CW 19 summary

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1 Understanding RF Specifications

1.1 Basic Terminology

digitizer amplitude error
The following formula provides the dampening or attenuation factor E of the digitizer:

$$E = 1 - \frac{R}{\sqrt{1 + R^2}} \tag{1}$$

A X-Hz digitizer is defined to have $E = \frac{1}{\sqrt{2}}$ at the frequency X, which implies $R = 1$ for the frequency X. X is called bandwidth of the digitizer in this context, and R is the ratio of the digitizer bandwidth and the maximum frequency of interest $\frac{f_d}{f_i}$.
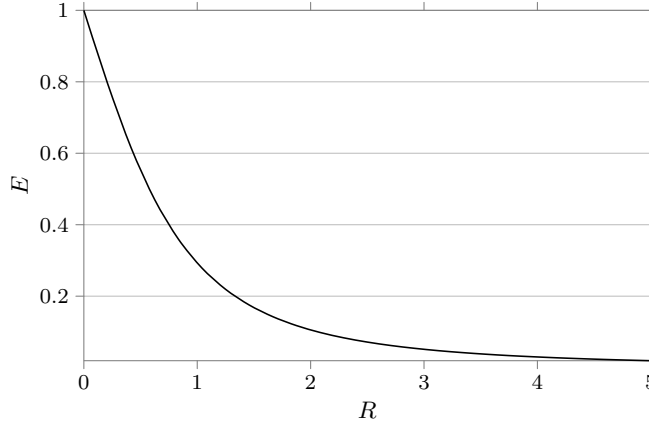

Figure 1: Digitization error verus bandwidth ratio

It is recommended by NI to have X be 3 to 5 times higher than the frequency of interest. This corresponds to errors or dampening between 1.94% and 5.13%

rise time
Rise time is defined as the time a signal needs to rise from 10% to 90% of its steady-state or periodic maximum.

- The rise time of a simple RC-circuit is about $\frac{0.35}{RC}$.

- The formula to calculate the total rise time of a digitized signal is:

$$T_{r_t} = \sqrt{T_{r_s}^2 + T_{r_d}^2}$$

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- In order to minimize rise time errors NI recommends to have T_{r_d} be around $\frac{1}{3}$ and $\frac{1}{5}$ of T_{r_s}.

Nyquist Theorem
The bandwidth of the digitizer must be at least 2 times the maximum frequency of the signal to avoid aliasing.

$\Leftrightarrow$ To extinguish aliasing in the passband one either has to make sure the Nyquist Theorem is matched or apply a lowpass filter to limit the signal's bandwidth.

phase noise
Phase noise is the frequency domain representation of time domain jitter. Jitter in turn is the first derivative of a delay. Phase noise is usually close to the carrier and thus measured in dBc (decibels relative to the carrier).

spectral density
Measures the power per frequency in a frequency domain [W/Hz].

resolution bandwidth
The resolution bandwidth equals the FFT bin size and is smallest resolvable frequency. It is inversely proportional to the number of samples.

noise density
Noise level below which signal cannot be detected. One has to distinguish between broadband noise density of a sinusoidal and random (perhaps AWGN) noise. In the latter case one can use a narrow band filter to improve our signal.

dynamic range
Ratio between the highest and lowest signal level a circuit can take. Spurious dynamic range is the ratio between the highest and lowest signal level, without any unwanted sinusoidal frequencies. It is usually expressed in dB.

voltage standing wave ratio (VSWR)

frequency response
Just as a reminder: the frequency response is the fourier transform of the impulse response $h(t)$.

$$H(f) = \int_{-\infty}^{\infty} h(\tau) \cdot \exp(-j2\pi ft)\, d\tau$$

modulation error ratio (MER)
A measure of SNR for digitally modulated signals, also expressed in dB.

$$MER = \frac{\sum_{j=1}^{N} \tilde{I}_j^2 + \tilde{Q}_j^2}{\sum_{j=1}^{N} (\tilde{I}_j - I_j)^2 + (\tilde{Q}_j - Q_j)^2}$$

Where the components with $\sim$ are the ideal and those without are the actually received components of the N symbols of the signal.

IQ procedure

error vector magnitude (EVM)

third-order intercept (TOI)

2 Physical Layer Challenge

2.1 Basic Terminology

2.1.1 FIR Filters

passband, transitionband, stopband
The passband is the frequency band that is not attenuated band of a filter, i.e. that band of allowed frequencies. The stopband is the band that a filter stops, or attenuates strong enough, so that the signal amplitude for those frequencies is below the stopband threshold. The transitionband is an attenuated band between passband and stopband.

filter tap
A filter tap is a (coefficient, delay) pair. The number of taps is often denoted as N. This number is a good mesure for the amount of filtering, the required space and the amount of calculation required by the filter.

2.1.2 Frame Synchronization

frame preamble

CRC-based framing

self-clocking signal

bit slip
A lost bit or an extra bit.

2.2 FIR Filters vs. IIR Filters

2.3 iNets PHY Layer

3 GNU Radio Techniques

3.1 Creating a hierarchical block directly in GRC

3.2 Read and Write Stream Tags

4 Good to Know...

4.1 Python

4.2 LaTeX

I learned...

- ... when to use input or include

- ... some tikz basics