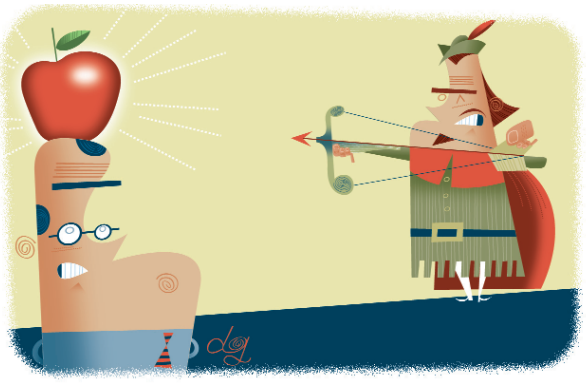
R A Q ' s

Rarely Asked Questions

Strange but true stories from the call logs of Analog Devices

Just How Accurate was William Tell, Anyway?

Q. *How accurate is an ADC?*



A. Modern ADCs are extremely precise, but their absolute accuracy does not always match their precision. If young Walter had happened to have a 10 cm apple on his head, William Tell could have afforded less than 5 cm of error. At a range of 50 m (and it was probably no more—in Bürglen today there is no central open space more than 50 m across)[1], this represents an error of one part in 1000, approximately 10-bit accuracy. A 16-bit ADC has a resolution of 1 part in 2^{16} (=1 part in 65536 or 15 parts per million [ppm]), and it is not uncommon for such ADCs to have linearity approaching 1 least significant bit [LSB]. This means that the transfer characteristic deviates from a straight line by less than 1/65536 of full-scale.

For most applications this linearity is far more important than absolute accuracy, but there are cases (ask William) where the absolute accuracy matters.

No presently available 16-bit ADC has an absolute accuracy of 15 ppm relative to full-scale. The best 16-bit ADCs have gain errors of several LSBs. So even with a perfect reference their initial absolute accuracy is, at best, about 14-bits or so. Of course we can calibrate them to well over 16-bits and even provide temperature compensation, but off the shelf they are probably closer to 14-bits.

This does not consider the voltage reference. Because most applications require linearity but not absolute precision, the voltage reference on the chip of many ADCs is about 10-bits accurate, and some are less. This is because a high-precision reference is quite large, would make the converter more expensive, and is not needed by most users.

Separate references are better, but still nowhere near 16-bits. The best available has an initial accuracy of 1 mV in 10 V, about 13-bits. Most high-performance references are of the order of 11- to 12-bit accurate. Even with calibration it is hard to achieve 16-bits, and it is very difficult to maintain it over temperature.

In most ADC applications relative accuracy and linearity are important, but absolute precision is not. Where higher absolute accuracy is necessary it is important to design a system that can be calibrated, and temperature compensated to the level required, and to understand the fundamental limitations of converters and references from any manufacturer. Remember that whatever its resolution the absolute accuracy of an ADC with an internal voltage reference is rarely more than 10-bits before calibration—much the same as old Bill achieved.

Footnote:

[1] http://uk.myswitzerland.com/en/swisscams/cam_detail.cfm?webcam_id=1016239307&rkey=2155

To learn more about ADC accuracy, Go to: http://rbi.ims.ca/5696-117

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Have a question involving a perplexing or unusual analog problem? Submit your question to:

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