Pre-lab 6: Diodes

Today we enter the exciting world of *nonlinear* devices, and, more interestingly, the charm of 3-terminal devices. The latter are things like *transistors*, which come in two flavors: FETs (field-effect transistors) and BJTs (bipolar junction transistors). Today we'll see only the former, in the form of the nearly ideal MOSFETs (metal-oxide semiconductor field-effect transistor, quite a mouthful); we'll see the less-ideal (but more useful for some tasks) BJTs in the next lab. Transistors dominate the world of electronics — there are probably a billion of them in your cellphone (no kidding)!

Diodes

A diode is a 2-terminal device that can be thought of as a one-way valve for the flow of current. In the forward direction it conducts, happily, but with a "forward drop" of about 0.6 V; it's pretty well behaved, as long as you are OK with the ∼0.6 V drop. In the reverse direction it is pretty good at blocking current from flowing, with a small "leakage current" down in the microamps (or less, for small diodes).

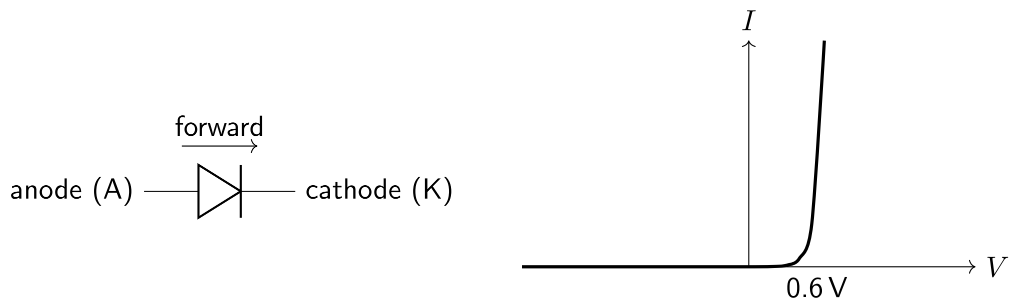

Figure 1: Diode and its current-vs-voltage curve.

At the *breakdown voltage* in the reverse direction a diode conducts abruptly (and often destructively), with breakdown voltages in the range of tens to hundreds of volts; you don't want to go there! But in carefully tailored *zener diodes*, the breakdown voltage is well defined, and such devices are useful for establishing a voltage within a circuit, as we'll see.

Diodes come in various sizes: the smallest are usually referred to as "signal diodes," and are expecting signals of low current, generally less than 100 mA. Big diodes are called *rectifiers*, and are used to deal with power conversion and the like, with currents up to many amperes.

Diode circuits

Let's review a couple of most common uses of diodes.

Clamp

Figure 2 show two types of voltage "clamps," which restricts the voltage range of the signal inside a fixed window. We've actually already built the circuit of part A, with LEDs instead of signal diodes, in Lab 2. As soon as the input voltage is higher than the diode's "forward drop," the diode starts conducting, drawing current through the resistor until the output voltage is just 0.6 V or −0.6 V, depending on the direction you placed the diode. These circuits are often used for protection: if you have a delicate

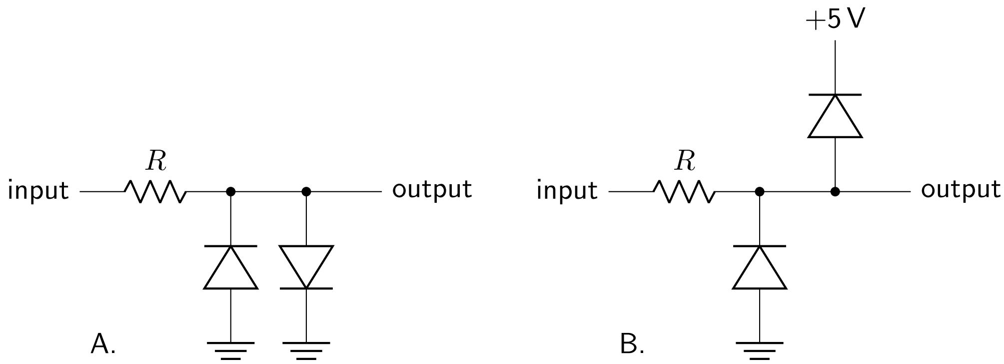

Figure 2: A. bidirectional clamp to allow signals between ±0.6 V. B. clamp to allow signals between −0.6 V and +5.6 V.

circuit, a diode clamp can ensure that the voltage entering the delicate circuit never exceeds a certain value.

Half-wave Rectifier Circuit

The circuit in Figure 3 exploits the nice properties of capacitors and diodes. If we send an AC signal through a diode (which acts, approximately, like a one-way valve for current flow) we'll get a lumpy "rectified" output waveform. Adding a capacitor stores charge in between the lumps, creating a smoothed DC voltage approximately equal to the peak voltage of the AC input signal.

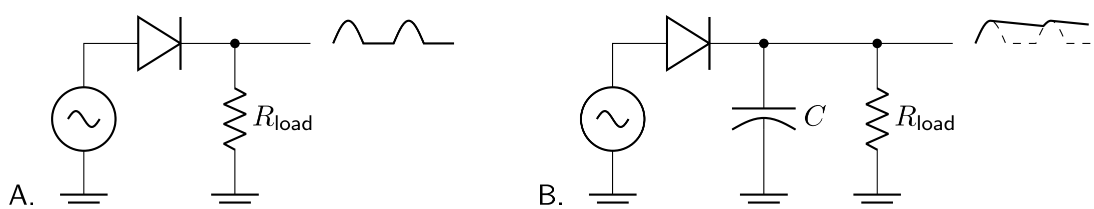

Figure 3: A diode rectifier captures the peak voltage of a varying input signal. This is how we convert AC to DC in every device that receives power from the AC powerline.

Pre-lab 6 Hand-in

Name: ____________________

Pre-lab 6.1 Sketch the output waveform you expect from the circuit of Figure 4 below, if it is driven with a $\pm 10\,\text{V}$, $1\,\text{kHz}$ triangle wave. (This circuit is often used to protect the inputs of logic circuits, which are damaged by signals that go beyond $+5\,\text{V}$ and ground)

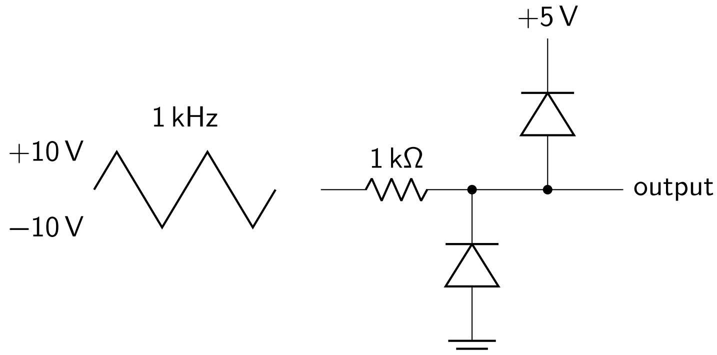

Figure 4: What does this circuit do?

From the last lab:

Pre-lab 6.2 RF Pickup A frequent problem, particularly in urban areas, is radio-frequency (RF) pickup into audio circuits (like stereos, or computer sound cards, etc.). Design a filter to eliminate $\sim 1\,\text{MHz}$ radio signals on a microphone input, while passing the full audio band (up to $10\,\text{kHz}$). Assume the microphone's source resistance is $100\,\Omega$, and that the sound card presents a load resistance of $10\,\text{k}\Omega$ (Figure 5).

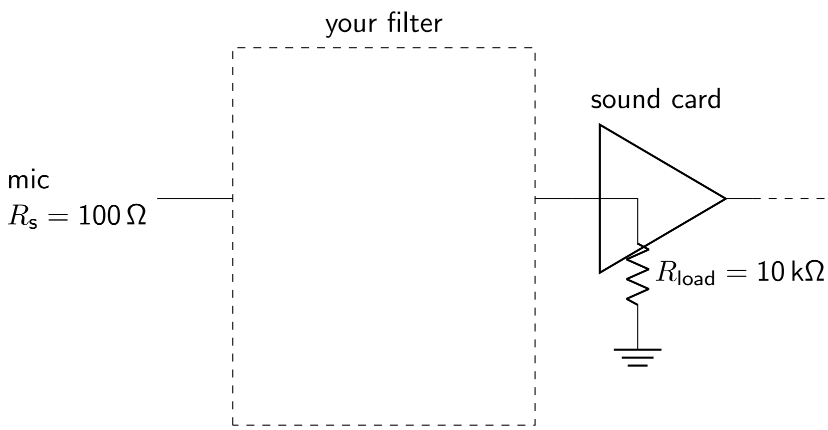

Figure 5: Audio circuit, missing a crucial filter.