Experiment 6: : Triac and Diac AC Power Circuit

Intended Learning Outcomes

1. Be able to analyze the operation and characteristics of DIAC and TRIAC.
2. Be able to interpret the data and results of experiments using DIAC and TRIAC.

Discussion

The DIAC (Diode for AC) is a two-terminal parallel-inverse combination of semiconductor layers that permits triggering in either direction. For a DIAC to conduct, the terminal voltage should exceed the breakover voltage in either direction. The TRIAC (Trigger on AC) is essentially a DIAC with a gate terminal for controlling the turn-on conditions of the bilateral device in either direction. In other words, for either direction the gate current can control the action of the device in a manner very similar to that demonstrated for an SCR. Both DIAC and TRIAC can be used in Power Control Circuits (Phase Control Circuits). With these bilateral devices, the AC power delivered to the load can be controlled by varying the firing delay angle in both positive and negative half cycle of the AC supply.

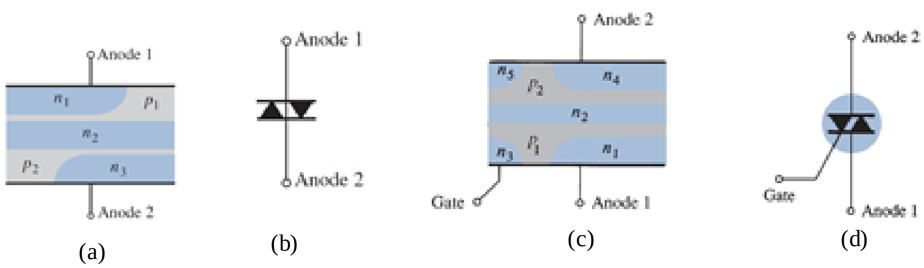

Fig. 6.1 (a) The construction and (b) schematic symbol of the DIAC, and (c) the construction and (d) schematic symbol of the TRIAC.

Materials

LTSpice Simulator

Experiment Proper

Part A.

1. Construct the circuit shown on Fig. 6.2. Don't forget to include the library model file of the DIAC. (Use the .include directive)

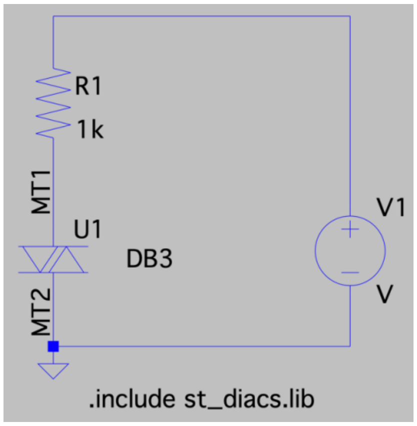

Fig. 6.2. Circuit for DIAC Characteristic Curve.

2. Sweep the supply voltage, V1, from -100V to 100V with a step size of 1V. (Use the .dc directive)
3. Change the X axis to the voltage across the terminals of the diac V(MT1).
4. Plot the current flowing through the Diac. This will plot the IV characteristic curve of the DIAC circuit. Measure and record the forward and reverse breakover voltages of the Diac on Table 1. Put your comments on the data and results on Table 1.

Part B

1. Construct the circuit shown on Fig. 6.3. Don't forget to include the library model file of the TRIAC and DIAC. (Use the .include directive)

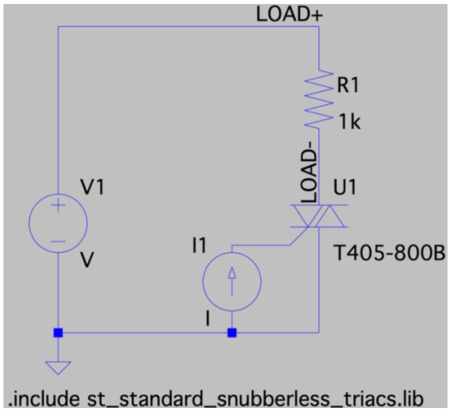

Fig. 6.3. Circuit for TRIAC Characteristic Curve (positive terminal voltages).

2. Set the current source I1 to zero.
3. Sweep the supply voltage, V1, from 0V to 2kV with a step size of 1 V. (Use the .dc directive)
4. Run simulation and change the X axis to the voltage across the Triac V(LOAD-). Plot the current flowing through the Triac. This will plot the IV characteristic curve of the TRIAC circuit **for positive terminal voltages**. Record the forward breakover voltage on Table 2 and paste a picture of the curves on the group report.
5. Change the current of I1 to 10mA and repeat step 4.
6. Change the circuit construction according to Fig. 6.4.

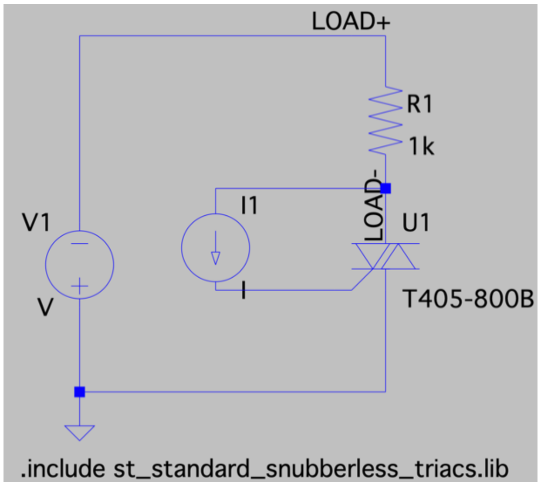

Fig. 6.4. The circuit for TRIAC Characteristic Curve (negative terminal voltages).

7. Again, set the current source I1 to zero.
8. Sweep the supply voltage V1 from 0 to 2kV with a step size of 1V. (Use the .dc directive)
9. Run simulation and change the X axis to the voltage across the Triac (VLOAD-).
10. Plot the current flowing through the Triac. This will plot the IV characteristic curve of the Triac **for negative terminal voltages**. Record the reverse breakover voltage of the Triac on Table 3 and paste a picture of the plot on the group report.
11. Change the current I1 to 10mA and repeat step 10.

Guide Questions: (a) What is the effect of the gate current in the operation of the TRIAC? (b) Why do we need to separate the simulation for positive and negative terminal voltages?

Part C

1. Construct the circuit shown on Fig. 6.5. Set the AC voltage source's amplitude and frequency to 100V and 60Hz, respectively.
2. Run a 100ms transient simulation. (Use the .tran directive)
3. Using different plot panes, plot the supply voltage V(LOAD+), load voltage **V(LOAD+,LOAD-),** and the TRIAC's terminal voltage **V(LOAD-)** for values of R3 shown on Table 4 (Group Report Format). Paste a picture of the voltages on the group report.

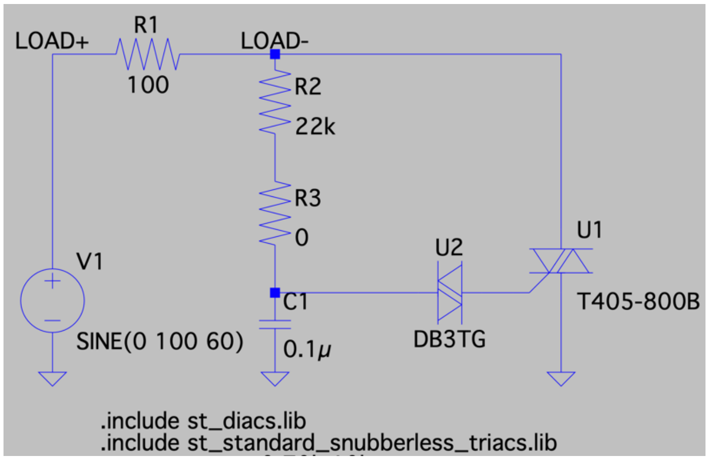

Fig. 6.5. The DIAC-TRIAC power (phase) control circuit

4. Measure and compute the firing delay angle for both the positive half and negative half of the signal. (See Appendix). Put your comments on Table 4.

Guide Question: What is the effect of the resistance R3 <u>to the average load power</u>?

· End of Experiment 6 ·

Group Report Format:

Group No.: ____________________

Group Members: ________________

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Part A:

Plot of Part A Simulations (Step 3):

<Insert Plot Here>

Table 1.

Forward breakover voltage	
Reverse breakover voltage	
Comments on the data and results	

Part B:

Plot of Part B Simulations (**Step 4**):

When $I_1 = 0\ A$:

<Insert Plot Here>

When $I_1 = 10\ mA$:

<Insert Plot Here>

Table 2.

Forward breakover voltage when gate current is equal to 0 mA	
Forward breakover voltage when gate current is equal to 10 mA	
Comments on the data and results and guide questions	

Plot of Part B Simulations (**Step 10**):

When $I_1 = 0\ A$:

<Insert Plot Here>

When $I_1 = 10\ mA$:

<Insert Plot Here>

Table 3.

Reverse breakover voltage when gate current is equal to 0 mA	
Reverse breakover voltage when gate current is equal to 10 mA	
Comments on the data and results and guide questions	

Part C:
Plot of Part C Simulations (Step 3):

When $R_3 = 0\Omega$:

<Insert Plot Here>

When $R_3 = 10k\Omega$:

<Insert Plot Here>

When $R_3 = 20k\Omega$:

<Insert Plot Here>

When $R_3 = 30k\Omega$:

<Insert Plot Here>

When $R_3 = 40k\Omega$:

<Insert Plot Here>

When $R_3 = 50k\Omega$:

<Insert Plot Here>

When $R_3 = 60k\Omega$:

<Insert Plot Here>

When $R_3 = 70k\Omega$:

<Insert Plot Here>

Table 4

R3	α^+	α^-
0		
10k		
20k		
30k		
40k		
50k		
60k		
70k		
Comments on the data and results and guide question		

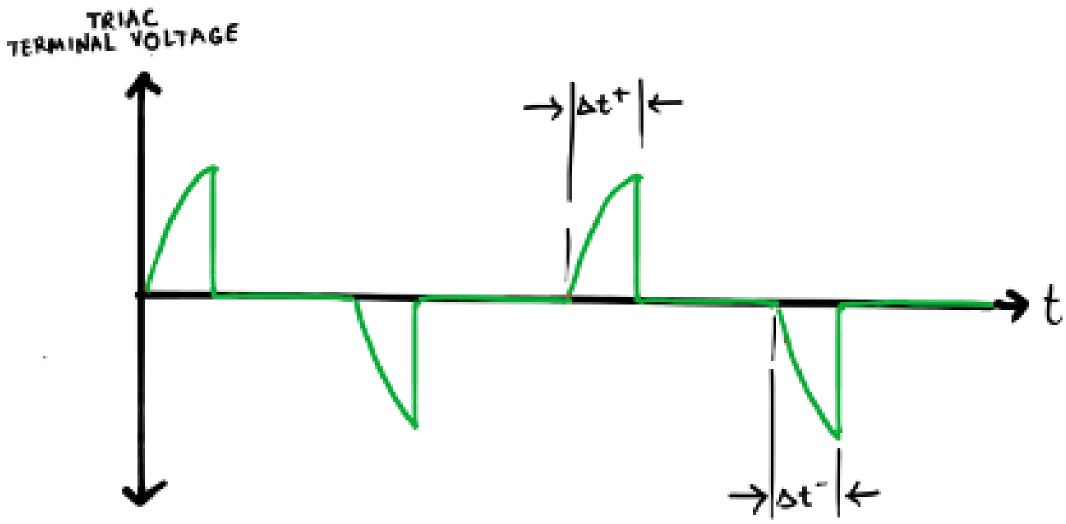
Conclusion:

<Inset Conclusion Here>

Appendix:

Computing the Firing Delay Angle

1. Plot the TRIAC's terminal voltage and zoom it in an area where the circuit already operates in the steady state.
2. Using cursor, measure Δt^{+} and Δt^{-} as shown below.



3. Compute for the firing delay angles:

$$\alpha^{+} = 60 \cdot 360° \cdot \Delta t^{+}$$

$$\alpha^{-} = 60 \cdot 360° \cdot \Delta t^{-}$$