# ORIGIN AND ELIMINATION OF INTERFERENCE RESULTING IN COEXISTENCE OF LTE, DVB-T AND SDARS

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**Abstract**: The article deals with emergency of interference on newly licensed frequencies for communication in NGA 4G LTE networks, which are the source of interference with radio and television broadcasters and serves to raise awareness about the problem of interference in access networks. The article deals with the sources of interference to the licensed bands, their origins and finally provides theoretical and applied possibilities of technical solutions interference between licensed bands.

**Keywords**: Interference, DVB-T, LTE, SDARS

## 1 INTRODUCTION

Every day in our lives we use communication technologies that can utilize different methods of data transfer which are using wireless transmission. Wireless transmission has become thanks to a broad spectrum usage a type of a tradable exhaustible commodity regulated by relevant authorities in each country. Authorities in all countries recognize a reality exhaustibility frequency bands and regulate it, manage and provide exclusive use of companies who buy these frequency bands or lease a license for the operation of communications services in the frequency domain.

In the system of frequencies allocation, an abnormal situations may be experienced. One of them is the interference between appropriated bands. Although the Authority guarantees the allocated band of frequencies, their interference in border areas may occur. The aim of this article is to analyze the concrete situation created on the example of satellite radio, Sirius Radio and XM Radio on SiriusXM later linked or even SXM and 4G networks in the US operated by local operators and suppliers of mobile network equipment.

The problem of interference in the frequency spectrum affects also the Czech Republic. Therefore the second part of the article is devoted to analysis of similar problem as interference frequency bands. In the Czech Republic when 4G LTE has been applied, the problem with interference affected primarily the provision of digital terrestrial DVB-T, which is operated as a free of charge service.

## 2 THE CURRENT STATE

Due to the massive expansion of mobile networks and their use by customers, in congestion situations it was necessary to add more carrier frequency bands in the selected zones. As suitable carrier frequencies seemed to be those around 2.3 GHz, classified into group WCS (Wireless Communication Services). In our case, a part of the operators acquisition were the frequencies from 2305 MHz to 2015 MHz for sending data and the frequencies from 2350 MHz to 2360 MHz for downloading data in the USA. Organization 3GPP indicates these frequencies as a zone 30 or B30. The granted frequencies are supervised by the US FCC (Federal Communications Commission). To launch 4G

networks in these frequencies US FCC commissioned conditions which should be met in accordance with the neighboring frequencies.

However, at frequencies intended to download data, interferences leading to a weakening of the satellite radio signal SDARS (Satellite Digital Audio Radio Service) has appeared on the border between upper carrier frequency SDARS and lower support frequencies of 4G mobile networks REAG (Regional Economic Area Grouping). Specific problems were detected on frequencies used by satellite radio – Sirius Radio – operating at a bandwidth from 2320MHz to 2333MHz, and XM Radio operating at a bandwidth from 2333MHz to 2345MHz. The problem has shown a very weak distance of an useful signal from noise. Operators are trying to solve the interferences by changing the tilt of antennas and by adjustments of transmitter's power. Transmitter's power adjustments of mobile access points are based on a mathematical definition of the effective signal distance Sn from the sum of the interference signals In and distortion of surrounding signals interfering carrier frequency σn, e.g. multipath propagation of the signal [1].

$$SINR_n = \frac{S_n}{I_n + \sigma_n} \tag{1}$$

Where:

$$I_n = \sum_{i=1}^{i \neq n} I_{ni} \tag{2}$$

A result of a lack of effective signal distance from noise and distortion is weak reception of satellite radio broadcasters in the nearby access points, fourth-generation networks. In connection with interference, impact on AMT (Aeronautical Mobile Telemetry), operating in the frequency range 2360MHz to 2395MHz, was investigated. Broadcasting conditions are supervised by AFTRCC (Aerospace and Flight Test Radio Coordination Council).

In the Czech Republic, the local regulator CTU is responsible for the situations when there is interference between the antennas of the particular technologies. CTU verifies the individual case of interference, based on reports from end users. According to the project Open Data managed by CTU, over 2,000 cases of interference were reported between January and June 2016.

In the Czech Republic broadband antenna preamplifiers are mainly used. They are directly applied to the antenna sectors. Due to integration of the antenna preamplifiers directly into the antenna sectors it was reached of redundancy selective elements, resistance to overload has increased and sectors increased the transmission power. On the other hand disturbing intermodulation products has appeared. They are blocking frequency bands and cause a cross modulation. Stated negative effects were intensified by previously installed analog amplifier with a high profit. These facts have resulted in more significant degradation of the transmitted and received signal.

At the present time Czech Republic uses version C2 for the digital television terrestrial broadcasting. Among the significant parameters of version C2 belong the number of OFDM carrier frequencies set to 8k, 64QAM modulation, code rate 2/3, degree of protection error correction code RS (188, 204, 8), guard interval 1/4 serving primarily to eliminate multipath signals and the useful transport stream 19.91 Mbit/s. When measuring the level of useful signal are in the Czech Republic monitored parameters of the standard CSN EN 60728-1. In cases when CTU receive a complaint because of interference between the block LTE and DVB-T, this stimulus is assessed on the basis of the parameters listed below [4]. Measured parameters in LTE networks are included references [2].

## 3 MAIN CAUSES OF INTERFERENCE

The interference of received DVB-T signal may have an essence in poor input components of the set top box (STB). These may not be well shielded and overall result reproduced by TV is thus distorted due to the unwanted signals on them captured. To capture the unwanted signals also usually occurs near the receiving antenna of TV signal DVB-T, because it is positioned inappropriately or in insufficient distance from the access point eNodeB, transmitting the interfering signal LTE to nearby frequency. The whole construction of DVB-T antennas can usually detect signals that have coupled to incompletely shielded line. Signals captured like that get to the conduction constituted mainly by coaxial cable thanks to broken shielding or incorrectly connected connectors [5].

At analog signals used in the past, interference has manifested on viewer's screen like grain, which intensified with the fading of available signal. In digital systems this does not happen. The image quality remains the same up to a certain level. If the interference rate reaches the maximum possible boundaries and signal to noise ratio no longer meets the requirements for transfer, from the perspective of the viewer it occurs to the effect that is called "cliff effect". This intense signal degradation is precisely that imaginary edge of the cliff. Upon reaching the border cliff, the image very rapidly begins degrade into random discontinuous units, as well as sound. It is possible to demonstrate the received signal strength with parameter RSSI (Received Signal Strength Indicator), whose calculation is indicated in the equation 3.

$$RSSI[dBm] = RSCP[dBm] - \frac{E_C}{I_O}[dB] \tag{3}$$

RSSI value is based on the difference RSCP (Received Signal Code Power) and the ratio of EC/IC. RSCP value indicates the power of the received signal and the useful ratio of EC/IO ratio expresses the received pilot energy to total received noise power. Hypothetically, if we achieve a zero interference from neighboring access points and satellite radios that broadcast on the same frequency, the value of the IO would express only the noise component around.

## 4 MEASUREMENT AND ELIMINATION OF INTERFERENCE

### 4.1 MEASUREMENT AND ELIMINATION OF INTERFERENCE IN CZECH REPUBLIC

For the elimination of interference in the Czech Republic, CTU defines the steps that must be followed prior to running the base station to the actual operation. Each base station operating in bands around 800MHz is at first put into trial operation, where it has to meet the requirements stated in decision on allocation of radio frequencies. Then the base station is tested for two months. During the testing period cases of interference to DVB-T signals are identified. For measurements are assembled working groups, consisting of representatives of the operators, DVB-T networks and LTE networks. Members of the team then communicate with the representatives of stakeholders any problems arising caused due to new frequency bands in the tested area. A methodical process for the analysis of interference has been issued, but it differs from the international measurements. Differences in measurements are given due to specific installations of antenna systems. Usually it is not possible to apply foreign methods in the Czech conditions [3]. For specifics of antenna systems in the Czech Republic can be considered broadband antenna preamplifier integrated in the antenna box, an absence of selective elements, poor resistance to distortion and the subsequent formation of intermodulation components and blocking and cross modulation.

Instruction for measuring interference broadband mobile radio communication networks in the Czech Republic are given by following documents [2].

### 4.2 MEASURING AND ELIMINATION OF INTERFERENCE IN THE USA

Measurement of interferences in the USA is subject to stringent network requirements. As in Europe and its individual states there are established responsible institutions to this task. However in the USA, interference as mentioned above began to occur in bands around 2300MHz. The bands 2305MHz up to 2360MHz, where already worked satellite radios, were about access points for WCDMA serious decline in the quality of reception of satellite radio. This led to subdued effect of sound component or its disappearance. So the useful signal seemed to be weak to inaudible, or it got lost in the noise. Upon notification of interference case to the local authorities, teams of technicians were dispatched to verify the reports. Interference measurement then took place in the similar way as in the Czech Republic. If the report was confirmed, it was announced to interested operators, that it is necessary to rectify the situation. Otherwise the local authorities usually imposed sanctions or in case of continuation of the problem, the license to broadcast on auctioned frequencies could be removed. An operator sent to designated locations technician with appropriate software and hardware equipment. A technician verified an access point settings in trial mode with low power corresponding to 10% of the real transmitting power. Subsequently requested the operational center for treatment of transmit power. Values that were measured had to meet the requirement for maximum spectral density of 50mW/MHz. The next step was the setting of mechanical and electrical tilt of the transmitting antenna. This reduces the emission of spurious waves in the area [6].

## 5 EXPERIMENTAL VERIFICATION OF APPLIED CORRECTION

To verify the effect of interference between access points equipped with fourth generation technologies and other devices operating on nearby frequencies, an experiment in Matlab has been created. The simulation demonstrates the effect of interference between access points on the transmission quality. A significant parameter for measuring of the transmission quality of the network was throughput.

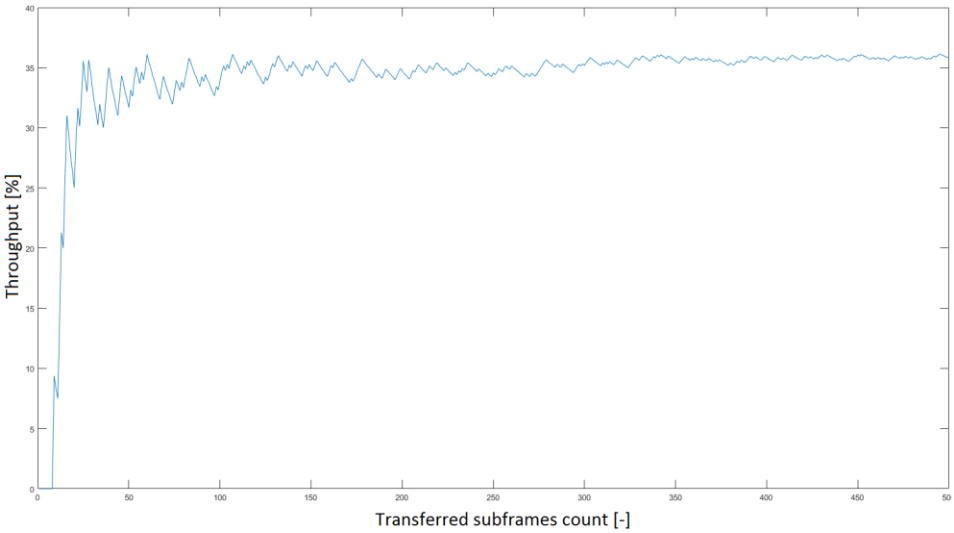


**Figure 1:** Subframes transfer in noisy environments with two neighboring access points.

The worked with SINR value = -3 db. The SNR substitute the interference of two nearby access points. Although the acceptable level SINR determined -5 dB, it has been for such an attenuation decrease troughput to 35.78%. The result of simulation is shown in figure 3. Simulation for borderline scenario, therefore SINR = -5 db was performed, but the result showed a throughput of less than 5%, and therefore is no longer graph simulation showed. Simulated throughput approaching a statistical error and adequate interconnection of two points downstream connection would probably failed or showed symptoms of effervescence incompatible with the quality of service requirements.

## 6 CONCLUSION

The paper was intended to inform the reader of interference in wireless networks that arise during the implementation of new equipment into the already functioning infrastructure. In the first part we were analyzed problems arising in the Czech Republic and also in the USA. The main differences arise from the manner of implementation of the technology at lower frequencies around 800 MHz and higher frequencies around 2300MHz. Lower frequencies, applied mainly in the Czech Republic, were weak particularly when measuring the signal strength of DVB-T in the nearby access points LTE. The consequences of interference in the Czech Republic have been disorders of TV picture and sound reception. In the USA, a similar problem occurred between satellite radios and access points LTE technologies. Implementation of LTE led to very similar consequences. Outages and weak radio signal have been reported to the local regulator. These reports led to the measurements and attempts to mitigate the consequences of their implementation.

The second and third part of the article introduces the reader to the possibilities of measurement, prevention and elimination of consequences of interference on neighboring channels in the Czech Republic and also in the USA. The article described cases of measurements of practices that are based on theoretical assumptions of the mathematical models describing the concomitants interference on nearby access points.

The last part of the article is devoted to the simulation scenario that suggests the consequences of poorly positioned or configured access points, LTE. Simulation shows on network throughput parameter affect interference from other access points on the transmission of data frames. Result of interference is evident from the graph and shows that interference between access points, LTE and DVB-T stations, or LTE, and SDARS negatively affect the actual transmission of TV broadcasts or satellite radio.


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