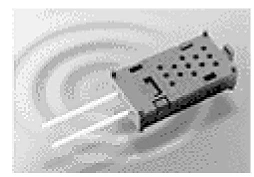
Ensuring RH Sensor Repeatability with Capacitance Testing

Secondary Relative Humidity (RH) sensors are almost universally used in OEM applications where RH sensing is required. Although an RH sensor might seem a simple device, its proper operation is highly dependent on careful humidity calibration. Unfortunately, few systems integrators are equipped (or inclined) to calibrate RH sensors on the production line where the sensor is added to the final product. The customer usually either bypasses the calibration step and risks a finished product that does not meet specifications or designs a dedicated system to test individual devices. These tests add time and cost to the finished product, making their complexity unsuitable for the production line. One solution is to purchase factory-calibrated RH sensors with such slight part-to-part variations as to require no calibration by the customer.

G-Cap Capacitive RH Sensors



A major manufacturer's G-Cap sensors have individual capacitance variations of only 1pF and part-to-part capacitance variations of 1%, which translates into a 3% variation in RH measurement. The typical industry values of 10%, by way of contrast, translate into an RH variance ~30%. The degree of interchangeability is such that if the electronics are designed properly, the sensor can be installed directly into the transmitter circuit without post-installation calibration. The sensors are essentially capacitors consisting of a film with a metalized layer deposited on both sides. Water molecules absorbed by the film change its dielectric constant, so the amount of water absorbed produces a corresponding change in capacitance that allows the sensor's use as an RH detector. While capacitance is the fundamental measurement parameter, the thickness of the metalized layer and its permeability are also crucial. Together these measurements produce a clear picture of device tolerances and hence the ultimate performance of the sensor.

The sensor film must have known and well characterized hydroscopic characteristics. After the coating process, the sensor die is subjected to a known RH environment. Its capacitance is measured by an IET 7600; the data is compared to desired values and used for trimming. The capacitors are separated, integrated into mechanical packages and placed in the final test chamber. The capacitance is measured at this stage to ensure that nothing has changed during packaging. A remote test fixture that interfaces with a second IET 7600 meter allows measurements to be made in a highly controlled environment. Measurement data is displayed on both the instrument and the computer monitor as well as logged to a PC for process control and later analysis. Refer to Figure 1. The tight control over capacitance allows systems integrators to eliminate the tedious task of humidity calibration.

IET LABS, INC.

www.ietlabs.com

TEL: (516) 334-5959 • (800) 899-8438 • FAX: (516) 334-5988

What's that look like?

Initial C measurement

Trimming RH sensor

Final test

Figure 1: G-Cap sensor test setup

Making sense of sensors

There are two types of RH sensors: fundamental (or primary) and secondary. Primary RH sensors perform direct measurements on some physical phenomenon or property. They are based on well-defined thermodynamic principles such as water vapor condensation as a function of air temperature and atmospheric pressure. They are highly accurate and easy to understand, but also expensive. Continuously controlled chilled mirror sensors, aspirated psychrometers, electrolytic sensors and gravimetric instruments are examples of fundamental sensors.

A secondary sensor measures the change that takes place in its own characteristics as a result of exposure to a phenomenon or property. Although easy to use and less expensive, secondary RH sensors require the person designing them into a system to know both how they work and the basic principles of humidity. For accurate performance, they must be calibrated. This type of sensor can respond to either relative humidity (RH) or absolute humidity (AH) by detecting:

- A change in the length of a material (the operating principle of extension hygrometers)
- A change in weight (the principle of absorption hygrometers)
- A change in either impedance or capacitance (true of most electronic hygrometers)

Verifying capacitance with the 7600

The 7600 Precision LCR Meter shown in Figure 1 and Figure 2 can measure and display any 2 of 14 impedance parameters simultaneously. Up to six different tests, each with its own conditions and limits can be run in sequence with a single push of the start button.

Figure 2: 7000 Series Precision LCR Meter

Unique to the meter are swept parameter measurements, graphical or tabular, for verification of component and material response to changes in AC test frequency, voltage or current without the need for complex programming or an external controller. Test setups can be stored and recalled either from internal memory or from standard DOS-formatted 3.5" floppies. The front panel controls can be locked out, with password protection. Measured data can be stored on a 3.5" floppy and transferred to a PC for data reduction and analysis. The NIST traceable IET 7000-09 Calibration Kit permits on-site calibration of the 7600 LCR meter.

Condensed product specifications

7600 Precision LCR Meter

General features

Measurement parameter	Measurement range	Measurement accuracy Fast	Medium	Slow
Ls, Lp	0000.001 nH – 99.99999 H	± (0.5%)	± (0.25%)	± (0.05%)
Cs, Cp	00000.01 fF – 9.999999 F	± (0.5%)	± (0.25%)	± (0.05%)
D_F	.0000001 – 99.99999	± (0.005)	± (0.0025)	± (0.0005)
Q	.0000001 – 999999.9	± (0.005)	± (0.0025)	± (0.0005)
Y, Gp, Bp	00000.01 µS – 9.999999 MS	± (0.5%	± (0.25%)	± (0.05%)
Z, Rs, Rp, Xs, ESR	000.0001 mΩ – 99.99999 MΩ	± (0.5%)	± (0.25%)	± (0.05%)
Phase angle (θ)	-180.0000° – +179.9999°	± (1.8°)	± (0.9°)	± (0.18°)

Test frequency:	• 10 Hz – 2 MHz, ± (0.25% + 0.02 Hz) (289,000 user programmable frequencies)				
Measurement speed:	• Fast (25m/s)	• Medium (8m/s)	• Slow (1m/s)	• m/s = measurements/second	
Source impedance:	• 25 Ω	• 400 Ω	• 6.4 kΩ	• 100 kΩ	
DC Bias voltage: • Internal: 2.0 V	• External: 0 to ±200 V		• External: 0 to ±500 V (7600 A)		
Interface:	• RS232	• IEEE-488	• Handler	• Printer	• 31/2" Drive
Trigger:	• Manual	• Internal (Automatic)		• External (IEEE-488, RS232, Handler)	
Results format:	• Engineering	• ΔNominal	• Δ% Nominal	• Pass/Fail	• No Display

Other features include:

- Automatic Calibration and Display of instrument accuracy for selected conditions.
- Self-Test routines to verify crucial instrument operation at Power-Up or when Menu selected.
- 7-digit Measurement Resolution
- Data Storage of 40,000 Measurements/Disk, ASCII Format
- Program Storage of 125 Programs/Disk, 25 Internal Setups, ASCII Format
- 0°C - 50°C Operating Temperature, -40°C - 71°C Storage Temperature
- 75% ± 5% Relative Humidity Range
- Meets MIL-T-28800E, Type 3, Class 5, Style E&F Specifications

7000-09 Calibration Kit