EELE 250: Circuits, Devices, and Motors

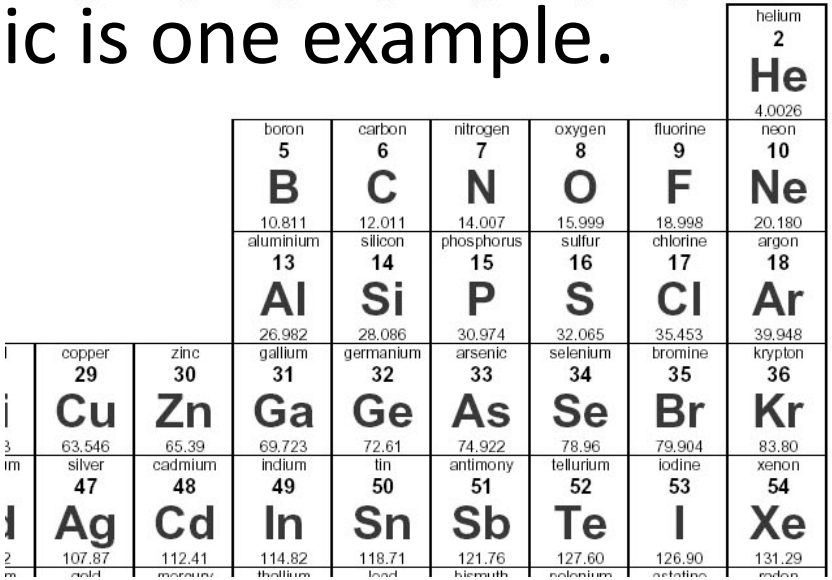
Semiconductors

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].

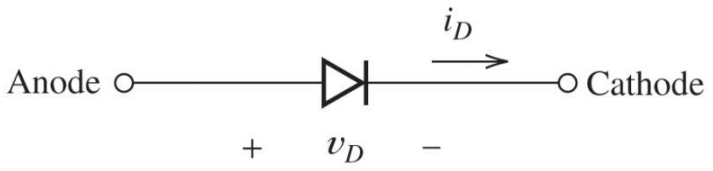
Semiconductors (cont.)

- 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.

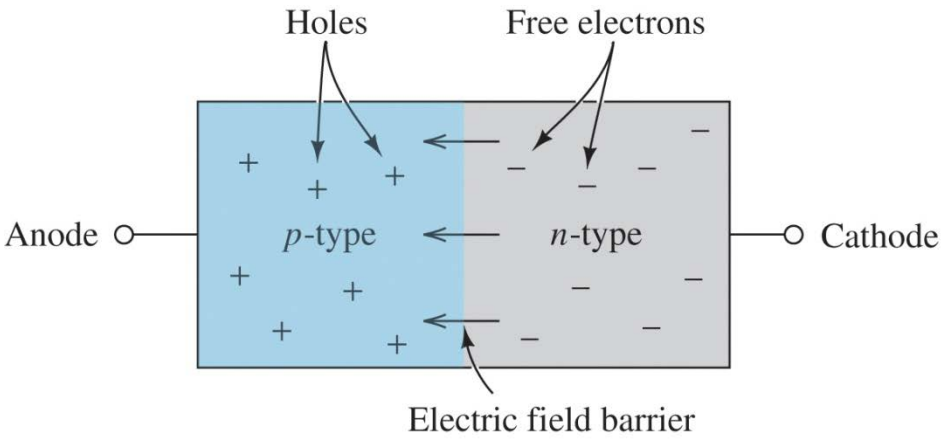


PN Junctions

- 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



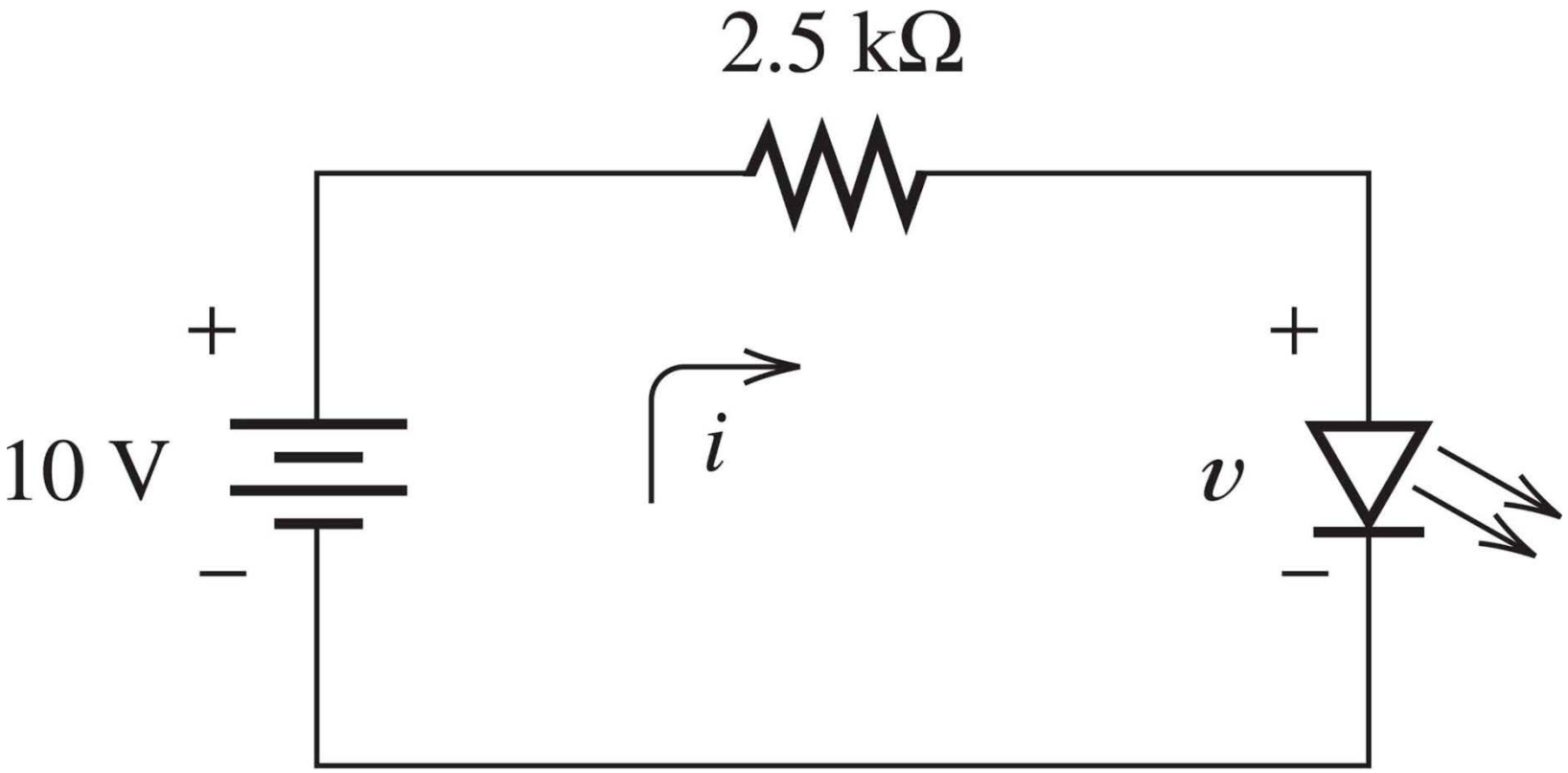
(c) Simplified physical structure

Other junction devices

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

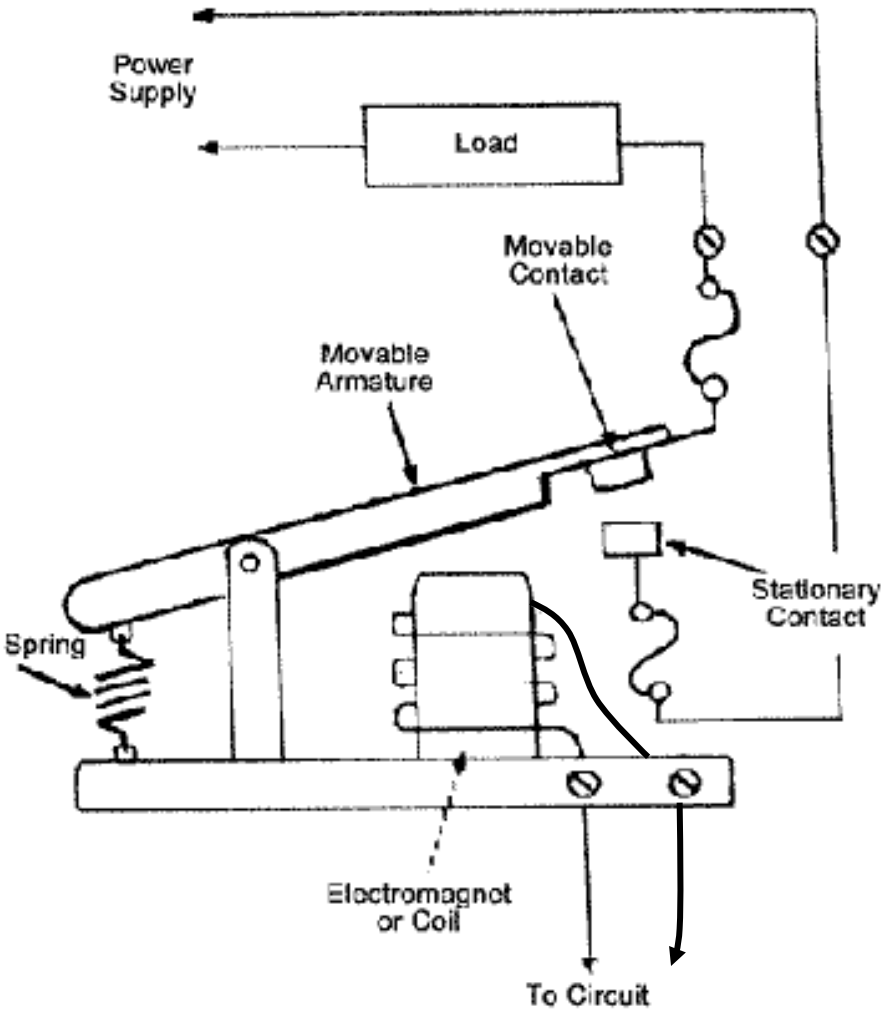
LED

- Resistor is essential! Need to limit current.



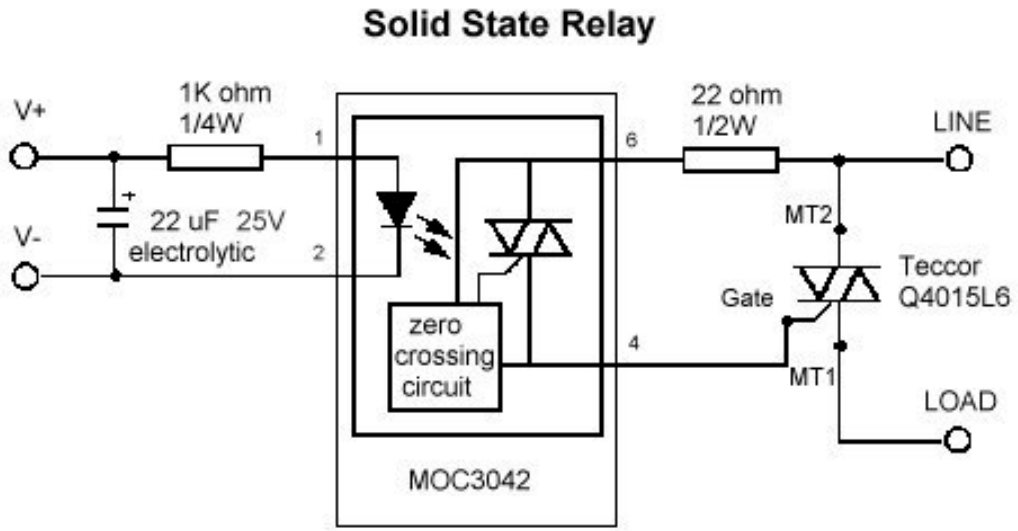
Electromechanical Relay

- 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

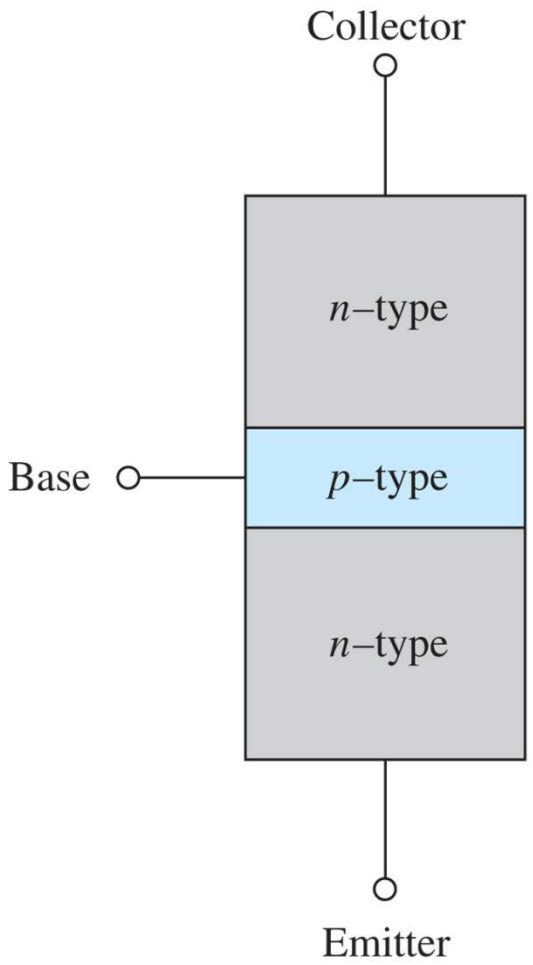
- An *optoisolator* uses an LED to activate a photodector triac. All solid state. No mechanical moving parts!



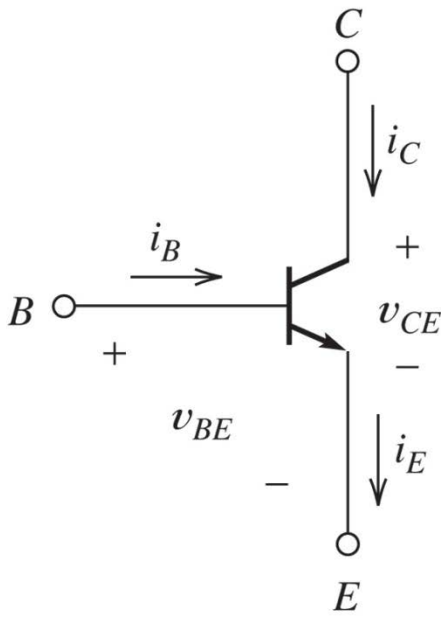
Transistors

- 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



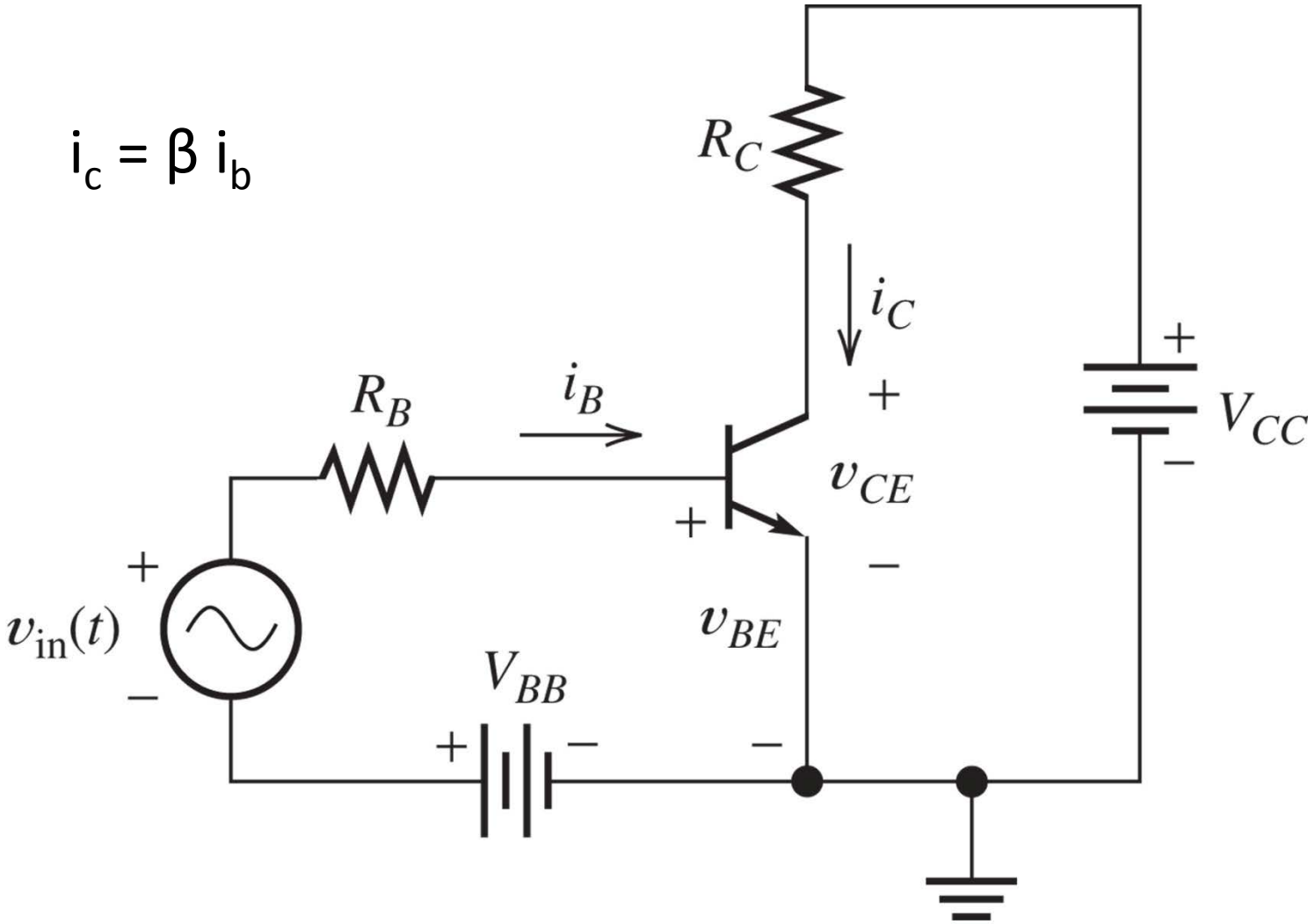
(a) Physical structure



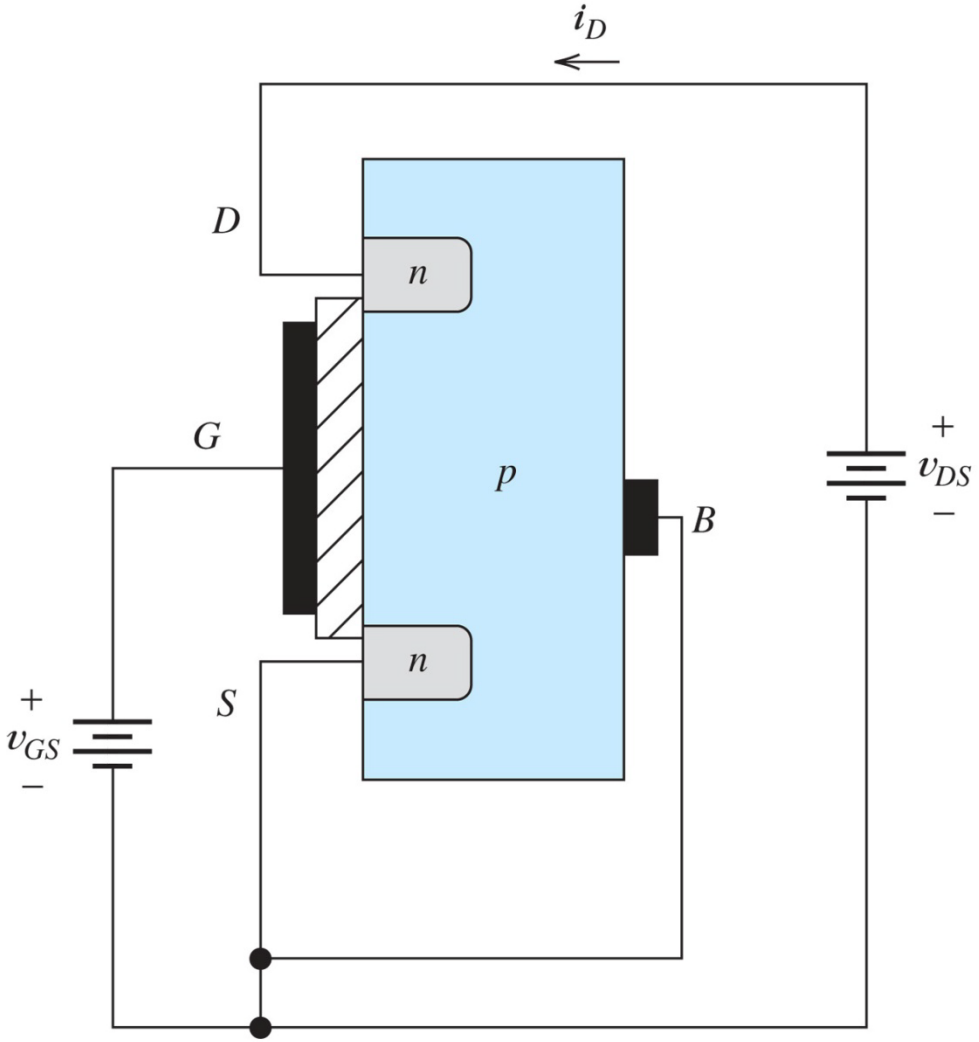
(b) Circuit symbol

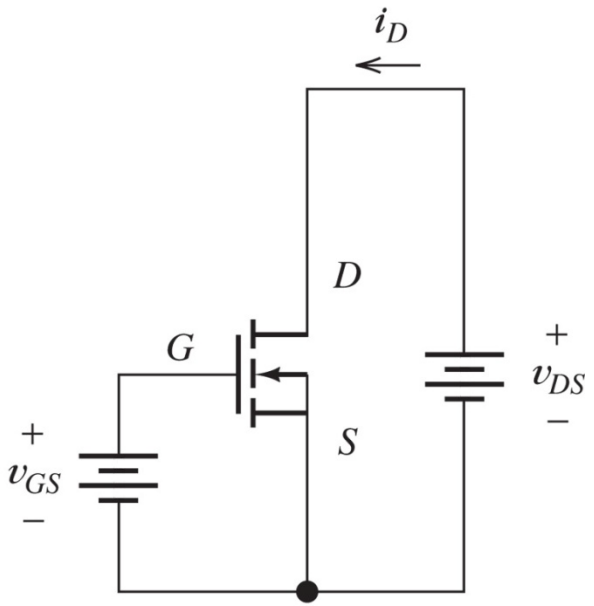
BJT (cont.)

$i_c = \beta\, i_b$



FETs





FET (cont.)