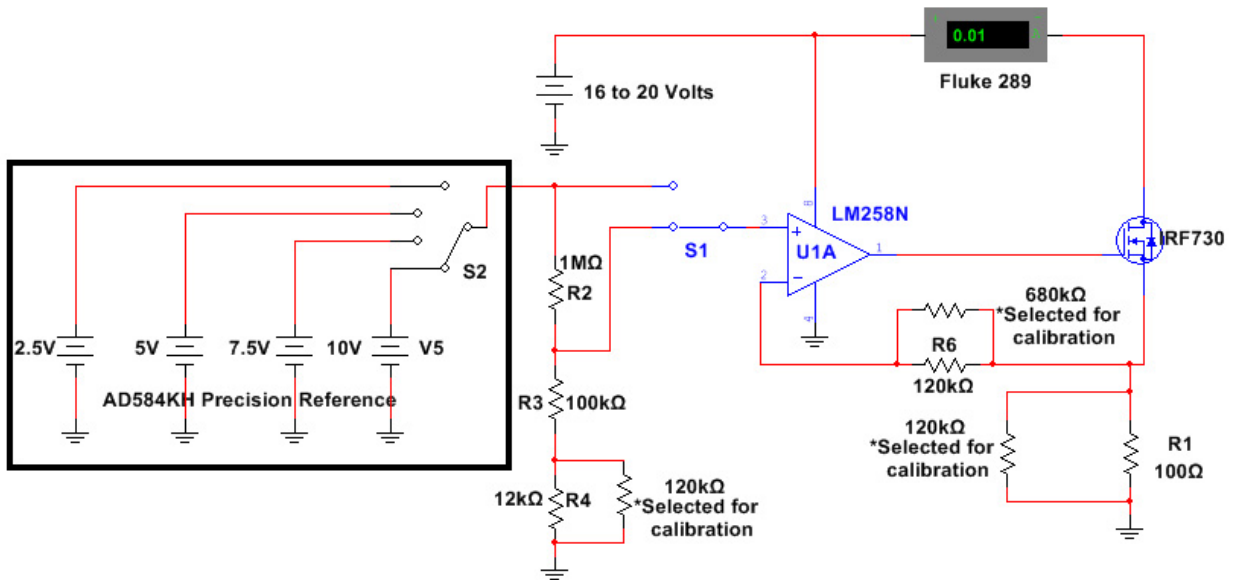


Inexpensive modules based on the AD584 precision reference are readily available. These usually provide four values from 2.5 to 10 volts. I wanted something for DC current. Current calibration is straightforward when a precision voltage source is available. The circuit below shows one approach. A calibrated current flows through a DMM such as a Fluke 289 and through R1, a precision 100 ohm resistor. The voltage across the resistor is fed back to the input of an op-amp. The other input of the op-amp is connected to the reference voltage. The op-amp will do what it can to eliminate differences in the two input voltages; in this circuit the op-amp output drives the gate of a power MOSFET which allows enough current to flow in R1 to produce a voltage drop equal to the reference voltage applied to the + input of the op-amp. S1 selects direct input or divide by 10. This circuit provides eight currents: 2.5, 5, 7.5, 10, 25, 50, 75 and 100 mA.



Vin	Vin/100	I <sub>meas</sub>	% Err
0.250158	0.00250158	0.0025	-0.063
0.499727	0.00499727	0.004995	-0.045
0.75013	0.0075013	0.0075	-0.017
0.99963	0.0099963	0.009993	-0.033
2.50158	0.0250158	0.025015	-0.003
4.99727	0.0499727	0.049999	0.053
7.5013	0.075013	0.07507	0.076
9.9963	0.099963	0.10004	0.077

The measured error is less than that of a Fluke 289 which is specified at an error of  $0.15\% + 2$  count or  $0.05\% + 10$  count, depending on the current range. For example, if the meter is displaying 2500.0  $\mu\text{A}$ , adding 10 count means the current could be as high as 2501.0  $\mu\text{A}$ , an error of 0.04%, for a total error of 0.09%.

The fluke is the best meter I have. I started this experiment with a good quality Vishay 100 ohm/12.5 watt power resistor rated at 1%. It was within specification but slightly higher than 100 ohms so I fooled around with parallel high-value resistors to get it closer in value. Yes, I used the Fluke ohmmeter function. This is a type of bootstrap operation where one makes assumptions and relies on other measurements to validate them. In this case, the voltage reference serves as the peg to anchor the final results. The voltage source was calibrated by the supplier using a 6-1/2 digit multimeter. *In supplier we trust* (not necessarily a good idea, but I don't have a lab with stuff directly traceable to N.I.S.T.). The table values above for  $V_{in}$  cannot be verified right now because my Fluke is not accurate enough (I have been looking at 6-1/2 digit meters but they are expensive).

The photo shows the setup. There is a capacitor on the circuit board (upper right corner) not shown on the schematic; it is connected across the power supply and is 470  $\mu\text{F}/35$  V. The Vishay resistor is below it. The divide by 10 switch is at the bottom. You can see how the divider accuracy was improved by tack soldering a resistor across another. This is a bit of a nuisance but often works better than using adjustable resistors when considering stability over time.

The voltage reference is in the plastic cube. There is a less expensive one available on a circuit board with 2 slide switches. I ordered one but it is currently out of stock. There is an unused op-amp in the IC package. I connected its output to the inverting (-) input.

