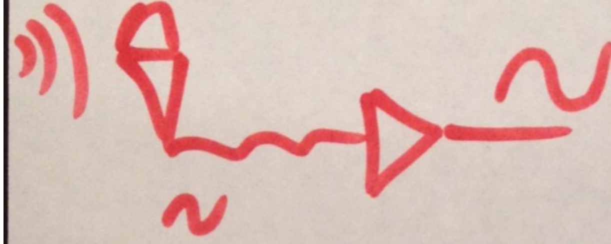
The Signal Path Blog

http://www.TheSignalPath.com

Tutorial on the Theory, Design and Characterization of a Single Transistor Bipolar Amplifier

Amplifire Design:



Audio App.

Specification:

Gain = 100 V/V

BW > 20 KHz

Supply = ± 2.5V

Power < 50mW

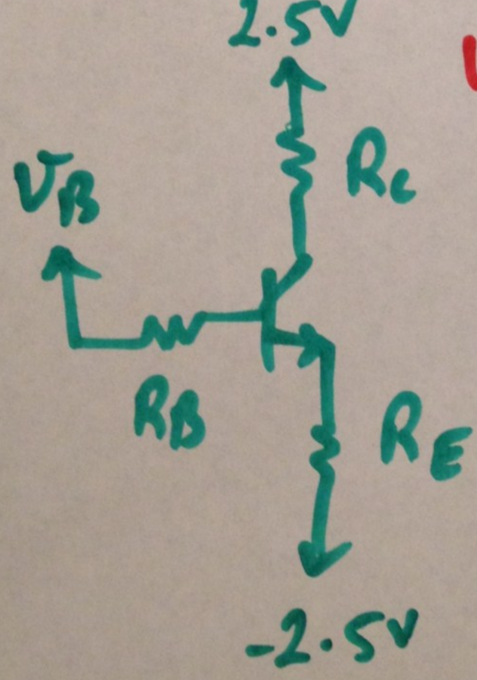
Common Emitter:

NPN Device: $\beta \approx 100$

$V_{BE} \approx 0.6V$

Assume: $\beta \approx \beta + 1$, $V_{CESAT} = 0.2V$

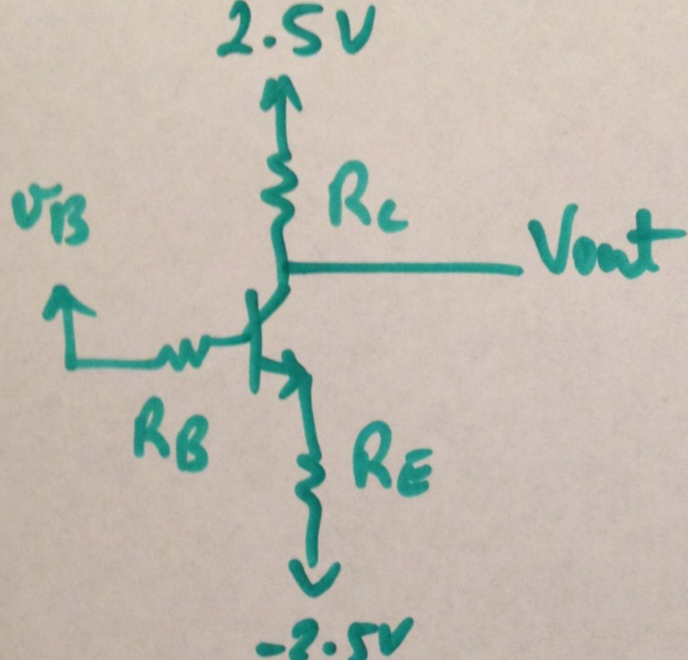
$I_C \approx I_E$

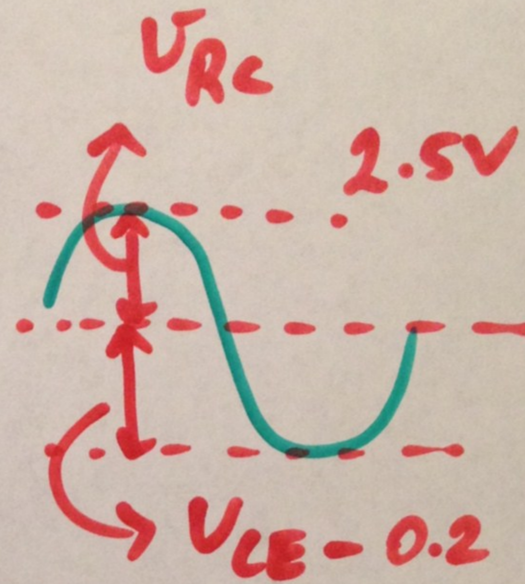


$$V_B - I_B R_B - V_{BE} - I_E R_E = -2.5V$$

$$I_E = \frac{V_B + 2.5 - V_{BE}}{\frac{R_B}{\beta} + R_E}$$

Signal Swing





Positive Swing = v_{RC}

Negative Swing = $v_{CE} - 0.2$

↑

$V_{CE\text{-}SAT}$

Maximize:

$$V_{RC} = (V_{CE} - V_{CE-SAT}) = V_{RE}$$

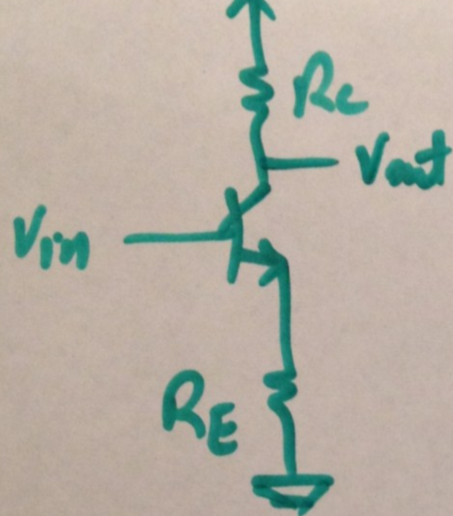
$$V_{RC} + V_{CE} + V_{RE} = 5V$$

$$\therefore \begin{cases} V_{CE} = 1.8V \\ V_{RE} = 1.6V \\ V_{RC} = 1.6V \end{cases}$$

①

$$\therefore R_C = R_E$$

Small Signal:

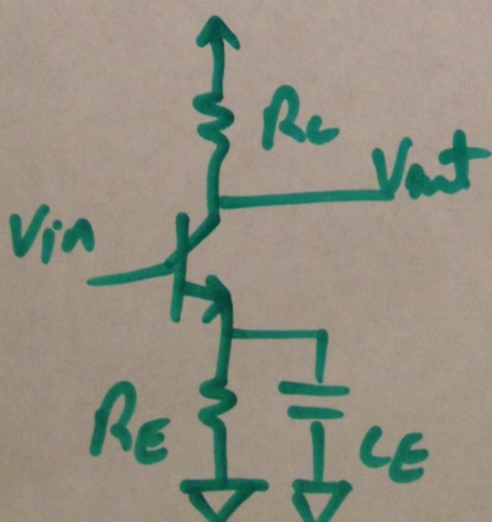


$$\frac{V_{out}}{V_{in}} = ?$$

$$= \frac{-g_m}{1 + g_m R_E} \cdot R_C \approx$$

$$-\frac{R_C}{R_E} = -1 \text{ V/V}$$

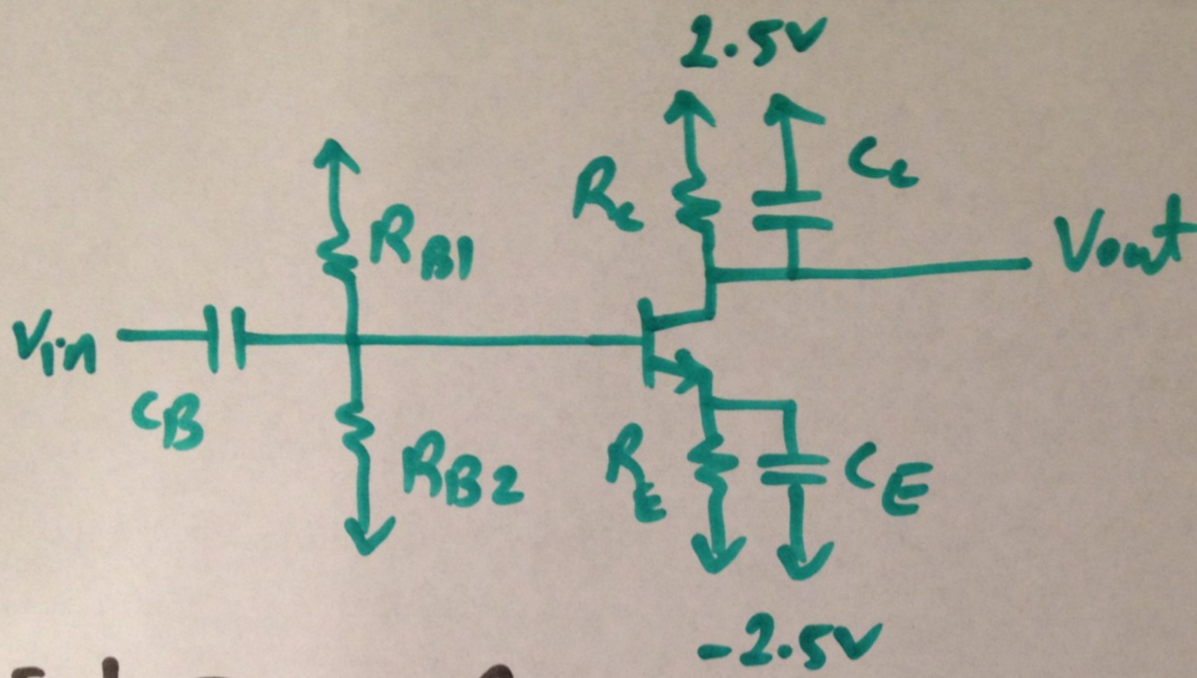
Add Cap:



$$A_v = -g_m R_C$$

$$= \frac{-I_C}{V_T} \cdot R_C$$

$$= -(1.6)(40) = -64 \text{ [V/V]}$$



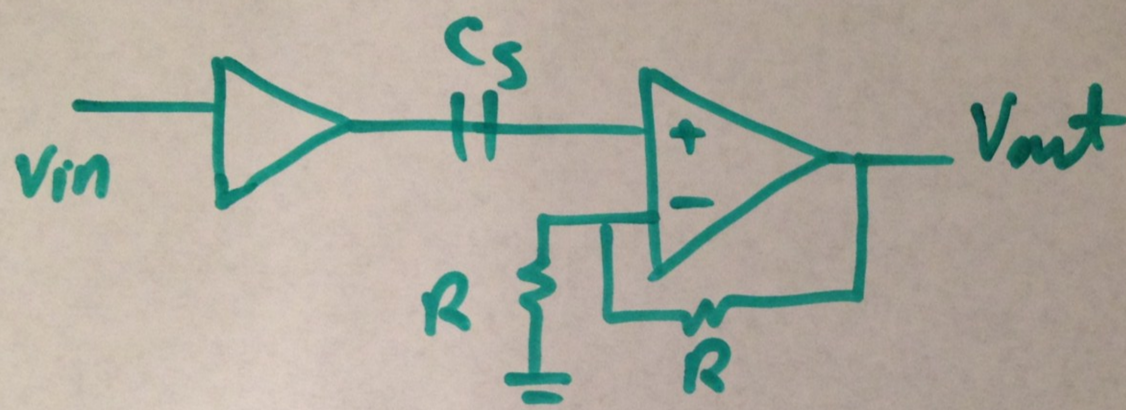
Set $I_C = 2mA$

$\Rightarrow R_C = R_E = 800\Omega$

$\Rightarrow R_{B1} =$ [redacted] $14K\Omega$, $R_{B2} = 10K\Omega$

$\Rightarrow C_C = 10nF \Rightarrow BW \approx 20KHz$

Two Stage Amp:



$$A = 1 + \frac{R}{R} = 2\ V/V$$