5G ADC 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 scale the requirement for a different radio air interface.

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

• 5G ADC input signal spectrum

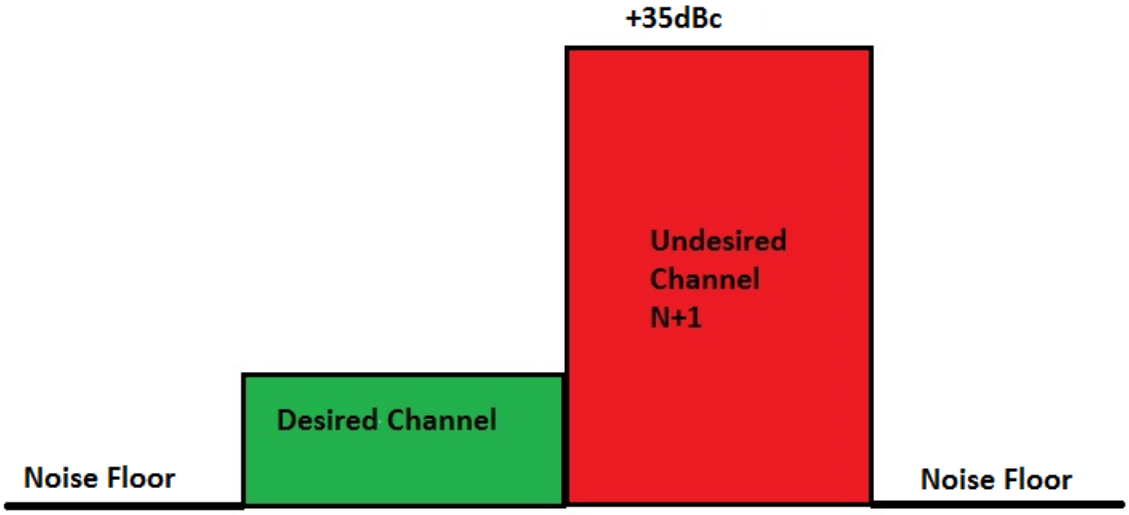

Figure 1: 5G ADC input signal spectrum

- dBc is referred to U/D
- The spectrum is noise like – power density is uniform over the channel
- Channel bandwidth is the same for both D and U
- Required $E_b/n_o \geq 25dB$ for a Gaussian noise 64-QAM with 7/8 code rate

Where, D and U stands for desired and undesired, respectively.

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The following calculation assumes that the next generation 5G demodulator can handle N ± 1 adjacent channels. In other words, the ADC has the number of bits overhead to maintain the required SNR even though there are adjacent channels are present.

$$1) \quad SNR_{ADC} = SNR_{Rx} + \left(\frac{U+D}{D}\right)_{Adjacent\_channel} + PAR_{dB} + 16.33dB - OSR$$

Where,

$\left(\frac{U}{D}\right)_{Adjacent\_channel}$ refers to "undesired" adjacent to "desired" channel level ratio in [dBc], and the 16.33dB margin insures that ADC noise floor is well below the RF/MW front end receiver noise floor so that it impacts the SNR only by 0.1dB. Also, OSR is the over-sampling-ratio. PAR is the peak-to-average power ratio in [dB].

$$2) \quad OSR = 10 \cdot \log_{10}\left(\frac{\frac{f_s}{2}}{CHBW}\right) = 10 \cdot \log_{10}\left(\frac{\frac{80MHz}{2}}{10}\right) = 6dB$$

$$3) \quad SNR_{ADC} = 25dB_{SNR} + 35dB_{U/U+D} + 16.33dB_M + 13dB_{64-QAM} - 6dB_{OSR} = 83.33dB$$

This assumes that sampling frequency 4x than Nyquist rate for the desired BW.

On the other hand, the ADC SNR for a sinusoidal can be written as;

$$4) \quad SNR_{ADC} = 6.02N + 4.8dB$$

$$5) \quad N \geq \frac{83.33dB - 4.8dB}{6.02} = 13.04bits$$

As a result, under the above assumptions, a 13-bit ADC is the minimum requirement for 5G ADC.

Observations:

1. Parameters that impact the above computation are PAR, SNR, U/D, CHBW, OSR, and Margin. Matlab or spreadsheet can be created to do similar calculations for various input parameters of interest.
2. The ADC MSB can be turned off to scale back the required power consumptions.
3. By turning of ADC LSB and/or MSB the dynamic range of ADC can be controlled, depending on the required noise floor and/or maximum power handling.