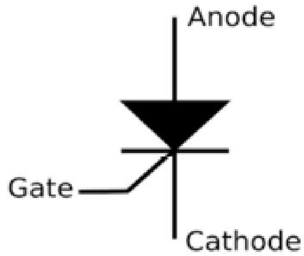
Al-Mustaqbal University
College of Engineering and Technologies
Medical Instrumentation Technique Engineering Department
Class: 2nd
Subject: Electronic Circuits
Lecturer: Dr. Rami Qays Malik
Lecture: 12- Other Semiconductor Devices

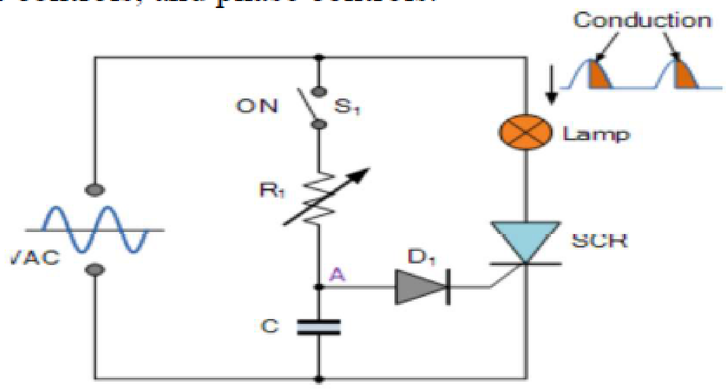
Other Semiconductor Devices

pnpn and Other Devices

1.SILICON-CONTROLLED RECTIFIER (Thyristor)

Some of the more common areas of application for SCRs include relay controls, time-delay circuits, regulated power suppliers, static switches, motor controls, choppers, inverters, cycloconverters, battery chargers, protective circuits, heater controls, and phase controls.





BASIC SILICON-CONTROLLED RECTIFIER OPERATION

1. As the terminology indicates, the SCR is a rectifier constructed of silicon material with a third terminal for control purposes. The third terminal, called a gate , determines when the rectifier switches from the open-circuit to the short-circuit state

2. It is not enough to simply forward-bias the anode-to-cathode region of the device. In the conduction region, the dynamic resistance of the SCR is typically 0.01 Ω to 0.1 Ω The reverse resistance is typically 100 kΩ or more.

3. A pulse of sufficient magnitude must also be applied to the gate to establish a turn-on gate current, represented symbolically by IGT

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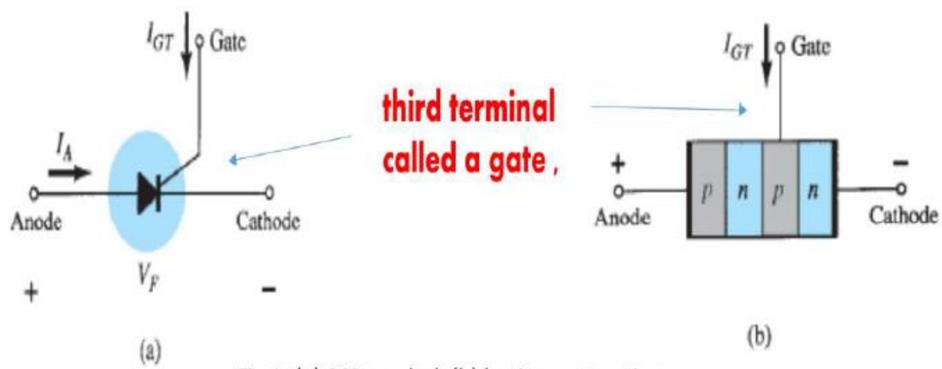

Fig 1. (a) SCR symbol; (b) basic construction.

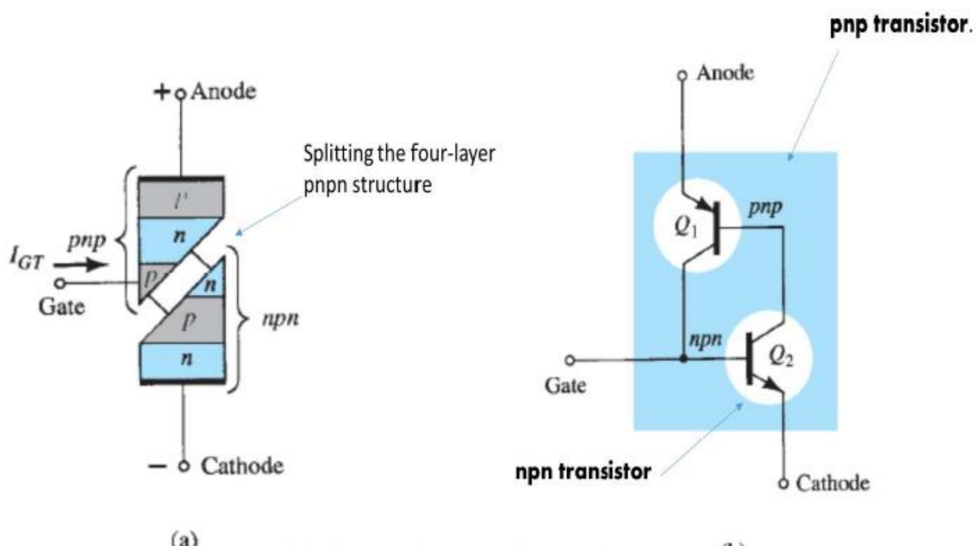

Fig 2.SCR two-transistor equivalent circuit.

Discussion purposes

1. For VBE2 = Vgate = 0 V, the base current IB2 = 0, and IC2 will be approximately I_{CO}. The base current of Q1, I_{B1} = IC2 = ICO

2. At t = t1 , a pulse of VG volts will appear at the SCR gate. The potential VG was chosen sufficiently large to turn Q2 on ($V_{BE2} = V_G$). The collector current of Q2 will then rise to a value sufficiently large to turn Q1 on ($I_{B1} = I_{C2}$). As Q1 turns on, IC1 will increase, resulting in a corresponding increase in I_{B2}.

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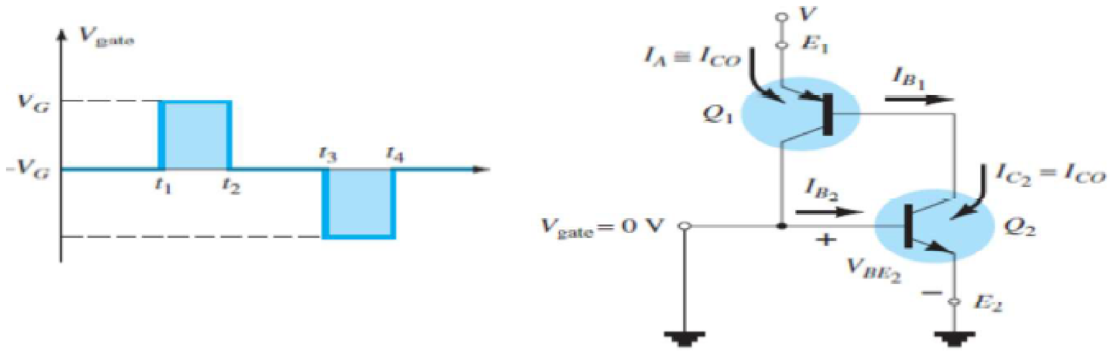
3. The increase in base current for Q2 will result in a further increase in I_{C2} The net result is a regenerative increase in the collector current of each transistor



(a) (b)

how is turn-off SCR

An SCR cannot be turned off by simply removing the gate signal

The two general methods for turning off an SCR are categorized as anode current interruption and forced commutation.

1. (series interruption) I_A is zero when the switch is opened

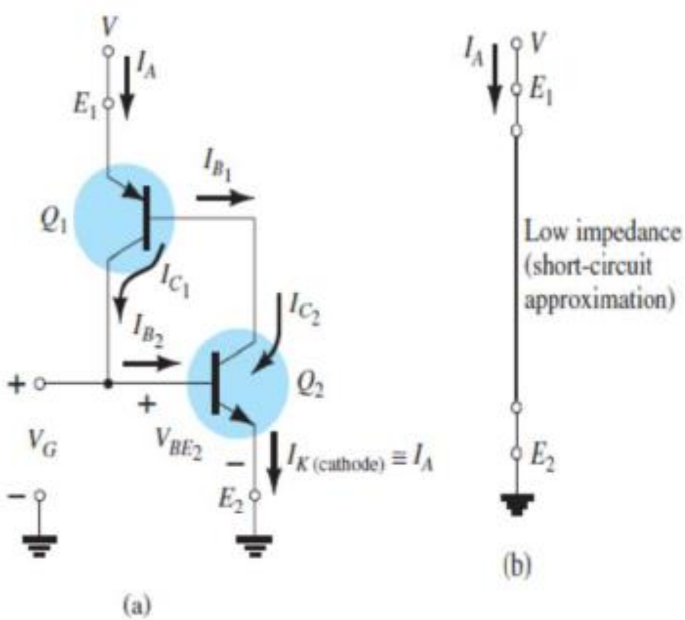


Fig 4. "On" state of the SCR.

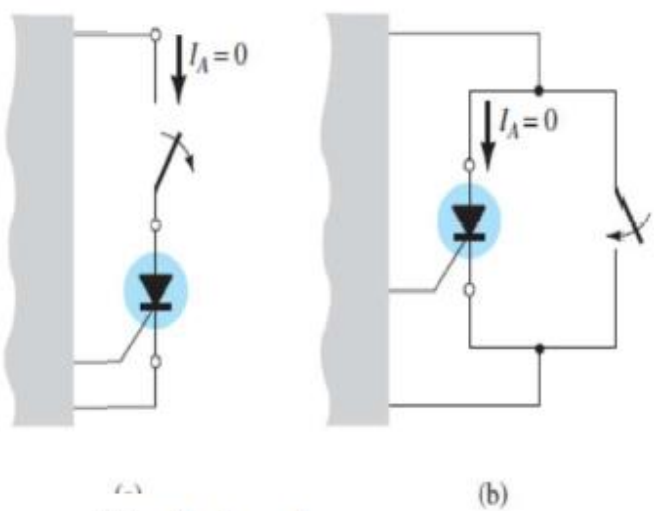


Fig 5. Anode

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how is turn-off SCR

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1. **(series interruption)** I_A is zero when the switch is opened

2. **Forced commutation** is the "forcing" of current through the SCR in the direction opposite to forward conduction., the turn-off circuit consists of an npn transistor, a dc battery V_B , and a pulse generator. During SCR conduction, the transistor is in the "off" state, that is, IB = 0, and the collector-to-emitter impedance is very high (for all practical purposes an open circuit). This high impedance will isolate the turn-off circuitry from affecting the operation of the SCR. For turn-off conditions, a positive pulse is applied to the base of the transistor, turning it heavily on, resulting in a very low impedance from collector to emitter (short-circuit representation). The battery potential will then appear directly across the SCR as shown in Fig.6b , forcing current through it in the reverse direction for turn-off. Turn-off times of SCRs are typically 5 ms to 30 ms.

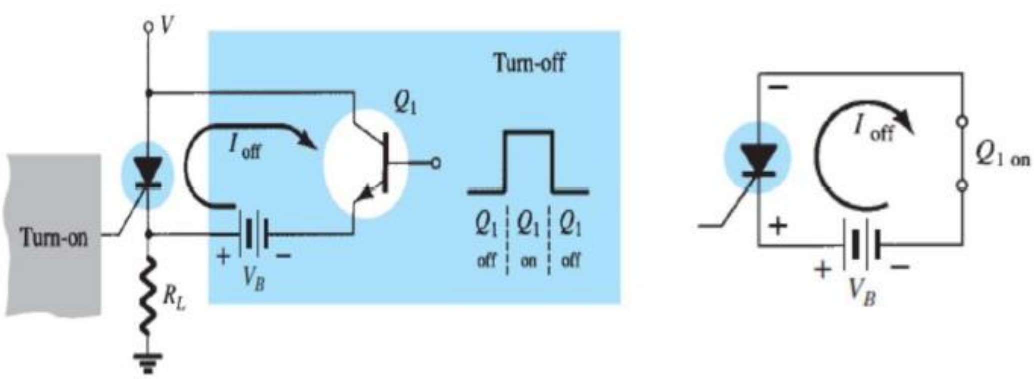

FIG. 6 Forced-commutation technique

SCR CHARACTERISTICS AND RATINGS

1. Forward breakover voltage $V_{(BR)F}$ is the voltage above which the SCR enters the conduction region which is dependent on

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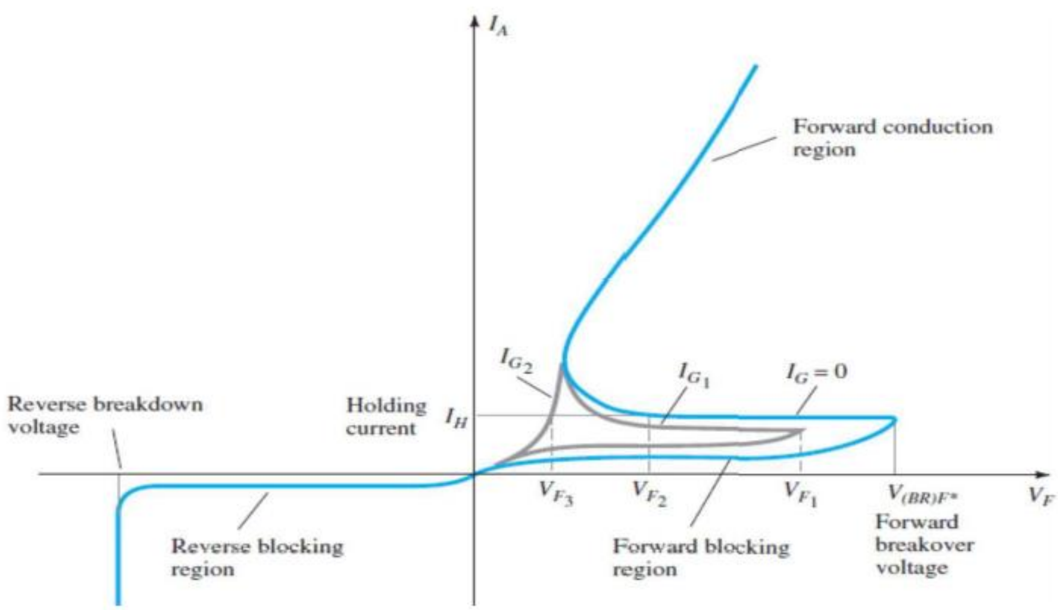


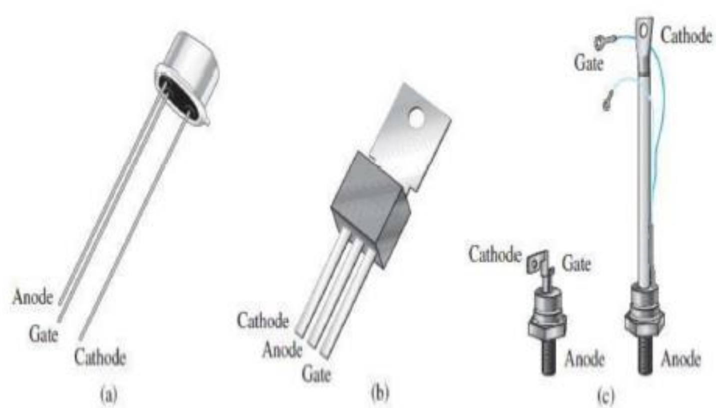
Fig 7. SCR characteristics

2. **Holding current I_H** is the value of current below which the SCR switches from the conduction state to the forward blocking region under stated conditions.

3. **Forward and reverse blocking regions** are the regions corresponding to the open-circuit condition for the controlled rectifier that block the flow of charge (current) from anode to cathode.

4. **Reverse breakdown voltage** is equivalent to the Zener or avalanche region of the fundamental two-layer semiconductor diode

5.



SCR case construction and terminal identification.

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SCR APPLICATIONS

1. Series Static Switch

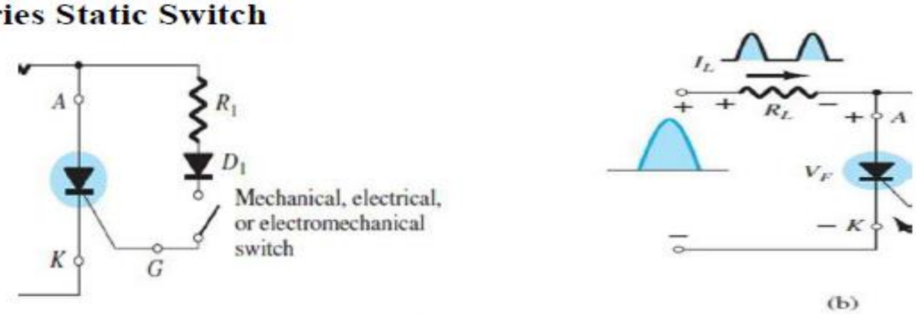

Fig8 .Half-wave series static switch.

2. Variable-Resistance Phase Control

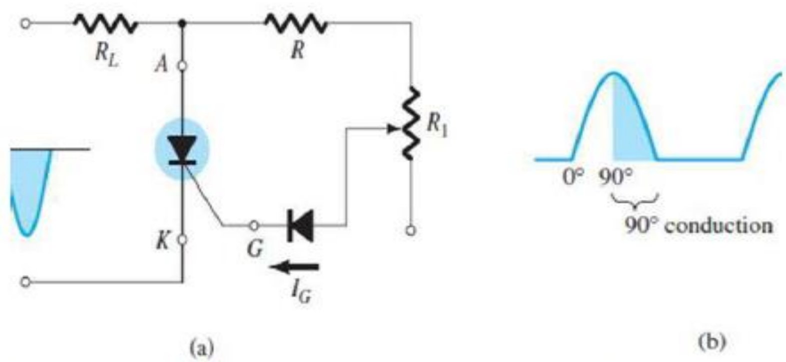

Fig 9. Half wave variable-resistance phase control

3. Battery-Charging Regulator

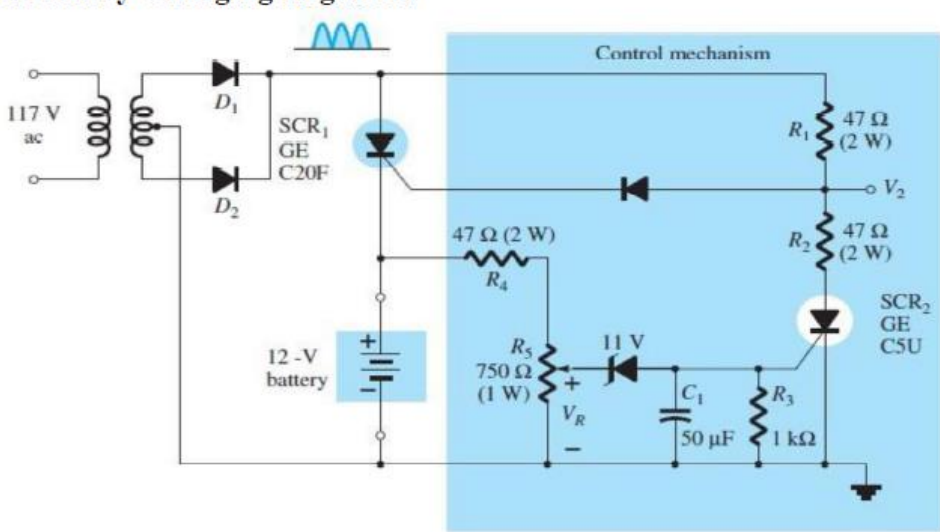

Fig 10. Battery-charging regulator.

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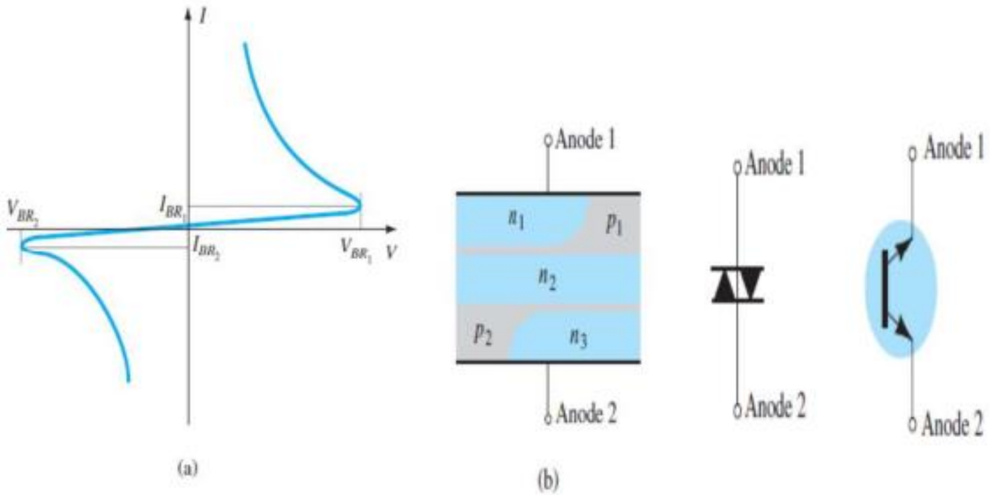
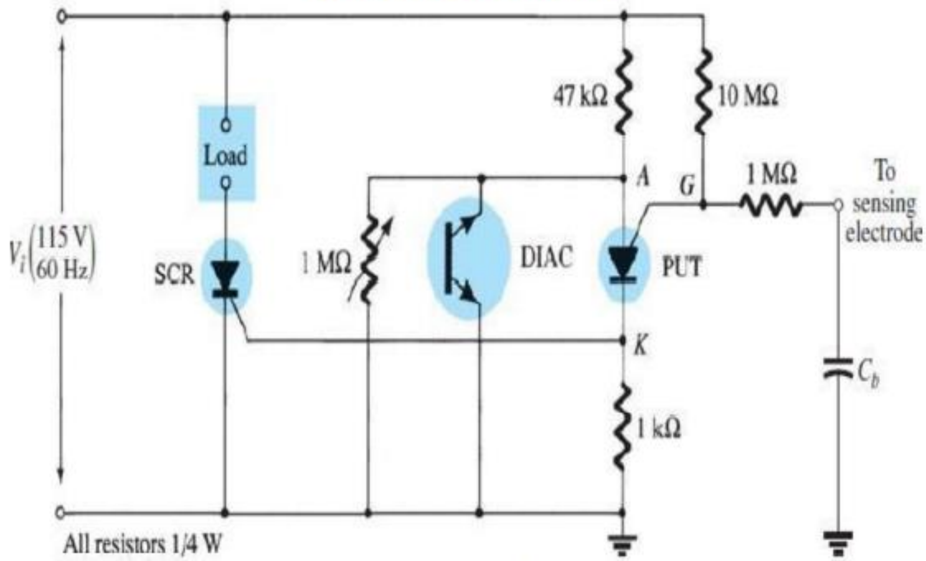
DIAC

The diac is basically a two-terminal parallel-inverse combination of semiconductor layers that permits triggering in either direction.



The diac: (a) characteristics; (b) symbols and basic construction.

Proximity Detector



Proximity detector or touch switch TRIAC

The triac is fundamentally a diac with a gate terminal for controlling the turn-on conditions of the bilateral device in either direction.

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TRIAC

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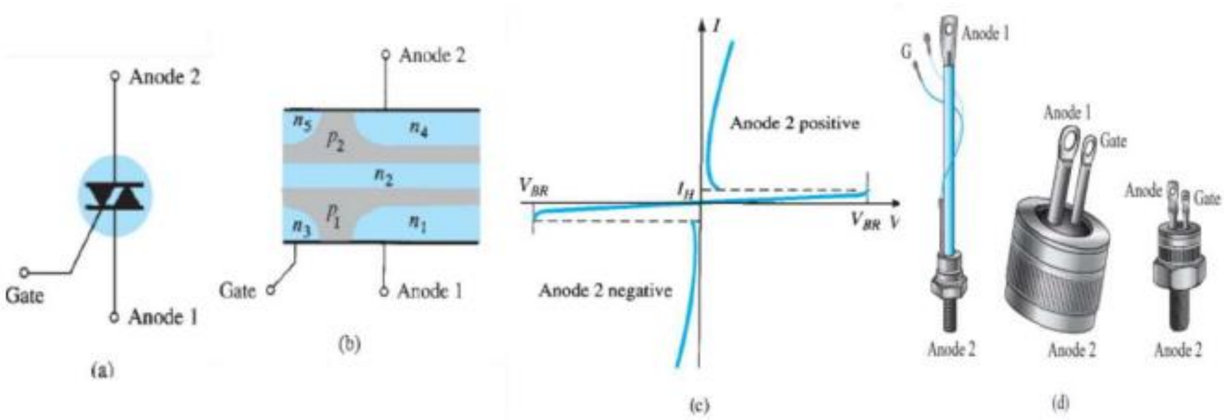

The triac: (a) symbol; (b) basic construction; (c) characteristics; (d) drawings

The triac:(a)symbol;(b) basic construction; (c) characteristics; (d) drawings

Phase (Power) Control

One fundamental application of the triac is presented in Fig. 17.33 . In this capacity, it is controlling the ac power to the load by switching on and off during the positive and negative regions of the input sinusoidal signal. The advantage of this configuration is that during the negative portion of the input signal, the same type of response will result since both the diac and the triac can fire in the reverse direction. The resulting waveform for the current through the load is provided in Fig. 17.33 . By varying the resistor R , one can control the conduction angle. There are units available that can handle in excess of 10-kW loads.

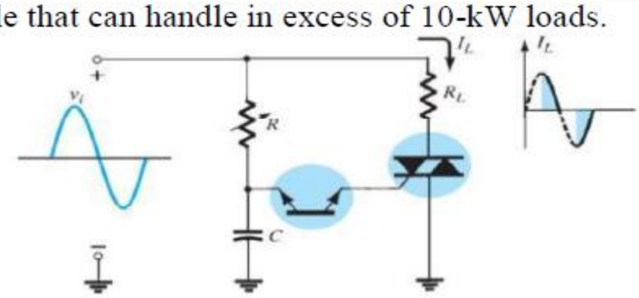

FIG. 17.33
Application of a triac: phase (power) control.