EXPERIMENT 5

Dated:____________

SCR DC MOTOR FORWARD/REVERSE CONTROL

Objective

1. Understanding the construction and operation of electromagnetic relays.
2. Understanding the turn-off methods of SCRs.
3. Performing the direction of rotation control of a dc motor.

Discussion

SCRs with the features of unidirectional conduction and easy to control are widely used to control the direction of rotation for dc motors.

Relay Applications

Relays are electrically operated switches. Relays, with the features of amplification and remote control and signal conversion, are widely used in modern industrial electronic circuits as remotely controlled mechanical switches to turn on or off a sequence of events.

An electromagnetic relay utilizes a current through a coil winding to provide a magnetic field that moves the switch contacts. If the current in the coil is sufficient, the magnetic force attracts the armature that moves the movable contact until it touches the stationary contact. If the current is disappeared from the coil, the movable spring moves the movable contact apart from the stationary contact. The mechanical construction and appearance of an electromagnetic relay are shown in Fig. 10-1. It consists of the armature, yoke, coil, core, contacts, springs. The housing either plastic or metal is used to protect the relay against the damage of foreign objects and the interference of electromagnetic field.

The commonly used circuit symbols of relays are shown in Fig. 10-2. Either circle or rectangle in Fig. 10-2(a) represents the relay coil. The normally open contacts are often abbreviated NO as shown in Fig. 10-2(b). The NO contacts will make when the coil is energized. The normally closed contacts (NC), shown in Fig. 10-2(c), will break when the coil is energized. Combination of two stationary contacts and one movable contact which engages one stationary contact when the coil is energized and the other stationary contact when the coil is not energized is called a single-pole double-throw (SPDT) relay as shown in Fig. 10-2(d). The movable contact is called common contact abbreviated as C. The normal contact (N) is NC and the transfer contact (T) is NO.

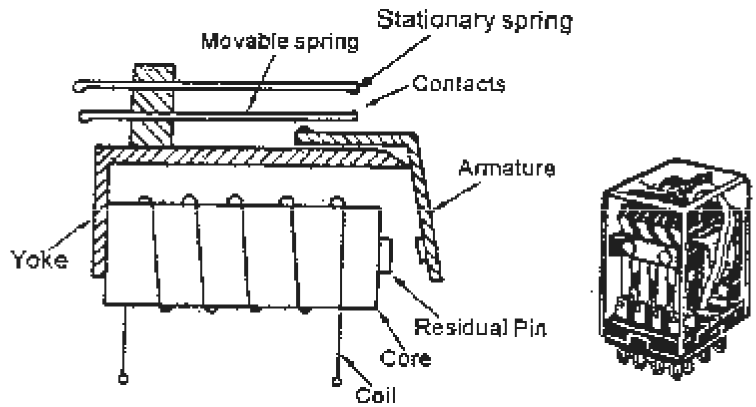

Fig. 10-1 Electromagnetic relay

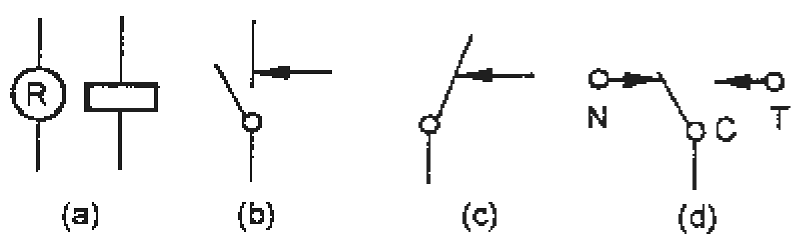

Fig. 10-2 Circuit symbols of relay

There are three popular driver circuits to control the operation of relay. Theses are:

(1) DC source driving

Applied a dc voltage to the relay coil will energize the relay as shown in Fig. 11-3(a). The applied voltage and current must be within the ratings.

(2) Transistor driving

Fig. 10-3(b0 shows a transistor driver used to energize the relay. The control signal is applied to drive the transistor to conduct. The conducting transistor provides sufficient current tot energize the relay.

(3) Thyristor driving

The thyristor such as an SCR can be used to drive a relay in dc circuits as shown in Fig. 10-3(c). In this application a reset switch is often necessary to turn the SCR off.

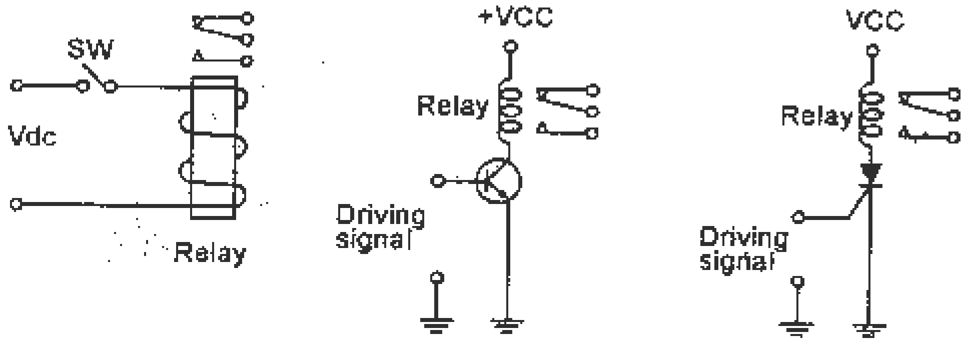

Fig. 10-3 Relay drivers

In most applications relays are used in electronic circuits as remotely controlled mechanical switches used to control a large current load which is isolated with the signal conditioning circuit. Fig. 10-4 shows an automatic light control circuit which consists of a relay, CDS, and transistor R and CDS form a voltage divider to provide a bias to the base of transistor Q. The value of R is designed to equal ten times CDS resistance in normal light level. This arrangement causes the transistor off in daylight so that the lamp off. At night, CDS resistance increases to apply a forward bias driving the transistor to conduct. The collector current through relay coil energizes the relay and the common contact is transferred to NO contact so that the lamp lights.

To reverse the direction of rotation of a dc motor, it is simply to reverse that polarity of applied voltage to the motor. In our experiment circuit we use two electromagnetic relays to switch the polarity of applied voltage. Fig. 10-5 show a typical electromagnetic relay with SPDT contacts. When the relay coil has no current flow, COM contact connects to NC contact. If a sufficient current flows though the relay coil, the COM contact is pulled to touch with NO contact. Therefore the relay acts as a switch.

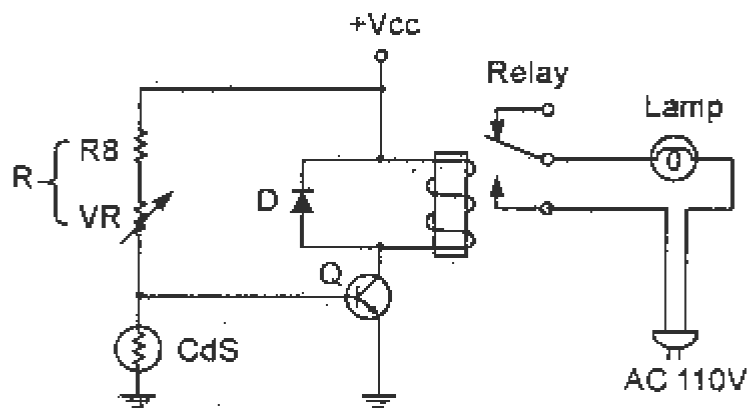

Fig. 10-4 Automatic lamp control circuit

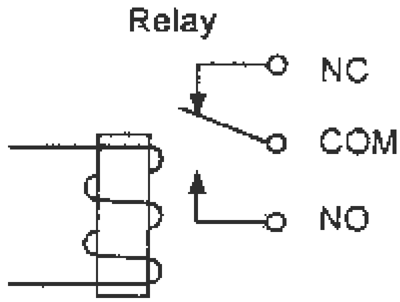

Fig. 10-5 Electromagnetic relay

Turn-off of SCR

The turn-off methods of the SCR are discussed in experiment 7. Fore convenience we summarize these turn-off methods as follows.

1. Reduce the anode-to-cathode current I_{AK} below the holding current I_H.
2. Short-circuit the anode and cathode terminals.
3. Open-circuit the anode-cathode loop.
4. Reverse the anode-to-cathode voltage.
5. Use self-commutation technique.

In Fig. 10-6, when neither SCR is conducting, there is virtually no charge on the capacitor C. if a triggering pulse is applied to the gate of the SCR1 current flows through RL, R1 and SCR1. Current also flows through R2, C, and SCR1 to charge the capacitor with the polarities of positive at the right-hand side and negative at the left-hand side. When a gate triggering pulse is applied at the SCR2, SCR2 conducts – dropping its anode voltage to approximately 1V. The capacitor voltage is then placed across the anode to cathode of SCR1. This reverse anode-to-cathode voltage causes SCR1 to turnoff. The capacitor discharge path is then RL, R1, and SCR2. Current flows through R1 and SCR2 to charge the capacitor to the opposite polarity. The circuit is now ready for a gate triggering signal at SCR1 and the cycle repeats.

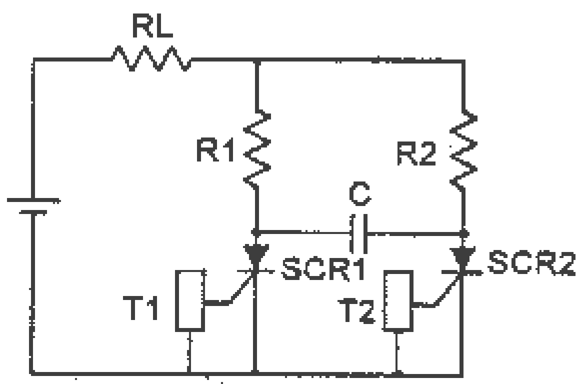

Fig. 10-6 SCR self-commutation technique

Description of Experiment Circuit

Fig. 10-7 shows a dc motor forward/reverse control circuit. The SCR self-commutation technique is used in this circuit to control the direction of rotation for a dc motor. When the instant the dc power is applied, SCRs are off and relays are off. The dc motor does not run since its two terminals are grounded through relay's NC contacts. If the light to CDS1 is blocked, the resistance of CDS1 increases to turn SCR1 on and RELAY on. The COM1 transfer to NO1 contact, hence the dc motor runs in forward direction. The capacitor C1 charges through RELAY2 coil and SCR1. The negative charges are at the left terminal of C1. When the light to CDS2 is blocked, SCR2 begins to conduct and the negative potential at SCR1 anode turns SCR1 off. The on SCR2 energizes RELAY2 and hence COM2 transfers to NO2 contact. Therefore the dc motor runs in reverse direction.
The SW switch is used to stop the motor by moving switch in downward position.

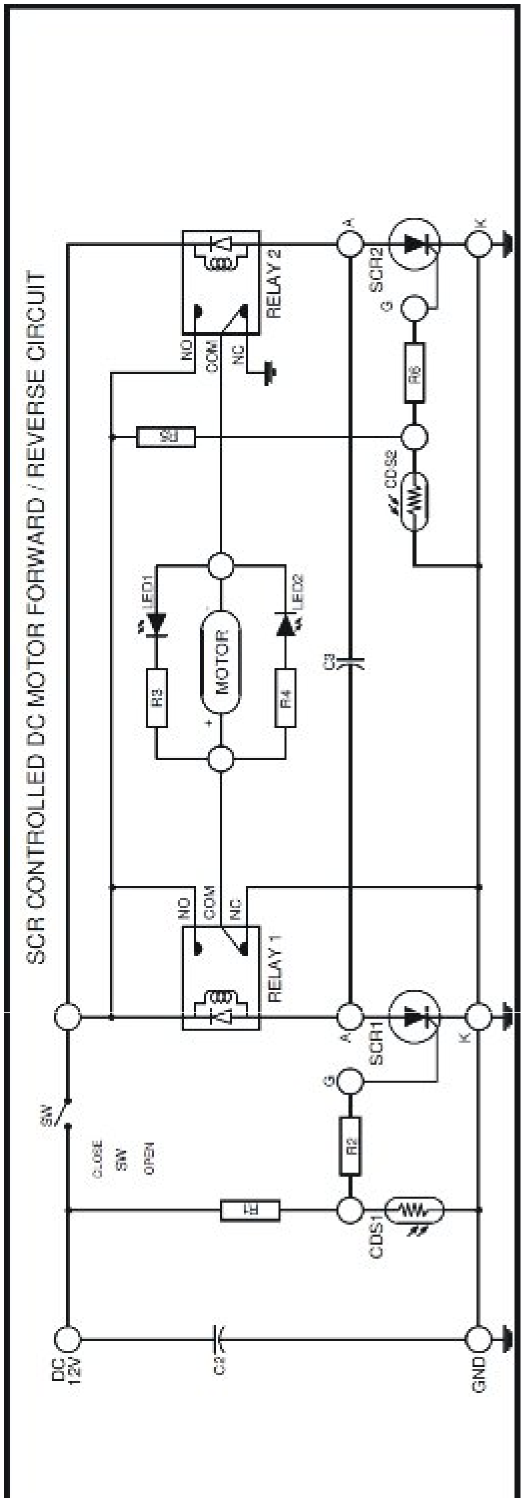
SCR CONTROLLED DC MOTOR FORWARD / REVERSE CIRCUIT
RELAY 1
RELAY 2
NO
COM
NC
SCR1
SCR2
A
G
K
R2
R3
R4
R6
CDS1
CDS2
LED1
LED2
MOTOR
SW
CLOSE
OPEN
DC 12V
C2
C3
GND

Fig 10.7

Equipment Required

1 – Power Supply Unit IT-9000
1 – Module IT 9004
1 – Multimeter

Procedure

1. Connect DC12V power supply from Power Supply Unit IT-9000 to Module IT 9001.
2. At this time the SCR should be off. Observe and record the state of LED.

   ____

   Using the multimeter, measure and record the anode-to-cathode voltages of SCR1 and SCR2.
   V_{AK1} = ____________________ V; V_{AK2} = __________________ V

   Record the state of each SCR.

   ____
3. Using the multimeter, measure an record the voltages at COM contacts of RELAY1 and RELAY2.
   V_{COM1} = ______________ V; V_{COM2} = ______________________ V

4. Using the multimeter, measure and record the voltages across CDS1 and CDS2.
   V_{CDS1} = ______________ V; V_{CDS2} = ______________________ V
   Record the state of each SCR.

   ____

5. Expose CDS1 to high light level. Measure the voltage across CDS1 using the ohmmeter. Is this voltage changed? ______________________

   Measure the anode-to-cathode voltage of SCR1. Is SCR1 on or off?

   ____

   Cover CDS1 window with your hand. Observe and record the state of relay.

   ____

   Remove your hand from CDS1 window. Measure the voltage across CDS1 using the ohmmeter. Is this voltage changed? _____________
   Measure the node-to-cathode voltage of SCR1. Is SCR1 on or off?

   ____

   Measure and record the voltage at point COM1. ____________
   Does LEDf2 light?____________________________________

6. Using the multimeter, measure and record the voltage across the capacitor C1.
   V_{C1} = ________________ V
   The polarity of V_{C1} at the anode terminal of SCR1 is ____________________ (positive or negative).

7. Cover CDS2 window with your hand. Does the LED2 extinguish?

   ____

Does the LED1 light?

____

Using the multimeter, measure the voltage across CDS2 and V_{AK} of SCR2. Is SCR2 on? ______________________

Measure V_{AK} of SCR1. Is SCR1 off? ______________________

V_{COM1} = ______________ V; V_{COM2} = ______________ V

Remove your hand from CDS2 window. Observe and record the state of SCRs.

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8. Using the multimeter, measure and record the capacitor voltage.
   The polarity of capacitor voltage at SCR2 anode terminal is _________(positive or negative). V_C = ______________________ V

9. Cover CDS1 window with your hand. Does the LED1 extinguish?

   ____

   Does the LED2 light? ______________________

   Cover CDS2 window with your hand. Does the LED2 extinguish?

   ____

   Does the LED1 light? ______________________

10. Press S1 S1 to stop motor. Do the LED2 extinguish?

    ____

    To start motor, cover any CDS with your hand.

Conclusion

You have experimented the operation of a dc motor control circuit for the direction of rotation. The use of CDS is just an application example in this circuit. You may use other sensors or switches to design a control circuit similar to this application.

The self-commutation technique is very useful and widely used to turn off SCRs. For normal operation the commutation time of the SCR should be short to avoid SCRs conducting simultaneously. Since the commutation item of an SCR is typically 10μS, it can be ignored in this circuit.

Signature of Subject Engineer