Measurement of the Shielding Effectiveness of Passive Cable Television Elements

Péter Prukner[1], István Drotár[1], Máté Liszi[1], Szilvia Nagy[2]

Abstract – **The frequencies that are available due to the digital switchover of the terrestrial television broadcasting overlap with the frequencies used in cable television systems. Theoretically the two systems are independent of each other, but in practice, in case of not sufficient shielding, the cable television signals can disturb or can be disturbed by the signals from the over the air frequency bands. The main objective of the study was to find out about the shielding effectiveness of various cables and taps. During the measurements we also investigated how the measured results change in the case of broken cables, damaged multitaps and not properly secured closings using the specifications and directions of the 50083-2 EMC standard as a guideline.**

Keywords – **EMC, Digital dividend, Digital switchover CATV, Shielding effectiveness.**

I. Introduction

A. Digital Dividend

Switchover from analogue to digital television broadcasting resulted in a significant difference in the spectrum usage. The introduction of the DVB-T system caused the decrease of the channel need and resulted in an increase of the quality of the programmes, compared to the former, analogue systems. The frequency bands unused by the new system is called digital dividend [1].

Due to the advanced compressing and coding methods (H.264/MPEG-4 AVC, HEVC/ITU-T H.265) as well as the transport techniques applied in the present networks, a broadcasting system needs smaller and smaller part of the spectrum, moreover, further decrease can be achieved by new base band coding and multiplexing methods. Thus, we can conclude that the final size of the digital dividend can not be determined yet. It is clear, however, that these new frequency bands can be used for other purposes and technologies, and the most effective usage would be a harmonized one, i.e., if all the countries would have the same allocation.

As the bandwidth demand of the mobile telecommunication increases rapidly, the question arose, whether the whole former television band is necessary for DVB-T broadcasting. Due to the favorable wave propagation properties and the LTE technology, the 800 MHz band is more useful for mobile purposes [2-6], thus the EU regulations adapted quickly: CEPT developed a mobile allocation plan to band 790-862 MHz. During World Radiocommunication Conference, WRC 2007, the decision was made that allows the alternative use of the frequency band, and in its footnote 5.316A part of the countries intended to allocate the band for mobile communications as well.

According to the calculations, the two services (mobile and TV) could not work beside each other without distraction [4,5], thus the only solution was to empty the band first, before the mobile providers could start to use it. The channel allocation of the band is given in decision *ECC/DEC/(09)03.*

B. CATV Frequency Bands

In case of cable television (CATV) networks, spectrum allocation is different from that of the terrestrial or satellite broadcasting, due to the fact that the network communication takes place on shielded network that is isolated from its environment, thus the complete available frequency domain belongs practically to the service provider. Fig. 1 shows the frequency allocation valid from 2014.

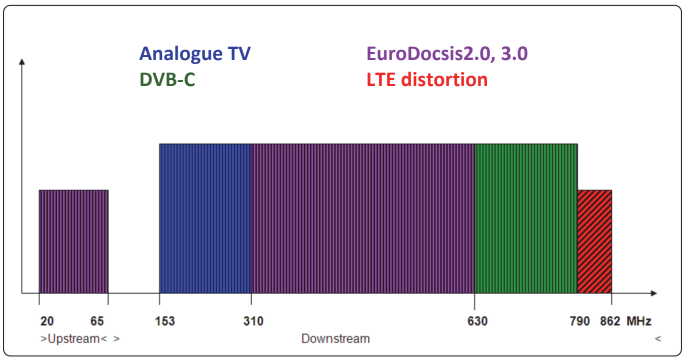

Fig. 1. Frequency allocation of CATV systems from 2014

C. Noise in Coaxial Networks

A CATV system has significantly better signal to noise ratio than the terrestrial or satellite broadcasting [7], due to its shielding. The shielding can suppress the disturbing signals and noise from over-the-air waves, thus modulations with higher number of states can be applied. This is the main reason why the shielding of the CATV networks is an essential task.

In case of coaxial networks both radiated and conducted waves can cause disturbance. The aim of this work is to focus on radiated noise. In case of radiated disturbance, the waves propagating over-the-air enter the coaxial network either through the cables or though the equipments on the network [8,9]. The reason of this undesired coupling can be multiple, like damaged or broken shielding, connector error, poor quality parts, faulty building of the network, or such large

[1]IstvánDrotár, Péter Prukner and Máté Liszi are with the Radio Frequency Test Laboratory of the Széchenyi István University, Egyetem tér 1., H-9026 Győr, Hungary drotar.istvan@sze.hu, prukpe@sze.hu, mate.liszi@rf.sze.hu.
[2]Szilvia Nagy is with the Department of Telecommunications at Széchenyi István University, Egyetem tér 1., H-9126 Győr, Hungary, nagysz@sze.hu

external noise that the shielding can not filter it. Decreasing the noise can be carried by determining the reason and the then either mending it or supressing by other means, like applying more effective or extra shielding. The parameter determining how much the cable or equipment is protected from the noise sources is called shielding effectiveness (SE). Measurements of the SE of active or passive CATV network elements can be carried out according to EN 50083-2 [10].

D. The Goal of the Measurements

Looking at the CATV frequency bands, we can conclude that over-the-air band DD1 overlaps with the upper part of the CATV frequency domain. In free space the mobile providers have the license for the frequency band, and the CATV systems are theoretically independent of the over-the-air frequency domains, however, in reality over-the air signals can penetrate into coaxial networks, thud CATV service providers had to develop methods for overcoming the problems of this noise source already. The aim of this study is to determine the disturbances caused by mobile channels in CATV network passive elements.

The examined units were coaxial cables of types RG 6, RG 11, QR540, by two different manufacturers, one multitap and two line splitters. IT was also necessary to simulate other elements, like damaged or broken cable, not properly closed multitap, damaged splitter, or soaked splitter.

II. Method of Measurement

A. EN 50083-2

European standard EN 50083-2 [10] determines the radiation and immunity properties of transmission, receiving, processing and broadcasting of signals from video, audio and interactive systems. In the newer, 2012 version the new EMC environment arisen by the DD1 mobile channel is also taken into account, thus the measurement methods are developed considering the 790-862 MHz LTE systems. The standard gives the shielding effectiveness limits of passive elements between 5 MHz and 3.5 GHz both for analogue and digital signals.

Point 5.5 of the standard determines 3 measurement methods for shielding effectiveness of passive devices, of which one can be applied for our frequency band: the method of absorption measuring clamp. The main problem of the method that is designed for emission, and the standard does not give immunity measurement setups. The limits corresponding to this measurement are to be found in Table 1. In the band DD1 the limit for a Class A device is 75 dB.

Table 1
Limits of shielding effectiveness of passive elements within the nominal frequency bands

Frequency domain MHz	**Limit** dB	
	Class A	***Class B***
5 – 30	85	75
30 – 300	85	75
300 – 470	80	75
470 – 1000 [a)]	75	65
950 [b)] – 3500	55	50

[a)] For equipments with upper band limit ≤ 1000 MHz.
[b)] For equipments with lower band limit ≥ 950 MHz.

According to Note 2 of the standard, the calculation for disturbances up to 120 dB(μV/m) is the following. At 800 MHz the coupling coefficient is approximately 25 dB, SE 75 dB, thus the remaining undesired signal level is still 20 dB(μV). The standard also mentions in Note 3 that in the band large fields are also possible, thus Class B devices can not be used.

The standard does not specify the measurement techniques or setups for cable immunity, the absorbing clamp setup can not be modified for the purposes specialized by the service providers, thus we have developed a new method based on Note 2 of point 5.5 of the standard.

B. Measuring Shielding Effectiveness

According to Note 2 of point 5.5 of standard EN 50083-2 [10] the undesired signal level can be calculated as

$$120\ \text{dB}(\mu\text{V/m}) - 25\ \text{dB} - 75\ \text{dB} = 20\ \text{dB}(\text{uV/m}), \quad (1)$$

i.e.,

$$E_{\text{disturbing}} - a_{\text{coupling}} - \text{SE} = E_{\text{undesired}}, \quad (2)$$

where $E_{\text{disturbing}}$ is the field intensity of the disturbing signal [dB(μV/m)], a_{coupling} the coupling constant at 800 MHz [dB], SE the shielding effectiveness and $E_{\text{undesired}}$ the field intensity of the undesired signal in the channel.

If SE is expressed from formula (2) we arrive at

$$\text{SE} = E_{\text{disturbing}} - a_{\text{coupling}} - E_{\text{undesired}}, \quad (3)$$

thus if we know the level of the disturbing signal over-the-air at the passive element and the undesired signal inside the passive device, and the coupling constant, the shielding effectiveness can be determined. It is easy to see that if the level of the disturbing signal is increased, the field intensity of the undesired signal increases simultaneously, thus the field intensity determined by the service provider can be applied in this measurement setup, and the result can be deducted to the limits of the standard.

C. Measurement Setup

We generated 10 V/m field intensity at the measuring table using an antenna 4 m apart from the position of the equipment under test (EUT). All the passive elements had F-type connectors and 75 Ω impedance.

After determining the path attenuation and the field homogenity a Python programme was used to control and carry out the measurements in the 792-862 MHz band.

In the frequency domain 790 to 862 MHz the signal path loss of the measuring equipments is 9,87 dB.

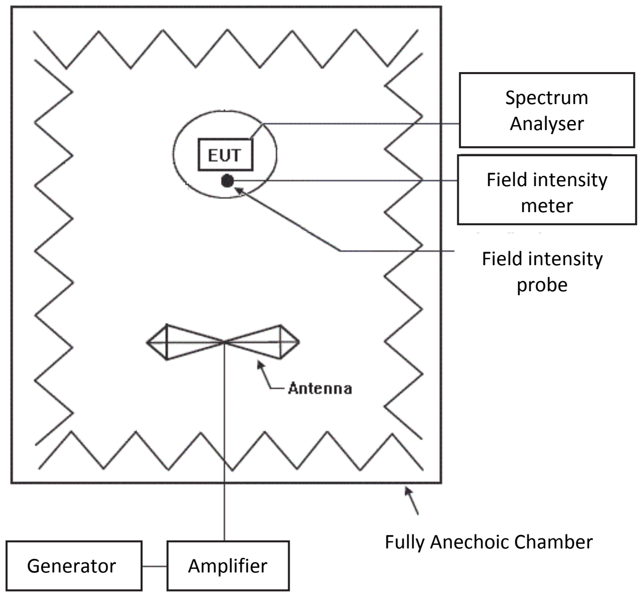

Fig. 2. Measurement setup for shielding effectiveness measurement

Standard IEC 61000-4-3 "Electromagnetic immunity tests of radiated radiofrequency fields" [11] determines the method of measuring field homogeneity, which is summarized in Fig. 3. It is essential to have homogeneous field on the whole geometry of the EUT.

During the measurement the largest deviation was 0,2 V/m which is acceptable.

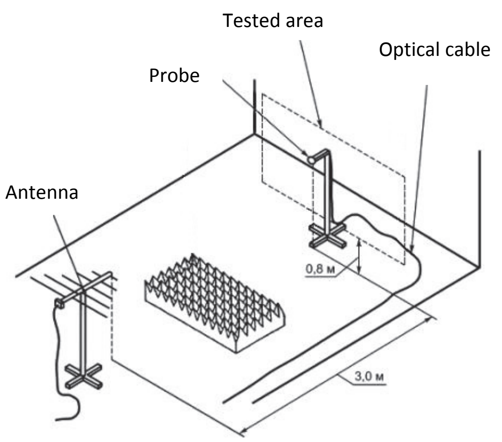

Fig. 3. Measurement setup for field homogeneity test according to standard IEC 61000-4-3

III. Measurement and Results

A. Shielding Effectiveness of Coaxial Cables

According to our measurements the shielding effectiveness values of cables from the two manufacturers and of the three studied types are different, as the technologies of the production are different. As an example, in Fig. 4. SE vs frequency functions of two cables of type RG6 can be seen. The two subfigures mean two different service providers and the different colours cover different geometrical, shielding and impedance matching conditions as mentioned in the caption.

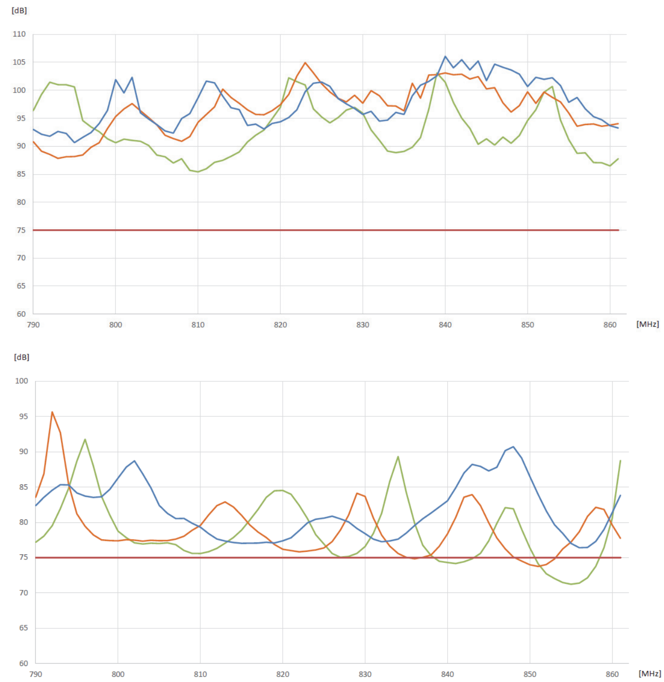

Fig. 4. Shielding effectiveness of RG6 cables of two different service providers. Line colours belong to the following conditions. Green: cable on table, horizontal position, matched terminator, unshielded; orange: cable on table, horizontal, matched terminator, shielded; blue: vertical position, matched terminator. The straight, thick, dark red line gives the limit of the class A devices according to EN 50083-2

According to the measurements we can conclude, that the cables – except for one case – satisfy the limits given in the standard, moreover, in most cases the shielding effectiveness is much better than necessary. Applying multiple shielding can improve the results.

B. Shielding Effectiveness of Multitaps and Line Splitters

Measuring multitaps or line splitters are carried out with a reference cable. In both cases the equipments were tested with different termination conditions, i.e., with proper, matched terminators, with one or more loose terminator, and with open outputs. Also other damages, like soaking are modelled. As an example, the results of a multitap can be seen in Fig. 5, and measurements of a splitter is given in Fig. 6.

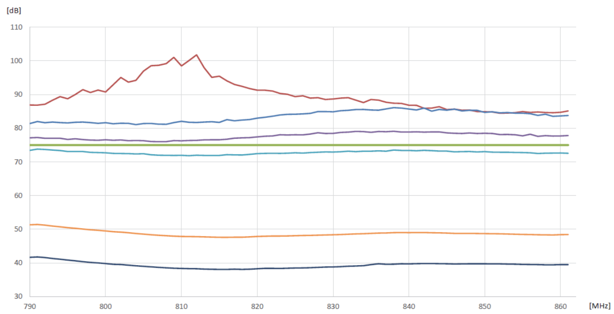

Fig. 5. Shielding effectiveness of a multitap. Red line gives the SE of the reference cable, blue line the SE of the multitap with properly closed outputs, purple with one access gate open, cyan with all the access ports open, orange with loosely closed access gates and black with all the outputs loosely terminated. Green line is the limit for class A devices according to standard EN 50083-2

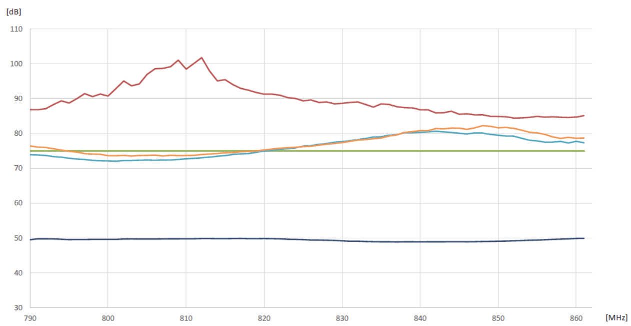

Fig. 6. Shielding effectiveness of a splitter. Red line gives the SE of the reference cable, cyan line the SE of the splitter with properly closed outputs, orange with loosely closed outputs and black with the splitter soaked, but all the outputs properly terminated. Green line is the limit for class A devices according to standard EN 50083-2

It can be seen, that all the devices met the conditions of the standard, if the connections were properly closed.

From the measurements we have concluded that in case of properly assembled CATV network provides sufficient shielding against the disturbances from the new DD1 bands. However, a broken shielding or a loosely connected cable or terminator can cause significant increase in the noise level of the network. Thus, it is essential to select cables of proper quality, and to assemble the network properly with the designated torque, and to apply the terminators everywhere.

IV. Conclusion

To summarize, we can state that in case of a well-built CATV network the risk of such disturbances which causes such a high noise level that the network management needs to intervene is very low. In case of poor materials or assembly, high noise can arise, and intervention of the service manager can be necessary. Intervention would mean carrying out such steps as decreasing the number of states of the modulation e.g. from 256 QAM to 64 QAM, thus decreasing the data rate.

The significance of the studied problem is increasing as the frequency domains occupied by mobile services tend to penetrate deeper and deeper under 900 MHz, moreover within a couple of years the second digital dividend band will also be available for mobile service providers (under 700 MHz), and the 450 MHz band also needs to be carefully studied.

As it is important for both the CATV and the mobile network providers to operate disturbance-free, their common interest is to develop their systems so, that the other party's services would be able to run properly. The regulations should also ensure the cooperation of these services.

Acknowledgement

Supported by the ÚNKP-16-4 New National Excellence Programme of the Ministry of Human Capacities of Hungary.

References

[1] *Digital Dividend - Insights for Spectrum Decisions*, ITU, August 2012.

[2] H. R. Karimi, M. Fenton, G. Lapierre, and E. Fournier, "European Harmonized Technical Conditions and Band Plans for Broadband Wireless Access in the 790-862 MHz Digital Dividend Spectrum", *IEEE Symposium on New Frontiers in Dynamic Spectrum (2010 DySPAN)*, Singapore, 6-9 April 2010.

[3] D. Setiawan, D. Gunawan, and D. Sirat, "Interference Analysis of Guard Band and Geographical Separation Between DVB-T and E-UTRA in Digital Dividend UHF Band", *IEEE-International Conference on Instrumentation, Communications, Information Technology, and Biomedical Engineering (ICICI-BME)*, Bandung, 23-25 November 2009.

[4] W. Wang, B. Wang, Z. Lv, W. Huang, and Y. Zhang, "Analysis of Interference From Digital Terrestrial Television Broadcast to LTE TDD in Digital Dividend Spectrum", *2nd IEEE International Conference on Network Infrastructure and Digital Content*, Beijing, 24-26 September 2010.

[5] J. Ribadeneira-Ramírez, G. Martínez, D. Gómez-Barquero, and N. Cardona, "Interference Analysis Between Digital Terrestrial Television (DTT) and 4G LTE Mobile Networks in the Digital Dividend Bands", *IEEE Transactions on Broadcasting*, vol. 62, pp. 24-34, 2016.

[6] B. Modlic, G. Sisul, and M. Cvitkovic, "Digital Dividend - Opportunities for New Mobile Services", *International Symposium ELMAR '09*, Zadar, 28-30 September 2009.

[7] R. P.C. Wolters, "Characteristics of Upstream Channel Noise in CATV-Networks", *IEEE Transactions on Broadcasting*, vol. 42, pp. 328-332, 1996.

[8] Y. Hayashi, Y. Kayano, T. Mizuki, H. Sone, and H. Inoue, "Contact Conditions in Connectors that Cause Common Mode Radiation", *IEICE Transactions on Electronics*, vol. E94, pp. 1369-1374, 2011.

[9] J. Putz, "Future Challenges in CATV Broadcasting (A jövő kihívásai a kábeltelevíziózásban, in Hungarian)", *Infocommunications Journal*, vol. LX, pp. 9-14, 2005.

[10] *EN 50093-2 Cable Netvorks of Television Sigals, Audio Signals and Interactive Services*, (MSZ EN 50093-2, Televíziójelek, hangjelek és interaktív szolgáltatások kábelhálózatai, MSZT, 2012).

[11] *EN 61000-4-3 Electromagnetic Compatibility (EMC)*, (MSZ EN 61000-4-3 Elektromágneses összeférhetőség (EMC), MSZT, 2006).