EE210: Microelectronics-I

Lecture-36
Review of BJT Circuits-part-2

https://youtu.be/G-Vh233-ECM

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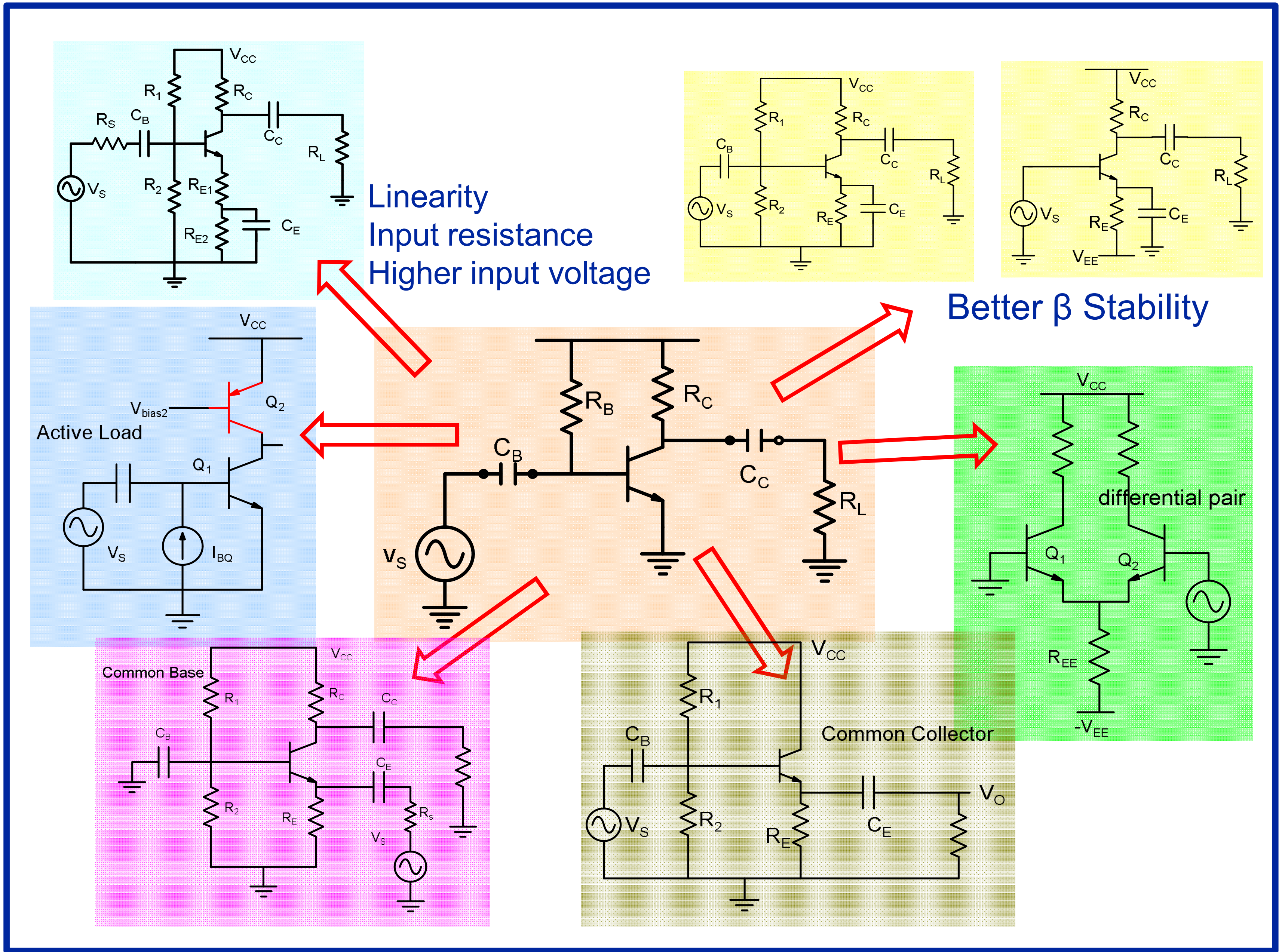
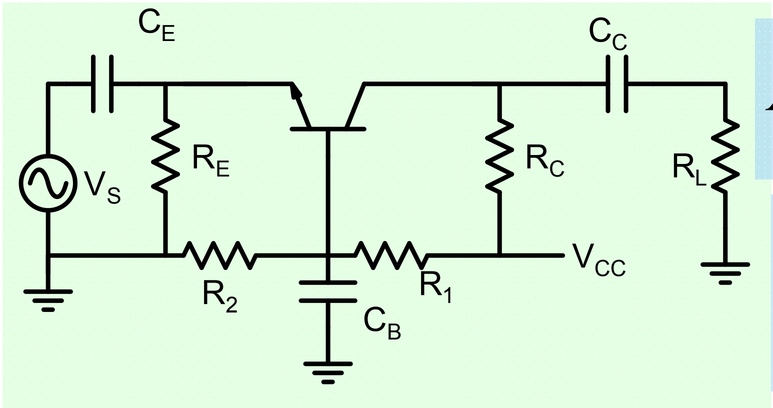
CE Amplifier : Problems and Solutions



CB Amplifier

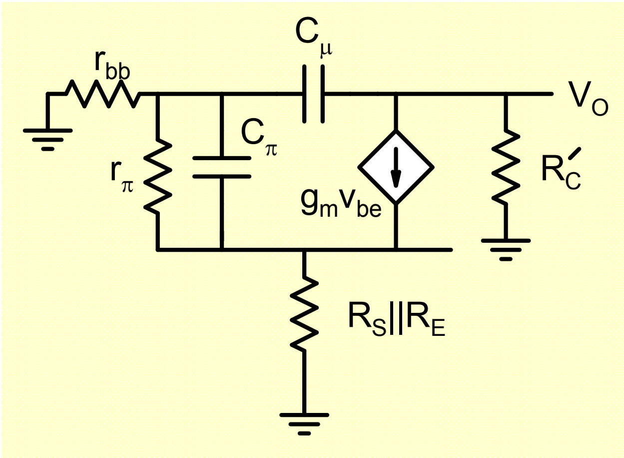


$$A_V = \frac{I_{CQ}}{V_T} \times R_C \| R_L$$

$$R_o = R_C$$

$$R_{in} \cong \frac{r_\pi}{\beta} \| R_E$$

$$\frac{A_V \times R_{in}}{R_O} \leq 1$$



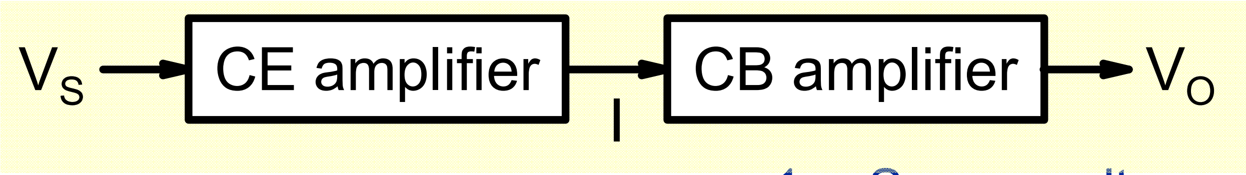
$$\frac{A_V(CE)}{A_V(CB)} \times \frac{R_{in}(CE)}{R_{in}(CB)} \times \frac{R_O(CB)}{R_O(CE)} \sim \beta$$

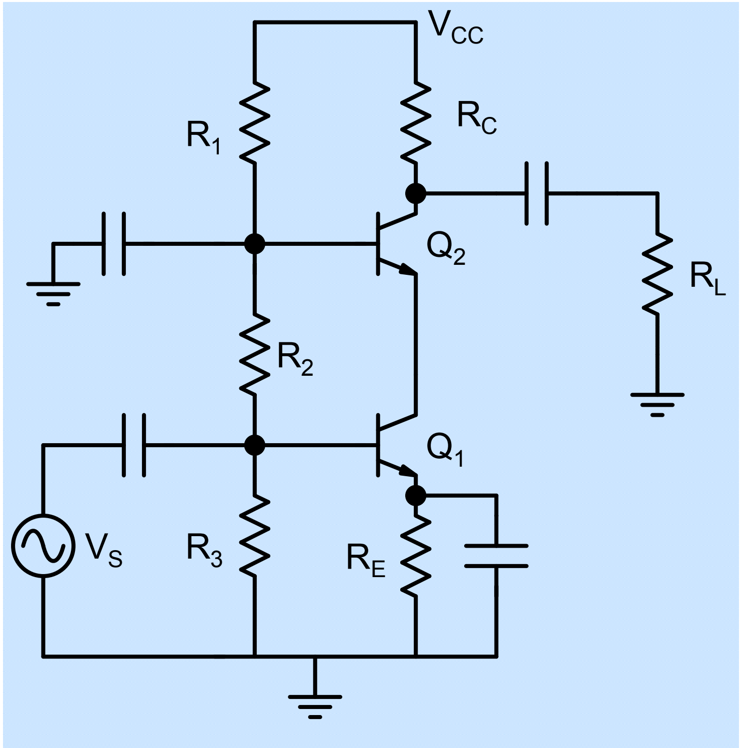
For large effective emitter resistance high bandwidth is obtained:

$$\omega_H \cong \frac{1}{(r_{bb} + R_C')C_\mu + \dfrac{C_\pi}{g_m}}$$

Cascode Amplifier

Central idea: A CB amplifier has good frequency response when driven by current source and a CE configuration is a good voltage to current converter



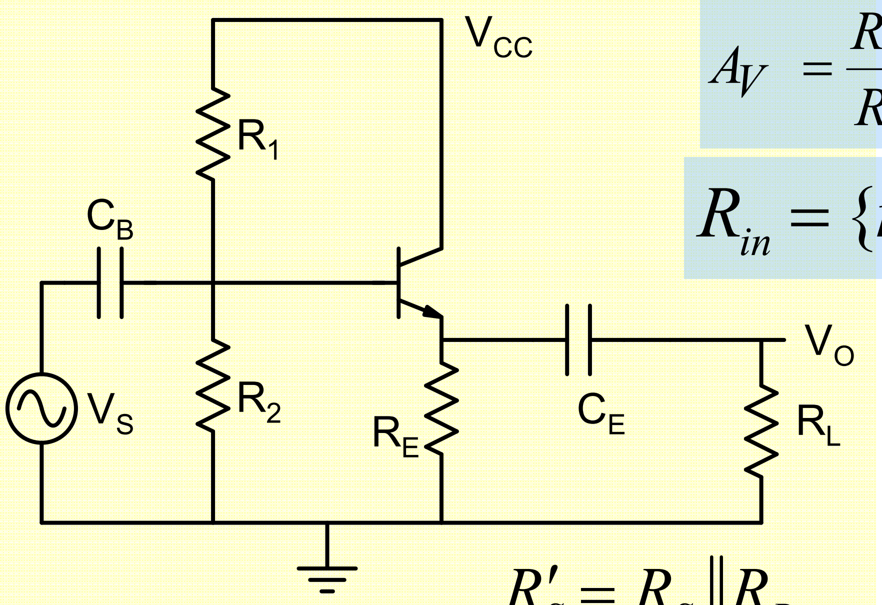


1. Same voltage gain, input and output resistance as a CE amplifier

2. Improved upper cutoff frequency

3. Reduced sensitivity of upper cutoff frequency to increase in voltage gain

CC Amplifier-1



$$R'_S = R_S \| R_B$$

$$A_V = \frac{R'_S}{R_s} \times \frac{(\beta+1)\times R'_E}{R'_S + r_\pi + (\beta+1)\times R'_E}$$

$$R_{in} = \{r_\pi + (\beta+1)\times R'_E\} \| R_B$$

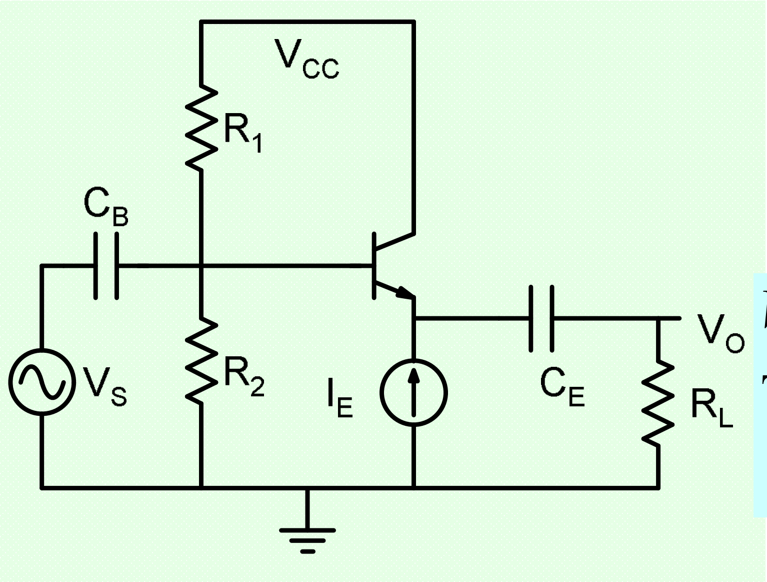
$$R_O = \frac{(r_\pi + R'_S)}{\beta+1} \| R_E$$

$$\frac{R_{in}}{R_O} >> \beta$$

A common collector amplifier can deliver much lower output resistance and higher input resistance as compared to CE amplifier. Further it has higher swing and low distortion

$$v_O \le I_{CQ} R_E \| R_L ; V_O \le V_{CC} - V_{BE} - I_{CQ} R_E$$

CC Amplifier-2



$$v_O \le I_{EQ} R_L$$

$V_E - v_O > 0$ so as to maintain

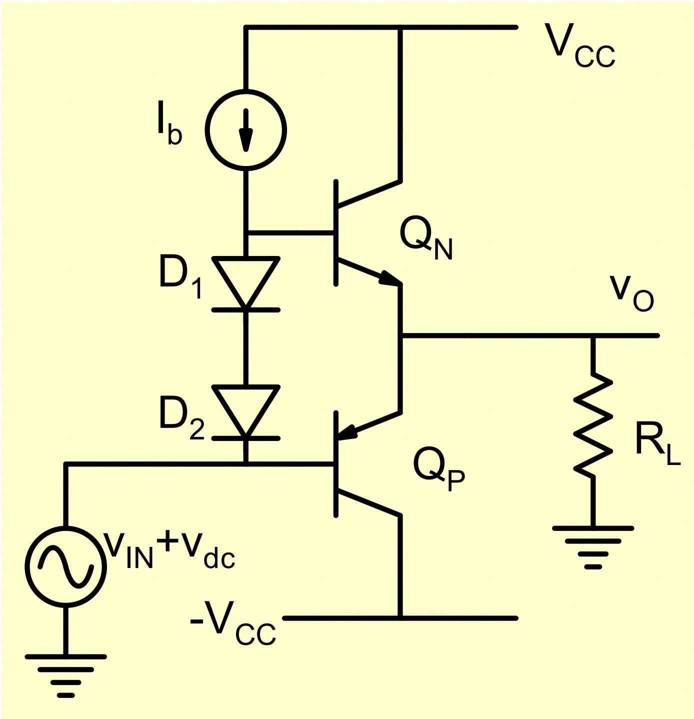
Tr. implementing current source

in active region

$$H(s) \cong \frac{1 + \dfrac{C_\pi}{g_m} s}{1 + (R'_S C_\mu + \dfrac{C_\pi}{g_m}) s + \dfrac{R'_S}{g_m} C_\pi C_\mu s^2}$$

Due to pole-zero cancellation effect , bandwidth is often decided by non-dominant pole resulting in a very high bandwidth amplifier

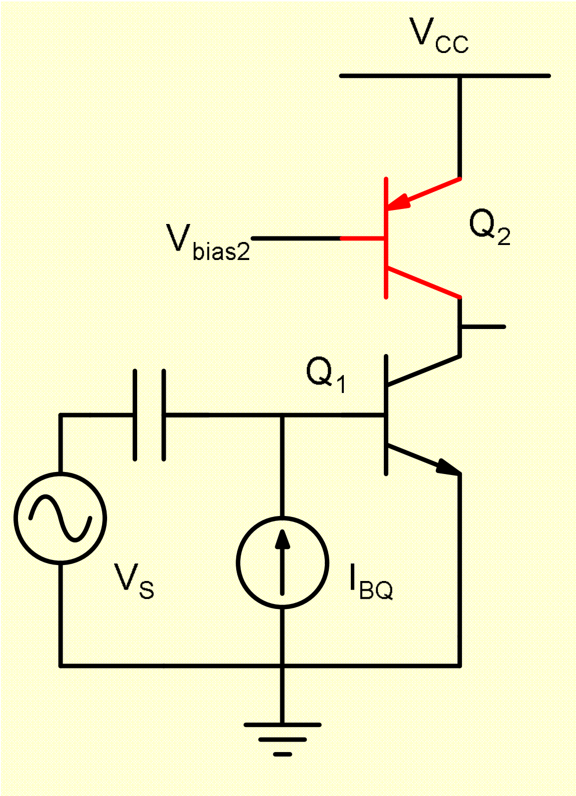
Class AB Output stage



$$\eta < \frac{\pi}{4} \times \frac{v_{op}}{V_{CC}} \times 100$$

An efficient amplifier should take power from the supply only when power is to be delivered to the load !

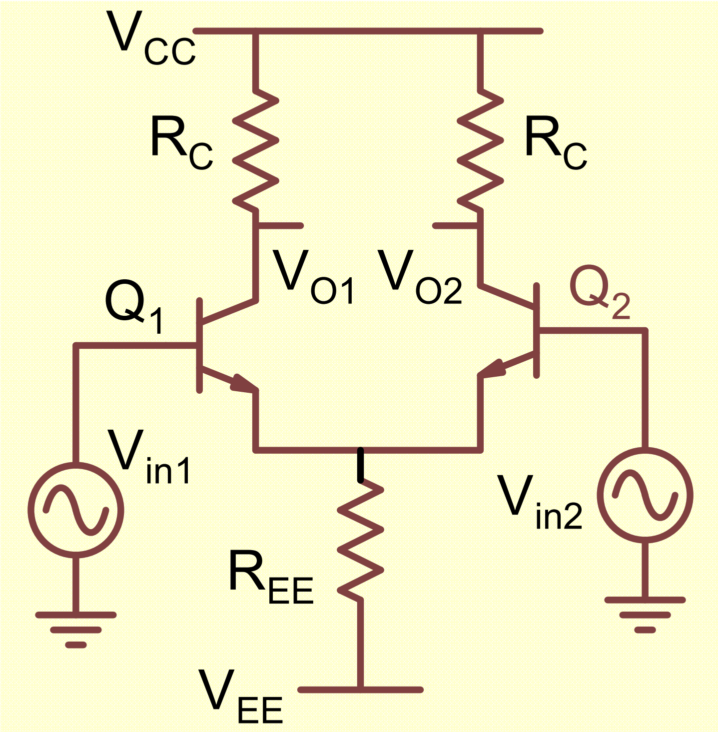
Active Load



$$\left|A_V\right| = \frac{1}{V_T} \times \frac{V_{AN} \times V_{AP}}{V_{AN} + V_{AP}}$$

Active load allows us to obtain higher voltage gain without requiring very high supply voltage

Differential Amplifier-1



- An amplifier does not use any coupling or bypass capacitors thereby allowing monolithic implementation
- An amplifier that amplifies differential input signal and rejects common mode signals

$$A_{dm} = -0.5 g_m R_C$$

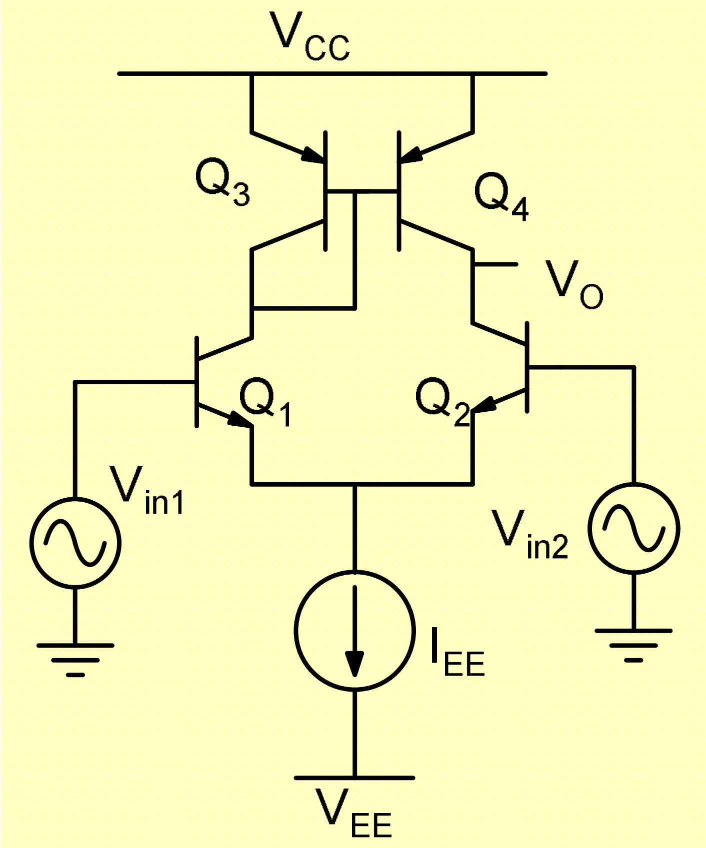
$$A_{cm} = -\frac{g_m}{1 + 2 g_m R_{EE}} R_C$$

$$R_o = R_C$$

$$R_{id} = 2 r_\pi$$

$$R_{ic} = r_\pi + (1 + \beta) \times 2 R_{EE}$$

Differential Amplifier-2

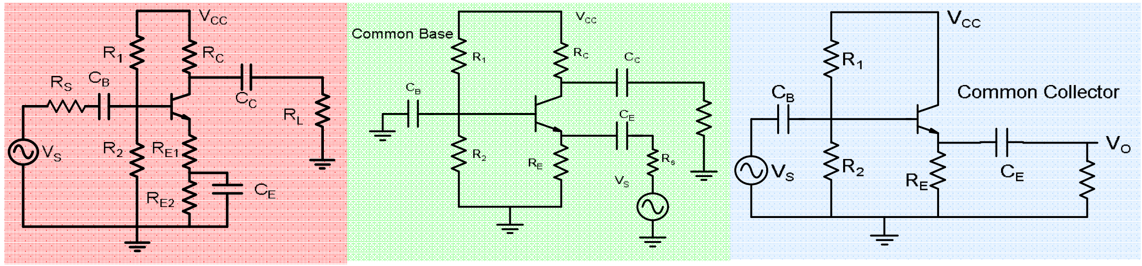


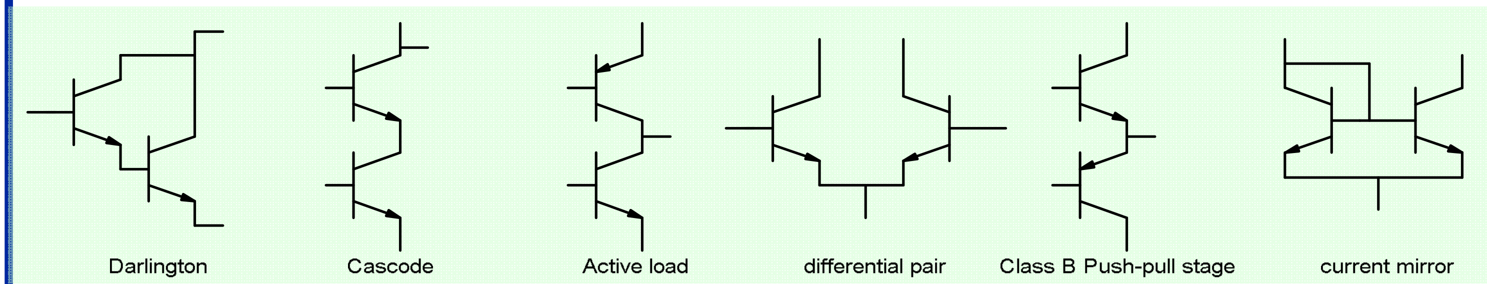
- This amplifier with current mirror load and current source biasing allows stable biasing, high differential mode gain and very low common mode gain

$$A_{dm} = \frac{v_o}{v_{id}} = 0.5 g_m \times r_{o2} \| r_{o4}$$

The two inputs contribute in an opposite manner to the output voltage resulting in low common mode gain

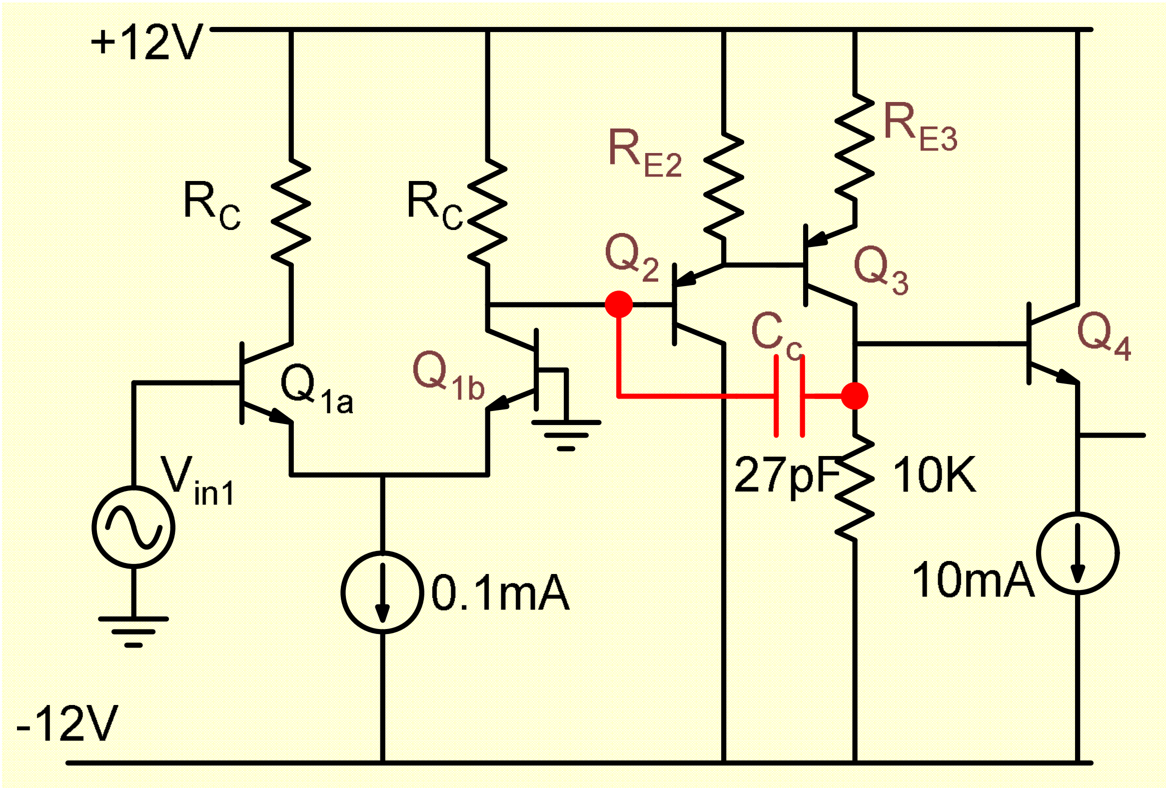
Basic building blocks





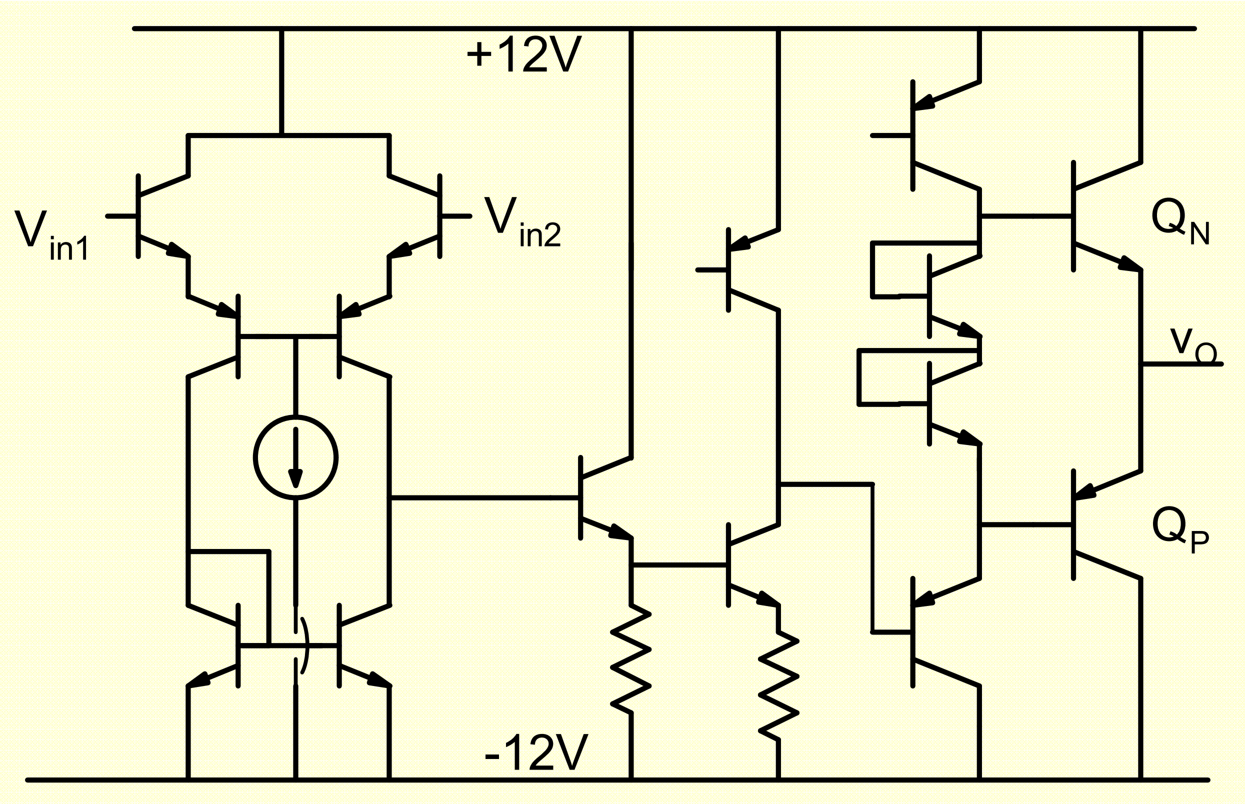
Many new circuits can be created by connecting and combining these basic building blocks

Operational Amplifier-1



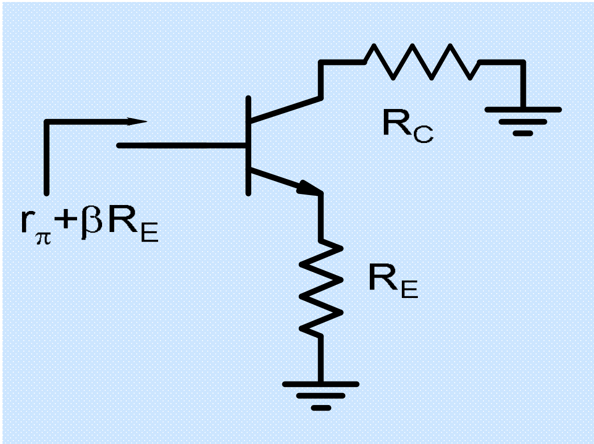
Note the use of complementary transistors and compensation capacitor

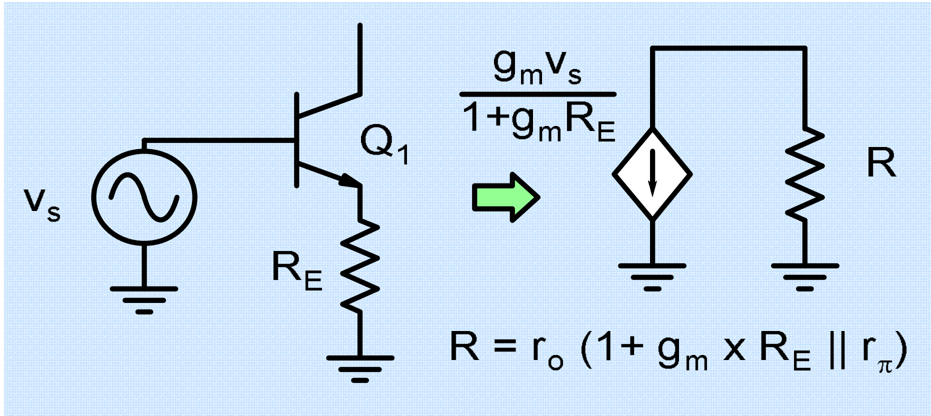
Operational Amplifier-2

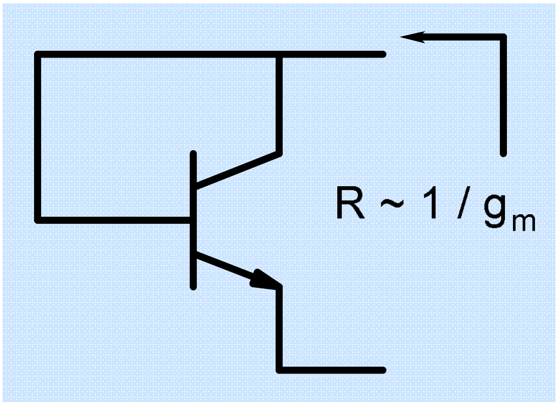


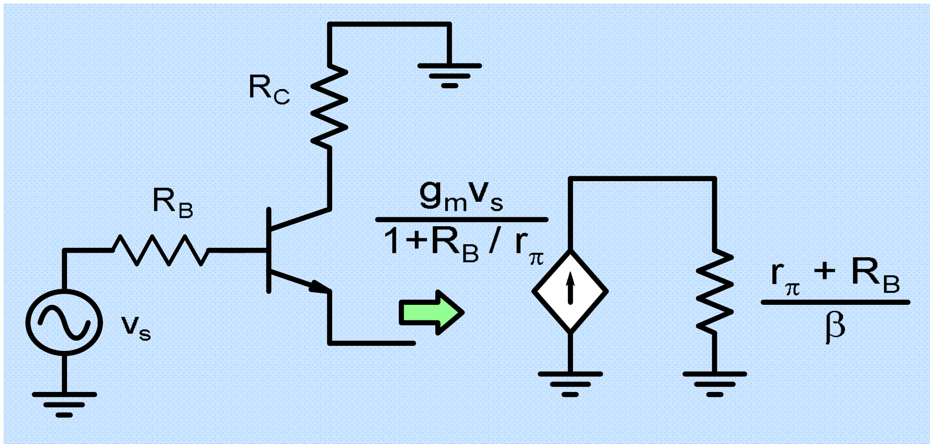
Note the use of active loads, class AB push-pull stage and NPN-PNP pair at the input

Analysis Using "Divide & Reuse" Methodology-1

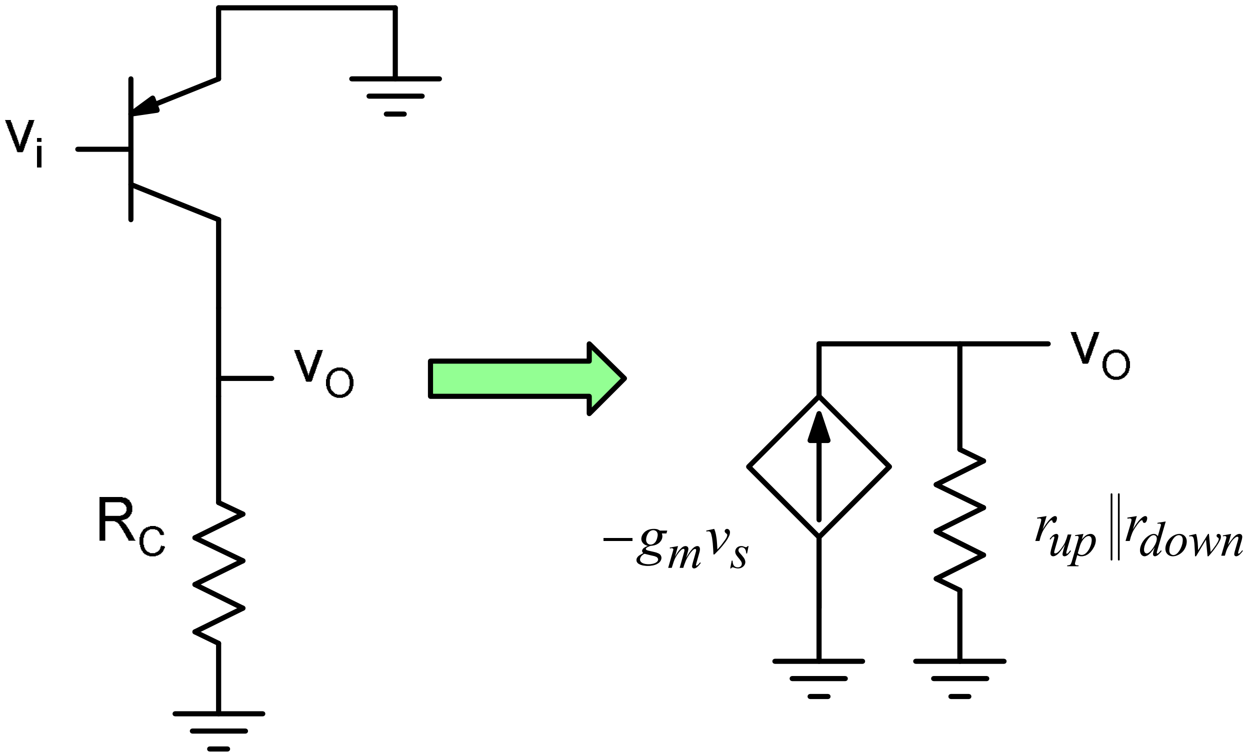








Analysis Using "Divide & Reuse" Methodology-2



Build Norton's equivalent at the node of interest by using pre-derived and pre-verified results

MOS Amplifiers