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CO-SITE INTERFERENCE IN RADIO NETWORKS

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Abstract:

The radio spectrum is a limited national resource, essential for some governmental applications and increasingly important for a series of non-governmental applications. RF co-site interference has been around since the advent of wireless communications equipment and the problem is getting worse as the need for new RF/Microwave communication systems grow. It has become more important than ever to have an understanding of RF co-site interference, what the terms mean and what tools are available to address the problem. One thing is certain; RF co-site interference is not going away and will become worse over time as new wireless systems proliferate the environment. The article addresses the issue of radio resource allocation when using a large number of emission and reception sources for means of communication and non-communication in a small area. Locating several emission sources in the same site leads to different types of disturbing signals: emissions outside the bandwidth, harmonics and intermodulation. The article categorizes and describes these sources, presents the results of measurements distinguishing them, as well as the results of implementing some protective measures.

Keywords: co-site interference , intermodulation, out of band emissions.

1. Introduction

The electromagnetic spectrum is composed of an infinity of electromagnetic waves. Though infinite, this spectrum can not provide unlimited resources to any user because there are a number of limitations which make the frequency band available for applications that use electromagnetic waves to be confined to a subdomain of the electromagnetic spectrum, known as the radio waves domain. A first limitation is imposed by the technology that we have. A second limitation is related to the specific nature of wave propagation: the smaller the wavelength, the greater the signal attenuation with respect to the distance, which leads to reduced terrestrial link distances. In terms of frequency distribution, the most important limitation is imposed by the effect of interferences. In their propagation from the transmitter to the receiver, waves move using the electromagnetic field. Within its borders, every state is the owner of the entire electromagnetic spectrum. Due to the nature of wave propagation, which does not respect geographical boundaries, access to the spectrum is regulated by national, regional and global decisions. The area of the electromagnetic spectrum covered by regulations is only that of radio frequencies. RF co-site interference occurs when two or more co-located RF systems affect one another negatively (fig.1) [1]. This normally occurs when two or more RF systems are operating physically close to one another (within several meters to hundreds of meters) and they are operating in such a way that one of the system transmitters negatively impacts one or more system receivers.

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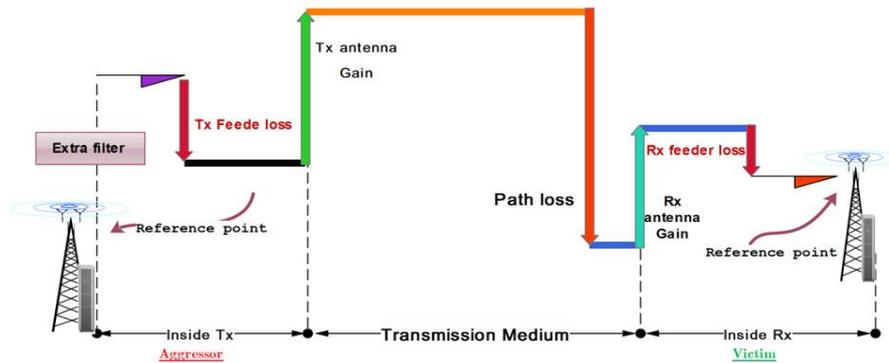


Fig.1 (Interference Related Factors)[1]

Chasing and resolving these RF co-site interference problems often becomes a “reactive” endeavor instead of a “pro-active” exercise.

2. Local sources of perturbations

According to ITU - Radio Regulation (International Telecommunication Union), interference represents “... the effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radiocommunication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy”. [2]

During the processing of the emitted signal, due to the nature of signal modulation and the nonlinear characteristics of some levels in the emission chain, in the transmitter’s antenna, in addition to the desired signal, there arrive numerous other signals. ITU-RR defines these unwanted emissions as being composed of out-of-band emissions and spurious emissions. *Out-of-band emission* represents emission on a frequency or frequencies immediately outside the necessary bandwidth which results from the modulation process. *Spurious emission* represents emission on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products [2].

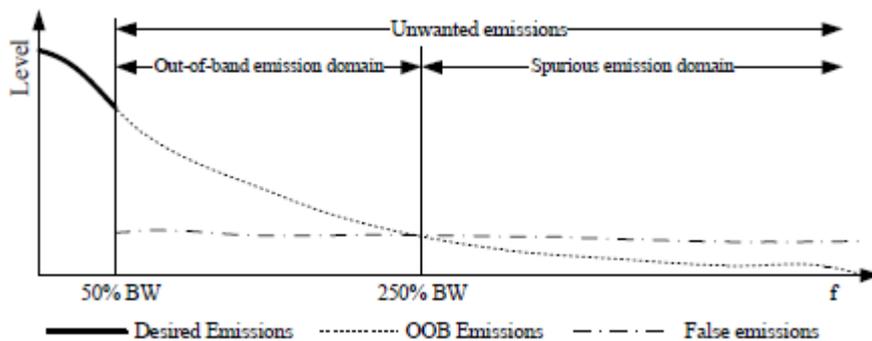


Fig.2 (Level of unwanted emissions)[3]

The effect of interferences due to unwanted emissions is felt especially when multiple radios are co-located. Although radio equipment manufacturers are working hard to reduce unwanted emissions, they succeeded only to mitigate these emissions and not to totally eliminate them. Significant reduction of false emissions with values of at least 60

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dB (typical 90 dB) causes the unwanted effect of interference from these signals to be felt only in the vicinity of emission sources.

2.1. Adjacent channel interference

Out-of-band emissions (OOB) have the highest levels of interference. To avoid adjacent channel interferences, no adjacent frequency channels are assigned in the same service area [4]. From Fig. 2 there can be deduced (1).

$$f \neq (fa - 3 \cdot BW \dots fa + 3 \cdot BW) \quad (1)$$

where fa is the central frequency assigned to a channel with a bandwidth of BW , and f is the central frequency of another channel that can be assigned. Therefore in the assignment process there will not be assigned six adjacent channels (three left and three right of the assigned frequency)[5]. To assess the OOB emission levels, a real-time analyzer of the Software Define Radio type was used, consisting of a dongle HackRF One from Great Scott Gadgets capable of transmission or reception of radio signals from 1 MHz to 6 GHz. Designed to enable test and development of modern and next generation radio technologies, HackRF One is an open source hardware platform that can be used as a USB peripheral or programmed for stand-alone operation [6] along with the SDRSharp V1.0.0.1163 application [7]. The emission source, located at a distance of 10m, issued an FSK signal with $BW=25$ kHz on the frequency of 46 MHz. The measurement result is shown in Figure 3.

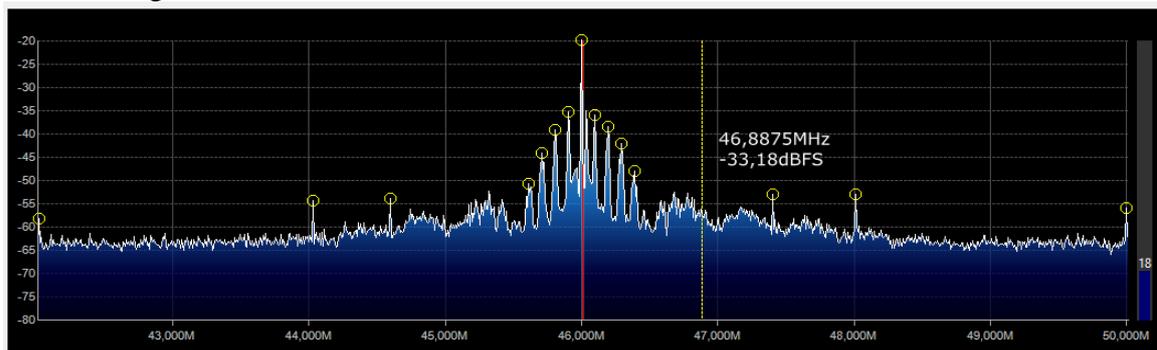


Fig.3 (OOB and useful signal emissions for a STANAG 5042 source type)

2.2. Harmonics

When a single frequency (the *fundamental*) passes through a nonlinear circuit, distortion signals appear at integer multiples of the fundamental frequency (*harmonics*, see Fig.1). We identify each harmonic by its relation to the fundamental: The second harmonic is at two times the original frequency, the third at three times the frequency, and so forth. We use frequency multiplier circuits to produce only desired harmonics. *Unwanted* harmonics can cause interference wherever they occur, ranging from Hf transmitter harmonics that interfere with a TV, to a 49-MHz transmitter's third harmonic that interferes with a 147-MHz 2-meter station ($49 \times 3 = 147$)[8].

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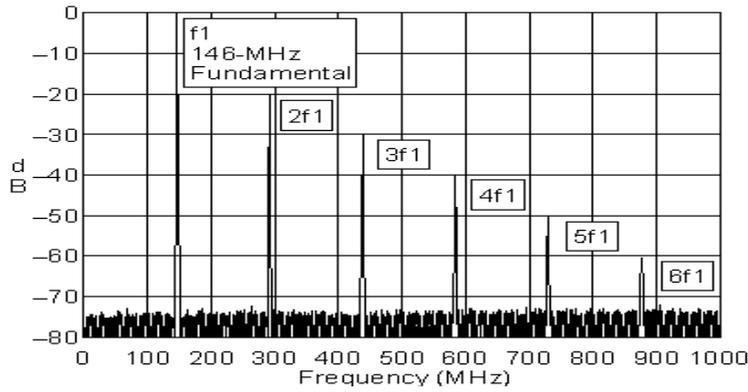


Fig.2 (Level of harmonics from fundamental 146 MHz)[8]

2.3. Intermodulation interference

PIM occur when coupling two or more transmitters. Useful and spurious signals emitted by each transmitter are induced in the antennas of other co-located transmitters and end up in nonlinear output floors where they are composed with the signals produced by each transmitter. When there are more transmitters, then more PIM are obtained. The exact level of intermodulation products depends, as in the case of harmonics, on a series of equipment parameters, but it follows a Gaussian pattern. One of the most common shared site interference mechanisms is transmitter intermodulation. Signals coupled into the output stage of a non-linear base station transmitter can result in intermodulation products being generated that interfere with other receivers at the site or with mobile receivers near the site. Intermodulation products are generated at frequencies described by the following expression:

$$F_{\text{intermodulation}} = mf_1 + nf_2$$

where m and n are integers and (|m| + |n|) is the order of the intermodulation product. Part of the output spectrum of a non linear device excited by two signals f1 and f2 is shown in the following figure[9].

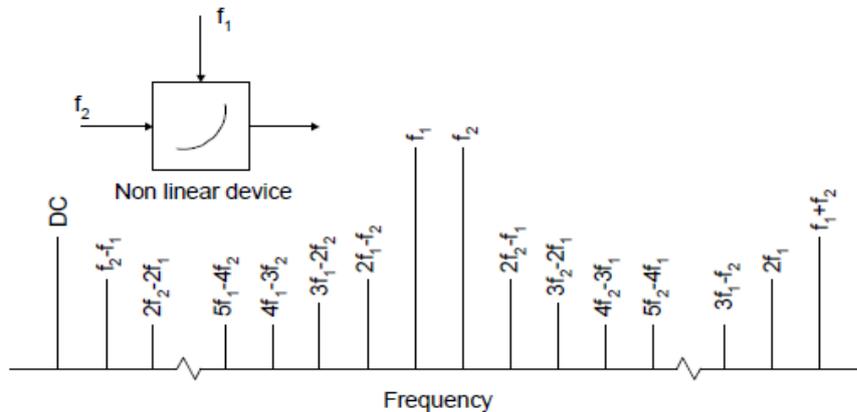


Fig.4 (Intermodulation products)

3. Conclusion

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The article discussed the basics of RF co-site interference and its various mechanisms. There are many aspects to understanding and resolving RF co-site interference problems. The article describes sources of in-site interferences, presents the results of measurements distinguishing them, as well as the results of implementing some protective measures.

There are many tools and techniques available to the system designer to solve complex RF co-site interference problems in the field. This paper provides a basic understanding of these issues. It is important for those involved in the operation and deployment of RF wireless systems to continue to gain a more advanced understanding of the issues surrounding this topic to ensure that their RF wireless systems continue to meet the ever increasing challenges that are coming towards this industry at an ever increasing rate.

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