CAPABILITIES OF SOFTWARE DEFINED RADIO PLATFORMS TO ASSESS THE HUMAN EXPOSURE TO WIRELESS COMMUNICATION SIGNALS

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Abstract: This paper investigates the possibility to assess human exposure to signals emitted in 3G and 4G comunication standards by using software defined radio (SDR) platforms. The obtained results indicate that the critical parameters of the SDR platforms are the sampling rate and the resolution of the analog to digital converter (ADC). The accuracy of the signal level is mainly limited by the sampling rate, that can limit the channel bandwidth, and by the ADC resolution that can influence the dynamic range of the magnitude of the signal.

Keywords: electromagnetic field exposure, software defined radio, sampling rate, ADC resolution.

1. INTRODUCTION

The exposure assessment to radiation emitted by sources belonging to the latest generation of communication standards (3G and 4G) presents some peculiarities given by the quasi-stochastic nature of the generated signal. Communication channels are broadbanded, with a badwidth of 5 MHz - for the 3G standard, and with a badwidth of (1.4-20) MHz - for the 4G standard. It should be noted that the Orthogonal Frequency Division Multiplex (OFDM) technique is used, which has a high peak to average ratio. In this situation, the accurate evaluation of the level implies real-time monitoring of the broadband channel, which conducts to the use of a a spectrum analyzer with real-time analysis capability [2].

Lately, the development of software defined radio (SDR) platforms, starting with the implementation of low cost platforms and ending with complex SDRs with real-time processing capabilities over large bandwidths (> 100 MHz), is remarkable. Their acceptable performance and costs leads to the idea that SDR platforms could also be successfully used for assessing the exposure level emitted by 3G and 4G equipment. The sampling rate and the resolution of the analoque digital converter (ADC) are critical parameters that will limit the performance of the SDR platform [3]. The sampling rate will limit the maximum bandwidth that can be processed in real time. The resolution will influence the sensitivity and dynamic range of the SDR receiver. One bit added to the ADC resolution will improve the dynamic range by as much as 6.02 dB [3].

This paper proposes a comparative analysis of SDR platforms features and their testing in order to use them for assessing the exposure to 3G and 4G communication signals. The test results are useful in highlighting SDR platform limitations when seeking to obtain an acceptable accuracy in the measurement report.

2. RESULTS AND DISCUSSION

Table 1 presents the main characteristics of some SDR platforms [3], [4]. The differences that arise are highlighted by the sampling rate, the resolution of the numerical analog converter and the frequency range that can be monitored. It can be noticed that the sampling frequency allows the monitoring of a 3G or 4G channel even with less complex SDRs and at an acceptable cost, such as the HackRF One platform. The question, however, is to what extent these SDR platforms with an 8-bit ADC resolution can achieve 3G or 4G signal

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evaluations with acceptable accuracy.

Table 1. Main features of some SDR platforms proposed for exposure assessment

SDR Type	Frequency Range [MHz]	ADC Resolution [bits]	ADC Sample Rate [MS/s]
RTL-SDR	24 - 1766	8	2
HackRF One	0.1 - 6000	8	20
BladeRF	300 - 3800	12	80
USRP N200	DC - 6000	14	100
USRP X310	DC - 6000	14	200

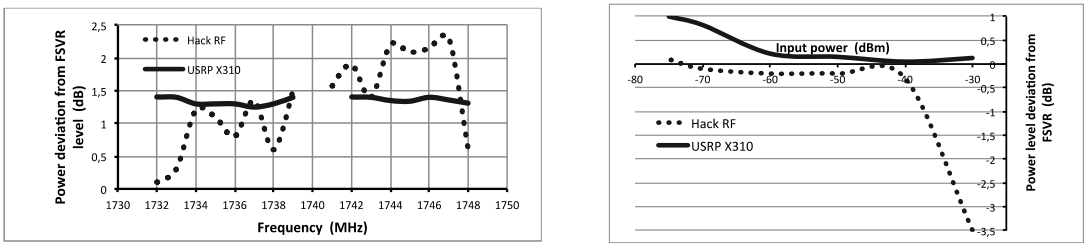

Fig.1. Comparative results of two SDR platforms: Left - Magnitude uniformity over a 20 MHz bandwidth; Right - Relative power variation for a WCDMA 3GPP test signal with a symbol rate 3.84 MS/s (3G standard)

For the estimation of the exposure, the channel power measurement was considered as a suitable parameter to investigate [2]. Validation of SDR platforms was performed by comparing the results with a reference value received from a real-time spectrum analyzer model FSVR 7, Rohde & Schwartz. Two SDR platforms were tested, one with a 8-bit resolution (HackRF One) and the second with a 14-bit resolution (USRP X310). The test signal was provided by a vector signal generator SMBV 100A, Rohde & Schwartz. The following features of SDR platforms have been tested: dynamic range of the magnitude, frequency response, non-uniformity of the signal level over the bandwidth and displayed average noise level (DANL). Some of the test results are presented in Figure 1. The influence of the sampling frequency on the two SDR platforms is highlighted on the left side of this figure. For a channel of 20 MHz bandwidth, belonging to Long Term Evolution (LTE) standard, the USRP X310 platform shows a reduced non-uniformity of the signal over the bandwidth (< 0.5 dB) while the HackRF One SDR shows a high non-uniformity (approximately 2.5 dB). For smaller bandwidths (< 5 MHz), the non-uniformity of HackRF is relatively low (< 1 dB). In Figure 1 on right side can be observed that while the USRP X310 has a relatively constant response in magnitude (< 1 dB), the HackRF One SDR platform, starting with signal levels greater than -40 dBm, presents an error in magnitude assessment that gradually can increase up to 12 dB.

4. CONCLUSION

The obtained results proved that the maximum sampling frequency and the ADC resolution are limiting the performance of SDR platforms. The 8-bit platform limits the dynamic range of the input signal (innacuracy can be high if the signal level exceeds -40 dBm). Also, the sampling frequency limits the bandwidth of the channel, and therefore choosing a proper platform for assesing 4G signal levels, for which the bandwidth may achieve 20 MHz, should be done with great precaution.

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