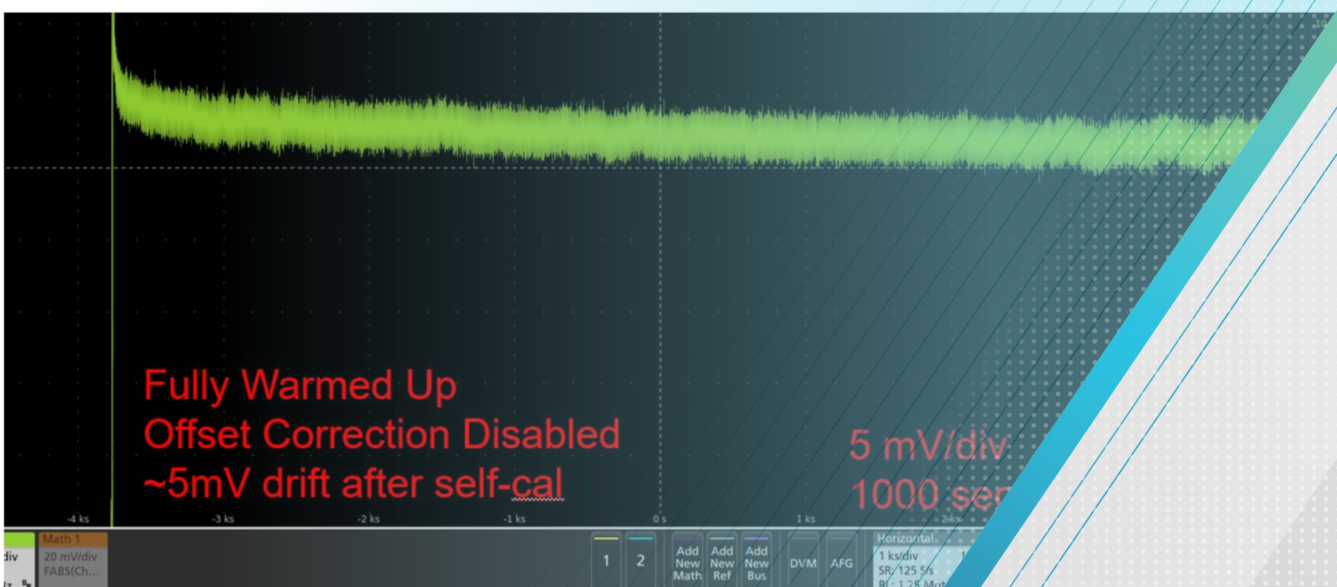
Making Accurate Measurements with IsoVu® TIVH Isolated Measurement Systems

TECHNICAL BRIEF



Tektronix®

Introduction

The Tektronix IsoVu Isolated Measurement System represents a paradigm shift in high bandwidth, high voltage applications. With its extremely high common mode voltage rating and unbeatable common mode rejection, IsoVu customers see more of their real signal to make better designs.

To accomplish these impressive specifications, IsoVu designers used what they knew about optical electronics and fiber optic communication to innovate and adapt, creating the best high voltage measurement system in the world.

While the IsoVu Isolated Measurement System makes great use of the advantages of optical technologies such as high bandwidth, galvanic isolation, and extreme common mode voltage rating, it also inherits the idiosyncrasies and foibles of fiber-optic technologies. Don't worry—fiber optic communication companies have been documenting and designing around many of these problems for years, and Tektronix IsoVu designers were able to leverage that mature industry to create an easy to use system. Most accommodations are already implemented in the IsoVu's firmware with only a few characteristics of which any user of IsoVu should be aware.

This technical brief describes the remaining performance non-idealities and provides strategies for working around them.

DC Drift

To achieve complete galvanic isolation between the sensor head and the oscilloscope, the electrical signal from the device under test (DUT) must be converted to optical modulation before being sent to the controller box and recovered back to electrical. This process is slightly secretive (i.e., patents are public but trade secrets are not disclosed) but suffice to say that as the probe warms up, the DC reference voltage will shift over time, adding a fake DC offset to the waveform.

Anticipating this effect, TIVH engineers added an automatic temperature compensation algorithm and a manual "SELF-CAL" feature to force the probe to reconfigure internal bias voltages and reset its DC offset. The temperature compensation is enabled by default and has three different modes: Normal, Disabled, and Enhanced.

NOTE: Enhanced Offset Correction was added in late 2018 in TIVH Firmware Version 2.02. TIVH firmware can be updated at tek.com. In almost all cases, Tektronix recommends using the new, Enhanced Offset Correction mode.

To change Offset Correction mode, hold MENU and press CLAMPING on the TIVH controller box. The Overrange LED will blink to indicate the current Offset Correction Mode.

Overrange LED Blink Count	Offset Correction Mode
One	Normal
Two	Disabled
Three	Enhanced

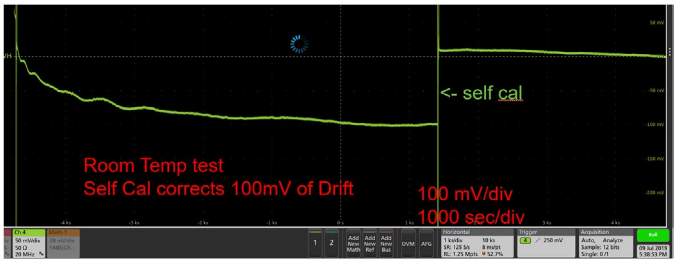
To force the TIVH to run its offset compensation algorithm, remove any input signal and press the SELF-CAL button on the controller box. After a few seconds of blinking, the SELF-CAL Status LED should illuminate green.

The final strategy for accommodating the DC drift is to simply plug in the probe and wait for it to completely warm-up before running tests. This process does take over 90 minutes in our testing from 20 ˚C but removes 95% of drift.

DC Drift – Data

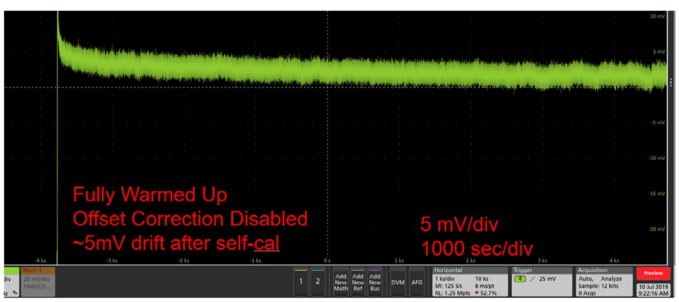
In Tektronix lab experiments TIVH drift was quantified with these values:

Offset Correction Disabled (control):
100 mV drift over 1.5 hours
Drift corrected to 5 mV after SELF-CAL



Enhanced Offset Correction:
10 mV drift over 1.5 hours

Completely Warmed Up:
5 mV drift over 1.5 hours

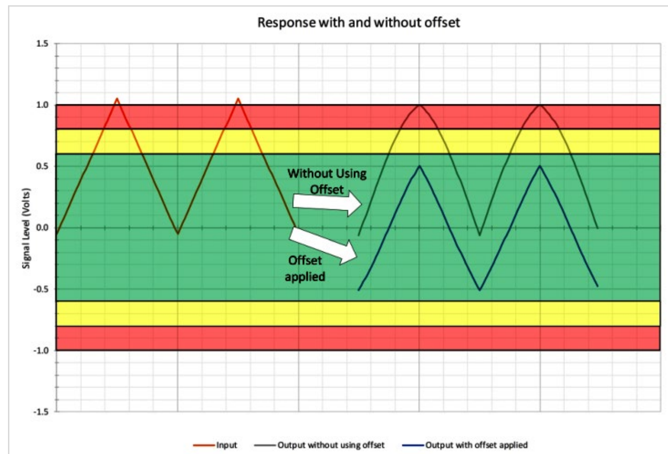


NOTE: All numbers in this post are "input referred" meaning they were taken without any tip attached. The tip attenuation and Range setting will multiply the error. For example, 100 mV of drift will show as 5 V of drift with a 50X tip attached in 1X range setting.

Non-Linearity

Like most amplifier designs, the conversion from input electrical signal and output optical signal is not completely linear over its full range. For example, an amplifier might "clip" the output if the amplified signal exceeds the PSU rail voltage. Similarly, the electro-optic conversion in IsoVu TIVH can exhibit non-linearity at the edges of its dynamic range.

The effects of non-linearity can be viewed in this exaggerated figure from the TIVH User Manual:



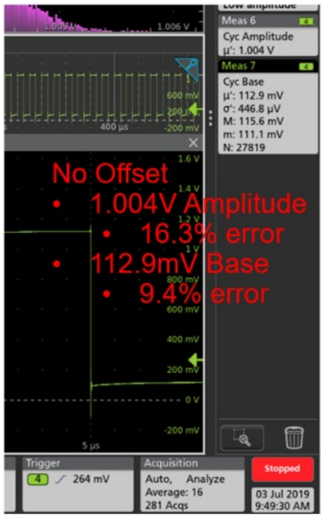
The green, yellow, and red areas correspond to ±60% range, ±80% range, and ±100% range, respectively. TIVH DC Gain accuracy is most accurate within the green range with a ±3% specification and falls to –7% at the extreme 100% edge.

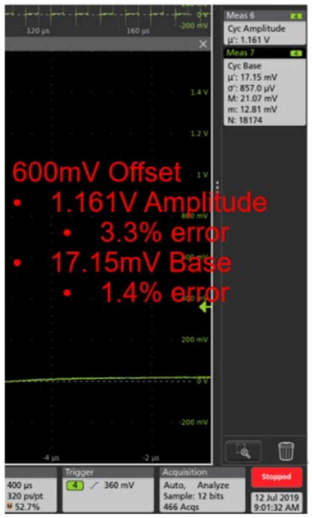
This effect can look like "compression" of the input signal where the on-screen peaks are lower amplitude than in reality. For measurements where the amplitude of the peak is of critical importance, take care to keep the input signal within ±60% of the TIVH's input range.

Additionally, using offset is critical to making accurate amplitude measurements. Use input offset to center the probe's dynamic range around your signal of interest. For example, when examining a 0 V–400 V transition (for example, on a Vds measurement) add 200 V of offset and use a tip that keeps the ±200 V signal within 60% of the input range of that tip.

Non-Linearity – Data

In testing, amplitude error was reduced from 16.3% error to 3.3% error by adding offset.

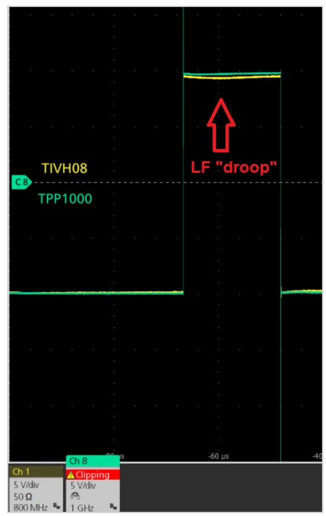




LF Inaccuracy ("Droop" or "Dribble Up")

One other phenomenon that might be observed with "low" frequencies (sub 10 kHz) is a "dribble up" or "droop" effect. This is a result of poor compensation of the tip and can be resolved by replacing the worn out tip or sending it back to Tektronix for adjustment. The frequency response of each tip is tuned at the factory, but, because the tips are considered to be consumable items, they will not last multiple years.

To test the LF tip compensation, put a 10 kHz square wave into the TIVH and observe the flat portions of the input. With poor LF compensation, the rising/falling edges will look accurate, but the flat portions of the input signal will show a "droop" or "dribble up" over a period of –140 μs.



Conclusion

To summarize, most TIVH tricks involve using Self-Cal, Offset Correction, proper tip selection, and most importantly Offset to get the most accurate results.

Most of the tricks and fixes of fiber optic technology have been incorporated into the TIVH firmware but other effects can be visible without proper care. The IsoVu TIVH Isolated Measurement System is not as intuitive as a passive probe, but the improved measurement results on high frequency, fast transient signals with huge common mode interference are worth it for thousands of happy customers.

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