

## Checking your Heat Process on a Budget

### Your Test Instruments: Buy two, make two yourself

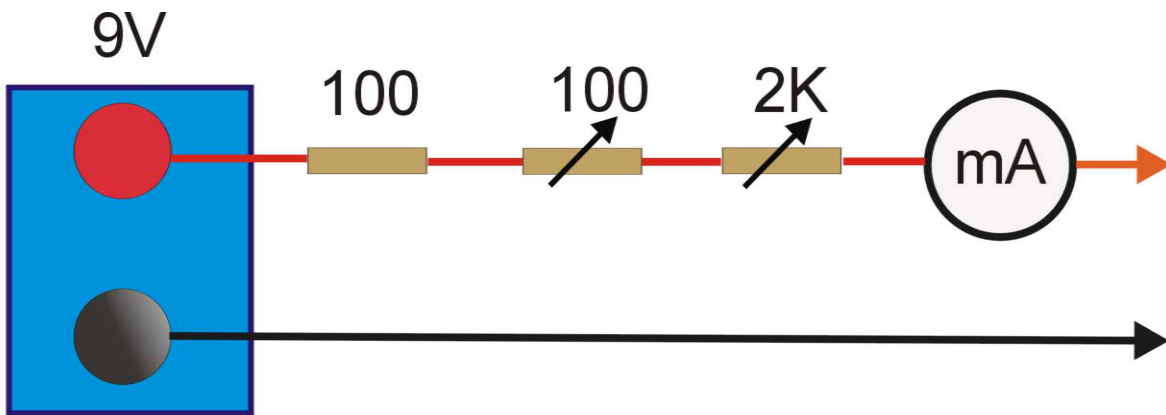
Your task: To check the control circuits of items such as valve actuators, motor drives, SCRs and heaters, manipulate test signals and analyse the results.

. I will be covering controllers, recorders, indicators, signal converters, temperature sensors and shaft speeds. **Most important.** None of your tests must endanger the plant or its product.

It is a given that you already own a good digital multimeter and a clamp-on ammeter.

You also need a **run-up box**. What's that? A little device that puts a 4 – 20mA signal into the signal input of say, a control valve or SCR unit. It simulates the output signal of a controller or transmitter.

Wasn't in the budget? Make one yourself, using the components in Fig 1. mounted in a plastic hobby- project box. All to be found in any Radio Shack or similar store - if not in the maintenance shop. If you can't find a cheap milliamp meter (mA in Fig 1) use your multimeter set on a milliamp range. String together a 9V battery, a 100 ohm fixed resistor, a 100 ohm and a 2000 ohm variable resistor and your meter. Connect the ends into the signal input and run the valve, SCR, motor drive etc through its range as you vary the current between 4 and 20 mA.



#### 1. Check an electropneumatic control valve.

Adjust the valve stroke (span and zero) to the range you want that corresponds to 4 and 20mA. Check for any stiction as you go up the range. Verify that it has the action you want - milliamps-to-open or milliamps-to-close; and while you're about it - air-to-open or air-to-close. If you want to verify the stroke response to diaphragm or cylinder pressure you will watch the gage and the valve movement.

If the valve has a feedback potentiometer or equivalent, transmitting valve position back to the control room, use your multimeter to check that this signal corresponds to the observed valve position.

**Motorized valves.** For 4 – 20mA actuation check the valve travel as above. If you have access to the feedback signal check it. It is often inaccessible, buried inside the servo drive of the motor. With this system if the feedback potentiometer fails, control fails. In this event some controllers can be configured to make the valve go to one or other end of its stroke as a fail safe position. Worth checking.

Another type of valve actuator uses **boundless control**. Here the forward and reverse motor windings are connected together at a common terminal. The non-common ends are joined by a capacitor so that the winding not directly energized receives a phase-shifted current when its partner is energized.

The temperature or process controller has two output switches that energize one winding for forward and the other winding for reverse rotation.. The signals cease only when the temperature controller sees no deviation from the set point. If a feedback potentiometer is fitted. it is usually only for indication. However some controllers can exploit it for override control.

**Here's a trap.** When testing the switching action it's no use connecting lamps across the windings hoping to see which one is being energized. They both are, one via the capacitor, until the controller is sees no deviation from set point, then and stops switching. To check the controller's switching action you would have to lift the forward and reverse controller wires off the windings and use two lamps to check the switching outputs directly off the controller.

**Electric Heaters.** If there are no installed ammeters, put your clamp-on ammeter on the heater conductor. Check that current goes up and down as temperature goes down and up through set point. Without a sensor simulator you cannot easily swing the temperature, so take the set point up and down through the indicated temperature and watch the output change.

If your final control device is an SCR with a 4 – 20mA input, you can leave the controller out of the loop, inject a measured mA signal and watch the heater ammeter respond. It will pulse with increasing % on-time (time-proportioning control) or increase progressively as you increase the milliamp signal (phase-angle control).

**Testing controllers, recorders and indicators with 4 – 20mA inputs.** Use your run-up box and to inject a measured milliamp input. Check that the indication on the instrument shows the corresponding engineering units.

Some current loops that you break into may have too high resistance to make the full 20mA. In this case add one or more extra 9V batteries in series to your run-up box.

## Controllers, recorders, indicators, signal converters, temperature sensors and shaft speeds.

### Thermocouple Instruments.

Problem: you want to check a thermocouple-activated instrument and you can't get your hands on a calibrator.

Make yourself a millivolt run-up box using the circuit shown in Fig 2. With a 1.5V battery you can get 0 - 70mV out of the mV output.

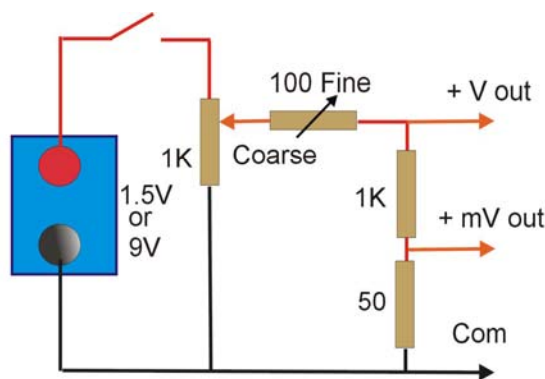


Fig 2. Millivolt and Volt source

Connect this mV signal to a temperature controller in place of the thermocouple. If it is safe to do so you can leave the temperature controller connected to the process and watch it modulate the heat as you vary the millivolts up and down through set point. Use your clamp-on ammeter to watch heater current.

To check the controller calibration, connect the mV signal to a temperature indicator intended for the same type of thermocouple. Better still if you have a hand-held model such as the Fluke 51 that has several thermocouple selections. Otherwise use a known good controller or thermocouple temperature indicator having the same

input sensor and range. Don't forget to use thermocouple extension cable. Compare both indications as you run the signal through its range. Disconnect any installed controller from the process at this stage. With this simple run-up box the minimum setting should show room temperature, not 0 °C (32 °F) on both instruments. You can verify this with a thermometer placed near the thermocouple input terminals.

If you can't find a dependable spare controller or indicator use in its place a multimeter having 10 microvolt resolution – e.g. the Fluke 87. In your thermocouple table look up the millivolts corresponding to the current room temperature. Subtract this from the millivolts corresponding to the temperature you want to inject.

Set the injected millivolts to this difference using the indication on your multimeter.

**Checking devices having dc voltage inputs.** 0 – 5V and 0 – 10V are the most common. These devices usually come with input impedance in the megohm range. The circuit in Fig will tolerate impedances down to some 0.1 megohm.

Use the V+ Out terminal in Fig 2. and monitor it with your multimeter. If you need more than 9V you can add more batteries.

**Platinum resistance-thermometer (RTD) instruments.**

The most commonly used RTD has a resistance of 100 ohm at 0 ° C and 138.51 ohm at 100 ° C. Tables of temperature vs resistance are readily available for the whole useable temperature range so you can connect a known resistor to your instrument in place of the RTD and check the instrument's calibration.

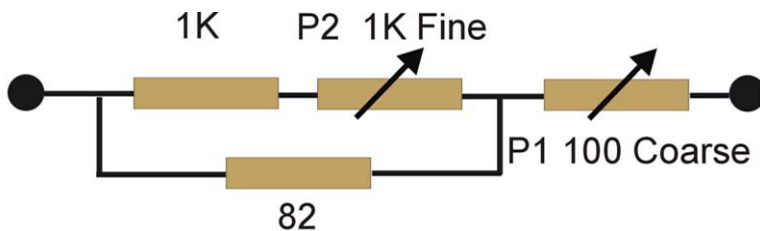


Fig 3. RTD Simulator

You would normally use a calibrator (aka RTD simulator). This is a precision variable resistor circuit with a digital indication expressed in degrees. You can improvise one from the circuit in Fig 1. This design covers about –50 to + 200 ° C. Use your multimeter to set the resistance to represent various temperatures then connect it to your controller in place of the RTD. To extend the range to 500 ° C change P1 to 200 ohm.

Note: Multimeters can introduce an uncertainty of some 0.4 ohm (1° C) on top of the tolerance of the sensor in your process.

**Two-wire connection.**

Some low-cost instruments have only two input terminals so they add the connecting wire resistance in their measurement of temperature. This amounts to about 2.5 ° C error per ohm of go and return wire. This may be acceptable and can be minimized by using short runs and thick cable.

**Three-wire connection**

Most instruments use the three-wire connection where the third wire allows the instrument to compensate for line resistance error. Here one white lead connects to one end of the RTD and two red leads go to the other end. They are connected to three terminals on their instrument.

Colors vary but all you need to know is, one end has two leads of the same color and the other end has one of a different color. The same code should apply in the plant wiring.

If you are calibrating an instrument with your simulator direct on the input terminals you don't need correction for line resistance so you connect the two red-wire terminals together.

**Signal converter calibration.**

Here you have to inject a range of known signals at the input and at the same time measure the output; e.g. J thermocouple in and 4- 20mA out. So you need two precise instruments.

**Shaft speed.**

If you can locate any rotating steel part bring a magnetic pickup or proximity probe up close and read the signal as revs/s on the Hz function of your multimeter. A few turns of wire on a small magnet works. A rotating strip of foil can do the same job activating a photo cell.

**Other checks using your multimeter.**

Ac and dc power supply voltage, heater resistance, continuity using the beeper.

Improvising3.doc 2004/Dec/20 Arhur Holland. Holland Technical Skills. Ph 905 827 5650. email: aholland51@cogeco.ca