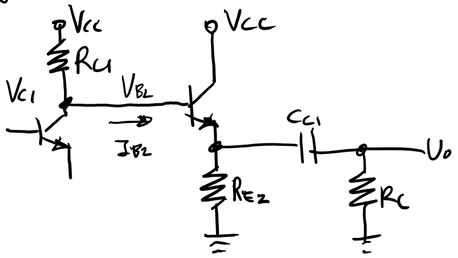
Common Collector Amplifier

October 26, 2017 3:48 PM

- + Power Gain
- + High Input Impedence
- + Low output Impedence
- + Wide bandwidth
- + DC coupled input.

Typical CC amplifier:



$V_{B2} = V_{C1}$

$$I_{B2} = \frac{V_{B2} - 0.7}{(1+\beta_2) R_{E2}} \quad \text{(mesh analysis.)}$$

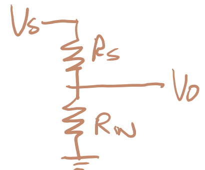
$$I_{C1} = \frac{V_{cc} - V_{C1}}{R_{C1}} - I_{B2}$$

Resistance seen into the base of Q2 at DC β

$$R_{in2} = \frac{V_{B2}}{I_{B2}} = \frac{V_{B2}}{V_{B2} - 0.7}(1+\beta_2)R_{E2}$$

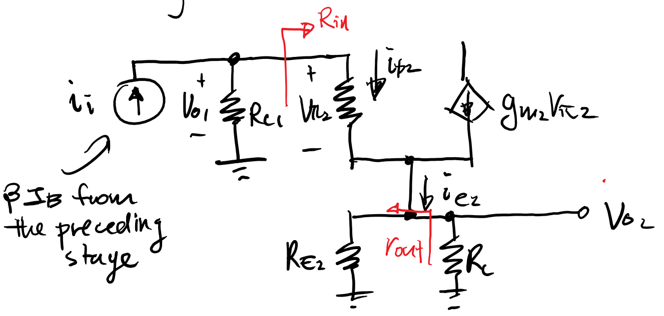
For typical setup, R_{In2} will be tens of kΩ. (Large input impedence)

Consider voltage divider:



Big R_{in} ⇒ Bigger gain $\left(\frac{V_o}{V_s}\right)$

Small Signal Model



$$R_{in2} = r_{\pi 2} + (1+\beta_2)(R_{E2} \parallel R_L)$$

$$i_{b2} = \frac{V_{\pi 2}}{\ } = \frac{V_{o1}}{\ }$$

$$R_{in2} = r_{\pi2} + (1+\beta_2)(R_{E2} \| R_L)$$

$$i_{b2} = \frac{v_{\pi2}}{r_{\pi2}} = \frac{v_{o1}}{R_{in2}}$$

$$i_{e2} = (1+\beta)\, i_{b2}$$

$$i_i = \frac{v_{o1}}{R_{L1}} + i_{b2}$$

$$= \frac{v_{o1}}{R_{L1}} + \frac{v_{o1}}{R_{in2}}$$

$$= \frac{v_{o1}}{R_{L1} \| R_{in2}}$$

$$= \frac{i_{b2} R_{in2}}{R_{L1} \| R_{in2}}$$

$$\frac{i_{e2}}{i_i} = \frac{(1+\beta)\, i_{b2}}{\left(\frac{i_{b2} R_{in2}}{R_{L1} \| R_{in2}}\right)} = \frac{(1+\beta_2) R_{L1}}{R_{L1} + r_{\pi2} + (1+\beta_2)(R_{E2} \| R_L)}$$

$$\approx \frac{R_{L1}}{R_{E2} \| R_L}$$

(current gain)

Since $v_{o2} = i_{e2} R_{E2} \| R_L$,

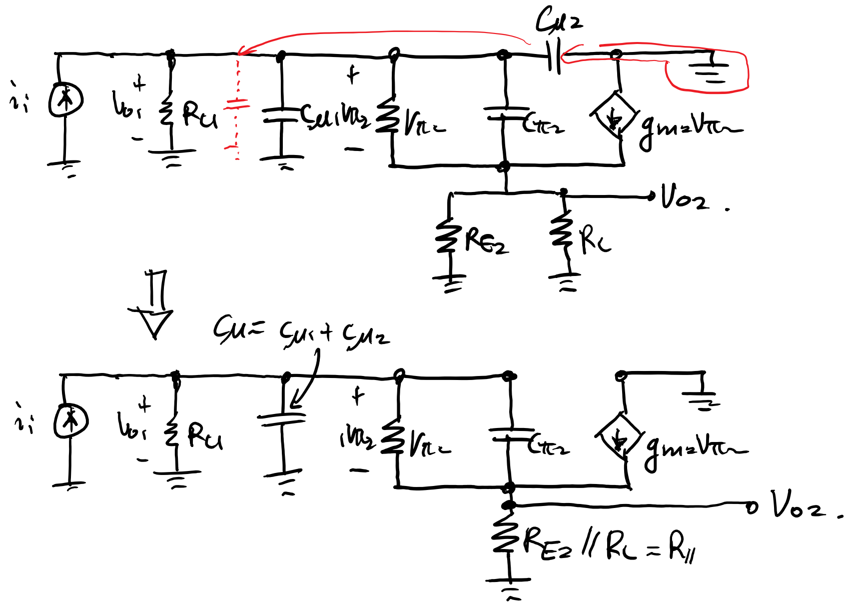
$$\frac{v_{o2}}{v_{o1}} = \frac{(1+\beta_2)(R_{E2} \| R_L)}{r_{\pi2} + (1+\beta_2)(R_{E2} \| R_L)}$$

$$\approx 1 \quad \text{(typically)}$$

$$R_{out} = R_{E2} \,\Big\|\, \frac{r_{\pi2} + R_{L1}}{1+\beta_2} \quad \text{(found by applying test source \& KCL)}$$

$$\approx \frac{r_{\pi2} + R_{L1}}{1+\beta_2}$$

High Frequency Response.

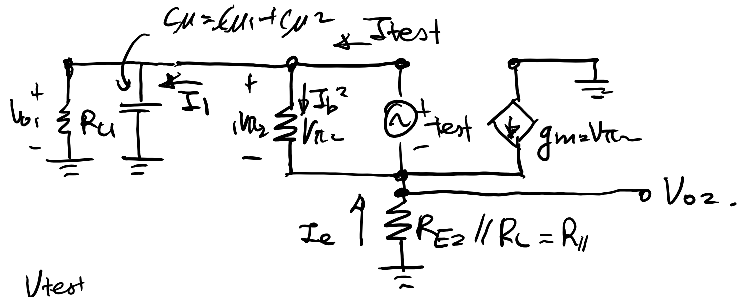


We shall do OSTC / SCTC tests:

$$\tau_{OC}^{C\mu} = (C_{\mu1} + C_{\mu2}) \cdot \left[R_{L1} \,\|\, (r_{\pi2} + (1+\beta_2) R_{\|}) \right] \approx (C_{\mu1} + C_{\mu2}) \cdot R_{L1}$$

$$\tau_{SC}^{C\mu} = (C_{\mu1} + C_{\mu2})(R_{L1} \| R_{\|}) \approx (C_{\mu1} + C_{\mu2}) \cdot R_{\|}$$

For C_μ, we use test source, then use OCTC/SCTC tests:



$$R_{test} = \frac{V_{test}}{I_{test}}$$

KCL: $i_{test} = -e + i_{b2} + g_{m2} V_\pi$

$= i_e + i_{b2} + \beta_2 i_{b2}$

KCL: $i_{test} = i_{e2} + i_1$

$V_{test} = i_1 R_{C1} + i_e R_{//}$, where $i_e = i_1 - \beta \cdot i_{b2}$

$$\Longrightarrow \frac{i_1}{i_{b2}} = \frac{r_{\pi 2} + \beta_2 \cdot R_{//}}{R_{C1} + R_{//}}$$

$$R_{test} = \frac{V_{test}}{I_{test}} = \frac{i_{b2} r_{\pi 2}}{i_{b2} + i_1} = \frac{r_{\pi 2}}{1 + \frac{i_1}{i_{b2}}} = \frac{r_{\pi 2}}{1 + \left(\frac{V_{\pi 2} + \beta_2 R_{//}}{R_{C1} + R_{//}}\right)}$$

Thus,

$$\tau_{OC}^{C_{\pi 2}} = C_{\pi 2} \cdot \left(\frac{r_{\pi 2}}{1 + \left(\frac{r_{\pi 2} + \beta_2 \cdot R_{//}}{R_C + R_{//}}\right)}\right) \approx \frac{C_{\pi 2} r_{\pi 2}}{1 + \frac{\beta_2 R_{//}}{R_{C1}}}$$

dominant HF poles are dictated by C_μ..

$$\tau_{SC}^{C_{\pi 2}} = C_{\pi 2} \left(\frac{r_{\pi 2}}{1 + \beta_2} // R_{//}\right)$$