# SCR PHASE CONTROL

## Objective

1. Understanding the principle of phase control.
2. Understanding the operation of RC phase control circuit.
3. Studying the application of UJT relaxation oscillator in SCR phase control.

## Discussion

The basic purpose of industrial electronic controls is to regulate the transfer of energy from a source to a load. It may be a weld control to control to control the conversion of electrical energy to heat; it may be a motor control to control the conversion of electrical energy to mechanical force; or it may be a safety alarm to convert electrical energy to sound. If the energy transfer is at a constant rate, then the control may be as simple as an ON-OFF switch. Quite often it is necessary to adjust the rate of energy transfer to control the output, such as speed of a motor, loudness of an alarm, or brightness of a lamp.

The most convenient way to control the rate of energy transfer from an ac source is to control the portion of each cycle that current is allowed to flow into the load. This is accomplished in SCR and TRIAC circuits by controlling the phase angle at which the thyristor is turned on during each cycle of the ac voltage. The technique is called phase shift control.

## Basic Phase Control Circuits

There are many forms of phase control possible with the thyristor, as shown in Fig. 8-1. The simplest form is the half-wave control of Fig. 8-1(a) which uses one SCR for control of current flow in one direction only. This circuit is used for loads which require power control from zero to one-half of full-wave maximum and which also permit (or require) direct current. The addition of one rectifier diode D, Fig. 8-1(b), provides a fixed half-cycle of power which shifts the power control range to half-power minimum and full-power maximum but with strong dc component. The use of two SCRs, Fig. 8-1(c), controls from zero to full-power and requires isolated gate signals, either as two control circuits or pulse-transformer coupling form a single control. Equal triggering angles of the two SCRs produce a symmetrical output wave with no dc component. Reversible half-wave dc output is obtained by controlling symmetry of triggering angle.

An alternate form of full-wave control is shown in Fig. 8-1(d). This circuit has the advantage of a common cathode and gate connection for the two SCRs. While the two rectifiers prevent reverse voltage from appearing across the SCRs, they reduce circuit efficiency by their added power loss during conduction.

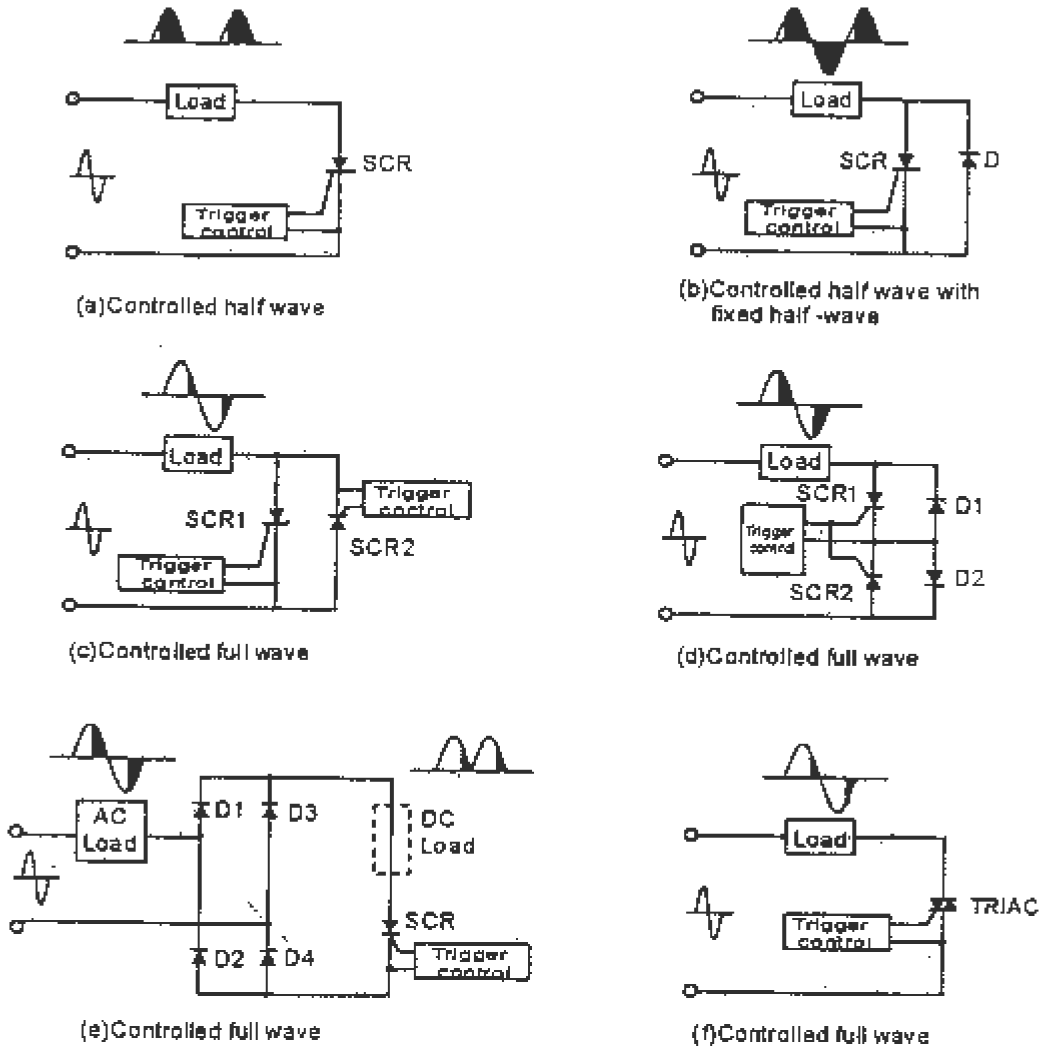



**Fig. 8-1 Basic types of AC phase control**

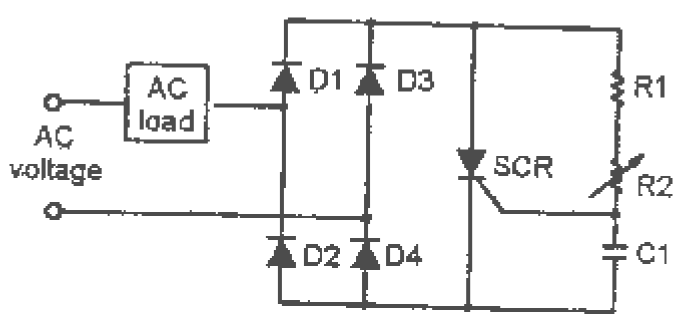



**Fig. 8-2 SCR power control with RC phase shift circuit**

The most flexible circuit, Fig. 8-1(e), uses one SCR inside a bridge rectifier and may be used for control of either ac or full-wave rectified dc. When an AC load is used, it must be connected between ac voltage and bridge rectifier. If a DC load is desired, it should locate at the dotted block in Fig. 8-1(e). Losses in the rectifiers, however, make this the least efficient circuit form, and commutation is sometimes a problem.

By far the most simple method of controlling AC power is the use of the bi-directional triode thyristor, the TRIAC, as shown in fig. 8-1(f). We will discuss the operation of this circuit in the description of experiment circuit section.

Fig. 8-3 shows the UJT-SCR phase control circuit used in this experiment. The bridge rectifier, D1 to D4, provides a pulsating dc form the 18V ac voltage. Zener diode ZD1 clamps the pulsating dc voltage at 12V for the relaxation oscillator. Resistor R1 protects the zener form over-current damage.

When no gate triggering pulse is applied to the gate of SCR, the SCR is in off state and lamp is off. If the UJT relaxation oscillator operates, the pulses at base one will trigger the SCR to conduction at each positive half cycle, the current thus flows through the lamp. The load power is controlled by the conduction angle of SCR. In short, the load power is inversely proportional to the period of triggering pulse.

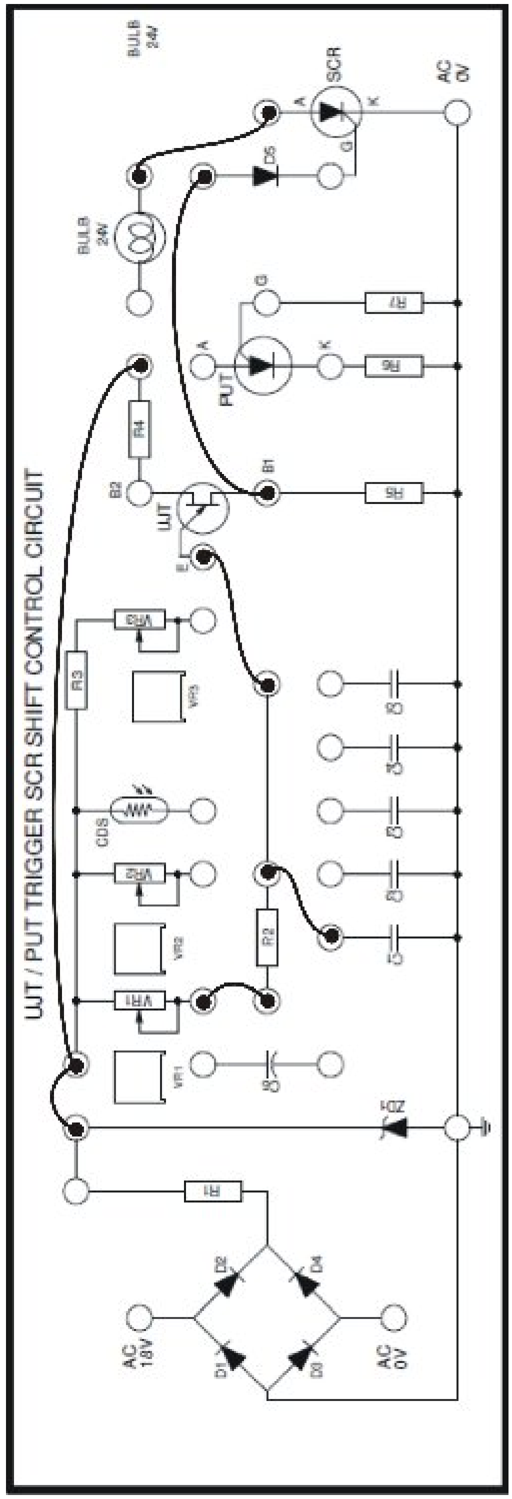

UJT / PUT TRIGGER SCR SHIFT CONTROL CIRCUIT
BULB 24V
SCR
AC 0V
AC 18V
PUT
UJT
CDS

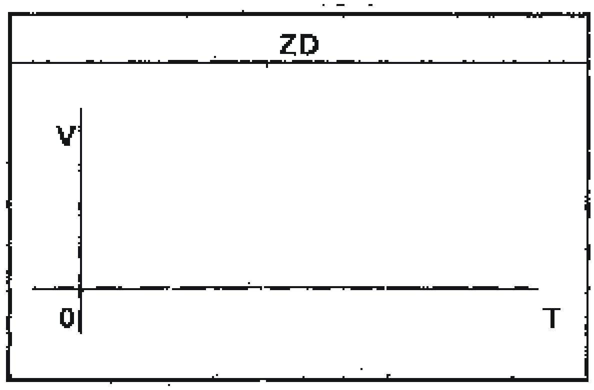
**Fig. 8.3**

**Equipment Required**
1 – Power Supply Unit IT-9000
1 – Module IT-9002
1 – Oscilloscope

**Procedure**

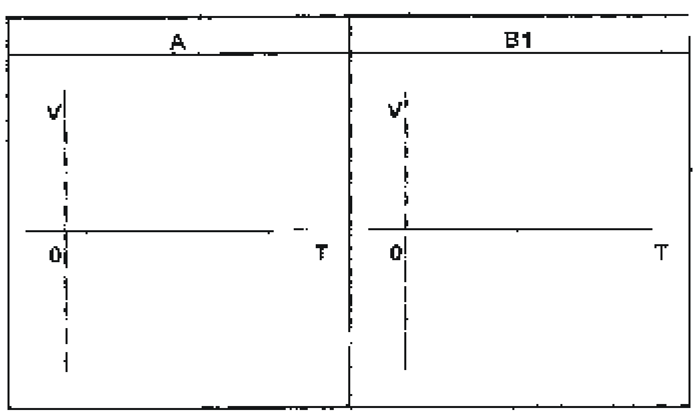
1. Locate the UJT trigger SCR shift control circuit, shown in Fig. 8-3, on Module IT-9002. Apply 18V AC voltage to this circuit from Power Supply Unit IT-9000.
2. Draw a circuit diagram by connecting points as shown in Fig 8-3. Rotate the VR1 fully CCW to get the minimum resistance.
3. Using the oscilloscope, measure the voltage waveform across the zener diode ZD and record the result in Table 8-1.

**Table 8-1**



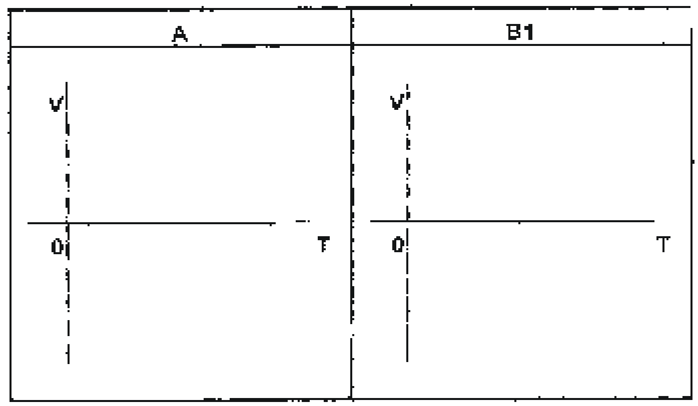

4. Using the oscilloscope, measure the voltage waveforms at the $B_1$ of UJT and across the anode-cathode (A-K) of SCR, and record the results in Table 8-2. Observe and record the brightness of lamp.

**Table 8-2**




5. Set the VR1 to the midposition. Repeat step 4 and record the results in Table 8-3. Observe and record the brightness of lamp. ________________

**Table 8-3**




6. Rotate the VR1 arbitrarily and observe the waveform of VAK and the brightness of lamp. Record the variations of Lamp brightness and triggering angle.

   ____________________________________________________________

   ____________________________________________________________

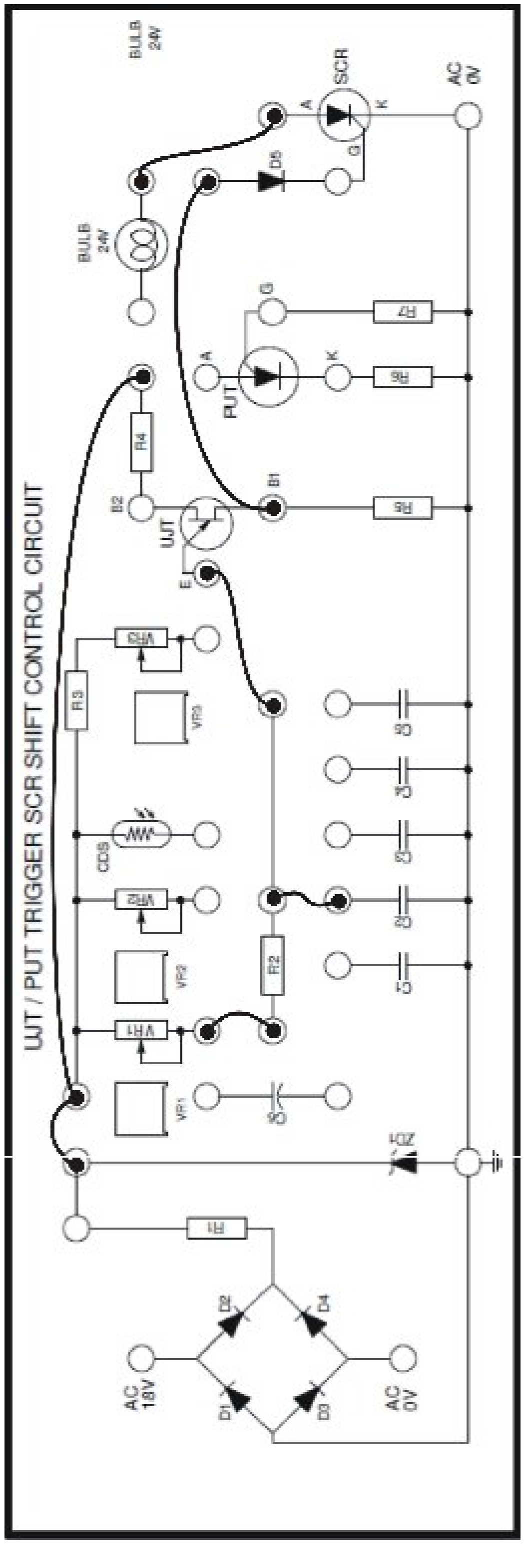

UJT / PUT TRIGGER SCR SHIFT CONTROL CIRCUIT
BULB 24V
SCR
AC 0V
AC 18V
PUT
UJT
CDS


**Fig 8.4**

7. Make connection as in fig 8-4. Repeat steps 4 and 5.

8. Rotate the VR1 arbitrarily and observe the waveform of $V_{AK}$ and the brightness of lamp. Record the variations of lamp brightness and triggering angle.

   ______________________________________________________________

   Compare and comment the difference between this result and the result of step 6.

   ______________________________________________________________

   ______________________________________________________________

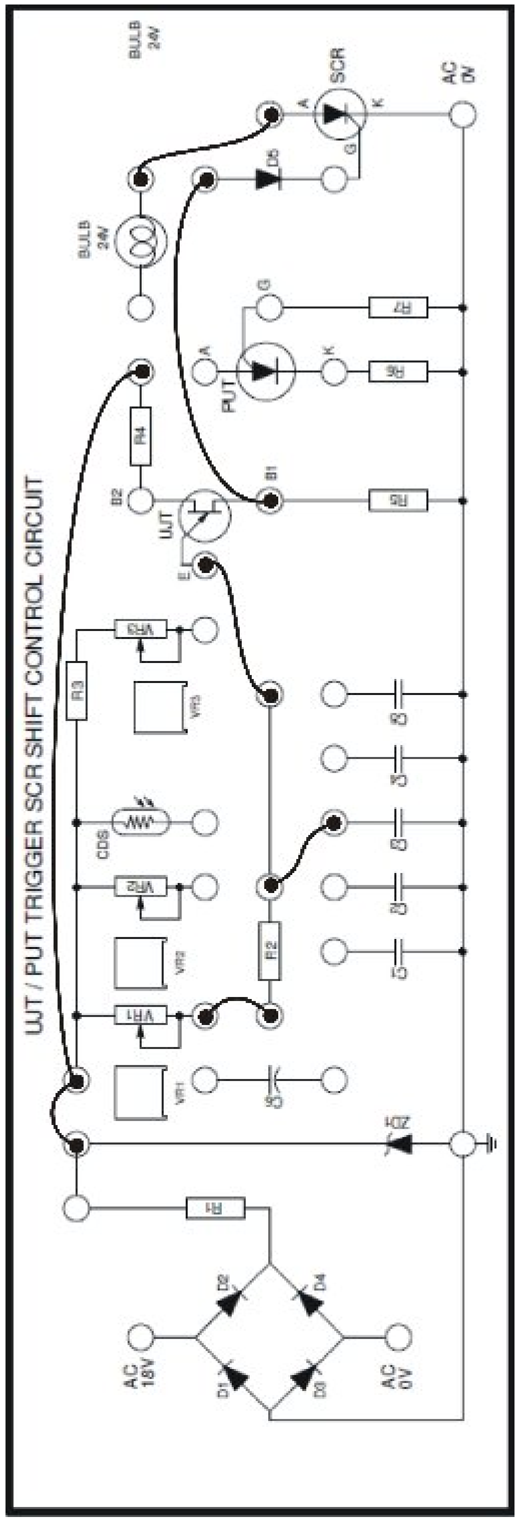

UJT / PUT TRIGGER SCR SHIFT CONTROL CIRCUIT
AC 18V
AC 0V
BULB 24V
SCR
PUT
UJT
CDS

**Fig 8.5**

9. Make connection as shown in fig 8-5. Repeat steps 4 and 5.

10. Turn the VR1 arbitrarily and observe the waveform of VAK and the brightness of lamp Record the variations of lamp brightness and triggering angle.

    ______________________________________________________________

    ______________________________________________________________

    Compare and comment the difference between this result and the result of step 8.

**Conclusion**

In this experiment we found that as VR1 varies, the period of oscillation of UJT relaxation oscillator varies so the conduction angle of SCR will vary. The emitter voltage of UJT is a sawtooth wave and B1 voltage is the triggering pulse for SCR.

Signature of Subject Engineer

**EXPERIMENT 03** Date: _____/______/___________

## PUT-SCR POWER CONTROL

### Objective

1. Understanding the operation of a PUT-SCR Power control circuit.
2. Constructing and measuring the automatic light control circuit.

### Discussion

The PUT is flexible and suitable for the use of relaxation oscillator or delay circuit since its important parameters are programmable. The SCR is an ideal ac power switch. With appropriate gate triggering techniques, the SCR performs excellent control function in ac power circuits. In this experiment, we combine the PUT and SCR to form an ac power control circuit.

Fig. 9-1 shows the PUT-SCR ac power control circuit. The power applied to the PUT oscillator is a pulsating dc voltage with the peak limited by zener diode. The pulsating dc that comes from 18-V ac input voltage followed by bridge full-wave rectifier D1-D4 is used to synchronize with ac line input.

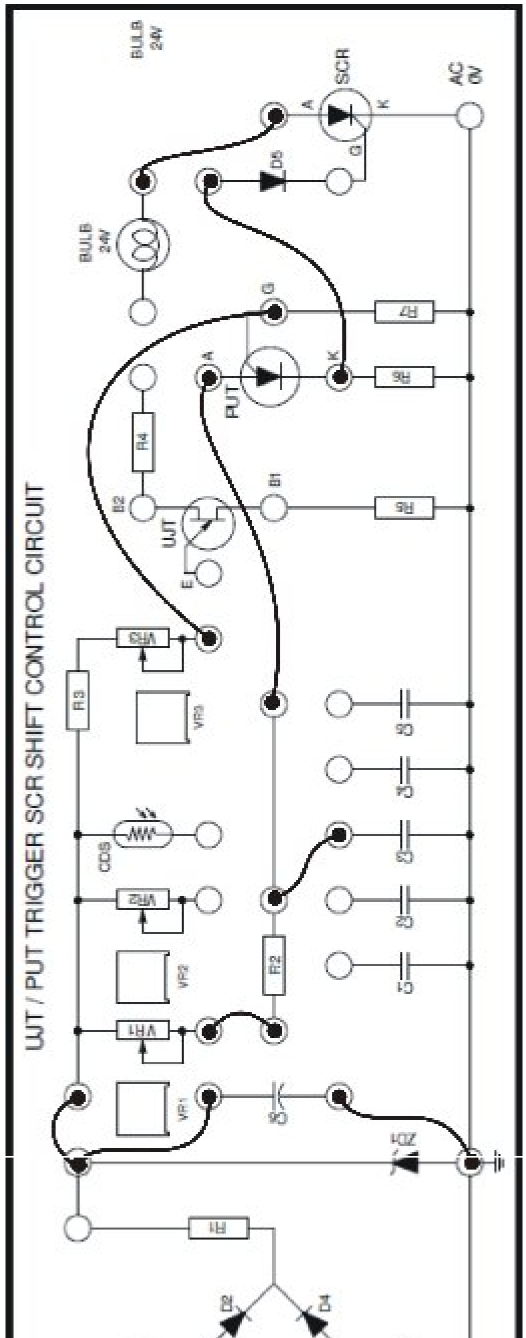

UJT / PUT TRIGGER SCR SHIFT CONTROL CIRCUIT
BULB 24V
SCR
AC 0V
PUT
UJT
CDS
AC 18V

**Fig 9.1**

The PUT acts as a relaxation oscillator. When the gate voltage $V_G$ is fixed, the PUT switches on it its anode voltage is greater than $V_G$ plus $V_T$. The anode voltage is the capacitor voltage determined by the charging current and RC timing network. The capacitor charges through R2 and VR2. When the capacitor voltage reaches the value of $V_P$, the PUT turns on and then a positive pulse is developed on R6. The positive pulse is applied to the gate of SCR to fire the SCR.

The RC time constant network determines the period of oscillation, which controls the firing angle of the SCR. In other words, the longer the time constant, the larger the firing angle becomes. Since the load is a lamp, the conduction angle of the SCR determines the power delivered to the load and the brightness.

The CDS connected to the gate of the PUT is used to vary the gate voltage according to the light level. When the CDS is exposed to different light levels, the different gate voltages determine the variation of the firing angle and therefore the brightness of lamp is controlled by the light level.

**Equipment Required**

1 – Power Supply Unit IT-9000
1 – Module IT-9002
1 – Oscilloscope
1 – Multimeter
1 – 20-W Lamp

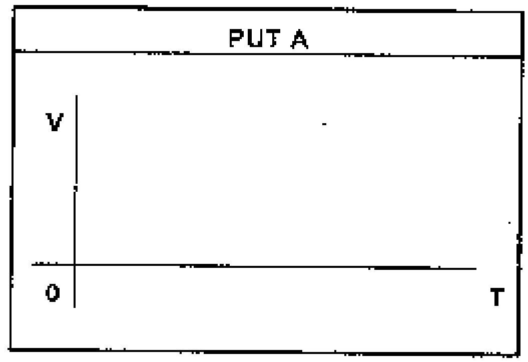
**Procedure**

Connect ac power supplies 18Vac and 110Vac from Power Supply Unit IT-9000 to Module IT-9002.

1. Install the 20-W lamp in the socket on IT-9002. Turn VR1 fully CW. Draw a circuit diagram by connecting points as shown in Fig 9-1. Now locate these components on the Module and complete the circuit diagram by connecting the components using the leads with 2mm male pins.
2. Observe and record the state of LP. ______________________________
   Using the multimeter, measure and record the gate voltage of the PUT. $V_G$ = ______________________________ V.
3. Slowly turning VR1 to the left, observe and record the state of LP.
   __________________________________________________________

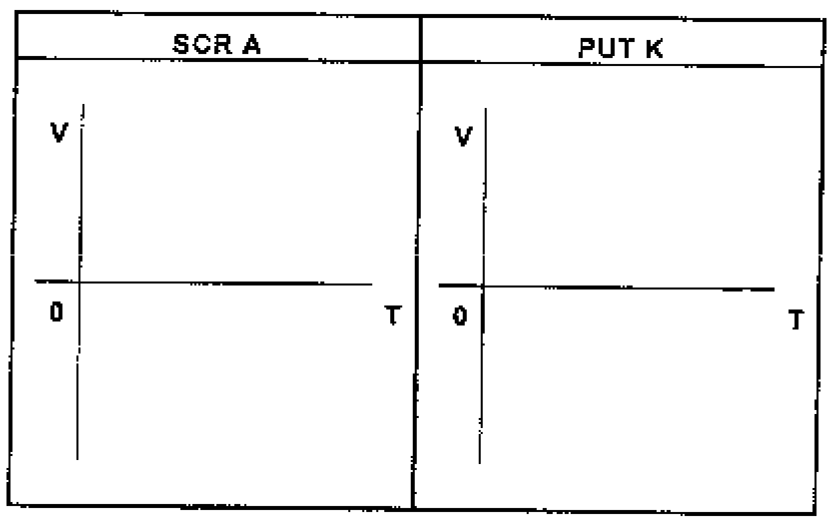
   Stop VR1 at midpoint. Using the oscilloscope, measure and record the voltage waveform at the anode of PUT in Table 9-1.

**Table 9-1**




4. Measure and record the voltage waveforms of PUT cathode and SCR anode in Table 9-2.

**Table 9-2**




5. Turn VR1 fully CCW. Observe and record the change of LP brightness.

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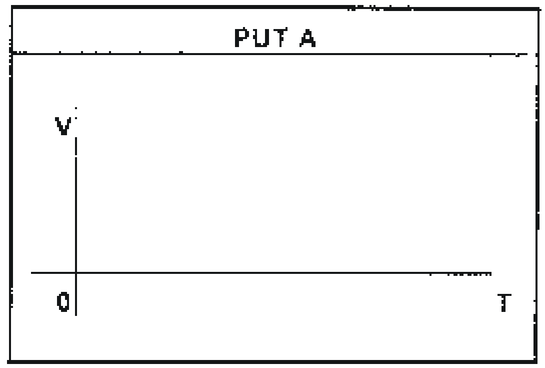
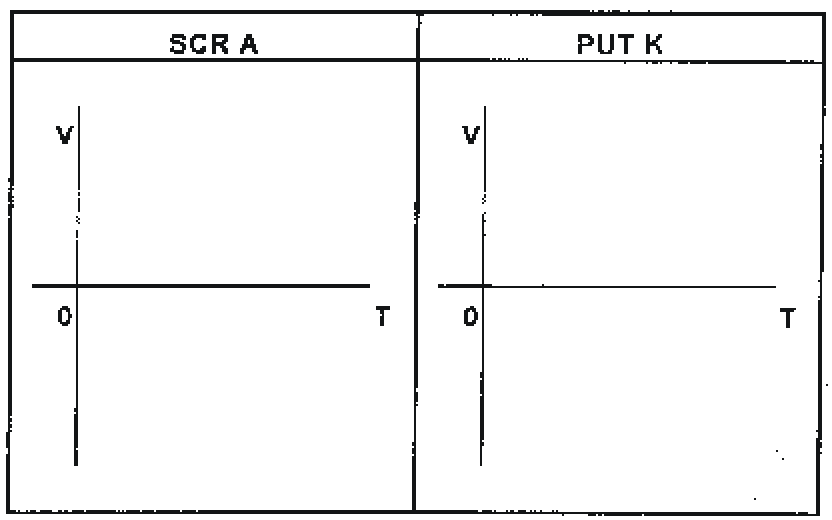
   Measure and record the voltage waveform of PUT anode in Table 9-3.

**Table 9-3**




6. Measure and record the voltage waveforms of PUT cathode and SCR anode in Table 9-4.

**Table 9-4**




7. Turn VR1 randomly. Observe and record the change of LP brightness.

   ______________________________________________

   Is the power on the load controlled VR1?

   ______________________________________________

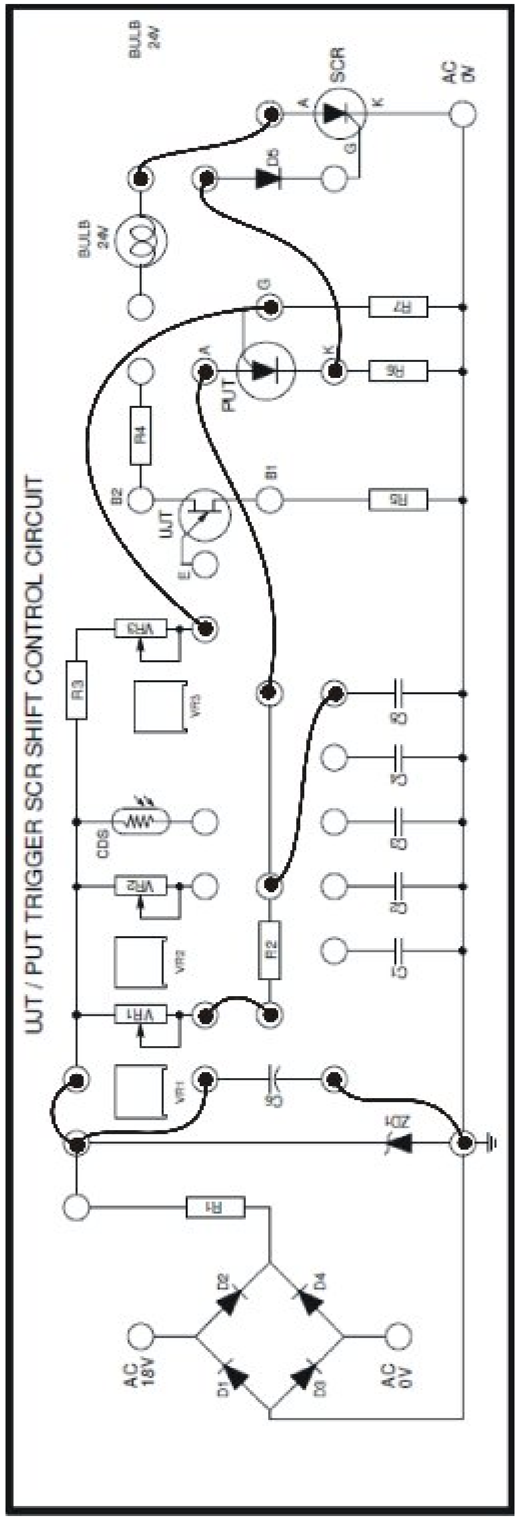
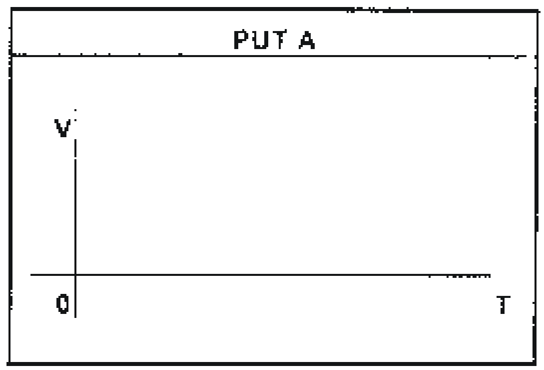

UJT / PUT TRIGGER SCR SHIFT CONTROL CIRCUIT
AC 18V
AC 0V
D1
D2
D3
D4
R1
ZD1
C6
VR1
VR2
VR3
R2
R3
R4
R5
R6
R7
C1
C2
C3
C4
C5
CDS
UJT
E
B1
B2
PUT
A
K
G
BULB 24V
D5
SCR
AC 0V

**Fig 9.2**

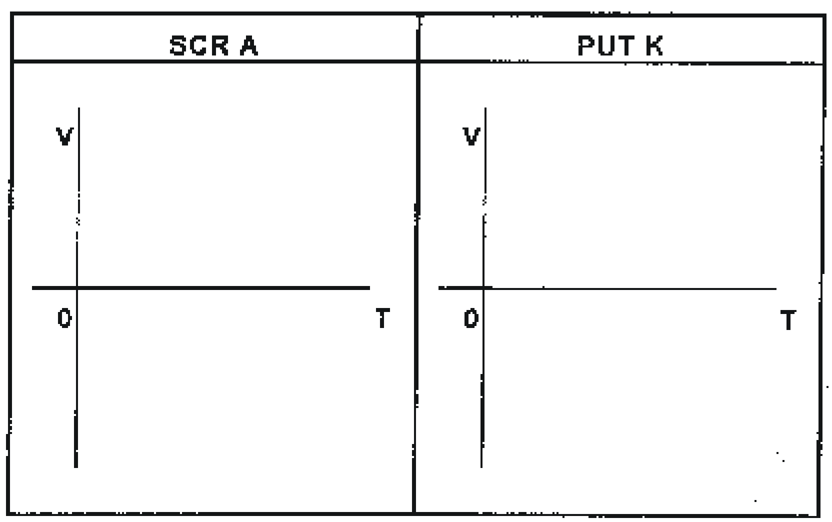
8. Turn VR1 fully CW. Make connection as in fig 9-2. Repeat steps 3 and 4 and record the result in Table 9-5.

**Table 9-5**



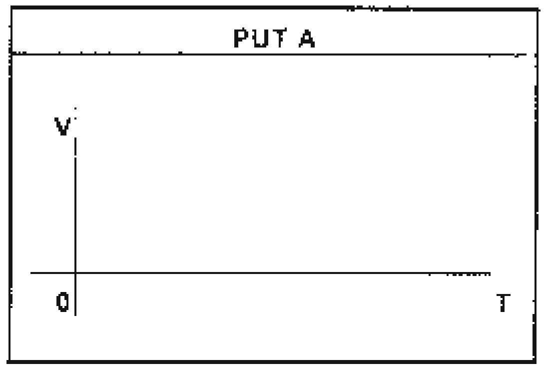

9. Repeat step 5 and record the results in Table 9-6.

**Table 9-6**



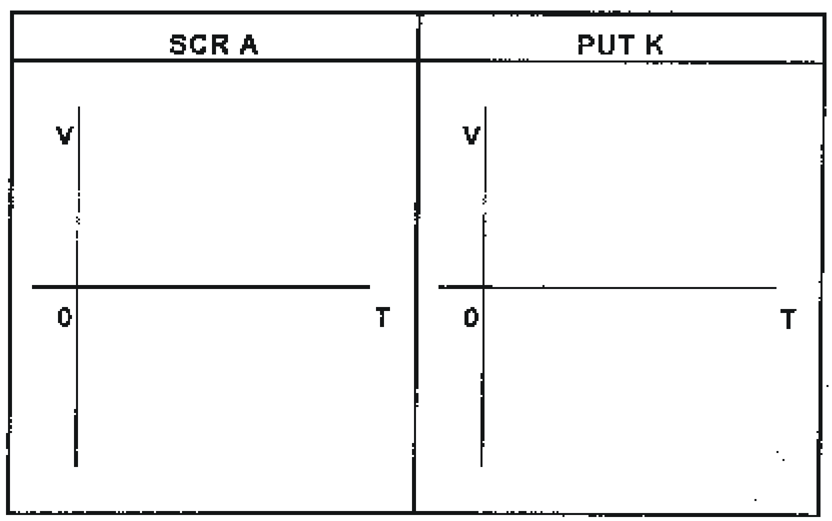

10. Repeat step 6 and record the result in Table 9-7.

**Table 9-7**




11. Repeat step 7 and record the results in Table 9-8.

**Table 9-8**



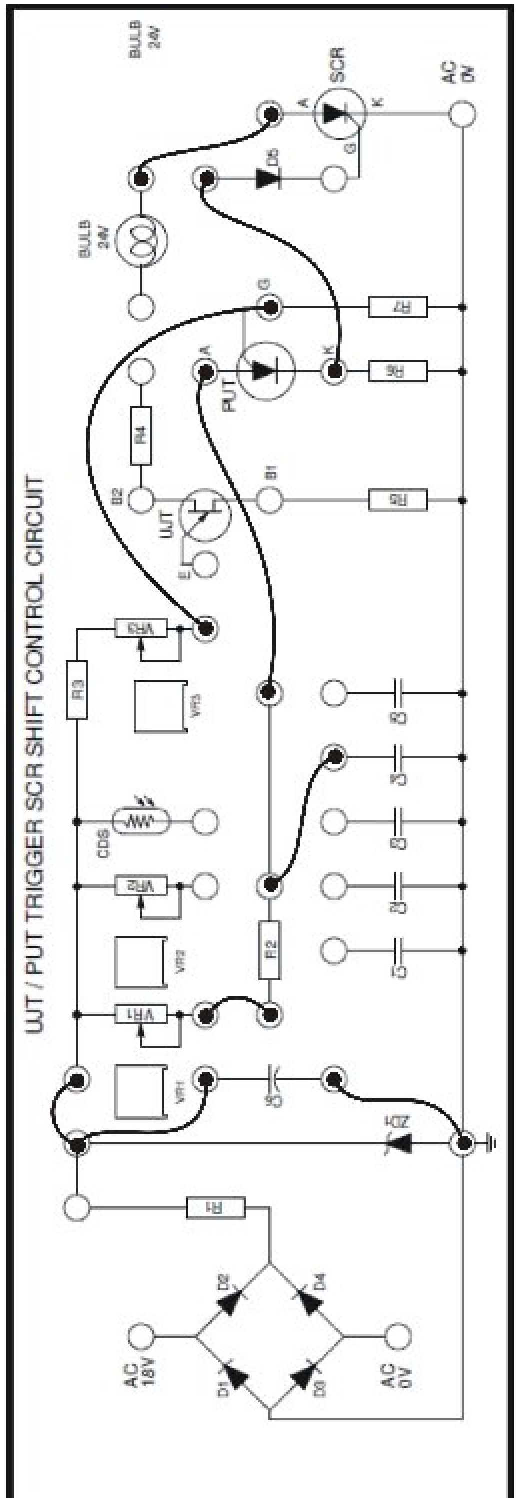

UJT / PUT TRIGGER SCR SHIFT CONTROL CIRCUIT
BULB 24V
SCR
AC 0V
AC 18V
PUT
UJT
CDS

**Fig 9.3**

12. Turn VR1 fully CW. make connection as in fig 9-3. Repeat steps 3 through 7. Observe and record the relationship among the waveforms.

______________________________________________________________

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13. Form the above steps, comment on the relationship between the capacitor and conduction angle of SCR.

______________________________________________________________

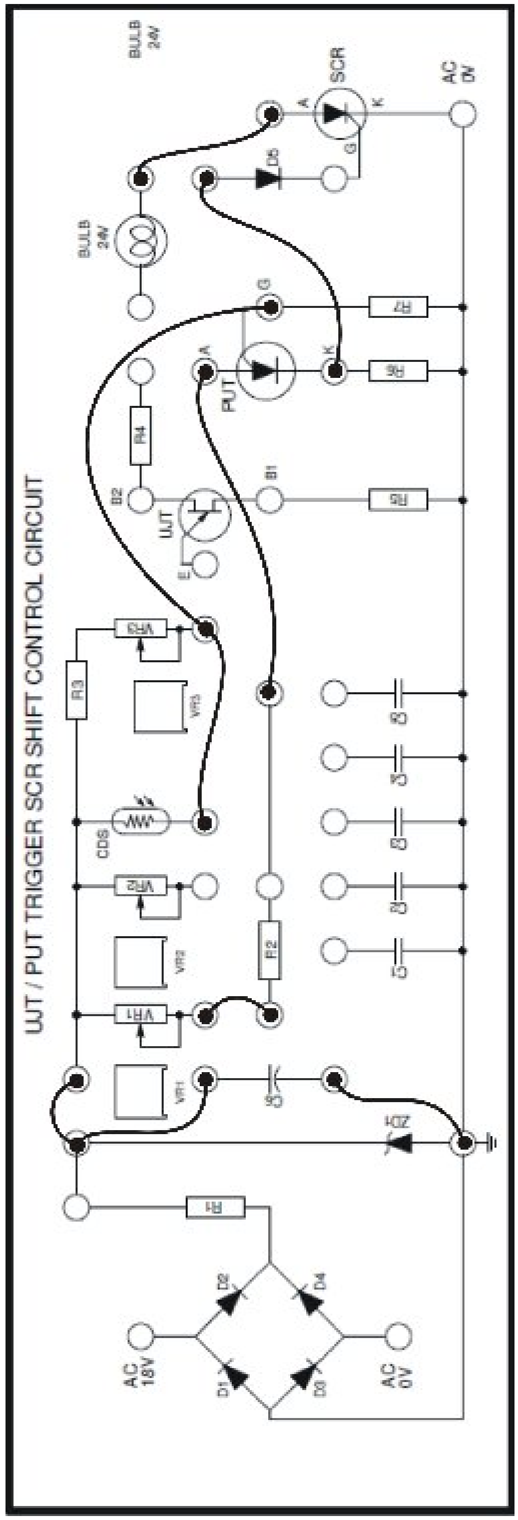
UJT / PUT TRIGGER SCR SHIFT CONTROL CIRCUIT
AC 18V
AC 0V
BULB 24V
SCR
PUT
UJT
CDS

**Fig 9.4**

14. Turn VR1 fully CCW. Make connection as in fig 9-4.

15. Expose the CDS to normal light level. Measure and record the gate voltage of PUT. $V_G$ = ____________________ V.

    Adjust VR1 to keep PUT in off state before conducting.

16. Cover the CDS window with your hand. Is the lamp lighting? ____________________________________________________________

    The PUT and SCR are ____________________________ (on or off).

17. Remove your hand from CDS window. Is the lamp lighting? ____________________________________________________________

    The PUT and SCR are ______________________ ( on or off)

**Conclusion**

In this experiment the PUT oscillator is used to trigger the SCR with its pulse output. The SCR controls the ac power delivered to the load with different conduction angles. The firing angle is controlled by the RC network in the anode circuit of the PUT relaxation oscillator. Adjusting either VR1 or capacitance can change the RC time constant. The longer the period, the smaller the power on load becomes.

Automatic light control circuit in this experiment was built by the CDS sensor and PUT-SCR power control circuit. The CDS changes the gate voltage of PUT in the variation of light level. Therefore the power on the load is controlled by the light level automatically.

Signature of Subject Engineer