Experiment 1: The Silicon Controlled Rectifier

Intended Learning Outcomes

1. Be familiarized with the operation of an SCR.
2. Be able to obtain the commonly used SCR voltage and current parameters.
3. Be able to plot the SCR's characteristic curve.

Discussion

A Silicon Controlled Rectifier or the SCR is a unidirectional semiconductor device that behaves similar to a PN junction diode. However, unlike the PN junction diode, an SCR typically needs more conditions to start conducting. The SCR's schematic symbol and basic construction is shown on Fig. 1.1.

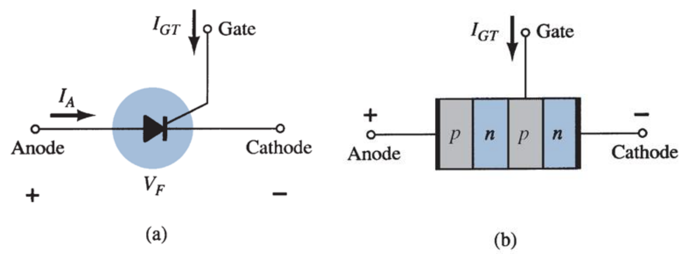

Fig. 1.1 (a) Schematic symbol and (b) basic construction of an SCR

SCRs are used in various applications such as controlled rectifier circuits, battery charging regulator, temperature controller, emergency lighting systems, etc. The main goal for this experiment is to familiarize the basic operation of an SCR and plot its characteristic curve.

Materials

LTSpice Simulator

Pre-Experiment: How to include the SCR's model file?

For this experiment (and for experiments that will use an SCR), we will be using a model file for the SCR devices since there are no built-in models for SCRs in LTSpice.

1. Download the text file attached and save it as EC103XX.txt in the LTSpice folder directory.
2. Use the SPICE directive: `.include /FILE_LOCATION/EC103XX.txt`. Do not forget to append the name `EC103XX.txt` in the SPICE directive.

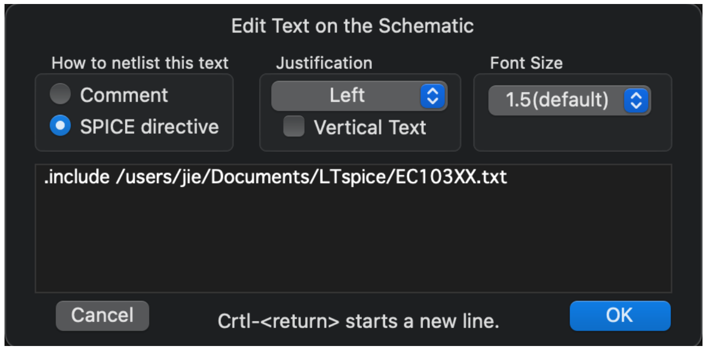

Fig. 1.2 Sample SPICE directive using `.include`

3. Search for circuit component `SCR` and add the component on your workspace.

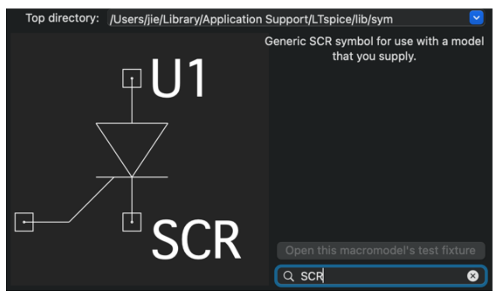

Fig. 1.3 The SCR component in LTSpice

4. Right click on the SCR's symbol in your workspace and change the value of the component `SCR` to `EC103D1` then select `OK`.

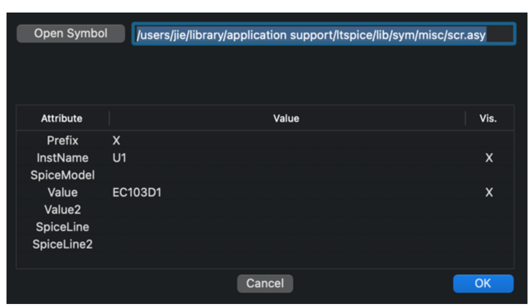

Fig. 1.4 Replacing `SCR` with `EC103D1`

Experiment Proper

Part A. Turning ON the SCR

1. Construct the experimental circuit shown in Fig. 1.5. Label the terminals across the resistor R5 as `V_LOAD+` and `V_LOAD-`. Also, take note that the values of R1 and R2 are parameters `{1k-RX-1f}` and `{RX+1f}`, respectively. With this arrangement, R1 and R2 simulates the sweeping action of a $1k\Omega$ potentiometer.

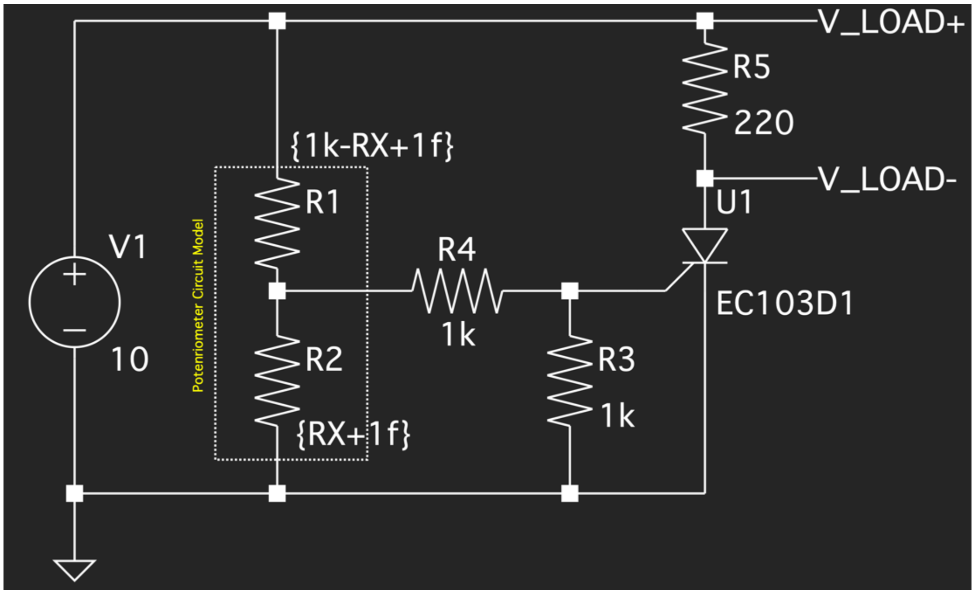

Fig. 1.5: Experimental Circuit for Procedure A

2. Using DC sweep simulation of circuit parameters, sweep the value of RX from 0Ω to $1k\Omega$ with a step of 1Ω.
3. Plot the voltage **across** the load resistor R5, the anode to cathode voltage, and the gate voltage of the SCR. In another plot pane, plot the anode current. **Label the region in which the SCR is ON and OFF.**
4. Using the plot pane's cursor, determine the value of RX that will turn ON the SCR. Record the data on Table 1.1.
5. Measure the load voltage, anode to cathode voltage, gate voltage, and the anode current when the SCR is ON and OFF, respectively.

Part B. Plotting the SCR's Characteristic Curve

1. Construct the experimental circuit shown in Fig. 1.6.

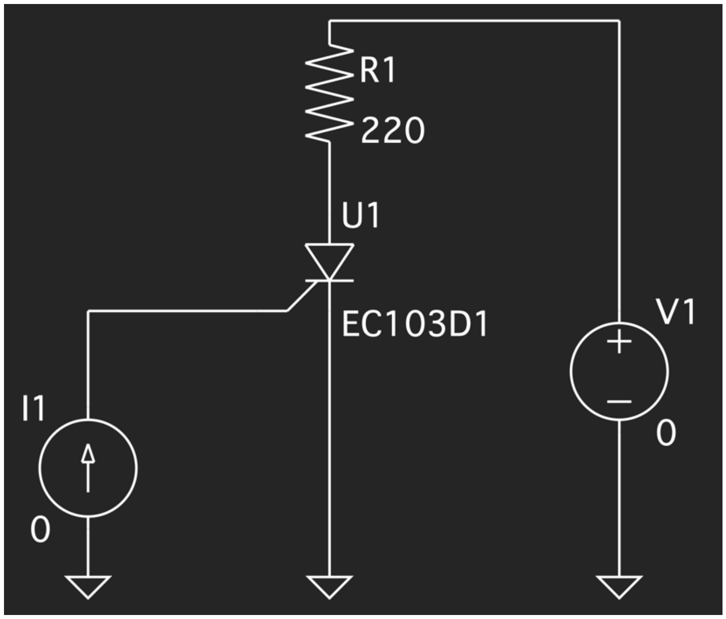

Fig. 1.6 The experimental circuit in plotting the device's IV curve

2. Using the DC sweep simulation, the **output characteristic curve** of the device can be plotted. Run a simulation that sweeps the voltage source V1 from 0V to 12V using a step size of 0.1V. Change the voltage displayed on the X axis with the voltage at the anode of the SCR.
3. Plot the anode current. This is the output characteristic curve of the device when the gate current is 0A.
4. Using the plot pane's cursors, measure the **average resistance of the SCR by using the cursors**. Kindly see Fig. 1.7 for your reference. To calculate the average resistance, take the ratio of ***Horz*** measurement to ***Vert*** measurement. Record the result to Table 1.2.

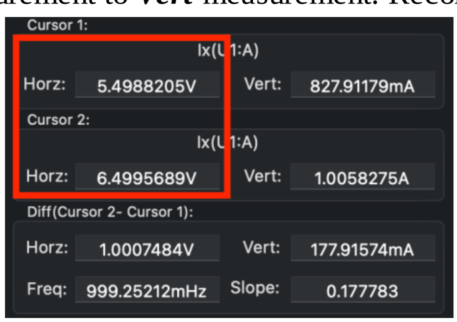

Fig. 1.7 Cursor setting

5. Change the value of the current source to 3mA and repeat steps 2 to 4, but this time measure the average resistance of the SCR on the region when it is conducting using the cursors.

6. Using the DC sweep simulation, the **output characteristic curve** of the device, including the breakover voltages, can be plotted. Run a simulation that sweeps the voltage source V1 from -1000 V to 1000 V using a step size of 0.1V. Change the voltage displayed on the X axis with the voltage at the anode of the SCR.
7. Plot the anode current. This is the output characteristic curve of the device when the gate current is 0A. Record the forward breakover voltage and reverse breakover voltage of the SCR on Table 1.3. Paste a picture of the characteristic curve on the report.
8. Change the value of the current source (also the gate current) to 5, 6, 7, 8, 9 and then 10 microamperes, and determine the lowest gate current at which the SCR is triggered before it reaches the forward breakover voltage. This is the IGT for the given conditions. Record it on Table 1.3.

· End of Experiment 1 ·

Group Report Format:

Group No.: ____________________
Group Members: ________________
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Part A:
Plot of Part A Simulations (Procedure 3):

<Insert Plot Here>

Table 1.1

Procedure 4		
R_X		
Procedure 5		
	ON	OFF
V_{LOAD}		
V_{AK}		
V_G		
I_{LOAD}		

Comment on the results for part A.

<Insert Comments Here>

Part B:
Plot of Part B Simulations (Procedure 3):

When I1 = 0A:

<Insert Plot Here>

When I1 = 3mA:

<Insert Plot Here>

Table 1.2

When I1 = 0	
Average Resistance of the SCR when off	
When I1 = 3mA	
Average Resistance of the SCR when on	

Steps 6 to 10 of Part B:

When I1 = 0A:

<Insert Plot Here>

Table 1.3

Forward Breakover Voltage When Gate Current = 0 A	
Reverse Breakover Voltage When Gate Current = 0 A	
Minimum Gate Current Required to Trigger SCR (IGT)	

Comment on the results of Part B:

<Insert Comments Here>

Conclusion:

<Insert Conclusion Here>