AN-23: Understanding Analog to Digital Converter Transition Noise

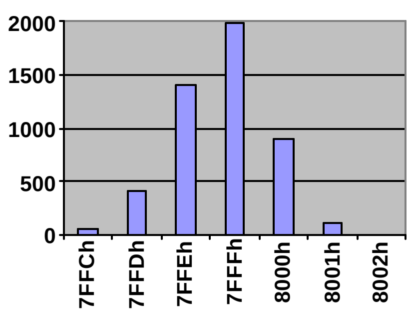
January 7, 2004 David Fitzgerald

There are many sources of noise in digital to analog converters. Power supply, reference, cabling or interconnect, and system induced noise can all add significant error to the voltage being digitized. One noise source that is often overlooked and misunderstood is converter transition noise.

Converter transition noise is the noise that occurs within the ADC itself during every conversion. Transition no ise affects the DC performance of the analog to digital converter, which is of primary concern in precision industrial control applications. It is usually specified as either some number of least significant bits of deviation, or as a deviation of the refe rence voltage in parts per million.

To measure the transition noise of an analog to digital converter, apply a low noise, stable DC voltage to the input and record the converter data over a reasonably large number of conversions. The distribution of the output data, or deviation from the code that corresponds to the actual input voltage, is the converter transition noise. To put it another way, if we are looking at a bipolar +/- 10 volt range with the input grounded (0.0 volts), the digital output code from a 16 bit converter in straight binary is ~7FFF hex. The code in subsequent conversions might be plus or minus 4 counts for the same input voltage. This is the converter transition noise for the ADC used. Of course, this does not account for other sources of noise that might contribute to the code deviation.

A practical example using the method described above can be applied to the WinSystems PCM-ADIO advanced analog I/O card. The card is based on the LT1609 16bit successive approximation analog to digital converter from Linear Technology. The data sheet specification defines the converter transition noise as ~0.9 LSB RMS. Using the standard conversion factor of 6.6 to convert from RMS to peak deviation yields ~+/-3 LSB noise figure. The PCM-ADIO is programmed to convert one channel in +/-10 volt bipolar mode with the input grounded. The output data is recorded for 4096 samples and a histogram is plotted from the resulting output codes to demonstrate the transition noise performance.



Converter transition noise for the PCM-ADIO correlates very closely to the datasheet specification of 0.9LSB RMS. Similar results can be obtained with just a few conversions, but keep in mind that this is noise. The distribution is Gaussian and will appear less random as the sample quantity increases. Simple averaging techniques can also be utilized to realize the full potential of the converter with the smallest number of conversions. The reduction in noise is the square root of the number of samples averaged. If 14bit DC resolution is adequate for a given application, a single conversion in this case is all that is required.

Converter transition noise exists in all converters and dictates the DC noise performance of any analog to digital converter at the most basic level. Understanding converter transition noise is necessary to achieve the highest performance from modern precision analog to digital converters.

More information is available at www.winsystems.com, or, contact the WinSystems Application Engineering department at (817) 274-7553