DIAC & TRIAC

DIAC & TRIAC

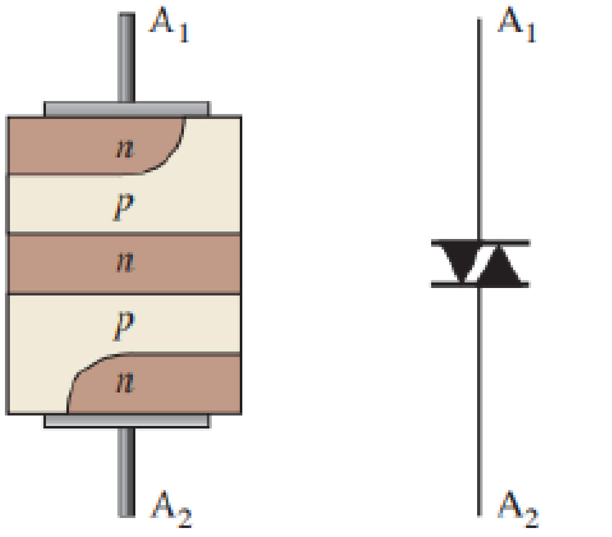
- Both the diac and the triac are types of thyristors that can conduct current in **both** directions (bilateral).
- The difference between the two devices is that a diac has two terminals, while a triac has a **third terminal**, which is the gate for triggering.
- The diac functions basically like two parallel 4-layer diodes turned in opposite directions.
- The triac functions basically like two parallel SCRs turned in opposite directions with a common gate terminal.

DIAC

Diode for Alternating Current

DIAC

- A diac is a two-terminal four-layer semiconductor device (thyristor) that can conduct current in either direction when activated.
- The basic construction and schematic symbol for a diac are shown in Figure 3–1.



(a) Basic construction (b) Symbol

FIGURE 3-1

The diac.

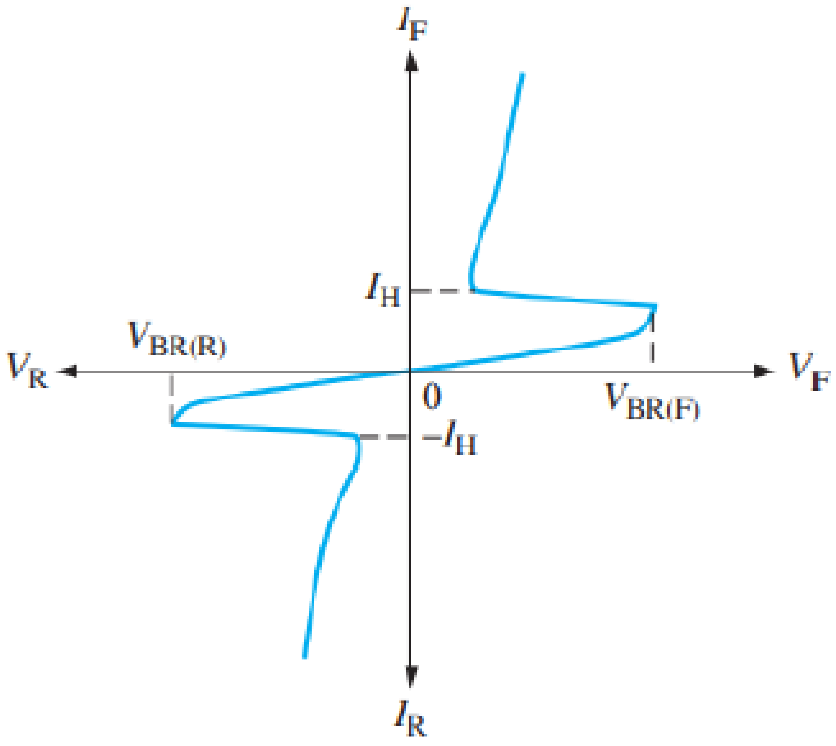


FIGURE 3-2

Diac characteristic curve.

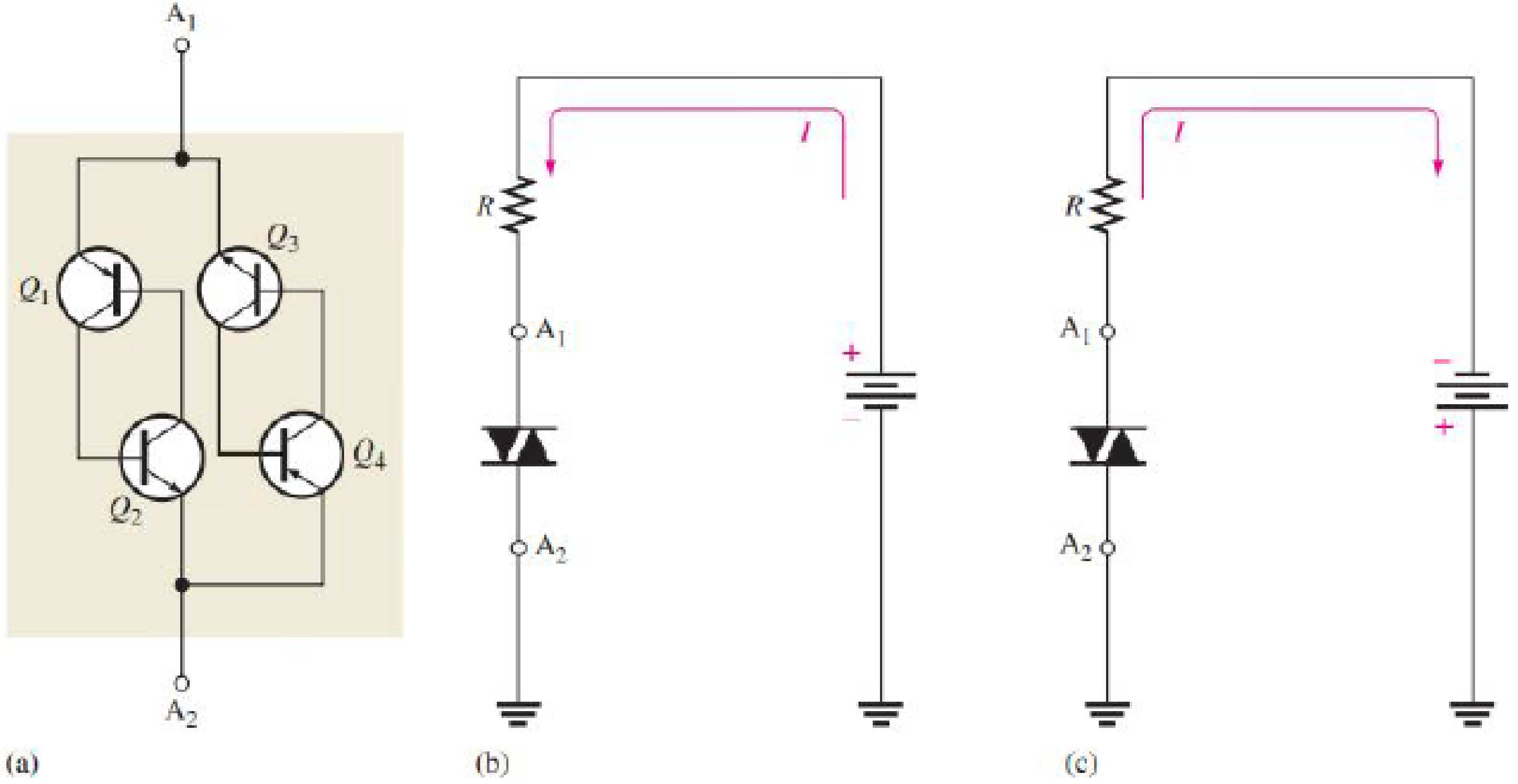
DIAC

- Notice that there are two terminals, labelled A1 and A2.
- The top and bottom layers contain both *n* and *p* materials.
- The right side of the stack can be regarded as a *pnpn* structure with the same characteristics as a four-layer diode, while the left side is an inverted four-layer diode having an *npnp* structure.
- Conduction occurs in a diac when the breakover voltage is reached with either polarity across the two terminals.
- The curve in Figure 3-2 illustrates this characteristic. Once breakover occurs, current is in a direction depending on the polarity of the voltage across the terminals.
- The device **turns off** when the current drops **below the holding** value.

Equivalent Circuit of a Diac

- The equivalent circuit of a diac consists of four transistors arranged as shown in Figure 3–3(a).
- When the diac is biased as in Figure 3–3(b), the pnpn structure from A1 to A2 provides the same operation as was described for the 4-layer diode.
- In the equivalent circuit, Q1 to Q2 are forward-biased, and Q3 to Q4 are reverse-biased. The device operates on the upper right portion of the characteristic curve in Figure 3–2 under this bias condition.
- When the diac is biased as shown in Figure 3–3(c), the pnpn structure from A2 and A1 is used. In the equivalent circuit, Q3 and Q4 are forward-biased, Q1 and Q2 and are reverse-biased. Under this bias condition, the device operates on the lower left portion of the characteristic curve, as shown in Figure 3-2

Equivalent Circuit of a Diac



▲ FIGURE 3-3

Diac equivalent circuit and bias conditions.

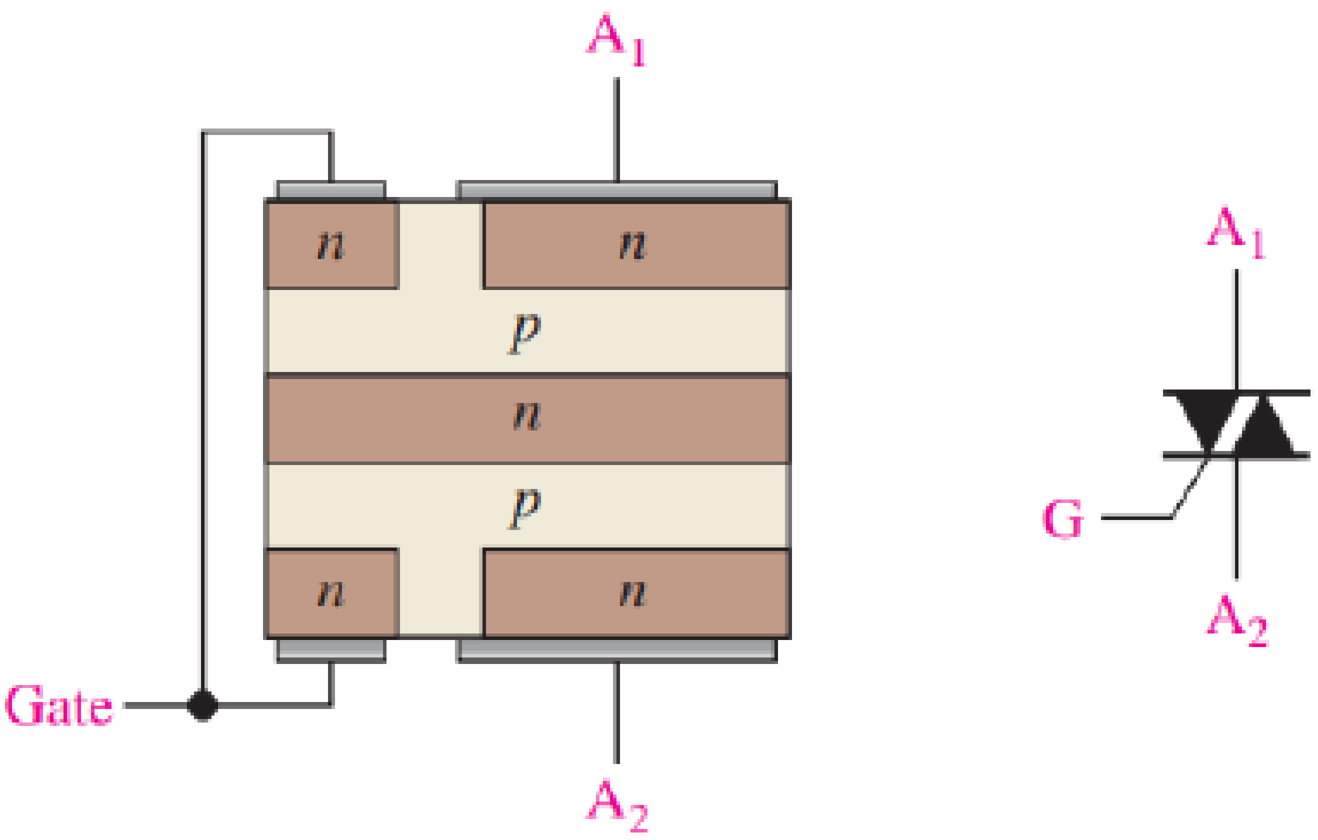
TRIAC

Triode for Alternating Current

TRIAC

- A triac is like a diac with a gate terminal.
- A triac can be turned on by a pulse of gate current and does not require the breakover voltage to initiate conduction, as does the diac.
- Basically, a triac can be thought of simply as two SCRs connected in parallel and in opposite directions with a common gate terminal.
- Unlike the SCR, the triac can conduct current in either direction when it is triggered on, depending on the polarity of the voltage across its A1 and A2 terminals. Figure 3–4 shows the basic construction and schematic symbol for a triac.

TRIAC

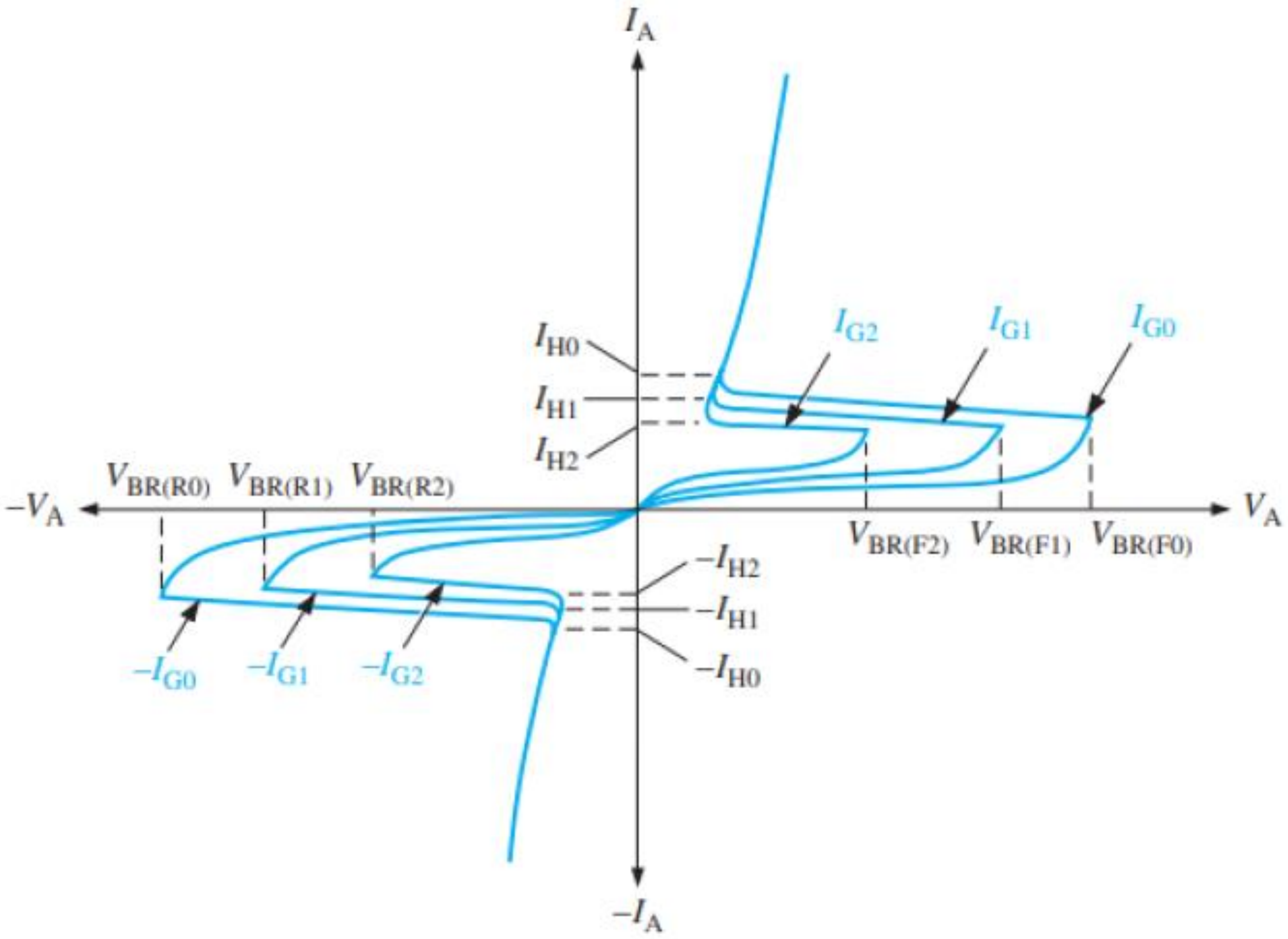


(a) Basic construction (b) Symbol

FIGURE 3-4

The triac.

TRIAC Characteristic Curve



▲ FIGURE 3-5

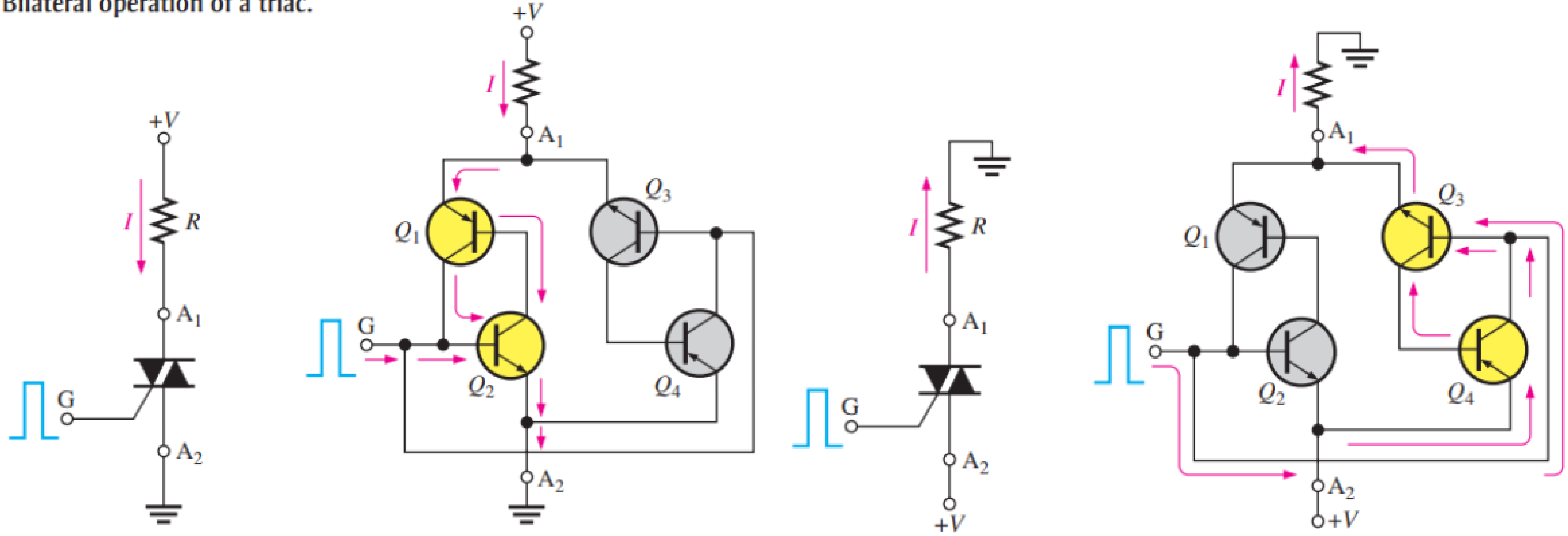
Triac characteristic curves.

- The characteristic curve is shown in Figure 3–5. Notice that the breakover potential decreases as the gate current increases, just as with the SCR.
- As with other thyristors, the triac ceases to conduct when the anode current drops below the specified value of the holding current, IH.
- Thus, the only way to turn off the triac is to reduce the current to a sufficiently low level.

Bilateral Operation of TRIAC

FIGURE 3-6

Bilateral operation of a triac.



(a) (b) Q_1 and Q_2 on (c) (d) Q_3 and Q_4 on

Bilateral Operation of TRIAC

- Figure 3–6 shows the triac being triggered into both directions of conduction.
- In part (a), terminal A1 is biased positive with respect to A2, so the triac conducts as shown when triggered by a positive pulse at the gate terminal.
- The transistor equivalent circuit in part (b) shows that Q1 and Q2 conduct when a positive trigger pulse is applied.
- In part (c), terminal A2 is biased positive with respect to A1, so the triac conducts as shown.
- In this case, Q3 and Q4 conduct as indicated in part (d) upon application of a positive trigger pulse.

Applications

- Like the SCR, Triacs are also used to control average power to a load by the method of phase control.
- The triac can be triggered such that the ac power is supplied to the load for a controlled portion of each half-cycle.
- During each positive half-cycle of the ac, the triac is off for a certain interval, called the **delay angle** (measured in degrees), and then it is triggered on and conducts current through the load for the remaining portion of the positive half-cycle, called the conduction angle.
- Similar action occurs on the negative half-cycle except that, of course, current is conducted in the opposite direction through the load.

Applications

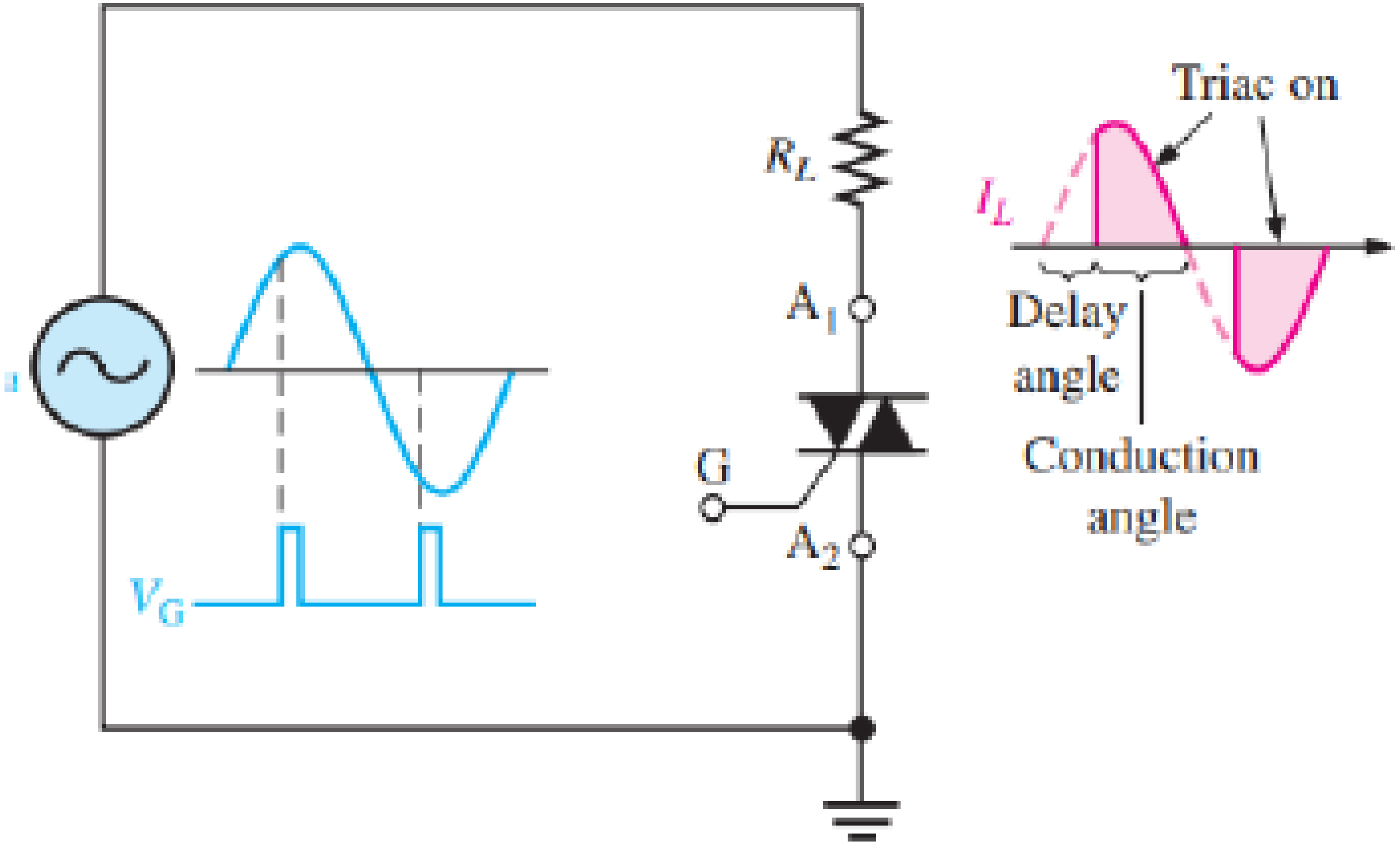


FIGURE 3-7

Basic triac phase control.

Applications

- One example of phase control using a triac is illustrated in Figure 3-8(a).

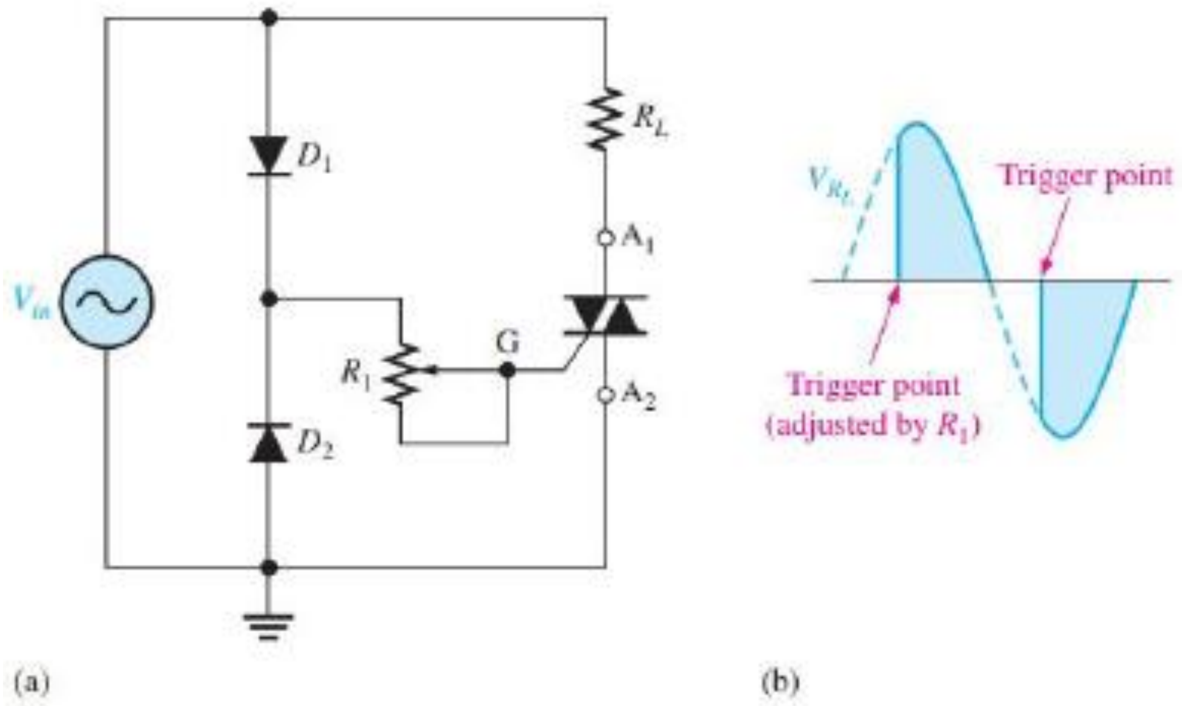


FIGURE 3-8
Triac phase-control circuit.

- Diodes are used to provide trigger pulses to the gate of the triac. Diode D1 conducts during the positive half-cycle. The value of R1 sets the point on the positive half-cycle at which the triac triggers. Notice that during this portion of the ac cycle, A1 and G are positive with respect to A2.

Applications

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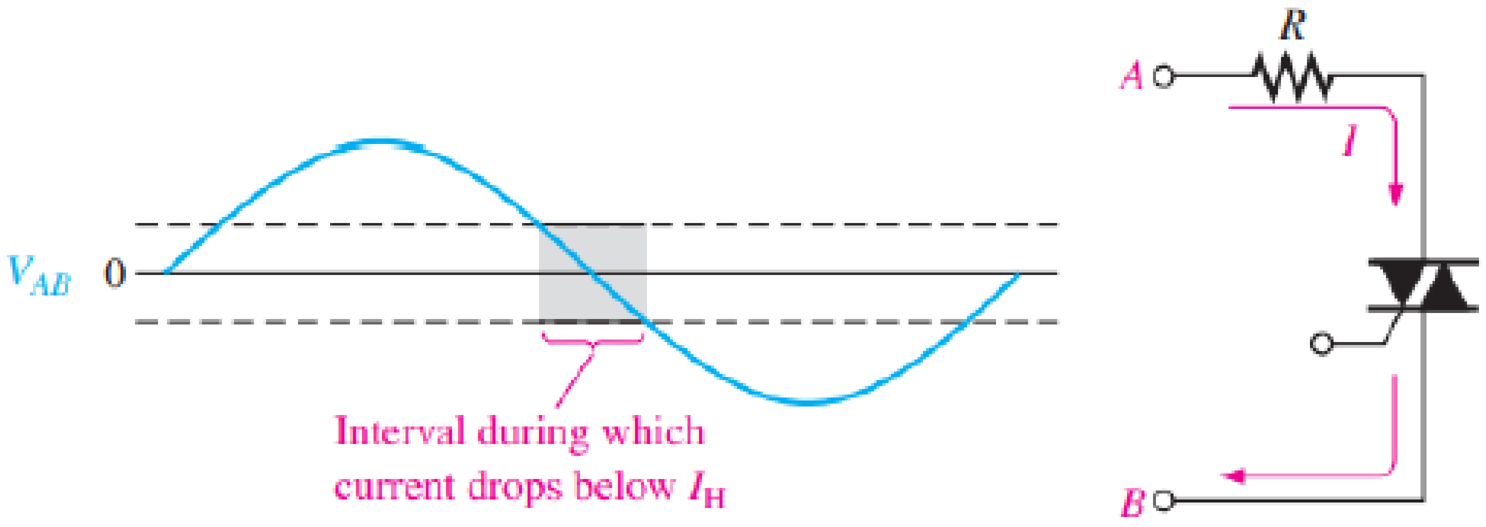
Applications

- In the phase-control circuit, it is necessary that the triac turn off at the end of each positive and each negative alternation of the ac. Figure 3–9 illustrates that there is an interval near each 0 crossing where the triac current drops below the holding value, thus turning the device off.

FIGURE 3-9

Triac turn-off interval.



Sample Problems

Problem #1

- Name the three leads of a triac.

Ans.

Anode1, Anode2, Gate

Problem #2

- What is the main advantage of a triac versus an SCR?

Ans.

Bilateral Operation

Problem #3

- How can the forward breakover voltage of a triac be reduced?

Ans.

Trigger voltage (Gate)

Problem #4

- Can a triac be triggered with a negative gate voltage?

Ans.

Yes (Bilateral)

Problem #5

- How can a triac be turned off?

Ans.

Reduce anode current below I_H.

Problem #6

- Why is a triac said to be asymmetrical?

Ans.

Because of its internal construction.

(Due to slight differences between the two halves, these electronic components do not fire symmetrically.)