Is your converter accurate?

WHAT DOES ADC ACCURACY really mean? You might say that it means that the ADC output code represents the actual analog-input voltage minus the quantization error. This scenario makes sense, but do you see a precise determination of the analog input?

Does accuracy also mean that the A/D-conversion results are repeatable? Is the converter output code repeatable from transition to transition, with everything remaining unchanged in the circuit during successive conversions?

Theoretically, an ADC code-to-code transition may be sharp, occurring at a unique input voltage. Actually, the transition regions in the ADC-transfer function may be wide. In fact, these regions may span several digital-output codes. In **Figure 1**, a transition point occurs where the digital output switches from one code to the next with respect to a specific analog-input voltage. But, because of ADC internal noise, the transition point is typically not a single threshold, but rather a small region of uncertainty. Consequently, you need to define the transition point as the statistical average of many conversions. In other words, the voltage-input value is the point at which half the conversions produce one digital code and the other half produce the adjoining digital code. Upon closer inspection, the conversions you collect appear to be noisy, with a Gaussian probability curve.

Assuming that you are using good layout techniques, bypass capacitors, and so on in your circuit, one quick converter experiment grounds the input of a good 16-bit ADC. Next, collect 1024 samples at the converter's specified conversion rate. Multiple codes in the output data exist. Witness the converter's transition noise. Some manufacturers indicate the rms transition noise for their ADCs. Multiply the rms-transition-noise specification by 6.6 to obtain a peak-to-peak value.

Taking this discussion a step further, the offset, gain, differential nonlinearity, and integral nonlinearity are the accuracy specifications for ADCs. Some manufacturers also call these characteristics the dc specifications, because these device tests use a dc-input voltage for the conversions. But these specifications do not indicate how repeatable the results are from conversion to conversion. They indicate only that, on the average, these errors are no more or no less than the minimum and maximum in your ADC manufacturer's data sheet. To precisely describe your converter's accuracy, you need to combine the ac specifications with the dc specifications.

Three types of ac specifications exist, but one is particularly interesting for this discussion: the SINAD (signal-to-noise-plus-distortion) ratio. The counterpart of this specification is ENOB (effective number of bits). ENOB= (SINAD-1.76 dB)/6.02. Combining this specification with the dc specifications gives you a stronger feel for how accurate your converter really is.□

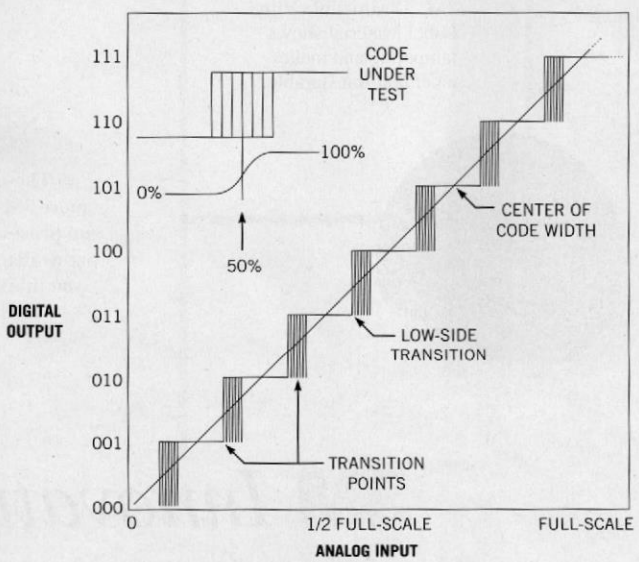

Figure 1 **This 3-bit ADC's nonideal transfer function illustrates the transition noise of every code.**

REFERENCES

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