EEE419/519 Experiment #3

Preliminary Part:

1. Design a circuit to demonstrate the storage time of a p-n junction diode. Note that the signal generator in the lab is able to generate a pulse with a DC offset. It has an internal source resistance of 50Ω. Explain how you find the lifetime of carriers (typically τ_p). Simulate the designed circuit with LTSpice using 1N4007 and UF2003 (UF4003) and find the lifetime of carriers in those devices.
2. Using LTSpice simulate the circuit given below containing 2N6509 thyristor. Use LM339.lib to simulate the comparator. A comparator is an uncompensated OPAMP that has a fast response. It should not be used with negative feedback since it may oscillate. Use EC103M thyristor in EC1033xx.lib to simulate the thyristor. Use a 36Vrms 50Hz sinusoidal signal generator to excite the circuit. Use 1N4007 to simulate the pn diode. Find the power dissipated on the load resistor R_L as a function of the value of the variable resistor (trimpot). Note that for an accurate power measurement you have to have an integer number of cycles on the window.

Experimental Part:

1. Setup your circuit to demonstrate the storage time of a 1N4007 P-N diode. Find the lifetime of carriers (typically τ_p) using your method.

2. Replace the diode with a UF2003 diode. Find the lifetime of carriers for this diode.

3. Set up the following thyristor circuit. Use the available line-voltage transformer (220Vrms to 36Vrms).

   By adjusting the variable resistor, set the position of the gate pulse (generated at the output of the comparator) at 3ms delayed with respect to the zero of the sine wave.

   Measure the voltage across the load resistor R_L=68Ω (11W resistor) using the oscilloscope. Note that you can use AC Line as the source for triggering the scope. Measure V_T and V_A with respect to the ground. A second probe is needed to measure the voltages simultaneously. You can use the MATH menu to find the difference between two measurements. The voltage across R_L is the difference between these two measurements.

   If you cannot use a second probe, measure the voltage across R_L using the oscilloscope directly without the difference operation (Connecting the ground end of the oscilloscope to a non-ground node is, in general, not the recommended method). As long as there is no other ground point, you can connect the oscilloscope ground to either terminal of R_L.

   Measure the voltage across R_L using the DC voltmeter of your multimeter.

4. Measure the forward ON state voltage, V_{TM}, of the thyristor with R_L=68Ω using the oscilloscope. This is the voltage across the anode, V_A, after the thyristor is triggered.

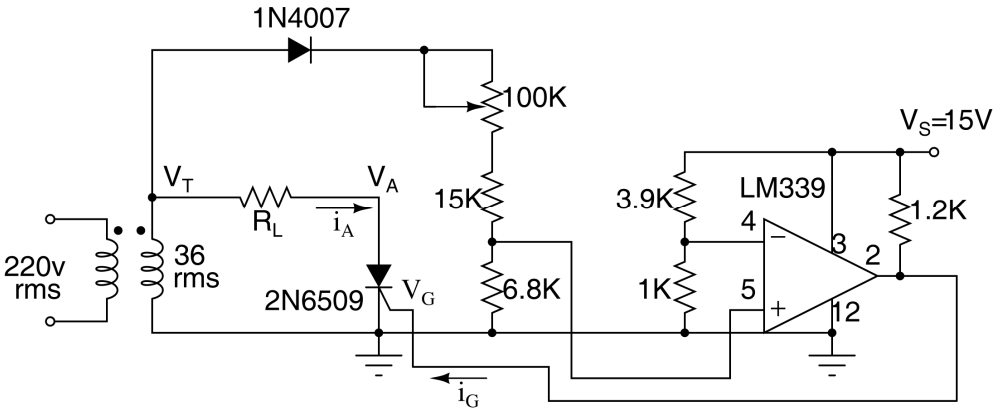
5. Measure the gate voltage, V_{GT}, of the thyristor while it is conducting.

6. Measure the minimum gate current, I_{GT}, required for triggering by adjusting the V_S=15V supply voltage of LM339. Since 1.2K supplies the triggering current, the trigger current is $I_{GT}=(V_S-V_{GT})/1.2K$.

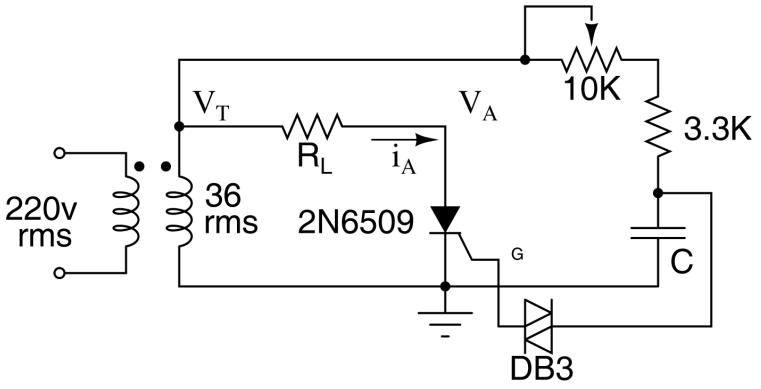
7. Measure the holding current, I_H, with R_L=1K. With a current less than the holding current, the thyristor does not stay ON after the trigger current is removed. You can find this value by measuring the anode current at which the thyristor turns off. Use the oscilloscope to determine the supply voltage, V_T, just before the thyristor turns off. The holding current is $I_H=(V_T-V_{TM})/1K$.

   For an accurate measurement, save the voltage V_A to RefA using SAVE/RECALL button. This waveform shows the time point where the thyristor turns off. Use REF MENU button to display the stored RefA while measuring V_T.

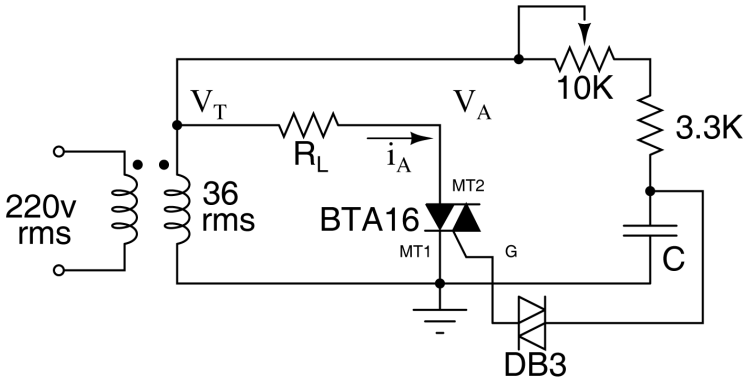
8. Record the turn-on transient with R_L=68Ω by focusing on the fall time of the voltage V_T. Notice that you need to trigger the oscilloscope on the falling edge of the signal to measure the fall time accurately.



9. Set up the following circuit where LM339 is replaced with a diac DB3 and RC circuit. With R_L=68Ω measure and record V_A for C=0 (no cap), 0.1μF and 0.22μF (unpolarized). Find the breakover voltage, V_{BO}, of diac DB3 by measuring the voltage across the capacitor, VC, at the point of trigger: $V_{BO}=V_C-V_{GT}$.



10. Replace 2N6509 with a triac (bidirectional thyristor) BTA16-800SW3G (MT1 at cathode, MT2 at anode position) as in the following circuit. Record V_A waveform for C=0, 0.1 and 0.22μF. Measure the voltage across the load resistor for one of the cases using a true-rms and a non-true-rms AC voltmeter. Note that if the AC voltmeter is not true-rms, the reading will be erroneous since the waveform is not sinusoidal.



In your report, compare your measurement results with those in the datasheet of the relevant components.