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.
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: \textit{nnp} or \textit{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.)

The diagram shows a FET circuit with the following components:

- $v_{in}(t) = \sin(2000\pi t)$ as the input signal.
- $V_{DS}$ connected to $V_{DD}$ at 20 V.
- $R_D$ is 1 kΩ.
- $i_D$ is the drain current.
- $V_{GG}$ is 4 V.

The circuit is designed to demonstrate the operation of a FET under sinusoidal input conditions.