RAQ's

Rarely Asked Questions

Strange stories from the call logs of Analog Devices

Bring on the Converter Noise! – Part 2

Q. How does resistor noise compare to A/D converter's noise?

A. In the first installment Noise Figure (NF) considerations were discussed. Remember, think noise spectral density (NSD), here's why.

The A/D converter's total NSD performance is really a number of parameters like thermal noise, jitter, and quantization noise, ie — signal-to-noise ratio (SNR) over a specified bandwidth (BW). SNR reported in a converter datasheet, can give the designer a realistic expectation when trying to understand the converter's lowest resolvable "step" in the signal being sampled. This step, is also called a least significant bit or LSB. Given an N-bit converter and input fullscale value SNR and LSB size can be determined. Where, SNR = 20*log(Vsignal-rms / Vnoise-rms) and LSB = (Vrms Fullscale/(2^N)).

By re-arranging this equation, one can determine the converter's noise or Vnoise-rms = Vsignal-rms*10^-SNR/20. So, for a typical 16-bit, 80MSPS A/D converter with an SNR of 80dB that has a 2Vpp input full-scale will have a Vnoise-rms = 70.7uVrms or LSB size of 10.8uVrms.

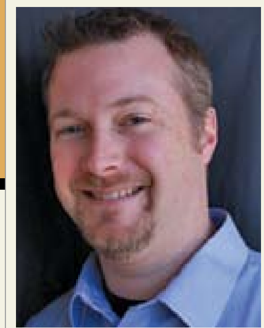
Now let's look at resistor noise. Resistor noise is defined as Vresn = sqrt(4*k*T*BW*Resistance), therefore a 1kohm resistor adds about 4nV of noise in a 1 Hertz BW. Where T is temperature in Kelvin (room temperature = 290K), BW is bandwidth and k is Boltzmann's constant (1.38x10E-23 Watt/second/Kelvin). With respect to the converter resistor noise doesn't seem to be much to worry about. Don't be fooled.

Now let's continue to discuss driving down NF in order to increase sensitivity. This can be achieved by adding gain and resistance on the converter's frontend design. In the case of a passive frontend a decrease in the input full-scale by a factor of 2, means the NF goes down by 6dB. Yeah! However, consider the uncorrelated resistor noise as well.

The gain of 2 in the signal chain really makes a 50ohm resistor look like 14.4uVrms and the 200ohm termination resistor noise on the opposite side will add another 14.4uVrms. These two uncorrelated noise sources root sum square (RSS) together bringing the total noise to 20.3uVrms. That's 2 LSBs!

The point here is converter noise is >> bigger in terms of resistor noise even with some gain applied. However, as higher value resistors and gain are applied throughout the signal chain the total noise will easily start to erode SNR away (LSB = 1bit = 6dB). Be wary about employing gain in the signal chain, the factors add up fast.

To Learn More About Noise Spectral Density (NSD)
http://designnews.hotims.com/23129-100



Contributing Writer Rob Reeder is a senior converter applications engineer working in Analog Devices high-speed converter group in Greensboro, NC since 1998. Rob received his MSEE and BSEE from Northern Illinois University in DeKalb, IL in 1998 and 1996 respectively. In his spare time he enjoys mixing music, art, and playing basketball with his two boys.

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

For Analog Devices' Technical Support, Call 800-AnalogD