A Study of LTE Radio Coexistance Risk with Narrow and Broadband RFI Noise

Jaejin Lee[1], Kae-an Liu[2], Hao-han Hsu[3], Chung-hao Chen[4], and Dong-ho Han[5]
Client Research and Development
Intel Corporation
Hillsboro, OR, USA
[1]jaejin.lee@intel.com; [2]ka.liu@mail.utoronto.ca; [3]hao-han.hsu@intel.com; [4]joseph.chen@intel.com; [5]dong-ho.han@intel.com

***Abstract*—Impact of narrow and broadband RFI noise on LTE performance is quantitatively characterized. Both narrow and broadband RFI noise starts to decrease throughput at the level of −101 dBm/100kHz. However, broadband noise causes throughput degradation at higher rate of 1.7 Mbps/dB than 1.1 Mbps/dB of narrowband noise. This study provides understanding of RFI noise characteristics and quantitative RFI impact on LTE performance. It can also provide good insights for designers to design reliable mobile platform and radio communication.**

Keywords—Long-Term Evolution (LTE); radio frequency interference (RFI); platform; throughput; signal-to-noise ratio

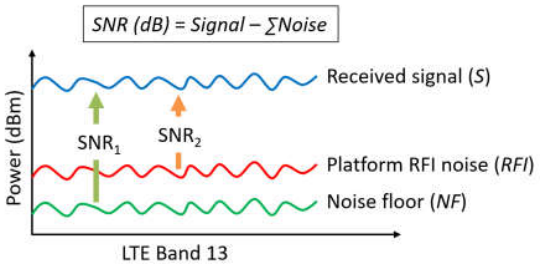
I. Introduction

Long-Term Evolution (LTE) communication to support wireless data connection has been widely populated in mobile computer systems, including smart phones, tablets, and laptops. It is critical to ensure reliable wireless performance for good user experience. Wireless data throughput depends on signal-to-noise ratio (*SNR*) [1] and increases with high *SNR*. However, unintentional platform noise can interfere with LTE radio and deteriorate *SNR*. Degradation factor (*DF*) of wireless performance is a function of platform RFI noise as shown in Fig. 1. Platform RFI noises have narrow and broadband characteristics. Narrowband noise can interfere with a small number of sub-channels, while broadband noise can occupy in substantially large channel band [2, 3]. The impact of narrow/broadband platform noise to LTE radio has not been characterized. It is necessary to study LTE radio coexistence risk and quantify throughput degradation with platform RFI noise.

In this work, the impact of narrow and broadband RFI noise on LTE data throughput is experimentally investigated. RFI noise threshold and throughput degradation factor for two different RFI noise characteristics are also quantitatively determined.

II. Experiment

Wireless data throughput is measured with a LTE radio communication analyzer and reverberation chamber that generates multi-reflective indoor or urban environment. The radio communication analyzer is wirelessly linked to a device under test (DUT). Downlink LTE throughput is then characterized by varying received power (P_{RX}) and RFI noise level. A narrowband 750-MHz clock signal and a broadband



$SNR_1 = S - NF$

$SNR_2 = S - (NF+RFI)$

Degradation factor (DF) = $\Delta SNR = SNR_1 - SNR_2 = RFI$

Fig.1. Relation of signal-to-noise ratio (*SNR*) to platform RFI noise. Wireless performance can be deteriorated by degradation factor (*DF*).

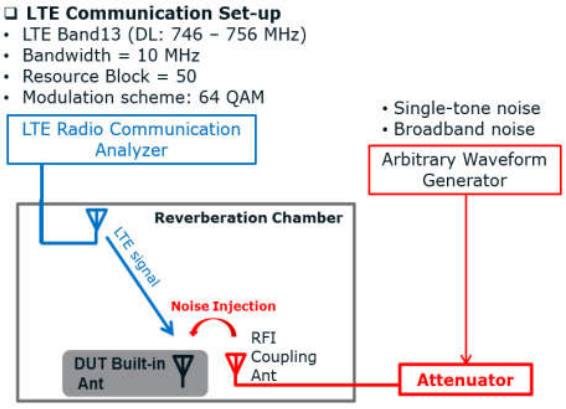


Fig.2. LTE throughput test setup and schematic of RFI noise coupling to DUT built-in antenna.

noise of 5-Gbps pseudorandom binary sequence (PRBS) are produced, respectively, using an arbitrary signal generator (AWG) to mimic different characteristics of platform noise. An external RFI coupling antenna in proximity to DUT built-in LTE antenna is employed to inject the platform RFI noise generated by the AWG. An external attenuator is used to control RFI noise level. Fig. 2 shows LTE throughput test setup and parameters of LTE radio communication analyzer.

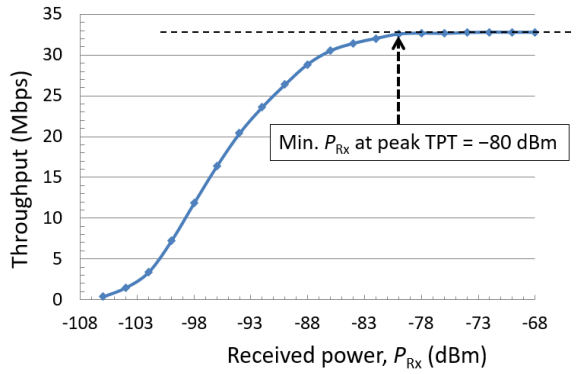


Fig.3. Measured downlink LTE throughput in Band 13 as a function of received power (P_{RX}) without platform RFI noise.

III. Results and Discussion

Wireless throughput (*TPT*) is a function of received signal, noise floor of the receiver, and platform RFI noise in Eq. (1).

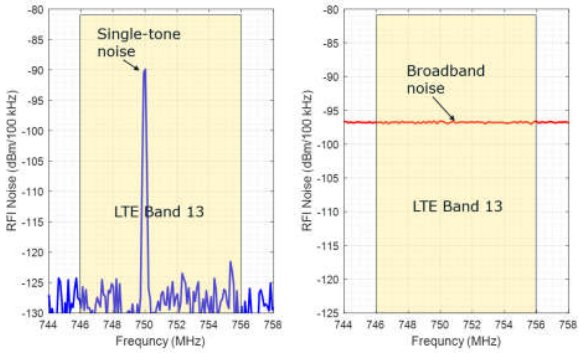
$$TPT = f(SNR) = f\left(\frac{Signal}{Nois\ Floor+Noise\_RFI}\right) \quad (1)$$

LTE throughput is first characterized without platform RFI noise while the received power (P_{RX}) varies from −68 to −108 dBm. Maximum throughput of 33 Mbps is measured at high P_{RX} of −68 dBm and maintained until P_{RX} of −80 dBm. As the received power further decreases, throughput gradually decreases. At low P_{RX} of −106 dBm, poor throughput of below 1 Mbps is observed. Without addition of platform RFI noise, the decreasing P_{RX} deteriorates *SNR*, consequently, wireless throughput [1].

The minimum received power at the maximum throughput is experimentally determined to be −80 dBm and used to investigate the impact of platform RFI noise on LTE throughput. Fig. 4 shows narrow and broadband RFI noise spectrum in LTE band 13. Broadband noise occupies in wider LTE band and can affect a larger number of LTE sub-carriers than those of narrowband noise. LTE throughput as a function of RFI noise level at a constant P_{RX} of −80 dBm is shown in Fig. 5. Both narrow and broadband RFI noise below −101 dBm/100kHz shows no impact on LTE throughput, where the maximum throughput of 33 Mbps is achievable. However, it starts to decrease when RFI noise is greater than −101 dBm/100kHz, which is defined as RFI threshold in this study. Throughput degradation factor is estimated for narrow and broadband RFI noise by linear curve fitting of the decline slope. The degradation factor is 1.1 Mbps/dB for narrowband and 1.7 Mbps/dB for broadband RFI. The single-tone noise affects a small number of LTE subcarriers. On the other hand, broadband noise decreases signal-to-interference ratio for a larger number of subcarriers and increases bit error rate [4].

IV. Conclusion

LTE radio coexistence risk with platform RFI noise is characterized in terms of narrow and broadband noise. Both



(a) (b)

Fig.4. (a) Narrowband and (b) broadband RFI noise spectrum in LTE band 13.

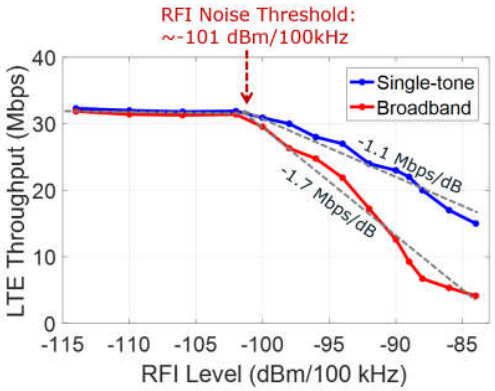


Fig.5. Measured LTE throughput as a function of RFI noise level for narrow and broadband noise at a constant P_{RX} of −80 dBm.

narrow and broadband RFI noise starts to degrade throughput at level of about −101 dBm/100kHz. However, broadband RFI noise affects throughput at higher degradation factor of 1.7 Mbps/dB than 1.1 Mbps/dB of narrowband RFI noise. The risk assessment and characterization of RFI noise impact on LTE performance can assist platform and communication engineers to develop reliable mobile platform and radio communication.

References

[1] I. Cho, C. Seo, G. Yoon, J. Lee, S. Portugal and I. Hwang, "Improvement of the throughput-SNR trade-off using a 4G adaptive MCM system," 2010 IEEE International Conference on Wireless Information Technology and Systems, Honolulu, HI, 2010, pp. 1-4..

[2] J. Lee, H. H. Hsu, P. Davuluri, Y. Ho, and J. Chen, "Impact of broadband and out-of-band radio frequency interference (RFI) noise on WiFi performance," 2017 IEEE International Symposium on Electromagnetic Compatibility (EMC), Washington, DC, 2017, pp. 159-164.

[3] E. X. Alban, S. Sajuyigbe, H. Skinner, A. Alcocer and R. Camacho, "Mitigation techniques for RFI due to broadband noise," 2014 IEEE International Symposium on Electromagnetic Compatibility (EMC), Raleigh, NC, 2014, pp. 159-164.

[4] S. S. Prasad, C. K. Shukla and R. F. Chisab, "Performance analysis of OFDMA in LTE," Computing Communication & Networking Technologies (ICCCNT), 2012 Third International Conference on, Coimbatore, 2012, pp. 1-7.