Bipolar Transistors

Session 5d for Electronics and Telecommunications
A Fairfield University E-Course
Powered by LearnLinc

Module: Semiconductor Electronics (in two parts)

- Text: "Electronics," Harry Kybett, Wiley, 1986, ISBN 0-471-00916-4
- References:
  - Electronics Tutorial (Thanks to Alex Pounds)
  - Electronics Tutorial (Thanks to Mark Sokos)
- Semiconductors, Diodes and Bipolar Transistors
  - 5 on-line sessions plus one lab
- FETs, SCRs, Other Devices and Amplifiers
  - 5 on-line sessions plus one lab
- Mastery Test part 3 follows this Module

Section 5: Semiconductors, Diodes and Bipolar Transistors

- 0BJECTIVES: This section reviews semiconductors, doping and junctions. The characteristics and application of Diodes and Bipolar Transistors are then studied.

Section 5 Schedule:

Session 5a – 09/18	Semiconductors and Doping	Elect 1-7 1.23 – 1.39
MT2 Results – 09/23	We'll discuss MT2	
Session 5b – 09/25	Diodes	Kybett Chapter 2
Session 5c – 09/30	Diode Applications	Kybett Chapter 11
Session 5d – 10/02 (lab - 10/05, Sat.)	**Bipolar Transistors**	**Kybett pp 51 - 70**
Session 5e – 10/07 (Quiz 4 due 10/12)	Transistor Amplifiers	Kybett pp 173 - 201
Session 5f – 10/14	Review (Discuss Quiz 4)	
Break to introduce Learnlinc version 6.1	About 2 weeks to set up the computers and retrain us	

Diode Review

- Diodes are electronic one-way valves
  - Current can flow from anode to cathode
  - Current is blocked in the reverse direction
- Forward voltage drop

Current flows from A to B
but not from B to A.

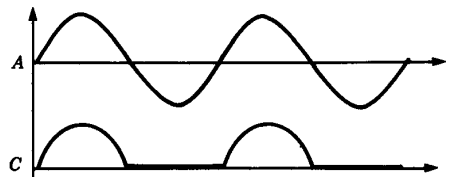
  - Silicon $V_f = 0.7$ volts
  - Germanium $V_f = 0.3$ volts
  - Schottky $V_f = 0.1$ volts
  - GaAs $V_f = 2$ volts
- Peak Inverse Voltage (PIV, PRV, Zener)
- These are non-linear devices (no superposition)

Diode Analysis Review

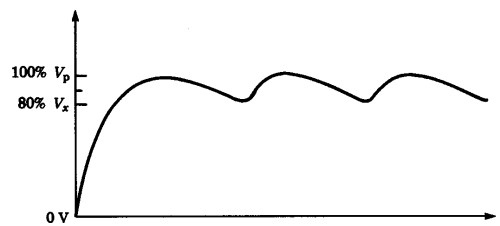
- First determine if the diode is:
  - Forward biased: conducting with a small voltage drop
  - Reverse biased: an open switch
  - In reverse breakdown (PIV): conducting with a large voltage drop (The Zener voltage)
- Replace the diode with a simple equivalent and then analyze the circuit (Ohm and Kirchoff)
- Check power dissipation in each component to avoid overheating

Rectifier Review

- Power diodes are used to convert AC to DC
- Half-wave rectifier
  - One diode blocks the negative half cycles of sine waves
  - Produces “pulsed” DC

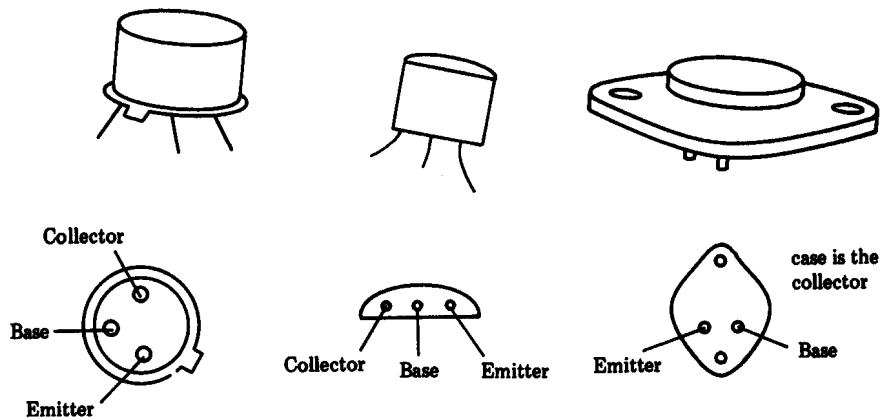


- Full-wave
  - Two diodes (or bridge) fills in the half wave gaps for better efficiency and less “ripple”
- Electrolytic capacitors used to smooth (filter) the DC output for less ripple.
  - The output follows the peaks in the pulsed DC
  - Ripple: the discharge of the capacitor between pulses



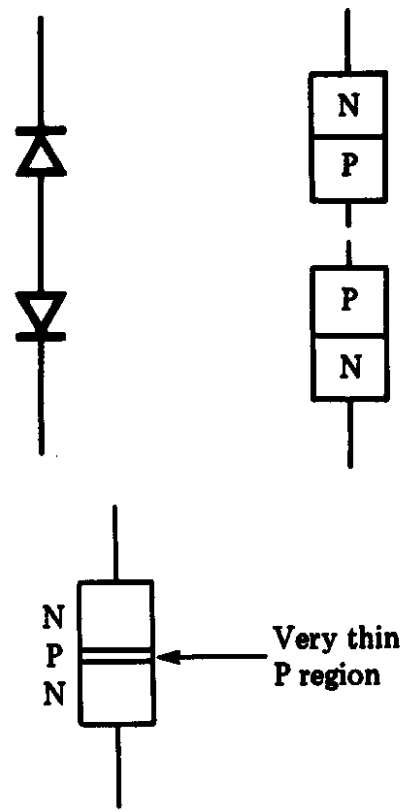
Real Transistors

- The silicon “chip” is sealed inside a package
- Large metal packages handle more current/power
- There are three connections;
  Base, Emitter, and Collector



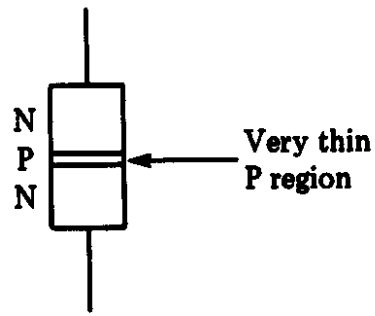
Transistor PN Junctions

- Transistors: two junctions
  - NPN or PNP structure
  - Center region (Base) is very thin (produces the "Transistor Action")
- The lower diode ("Base-Emitter") current controls the transistor (input)
- The upper diode ("Base-Collector") current is the output
- If base current flows, the collector current is: $I_C = \beta * I_B$ (unless the transistor is "saturated")



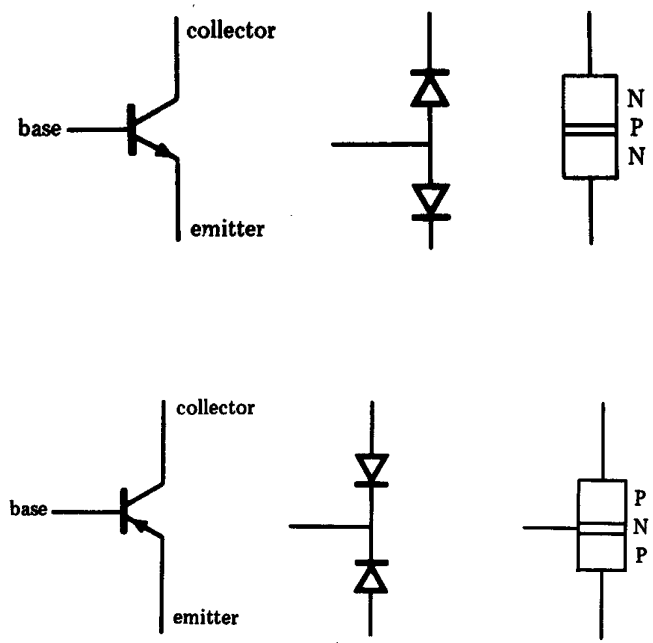
Transistor Action

- Normal biasing
  - Base-Emitter diode: forward biased
  - Base Collector diode: reverse biased
- Base-Collector “depletion region” extends across the thin base region
- Each Base-Emitter carrier penetrates the Base Collector depletion region causing an“avalanche” breakdown (the Zener effect)
- A large collector current flows



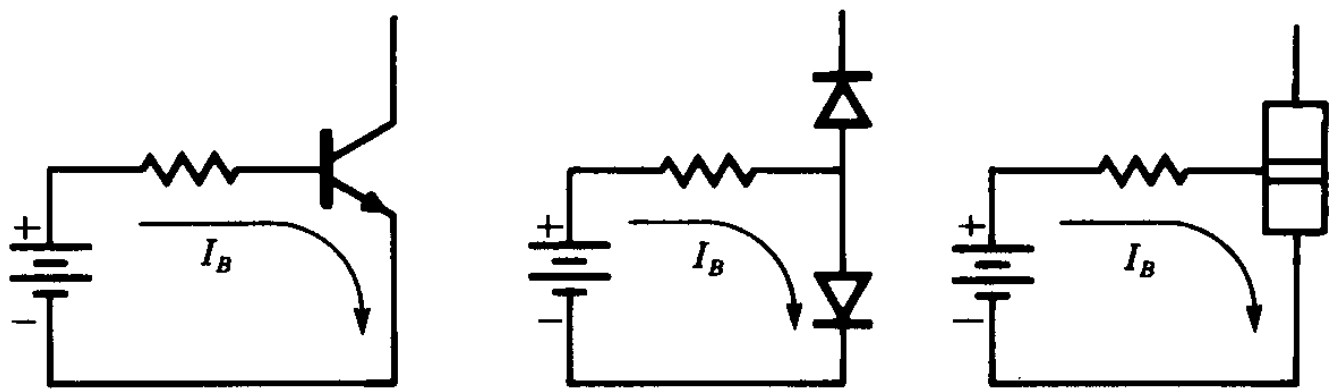
NPN and PNP

- Complemetary Transistors
  - Voltages and currents in PNP transistors are all opposite those of NPN transistors
  - NPN transistors are more common



The Base-Emitter Junction

- Analyze Base current (I_B) flow as a diode (usually silicon)

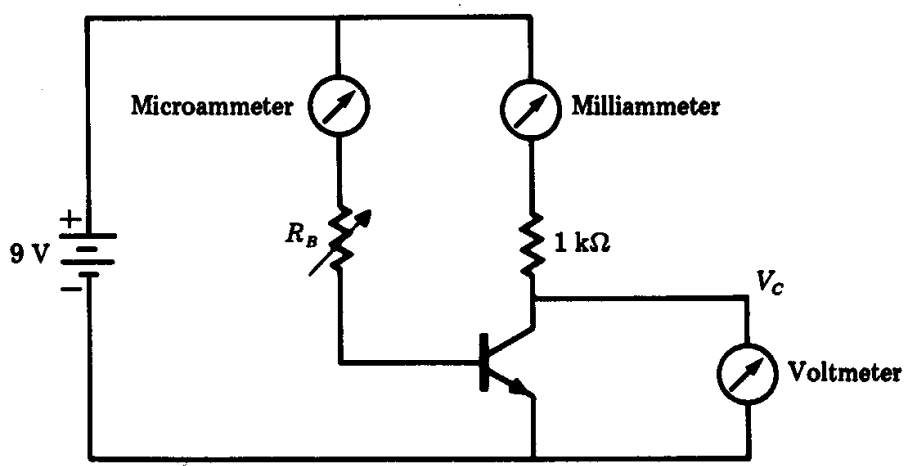


Transistor Action

- Beta (β) is a property of the transistor design. (thinner base – higher β)
- Note: reversing the emitter and collector leads produces poor transistor action

- Properly biased

$$I_C = \beta * I_B$$



Summary

- Bipolar Transistors produces current-controlled current
  - If a base current flows, the collector current is: $I_C = \beta * I_B$ (unless the transistor is "saturated")
  - The Base-Emitter diode will have a 0.7v voltage drop (if the transistor is to be on)
- PNP transistors behave the same as NPN transistors, but all voltages and currents are reversed.
- Transistors are tested using an ohmmeter; test each of the diodes (base-emitter and base-collector) separately for low impedance when forward biased and high impedance when reverse biased.

Section 5 Schedule:

Session 5a	– 09/18	Semiconductors and Doping	Elect 1-7 1.23 – 1.39
MT2 Results	– 09/23	We'll discuss MT2	
Session 5b	– 09/25	Diodes	Text Chapter 2
Session 5c	– 09/30	Diode Applications	Text Chapter 11
Session 5d	– 10/02	Bipolar Transistors	Text pp 51 - 70
(lab - 10/05, Sat.)			
Session 5e	**– 10/07**	**Transistor Amplifiers**	**Text pp 173 - 201**
(Quiz 4 due 10/12)			
Session 5f	– 10/14	Review (Discuss Quiz 4)	
Break to introduce Learnlinc version 6.1		About 2 weeks to set up the computers and retrain us	