TIPS from TITUS

Unbelievably useful info on data measurement, collection and analysis from the test expert

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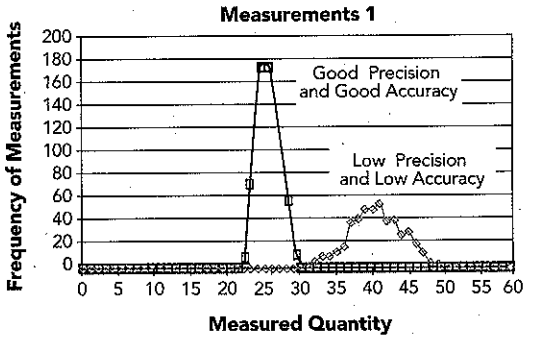
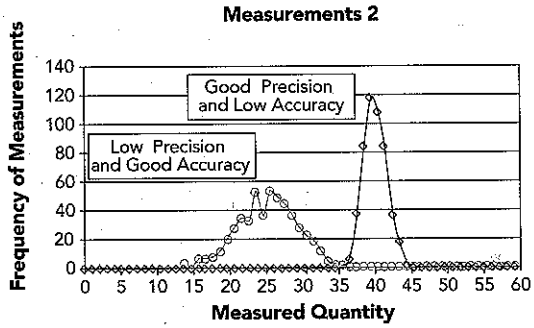
Jon Titus, a former designer and chief editor of EDN *and* Test & Measurement World *magazines, remembers when "fast" signals operated at 10 MHz and programs came on paper tape.*

Accuracy, Resolution, Precision

AS YOU DEVELOP AN ERROR BUDGET FOR A CIRCUIT or data-acquisition system, you also must think about the accuracy and resolution of the measuring device. Unfortunately, some people confuse accuracy and resolution or think they mean the same thing.

I use a Fowler digital caliper in my workshop and its digital display indicates measurements with a resolution of five ten-thousandths of an inch or one hundredth of a millimeter. But this display resolution can lull you into a false sense of accuracy. The caliper data sheet notes an accuracy of ±0.001 inch or ±0.02 mm. So, the number of displayed digits doesn't reflect the accuracy of the instrument. In other words, a display of 0.500 inches most likely indicates a dimension between 0.501 and 0.499 inches. Think of accuracy as the "correctness" of measurements.





These graphs show the relationships between accuracy and precision for a measured quantity of "25."

In short, resolution describes how small a measurement an instrument can make. Accuracy defines how well the instrument makes those measurements. Suppose I use a 3½-digit DMM with an accuracy of ±1 mV (±1 count) to measure a known 0.1667-V signal. In this case, the meter probably displays 0.167, so the voltage could range from 0.166 to 0.168 mV. The measurement is not accurate because the DMM doesn't offer enough resolution. If you want a better measurement use a 4½-digit DMM with an accuracy of ±100 µV (±1 count) to provide a reading of 0.1666 to 0.1668V. If that measurement doesn't come close enough, you could use a 5½-digit DMM with an accuracy of ±10 µV (±1 count). But, if you have a 5½-digit DMM that no one has calibrated in years, you will still see a 5½-digit resolution, but probably not an accuracy of ±10 µV. Always check manufacturers' data for instrument-accuracy information.

When you build a measurement circuit from scratch or assemble one from modules you must budget for errors that can occur within an analog-to-digital converter and its front-end components such as amplifiers and multiplexers. You can have more resolution than accuracy, but not more accuracy than resolution.

Although accuracy and resolution dominate conversations about electrical measurements, engineers should also know about precision, which determines whether they can make reliable and repeatable measurements. As shown in the diagrams, you can have precision and accuracy independently, but you should aim to have them simultaneously.

For More information

REFERENCES

1. Taylor, John R., "An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements," University Science Books, 1996.
http://dn.hotims.com/27755-508
2. "Accuracy versus Resolution," AN114, Dataforth.
http://dn.hotims.com/27755-509