RAQ's

Rarely Asked Questions

Strange stories from the call logs of Analog Devices

Bring on the Converter Noise! – Part 1

Q. Is Noise Figure important from the A/D converter's perspective?

A. In terms of the converter, noise figure (NF) and signal-to-noise ratio (SNR) are interchangeable. NF is great for understanding noise density, while SNR measures the total amount of noise in the band of interest. Let's take a closer look at NF though. Some tradeoffs can be misleading, and low NF does not always translate into lower front-end noise seen by the converter.

NF is easy to use in cascaded signal chains when trying to understand the dynamic implications of the design. Remember, that as the source resistance is quadrupled, the NF will improve by 6 dB, but the increased resistance will also increase the Johnson noise that will be seen by the converter. With more source resistance, or half of the full-scale input signal across the converter's analog front-end (transformer, amplifier, or otherwise), noise becomes more difficult to manage over the band of interest, ultimately making the converter's performance worse.

Why is this? If the full-scale input to the transformer or amplifier is lowered, the gain must be increased. This looks fine on paper, for transformers they are more gain-bandwidth dependent than amplifiers. Therefore, optimizing the NF to be as low as possible using a high-impedance ratio transformer, for example, makes it difficult to realize common high-IF applications of 100 MHz and above.

The problem with amplifiers is similar: as the gain of the amplifier is increased the amplifier not only amplifies the signal, it also amplifies its own inherent noise, thus

rapidly degrading the converter's performance. In order to preserve performance, a more complicated (higher order) anti-aliasing filter is required, making it rich with resistive and "lossy" components.

When designing a front-end, keep noise spectral density (NSD) in mind instead. Usually specified in nV/rt-Hz, this is what's really important to the converter, as this is what will be reported and crunched in the digital domain in order to differentiate and ultimately "pick out" the signals of interest within band.

In summary, make sure all the input and output full-scale signals are maximized throughout the signal chain by positioning gain where appropriate. Attenuation, padding, or resistance is not a good NF tradeoff in any signal chain, as it wastes power and increases noise due to resistors. Part 2 will discuss the comparison between resistor noise and converter noise.

A/D Converter Noise Figure equation: NF = Pfs(dBm) + 174dBm – SNR – 10*log (BW). Where Pfs = the fullscale power of the input network used.

To Learn More About the Importance of ADC Noise Figure
http://designnews.hotims.com/23125-101

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Have a question involving a perplexing or unusual analog problem? Submit your question to: raq@reedbusiness.com

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