The Influence of the LTE System on DVB-T Reception

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Abstract—**The WRC-07 (World Radiocommunication Conference 2007) co-allocated the band 790 - 862 MHz (channels 61 to 69) to mobile services from June 2015. There is a lot of interest to use this part of the spectrum before 2015 for mobile services, mainly UMTS (Universal Mobile Telecommunications System) and LTE (Long Term Evolution) services. Before the introduction of these new mobile services, the influence of these mobile services to the reception of existing DVB-T (Digital Video Broadcasting – Terrestrial) networks operating on adjacent channels needs to be assessed. This paper describes the interference caused by the LTE system to the DVB-T system. The fundamentals of the DVB-T system network planning and the required interference protection from the LTE system are described in this paper. The aim of this paper is to simulate the various interference scenarios caused by the LTE Base Stations both for fixed and portable DVB-T reception operating on adjacent channels.**

Keywords - DVB-T; LTE; interference; protection ratio

I. INTRODUCTION

On the WRC-07 [1] the band 790 – 862 MHz was co-allocated to mobile services (except aeronautical mobile), on a primary basis from June 2015 in ITU Region 1 with an identification of the band IMT (International Mobile Telecommunications). Several European Countries would like to allocate this band to IMT before 2015, as their transition from analogue to digital video broadcasting will end before 2015. After the successful finish of the transition process the band 790 – 862 MHz should not be used for broadcasting services in most of the countries.

Most of the European Countries have finished their transition from analogue to digital video broadcasting. The transition in Croatia is expected to end by the end of 2010. Several regions in Croatia have already switched off their analogue television transmitters. The DVB-T standard [2] is being used in Croatia and there are currently two national coverage multiplexes in operation (MUX A and MUX B). Both of these multiplexes have reached population coverage higher than 90% at the end of 2009. It is expected that after the transition from analogue to digital broadcasting in Croatia ends, the channels 61 to 69 (the band 790 - 862 MHz) will not be used for broadcasting any longer. This opens an opportunity to introduce mobile services in the band 790 – 862 MHz before 2015.

There are several issues that need to be attended before the realization of this opportunity. The first is the coordination with the neighbouring countries. A majority of countries that are direct neighbours of Croatia use the channels above channel 60 for DVB-T broadcasting during the transition period from analogue to digital television broadcasting. This is mostly because this part of the spectrum was previously unused in these countries. Without careful network planning and coordination with neighbouring countries this could lead to cross-border interference between broadcasting and mobile services [3]. It is probable that the introduction of mobile services in the band 790 – 862 MHz will be possible in Croatia after the analogue switch off has been completed in the neighbouring countries.

The second issue is the interference from mobile systems operating in the band 790 – 862 MHz (channels 61 to 69) into DVB-T operating on channels up to channel 60. This interference can occur up to the ninth adjacent channel (N+9). A lot of work has been conducted in order to determine the performance of DVB-T receivers in the presence of interference from mobile services, both from UMTS [4] and LTE [5]. It is very important to determine the interference level of mobile systems into DVB-T with before their start of operation in the band 790 – 862 MHz.

This paper is organized as follows. Section II describes the fundamentals of DVB-T network planning and outlines the protection ratios for DVB-T interfered by LTE. Section III examines the influence of the LTE system on DVB-T reception and presents simulation results. Section IV gives our conclusions.

II. PROTECTION OF DVB-T RECEPTION

A. The fundamentals of DVB-T network planning

In order to protect the DVB-T network reception, it is important to ensure that the maximal interference reduction is obtained when a specific channel/frequency is assigned to a DVB-T transmitter. This is one of the main goals of broadcast network planning. There are two parameters that are crucial in achieving this goal:

Minimal usage field – $F_{k,min}$ (dB(μV/m)) (1)

Minimal signal-to-interference ratio – C/I (dB) (2)

The values for the minimal usage field $F_{k,min}$ for the DVB-T system are specified in the ITU-R recommendation BT.1368-8 [6].

The minimal C/I ratio is also called protection ratio (PR) and it is crucial for achieving the reception of the signal and proper decoding procedures. If the harmful interference level is above the wanted signal level on the receiver input, the reception will not be possible. Reception is possible when the minimal usage filed strength is for the value of the protection ratio above the interference signal level. If this condition is not set, the picture quality will degrade very fast. This is one of the characteristics of the DVB-T system and, consequently, the field strength calculations should be made with a high percentage of covered locations (between 70% and 99% location probability) [7].

The DVB-T system uses the COFDM (Coded Orthogonal Frequency Division Multiplexing) modulation technique [8]. In accordance with network requirements there are several parameters that can be set in the COFDM: carrier modulation, code rate and guard interval. A combination of these parameters is called the DVB-T system variant. The choice of the system variant depends on the requirements in the network planning process.

Each of the system variants has its own protection ratio, minimal usage field strengths and maximal data rates. In order to increase robustness of the DVB-T network a lower modulation scheme and/or lower code rate could be used. This decreases the maximal data rates of the DVB-T network, but on the other side it decreases the value of the necessary protection ratio. This approach collides with the principle of maximal interference reduction and it is not preferable.

The GE06 Final acts [9] defined the RPC-s (Reference Planning Configurations) in order to simplify the broadcast network planning process. The RPC-s defined in the GE06 Final acts represent the most often planning configurations. Table I shows the three different Reference Planning Configurations, their corresponding reception conditions and minimal usage field - $F_{k,min}$ strengths.

TABLE I. REFERENCE PLANNING CONFIGURATIONS

Planning Configuration	Reception condition	$F_{k,min}$ dB(µV/m) at 10 m
RPC-1	Fixed	56
RPC-2	Portable outdoor, mobile	78
RPC-3	Portable indoor	88

B. Protection ratios for DVB-T interfered by LTE

There are two main types of tuners that can be found in DVB-T receivers on the market today. Those are "Can" type and "Silicon" type tuners. They can be either integrated in the television set (iDTV) or standalone in a Set Top Box (STB) or USB stick. "Can" tuners are classical super heterodyne tuners housed in a metal enclosure containing discrete components. "Silicon" tuners are integrated circuit based tuners integrating all tuner circuitry into a small package directly to be fitted onto main boards. The performance of "can" type and "silicon" type tuners in the presence of an LTE interfering signal varies and the protection ratios are not the same.

The protection ratios required to receive the DVB-T signal in the presence of an LTE BS (Base Station) interfering signal for 90% of receivers measured [5] are listed in Table II. These protection ratios are defined for a DVB-T system using 64-QAM modulation and 2/3 code rate and for a LTE Base Station using 5 MHz channel bandwidth with Transmit Power Control (TPC) off. Correction factors are available in the event of using a different DVB-T system variant (Table III). It should be noted that the usage of the 10 MHz channel bandwidth in the LTE Base Station does not significantly increase the protection ratios values over the protection ratio values for the 5 MHz channel bandwidth.

TABLE II. PROTECTION RATIOS FOR DVB-T INTERFERED BY LTE-BS

Channel edge separation (MHz)	**Protection ratio (dB)**		
	Can STB/iDTV	***Silicon STB/iDTV***	***Silicon USB***
1	-33	-33	-33
9	-42	-40	-36
17	-39	-44	-36
25	-56	-48	-38
33	-63	-49	-42
41	-58	-50	-43
49	-66	-50	-43
57	-66	-52	-43
65	-39	-45	-44

TABLE III. CORRECTION FACTORS FOR PROTECTION RATIOS (DB) FOR DIFFERENT SYSTEM VARIANTS RELATIVE TO 64-QAM 2/3 DVB-T SIGNAL AND FOR DIFFERENT RECEPTION CONDITIONS

DVB-T system variant	Gaussian channel	Fixed reception	Portable outdoor reception
QPSK 1/2	−13.5	−12.5	−10.3
QPSK 2/3	−11.6	−10.5	−8.2
QPSK 3/4	−10.5	−9.3	−6.9
QPSK 5/6	−9.4	−8.1	−5.6
QPSK 7/8	−8.5	−7.1	−4.5
16-QAM 1/2	−7.8	−6.8	−3.6
16-QAM 2/3	−5.4	−4.3	−2.0
16-QAM 3/4	−3.9	−2.7	−0.3
16-QAM 5/6	−2.8	−1.5	1.0
16-QAM 7/8	−2.3	−0.9	1.7
64-QAM 1/2	−2.2	−1.2	1.0
64-QAM 2/3	0.0	1.1	3.4
64-QAM 3/4	1.6	2.8	5.2
64-QAM 5/6	3.0	4.3	6.8
64-QAM 7/8	3.9	5.3	7.9

III. SIMULATION

The simulation of the influence of the LTE system on DVB-T reception was conducted in the area of Zagreb. The channel chosen for the DVB-T network was channel 60, which is a part of the GE06 Digital Plan and is intended to be used in the Croatian D41 allotment. The DVB-T channel 60 is the first adjacent channel to the 790-862 MHz band and the interference to the DVB-T reception from the LTE system will be largest on channel 60. This channel and allotment were chosen because Zagreb is the capital city of Croatia and it has the largest number of inhabitants in Croatia. It also has the largest number of transmitter sites for mobile services, which could cause interference to DVB-T reception if used as LTE-Base Station transmitter sites. Because of the largest number of inhabitants, it is expected that the LTE system will be introduced first in Zagreb and then gradually in the rest of Croatia.

In this simulation ten DVB-T transmitters were used with the parameters given in Table IV. All ten of these locations are a part of the GE06 Digital Plan. The DVB-T system variant that was used in this simulation uses 64-QAM modulation with a guard interval of 1/4, code rate of 2/3 and horizontal polarization. This is a common system variant for DVB-T in Croatia and it offers a maximum data rate of 19.91 Mb/s.

TABLE IV. DVB-T TRANSMITTERS USED IN THE SIMULATION

Transmitter name	ERP [dBW]	Longitude	Latitude	Antenna pattern
D. STUPNIK	30	015E5307	45N4335	ND
VELIKA GORICA	30	016E0503	45N4250	D
DUGO SELO	30	016E1424	45N4924	D
VUGROVEC	24	016E0634	45N5330	D
KASINA	24	016E0755	45N5513	ND
SVETA NEDELJA	37	015E4618	45N4720	D
ZAGREB-ISTOK	37	016E0432	45N4806	ND
ZAGREB-JARUN	30	015E5650	45N4720	ND
ZAGREB-OTOK	34	015E5931	45N4551	ND
ZAGREB-TV DOM	30	015E5905	45N4736	ND

The predicted coverage area for the DVB-T system operating on channel 60 in the D41 allotment is shown in Fig. 1. Fixed reception is shown in yellow and corresponds to minimal usage field strength of 56 dB(μV/m). Portable outdoor reception is show in brown and corresponds to minimal usage field strength of 78 dB(μV/m).

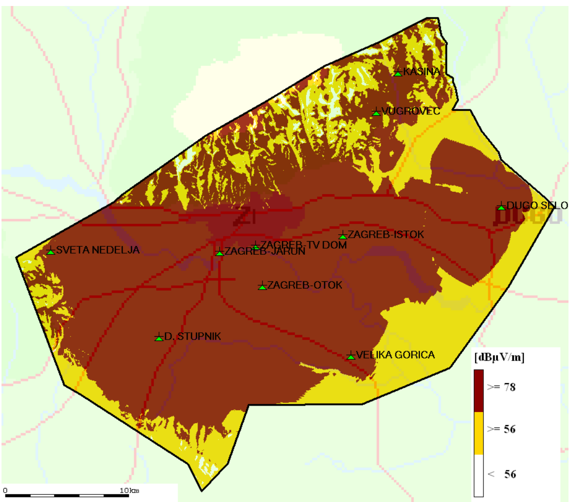

Figure 1. DVB-T coverage on channel 60 in the D41 allotment

One hundred and twenty LTE Base Stations operating on the frequency of 791MHz (channel 61) in the Zagreb area were used in order to simulate the worst case scenario of interference into the DVB-T system.

The locations of these transmitters were chosen in accordance with real mobile operators transmitter locations in the area of Zagreb. Real transmitter locations were chosen under the assumption that the mobile operators will try to use their existing transmitter locations as much as possible when introducing LTE services. Furthermore, the antenna heights were chosen in accordance to real antenna heights on the transmitter locations. The effective radiated power (ERP) and the antenna patterns were the same for all of the one hundred and twenty LTE Base Stations. The effective radiated power was set to 30 dBW (60 dBm) and the antenna patterns were omnidirectional.

In densely populated areas like Zagreb the mobile services transmitters are usually on the rooftops of buildings. If LTE Base Station transmitters were to be mounted on the same locations as the existing mobile services transmitters this could lead to whole buildings, or in some cases blocks loosing DVB-T reception. The influence of the LTE Base Station on DVB-T reception is expected in the area of up to a few kilometres around the LTE Base Station transmitter. This affect is especially expected to arise in the city centre where the density of the LTE-Base Stations would be the largest. This could mean that a large part of the city centre would lose DVB-T reception.

Two cases were simulated in order to evaluate LTE Base Stations interference on fixed (RPC-1) and portable outdoor (RPC-2) DVB-T reception.

The protection ratio for “silicon” type USB tuners was used because the majority of the receivers on the market have “silicon” type tuners built in them. “Silicon” type tuners are cheaper to produce and smaller in size then “can” type tuners and that is the reason why they are dominant on the market. On the other side the “silicon” type tuners are more sensitive to interfering signals. Following that note this is a simulation of the worst case scenario of LTE Base Stations interfering into DVB-T.

The resulting coverage’s for RPC-1 and RPC-2 can be found in Fig. 2 and Fig. 3. In both cases the LTE-Base Stations notably reduce the coverage of the DVB-T network. This occurs in the area around the LTE Base Stations and can be perceived as holes in the DVB-T coverage.

Information about the population and population density was used for the statistical analysis shown in Table V. The results of the statistical analysis show that the coverage of the DVB-T network in the presence of interference from LTE-Base Stations is reduced in both fixed and portable outdoor reception.

The reduction of DVB-T fixed reception is slightly higher than the reduction of DVB-T portable outdoor reception. Although the percentage of the coverage reduction seems low, in a densely populated area like Zagreb these four to six percent mean that up to fifty thousand people could lose DVB-T coverage.

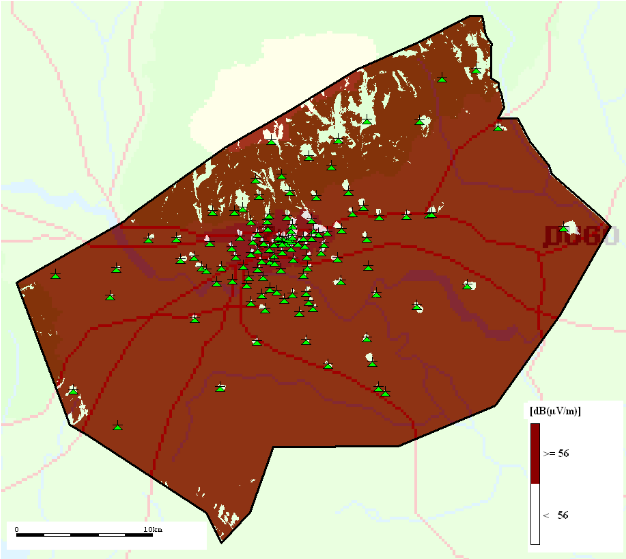

Figure 2. The influence of LTE BS on DVB-T RPC-1

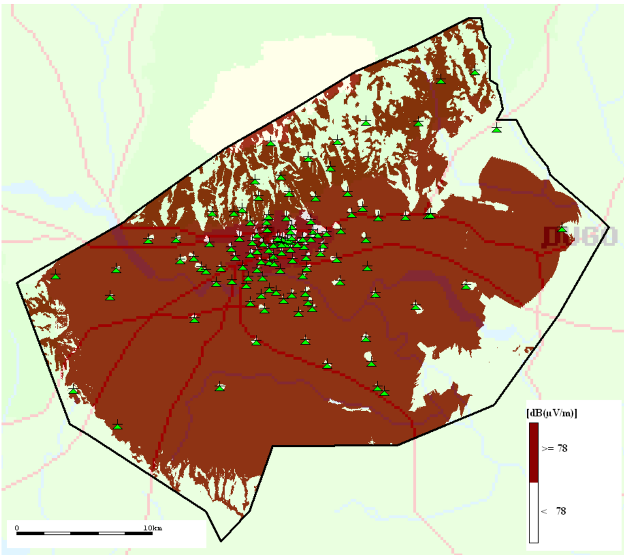

Figure 3. The influence of LTE BS on DVB-T RPC-2

TABLE V. DVB-T COVERAGE REDUCTION ON CHANNEL 60 IN THE PRESENCE OF LTE BS OPERATING ON CHANNEL 61 IN THE D41 ALLOTMENT

Covered Area [sqKm]	Population Coverage	RPC	Interfering signal	Population coverage reduction [%]
874.25	864797	RPC-1	no	-
662.26	819312	RPC-2	no	-
847.66	815358	RPC-1	LTE-BS	5.71
672.74	782562	RPC-2	LTE-BS	4.48

This simulation shows that the biggest looses in DVB-T reception are in the city centre of Zagreb, because this is where the most of the LTE-Base Stations were located. Fifty thousand is a very large number and further network optimisations should be made in order to decrease the number of population losing DVB-T reception as much as possible.

The minimization of interference could be achieved through careful network planning and optimization procedures. Detailed studies on the influence on DVB-T reception should be made before the introduction of LTE services, especially in large and densely populated cities, like Zagreb.

IV. CONCLUSION

This paper shows the influence on DVB-T reception in the presence of a LTE-Base Stations interfering signal. From the simulation results it is clear that the LTE-Base Stations have influence both on fixed and portable outdoor DVB-T reception. This paper has covered the worst case scenario, which is a densely populated urban area with a high number of LTE-Base Station transmitters, and the usage of adjacent channels for DVB-T (channel 60) and LTE-Base Stations (channel 61). The results have shown that up to fifty thousand people could lose DVB-T coverage in the Zagreb area. It is important to avoid this worst case scenario through careful network planning and optimization procedures. Further studies are needed in order to determine and evaluate the best possible mitigation techniques which could minimize the influence of LTE-Base Stations on DVB-T reception. The influence of LTE User equipment on DVB-T reception should also be assessed.

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