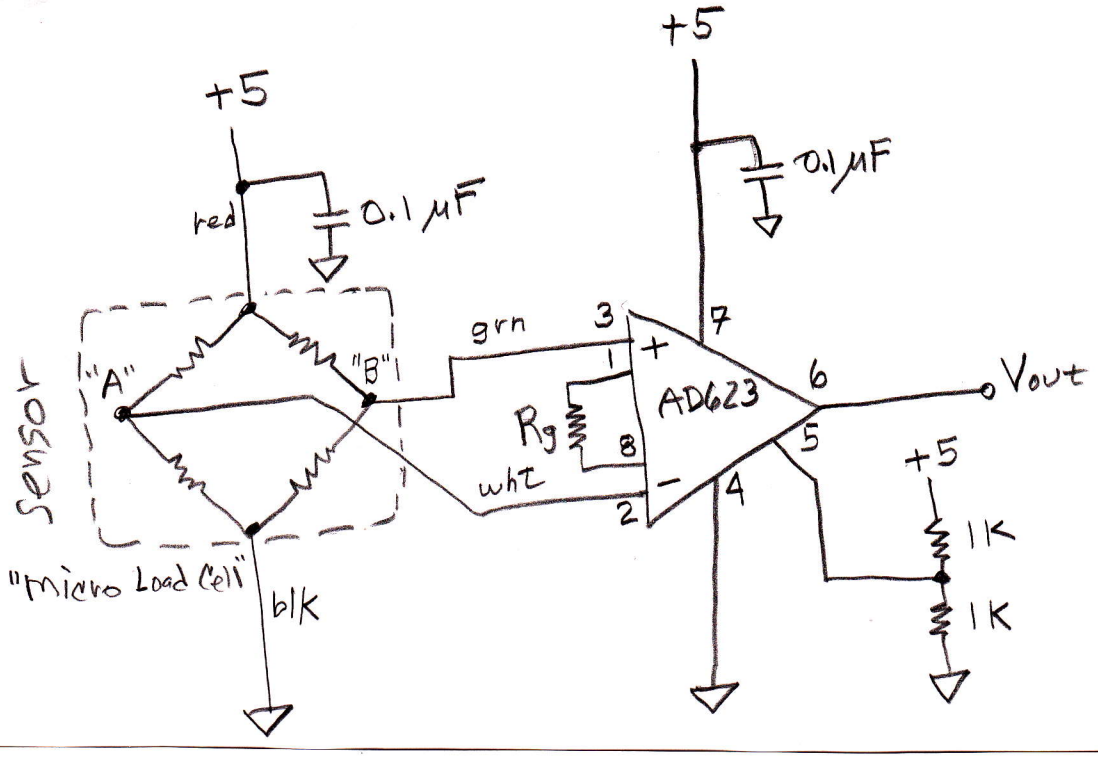

Strain gage sensor and instrumentation amplifier

(Steve Roberts - 6 Feb 2014)

Overview: The circuit shown above consists of an Analog Devices AD623 instrumentation amplifier (IA) used to condition the output of a small strain gage sensor. The amplifier is powered by 5 volts (pin 7) and ground (pin 4). Internally the sensor is a bridge circuit composed of four strain gages. The excitation voltage for the sensor is 5 volts (red wire) applied across the bridge to ground (black wire). As a load is applied to the sensor, the bridge output is a voltage difference developed between bridge points A and B. This voltage difference is brought out on the green and the white wires to the amplifier input pins 2 and 3. The final circuit output appears at pin 6 of the AD623.

Ratiometric measurement: Normally, voltages measured with the Arduino are measured with respect to ground. However, in this circuit the sensor can be loaded in either the positive or the negative direction. The Arduino cannot directly measure negative voltages. Thus, we need to ***"bias"*** the bridge output upwards (in the more positive voltage direction) to keep the output within the required 0-5V range which the Arduino *can* measure. This is done by connecting the reference pin 5 on the AD623 to 2.5V rather than to ground. Since the 2.5V voltage divider output is derived from the same 5V used to power the sensor, this results in a ***"ratiometric"*** type of measurement which tends to reject effects of variation in the 5 volt supply. For example, if the 5V supply were to droop to say 4.8 volts, the bridge output would droop proportionally, but the 5V Arduino ADC reference would also droop in proportion so that the same load on the sensor would drive the Arduino ADC result to the same degree, thus cancelling the effect of the 5V droop.

Reference pin 5: This is the ***reference*** pin for the IA output. Pin 5 is often connected to ground. However, in a ***single-supply*** application such as the circuit above, we are putting 2.5 volts on pin 5. This means that with a zero load on the bridge sensor the amplifier will have an output of 2.5 volts. A negative load on the sensor will drive the IA output toward zero volts; a positive load will drive the IA output toward +5 volts. Thus the effect of setting the IA reference pin at 2.5 volts allows you to measure both positive and negative excursions of the sensor strain gage bridge.

Instrumentation amp *vs* opamp: Note that an instrumentation amplifier is not an "opamp" so you won't see a typical opamp circuit here with a feedback resistor network trying to keep the two inputs equal. Rather, the voltage difference between pins 2 and 3 remains at whatever it is, and this difference is multiplied by the gain of the IA. Unlike an opamp, with IA's such as the AD623 the gain is set by a single ***gain resistor,*** Rg, connected between pins 1 and 8. You choose the gain you want by referring to the table on page 16 of the AD623 data sheet which gives the relation between the gain resistor value and the resulting gain of the amplifier. You can also use the gain equation given on page 16 of the data sheet