BY BONNIE BAKER

Analog filter eases delta-sigma-converter design

Delta-sigma converters with sinc (sinx/x) digital filters change the signal chain's complex antialiasing-filter requirements to a simple, first-order, passive filter. With this "easy-to-design" circuit, you can tackle the major noise contributors around the delta-sigma modulator's sampling frequency. The converter's characteristics that you use in this filter design are the modulator-sampling rate, F_S, and output-data rate, F_D.

The frequency response of a sinc digital filter looks like a comb (**Figure 1**). The frequency of the first null in this **figure** is equal to the F_D of the converter. If you look at the frequency response of a sinc filter up to the modulator's sampling rate, you can see that the sampling frequency is much faster than the converter's output-data rate.

Because a delta-sigma converter is a sampling system, all noise and signals above one-half of the F_S alias back. The sinc digital filter rejects noise over a wide frequency band, but it does not reject system noise around the F_S. The amplitude of the noise and signals hovering around the sampling frequency is small, but noise is a reality. The lower bits may fluctuate because you have a high-resolution converter.

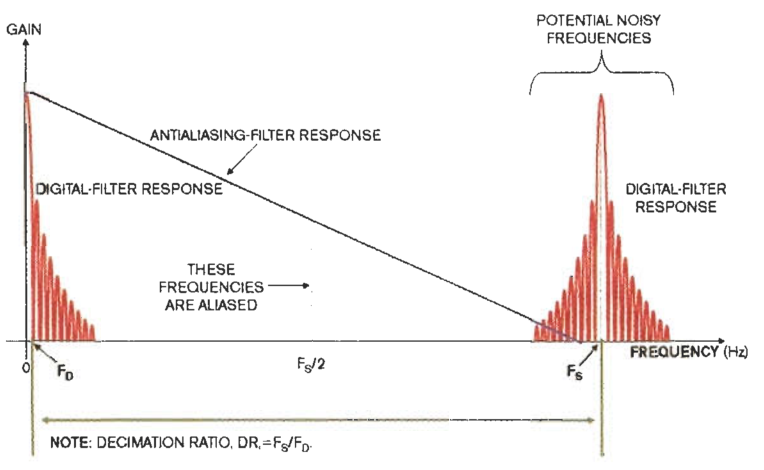

Figure 1 The sinc-digital-filter response is compressed near 0 Hz, and the converter's sampling frequency mirrors and duplicates that response.

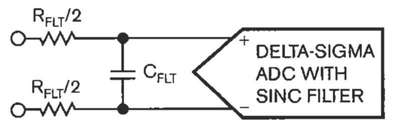

Figure 2 This filter has two equivalent resistors and a capacitor.

The corner frequency of your analog filter is equal to the output-data rate, or F_D. Fortunately, this filter has a low-order function, and the appropriate choice is a simple RC filter. If your system has a lot of noise or signals around the region of F_S or if the decimation ratio is less than 100, consider using a second-order, lowpass filter.

Place the analog antialiasing filter before the input of the converter. **Figure 2** shows the best option for this passive, lowpass filter for a single-channel device, where $F_D=1/(2\pi R_{FLT}\times C_{FLT})$. Because the lowpass filter is a simple RC pair, the values of the filter's resistors ($R_{FLT}/2$) are easy to choose as long as the resistor noise from dc to the filter's corner frequency is less than one-third of the noise that the delta-sigma converter generates. The value of the capacitor (C_{FLT}) should be at least 20 times higher than the input capacitance of the converter. It can be as high as you want, as long as you keep in mind that your filter's corner frequency is equal to or greater than the converter's output-data rate.

If you have extraneous noise in your system, you will be pleased with the results of using this antialiasing filter. You may not find noise in your lab conversions, but make sure you anticipate the location of your system. In the field, extraneous and noisy signals may very well just creep into your converter. EDN

Bonnie Baker is a senior applications engineer at Texas Instruments and author of A Baker's Dozen: Real Analog Solutions for Digital Designers. *You can reach her at bonnie@ti.com.*