Worksheet No. XX: Experiment - Diode Temperature Sensor

Commented [1]: Only students who choose to make this sensor will get this worksheet

Background Reading

Background information on diodes and how they can be used as temperature sensors. Keep it short and simple - 1 to 2 pages with plenty of pictures. The main points to cover: (1) Diodes are electronic devices which are similar to resistors except their current grows exponentially rather than linearly with applied voltage, (2) the current for an applied voltage is dependent on the temperature of the diode. There are a couple of ways we can explain this - like using an analogy to water flow, or using a piecewise linear diode model (battery model or resistive model). We just need to give them the idea that they can measure the voltage across the diode to determine the temperature.

If the information is ok, then only needs rewording. If anything should be added/removed please add comments

Process behind a diode:
https://docs.google.com/document/d/1jKWdB0HIlwtrgEiBf8ivpGS5MVpOtIlHeml9zjOy-yl/edit?usp=sharing

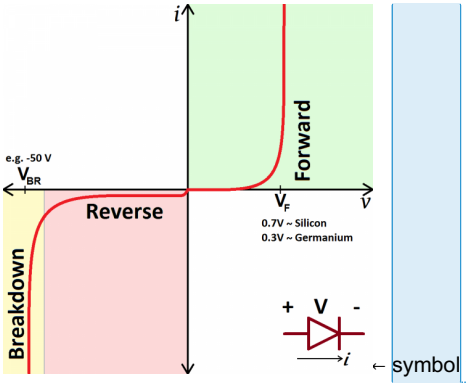
A diode is an electric component that can be used in a circuit. It operates similar to a resistor.

Deleted: looks

Remember that resistors are a simple component that cause a linear relationship between current and voltage. Ohm's law says Voltage = Current x Resistance. With a diode, the relationship between current and voltage is non-linear and looks like this:

Commented [2]: Remember to put in references

Commented [3]: It might be helpful for them to see the I-V of a resistor overlaid on top of the diode's



← symbol for a diode

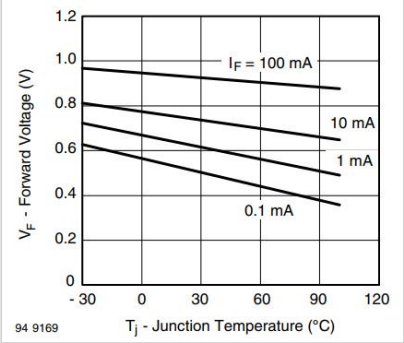
There are three important parts of this graph which are highlighted: forward, reverse, and breakdown. Based on the voltage applied, the diode will work differently.

When the voltage across the diode is positive, the diode will let current through. Once the voltage is greater than the forward voltage, current can be measured. This is the green, forward section of the graph.

When the voltage across the diode is negative but not too large, the diode will block effectively all of the current. This is the red, reverse section of the graph.

When the voltage across the diode is negative and large, it will overpower the diode and allow current to flow in the other direction. With the voltage used in most experiments you won't experience this. This is the yellow, breakdown section of the graph.

So a diode is like a one-way street. A one-way street only lets cars travel in one direction, like that a diode only lets current flow in one direction.
When voltage across a diode is positive and letting current through, another variable may affect the forward voltage of the diode. That forward voltage is the positive voltage point at which current becomes significant and something we can measure. If we keep current constant, and change the temperature, the amount of voltage across the diode will change.



What if we keep the voltage constant, will a change in temperature change something else?

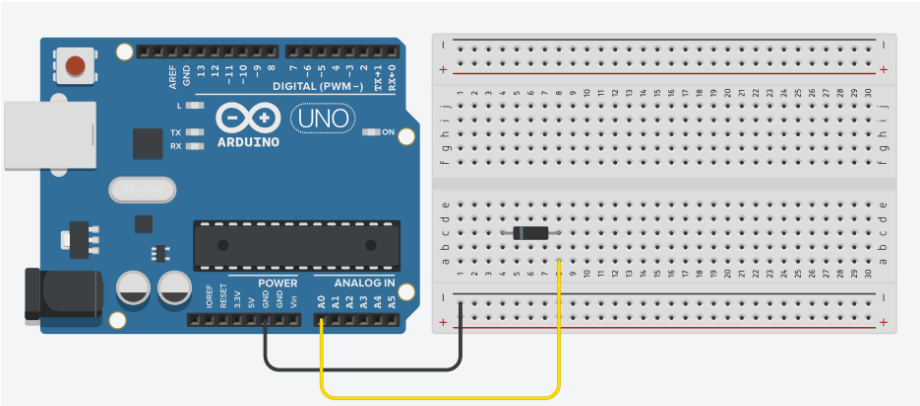
Commented [4]: I would say just ignore this part and put up a plot that only has the forward I-V. Use this space to explain the diode as an being on (V<Vf) or off (V>Vf), and maybe expand on the one-way street analogy (maybe the on/off can be a stop light).

Commented [5]: If we have the diode in series with a resistor, a change in temperature will cause both the voltage across the diode and the current through the elements to change. We should use the shifted I-V plots mentioned below and instead point out that the diode is 'turning on' at a much lower voltage and/or the current is much higher with increasing temperature.

Commented [6]: Use the shifted I-V plots instead - this will be difficult for them to interpret

Commented [7]: https://i.stack.imgur.com/Hqdpl.png

Commented [8]: I *think* at this point we will have shown them a voltage divider circuit and let them play with it. We should phrase this question as something like, "If we replace one of the voltage divider's resistors with a diode, how do you think the output voltage will vary with temperature?" And they just have to come to the conclusion that it will output voltage will decrease with increasing temperature.
We can talk about this at the mtg today though.



Equipment Required

- Arduino and Laptop
- Diodes
- Resistors
- Hot plate/ice cubes
- Thermometers or other temperature sensor for calibration
- Soldering equipment
- Multipurpose PCB

Worksheet No. XX

Instructions to guide the students through running an experiment in which they place a diode in series with a resistor, and measure the voltage across the diode at different temperatures. They will come up with an equation to determine this relationship, and program their arduino to convert voltage readings into temperature values.

Commented [9]: This might be better as a second worksheet. ALSO, the relationship here is exponential, which they are probably not familiar with. We should either let them plot their data in excel and choose a best fit trend line, or have them make an approximate linear fit. Not sure what would be best.