MINISTRY OF HIGHER EDUCATION & SCIENTIFIC RESEARCH
DIYALA UNIVERSITY
COLLEGE OF ENGINEERING
ELECTRICAL POWER & MACHINE DEPARTMENT

INDUSTRIAL POWER ELECTRONIC LABROTORY

PRACTICAL EXPERIMENTS IN POWER ELECTRONIC

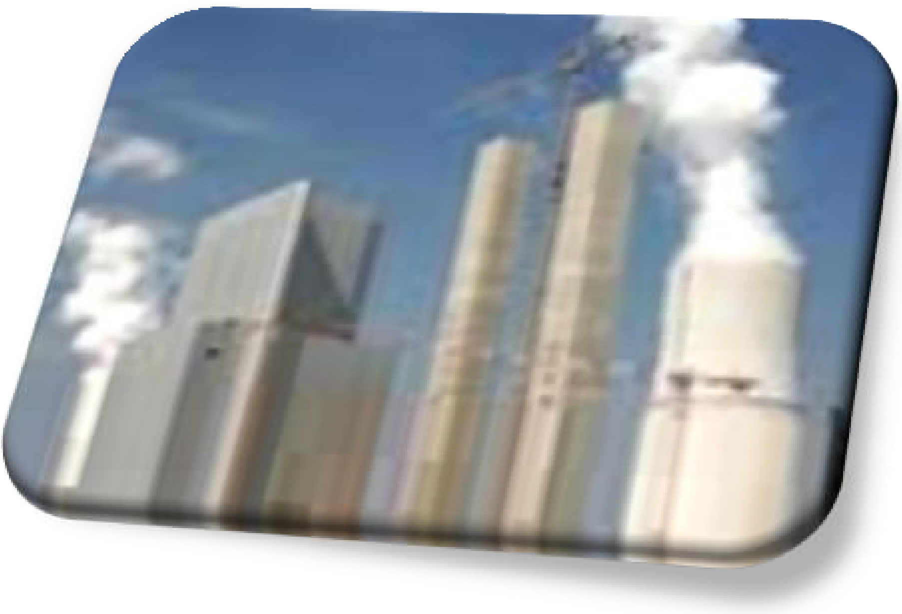
FOR STUDENTS OF THIRD STAGE

EXPERIMENT NO.8

EXPERIMENT NA.SCS CHARACTERISTICS

PREPARED BY: MOHAMED ABD ALLA KHALID.
HASSAN ALI TAEEH.
AMMAR AHMED AL- MAFRAJY.

THE RESPONSIBLERS OF POWER ELECTRONIC LABORATORY
OLDEST CHIEF ENGINEER. MOHAMED ABD ALLA KHALID.
OLDEST TECHNICAL MANEGER. HASSAN ALI TAEEH .



XPERIMENT 8

SCS CHARACTERISTICS.

A WORD OF THE CHIEF OF ELECTRICAL POWER & MACHINE DEPARTMENT

Dear students

I'm hoping you will be benefit from studying this experiment. ask your teacher about all problems that will accrued in connection of the experiment circuit &

look please ....

You must success in all measurements you followed according to the experiment procedure & You must getting about the products to be enabled in scs characteristics. the discussion will help you in understanding & conclusion ,be remembered your answers must be right & limited.

Good luck

the Chief of electrical power & machine department

PH.D

NISREAN KHAMMASS SABAE

OBJECTIVE

1. Understanding the construction and characteristics of an SCS.
2. Understanding the operation of SCS circuits.
3. Measuring and plotting the characteristic curve of the SCS.

DISCUSSION

The silicon-controlled switch (SCS) is a four-terminal semiconductor device including two control gates. The SCS is usually used as a control element in low power control systems.

SCS Construction and Characteristics

The SCS, like the conventional SCR, is a four-layer PNPN device shown in Fig. 8-1(a). All four layers of the SCS are available due to the addition of an anode gate G_A. The additional gate allows the designer more flexibility in turn-on and turn-off controls than the conventional SCR. In addition, a proper bias applied to the anode gate increases the trigger sensitivity for the cathode gate. The cathode gate can be employed as an output terminal.

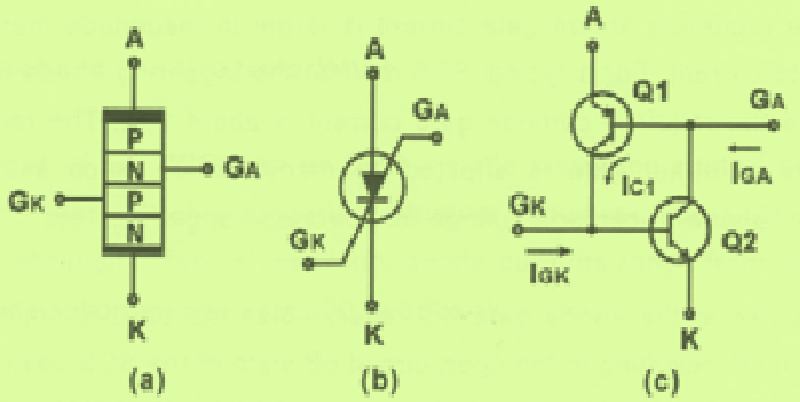


Fig.8-1 SCS. (a) PNPN structure, (b) circuit symbol, (c) two-transistor equivalent

Fig. 8-2 shows the anode characteristics for the SCS. We will notice the similarity to the SCR anode characteristics. With no gate signal applied, when the anode forward voltage reaches the breakover voltage V_{BO}, the SCS is turned on. If the anode current decreases below the holding current I_H, the SCS turns off. In most applications the SCS is usually turned on or off by gate signals with operating voltage below V_{BO}.

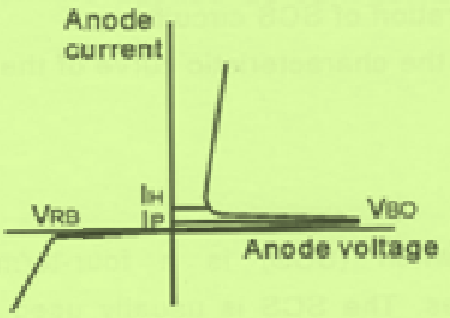


Fig.8-2 SCS anode characteristics

Form the equivalent transistor circuit, shown in Fig. 8-1(c), the cathode gate G_K of the SCS acts as the gate of SCR. The anode gate G_A can be used to turn the SCS either on or off. To turn on the device, a negative pulse must be applied to the anode gate G_A, while a positive pulse is required to turn off the SCS.

A negative pulse at the anode gate will forward-bias the base-to-emitter junction of Q1 (PNP), turning it on. The resulting heavy collector current I_{C1} will turn on Q2 (NPN), resulting in a regenerative action and the on state for the SCS device. In general, the triggering anode gate current is larger in magnitude than the required cathode gate current. For a typical SCS device, the triggering anode gate current is 1.5mA while the required cathode gate current is about 1μA. The required turn-on gate current at either gate is affected by many factors, such as the operating temperature, anode-to-cathode voltage and circuit arrangement, etc.

A positive pulse at the anode gate will reverse-bias the base-to-emitter junction of Q1, turning it off, resulting in the open-circuit off state of the SCS device.

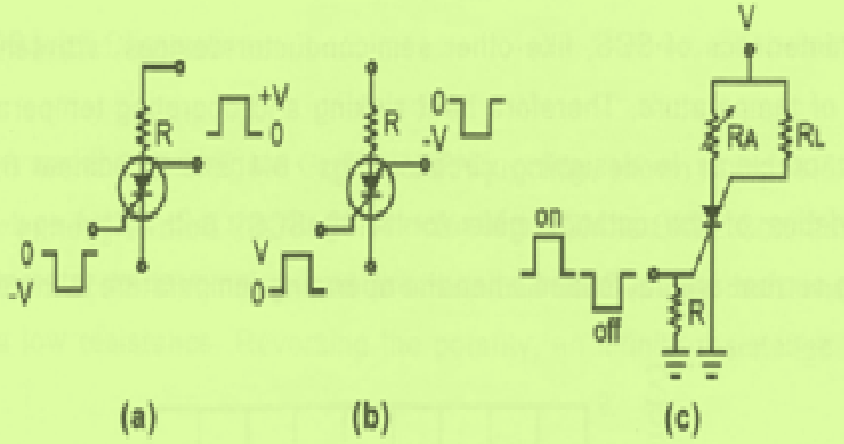


Fig.8-3 SCS gate turn-on and turn-off methods

Fig. 8-3 shows the types of gate turn-on and gate turn-off the SCS circuits. A positive pulse applied to G_A or a negative pulse applied to G_K will turn the SCS off as shown in Fig. 8-3(a). Fig. 8-3(b) shows that either applying a negative pulse to G_A or applying a positive pulse to GK can turn on the SCS. The circuit of Fig. 8-3(c) can be turned either on or off by a pulse of the proper magnitude at the G_K. The turn-off characteristic is possible only if the correct value of R_A is employed. It will control the amount of regenerative feedback, the magnitude of which is critical for this type of operation. Note the variety of positions in which the load resistor R_L can be placed. Another type of turn-off circuits for the SCS can be achieved by connecting the collector and emitter of an NPN transistor to the anode and cathode of the SCS in parallel. When a positive pulse is applied to the base, the transistor conducts heavily, resulting in a low-impedance characteristic between collector and emitter. This low-impedance branch diverts anode current away from the SCS, dropping it below the holding value and consequently turning it off.

SCS Specifications and Characteristics

The advantages of the SCS over an SCR include increased control and triggering sensitivity and more flexible triggering situation. However, the SCS is limited to low-power applications. Typical maximum anode currents range from 100 to 300mA with power dissipation ratings from 100 to 500mW.

A remaining advantage of the SCS over a corresponding SCR is the reduced turn-off time, typically within the range 1 to 10μS for the SCS and 5 to 30μS for the SCR.

The characteristics of SCS, like other semiconductor devices, are sensitive to the variation of temperature. Therefore heat sinking and operating temperature are the important problems in designing circuits. Figs. 8-4 and 9-5 show the triggering characteristics of the cathode gate for 3N82 SCS. Both triggering voltage and triggering current are decreased when the operating temperature is increased.

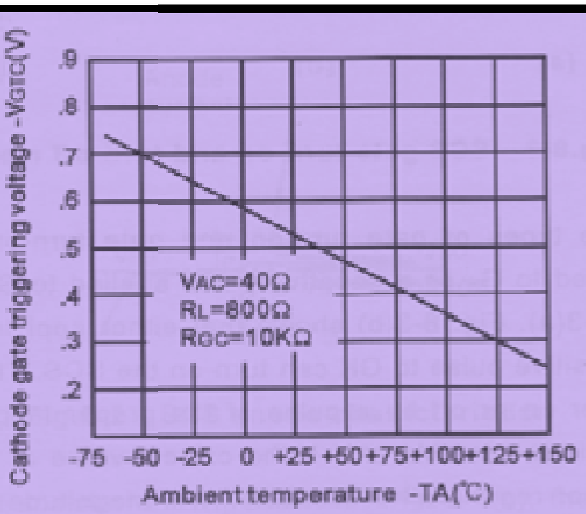


Fig.8-4 G_K triggering voltage vs. temperature

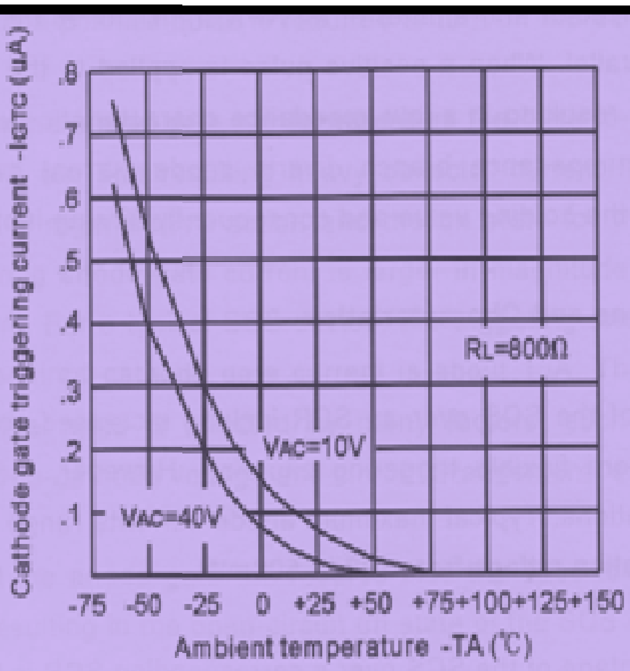


Fig.8-5 G_K triggering current vs. temperature

Testing SCS with Ohmmeter

The anode A and the anode gate G_A form a PN junction, shown in Fig. 8-6, as p-type for A and n-type for G_A. Set the range selector of a VOM to OHM. Connect the black lead of ohmmeter to terminal A and the red lead to G_A. The resistance reading should be a low resistance. Reversing the polarity, an infinite resistance should be indicated.

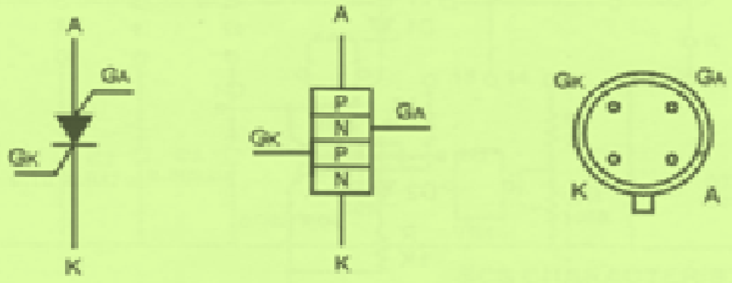


Fig.8-6 Symbol, PNPN structure and terminal identification for SCS

The PN junction between the cathode K and cathode gate GK is similar to the junction between the anode and anode gate except that the polarity is reversal. Connect black lead of the ohmmeter to G_K and red lead to K, the resistance reading should be a low resistance. Reversing the polarity, an infinite resistance should be indicated.

The resistance between G_A and K or between A and G_K is always infinite.

With both G_A and G_K open and connecting the black lead to A and the red lead to K, a low resistance should be indicated on the scale. Reversing the polarity, the resistance reading should be infinite. Connecting A to G_A directly or a small resistor between them, the resistance between A and K is infinite despite the polarity. The same results are available when the A and G_K terminals are connected together or a small resistor is connected between them.

Simulating SCS with Two Transistors

The SCS, like the PUT, can be built by using NPN and PNP transistors connected as shown in Fig. 8-7. The diode D1 is used to increase the reverse anode voltage. D2 and R are used to lower the gate triggering sensitivity. The smaller the resistance, the lower the sensitivity becomes.

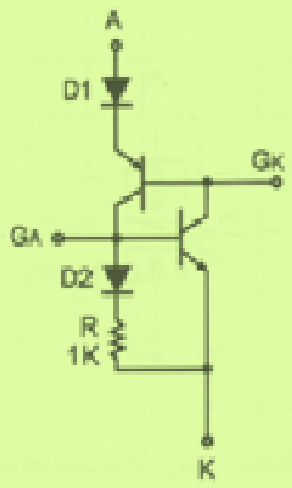


Fig.8-7 Two transistors simulating an SCS

Description of Experiment Circuit

The experiment circuit for SCS characteristics is shown in Fig. 8-8. The magnitude of resistance connected to the cathode gate G_A determines the triggering sensitivity of the cathode gate. Therefore we use VR5 to vary the gate triggering sensitivity in the experiment of SCS characteristics measurement. When R_{GA} increases, the triggering sensitivity of G_K increases. In other words, the blockover voltage is reduced by an increase in triggering sensitivity under a specified I_{GK} condition. With G_K open or connecting a small resistor in parallel with terminals G_K and K, the operation of SCS is like the PUT.

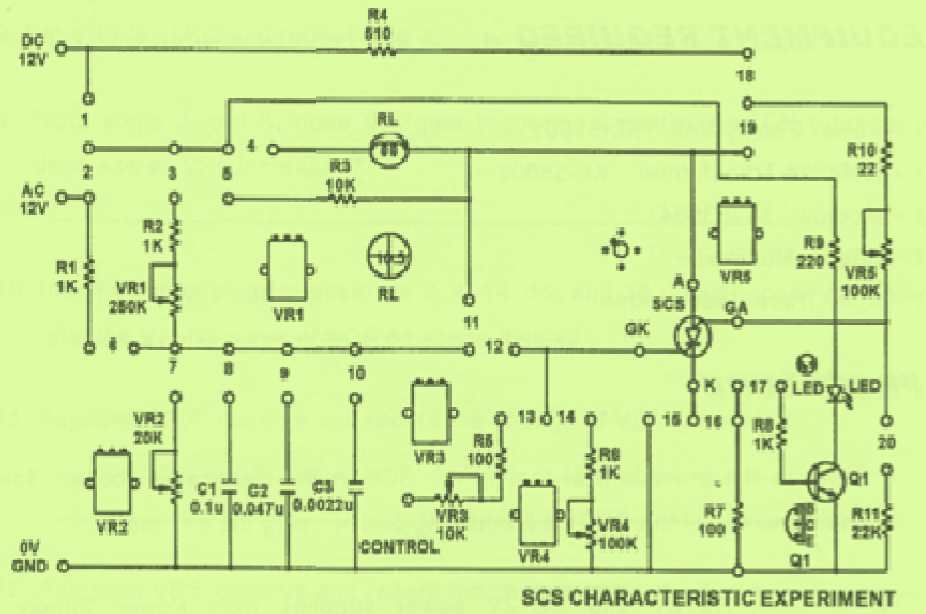


Fig.8-8 Experiment circuits

There are a number of methods used to turn off the SCS in conduction. The turn-off methods used in SCR circuits are available in SCS circuits. In addition, appropriate pulses can be applied to the gates to turn off the SCS. As shown in Fig. 8-9, applying a negative pulse to the cathode gate or a positive pulse to the anode gate will turn the SCS off. When a capacitor is connected in parallel with the anode and cathode as shown in Fig. 8-9(c), a negative pulse is able to turn off the SCS too.

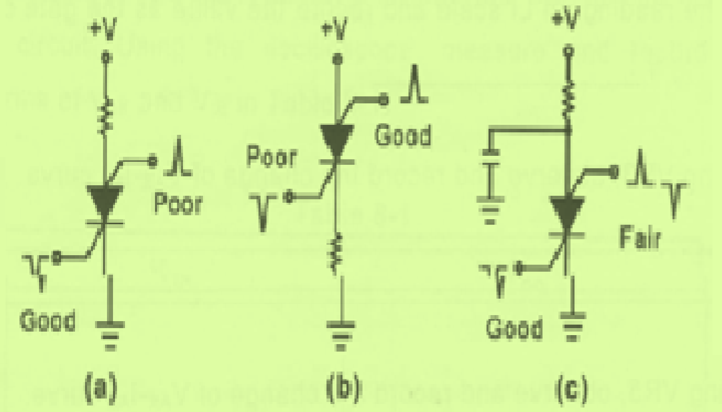


Fig.8-9 Comparison of gate triggering sensitivity to turn off the SCS

EQUIPMENT REQUIRED

1 – Power Supply Unit KL-51001
1 – Isolation Transformer KL-58002
1 – Module KL-53004
1 – Analog Multimeter
1 – Dual-Trace Oscilloscope

PROCEDURE

1. Refer to the procedure of testing the SCS in the discussion above. Identify the terminals of the SCS on Module KL-53004 using the ohmmeter.

2. Connect AC12V and DC12V power supplies from Power Supply Unit KL-51001 · KL-58002 to Module KL-53004. Insert connect plugs in positions 2, 4, 13, 15, and 19. Connect the H input of oscilloscope to the test point at the left end of RL, terminal GND to the cathode, and the V input of scope to the anode of the SCS.

3. Set the oscilloscope to X-Y mode. Connect the black lead of ohmmeter to CONTROL terminal and the red lead to GND. Adjust scope controls to plot V_{AK}-I_{AK} characteristic curve of the SCS on scope display.

4. Read the reading on LI scale and record the value as the gate current I_G of the SCS. I_G = ________________

5. Adjusting VR3, observe and record the change of V_{AK}-I_{AK} curve.

6. Adjusting VR5, observe and record the change of V_{AK}-I_{AK} curve.

7. Adjust VR5 to 1KΩ. Adjust VR3 to set the SCS blockover voltage to 10V. Repeat step 4. I_G = ________________

8. Set VR5 to 10KΩ and repeat step 7. I_G = ____________________

9. From steps 7 and 8, does the gate triggering sensitivity of GK increase or decrease as VR5 increases?

10. Insert connect plugs in positions 2, 4, 14, 15, and 18. Adjust scope controls to plot the V_{AK}-I_{AK} curve of SCS on scope display.

11. Adjusting VR4, observe and record the change of V_{AK}-I_{AK} curve.

12. Adjusting VR5, observe and record the change of V_{AK}-I_{AK} curve.

13. Compare the difference of the G_K triggering sensitivities at the higher and lower values of VR5.

14. Connect connect plugs in positions 1, 5, 6, 7, 12, and 15. Adjust VR2 to get the voltage of 3V across VR2. At this time the SCS circuit acts as Schmitt trigger circuit. Using the oscilloscope, measure and record the voltage waveforms of V_{AK} and V_{IN} in Table 8-1.

Table 8-1

V_{IN}	V_{AK}

15. Using the oscilloscope, determine and record the upper and lower voltages of Schmitt trigger circuit.

V+= ________________ V; V-= ________________ V

Connect a sinewave to the input of Schmitt trigger. Observe the output voltage waveform. Is the output waveform a square wave?

16. Insert connect plugs in positions 1, 3, 10, 11, 16, 17, 18, and 20. Firstly turn the knob C.W. fully. Adjust VR5 to get $V_{GA} \geqq 5V$. Adjust VR1 to obtain a visible waveform of the capacitor voltage on scope display. Measure and record the voltage waveforms of V_{GAK} and V_K in Table 8-2.

Table 8-2

V_{GAK}	V_K

17. Remove the connect plug from position 10 and then insert it in position 9. Adjust VR1 to obtain a visible waveform of the capacitor voltage displayed on scope. Measure and record the voltage waveforms of V_{GAK} and V_K in Table 8-3.

Table 8-3

V_{GAK}	V_K

18. Remove the connect plug from position 9 and then insert it in position Adjust VR1 to obtain a visible waveform of the capacitor voltage displayed on scope. Measure and record the voltage waveforms of V_{GAK} and V_K in Table 8-4.

Table 8-4

V_{GAK}	V_K

19. Is the SCS operation similar to the PUT?

CONCLUSION

You have examined the characteristics of the SCS and constructed several SCS application circuits.

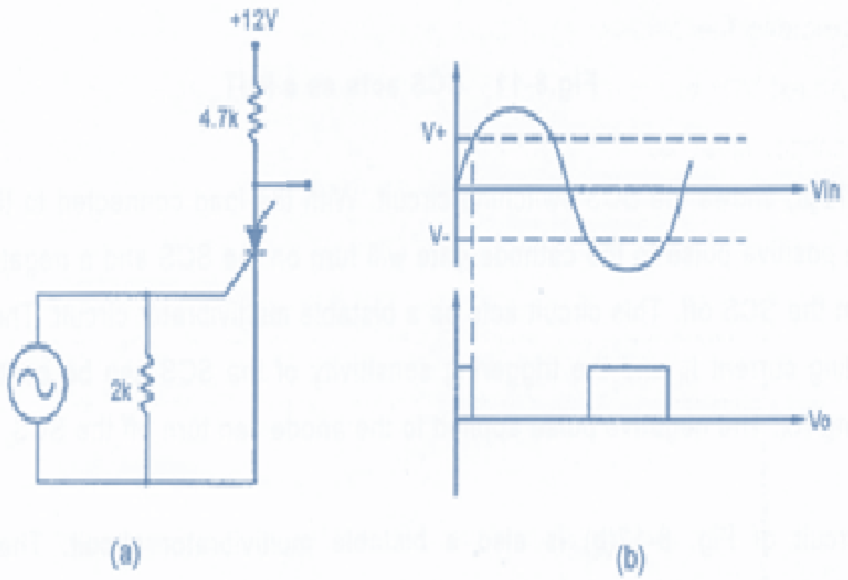


Fig.8-10 (a) SCS Schmitt trigger circuit,
(b) input and output waveforms

Fig. 8-10(a) shows an SCS Schmitt trigger circuit with the anode gate open. When the input signal V_{in} is positive and greater than the upper voltage level V+, the SCS turns on and a low-level output presents at the anode. If the input signal is negative and smaller than the lower voltage level V-, the SCS turns off and a high-level output presents at the anode. The relationship between the input and output signals is shown in Fig. 9-10(b).

The SCS can be used to simulate the operation of a PUT as shown in Fig. 8-11(a). The cathode gate resistor R_{GK} is used to adjust the triggering sensitivity of the PUT. As the R_{GK} value increases, both I_P and I_V are reduced. The characteristic of the SCS shown in Fig. 8-11(b) can be considered as the characteristic of PUT with programmable I_P and I_V.

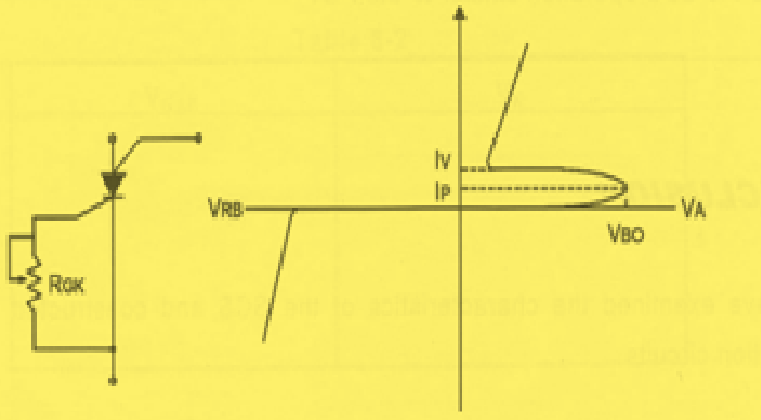


Fig.8-11 SCS acts as a PUT

Fig. 8-12(a) shows the SCS switching circuit. With the load connected to the anode gate, a positive pulse to the cathode gate will turn on the SCS and a negative pulse will turn the SCS off. This circuit acts as a bistable multivibrator circuit. The amount of holding current I_H and the triggering sensitivity of the SCS can be controlled by adjusting R_A. The negative pulse applied to the anode can turn off the SCS.

The circuit of Fig. 8-12(b) is also a bistable multivibrator circuit. The load is connected between the cathode and ground and the trigger signal is applied to the anode. A positive pulse will cause the SCS to turn on while the negative pulse switches the SCS off. The series resistor to the anode gate is used to control the holding current and triggering sensitivity.

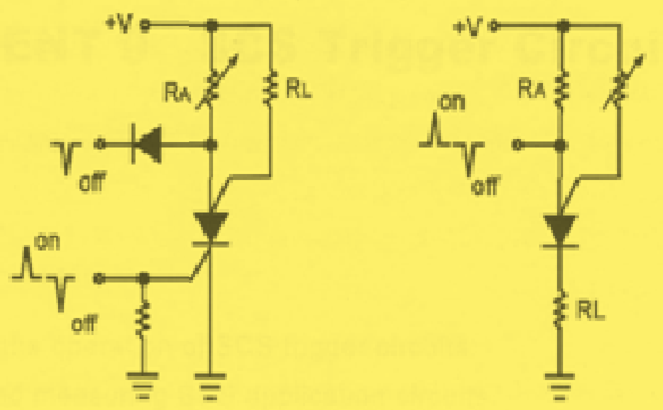


Fig.8-12 SCS bistable multivibrator circuits