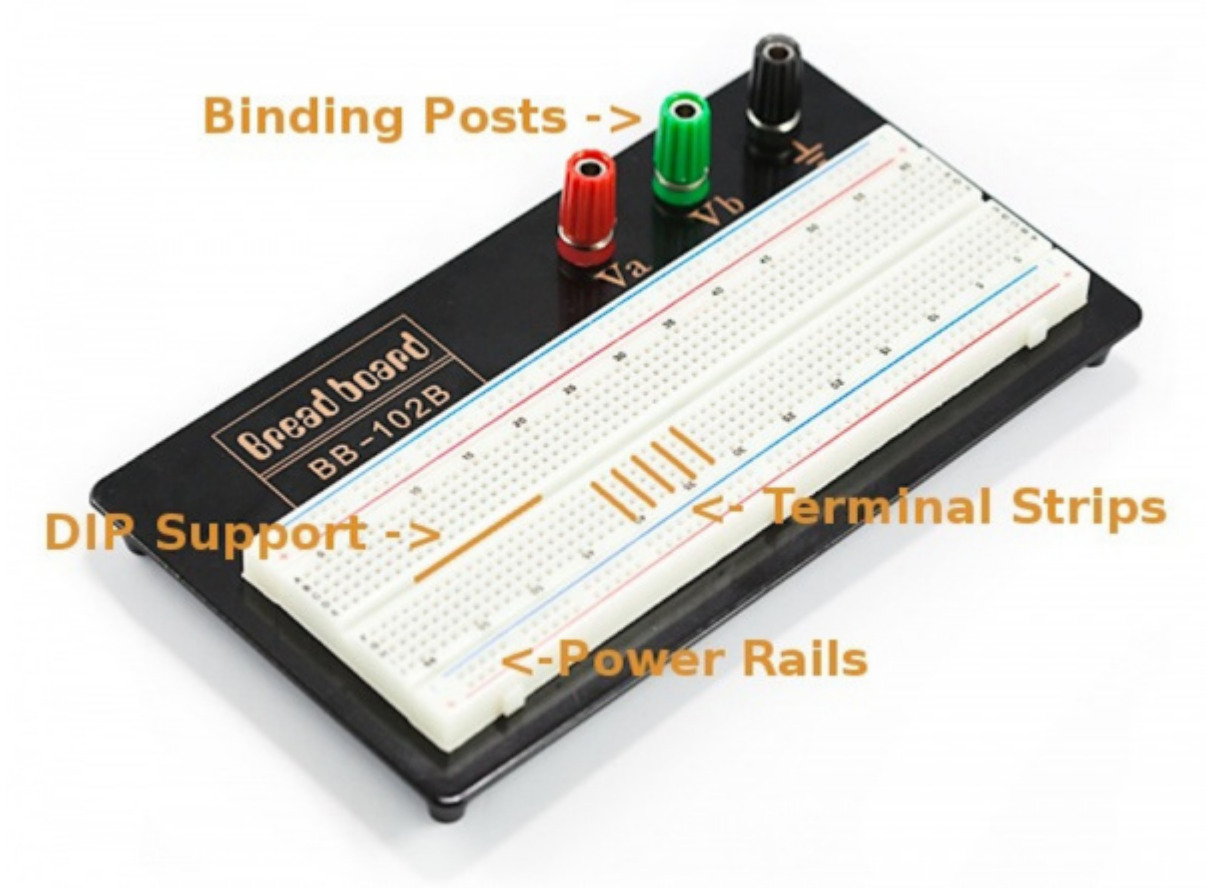
Voltage Divider and Breadboards Workshop

Learning Opportunities: breadboarding/prototyping, voltage and current basics, resistors, LEDs

Why Use Breadboards?

An electronics breadboard (as opposed to the type on which sandwiches are made) is actually referring to a solderless breadboard. These are great units for making temporary circuits and prototyping, and they require absolutely no soldering.



Prototyping is the process of testing out an idea by creating a preliminary model from which other forms are developed or copied, and it is one of the most common uses for breadboards. If you aren't sure how a circuit will react under a given set of parameters, it's best to build a prototype and test it out.

For those new to electronics and circuits, breadboards are often the best place to start. That is the real beauty of breadboards--they can house both the simplest circuit as well

as very complex circuits. As you might see in later workshops, if your circuit outgrows its current breadboard, others can be attached to accommodate circuits of all sizes and complexities.

Another common use of breadboards is testing out new parts, such as Integrated circuits (ICs). When you are trying to figure out how a part works and constantly rewiring things, you don't want to have to solder your connections each time.

As mentioned, you don't always want the circuit you build to be permanent. When designing new workshops, our Projects team will often use breadboards to build, test, and analyze the circuit. We can connect the parts we need, and once we've gotten the circuit setup and figured out any problems, we can take everything apart and put it aside for the next time we need to do some troubleshooting.

For 'prototyping' your project, we'll start with through-hole carbon film resistors since they're inexpensive and breadboard compatible. For the DIYer, the three important specifications of a resistor are the resistance value, the power (wattage) rating, and tolerance. (explain?)

Voltage Divider

Let's take a deeper look at how a voltage divider works.

Simply put, a voltage divider takes an input voltage and drops it by an amount that is proportional to the ratio of the two resistors that makeup the divider network. The output voltage across R2 is given by the following equation:

$$V_{out} = \frac{R_2}{R_2+R_1} * V_{in}$$

Let's talk a moment about how to decide the resistor values you will need for your voltage divider. To do so, you must take into account the load that will be connected to the output of the voltage divider. Let's assume our load is 1KΩ and requires 2V at 5mA. We now apply the "10% Rule" so that the "bleeder current" through R2 is 10% of the current that we want to follow through the load. In this case

$$I_{R2} = 0.10 \times I_{load} = 0.10 \times 5mA = 0.5\text{mA}$$

To calculate the value or R2 we calculate the following:

$$R_2 = V_{load} / I_{R2} = 5V / 0.5mA = 10K\Omega$$

Next we calculate the value for R1.

$$R_1 = \frac{Vbattery - Vload}{I_{R2} + I_{load}} = \frac{9V - 5V}{0.5mA + 5mA} = 727\Omega \cong 680\Omega$$

We can get closer to the calculated value by adding a 68Ω in series to the 680Ω resistor resulting in equivalent resistance of 748Ω.
Let's put all this together now and see if everything works out. First we have to make a slight modification to the first equation to take into account the series resistors and the loading on the circuit.

$$Vout = \frac{R_{eq}}{R_{series} + R_{eq}} \times Vbattery$$

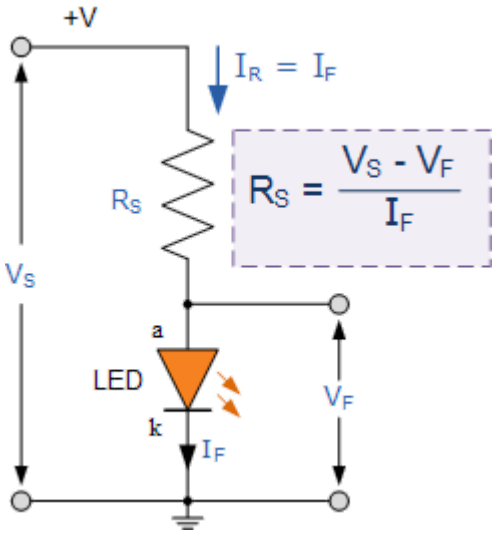
Where Req = R2 || R_load therefore Req = 909Ω and R_series = 680Ω+68Ω = 748Ω

Now apply those values to Equation 5.

$$Vout = \frac{909\Omega}{748\Omega + 909\Omega} \times 9V = 4.93V \cong 5V$$

Lastly, just make sure to calculate the power rating required for each resistor using the formula P=I^2*R. So there you have it, the voltage divider. A simple but useful circuit used in a great many applications we will be discussing.

LED and Resistor Series Circuit



Notes

- Power supplies, breadboards, and DMMs to be used in future projects; resistors and LEDs can be kept by students

BOM

- 9V power adaptors
- Small breadboard
- Digital Multimeter
- Resistors (?)
- LEDs