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Design and Evaluation of RF Receiver under LTE Interference using MATLAB

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ABSTRACT

In this paper, the advance experiment validations of cells coexistences situation in close to real life condition is presents. Interference is a main problem in radio communication, particularly when adaptable frequency reuse is an inherent condition for exploiting spectral efficiencies in heterogeneous network. A representative illustration is encounter in cellular communication where macro cell-edge user received interferences from minor cells transmission that use the identical radios frequencies bands. Transforming interferences managing algorithm is employ toward this ends because of their interdependency with many parameter of the targets operation situations and numerous low-level implementation aspect requirement to be prototype in real-time signals process platform to be believably verifying. The insertion of an responsive interferences managing schemes increases the signals process complexities at the physical layers. This improvement was properly addressed by attractive advance equivalent process technique, optimization of the arithmetic operation and intelligent reprocess of logics and recollection resource in the base band processing architectures.

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1. INTRODUCTION

The new generation of mobile communication system partnership a long term evolution standard specify the operations of small cell, whose aim to increase coverage, improve spectrum efficiencies, offloads traffics from macro cell and reduce the general transmit powers [1-5]. Similarly, small cell is called to play a main roles in the increase of heterogeneous networks deployment. The revealing examples are fem to cell, that LTE-based housing small cell capable to rise the attainable rate per areas units, while Address indoor topologies loss [6-10]. This will make possible via unscrupulously reuse the alike frequencies bands assign to main transmissions amongst the base station and the user equipment [11-15].

Though, the highlight benefit comes at the disbursement of in bands interferences. The instantaneous uses of the similar operation radios frequencies bands with identical signals band width could resulting in co-channels interferences which in turn could dramatically decline the presentation experience by the adjacent base station [16-20]. This occur in case of carrier-to-interference ratio, define as the averaged modulate carriers powered in relation to the average powers at the receivers, and is below confident dangerous level. To challenge the effect of interferences in the downlinks communications, it is necessary to apply an adaptive transmission among the base stations [21-25]. This can achieve thru developed interference managements schemes on top of a closes-loops

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communications systems. Recently, many researcher have propose a methods to decrease interferences, expand the link reliabilities and increased the capacities and performances in macro cells consequences [26-30]. The usage of highest levels program language and computers base simulation to provide a fast and flexible approaches to models and validation a novel inter-cell interferences management scheme capable to serves the operation need of LTE. Revealing samples of interferences-overcome methods are met in [31-35] and of interference-mitigations methods in [36-39]. Regarding to the mention in the overview, the usage of computers-base simulations environment to developing and legalize such scheme feature convinced limitation, which were address in the real-time prototypes present in this paper. Additional widespread approaches use for the experiment justification of interferences-managements algorithm is to developing a software-base PHY-layers implementations of a BS that run on a overall resolution computers that connect with commercials-off-the-shelf signals adaptation and RF processed devices [40].

This platform is denote as offline test beds. For example, in [46] an interferences arrangement method for MIMOs-OFDMs system is validate combine over-the-air transmission base on COTS RF signals generations instrument, via MATLAB develop PHY-layers features a BW of 1.4 MHz. Likewise, the performances gain of coordinate multipoint for LTE cell-edges user is evaluate in [41] through computers simulation that makes user of field trials data-capture.

2. MATERIAL AND METHOD

1. Materials and Method

The suggested model show how to characterizing the impacts of RF damage in the RF receiver of a new radios waveforms in harmonize with a long-term evolutions interferences. The base band waveform is generating by 5G Toolbox and LTE Toolbox. In addition, the RF receivers is modeling thru RF Block sets. To value the impacts of the interferences, the model perform the error vector magnitude differences at a assumed times among the ideals transmit signals and the measure receive signals. Adjacent channels leak ration measured of the quantity of power leak in adjacent channel. This will define as the ration of the filtering means power center on the assign channels frequencies to the filtering means power center on an adjacent channels frequencies. The occupy bandwidths that contain 98% of the entire integrate power of the signals, center on the assign channels frequencies. The impacts of the reception RF damage such as phase noise and amplifiers non-linearity is also consider in the propose model. This model work on a sub frames thru sub frames bas and uses a MATLAB models to perform the base band waveforms generation by 5G Toolbox feature and base band LTE waveforms by LTE Toolbox feature. The matching sample rates of the signal is performs under sample rate match blocks. In order to detention spectral regrowth, the signal over-sampling is done by a factors of 4 by use the FIR Interpolations blocks. The importing of base bands waveform to the RF receiver's subsystems blocks implementing through RF block. This module provide RF frequencies to every signal to carrying the base bands data in RF block. The effect of down sampling the NR signal to a middle frequencies is done by use the RF receiver's subsystems block. Figure 1 shows the suggested model of RF receiver with LTE interference.

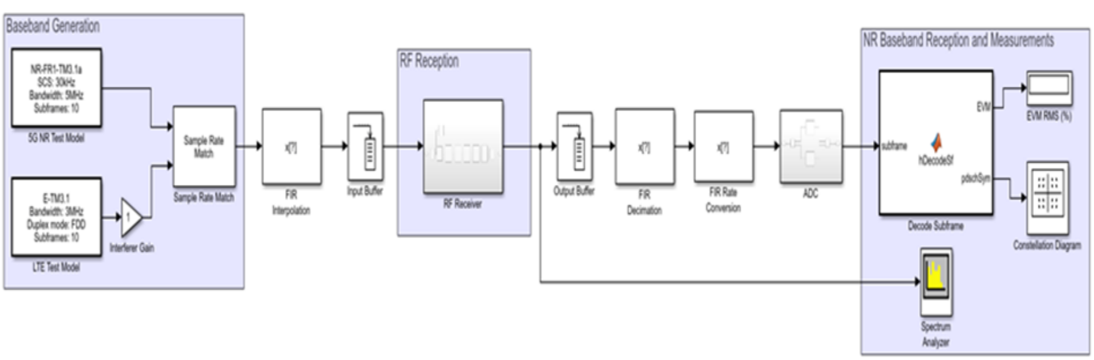

Figure 1: RF receiver structure with LTE interference

The RF receivers is created base on a super heterodyne architectures. This architectures model effected by down conversion the waveforms to an intermediate frequencies by characterized the RF components include band pass filter, low noise amplifier, and demodulator consist of mixer, phase shifters, and local oscillators as illustrated in Figure 2.

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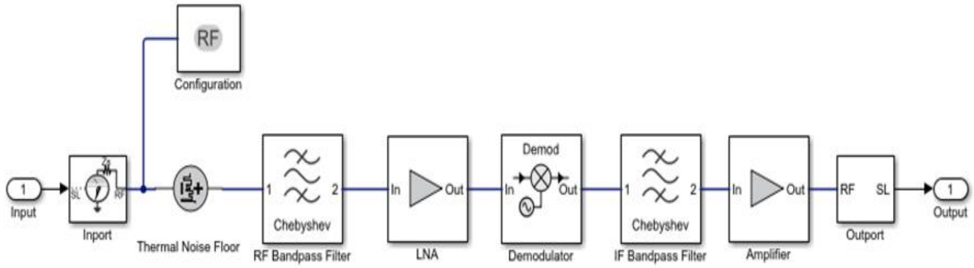

Figure 2: super heterodyne architecture

The input buffer blocks is used to send one sample at a times to the RF receiver block. The in port block within the RF receiver converting the two concatenate complex base band waveform into the RF circuits envelopes simulations environments. The **parameters of carrier frequencies** of in port specify the centers frequencies of the carrier in the RF domains. The Out port convert the RF signal back into simulink complex base bands. The RF receiver component is configured by mask block. The RF receiver models typical damage the phase noise, nonlinear amplifier, and impedance mismatches. The output buffer after the receiver is used to buffers all sample in sub frames. The RF decimation section and FIR rate conversion is used to down sampling the waveforms back to original sample rates.

1.3 Measurement and NR base band Reception

The Decoding blocks perform OFDMs demodulations of the receive section, channels estimations, and equalizations to recovered and plots the PDSCHs symbol in the constellation diagrams. The decoding blocks similarly regulars the EVMs over times and frequencies with plot all value of EVM per OFDMs symbols, EVMs per slots, EVMs per subcarrier, and overall ENM regulated over all allocating symbol in the transmit path.

Consequently, to receive one framed, the simulation of 11 ms for FDD include, 10 ms for the frames pluses, and 1 ms for the initial discard periods. When the simulate times is lengthier than 11 ms, then the 5G NR tests models blocks cyclical transmit the same NR frames. Likewise, the LTE test model blocks cyclical transmit a similar LTE frames.

3. RESULTS AND DISCUSSION

The impact of LTE interferences has been characterized on the NR receptions which compared the EVMs and ACLRs result for two different case include NR transmissions deprived of LTEs interferences, and NRs transmissions thru LTE interferences.

a. *Deprived of LTE interferences with Interferers gains = zero.* In order to remove the LTE interferences, his **Gains** parameters of the interferers gain block to zero. After running the simulations without interference, the constellation diagrams has captured as show in Figure 3 which display the EVMs and ACLRs measurement. The spectrum of LTE mask is illustrated in Figure 4. Clearly, there is no interference in LTE mode and the ACLR value is around 50 and 87 dB with overall EVMs is approximately 0.9%. Figure 5 shows the EVM per slot, per OFDM, and per subcarriers.

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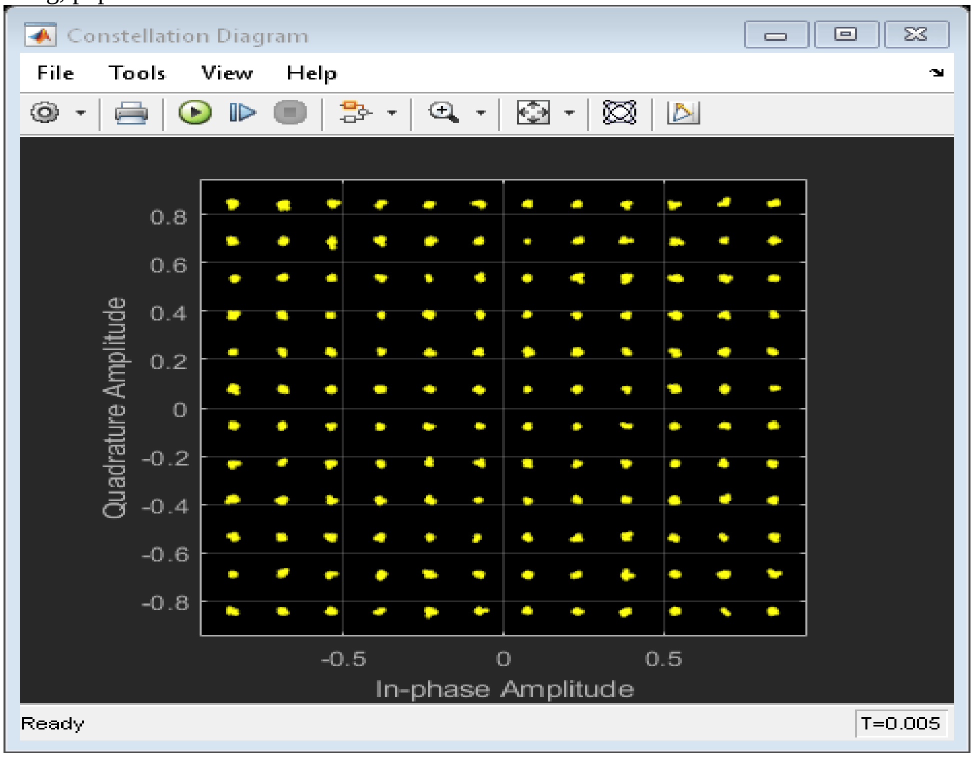

Figure 3: constellation diagram of EVM waveforms without interference

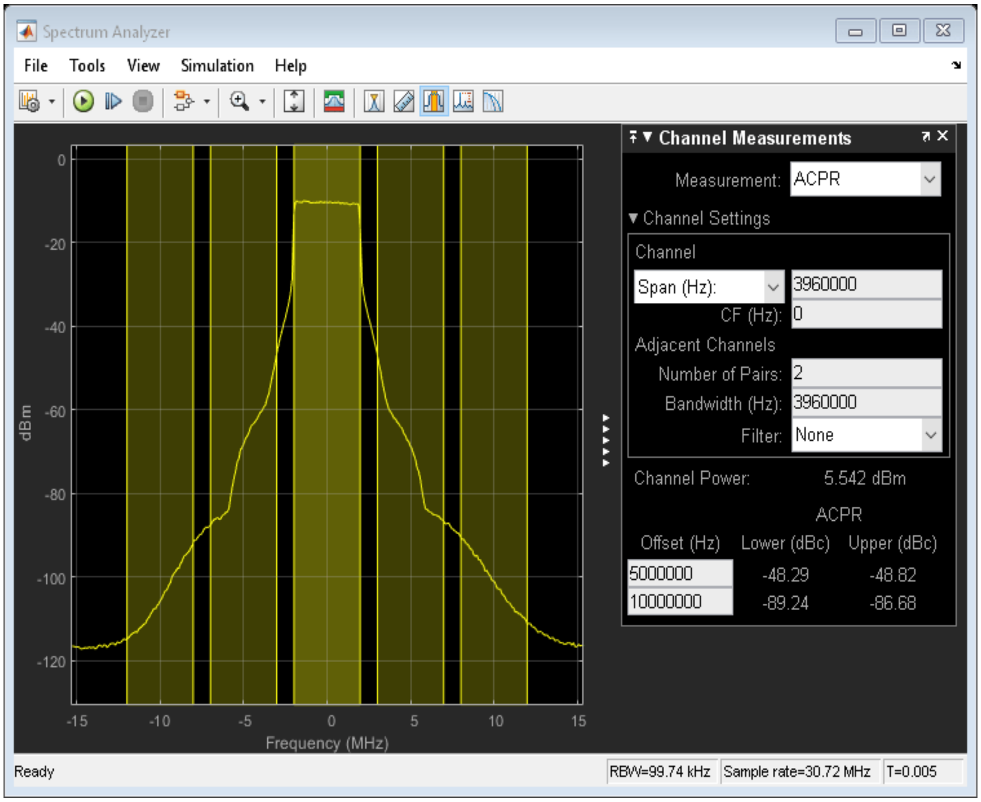

Figure 4: LTE frequency mask without interference

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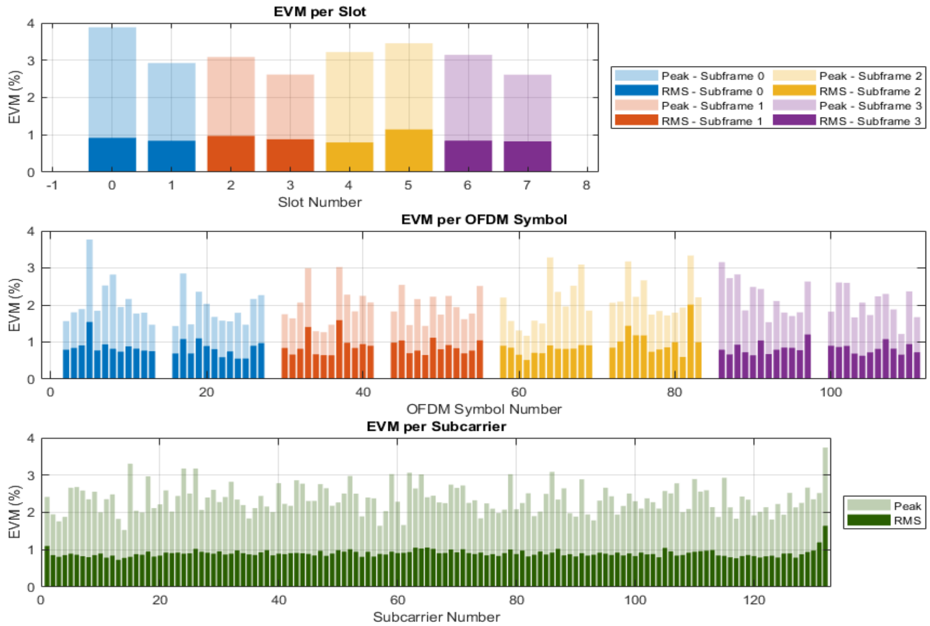

Figure 5: EVM per slot, OFDM, and per subcarriers without interference

b. *Through LTEs interferences with interferers gains = one.* To activate the LTE interference is activated by sets the **gains** parameters of the interferer's gains blocks to a values diverse from 0 such as one.

After running the simulations with interference, the constellation diagrams of received signals has captured as show in Figure 6 which display the EVMs and ACLRs measurement. The spectrum of LTE mask is illustrated in Figure 7. Clearly, there is no interference in LTE mode and the ACLR value is around 50 and 87 dB with overall EVMs is approximately 0.9%. Figure 8 shows the EVM per slot, per OFDM, and per subcarriers.

Compared to the results of the model without interference, the constellation diagrams looks more distort and the spectral regrowths is highest. In term of the measurement, the ACLR values are about 46 and 82 dB and the overall EVM is around 2%.

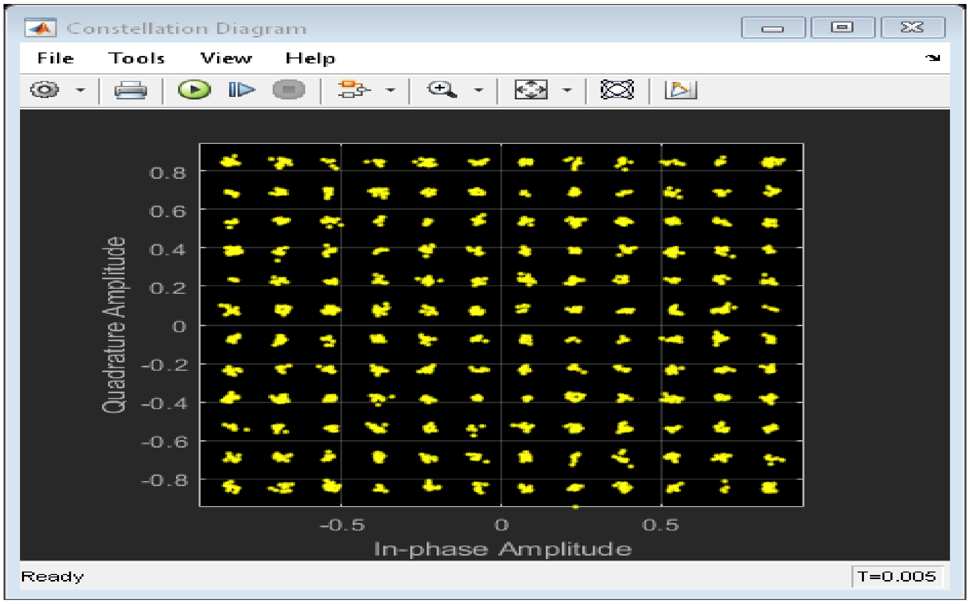

Figure 6: constellation diagram of EVM waveforms with interference

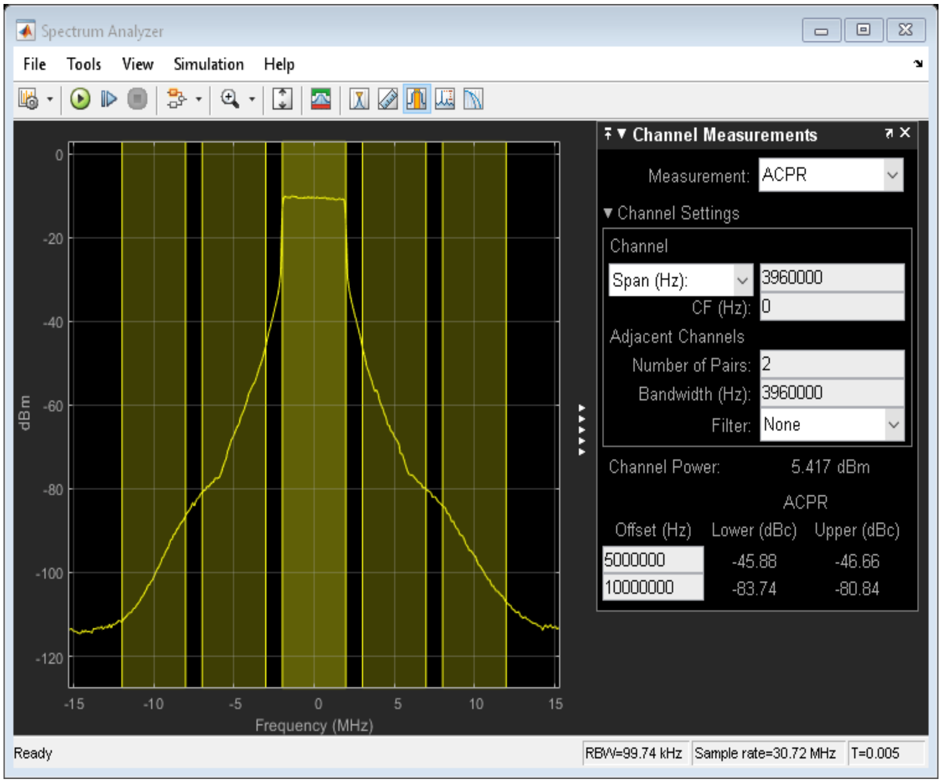

Figure 7: LTE frequency mask with interference

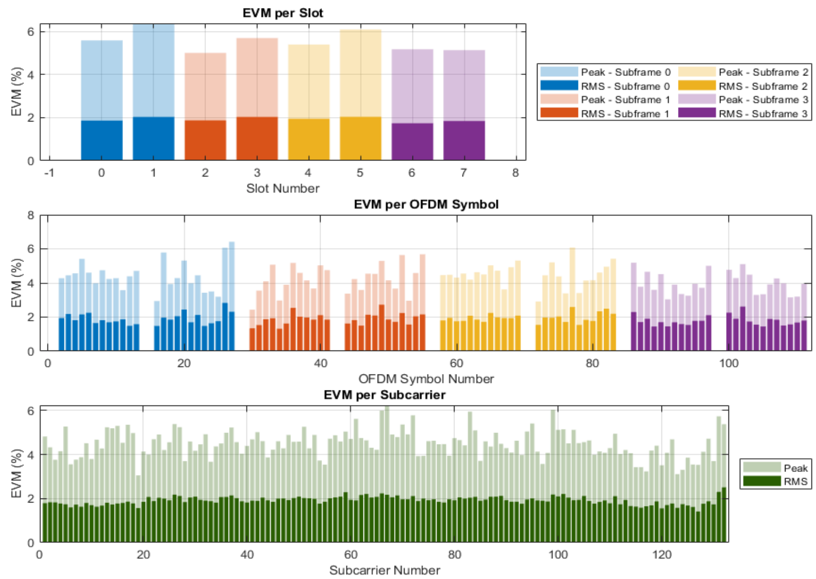

Figure 8: EVM per slot , OFDM, and per subcarriers with interference

In order to works with the waveforms configuration, the RF receiver is configured and select the 5G NR test model and the LTEs test model block with the NRs and LTEs carrier center at 2190 MHz and 2120 MHz, correspondingly. All this carrier is indoors the NR operation bands n65, TS 38.101-1, and the E-UTRA operation bands 1, TS 36.101.

In this model, the demonstration of how to model and tests the NR waveforms receptions were coexist with an LTEs waveforms. The RF receivers consist of band pass filter, amplifier and a demodulators. To estimate the impacts of the LTEs interferences, the model modify the gains of the LTEs signal and perform ACLR and EVM measurement. Hence, one could exploring the impacts of changing the RF impairment as well through increasing the phase noise by use **phases noise offset (Hz)** and **phase noise levels (dBc/Hz)** parameter on the **demodulators** tabs of the RF receiver subsystems blocks. Additionally, by reducing the inputs back off of amplifiers blocks via increase the **gain (dB)** parameters on the **LNAs** tab of the RF receiver subsystems blocks. Then, when modifying the carriers frequency of the RF receiver subsystems block or the NR-TM and E-TM configuration, one can checking if we require to updated the parameter of the RF receivers component as these parameter have been selecting to works for the present configurations. For illustration, the changed of carriers frequencies require reviewing the **pass band frequency** and **stop band frequency** parameter of the RF band pass filter blocks within the RF receivers. In case of selecting the bandwidths more than 20 MHz, then checked if updating is required the **impulse responses period** and **phase's noise frequencies offsets (Hz)** parameter of the demodulators. The offset of phase noise determine the lesser limited of the impulses reaction period. In addition, in case of the phase noise frequencies offsets resolutions is higher for a given impulses reaction period, a cautioning messages appeared, specify the smallest period appropriate for the require resolutions. This model could be used as the basis for testing the coexistences amongst NR-TM and E-TM signals for many RF configuration. Also, one can trying replaced the RF receiver in another RF system and then configured the model. Hence, by using a diverse NR-TM signal, opened the 5G signal **generator** apps and select the NR-TM configurations with exporting a new block.

4. CONCLUSION

This work presents the LTE-based interference managements arrangement which was established on top of closed-loop communication systems. The entity including the selecting end-use situation was conjointly model in MATLAB. These high-level systems represents assisted as the proposal to improve the HDL equivalents at RTL-levels. The goal of the proof of concepts was to confirm convinced performances of the cells edges of interference recognition and extenuation, while try to minimizing the impacts on the 5G communications. The test bed enables the endorsement of the targets situation under many interferences level and mobile condition. As a part from the truthful experiment endorsement of the developing interferences managements arrangement, the contributions of the present works is encounter on the important decreasing of the process loads of detailed base bands DSP function. This remained completed practicable by employ effective digital designs technique that enable resources share at base band, optimize parallelize of DSP operation and a hardware cognizant optimizing of arithmetic operation that reduce the computational complexities. The presents works could be extend to discover many test scenario, KPI and systems configuration, under many mobility condition and interferences condition.

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