Coexistence of LTE and Radar System: Methodology and assessment of radar receivers

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***Abstract*— As the need to satisfy the global demand for wireless services continues, so does the pressure for valuable spectrum adjacent to radiolocation services is a topic of contention between incumbent spectrum users and national spectrum policy makers and regulators. Of particular interest and concern is the use of wireless services and the coexistence of UHF, L-, S-, and C-band radars and geo-location services. Existing studies on the coexistence of radar systems and modern LTE communications systems tend to focus on the measurements of the radar spectrum and the interference of the radar on the wireless base station receiver. In this presentation, a methodology and technique for benchmarking the radar receiver performance of cooperative radar systems in the presence of wireless systems is proposed, and some preliminary results are show for a commercial radar system.**

I. Introduction

Due to the favorable RF propagation performance of the spectrum below 6 GHz, these frequency bands are ideal for the commercial wireless services (both terrestrial and satellite) and radiolocation services (radar). With the number of licensed LTE bands worldwide increasing from 11 to over 55 in the since 2011, several widely used radiolocation and geo-location service bands are now being encroached for use by commercial wireless services.

II. Overvieew

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Numerous studies and ITU-R recommendations [1-3] have focused on the impact of the radar transmission on the receiver in the wireless communications system. These studies have resulted in measurement procedures and recommended practices focused on the prediction of mitigation distances between the systems. An enabling factor is the accepted methodology on measuring the power of the radar, ITU-R M1177-4, and the 3GPP Technical and Test Specifications [4] define the minimum acceptable immunity performance of the wireless basestation and user equipment receivers. Radar receivers and wireless communication systems radio receivers have approximately the same sensitivity (~ -115 dBm). Logic would seem to dictate that since the power of the radar can be orders of magnitude higher than the typical 40 Watt basestation carrier signal, it would make sense to focus just on the impact of the radar transmission on the victim wireless basestation receiver. By means of the 3GPP standards, basestation receivers are designed to coexist on the same antenna tower (physically) a few feet apart with minimal frequency separation. Table 1 shows some of the common radar and geo-location services near popular wireless bands.

TABLE I. Popular radar and geo-location frequency bands

	Frequency Range	Example Service
L-band	1 – 2 GHz (NATO)	Global Positioning System carriers centered at 1176.45 MHz (L5), 1227.60 MHz (L2), 1381.05 MHz (L3), and 1575.42 MHz (L1) frequencies
S-band	2 – 4 GHz	ATC, maritime, weather radar: 2.7 – 3.1 GHz ASR: 3.1 – 3.5 GHz
C-band	4 – 8 GHZ	Magnetron/Klystron radar: 5.25 – 5.35 GHz SOTR – single object tracking radar: 5.45 – 5.825 GHz

However, performance of radar receivers are not subject to international or commercially assessed requirements and the lack of standard performance profiles limit the availability of data demonstrating the impact of the radar receiver from the transmission of a wireless communication system. The few standards that do exist on radars, example IEC 62388, focus on the coexistence and interoperability of similar systems.

The lack of standards on radar receivers will not prevent sovereign nationals from licensing spectrum in bands adjacent to radar infrastructure. The recent requirement the EU RED Article 3.2 places minimum performance standards on GNSS (geo-location) receivers as proof of this point. GNSS receivers in the EU are required to have minimum immunity performance such that adjacent spectrum can be licensed for terrestrial wireless services.

III. METHODOLOGY

The functional performance of a cooperative radar should be assessed over-the-air (OTA) or in a test chamber. The importance is to assure that all the components of the radar performance, including the antenna and LNA, are part of the system. While the most common tool for assessing the functional performance of a radar is the use of a single dihedral corner reflector or an array of reflectors fixed at fixed locations, this method is not as ideal as test tools that provide a scaled amplitude number of delayed echoes. Common tools with the ability to regenerate scaled echoes in an OTA RF environment include the use of digital radio frequency memory (DRFM) systems or radar echo generators (REG) as shown in Figure 1. These tools have the advantage of a controlled delivery of a series of radar echoes utilizing digital delay taps that are representations of the transmitted radar signal delayed in time and at variable attenuations (representing radar cross sections). This is important for assessing the radar receiver performance such as delay time (range), signal amplitude, and even the Doppler rate of an echo.

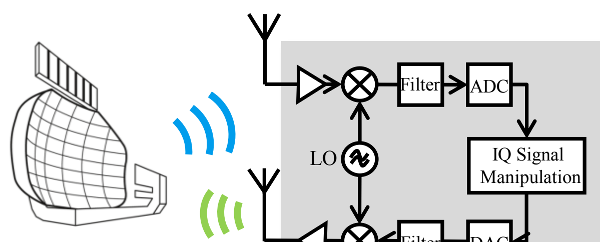

Fig. 1. Example of radar echo generator.

IV. RESULTS

The test of selectivity over amplitude provides guidance on the physical separation distance allowed for coexistence when conducted at a defined offset frequency. Due to the performance of the selectivity over frequency, the test for selectivity over amplitude was chosen at a large frequency offset (-3.733% fractional bandwidth). Figure 2 shows the results when the selectivity power is increased from +45 dB to +70 dB (-50 dBm to – 26 dBm with coupling losses).

Since the receiver performance of the radar receiver and the wireless basestation receiver have very similar levels of performance, when you compare the results the 3GPP standard, this plot re-enforces the need to have additional frequency guardband or stronger guidelines on the mitigation distances for mobile services.

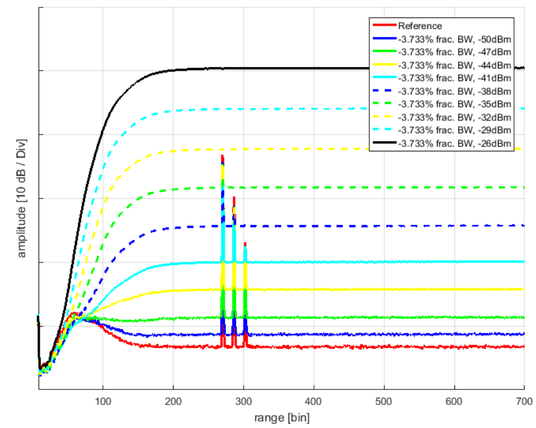

Fig. 2 Plot of selectivity over amplitude at fixed frequency

V. SUMMARY

Standards demonstrate the wireless systems design for co-siting and coexistence. A substantial focus to the blocking and selectivity immunity performance in the radio receiver has been specified by the 3GPP. When the transmit mask of the LTE base station and the receiver performance are compared, there is a relative reciprocity in the out-of-band emissions and the block and selectivity performance. The results of the performance of radar transmit mask and the radar receiver frequency dependent rejection (FDR) curves demonstrate a substantial difference in performance for out-of-band signal behavior. The radar receiver used in this study clearly has a FDR that would make it highly susceptible to interference from a wireless network at a close-in frequency and close-in distance..

Studies and mitigation distances for frequency and separation distances for radar and radio system need to consider the impact to the radar receiver. A standard methodology and approach will enable a baseline performance measure so these issues can get the necessary attention so the guidelines on frequency allocations can be determined.

REFERENCES

[1] ITU-R Recommendation M.1461, Procedures for determineing the potential for interference between radars operation in the radiodetermination service and systems in other services, Switzerland (2000)

[2] ITU-R Recommendation SM.337-6, Frequency and distance separations, Switzerland (2008)

[3] ITU-R Recommendation P.1546-1, Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 3000 MHz, Switzerland (2003)

[4] 3GPP TS 25.104 V14.1.0, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Base Station (BS) radio transmission and reception (FDD), (Release 14)", Technical Specification, Valbonne, France, Dec. 2016