Prognostics & health monitoring Built in self test and ready to run diagnostics

VTI Instruments – Nathan Henderson

29 NOVEMBER 2018
TECHNIEKHUYS
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TOMORROW'S RELIABILITY

Who are VTI Instruments?

- VTI Instruments has a 30 year history of providing scalable, synchronized complete test solutions to manufacturers globally where accuracy of test is critical.
- In the early 1990's we started out as a custom design house, and from this came standard products.
- In 2003 VTI purchased Agilent's mechanical test business unit
- In 2014 AMETEK acquired VTI and in 2016 VTI became part of AMETEK's Programable Power Division
- We are represented here in the Netherlands by our distributor C.N. Rood

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AMETEK® PROGRAMMABLE POWER

Agenda

- In this presentation we will look at factors that lead to lack of measurement confidence.
- What instrumentation smart features are available to improve confidence in test and measurement systems.
- Understand how and where this technology is applied.
- We will also look at cost and time implications of such smart features
- Then explore how modern techniques and technology have made this possible.

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Testing is needed to improve product reliability and reduce potential failures.

Single shot or high cost tests require that testing instrumentation capture data without loss and with the highest accuracy. Re-testing due to instrumentation failure or bad data is not possible or highly cost prohibitive. These types of tests include:

- Large Scale Static Structural Test
- Crash Testing
- Engine firing (Rocket or Turbofan)
- Pyro or separation testing

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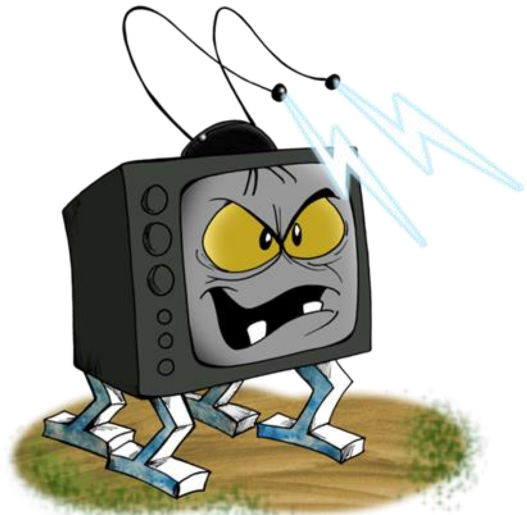
What gives the impression of measurment confidence ?

How many of us have at some point in the past wasted hours trying to understand the results from a test only to find the measurement equipment was not giving correct results?

At the time what gave you confidence that the data was going to accurate and that the measurement instrument was operational?

- A valid calibration certificate
- The power light is on, the screen works
- The brand name is a well-known one
- There's no smoke



What improves measurement confidence?

Two primary tools are available to improve measurement accuracy and measurement confidence.

- Built In Self Test (BIST)
- Self Calibration

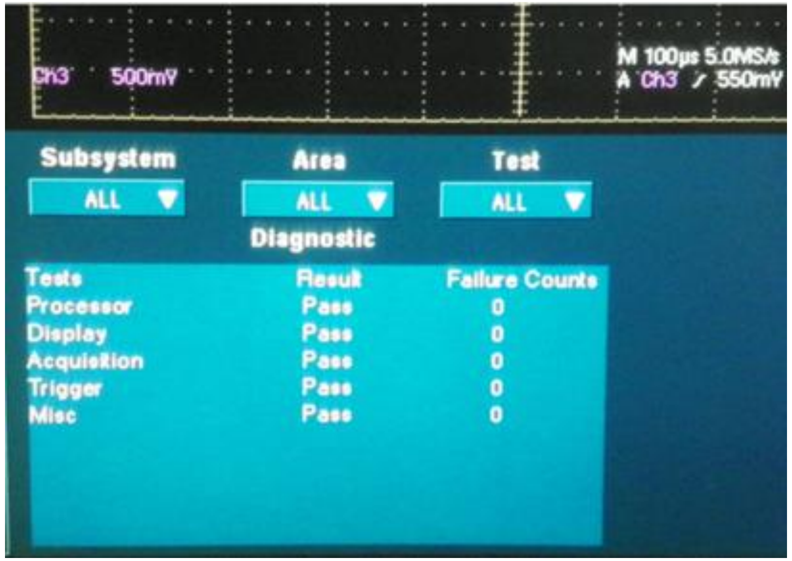
Any test and measurement system incorporating these functions stands a far higher chance of providing data that is reliable, first time, every time.

What is BIST?

- BIST gives the instrument the capability to test itself. This is done with no external requirements other than power.
- Usually run at instrument start up and often called Power On self Test (POST) but can be initiated on command or run continuously in the background.
- Usually run just prior to a critical test
- Can be a go/no go type of test or can provide feedback to allow the operator to determine if proceeding is prudent

What’s tested during BIST?

- Typical parameters measured during BIST for Data Acquisition include:
  - Power status or internal power supplies
  - Internal instrument temperature
  - Fan on/off or Fan Speed
  - Communication status
  - Critical component or sub-assembly status
  - Sensor status (open/short)

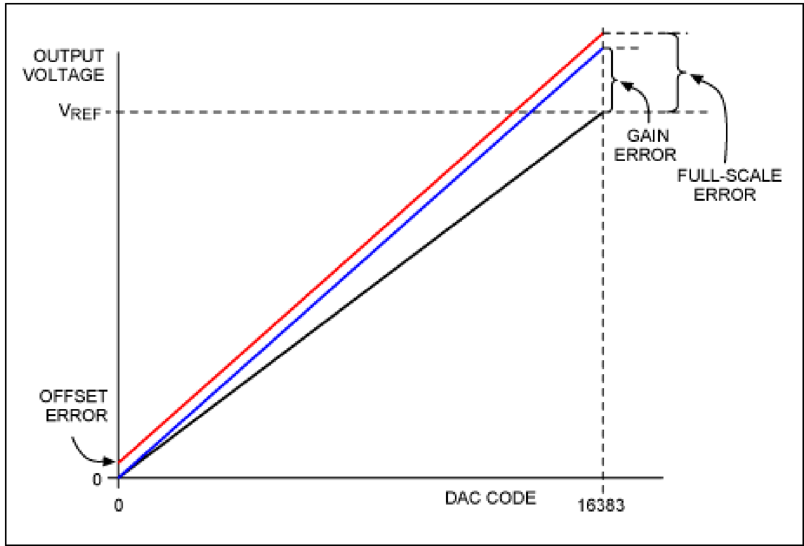


Designing in BIST for Test and Measurement

- FPGA's, Microcontrollers and Processors with embedded OS's are becoming the standard in Test and Measurement equipment.
- Creating a firmware that can self check the instrument is a logical next step, along with a small amount of additional hardware.
- Even the FPGA's, Microcontrollers, and Processors are being designed and built with their own BIST.
- While there is an additional cost and size associated with designing in BIST, the cost is insignificant when compared to having to purchase external hardware and manually test an instrument.

Self Calibration

- The instruments uses internal circuitry to adjust or maximize its accuracy relative to an internal standard
- Self-calibration can be done at instrument start up or upon command
- Of primary value when the instrument is in an environment that is in an unstable temperature location
  - Cool in the morning, warmer in the afternoon. Changes in temperature effect the gain and offset of an instruments measurement path and can be corrected with Self-Calibration
- Usually a quick process but inconvenient to run during a test
- Only corrects for the gain and offset at that moment in time. Further changes in temperature would require another Self-Calibration



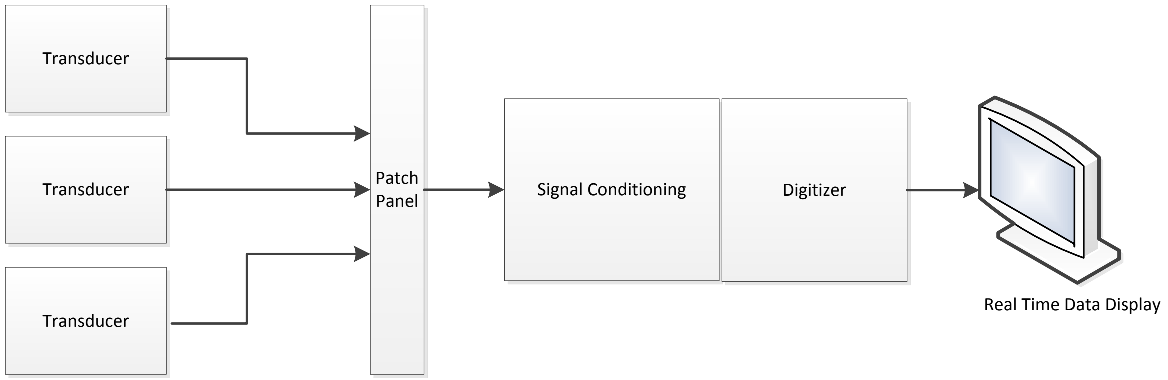
Self Calibration is not Factory Calibration

- With self calibration we use an internal precision voltage source to reference the Signal conditioning and ADC's
- This applied self calibration is simply an adjustment of the factory calibration data stored in the device.
- Self Calibration is generally stored in volatile memory, meaning that when the device is power cycled or reset the self calibration data is lost and the standard factory calibration constraints are loaded.
- Self Calibration does not require the disconnecting of external transducers.
- Factory calibration generally measures and adjusts the internal precision source used during self calibration.
- The internal source can be anything from a precision voltage or frequency to a capacitance or resistance.

Looking deeper into the measurement system

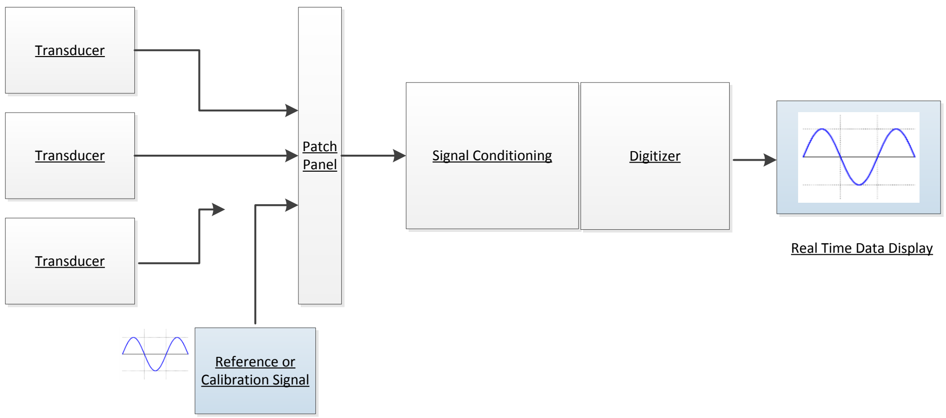
A typical measurement chain is composed of a number of components:

- Transducers are used to measure and transform physical phenomena into signals we can measure
- Patch panels are used to help us organize and easily “patch” or connect into the measurement chain
- Signal conditioning is required to condition or convert the output of our transducers into voltages
- Digitizers then convert the voltages into parameters that we can display, record, and understand



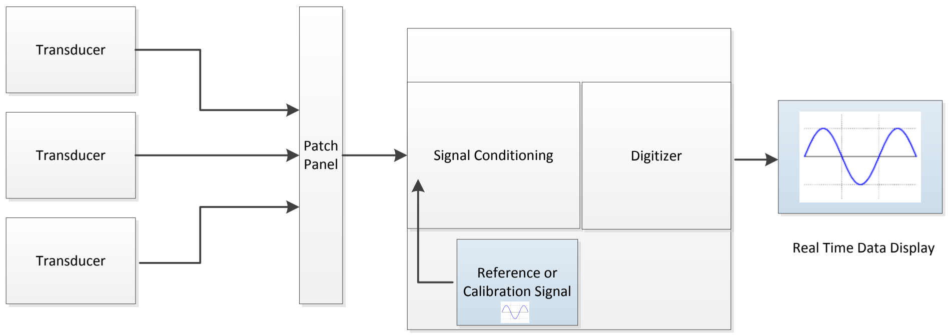
End to End calibration

- Still commonly used for critical testing situations
- Users patch in a known source at the front of the measurement chain and verify the output on the Data Measurement System
- Provides a reliable method of validating the signal path from the point of being patched all the way thought the system
    - Relies on the user inserting the correct signal
    - Patching can be problematic if not done correctly
- Digitizers then convert the voltages into parameters that we can display and understand



Built-in Self calibration

- This approaches requires that the signal conditioning and digitizer occupy the same instrument
- The system uses an internal or "Secondary calibration reference" and an internal calibration bus
- Provides a number of advantages over a manual "end to end" calibration
  - Quick, and can easily be executed by a software command
  - Eliminates cable patching errors by not requiring the user to patch into the signal path
  - Capable of calibrating all gain, filter, and input stages in the event
- Digitizers then convert the voltages into parameters that can be processed by the calibration routine and applied on top of the factory calibration.



Self Calibration

- If for example our instrument is a temperature measuring device designed for Thermocouples. Two internal measurements are needed, one is the internal temperature of the signal conditioning and ADC's, this is where gain and offset are most effected by temperature change. The other measurement is to check the output of the signal conditioning and ADC's against a known precision voltage reference.
- Keeping the precision voltage reference within the instrument enables the self calibration to be a completely contained operation with no external equipment needed.

Transducer Electronic Data Sheet (TEDS)

- It is also possible to go one stage further using another instrumentation standard called TEDS or IEEE 1451.
- TEDS allows the incorporation of a single wire EEPROM device into the transducer.
- The EEPROM can be located in one of three positions;
  - Within the transducer itself.
  - As a separate memory IC mounted next to the transducer.
  - At or in the transducer terminating connector.
- The location depends on a variety of requirements and environmental considerations. However the EEPROM is a simple TO92 small 3 pin IC.
- The important fact here is that the transducers calibration parameters are stored on this IC. This can be used to great effect when initialising BIST and Self Calibration.

Transducer Electronic Data Sheet (TEDS)

- Instrumentation designed for monitoring precise resistances such as strain gauges can take full advantage of TEDS in their calibration routine.
- Attaching a precision resistor to the instrument with a TEDS EEPROM reporting what the resistance is enables the instrument to check and adjust it's signal conditioning to match the data it's receiving.

Conclusion

- With BIST and Self-Calibration built into an instrument we are assured to achieve reliable data. This greatly reduces the risk of having to repeat an expensive test or fail to capture a one shot test.
- Incorporating BIST and self-calibration into an instrument does add additional cost and possibly increased size.
- The cost is insignificant however when compared to having to purchase external hardware and manually test an instrument, not to mention the time saved from completing a manual verification test of a test system.
- BIST and Self Calibration greatly reduce set-up time, as the instrument does not need external verification.
- Self-Calibration improves accuracy, especially in environments where temperature is changing.
- As you have seen, VTI Instruments offers these kind of features in our products

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