# Master Slave Temperature Control, Three Ways to Achieve it.

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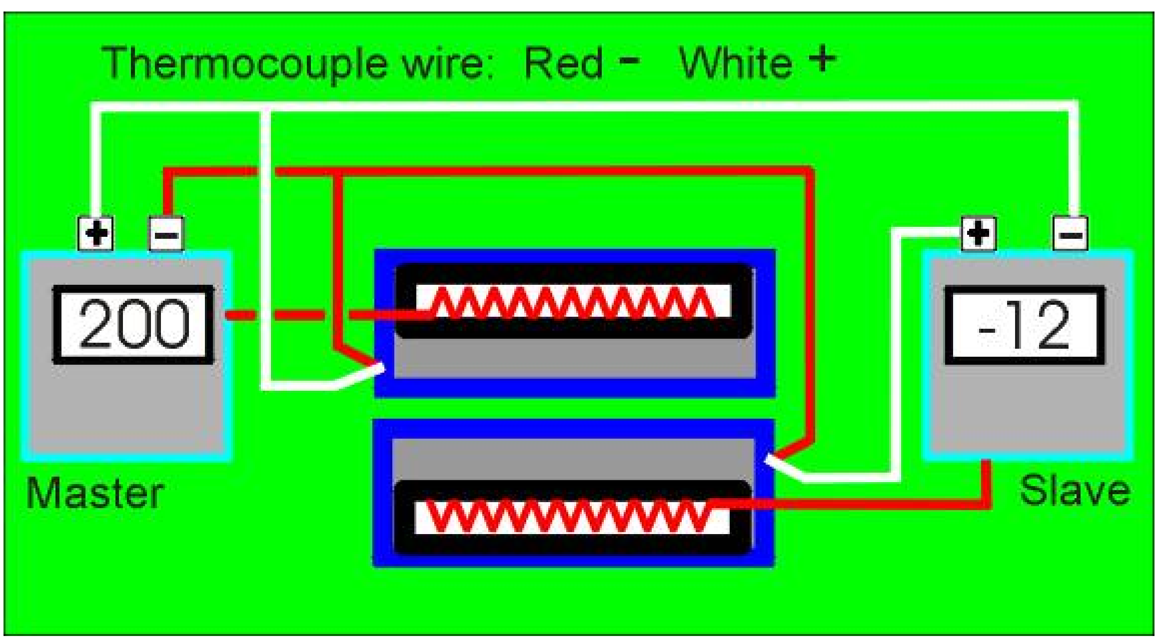
**Example:** You have a press with top and bottom heated platens, each with its own temperature controller (see Fig 1). You want to be able to set the temperature on one controller, say the top, (call it the master) and have the bottom, (the slave) adopt the same setting.

**Method 1. Back-to-back thermocouples**

You make the connections shown in Fig 2 where the master controller takes the signal from its own thermocouple and delivers power to its heater in the normal way until the temperature comes to set point.

The slave controller takes the signal representing temperature difference, from the two thermocouples connected back-to-back. You set its set point to 0 degrees. This controller decreases its output power for upscale readings increases it for downscale readings and will not be satisfied until it achieves its set point of zero degrees. This means that the two thermocouples therefore the two platens end up at the same temperature.

Note that the slave controller has to be configured to have no cold-junction compensation and to indicate in a range say, minus 100 ° to plus 100 °.  Most modern controllers can be reconfigured in this way.




## Fig 1. Master/slave Control of two Heated Platens

The circuit uses the North American color code for the Type J (Iron/Constantan) thermocouple where red denotes the negative wire. Be cautious: although an

internationally agreed color code has been out for a few years its adoption is going very slowly in North America.
You have to study the thermocouple polarity logic to understand how the slave circuit does its job and why two positive wires go into the + and – terminals of the slave controller.

**Avoid grounded thermocouples**

Unless you specify otherwise, your thermocouples may come with their hot junctions welded to the metal sheath, so when they are installed, the junctions become grounded and connected to each other. A grounded junction does no harm when only one control loop is involved but with the back-to-back connection here, the difference signal becomes totally unpredictable and inaccurate.
So make sure that you specify isolated hot junctions and avoid grounding any part of the two thermocouple circuits.

You can see from the circuit that the master thermocouple output acts as the set point for the slave controller. At cold start up, the master set point, being inside the controller, is at the target temperature right from power switch-on and the master controller will be delivering full power. The slave controller has to wait for the master's thermocouple signal to climb and bring a negative deviation to the slave controller so that it can start delivering power. This makes the slave temperature lag that of the master zone on start up. You will see the same kind of lag in following the master for set point changes and process disturbances. Bear this lag in mind when making control parameter (PID) adjustments on the slave controller.

There is no theoretical limit to the number of slave zones that you can connect to one master controller. The combined input resistance of a lot of slave controllers although in the megohm region could affect the accuracy of the thermocouple signals. The ground leakage of a lot of thermocouples and wiring in parallel (again many megohms) could also degrade accuracy. In the absence of specific figures I would put the limit at fewer than ten zones.

**Method 2. Analog transmission of set point:**

Consider again the press that we used in part 1. This time we'll connect each thermocouple only to its own controller as shown in Fig 2.
Unlike method 1, the slave will have the same full temperature range as the master.
Now let the master put out an analog dc signal representing its own set point. Let the slave receive this signal and assume a set point in proportion to it; that is, agreeing with that of the master.
This retransmission signal, as it is called, is commonly in the range 0 – 10V or 4 – 20mA dc, corresponding to the temperature range of the controllers.
When the operator changes the master's set point, the slave set point follows without delay, unlike the differential thermocouple method, where the slave set point suffers the heat-up lag of the master's thermocouple.

The analog transmission method also avoids wiring traps, misconnections and errors inherent in low millivolt thermocouple signals. The method can have some small errors, (Typically 0.1 to 0.2%) due to calibration inaccuracies of the dc signal and its interpretation by the slave.

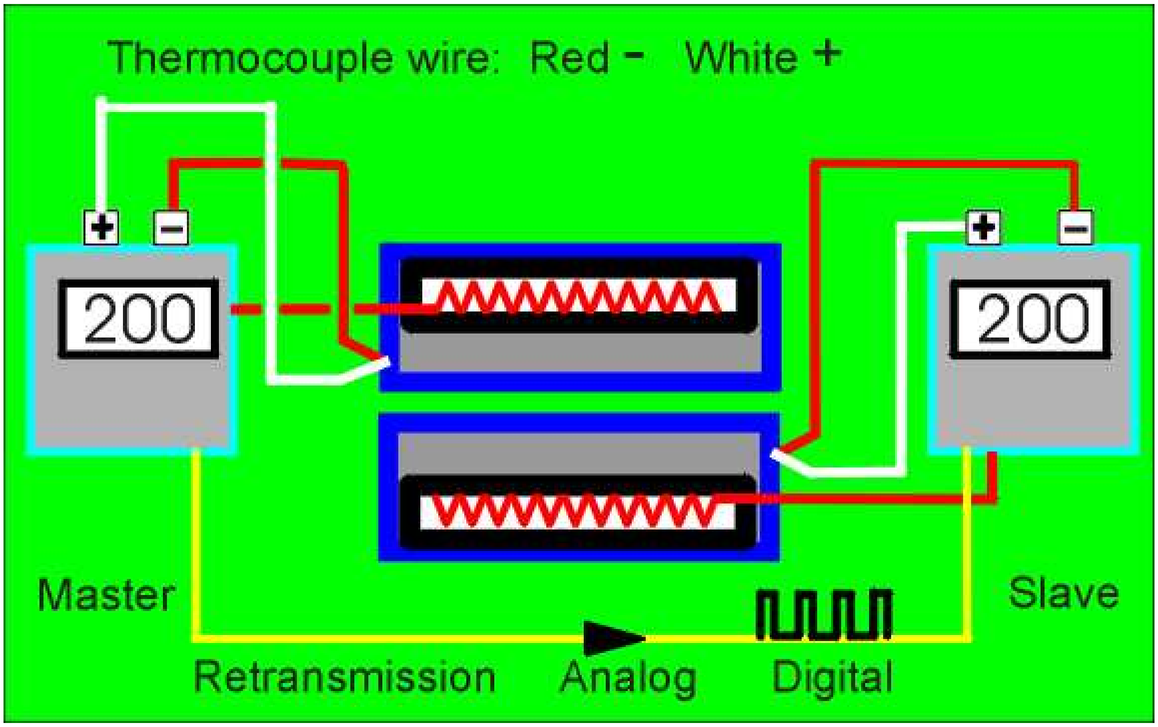



**Fig 2. Master/slave Control using dc or digital transmission**

If you have an unusually large number of slave zones you will probably use a 0-10V retransmission signal corresponding to the temperature range. Check with the controller supplier how many slave controllers you can connect to one master controller without pulling the voltage down and degrading the accuracy. Alternatively, calculate the loading effect of the combined parallel resistance of the slaves on the output resistance or current-delivering capacity of the master. The supplier can give you these values.
Make sure that the retransmission signal and the slave remote inputs are specified as isolated from ground and from the temperature sensors. Isolated means several hundred megohms including the panel wiring. Don’t use a high-voltage insulation tester to determine this.

**Method 3. Digital retransmission of set point**
Some manufacturers offer a proprietary digital input/output system for communication between instruments. Set point is just one of the variables that can be transmitted and received. Typically up to 30 slaves can be connected. Transmission errors with this

method are virtually zero. There is no signal degradation since the resolution of the digital signal is typically one part in 65000. In comparison, your controller readout resolution is commonly one degree in 1000.

**Ramp and soak control**

Just as the slaves follow manual settings of the master's set point they will follow any ramp-and-soak type program that a master controller/programmer puts out.

The actual temperatures will trail the program temperature. Some may arrive at the soak level a bit too long for your liking after the program arrives. This lateness subtracts from the soak time that the program is trying to give to the work. To obtain a guaranteed soak time you can add a **HOLDBACK** feature; a setting on each controller that halts the program's ascent until the sluggish zones catch up and come within a specified deviation from the program.

There are many computer supervisory systems on offer for use with controllers that have the EIA-485 communications option. You enter the set point at the computer and all controllers follow it.

The computer not the master controller can also perform ramp/soak programs. In this case, all controllers are equal so there is no need to promote one of the zones to a master programmer/controller.