

# EELE 250: Circuits, Devices, and Motors

Semiconductors

# Semiconductor Junctions

- Semiconductors are materials whose electrical conductivity can be manipulated during manufacturing by adding precise quantities of *dopant* atoms.
- Semiconductor *junctions* are made by changing the doping from one type to another during the manufacturing process.
- The most common semiconductor base material is silicon [Si, atomic number 14].

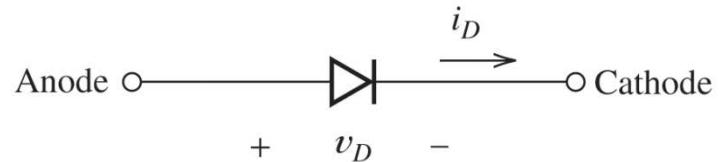
# Semiconductors (cont.)

- P-type semiconductors have added dopant atoms with one fewer valence electron (3) than silicon (4). Boron is one example.
- N-type semiconductors have added dopant atoms with one additional valence electron (5) than silicon (4). Arsenic is one example.

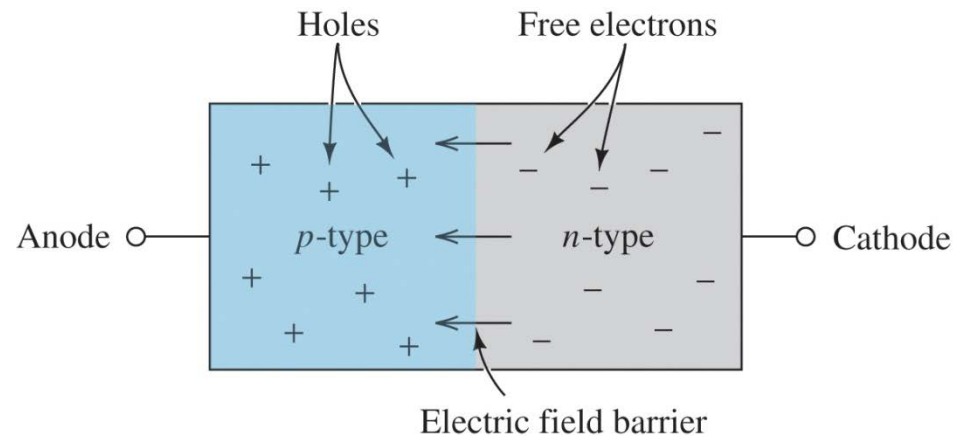
								helium 2 <b>He</b> 4.0026
			boron 5 <b>B</b> 10.811	carbon 6 <b>C</b> 12.011	nitrogen 7 <b>N</b> 14.007	oxygen 8 <b>O</b> 15.999	fluorine 9 <b>F</b> 18.998	neon 10 <b>Ne</b> 20.180
			aluminium 13 <b>Al</b> 26.982	silicon 14 <b>Si</b> 28.086	phosphorus 15 <b>P</b> 30.974	sulfur 16 <b>S</b> 32.065	chlorine 17 <b>Cl</b> 35.453	argon 18 <b>Ar</b> 39.948
	copper 29 <b>Cu</b> 63.546	zinc 30 <b>Zn</b> 65.39	gallium 31 <b>Ga</b> 69.723	germanium 32 <b>Ge</b> 72.61	arsenic 33 <b>As</b> 74.922	selenium 34 <b>Se</b> 78.96	bromine 35 <b>Br</b> 79.904	krypton 36 <b>Kr</b> 83.80
	silver 47 <b>Ag</b> 107.87	cadmium 48 <b>Cd</b> 112.41	indium 49 <b>In</b> 114.82	tin 50 <b>Sn</b> 118.71	antimony 51 <b>Sb</b> 121.76	tellurium 52 <b>Te</b> 127.60	iodine 53 <b>I</b> 126.90	xenon 54 <b>Xe</b> 131.29
	gold	mercury	thallium	lead	bismuth	polonium	astatine	radon

# PN Junctions

- A silicon crystal that is grown so that the dopants are switched from  $p$ -type to  $n$ -type, or with processing that diffuses or implants the dopants, creates a  $pn$  junction.
- Electrically, a  $pn$  junction acts like a diode.



(a) Circuit symbol



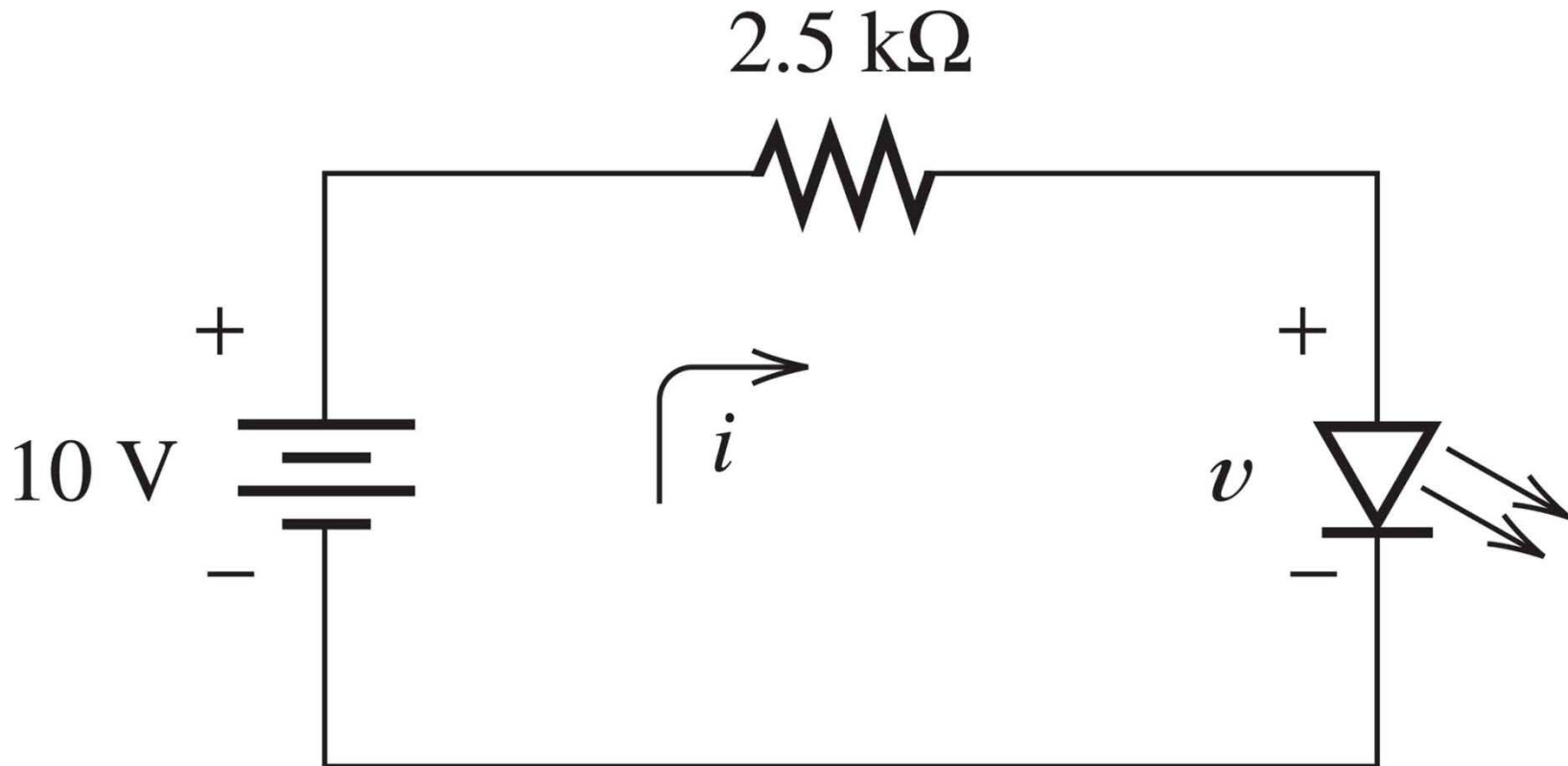
(c) Simplified physical structure

# Other junction devices

- Light-emitting diodes
  - Often Gallium-Arsenide junction
  - Electron-Hole recombination produces a photon
- Semiconductor lasers
- Transistors
- Triacs

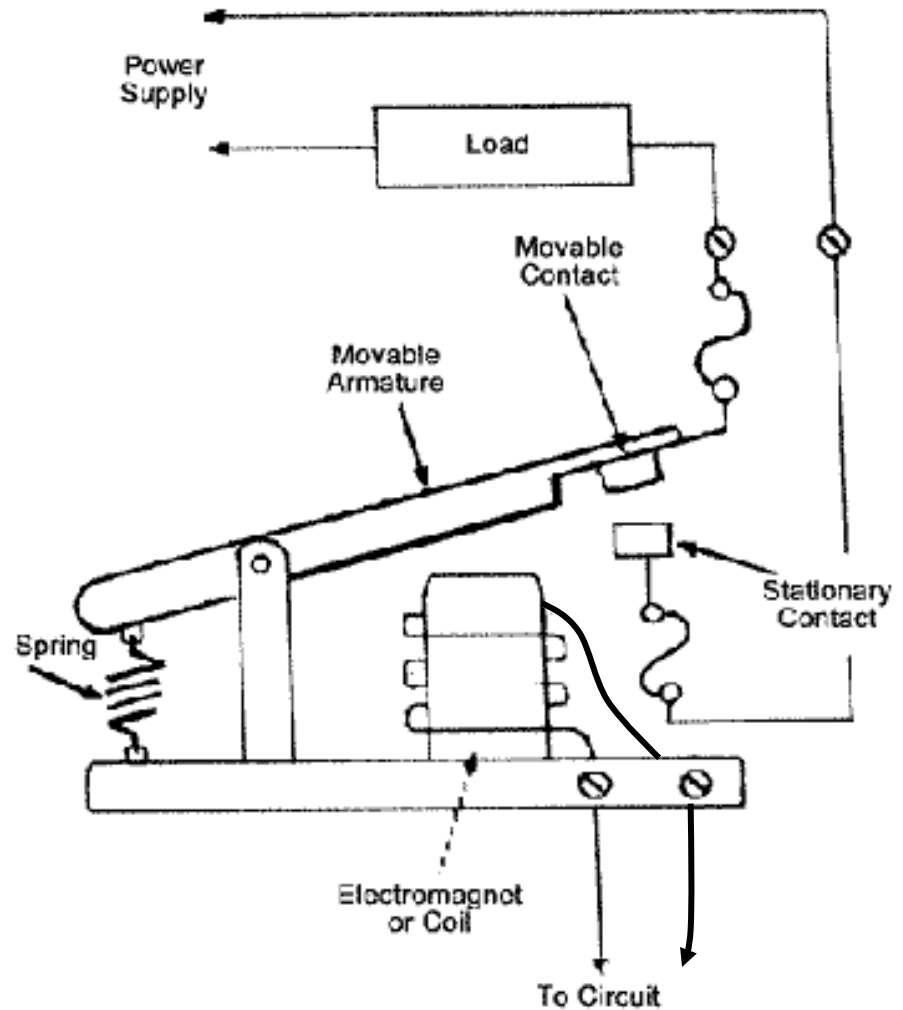
# LED

- Resistor is essential! Need to limit current.



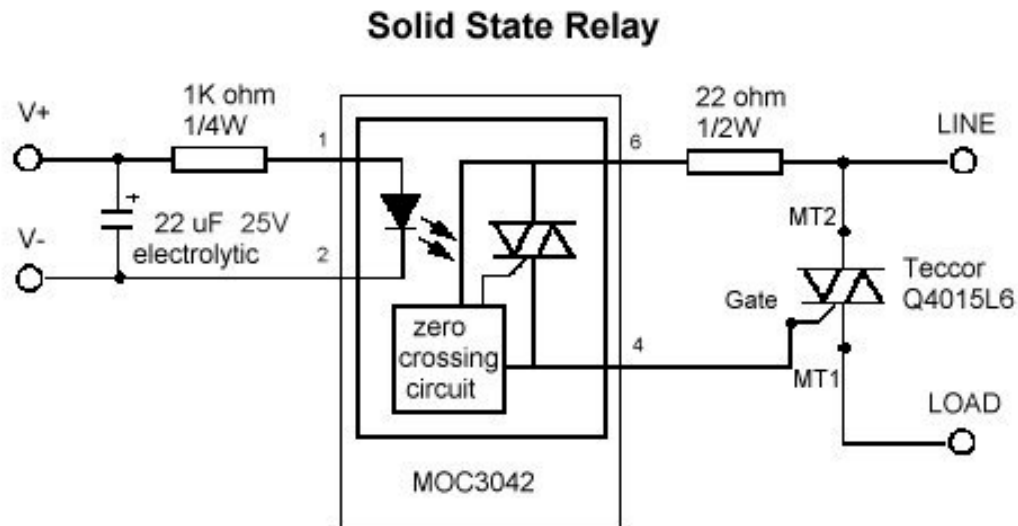
# Electromechanical Relay

- An electrical *relay* is an isolated switch.
- The control is a low-power circuit, often an electromagnet.
- The low-power electromagnet causes a separate high-power circuit to close or open.



# Opto-isolated Relay

- An *optoisolator* uses an LED to activate a photodetector triac. All solid state. No mechanical moving parts!

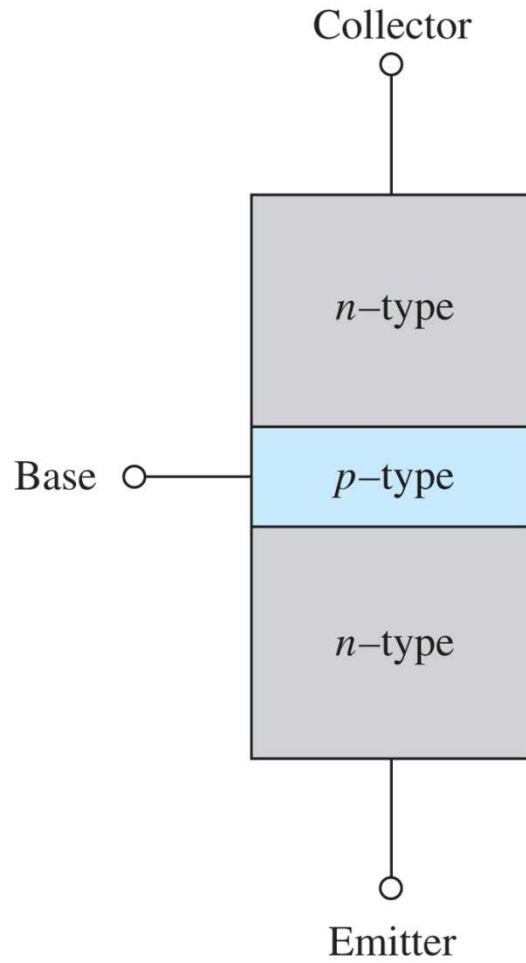




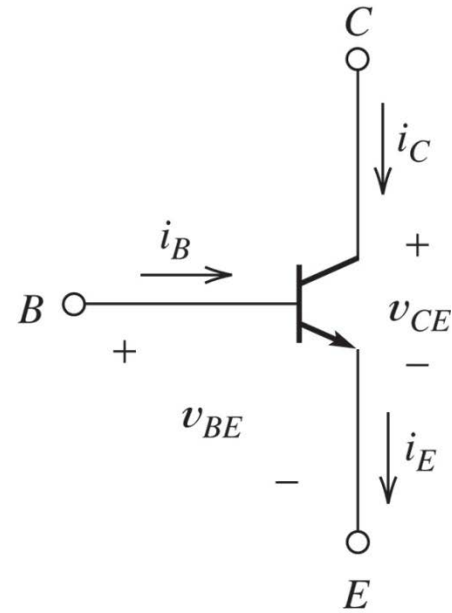
# Transistors

- A transistor is a solid-state semiconductor device that allows a small current or voltage to control (or “throttle”) a large current or voltage.
- Bipolar junction transistors (BJTs) have two semiconductor junctions: *npn* or *pnp*
- Field-effect transistors (FETs) use a capacitor-like electric field to control conduction

# BJTs

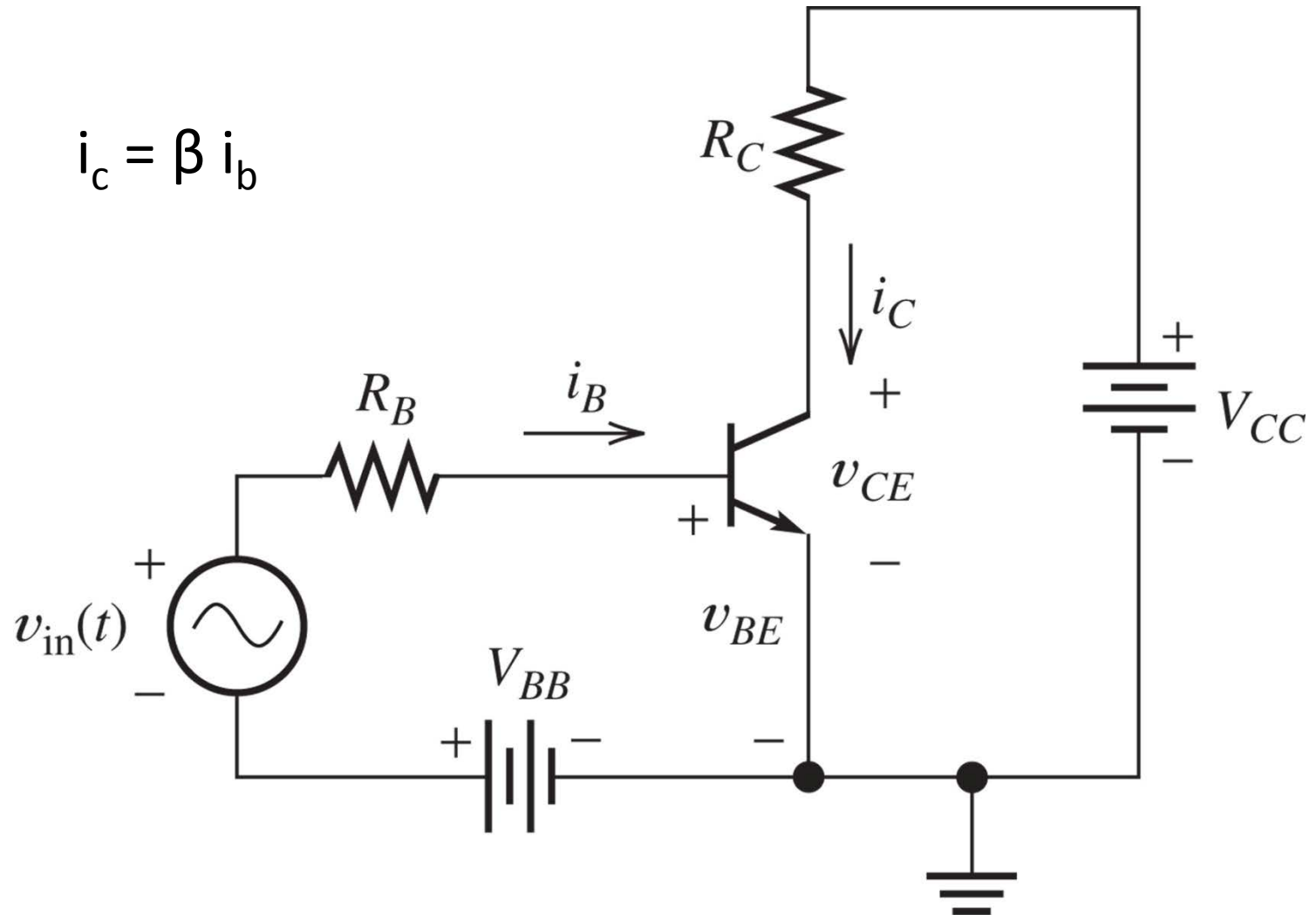


(a) Physical structure

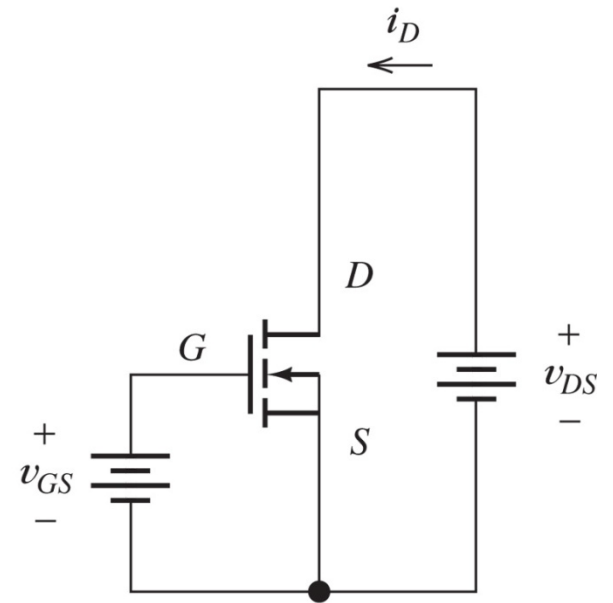
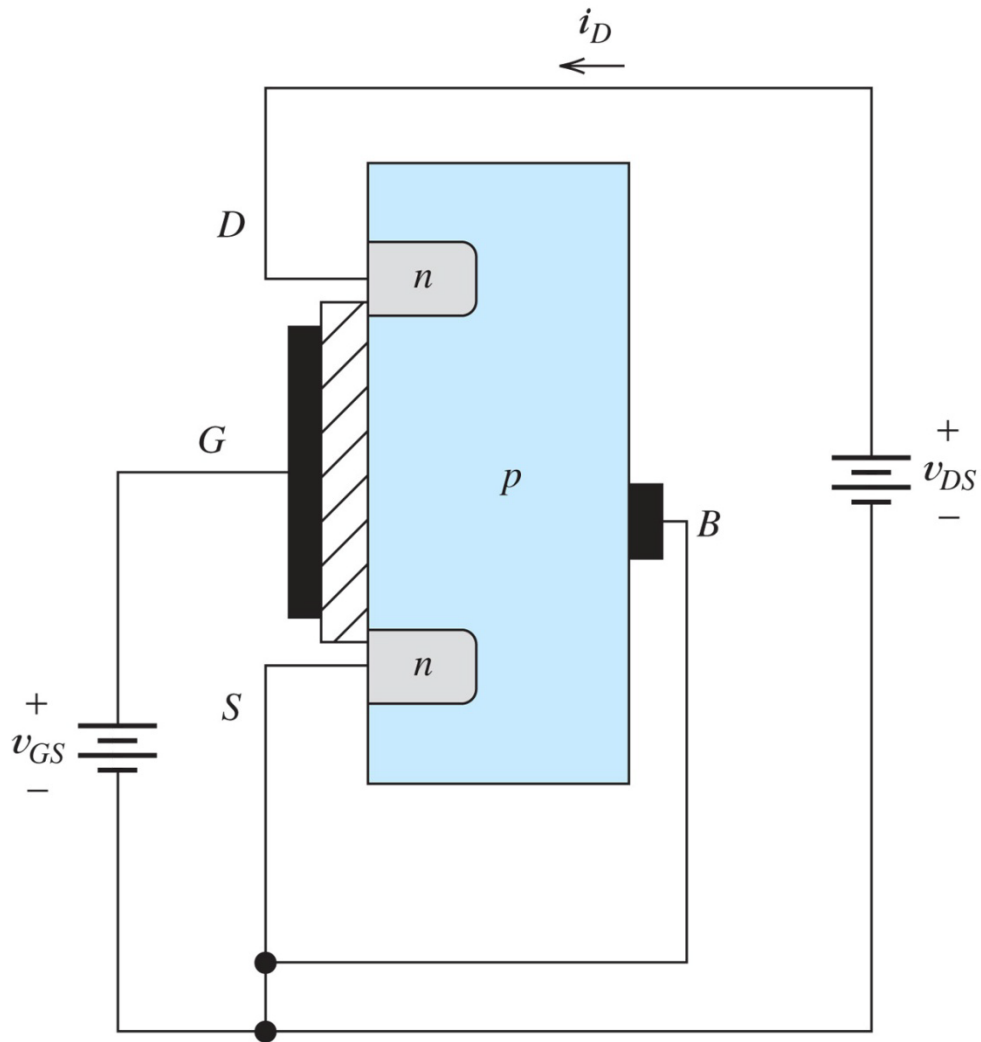


(b) Circuit symbol

# BJT (cont.)



# FETs



# FET (cont.)

