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4-20 ma Current Loop Experiments

Purpose

The purpose of the 4-20 ma demonstrators is to demonstrate how current loops work, demonstrate the response of different transmitters, and demonstrate that it is possible to do data logging on a pneumatic control system if you have the right equipment

Experiment 1 – Trace Out a Current Loop

Current loops are literally a loop of wire that carries a current that varies from 4-20 ma as variable measured by the transmitter varies. For instance, a 4-20 ma transmitter serving a 0-100°F temperature transmitter would have a current that varied linearly from 4 ma at 0°F to 20 ma at 100°F. The loop consists of:

- A power supply of some sort to drive the process. For the loops in the experiment, a 24 vdc power supply is used.
- A transmitter that varies the current as a function of the measured variable. For the experiments, the transmitters vary current as a function of temperature, static pressure, and pneumatic control system pressure.
- A load resistor that converts the current to a voltage for use by the control system. For the experiment, the load resistor is part of a cable that is plugged into the Hobo data logger. The blue and yellow wires are connected to a load resistor, that is hidden under the gray insulation. The voltage it generates is input to the Hobo logger via the jack that when the cable is plugged into the logger input. The wiring diagram provided with the power supply panels illustrates the details of this connection.

As a starting point for the experiment, try to trace out the current loop, from the power supply to the transmitter, to the load resistor, and back to the power supply.

For more details on current loops, see the www.Av8rdas.Wordpress.com blog posts starting in April of 2009.

Experiment 2 – Position Sensitivity

One of the dc power supply panels is connected to a Dwyer static pressure transmitter. With nothing connected to the transmitter, pick it up and rotate it from horizontal to vertical, and then past vertical. Observe the output of the transmitter in the indicator that is part of the package.

What happens to the output?

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Why does this happen?

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Experiment 3 – Noise and Resistance Immunity

1. Use a multi-meter to measure the resistance of the coil of telephone hookup wire that is provided with the lab set-up. (Note that the multi-meter will need to be set to the ohms scale with the ohm/voltage jacks, not the amp/milliamp jacks.) The coil is actually four wires but they are all wired in series to make one long single conductor and create a measurable resistance.

   You should measure at least several ohms of resistance, and maybe 10 to 40 or more ohms depending on which lab set-up you are using. Document the resistance you measured below.

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2. If there is not already a meter in the current loop, insert one so that you can read the current flow in the loop. Note that the meter needs to be wired in series with the current loop with the leads in the milliamp jacks and the range set to milliamps. Note also that current loop transmitters are often polarity sensitive. Meaning if you reverse the polarity they will shut down.
3. Note the current reading in the current loop, and document it below.

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   Bear in mind that this is proportional to the temperature being measured by the RTD and as long as the RTD temperature does not change the current flow should not change
4. Note that there is an alligator clip installed in the white lead coming from the RTD sensor that is the input to the transmitter. Disconnect the lead and then use it and the alligator clip on the coil of wire to insert the wire in series with the RTD sensor. What this does is add resistance to the circuit that is not the resistance associated with the temperature sensor itself, just as a long wiring run between an RTD and a controller or transmitter would. And, since the resistance of copper changes with temperature, the resistance of the coil of wire will also change with temperature. When you do this, what happens to the signal coming from the transmitter (document your observation below)?

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5. Based on you observations, do you think resistance type temperatures are sensitive to the resistance of the leads in the circuits between them and the controller they serve?
6. Remove the coil of wire from the RTD circuit and reconnect the RTD directly to the transmitter. Document the current flow in the current loop below (it should return to about the value you documented in step 3 if the temperature has not changed).

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7. Now insert the coil of wire into the current loop, effectively adding its resistance to the resistance of that circuit. Document the current flow in the current loop after you have added the resistance.

Did it change? Based on your observations, do you think current loops offer advantages in terms of being immune to lead resistance issues?

Experiment 4 - Thermal Response

1. Deploy the data logger for the DC power supply panel serving the static pressure and temperature transmitters so that it logs data as quickly as possible.
2. Take the temperature transmitter, and, with no thermowell in place, heat it up with the hair dryer for 15 seconds.
3. Allow the transmitter to cool back down for 5 minutes.
4. Insert the transmitter in a cup of water to fully cool it for 1 minute.
5. Place the transmitter in the stainless steel or brass thermometer well.
6. Heat the well up with the hair dryer for 15 seconds.
7. Allow the transmitter to cool back down for 5 minutes.
8. Pull data from the data logger and compare the thermal response of the temperature sensor with and without a well. Do you think any differences observed could impact the control system and its ability to achieve tight control?

Experiment 5 – Logging a Pneumatic Signal (Optional; Time Permitting)

1. Deploy the data logger for the DC power supply panel serving the pneumatic pressure transmitters so that it logs data at least once every 5 seconds.
2. Connect the 0-20 psig transmitter inputs to one of the pneumatic demonstrators in the adjacent area so that it is monitoring pressure to one of the lines to an actuator.
3. Allow the data logger to record the variations in pressure as the group working with the pneumatic demonstrator cycles the actuator.
4. Pull data from the logger and observe your results. Do you think that just because you are working with a pneumatic control system it is impossible to log data?

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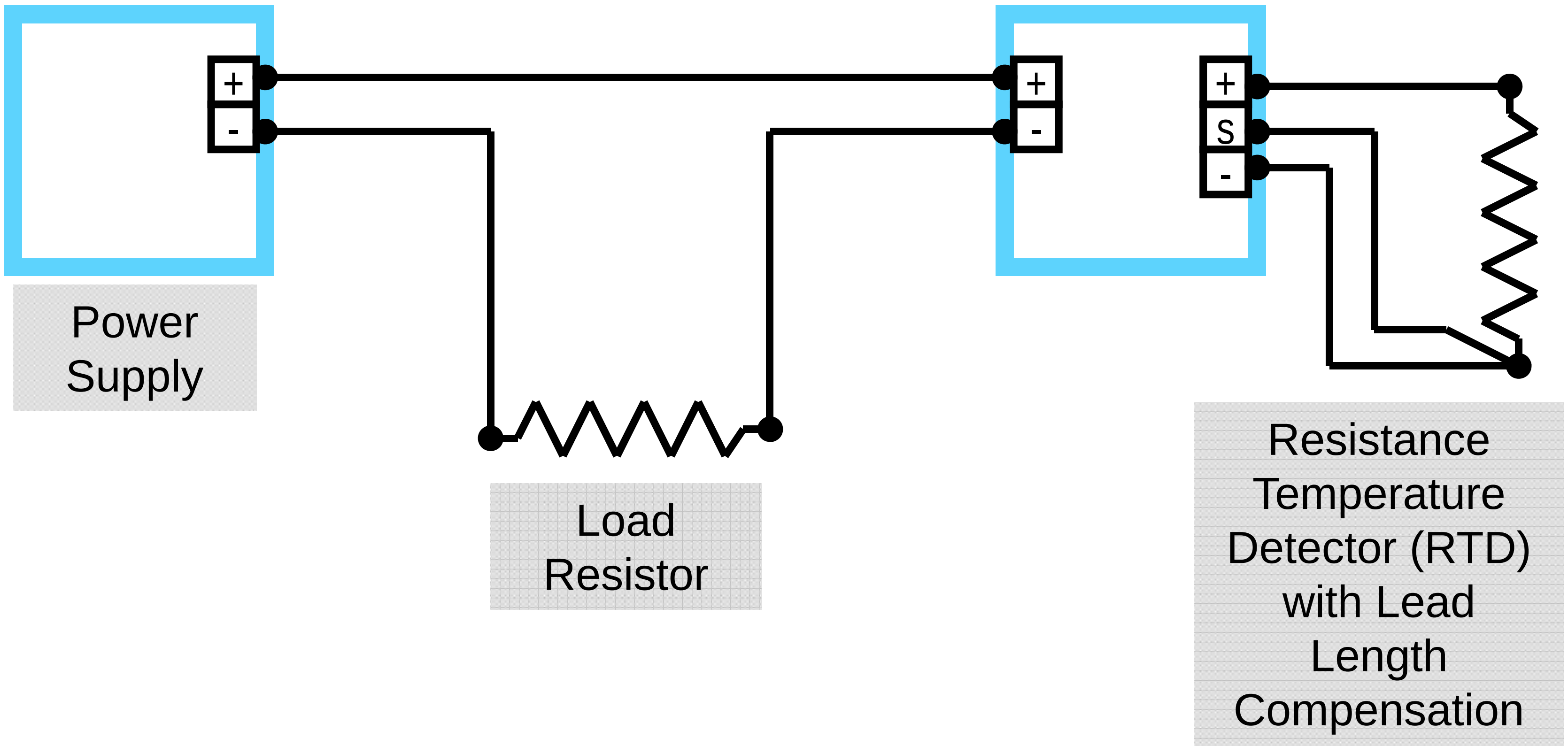
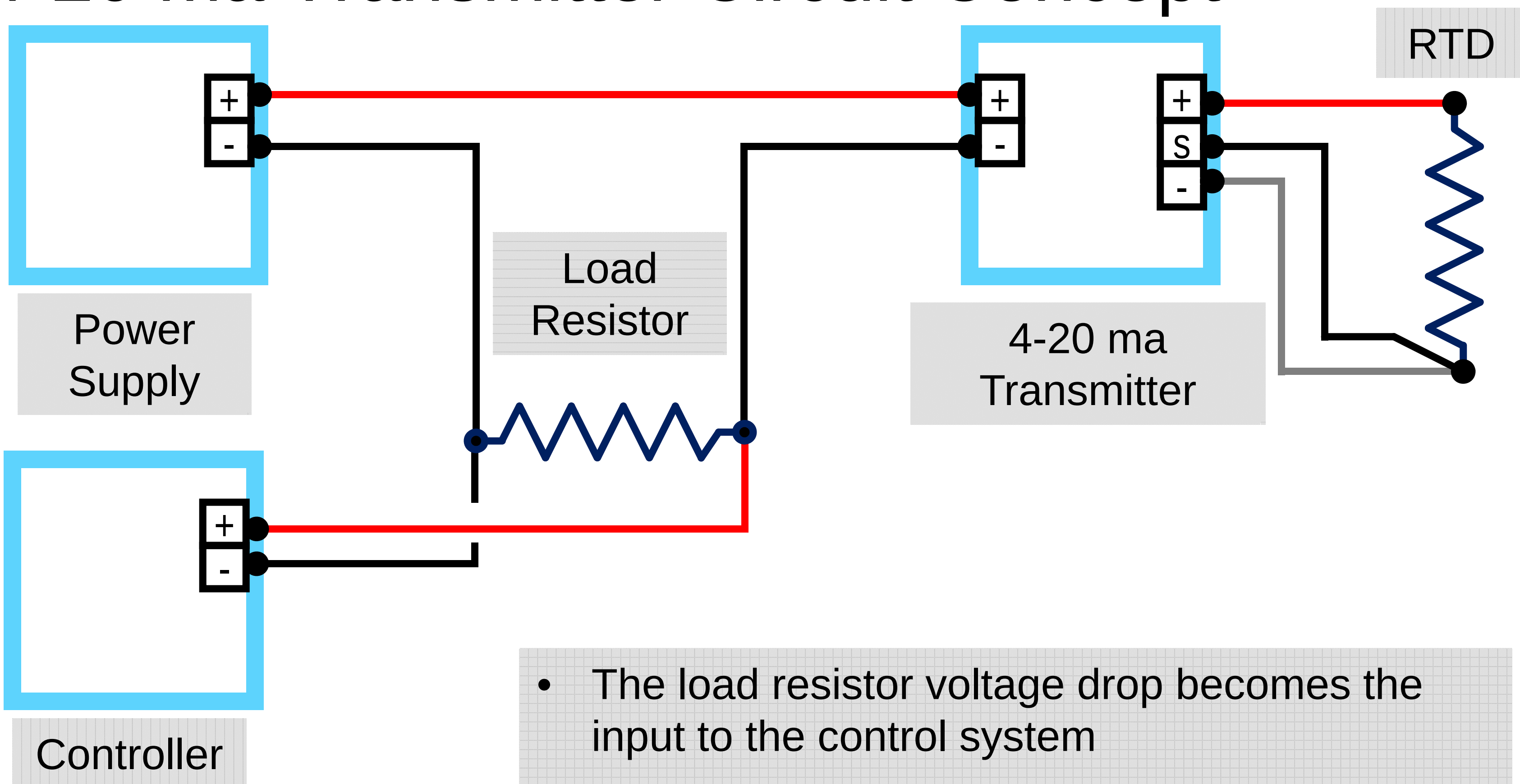
4-20 ma Transmitter Circuit Concept



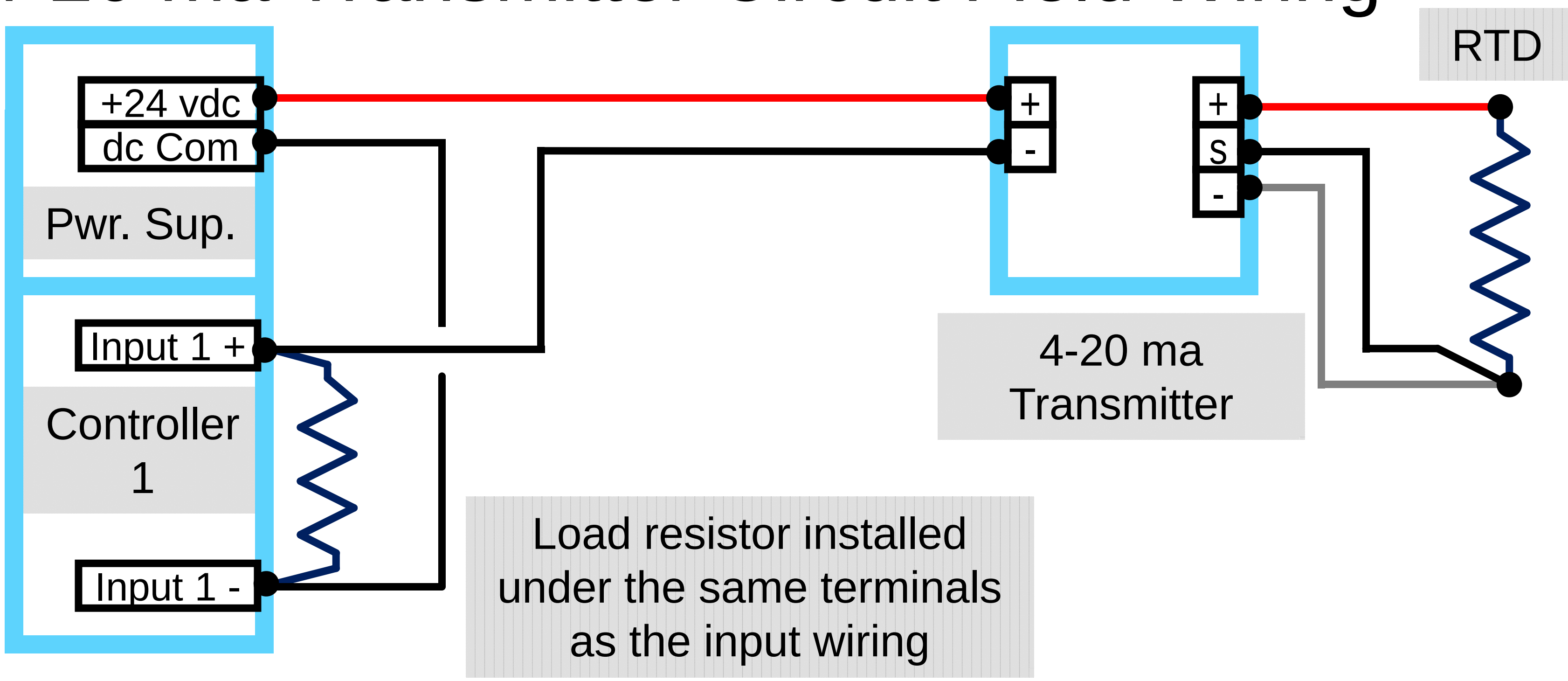
Solving E = I x R for Different Currents and Resistances				
Load resistance, ohms	250		500	
Current loop current, amps	0.004	0.020	0.004	0.020
Load resistance voltage drop, volts	1.000	5.000	2.000	10.000

4-20 ma Transmitter Circuit Concept

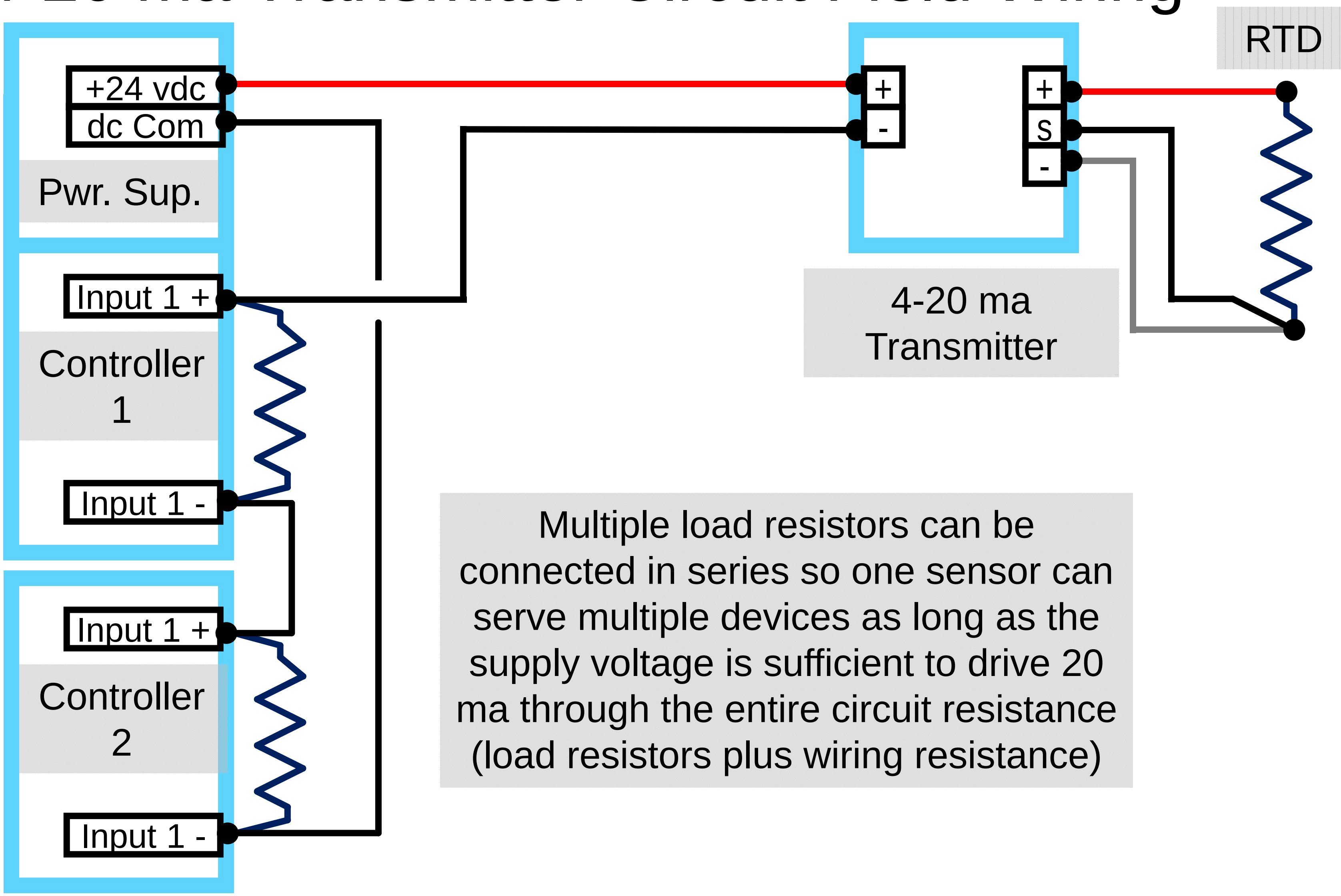


- The load resistor voltage drop becomes the input to the control system
- The loop can have multiple load resistors as long as there is sufficient voltage to drive 20ma through the total circuit resistance

4-20 ma Transmitter Circuit Field Wiring



4-20 ma Transmitter Circuit Field Wiring



Multiple load resistors can be connected in series so one sensor can serve multiple devices as long as the supply voltage is sufficient to drive 20 ma through the entire circuit resistance (load resistors plus wiring resistance)

4-20 ma Transmitter Circuit Field Wiring