EE 3310L/5310L · Electronic Devices and Circuits Laboratory

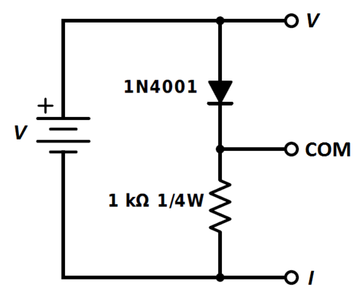
Lab 1: Forward Characteristics of Diodes; Clipping Circuit

Purpose

The purpose of this lab is to measure and plot the forward characteristics of two types of diodes and investigate a clipping/protection circuit.

Forward *V-I* Characteristics

In class, we mainly use a "constant-drop" model for diodes, in which a diode that is forward-biased is considered "ON" with a fixed voltage drop of $V_D \approx 0.7$ V for silicon rectifier diodes. We will measure the voltage of a 1N4001 rectifier diode and a red or green LED over a range of currents and use the data to plot V_D vs. I_D and V_{LED} vs. I_{LED}. Build the following circuit with a 1N4001 rectifier diode and 1-kΩ current sampling resistor as shown, and make sure the polarity is correct with the cathode (silver stripe) towards the resistor:



In order to make both voltage and current measurements at each data point quickly and with a minimum of rewiring, **we will monitor current by measuring the voltage drop across the 1-kΩ resistor**; this conveniently scales voltage to current in milliamperes. Then, to measure the diode voltage drop, we simply move the test probe to the other side of the diode. This way, we don't have to reconfigure our multimeter as an ammeter at each step. The only downside to this method is that we are technically measuring the voltage *rise* across the 1-kΩ resistor, so the measurements will appear negative; ignore that and just record the magnitudes.

1) Start with the variable DC bench power supply at its minimum voltage setting. Use an alligator clip lead to connect the negative (black) lead of your multimeter to the node labelled COM on the above schematic. Connect the positive (red) lead of the multimeter to the node labelled *I*. Slowly increase the power supply voltage while monitoring the voltage across the resistor until it reaches 20 mV, which corresponds to a forward diode current of 20 µA. Move the positive lead of the multimeter to the node labelled *V* and **record the forward diode voltage drop in the table**. Note that we are using a roughly geometric progression of currents in order to plot *V* vs. *I* over a usefully wide range.

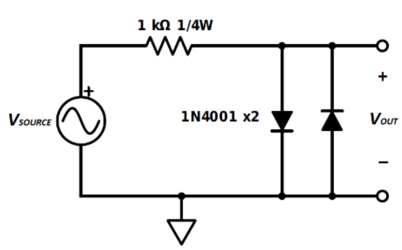
2) Repeat for each entry in the table. Note that the measurement at 20 mA dissipates 0.4 W in the 1-k resistor; this exceeds the ¼-W dissipation rating of the resistor, so make this measurement quickly and no damage is likely to occur.

3) **Repeat steps (1) and (2) for a forward-biased red or green LED.** NOTE: the easiest way to determine the polarity of an LED is to look at the lengths of the leads. The longer lead is the anode and points towards the power supply. You'll notice very quickly if it's installed backwards because the reverse currents will be very small. Fill in the corresponding column of the table. **Additionally, note the current at which light is first visible. Also, note the current at which the LED is sufficiently bright to serve as a "power on" indicator for an instrument or appliance.**

I **(mA)**	V_D **(V)**	Red Led V_{LED} **(V)**	
0.020	0.409	1.624	Dim
0.050	0.440	1.666	
0.10	0.464	1.696	bright enough to be a "power on" indicator
0.20	0.492	1.726	
0.50	0.530	1.765	
1.0	0.561	1.798	
2.0	0.594	1.838	
5.0	0.645	1.909	
10.0	0.681	1.984	
20.0	0.705	2.090	

Protection Circuit

In many sensitive instruments, such as the ECG preamplifier often found in clinical settings, it is important to protect against large-magnitude voltages and currents such as those that occur when a patient is defibrillated. Build the following circuit, often called a diode clipper; connect a function generator set to a 1-kHz sinusoid to the terminals marked V_{SOURCE} and an oscilloscope to V_{OUT}:



1) Set the oscilloscope for a clear view of at least one period of the sine wave with the generator set to minimum amplitude. Gradually increase the voltage until waveform distortion *just* starts to appear; **record the peak-to-peak amplitude at which this occurs**. Diode: 900mVPP Red LED: 2.9VPP

2) Now increase the function generator's output voltage to its absolute maximum. **Record the peak-to-peak amplitude of "hard" clipping, and also measure the generator's peak-to-peak voltage.**
Diode: 1.38VPP, 20.00VPP Red LED: 3.64VPP, 20.00VPP

3) Repeat (1) and (2) with a pair of red or green LEDs. Make sure their polarities are connected in opposition.
See above

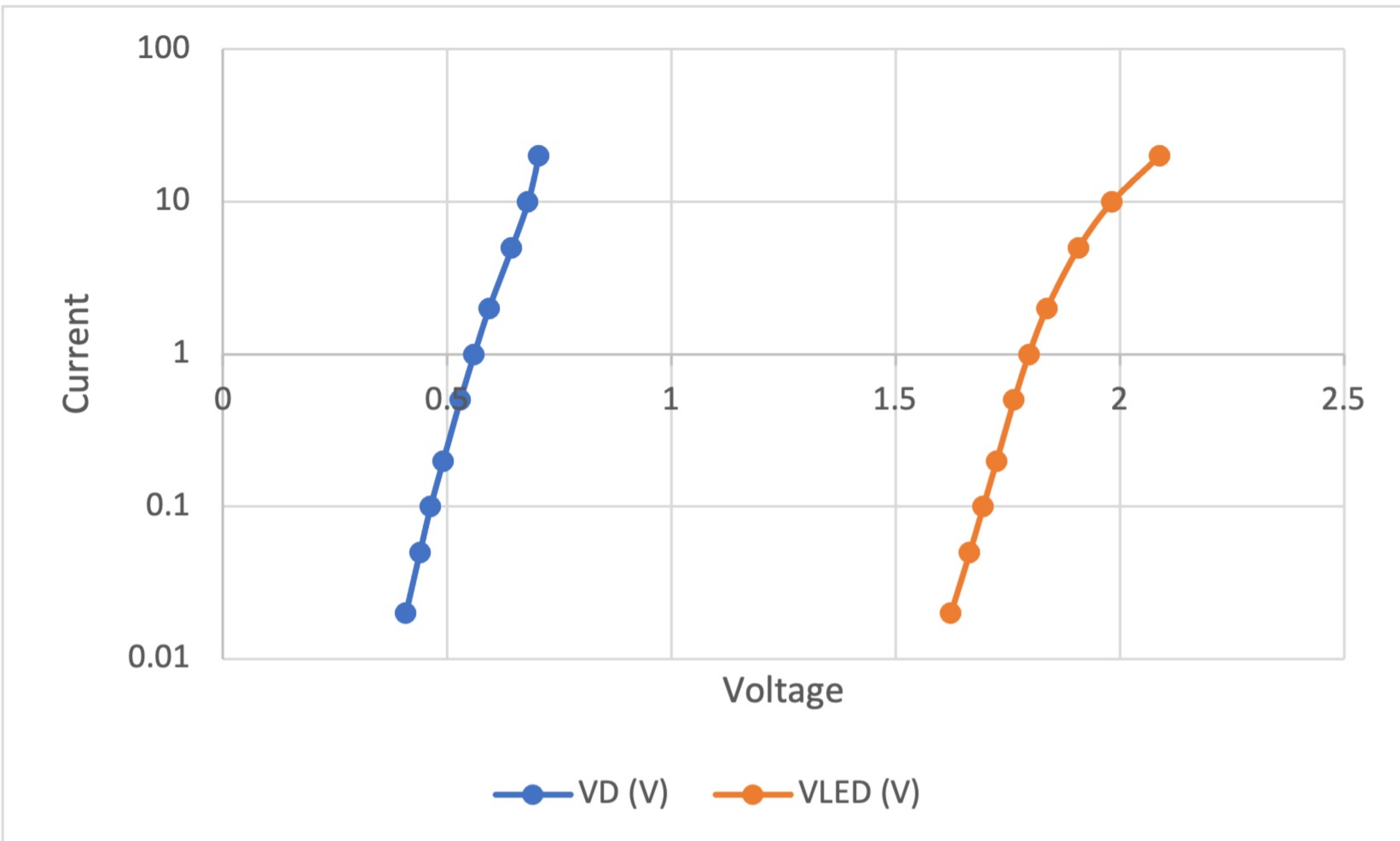
Postlab

1) Plot V_D vs. I_D and V_{LED} vs. I_{LED} on the same graph. Use the *y*-axis for current on a log scale, and the *x*-axis for voltage on a linear scale. See next page

2) Based on these curves, what would you estimate the constant-drop voltage to be for each type of diode, in the current range tested? Diode: approximately 0.681V Red LED: approximately 1.984V

3) Does the diode clipper circuit work as intended, to limit large peak-to-peak magnitude voltage swings? What is the ratio in dB between the maximum peak-to-peak generator voltage and the peak-to-peak voltage of the clipped output waveform?
yes

20log(20)/20log(1.38)=9.3011db around 9.3 to 1 ratio



100
10
1
0.1
0.01
Current
0
0.5
1
1.5
2
2.5
Voltage
VD (V)
VLED (V)