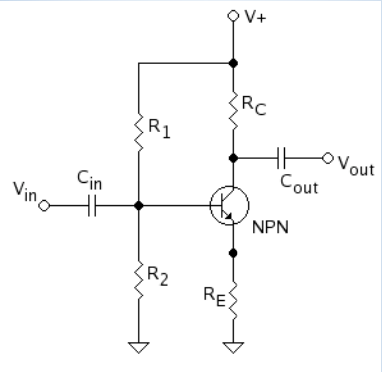
Transistor Amplifiers

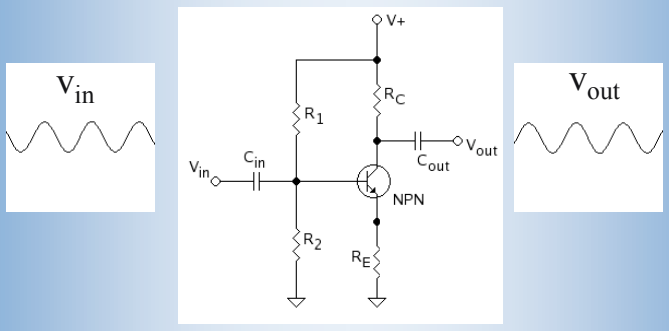
The Common Emitter Amplifier

Basic Design



Phase relationships

- The output voltage is 180 degrees out of phase with the input voltage.
- The output current is in phase with the input current



AC Emitter Resistance

- The base-emitter junction has an *ac emitter resistance* that can be approximated by

$$r'_e \cong \frac{25\,\text{mV}}{I_E}$$

- where

$$I_E = \frac{V_E}{R_E}$$

- This is a dynamic resistance that only appears in ac calculations.

AC beta

- The ac current gain for a transistor is different than the dc current gain.
- The ac current gain is defined as

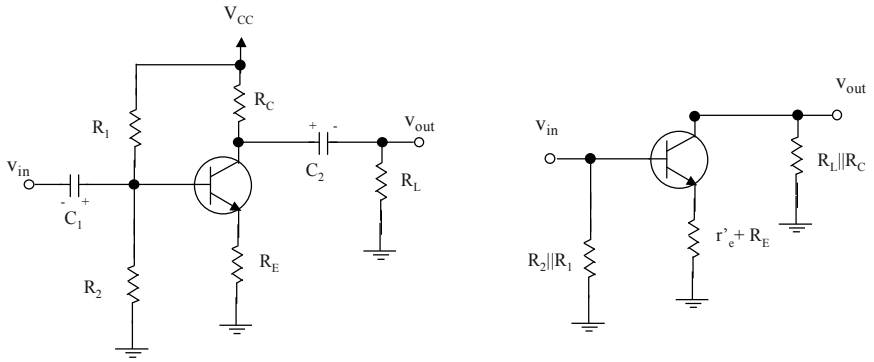
$$\beta_{ac} = h_{fe} = \frac{i_c}{i_b}$$

- Note that this is the gain of the transistor not the amplifier.
- h_{fe} values are usually listed on the specification sheets for the transistor.

Coupling Capacitor

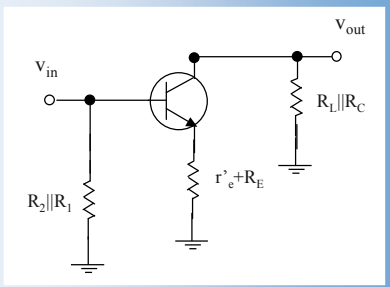
- In many applications amplifiers are connected in series with other amplifiers (cascaded) or with other complex circuits.
- Coupling capacitors are used to pass the ac signal from one stage to the next while blocking the dc signal.
- Coupling capacitors act as if they have infinite impedance for dc signals but very low impedance for ac signals.
- The dc equivalent of a circuit can be determined by replacing the capacitors by breaks in the circuits (open circuit).
- The ac equivalent of a circuit can be determined by replacing capacitors by shorts in the circuit.

AC Equivalent



Gain for the CE Amp

- The voltage gain for the CE amp can be derived using the ac equivalent circuit.



$$v_{in} = i_e(r_e^{'} + R_E)$$
$$v_{out} = i_c(R_C \| R_L)$$

$$A_v = \frac{v_{out}}{v_{in}} = \frac{i_c(R_C \| R_L)}{i_e(r_e' + R_E)} \cong \frac{R_C \| R_L}{r_e' + R_E}$$

Input impedance

- The input impedance of a CE amplifier with voltage-divider biasing is given by

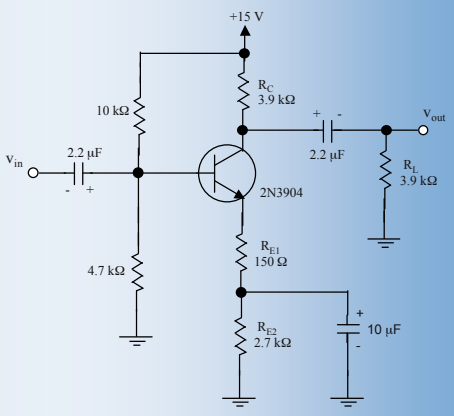
$$Z_{in} = R_1 \| R_2 \| Z_{in(base)}$$

- The ac input impedance of the transistor base is

$$Z_{in(base)} = h_{fe} r_e'$$

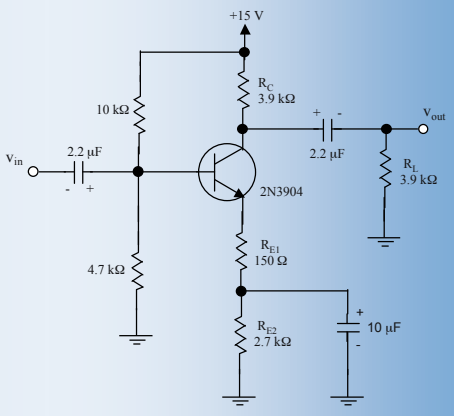
Swamping

- A bypass capacitor can be used to reduce the ac resistance of the R_E but maintain the gain-stabilization properties of an external emitter resistor.



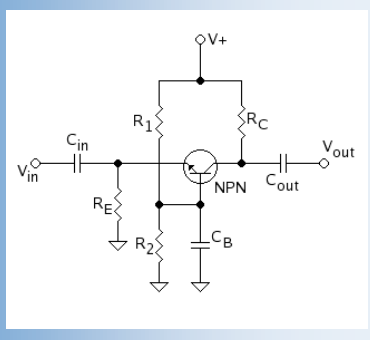
All Together Now

- Assume ac current gain is 150 for the transistor.
- Find A_v, and Z_{in}.

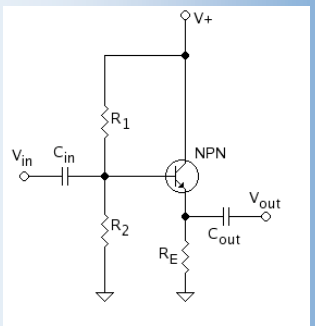


Other Basic Amplifier Designs

Common-Base



Common-Collector (Emitter-Follower)

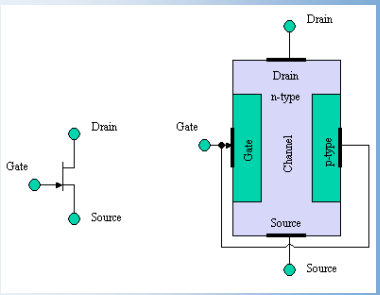


Transistors

Field Effect Transistors (FETs)

Junction Field Effect Transistors

- Width of conducting channel is controlled by gate voltage.
- Source → emitter
- Drain → collector
- Gate → Base



JFETs vs. BJTs

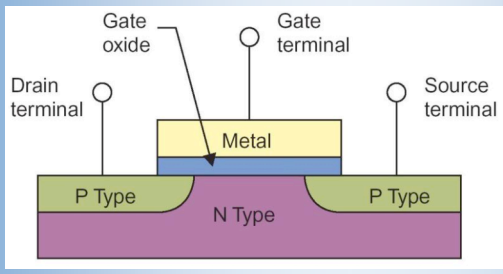
- JFETs have an extremely high input impedance for a given gain as compared to BJTs.
- Smaller size
- Higher frequency response
- Voltage controlled rather than current controlled

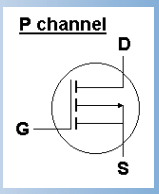
MOSFET

- Metal Oxide Semiconductor FET
- Very low current devices
- Most VLSI circuits use MOSFETs.
- Two types:
  - Enhancement
  - Depletion

MOSFET

- Enhancement





MOSFET

- Depletion