FLUKE®
Calibration

Measuring different types of sensors with the 1586A Super-DAQ

Application Note

The 1586A Super-DAQ is a flexible temperature scanner for the factory and the lab. In addition to accurately measuring temperature sensors, the 1586A can also be used for measuring other sensor types. This application note describes how the Fluke Calibration Custom Design Team used the 1586A to gather data from a variety of sensors (temperature, pressure, current, duty cycle) needed to design a custom calibration bath.

Design of a custom calibration bath

The Fluke Calibration Custom Design Team engineers and builds custom refrigerated fluid baths when a standard product will not meet a customer's application. Requested modifications vary in scope from temperature range to physical changes. Tight control of the bath's temperature stability and uniformity (sometimes in the sub-milli Kelvin range) is often required. Several physical properties are measured to ensure the custom bath will meet the requirements. These properties include refrigerator system pressure, system temperature, compressor current, and heater duty cycle.

Correlating sensor data relative to time

It is crucial in custom bath design to be able to compare measured parameters such as temperature, pressure, resistance, and voltage at specific points in time. The design team faced a real challenge in time-synchronizing sensor measurements since they were being acquired through a variety of devices such as thermocouples, PRTs, pressure, and voltage sensors. Some of the data could be recorded without a technician present and some could not. As a result, there were gaps in sensor data being collected, resulting in the loss of valuable information critical to the design engineers.

1586A Super-DAQ: data acquisition with one instrument

The 1586A Super-DAQ Precision Temperature Scanner was selected as the data acquisition system to solve this problem. The 1586A Super-DAQ can scan and record temperature, dc voltage, dc current, and resistance for up to 40 input channels with scan speeds as fast as 10 channels per second. Data collected by the 1586A is stored in one file with timestamps correlated to the recorded data.

Mx+B scaling feature of the 1586A

The 1586A includes an Mx+B scaling feature, which is a calculation that can be applied to a channel to scale a measurement value. This feature is useful in applications where an input measurement needs to be converted to a different unit or value to simulate an output.

The Mx+B feature takes a measured voltage or resistance and converts that value into a unit of measure defined by the user. This conversion works as long as the relationship is linear. As the name suggests, the Mx+B scaling is a linear conversion as shown in Equation 1. The *M*, otherwise known as the gain, is the slope in the equation for a line. The *B*, otherwise known as the offset, is the y-intercept of the equation for a line.

$$y=Mx+B$$

Equation 1. Mx+B scaling

Mx+B example: a resistive position sensor

The circuit for a theoretical resistive position sensor is shown in Figure 1. The sensor measures position over a range of 2 centimeters. For the test setup, a sensor reading of 12.5 kΩ is referenced as a position of 0 centimeters. The sensor responds as is shown in Figure 2. To convert this from the voltage output of the circuit to a position value, the conversion in Equation 2 is used. Using this conversion, the values for *M* and *B* are 0.012 cm/Ω and –150 cm respectively. These calculations are shown as part of Equation 2. In this equation *MR* signifies the slope times the resistance. Note that the "CM" units may be entered into the 1586A as part of this conversion.

$$POS = MR + B$$

$$M = \frac{rise}{run} = \frac{150cm - 0cm}{25000\ \Omega - 12500\ \Omega} = 0.012\frac{cm}{\Omega}$$

$$B = y(0) = y - Mx = POS - MR = 150cm - 0.012\ \frac{cm}{\Omega} 25000\ \Omega = -150cm$$

Equation 2. Mx+B calculations

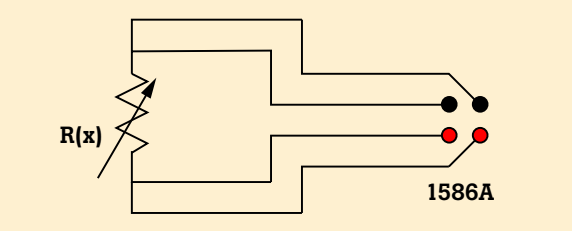

Figure 1. Theoretical example of a resistive position sensor

Measurement of pressure, current, and duty cycle parameters

The Fluke Calibration Custom Design Team used the 1586A Mx+B scaling feature to measure and record parameters such as pressure, current, and duty-cycle needed to design a new custom bath. The following sections summarize how the 1586A Super-DAQ was used to measure these parameters and the equipment configuration.

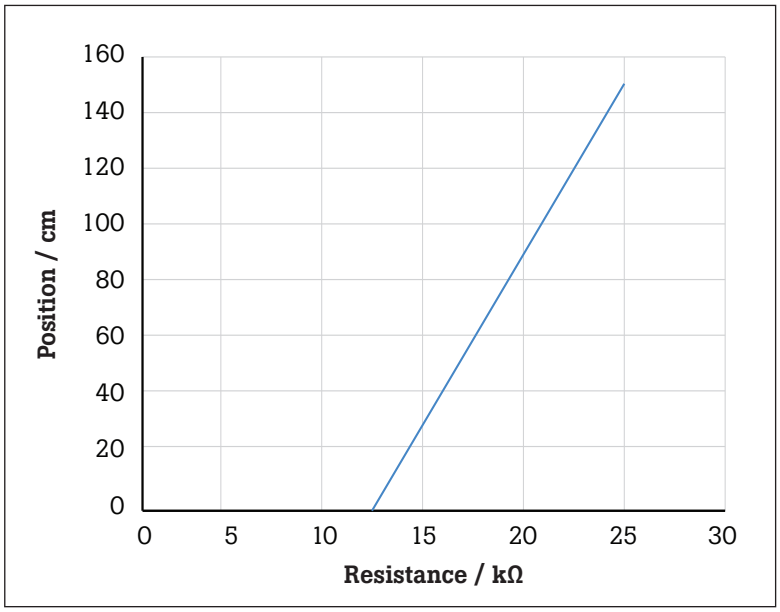

Figure 2. Position sensor response function

Pressure measurement

To monitor the performance of the custom bath's cooling system, several refrigeration pressure transducers were used. The pressure transducers have a supply voltage of 5 V dc, which is scaled relative to the measurement range of the transducer as is shown in Figure 3. The response of these transducers is linear. The response shown in Figure 3 is based on the transducer's data sheet. Following the same process described in the Resistive Position Sensor example, the calculated values for *M* and *B* are 37.5 psi/V and –18.75 psi respectively. The calculated pressure values and actual readings were accurate to within 2 psi. To further improve the accuracy of the measurement, a calibrated Fluke 700G07 Pressure Gauge Calibrator was used with a pressure manifold to further adjust the *M* and *B* values.

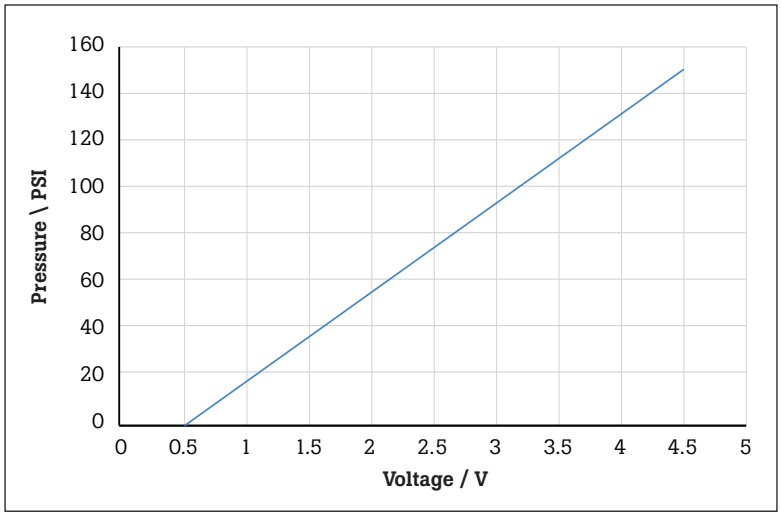

Figure 3. Refrigeration pressure sensor response

Current measurement

The custom bath compressor current is ac current. It was measured using a Fluke i200s ac Current Clamp. This clamp meter is a passive device that provides an ac voltage output. The clamp was set to 100 mV/A for this measurement. The 1586A measures dc voltage but not ac voltage. To make the conversion, a simple circuit based on a Linear Technology LTC1968 was used. This chip is a true RMS converter that converts the RMS ac voltage into a dc voltage of the same value. A block diagram of the circuit is shown in Figure 4. For the 1586A Mx+B scaling settings, gain was set to 10, offset was set to 0, and the units were Amperes (A).

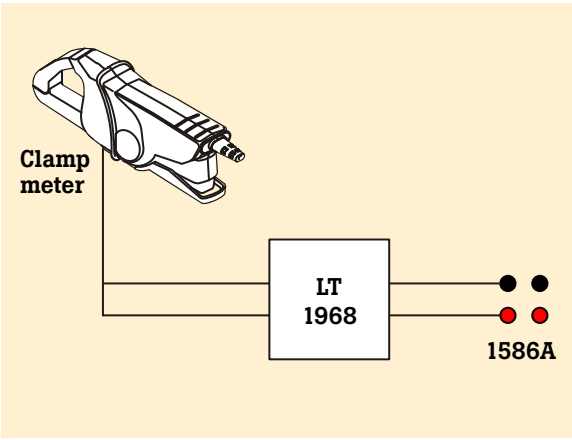

Figure 4. Current measurement with a Fluke i200s clamp meter

Note: The Fluke 2638A Hydra Series III measures ac voltage, but the 1586A Super-DAQ was selected because its temperature measurement accuracy is better, which was required for this application. Additionally, the 1586A meets the requirement of collecting all data into a single file.

Duty cycle measurement

The circuit board of the bath's temperature controller has an internal connector which is not user accessible. The voltage output of this connector is proportional to the heater duty cycle. A graph of this relationship is shown in Figure 5. This was implemented on the 1586A by using values for *M* and *B* of 10 and 50 respectively.

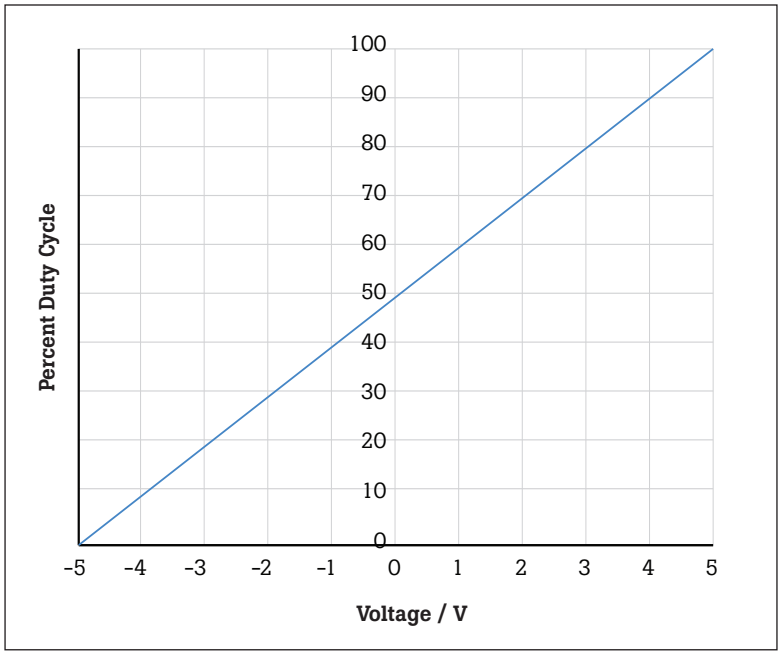

Figure 5.

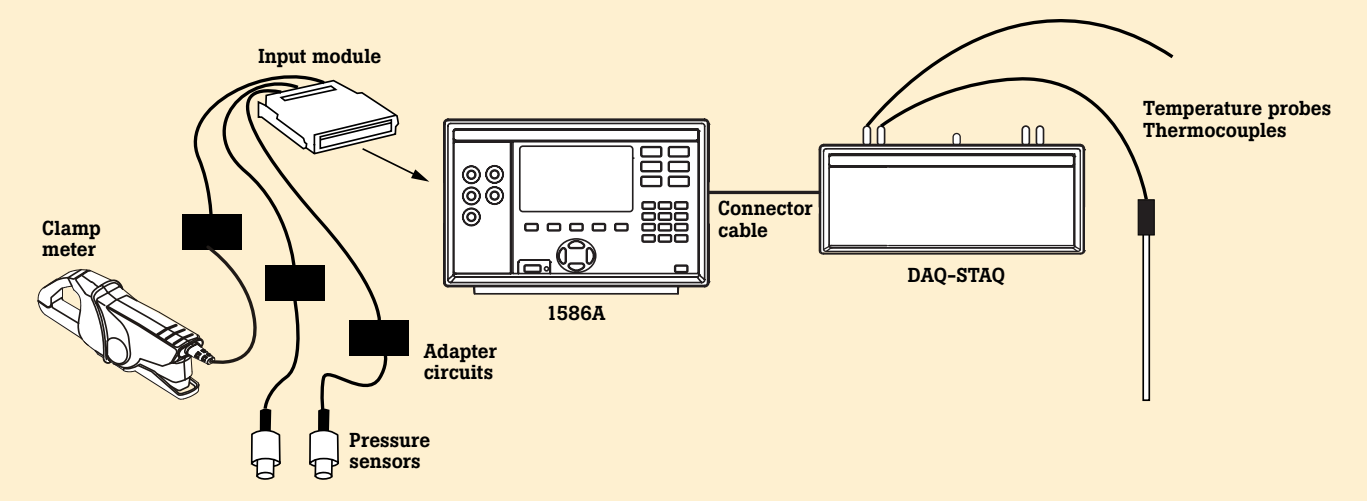

Figure 6. The 1586A measurement system used by the Fluke Calibration Custom Design Team.

1586A measurement system

The 1586A measurement system used by the custom design team is shown in Figure 6. In this configuration, the 1586-2586 High-Capacity Module was used to gather current and pressure measurements as well as heater duty cycle. Temperature measurements were made using a 1586-2588 DAQ-STAQ Multiplexer which makes connecting, disconnecting, and reconfiguring temperature sensors a simple task.

Summary

The 1586A Super-DAQ Precision Temperature Scanner is an accurate and flexible temperature data acquisition system for measuring PRTs, thermistors, and thermocouples. In addition, other sensor parameters may be measured provided there is a linear relationship between the parameter being measured and a voltage, resistance, or current output signal.

This application note described how the Fluke Calibration Custom Design Team used the 1586A Super-DAQ to efficiently measure and record various time-based parameters that increased engineering productivity and improved custom bath design. The 1586A Mx+B scaling feature was used to calculate these time-based parameters by scaling measured values from a various sensor types including pressure, current, and duty-cycle. Similar adaptations for measuring other parameters could be done for other applications.

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