LASCR, SCS & GTO

LASCR, SCS & GTO

- A family of four-layer pnpn devices will first be considered: the SCR (silicon-controlled rectifier), the SCS (silicon-controlled switch), the GTO (gate turn-off switch) and the LASCR (light-activated SCR).
- Those four-layer devices with a control mechanism are commonly referred to as thyristors, although the term is most frequently applied to the SCR.

Light-Activated SCR (LASCR)

Light-Activated SCR (LASCR)

- A four-layer semiconductor device (thyristor) that operates essentially as does the conventional SCR except that it can also be light-triggered.
- The LASCR conducts current in one direction when activated by a sufficient amount of light and continues to conduct until the current falls below a specified value.
- The LASCR is most sensitive to light when the gate terminal is open. If necessary, a resistor from the gate to the cathode can be used to reduce the sensitivity.
- Figure 4-1 shows a LASCR schematic symbol.
- a.k.a. Light Triggered Thyristor (LTT)

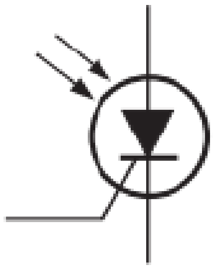


FIGURE 4-1

LASCR symbol.

Example Application of LASCR

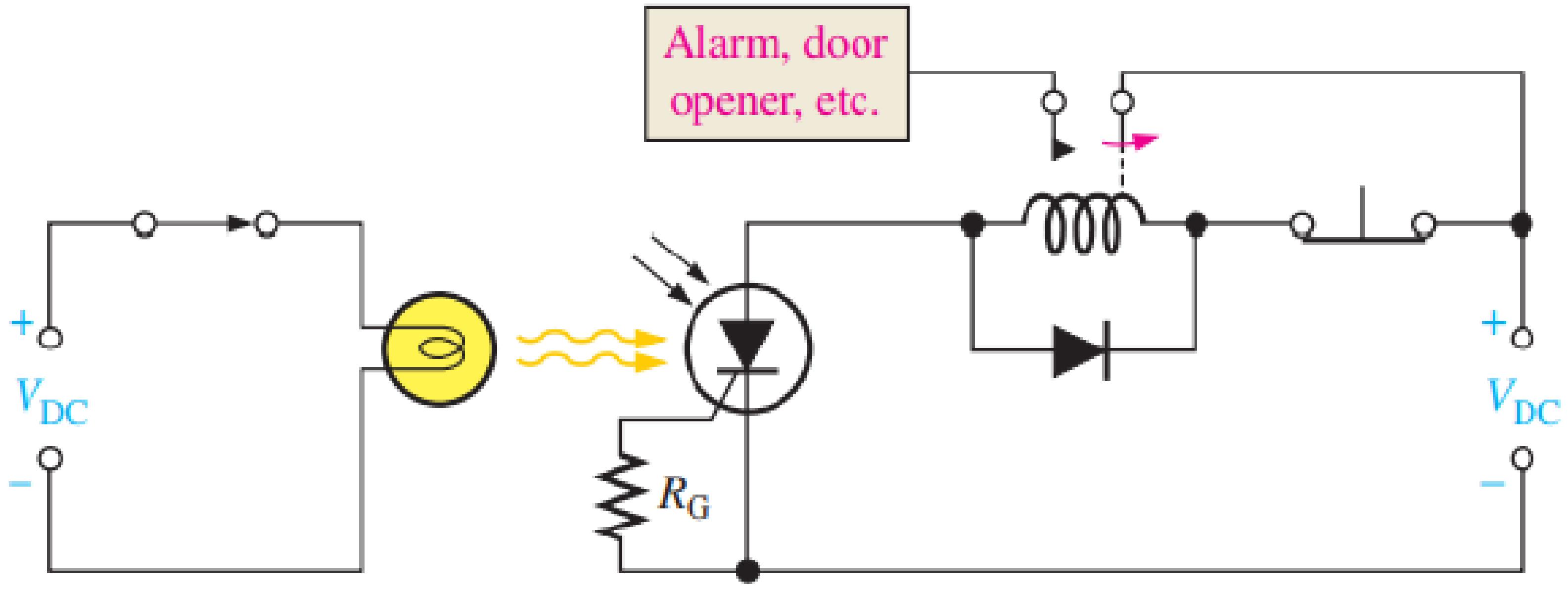


FIGURE 4-2

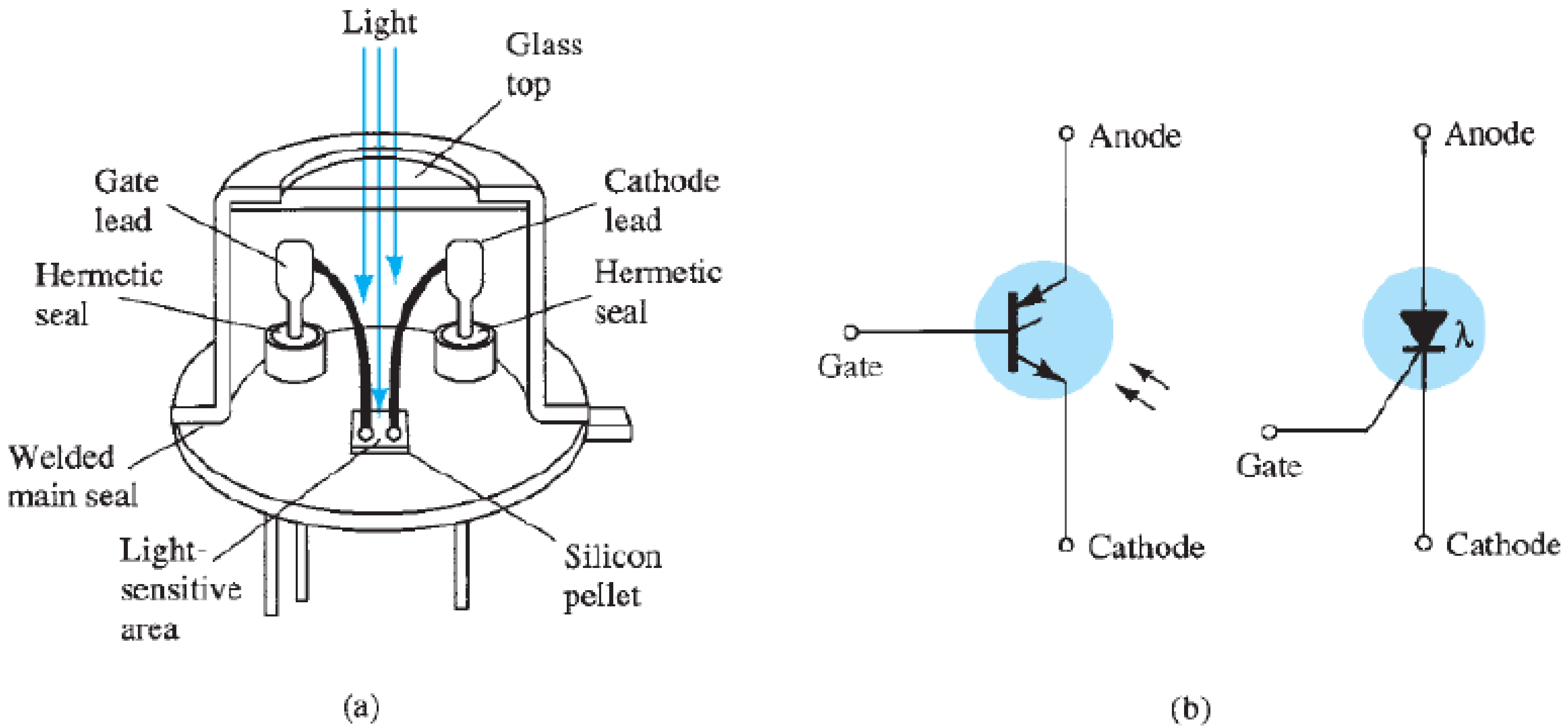
A LASCR circuit.

- Figure 4-2 shows a LASCR used to energize a **latching relay**. The input source turns on the lamp; the resulting incident light triggers the LASCR. The anode current energizes the relay and closes the contact. Notice that the input source is electrically **isolated** from the rest of the circuit

Latching Relay

- A latching relay is **a two-position electrically-actuated switch**.
- It maintains either contact position indefinitely without power applied to the coil.
- It is controlled by two momentary-acting switches or sensors, one that 'sets' the relay, and the other 'resets' the relay.

Basic Construction of LASCR



▲ FIGURE 4-3

Light-activated SCR (LASCR): (a) basic construction; (b) symbols.

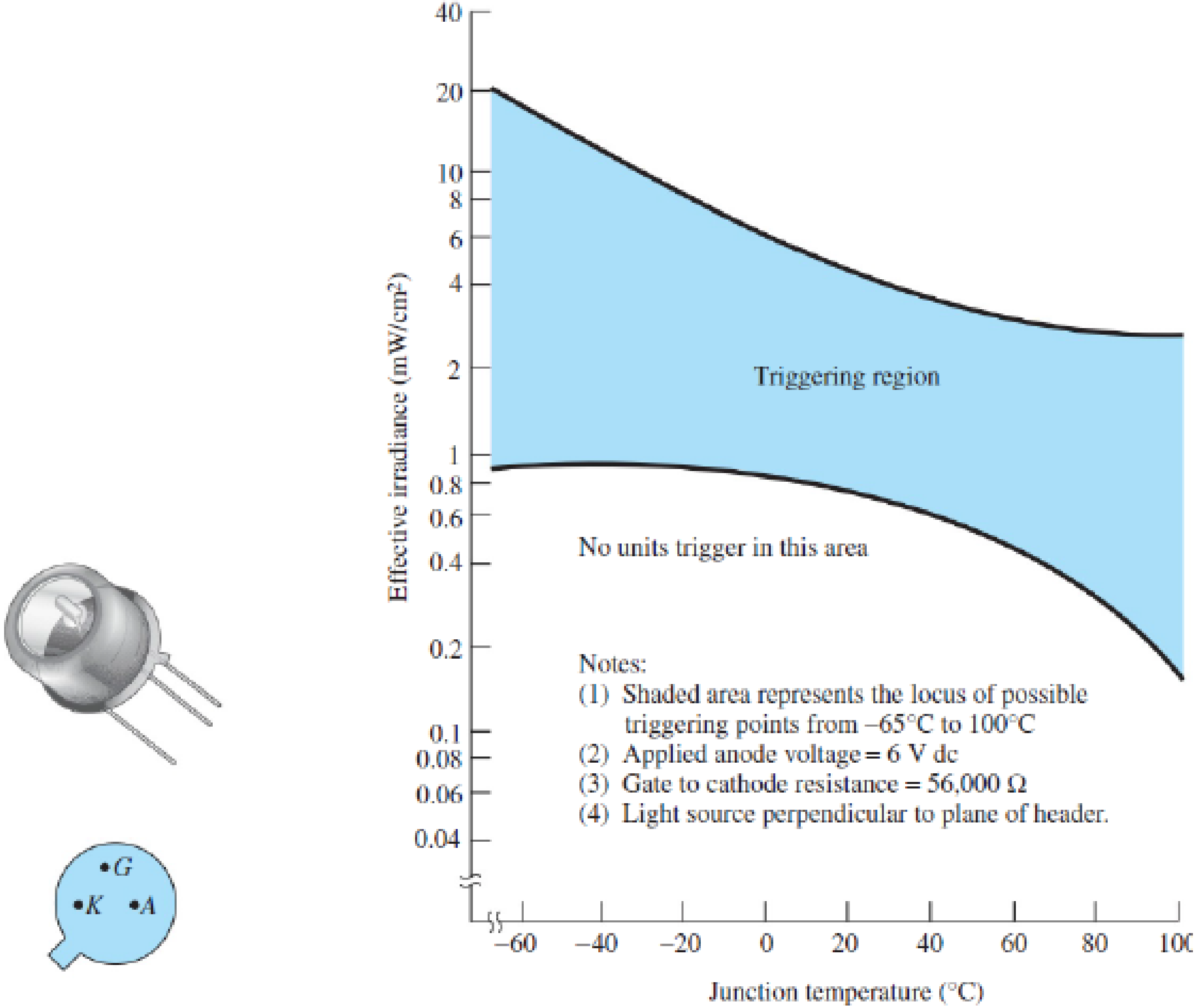
Basic Construction of LASCR

- As indicated by the terminology, it is an SCR whose state is controlled by the light falling on a silicon semiconductor layer of the device.
- The basic construction of an LASCR is shown in Figure 4-3(a).
- As indicated in Figure 4-3(a), a gate lead is also provided to permit triggering the device using typical SCR methods.
- Note also in the figure that the mounting surface for the silicon pellet is the anode connection for the device.
- The graphical symbols most commonly employed for the LASCR are provided in Figure 4-3(b).
- The terminal identification and a typical LASCR appear in Figure 4-4(a)

Light-Activated SCR (LASCR)

- Some of the areas of application for the LASCR include optical light controls, relays, phase control, motor control, and a variety of computer applications.
- The maximum current (rms) and power (gate) ratings for commercially available LASCRs are about 3 A and 0.1 W, respectively.
- The characteristics (light triggering) of a representative LASCR are provided in Figure 4-4(b).
- Note in this figure that an *increase in junction temperature* results in a reduction in light energy required to activate the device.

Terminal Identification & Light-triggering Characteristics



(a) (b)

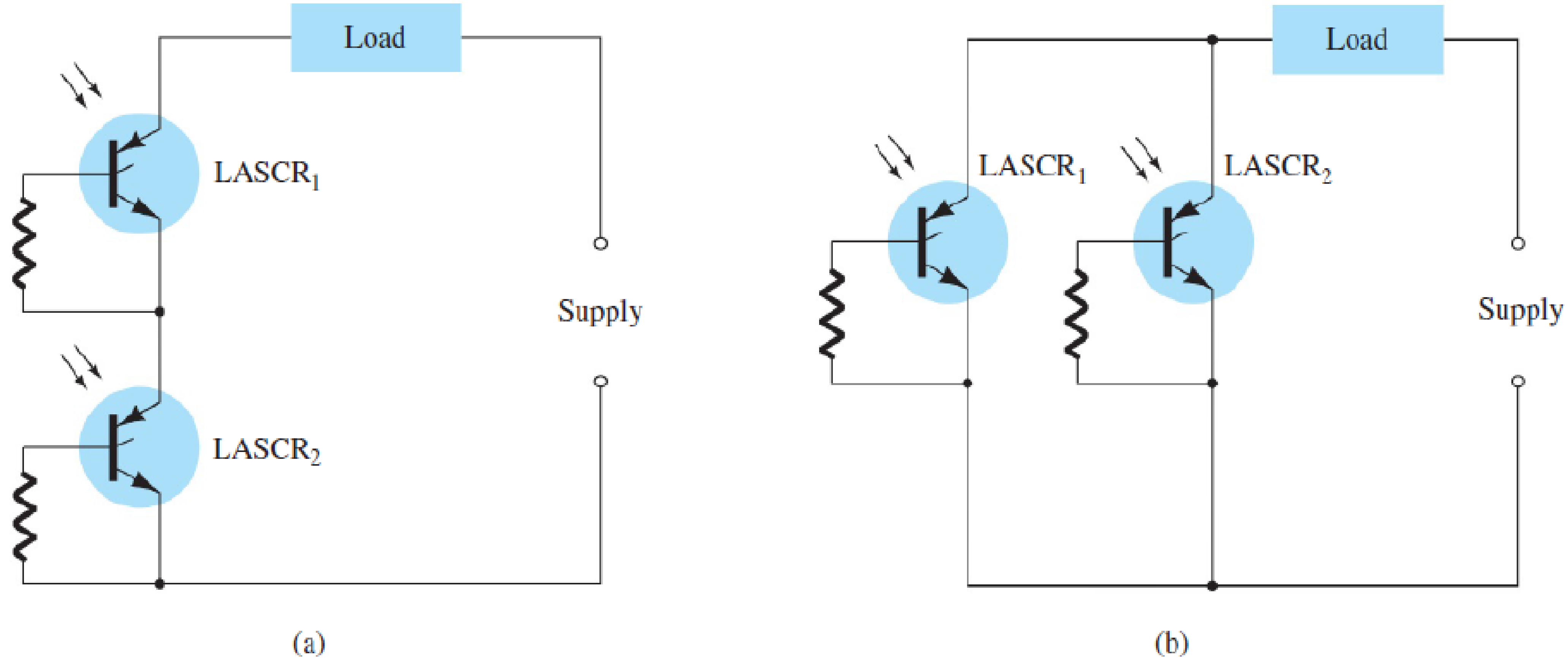
FIGURE 4-4

LASCR: (a) appearance and terminal identification; (b) light-triggering characteristics.

Applications
(AND/OR Circuits)

- One interesting application of an LASCR is in the AND and OR circuits of Figure 4-5.
- Only when light falls on LASCR1 and LASCR2 will the short-circuit representation for each be applicable and the supply voltage appear across the load. For the OR circuit, light energy applied to LASCR1 or LASCR2 will result in the supply voltage appearing across the load.
- The LASCR is most sensitive to light when the gate terminal is open. Its sensitivity can be reduced and controlled somewhat by the insertion of a gate resistor, as shown in Figure 4-5

AND/OR Circuits



▲ FIGURE 4-5

LASCR optoelectronic logic circuitry: (a) AND gate: input to LASCR$_1$ and LASCR$_2$ is required for energization of the load; (b) OR gate: input to either LASCR$_1$ or LASCR$_2$ will energize the load.

Latching Relay

- A second application of the LASCR appears in Figure 4-6.
- It is the semiconductor analog of an electromechanical relay.
- Note that it offers complete isolation between the input and the switching element.
- The energizing current can be passed through a light-emitting diode or a lamp, as shown in the figure.
- The incident light will cause the LASCR to turn on and permit a flow of charge (current) through the load as established by the dc supply.
- The LASCR can be turned off using the reset switch *S*1. This system offers the additional advantages over an electromechanical switch of long life, microsecond response, small size, and the elimination of contact bounce.

Latching Relay

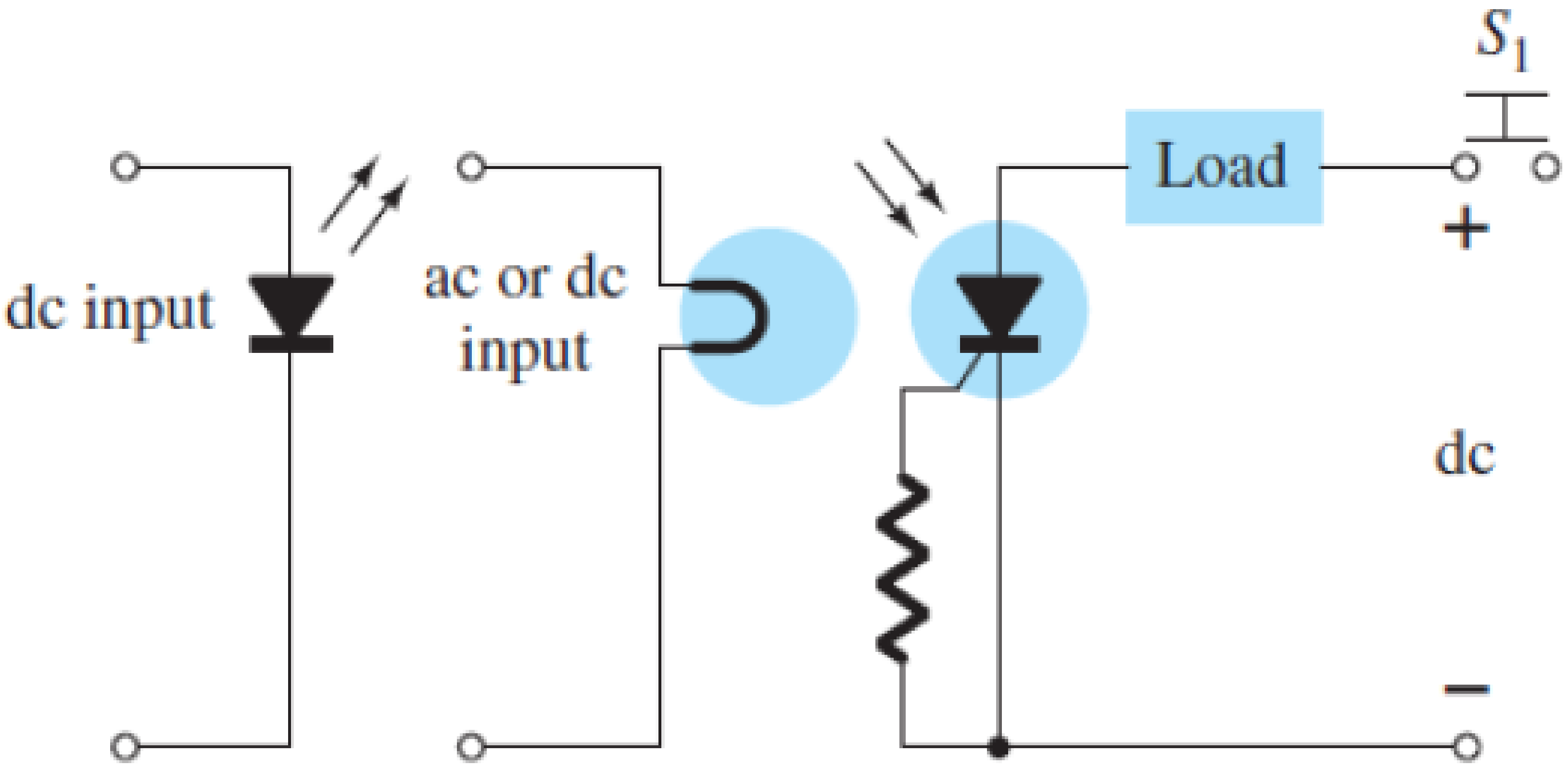


FIGURE 4-6

Latching relay.

SILICON-CONTROLLED SWITCH (SCS)

SILICON-CONTROLLED SWITCH (SCS)

- It is similar in construction to the SCR. The SCS, however, has two gate terminals, the cathode gate and the anode gate.
- The SCS can be turned on and off using either gate terminal.
- Remember that the SCR can be only turned on using its gate terminal.
- Normally, the SCS is available in power ratings lower than those of the SCR.

Basic Operation

- An SCS (silicon-controlled switch) is a four-terminal thyristor that has two gate terminals that are used to trigger the device on and off.
- The symbol and terminal identification for an SCS are shown in Figure 4-7.

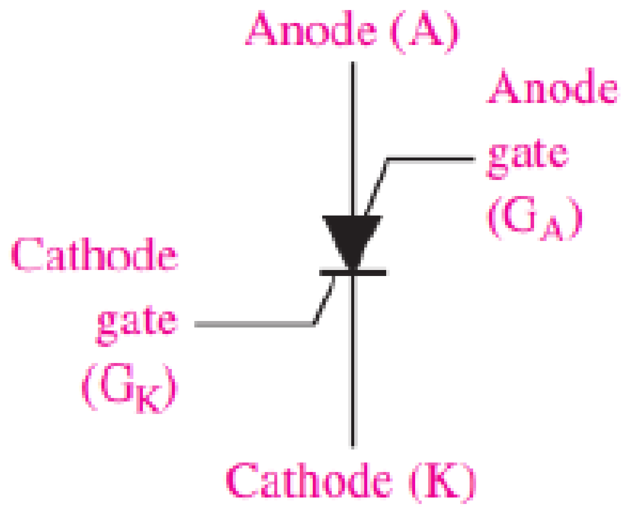
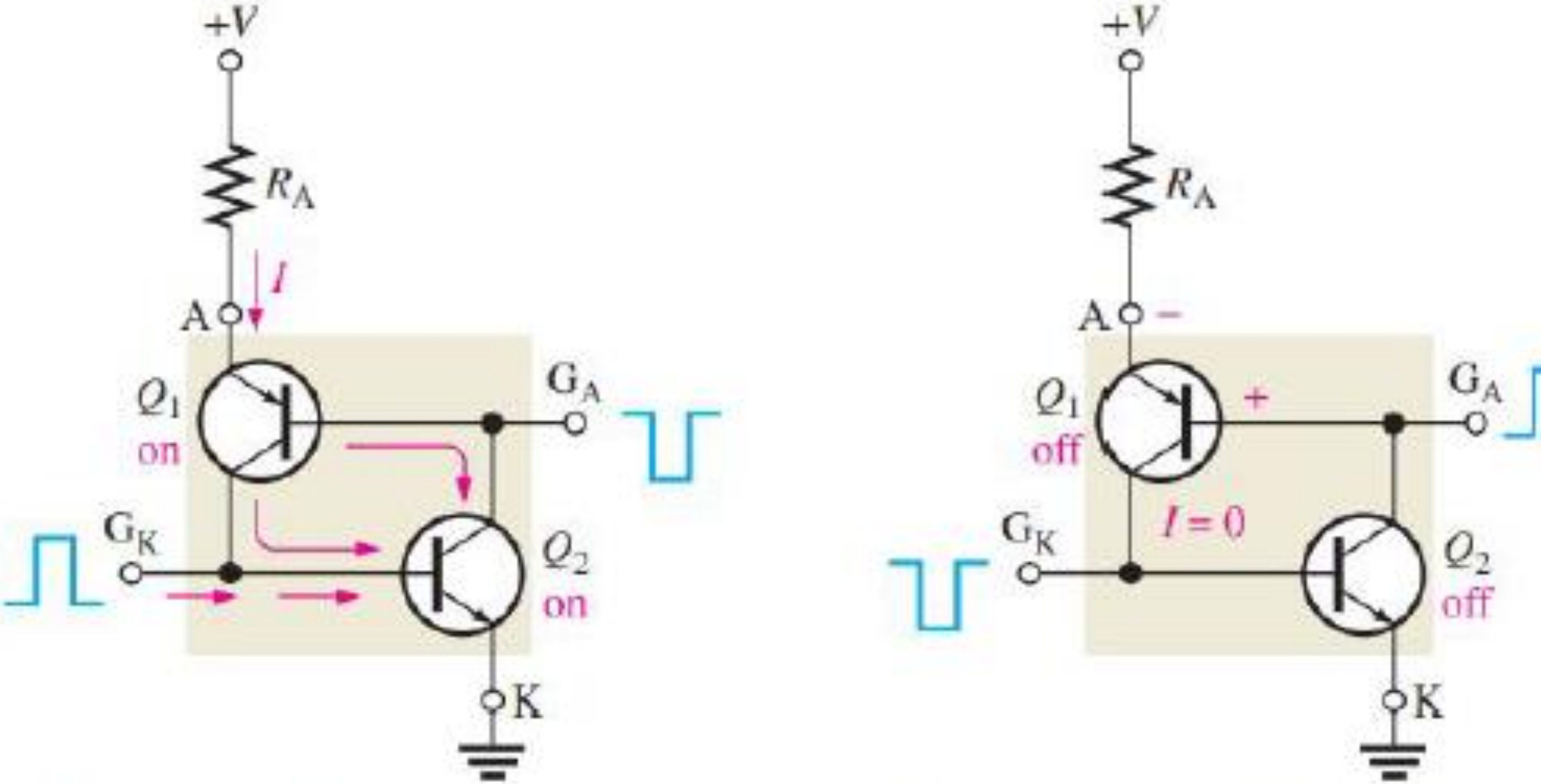


FIGURE 4-7

The silicon-controlled switch (SCS).

Basic Operation

- As with the previous thyristors, the basic operation of the SCS can be understood by referring to the transistor equivalent, shown in Figure 4-8.
- To start, assume that both Q1 and Q2 are off, and therefore that the SCS is not conducting.
- A positive pulse on the cathode gate drives Q2 into conduction and thus provides a path for Q1 base current.
- When Q1 turns on, its collector current provides base current for Q2, thus sustaining the on state of the device. This regenerative action is the same as in the turn-on process of the SCR and the 4-layer diode and is illustrated in Figure 4-8(a).



(a) *Turn-on*: Positive pulse on G_K *or* negative pulse on G_A

(b) *Turn-off*: Positive pulse on G_A *or* negative pulse on G_K

FIGURE 4-8

SCS operation.

Basic Operation

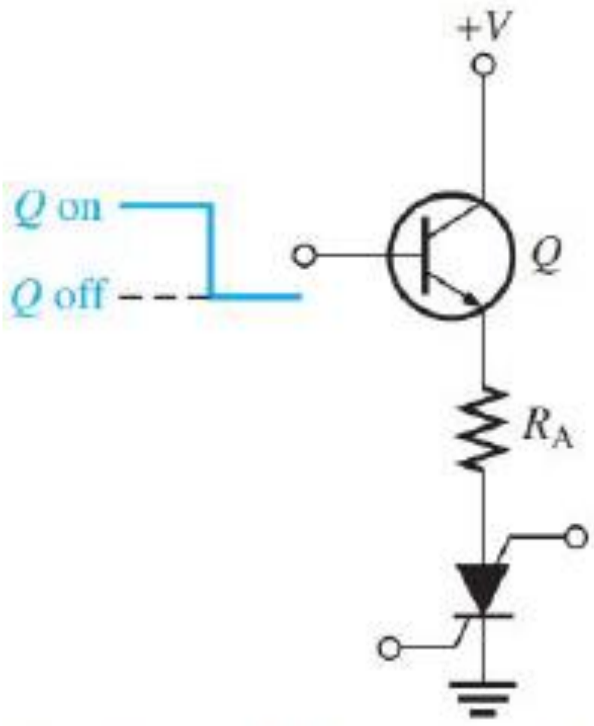
- To turn the SCS off, a positive pulse is applied to the anode gate.
- This reverse-biases the base-emitter junction of Q1 and turns it off.
- Q2, in turn, cuts off and the SCS ceases conduction, as shown in Figure 4-8(b).
- The device can also be turned off with a negative pulse on the cathode gate, as indicated in part (b). The SCS typically has a **faster turn-off time** than the SCR.

- In addition to the positive pulse on the anode gate or the negative pulse on the cathode gate, there is another method for turning off an SCS.
- Figure 4-8(a) and (b) shows two switching methods to reduce the anode current below the holding value.
- In each case, the bipolar junction transistor (BJT) acts as a switch to interrupt the anode current.

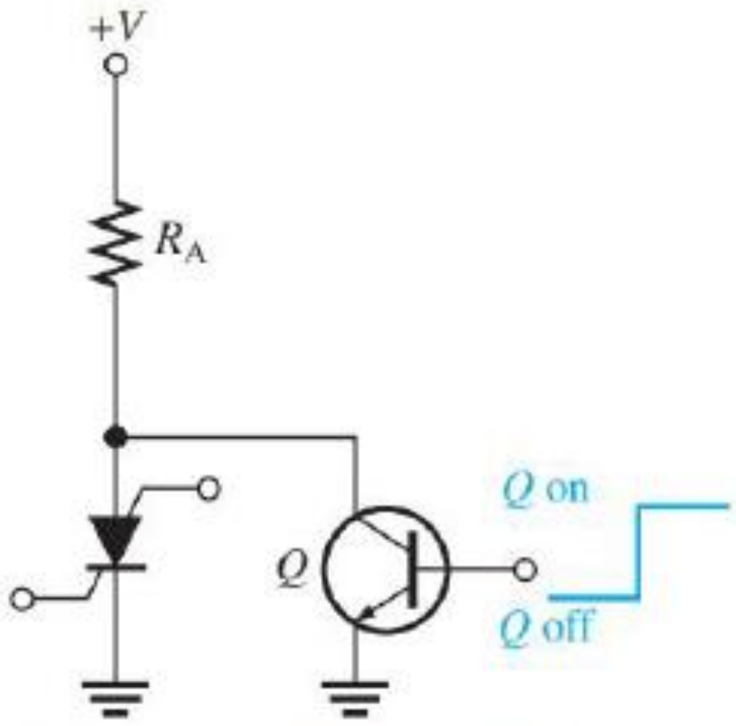
Applications

- The SCS and SCR are used in similar applications.
- The SCS has the advantage of faster turn-off with pulses on either gate terminal; however, it is more limited in terms of maximum current and voltage ratings.
- Also, the SCS is sometimes used in digital applications such as counters, registers, and timing circuits.

Applications



(a) Series switch turns off SCS



(b) Shunt switch turns off SCS

FIGURE 4-9

The transistor switch in both series and shunt configurations reduces the anode current below the holding current and turns off the SCS.

GATE TURN-OFF SWITCH (GTO)

GATE TURN-OFF SWITCH (GTO)

- The gate turn-off switch (GTO) is a pnpn device.
- Like the SCR, however, it has only three external terminals, as indicated in Figure 4-10(a).
- Its graphical symbol is shown in Figure 4-10(b).
- Although the graphical symbol is different from that of either the SCR or the SCS, the transistor equivalent is exactly the same and the characteristics are similar.

GATE TURN-OFF SWITCH (GTO) GATE TURN-OFF SWITCH (GTO)

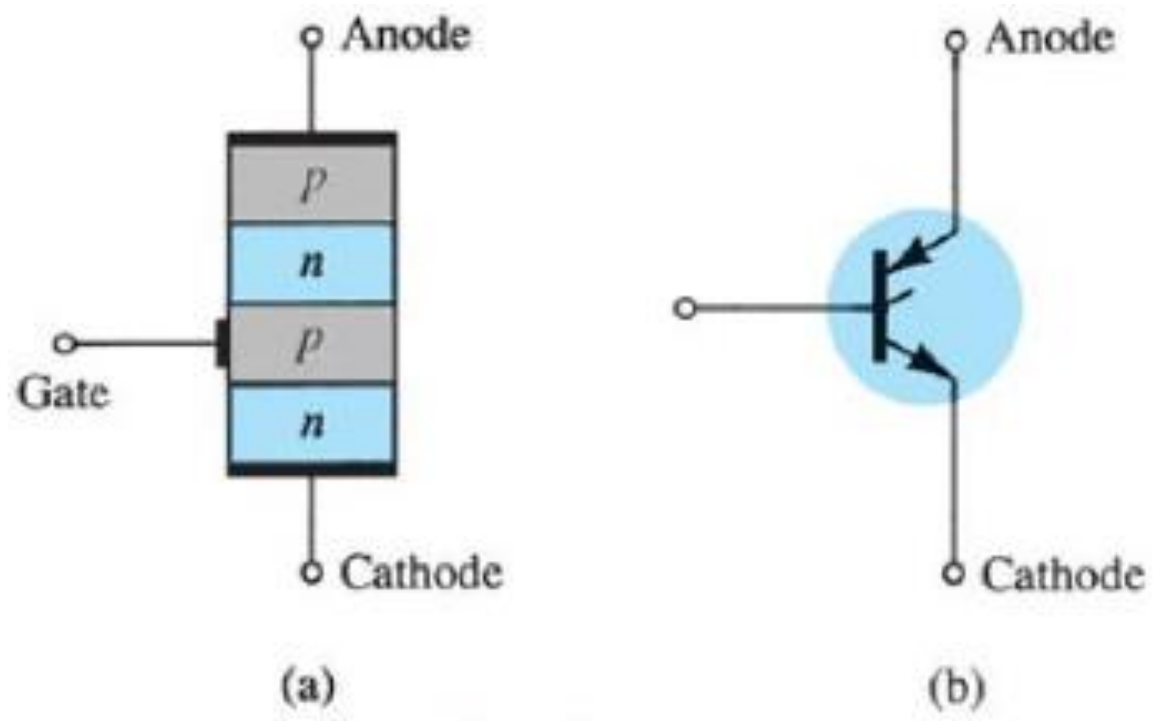


FIGURE 4-10

Gate turn-off switch (GTO):
(a) basic construction; (b) symbol.

GATE TURN-OFF SWITCH (GTO)

- The most obvious advantage of the GTO over the SCR or SCS is the fact that *it can be turned on or off by applying the proper pulse to the cathode gate* (without the anode gate and associated circuitry required for the SCS).
- A consequence of this turn-off capability is an *increase in the magnitude of the required gate current for triggering*.
- For an SCR and GTO of similar maximum rms current ratings, the gate-triggering current of a particular **SCR is 30 μA**, whereas the triggering current of the GTO is **20 mA**.
- The turn-off current of a GTO is slightly larger than the required triggering current. The maximum rms current and dissipation ratings of GTOs manufactured today are limited to about 3 A and 20 W, respectively.

GATE TURN-OFF SWITCH (GTO)

- A second very important characteristic of the GTO is **improved switching characteristics**.
- The turn-on time is similar to that of the SCR (typically 1 μs), but the turn-off time of about the same duration (1 μs) is much smaller than the typical turn-off time of an SCR (5 μs to 30 μs).
- The fact that the turn-off time is similar to the turn-on time rather than considerably larger permits the use of this device in high-speed applications.
- A typical GTO and its terminal identification are shown in Figure 4-11. The GTO gate input characteristics and turn-off circuits can be found in a comprehensive manual or specification sheet. The majority of the SCR turn-off circuits can also be used for GTOs.

GATE TURN-OFF SWITCH (GTO)

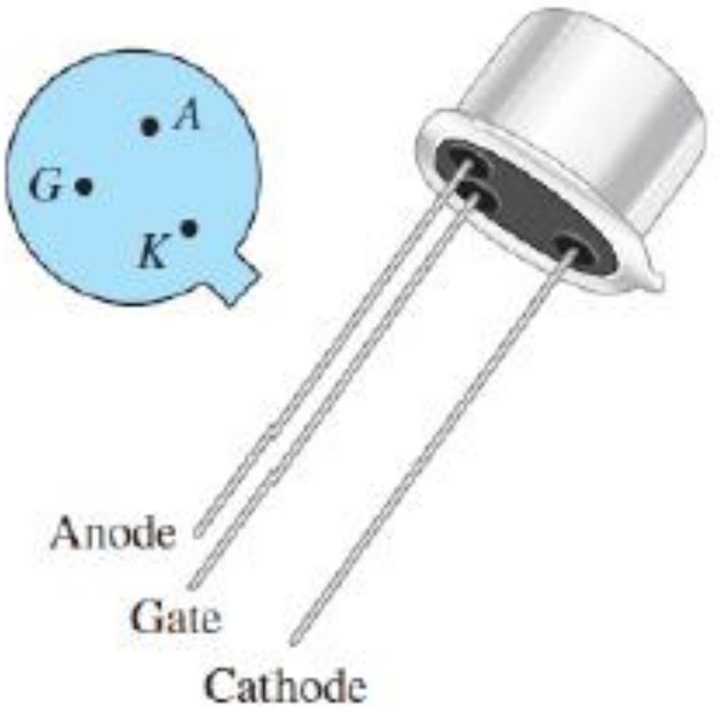


FIGURE 4-11

Typical GTO and its terminal identification.