
4		23	3,21E-07	1,009E-08	4,724E-05	1,61E-07	5,046E-09	2,362E-05
5		35	3,095E-08	5,401E-10	1,052E-05	1,547E-08	2,701E-10	5,259E-06

where *S/N* is signal-to-noise by the absence of interference from the analog PAL-K signal into the digital DVB-T signal (cannel).

The theoretical determination of BER is made through:

$$P_B = 0{,}89.[erfc\,(\sqrt{10^{(S/N_I-7{,}43)/10}/7})]$$

$$\times[1-0{,}44.erfc\,(\sqrt{10^{(S/N_I-7{,}43)/10}/7})]\,. \qquad (4)$$

The dependence of *BER* from *PR* is given in Fig.5 wherefrom is visible, that with antennas 1) and 2) and BPF the receiving of ch.40 is already possible, when *PR*≥15dB. At values less than 15dB, receiving with active filter (Fig.3) and any of the antennas is difficult (presence of sampling) or impossible (Fig.6).

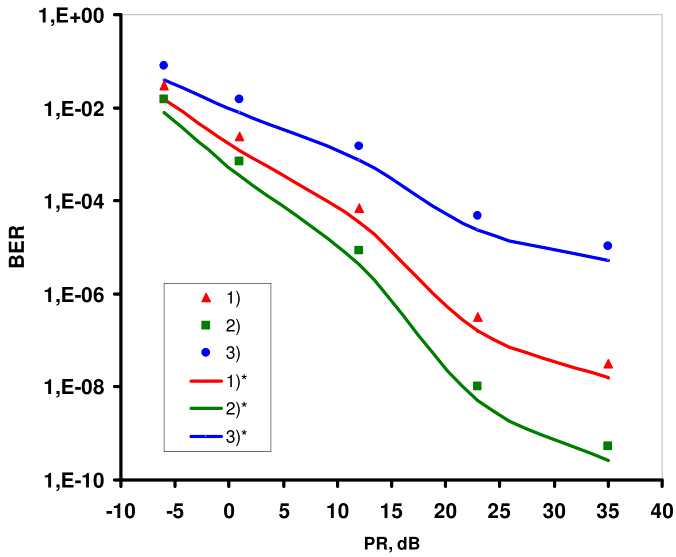
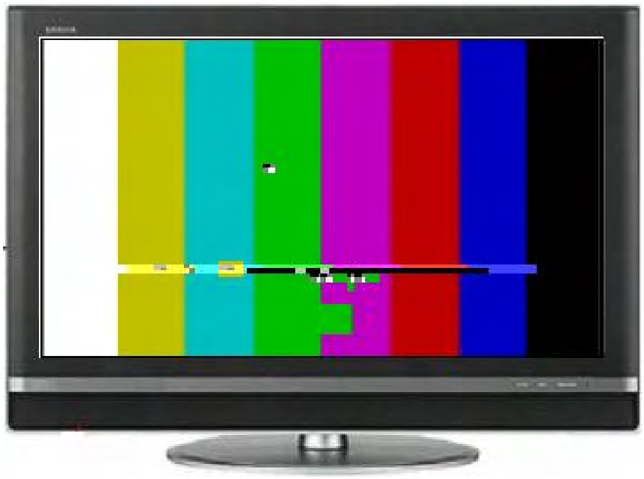


Fig.5. BER = func (PR [dB])

a) BER>10^{-4}



b) 10^{-6}<BER<10^{-4}

c) BER<10^{-6}

Fig.6. Pictures with BPF for different *PR* and *BER*

IV. Conclusion

The offered solution for improving the receiving with DVB-T receivers (computer TV-tuners) gives the opportunity to achieve the (placed) aims. By the practical realization is needed to change the filters for ch.40 and ch.52 or to remove them, and points 1 and 2 (Fig.3) to be connected directly with each other in order to receive all other channels. On Fig.3 is offered a version with shift of the three regimes. BPF can be realized with varicaps so that the passing channel is changed electrically. However, this solution requires an additional supply and so is the practical realization elaborated. At a subsequent publication will be offered another version, by which the mentioned problems would be removed and the practical application of the offered solution will be facilitated.

References

[1] ETSI EN 300 744 v.1.4.1, Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television, 2001.

[2] DIGIVOX mini Hybrid TV tuner and video capture unit. MICRO-STAR INT'L CO., LTD.

[3] USB TV tuner AVerTV Hybrid Volar HD. AVer Media Technology.

[4] TR 101 190: "Digital Video Broadcasting (DVB); Implementation Guidelines for DVB Terrestrial Services: Transmission Aspects". European Telecommunications Standards Institute (ETSI), 1997.

[5] P. Angueira, M. Vélez, D. De La Vega, G. Prieto, D. Guerra, J. M. Matías and J.L. Ordiales, "DTV reception quality field tests for portable outdoor reception in a single frequency network", IEEE Trans., Broadcasting, vol.50, no.1, pp.42-48, 2004.

[6] Rec. ITU-R BT. 1368-2 "Planning Criteria for Digital Terrestrial Television Services in the VHF/UHF Bands", 2000.

[7] http://www.ansys.com/Products/Simulation+Technology/Electromagnetics/Ansoft+Designer.

[8] S. O'Leary "Digital/Analogue Co-channel Protection Ratio Field Measurements" IEEE Trans., Broadcasting, vol. 44, no. 4, pp. 540-546, 1998.

[9] Regional Radiocommunication Conference for planning of the digital terrestrial broadcasting service (RCC-04), ITU-R Report, Geneva 2004.

[10] D. Dobrev, L.Yordanova, *Receiving on radio- and TV programs by means satellite and cable*, Sofia, Electroninvest, 1996.