Technical Article

The benefits of extreme precision from buried Zener technology in calibration

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Precision test equipment relies on precise data converters to make sure that any measurements taken accurately represent the device under test. For test and measurement, any offset error, gain error or decrease in the effective number of bits will negatively affect the measurements generated. Unfortunately, however, it's not possible to design all of these errors out of a high-precision system. Things like temperature drift or long-term drift will eventually present themselves in the form of a gain or offset error. For this reason, calibration must occur, in order to make sure that any measurements taken are accurate.

For calibration to be effective, there must be unchanging voltage levels available. Colloquially, you might call this a "golden reference." As the analog-to-digital converter (ADC) or digital-to-analog converter (DAC) measures these known voltage levels, it can compare the results and use any differences to determine the gain and offset error. Figure 1 illustrates an example configuration of this circuit.

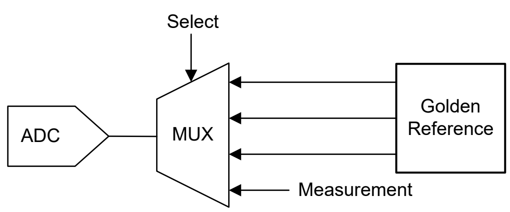

Figure 1. Example circuit configuration for ADC calibration

After quantifying the gain and offset error, software can compensate for the difference. This method of calibration is essential to maintaining accurate measurements for test applications, and it is totally reliant on the golden reference, which gets as close to unchanging as possible. Of course, no circuit is completely unchanging, so even a highly precise voltage reference does exhibit small amounts of drift with time.

Buried Zener diode voltage references and their importance in calibration

A golden reference that shifts with time affects the entire system's accuracy. Parameters of a golden reference that affect system accuracy include long-term drift, temperature drift and noise.

Selecting a voltage reference that minimizes the errors caused by the parameters listed in Table 1 leads to the selection of a buried Zener voltage reference that has an internal heater. Buried Zener voltage references provide a voltage level that drifts minimally with time and temperature and has ultra-low noise. An example of such a device is the REF80 from TI. Table 1 also includes some REF80 performance specifications.

Table 1. Voltage reference parameters and REF80 specifications

Voltage reference parameter	Specification
Long-term drift	10ppm (0 to 336 hours) 0.9ppm (336 to 1,000 hours)
Temperature drift	0.05ppm/°C typical 0.2ppm/°C maximum
0.1Hz to 10Hz noise	$0.16ppm_{p-p}$

0.1Hz to 10Hz noise and temperature drift affect the output of the voltage reference, therefore leading to calibration errors. The most important specification to consider for calibration is long-term drift, however, because that is the parameter that directly affects how often you need to calibrate the entire system.

Increasing time between system calibration in semiconductor test equipment

When calibrating ADCs and DACs throughout test and measurement equipment, a buried Zener voltage reference helps determine how the ADC and DAC output values have shifted. And although buried Zener voltage references shift very little with time, in high-precision test equipment you must still account for even small variations in the output voltage. Many test and measurement systems require calibrating the golden reference after a number of months to ensure that system calibration dependent on the golden reference remains accurate. Figure 2 shows the long-term drift of the REF80.

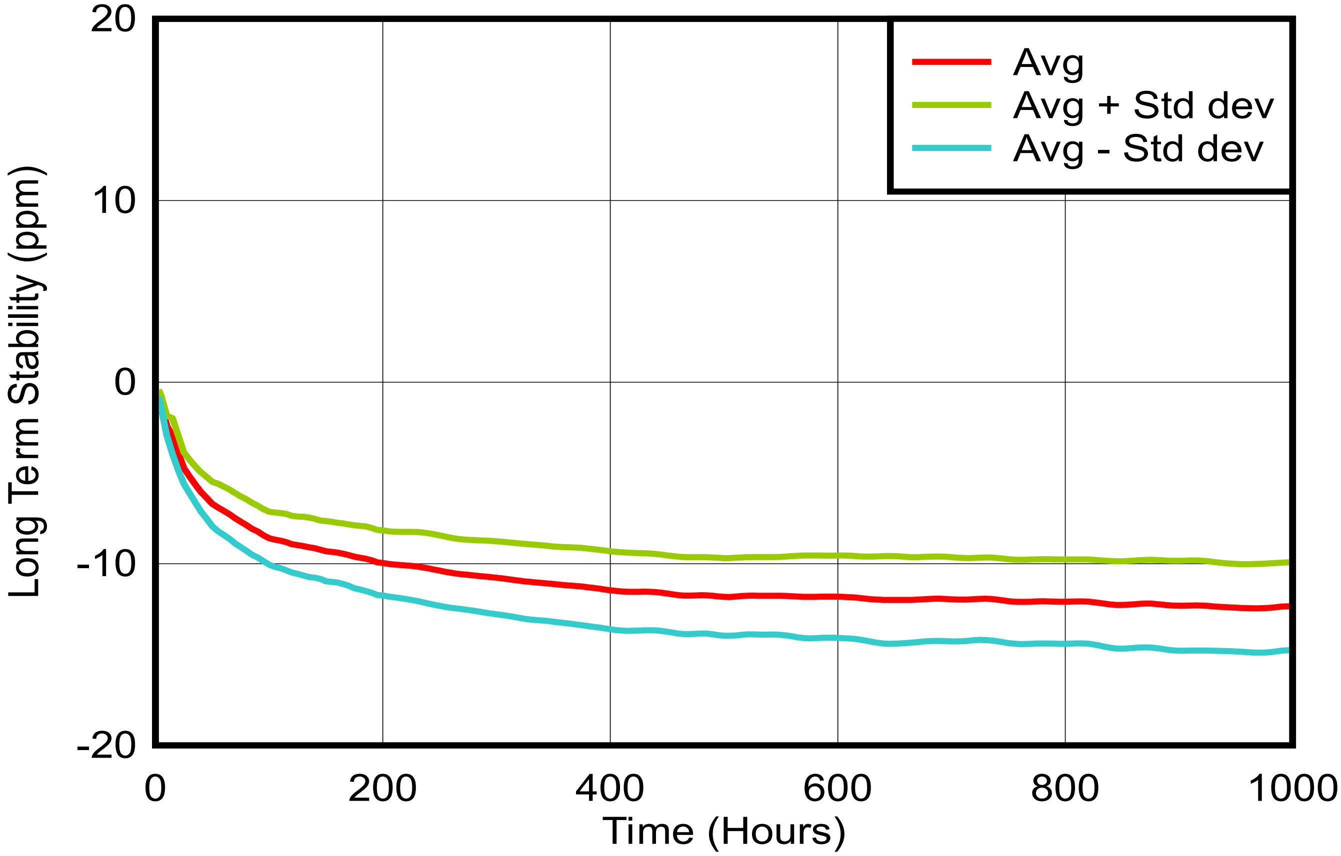

Figure 2. REF80 output voltage long-term drift

There are a few important aspects of Figure 2 that demonstrates why the REF80 is a good fit for the calibration of highly precise test and measurement systems. First, most of the output voltage drift happens in the first 336 hours, or 14 days, of device operation. This is important, because the quicker the output voltage drift settles, the less there is a need for calibration because the output voltage does not drift nearly as much. In other words, the decrease in long-term drift also decreases the number of calibrations needed. For a parametric measurement unit in automated test equipment, this outcome is especially pertinent (see Figure 3).

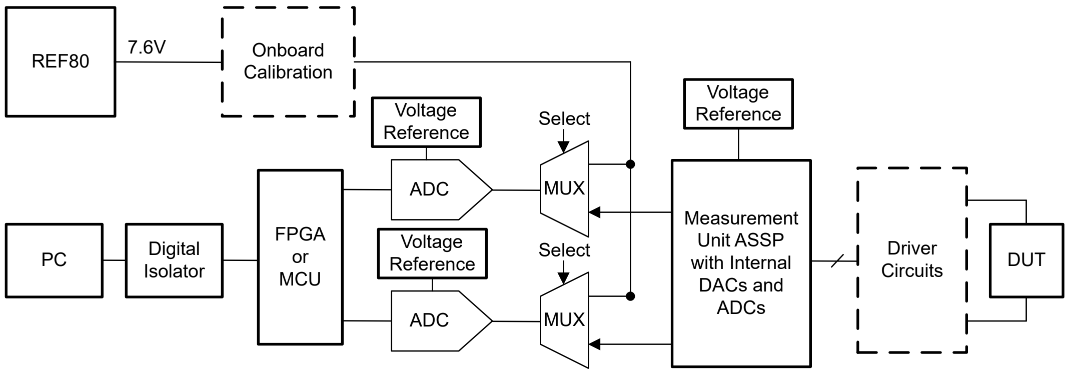

Figure 3. Block diagram of a parametric measurement unit in automated test equipment

Automated test equipment must be calibrated after a certain number of months to ensure that the golden reference output voltage drift has not affected the precision of the tester measurements. Each time calibration occurs, the entire system must go offline, which costs time and money. Using a buried Zener voltage reference such as the REF80 will decrease the time needed for and cost of calibration.

Conclusion

Using the REF80 with advanced calibration methods can allow precise test and measurement applications to maintain accurate for as long as possible. Without precision the likes of what REF80 can produce, test and measurement would fail to provide the necessary results to keep advanced electronics on the path of progression. As we strive to do our best to usher in a new era of precision, devices like the REF80 can lead the way.

Additional resources

- Download the REF80 evaluation module.

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