Transistor Amplifiers

Session 5e 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

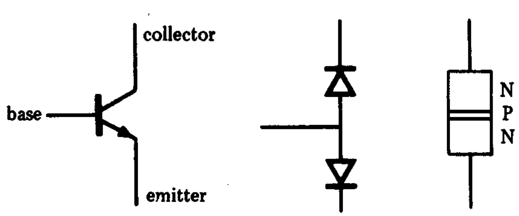
- 0BJECTIVES: This section reviews semiconductors, doping and junctions. The characteristics and application of Diodes and Bipolar Transistors are then studied.

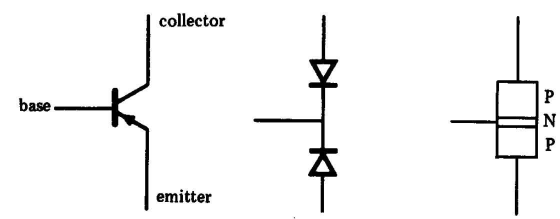
Section 5 Schedule:

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 (lab - 10/05, Sat.)	– 10/02	Bipolar Transistors	Kybett pp 51 - 70
Session 5e (Quiz 4 due 10/12)	**– 10/07**	**Transistor Amplifiers**	**Kybett pp 173 - 201**
Session 5f (Oct 14 is a holiday)	– 10/16	Review (Discuss Quiz 4)	
Break to introduce Learnlinc version 6.1		About 2 weeks to set up the computers and retrain us	

Transistor Review

- Transistors have three leads: base, emitter and collector
- Testing via ohm meter
  - Two diodes back to back: test each separately for impedance ratio
  - Check collector to emitter for high impedance (leakage)
- Beta (β): Current gain $\beta = I_C/I_B$, as long as no “saturation” ($V_{CE} > 0.2$v)
  - Transistor “action”
  - Carriers injected into “depletion region” (very thin base region)
- NPN and PNP: currents and voltages reversed
- Analyze Base current (I_B) flow as a diode
- Collector current: $I_C = I_B * \beta$
- Collector voltage: $V_C = V_{batt} - I_C * R_C$



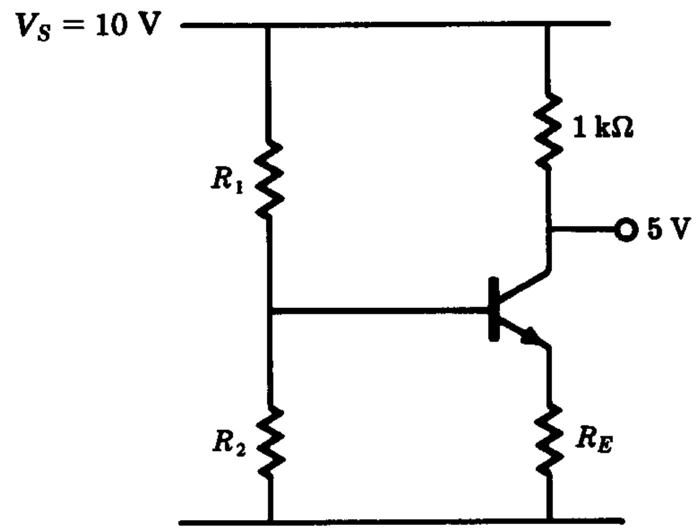


Today’s Topics

- Transistor Biasing
  - Setting the “Quiesent Point”
  - Stability
- Amplifier characteristics
  - Gain
  - Impedances (input and output)
- Amplifier Configurations
  - Common Emitter
  - Common Collector
  - Common Base

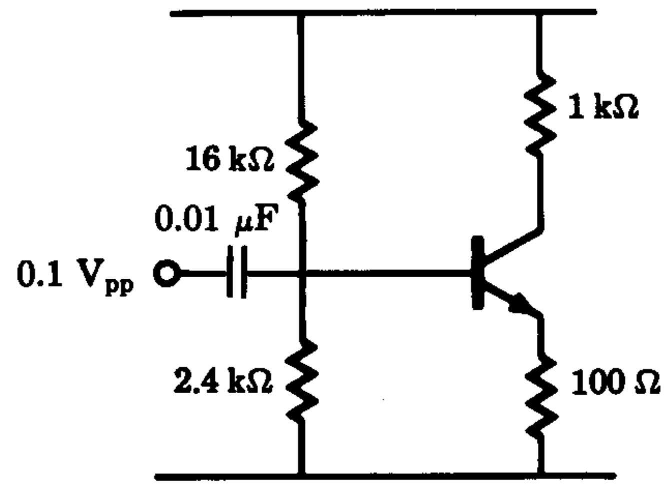
Transistor Biasing

1. Set $V_B = 0.7v + \text{desired } V_E$
2. R_1 & R_2 form a voltage divider
   $V_B = V_S * R_2 / (R_1 + R_2)$
3. Determine $R_E = V_E / I_E$
   $(I_E = I_C + I_B)$
4. DC gain is approx. R_C / R_E
5. Input Impedance is approx. $\beta * R_E$
   (in parallel with R_1 and R_2
   so keep them reasonably large)

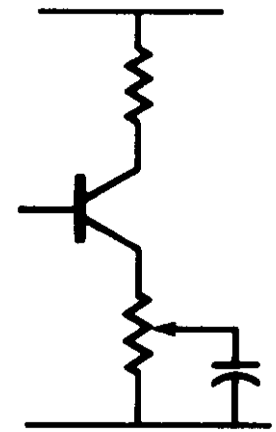


Biasing
(continued)

- $V_{bb} = 10$ v; $V_C = 5$ v
  $I_C = 5$ mA $\sim I_E$ ($I_B = I_C/\beta$)
- Set $V_E = 0.5$ v; $R_E = 100\ \Omega$
- $V_B = 0.5 + 0.7 = 0.12$v
- $R_2 / (R_! + R_2) = 0.12/10$
  (Use resistors at least 10 times those in the output)
  $R_2 = 2.2\ k\Omega$; $R_1 = 16\ k\Omega$



Amplifier characteristics

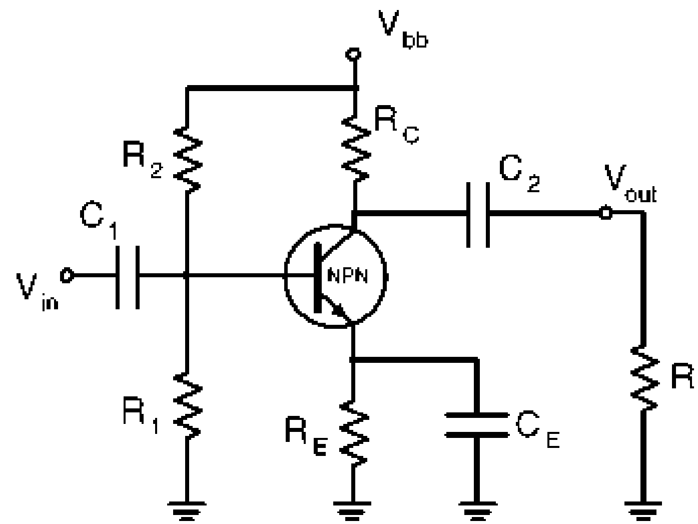


(1)

- Gain (AC and DC can be different)
  - Voltage (V_{out} / V_{in})
  - Power (P_{out} / P_{in})
- Impedance
  - Input: loads the source reducing the input
  - Output: A low output impedance makes the output voltage independent of the load impedance.

Common Emitter

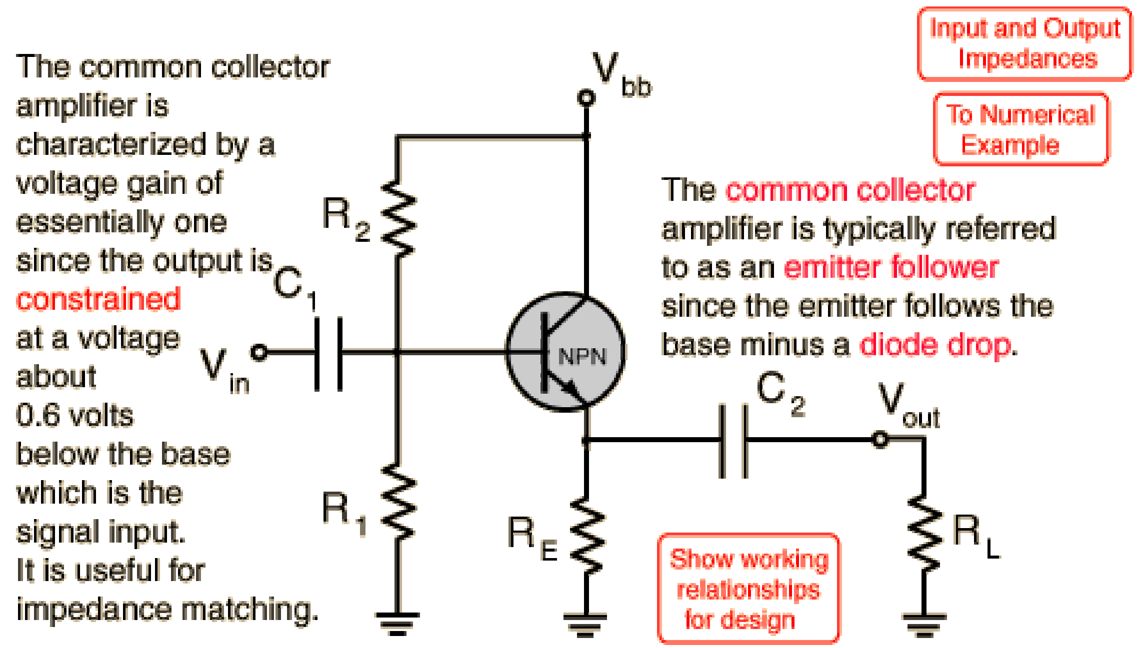
- High input impedance
  - $R_1 \parallel R_2 \parallel (R_{in}+\beta*R_E)$ … $R_{in} = h_{ie} \sim 1\ k\Omega$
- High voltage gain
  - $\beta*R_C/(R_{in}+\beta*R_E)$ (general case)
  - $\sim R_C / R_E$ (no bypass capacitor)
  - $\sim \beta* R_C / R_{in}$ (fully bypassed)
- Medium output impedance



Common Collector
(Emitter Follower)

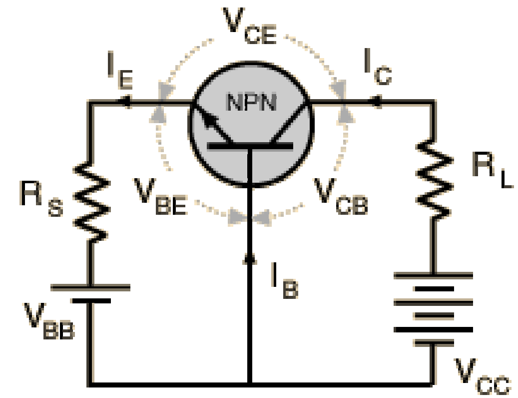
- The common collector junction transistor amplifier is commonly called an emitter follower. The voltage gain of an emitter follower is just a little less than one since the emitter voltage is constrained at the diode drop of about 0.7 volts below the base . Its function is not voltage gain but current or power gain and impedance matching.

- It's input impedance is much higher than its output impedance. The low output impedance of the emitter follower matches a low impedance load and buffers the signal source from that low impedance.



Common Base

- This configuration is sometimes used for high frequency applications because the base separates the input and output, minimizing oscillations at high frequency. It has a high voltage gain, relatively low input impedance and high output impedance compared to the common collector.



Summary

- Transistor Biasing
  - Setting the "Quiesent Point"
  - DC Stability
- Amplifier characteristics
  - Gain
  - Impedances (input and output)
- Amplifier Configurations
  - Common Emitter (voltage gain)
  - Common Collector (buffer, low output impedance)
  - Common Base
    (only used in some high frequency applications)

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