

# NB-IoT\_Inband\_UL\_RX\_TestBench

## Where To Find This Example

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## Design Notes

### NB-IoT In-band Uplink eNB RX Test Bench

This example demonstrates operation of NB-IoT inside an LTE signal band. The NB-IoT uplink signal is configured as in-band, NPUSCH format 1, compliant with 3GPP Release 13 specification.

NB-IoT signal is placed in an unused RB within the LTE band.

Configuration options include:

- Carrier frequency (in MHz)
- Transmit power sweep for BER and throughput test (TxOutLvlStart\_dBm, TxOutLvlSpan\_dBm, TxOutLvlStep\_dBm).

The TxOutLvl parameters are specified for "total transmit power". The BER plot, however, uses derived "per-subcarrier power" in the x-axis so that the BER performance of various subcarrier modes can be compared.

- NB-IoT subcarrier mode (NB-IoT\_SCMMode)

0: 3.75kHz single tone (use NB-IoT\_SCAssign parameter to specify between 0-47)

1: 15kHz single tone (use NB-IoT\_SCAssign parameter to specify between 0-11)

2-5: 15kHz three tone {0,1,2}, {3,4,5}, {6,7,8}, or {9,10,11}

6,7: 15kHz six tone {0,1,...,5} or {6,7,..., 11}

8: 15kHz with twelve tone

- NB-IoT subcarrier assignment when NB-IoT\_SCMMode is 0 or 1 (NB-IoT\_SCAssign)

- NB-IoT resource block location (NB-IoT\_RB)

- Use NB-IoT\_RB<0 or NB-IoT\_RB>N\_RB\_UL for guard band operation

- Use NB-IoT\_RB between 0 and N\_RB\_UL for in-band operation

- NB-IoT modulation type (NB-IoT\_ModType)

- Supports pi/2-BPSK or pi/4-QPSK (rotated)

• LTE source has selectable UL RB occupancy using N\_RB\_Channel. Default is {15,34} which means that the PUSCH0 occupies the first 15RBs and PUSCH2 the 34RBs. N\_RB\_Buffers parameter is used to select the buffer RBs between PUSCH0 and PUSCH1. Default setting is N\_RB\_Buffer=1 such that RB location 16 is left open for NB-IoT transmission. Thus selecting "NB-IoT\_RB=15" places the NB-IoT signal in RB location 16 which is blanked in the LTE UL configuration.

The test bench can be used to monitor:

- The TX signal spectrum at various points in the link
- NB-IoT link performance in the presence of LTE UL signal
- IQ constellation of the transmitted and demodulated signals
- Bit error rate (BER), block error rate (BLER), and throughput
- CRC error for each block

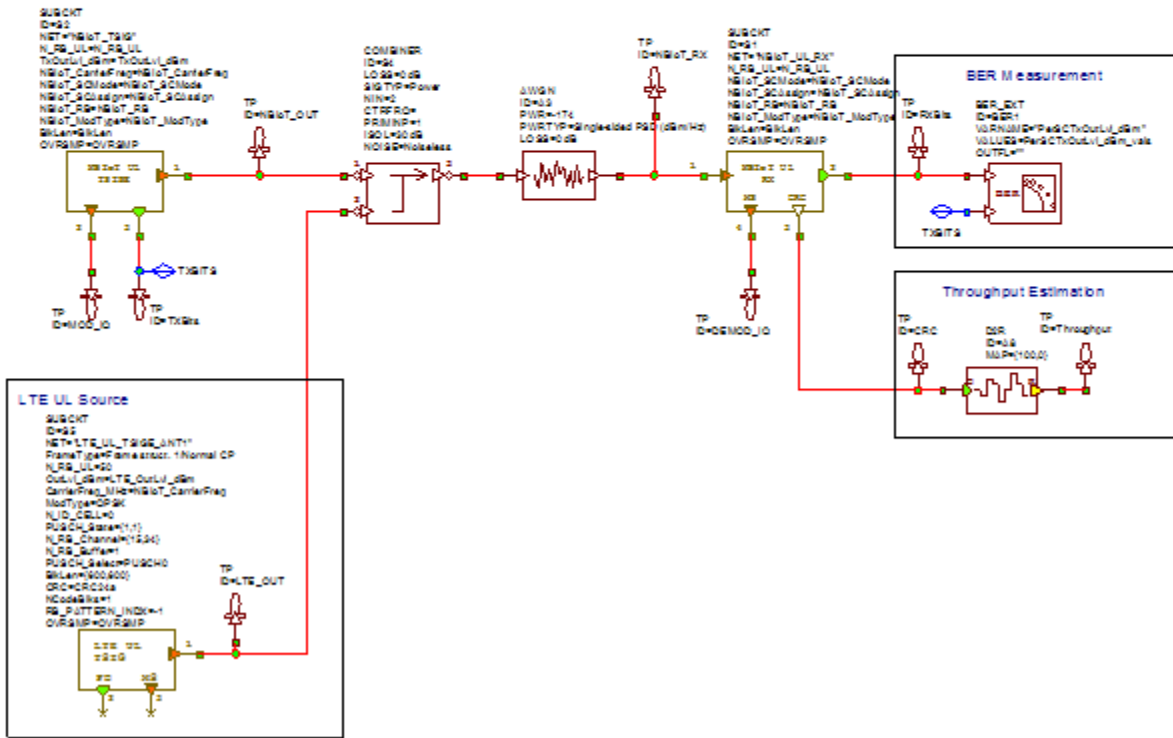
References:

TS 36.211 Release 13, Chapter 10

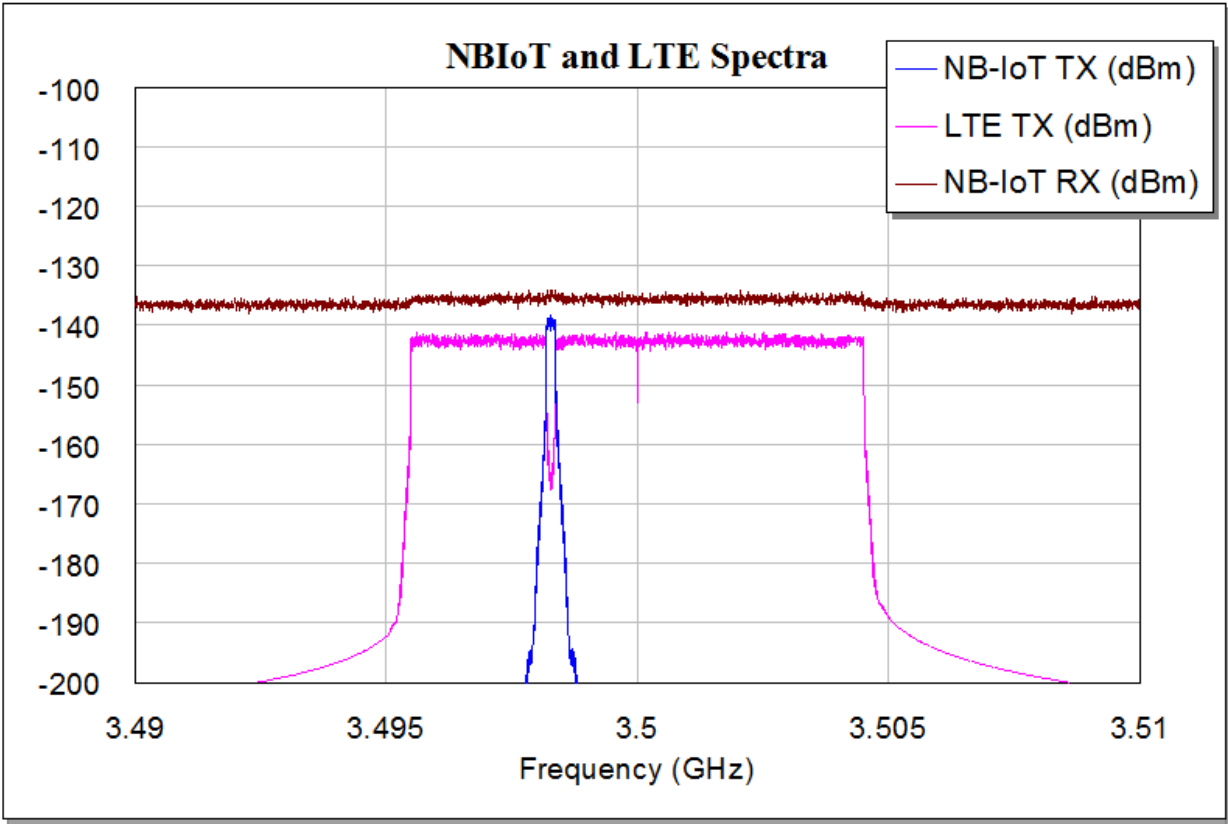
## System Diagram - NB IoT Testbench

### NB-IoT In-Band Uplink Testbench

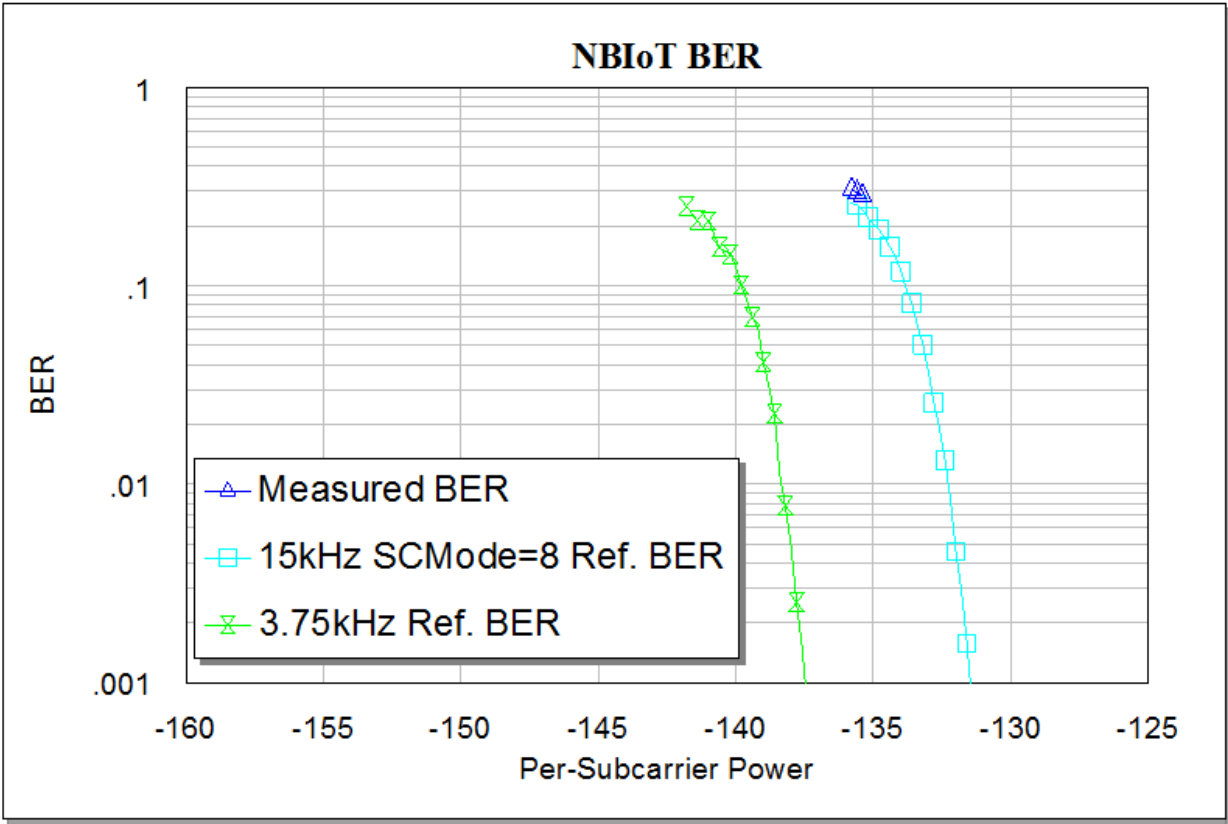
Top Level Parameters	Top Level Parameter Details
<pre> N_RB_UL=40 NB_IoT_CarrierFrag=3200 NB_IoT_SCMMode=6 NB_IoT_SCSAssign=0 NB_IoT_RS=12 OVRAMP=2 NB_IoT_ModType=0 SILEN=32 TxOutLvlGain_dBm=+122 TxOutLvlGain_dBm=6 TxOutLvlGain_dBm=0.2  LTE_OutLvlGain=-110                     </pre>	<pre> NB_IoT_SCMMode: 0: 3.75kHz Single Carrier (uses NB_IoT_SCSAssign, 0-47) 1: 15kHz Single Carrier (uses NB_IoT_SCSAssign, 0-11) 2: 15kHz (3,4,2) 3: 15kHz (6,7,6) 4: 15kHz (9,10,11) 5: 15kHz (1,2,3,4,2) 6: 15kHz (3,7,6,9,10,11) 7: 15kHz (2,...,11) 8: 15kHz (2,...,11)  Recommended TxOutLvlGain_dBm settings: SCMMode TxOutLvlGain_dBm 0 142 1 132.5 2-5 131 6-7 129 8 125  * NB_IoT_SCSAssign is used only when single carrier mode is selected. ** NB_IoT_RS specifies RB location with respect to N_RB_UL parameter. (e.g. NB_IoT_RS=1 is the far RB side subband in the lower guardband) *** NB_IoT_ModType: 0 for (15) 3.75K, 1 for (normal) (15) 15K **** Reference BER curve uses SILEN=32 for 3.75K, 128 for 15K                     </pre>
<pre> ParSubcarrier Averaging calculation N_SC=FN(NB_IoT_SCMMode+1)/NB_IoT_SCSAssign+1;FN(NB_IoT_SCMMode+2, FN(NB_IoT_SCMMode+6, 612)) Sqv(LvlGain_dBm)=TxOutLvlGain_dBm-20*log(FN(SC)) ParSubCtOutLvlGain_dBm=avg(Sqv(LvlGain_dBm),Sqv(LvlGain_dBm)-TxOutLvlGain_dBm,TxOutLvlGain_dBm) ParSubCtOutLvlGain_dBm=ParSubCtOutLvlGain_dBm-122.5 TxOutLvlGain_dBm=ParSubCtOutLvlGain_dBm+20*log(FN(SC)) NB_IoT_ModType and SILEN checked based on NB_IoT_SCMMode NB_IoT_ModType=FN(NB_IoT_SCMMode+2,1),NB_IoT_ModType SILEN=FN(NB_IoT_ModType+0,max(SILEN,32),FN(NB_IoT_ModType+1,max(SILEN,128)),SILEN)                     </pre>	<ul style="list-style-type: none"> <li>- Determine number of subcarriers used</li> <li>- Calculate per-subcarrier transmit power to sweep from</li> <li>- Create an array of per-subcarrier power sweep points</li> <li>- Total Tx power used in the NB_IoT_TxSIG block</li> </ul>



Graph - NB IoT and LTE Spectra



Graph - NB-IoT BER



Graph - NB-IoT Throughput

