5G LNA Requirements

5G Standards will be based on scalable platform which supports various radio air interfaces. The scalability will be in multiple dimensions, such as bandwidth, power consumptions, latency, efficiency, and etc.

This implies scalable requirements mixed signal converters in terms of sampling frequency, oversampling ratio, effective number of bits, image rejection, bandwidth, and etc.

This document walks through single scenario and shows detail in how to define LNA requirements. Spreadsheet/matlab/C++ computations for complete scenario over dynamic range of the receiver can be done. Let me know if you need my service.

Readers are encouraged to send their comments and/or questions to the author, Shafie@ieee.org, and I will be more than happy to address them.

5G LNA Requirements

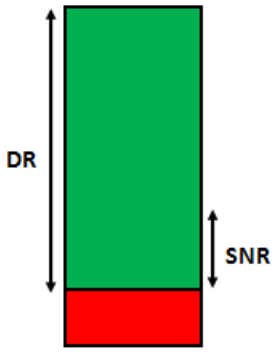
FCC is planning to release 4 bands above 24GHz dedicated to 5G.

It is believed that 28-29 GHz would be the first band.

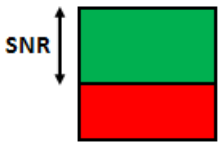
5G modulation will be having 10dB PAR.

Using SDR architecture and input ADC FS=1Vp, the LNA maximum voltage maximum gain, that is voltage gain which provide maximum allowed voltage at the ADC, i.e. Full Scale, can be calculated as:

$$G_v = \frac{V_{ADC}}{V_{in}} = \frac{1V_p}{\sqrt{P_{in} * R * PAR}} = \frac{1V_p}{\sqrt{10^{\frac{-100dBm}{10}} mW * 50\Omega * 10}} \equiv 103dB$$



That is the maximum voltage maximum again for minimum input power at the antenna port for having maximum dynamic range of ADC. Typically at the sensitivity level, the interferer are not specified in the Legacy Standards, therefore full dynamic range of ADC is NOT required for minimum input signal at the antenna port, which means we can tolerate lower gain so long as the desired signal is well above the quantization and thermal noise of ADC with adequate SNR. The required SNR for 5G could be in order of 30dB, which includes 10dB fade margin; consequently, the maximum voltage again for minimum input power level referenced to the antenna port is 50dB, which has built in 20dB adder to be above quantization and thermal noise of ADC.



The LNA gain has to be adjustable to account for various input power level at the antenna port. That would imply variable voltage gain LNA with a range of 0 to 50 dB. The gain step will be dependent on the required resolution of ADC and MODEM. Typically, for fine resolution this could be 0.1dB step size.

The required sensitivity for 1GHz bandwidth would be -79dBm, therefore the noise figure can be calculated as:

$$Sens = KT + 10 * \log_{10} BW + NF$$

$$NF = Sens - (KT + 10 * \log_{10} BW)$$

$$NF = -79\frac{dBm}{1GHz} - \left(-174\frac{dBm}{Hz} + 10 * \log_{10}(10^9 Hz)\right) = -79\frac{dBm}{1GHz} - \left(-84\frac{dBm}{1GHz}\right)$$

$$NF \leq 5dB$$