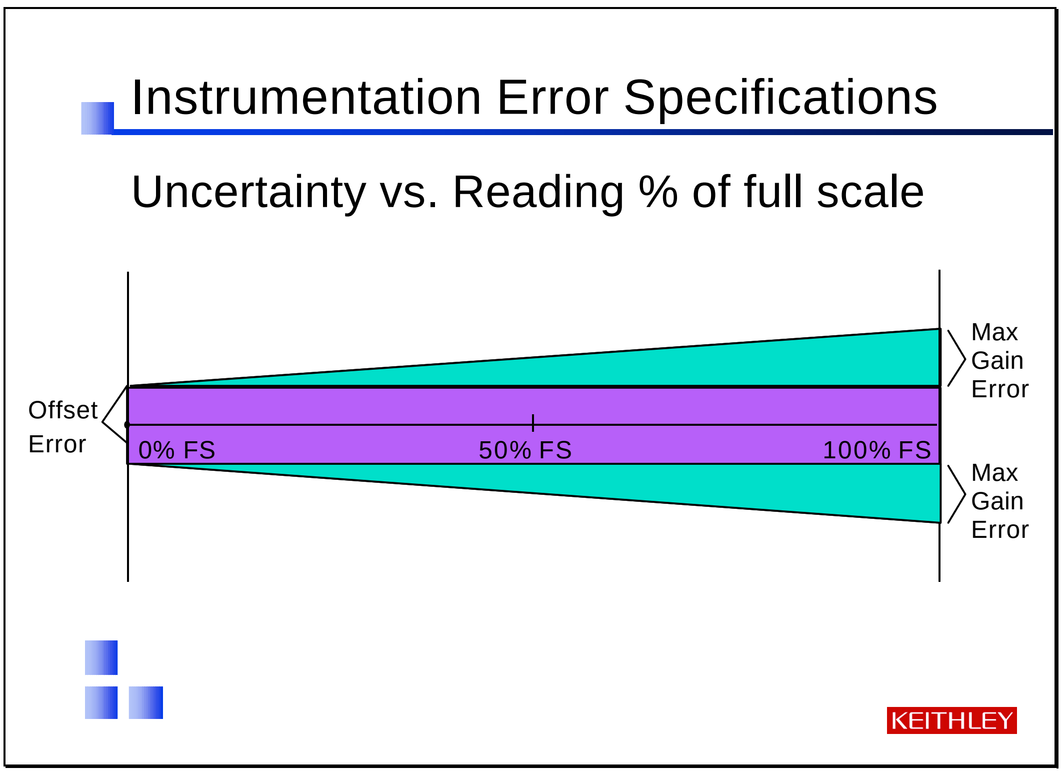
KEITHLEY

Applying an Instrument's Accuracy Specification

An accuracy specification represents the degree of uncertainty inherent in a measurement made by a specific instrument, under a specific set of environmental or other qualifying conditions. Generally, the accuracy specification is understood to be a level of performance that can be achieved by any sample of the product line.

A typical expression of accuracy is ±(gain error + offset error). However, manufacturers can use different formats to express accuracy, so it can be difficult to compare instruments. Gain and offset errors are sometimes bundled into a specification that expresses accuracy purely in terms of A/D counts or parts per million.

The graph below shows the relationship of the gain and offset error components over a measurement range. When the instrument is operated in the lower part of a selected range, the offset error is the dominant term. When operated near the full-scale value for a selected range, the gain error becomes significant.



Instrument specifications can be stated in a variety of ways: parts per million (ppm), percent or counts. *(ppm is used instead of percent when the magnitude of the numbers are small; 10,000 ppm = 1%)*

Below are some calculation exercises in ppm, percent and counts formats:

To calculate uncertainty when specifications are given in ppm:

Uncertainty = [(ppm of reading * applied value) + (ppm of range * range used)] / 1,000,000

Example

DC	Range	Accuracy ± (ppm of reading + ppm of range)
Voltage	100.00mV	30 + 35
Meter	1.00V	30 + 7

Uncertainty of 0.5V on the 1V range = [(30 * 0.5V) + (7 * 1V)] / 1,000,000 = ± 22uV

To calculate uncertainty when specifications are given in percentage:

Uncertainty = [(% of reading * applied value) + (% of range * range used)]

Example

DC	Range	Accuracy ± (% of reading + amps)
Current	1.00uA	0.035% + 600pA
Source	10.00uA	0.033% + 2nA

Uncertainty of 3.5uA on 10uA range = [(.00033 * 3.5uA) + 2nA] = ± 3.16nA = ± 0.09%

To calculate uncertainty when specifications are given in counts:

Unless specified, 1 count = 1 unit of the resolution on the range used

Uncertainty = (counts of reading + counts of range)

Example

Resistance	Resolution	Range	Accuracy ± (% of reading + counts)
Meter	100mOhms	2kOhms	0.04% + 2
(4.5 digits)	1 Ohm	20kOhms	0.05% + 2

Uncertainty of 1.75kOhm on 2kOhm range = [(0.0004 * 1.75kOhm) + (2 * 100mOhms) = ± 900mOhms

The accuracy specification provided in a data sheet usually reflects only measurement uncertainty attributable to the hardware. The hardware will always be affected by variations in the manufacturing of electronics components and subassemblies. Amplifiers, resistors, and A/D converters are the main contributors to these variations. The specifications also include a time span from the last calibration over which the specification applies such as 24-hour, 90-day, etc.

A possible source of an out-of-spec reading is that the hardware is defective, but has not failed outright. The adoption of calibration cycles for test and measurement instruments will help eliminate this possibility; experienced calibration technicians can recognize the need for abnormal adjustment to bring an instrument back into calibration.

However, external sources of error can also enter into measurements, including such sources as power line (50/60 Hz) noise, lead resistance, magnetic interference, ground loops, thermoelectric EMFs, and RF. These sources of errors are not included in accuracy specifications, so test procedures need to incorporate safeguards against them.