Abbreviations

A/D	- Analogue to Digital
D/A	- Digital to Analogue
GPS	- Global Positioning System
MOV	- Metal Oxide Varistor
PLC	- Programmable Logic Controller
RTD	- Resistance Temperature Detector

Calibrators

by D Howcraft, Instrotech

No matter how digital our world has become most primary measurements in process plants are still analogue by nature - they only become digital somewhere down the line.

Take temperature for instance, the measurement starts out as voltage derived from joining two dissimilar metals together or from a change in resistance from metals like platinum, nickel or semiconductors or measuring infrared radiation. Pressure, flow and force are mainly derived from physical deformation measured with strain gauges in wheatstone bridges or piezo-electric effects. Levels can be measured in many, many ways but usually start out with an analogue measurement. For this reason, in plant maintenance, commissioning and especially instrument workshops, process calibrators will always be indispensable. With LCD graphics and the power of microprocessors, displays can be numeric with additional background information or even in the form of graphs with selectable timebases, ideal for PID optimisation, trending or fault finding.

Accuracy

Because most field transmitters now have error limits of less than 0,5% the calibration equipment needs to be in the order of one magnitude higher, in other words 0,05%. Modern single chip voltage references, 24 bit serial A/Ds and 20 bit D/As can be within full scale limits of 0,01%. The trick is to design input circuits with low-drift amplifiers for voltage and high stability shunts for current and resistance so that one gains the minimum additional error. In linear or rotary measurement most inputs are already digital by nature from encoders, whether inductive, optical or magnetic. The calibrator's function is then to measure or source frequency or counts. This is referenced to the quartz timebase used for the microprocessor which is extremely accurate and, in some cases, where absolute realtime is needed, from GPS satellites.

Practical considerations

When a precision instrument like a process calibrator is going to be used in the field it had better be rugged, both physically and electrically, and have an acceptable battery life. The housing needs to be thicker than normal, have a rubber protection cover to withstand knocks and drops and be reasonably splashproof. Besides the normal CE requirements for electrical emission and noise immunity, inputs need additional surge protection with heavy duty MOVs and high speed fuses. In spite of this we still see some units damaged when 230 V is applied to the low level signal inputs!

About the author

Dave Howcroft is the CEO of the Instrotech Group of Companies and is respected as a leading entrepreneur in the process control industry. Instrotech was founded in 1981, followed eight years later by Digital Process Measurement and Instrotech (Australia). Dave served as President of the SAIMC in 2000.

Take Note

- even in our digital world, measurements still usually start out as analogue by nature
- although process calibrators are manufactured to the highest protection standards, they still need to be treated with the care they deserve
- precision calibrators are complex devices and must be sourced from experienced manufacturers

Modern compact battery development and management has been spurred on in recent years from the demands of the cellphone and notebook industry. We all recall the age of nickel-cadmium batteries going flat five minutes after the battery low warning light comes on. This is probably the reason most manufacturers have stuck with the old, but field replaceable, alkaline (torch) batteries. The electronics industry solved this problem with high capacity metal-hydride batteries and the development of an intelligent 'fuel-gauge' chip. This minute device monitors the voltage and measures the current in and out of the battery. It also monitors the battery temperature for controlled high speed charging. As a result of knowing the power (mA/hours) put in and used up the battery indicator can be linear. This technology has now been transferred into the handheld calibrator range with great success.

Loop calibrators

In spite of many digital bus formats coming on to the market the 4 to 20 mA two-wire analogue system is still popular. This 40 year old technique is readily understood by design engineers and plant technicians, requiring only a two-core cable to the sensor as the 4 mA minimum allows transmitter power to be taken off the signal line. For protection and monitoring, if the signal drops below 3,8 mA there is a cable open circuit or faulty electronics and if the signal goes above 22 mA there is likely to be a cable short circuit. Loop calibrators are designed to measure the mA inline in a passive mode with the power supply from the control room or, by switching in a current limited 24 V supply, in active mode, powering up the transmitter directly without any connection to the control room. This method is ideal for testing individual transmitters before commissioning. Loop calibrators can also be used as simulators (with the transmitter out of the loop) in order to test the 4 to

smart tools for process control and weighing

20 mA loop from the control room.

Process calibrators

PLCs have the ability to measure analogue inputs as well as frequency and counts from encoders, proximity switches, some flowmeters and other devices. For these PLC based systems an ideal process calibrator should be able to measure and source milliamps, voltages, millivolts, frequency and counts. Inputs and outputs need to be isolated from one another in order to test or calibrate transmitters. For instance, inject mV whilst measuring the output 4 to 20 mA. On a two-wire transmitter this could be carried out without connection to the control room as the transmitter could be powered from the calibrator. Where ground loops are a suspected cause of trouble during commissioning the calibrator could be set to mA in and mA out in tracking mode in order to check the circuit. Should this clear the problem then a mA loop isolator could be installed permanently. The frequency and counting functions should have selectable trigger levels for the inputs and scaleable output voltage levels and programmable counting frequency from 0,1 to 1 kHz.

Thermocouple calibrators

There are more than 15 different types of thermocouples whose choice depends on mV/°C, temperature range, corrosion resistance and cost.

The look-up linearising tables are quite extensive for each thermocouple type and require a large memory library. As thermocouples only measure the difference in temperature between the hot junction and the cold junction, ambient compensation is necessary to either automatically measure the terminal temperature and add it to the difference (internal) or the cold junction temperature is measured and keyed into the calibrator (manual) where it is added. It is due to uncertainties of measurement of this cold junction temperature that makes thermocouples unsuitable for ambient temperature measurement. It is vitally important that the thermocouple extension cable is connected with the correct polarity. If in doubt twist the hot junction end of the extension cable together and warm them with a lighter provided the area is safe to do so. The reading on the indicator or calibrator should increase. Thermocouple calibrators should also be able to measure and source mV and mA for testing or calibrating temperature transmitters.

RTD calibrators

Platinum and nickel have a very good correlation of resistance with temperature which makes them ideal for measuring temperature in the low to medium range. Pt100 and Ni100 (100 Ω @ 0°C) are industry standards with Pt500 and Pt1 000 used where higher accuracies or resolution are needed.

Copper and semi-conductor RTDs do not have the same accuracy. It is important that the line resistance or even change in resistance of the copper extension wires due to ambient temperatures does not cause additional errors. RTD calibrators must therefore be able to measure or source with a two-wire termination for direct connection or three-wire for longer leads. Four-wire termination is the most accurate form of resistance measurement or simulation as lead resistance does not affect the reading. Measuring resistance accurately is relatively simple but it is extremely difficult to simulate (source) resistance accurately, with high resolution and to suit various forms of instrumentation inputs. The RTD calibrator also requires the ability to measure and source mA in order to test or calibrate transmitters.

Pressure calibrators

The author's company's approach to accuracy and flexibility in pressure calibrators is to make use of the technology coming on to the market from the manufacturers in digital output pressure transmitters. With on-board microprocessors, temperature compensation and multi-point linearisation it is standard to have 0,1or 0,05% with a selection process. With an additional time and price penalty these selected transmitters can be supplied with error limits better than 0,02%, getting into the realm of deadweight testers!

Another real advantage of using these 'pre-calibrated' products is that various pressure units can be connected and the model, range and serial number can be read into the calibrator for scaling and over range displays. Therefore, a calibrator with a set of high accuracy transmitters to cover a wide selection of uses can be offered. The mA measure and source facility allows the calibrator to be used for testing and calibrating pressure to mA transmitters, current to pressure convertors and, with tracking activated, give a mA output that follows a selected pressure range, ideal for testing or emergency replacement.

Loadcell (strain gauge) calibrators

This product has been the author's company's greatest challenge: how to build a full wheatstone bridge analyser, an insulation tester and a process calibrator into one small handheld device. It took a year of conception, hardware and software development to achieve this and, amazingly it all worked beyond expectations.

By connecting a four or six-wire loadcell (or any strain gauge bridge circuit) to the calibrator resulted in having a full report including mV balance, in-and-output resistance and bridge balance in a few seconds. By connecting leads to the screen and housing resulted in a 50 V insulation test between bridge, housing and screen. With mV plus mA measure and source and excitation measurement, loadcell systems can be measured, weigh systems electrically pre-calibrated and mAs injected into indicators or SCADA systems.

Conclusion

Calibrators are some of the most critical tools available to the engineer and technician. They are also complex devices to design and manufacture, with practical considerations being as important as technical ones.

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