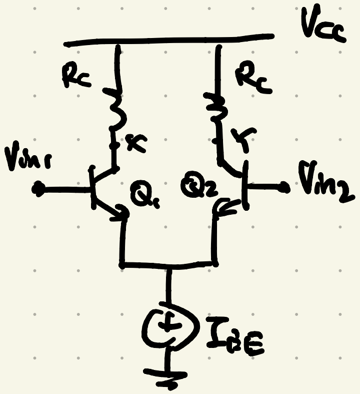
Lec 11

- Additional Examples on Bipolar Diff. Pair
- Intro. to MOS Diff. Pair



Example

$I_{EE} = 1\,mA$ $\quad R_C = 1\,k\Omega$

$I_S = 2\times10^{-18}A$ $\quad I_C = I_S \exp\frac{V_{BE}}{V_T}$

(a) Determine the bias conditions of Q_1 and Q_2.

(b) Construct the input-output charac.

(c) Voltage gain.

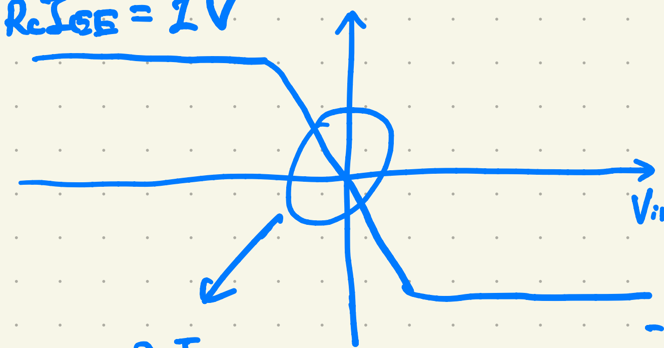
$V_{BE} = V_T \ln\frac{I_C}{I_S}$

Bias conditions:

$$I_{C1} = I_{C2} = \frac{I_{EE}}{2}$$

$$V_{BE1} = V_{BE2} = 862\,mV$$

(b)



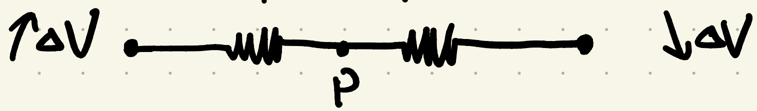
$$\text{Slope} = -\frac{R_C I_{EE}}{2V_T} = -19.2$$

Small-Signal Gain $= -g_m R_C$

$= -19.2$

Example

$R_1 = R_2 = R$



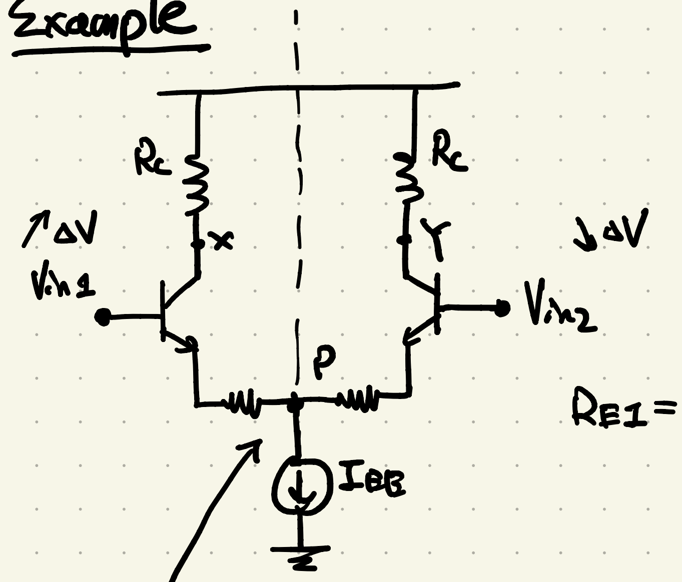
what happens to P ?

$$\text{Current} = \frac{2\Delta V}{2R} = \frac{\Delta V}{R}$$

Voltage drop across R_1: $\frac{\Delta V}{R}\cdot R = \Delta V$

$\Rightarrow$ V_P is constant

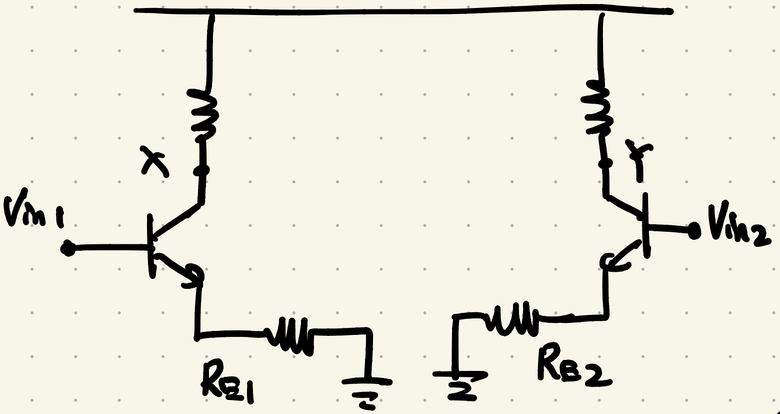
Example



$R_{E1} = R_{E2} = R_E$

V_P does not change with time

$\Rightarrow$ P is ac GND

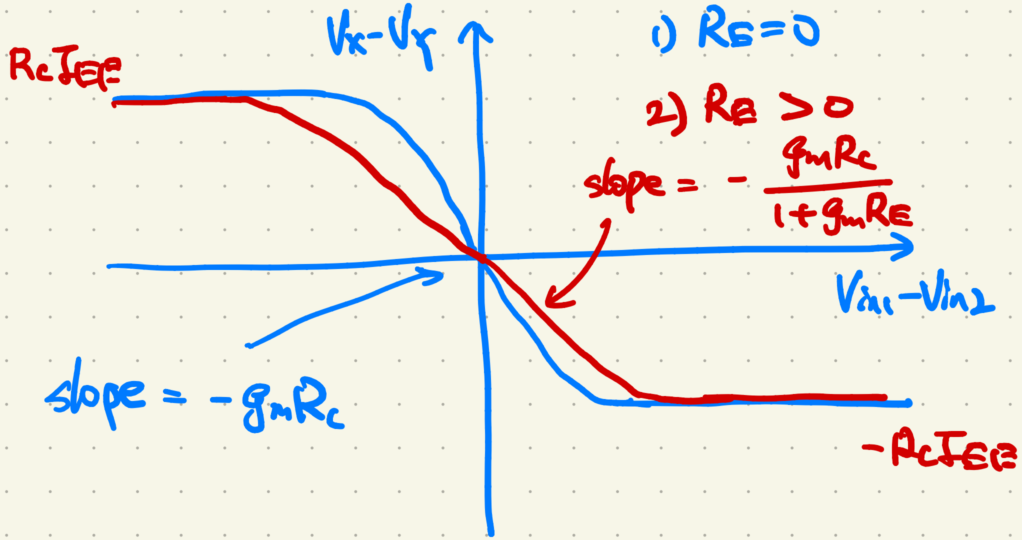


$$\frac{V_X}{V_{in1}} = -\frac{R_C}{\frac{1}{g_m} + R_{E1}}$$

$\Rightarrow$ Diff. Gain

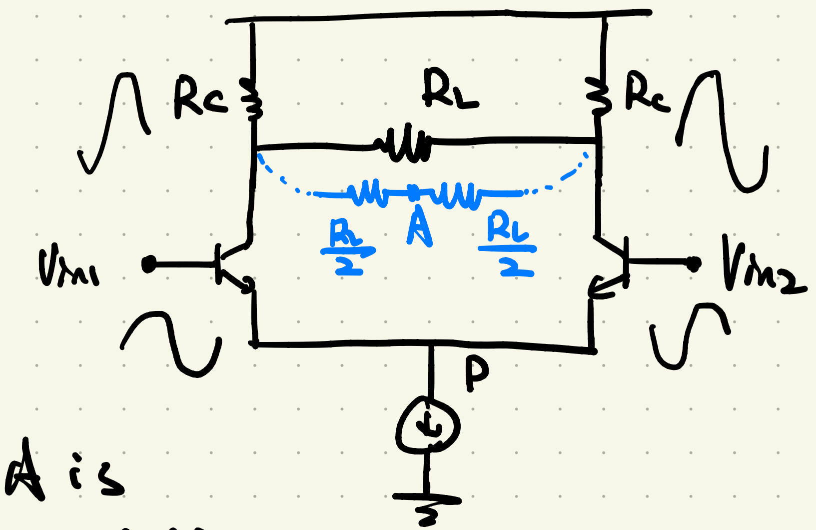
$$= -\frac{R_C}{\frac{1}{g_m} + R_E}$$

Quiz: Construct the input-output charac. of the degen. diff. pair



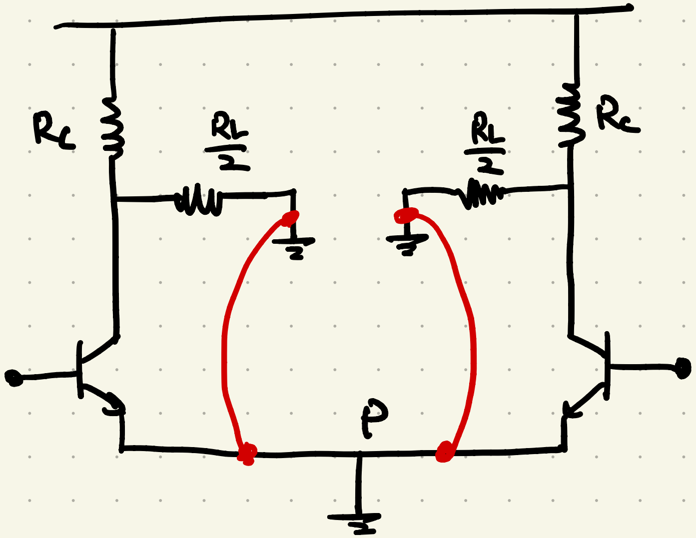
Emitter degeneration improves the linearity

Example



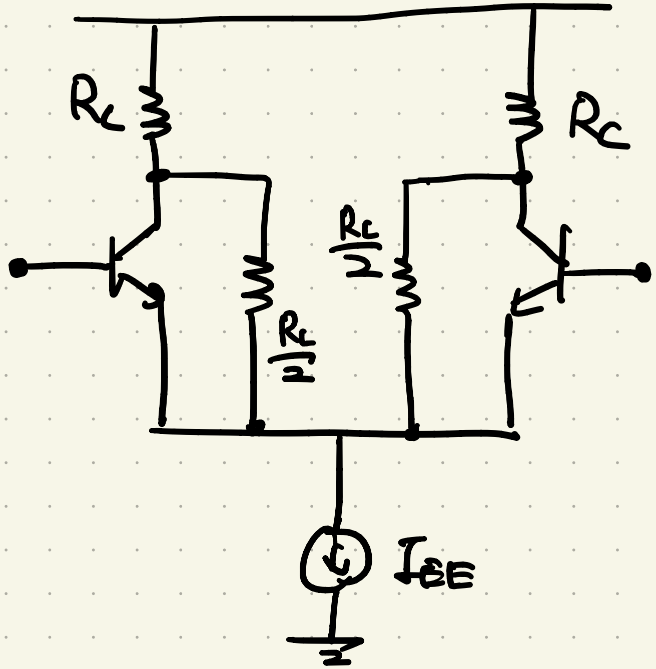
Node A is ac GND

Half-Circuit Equivalent



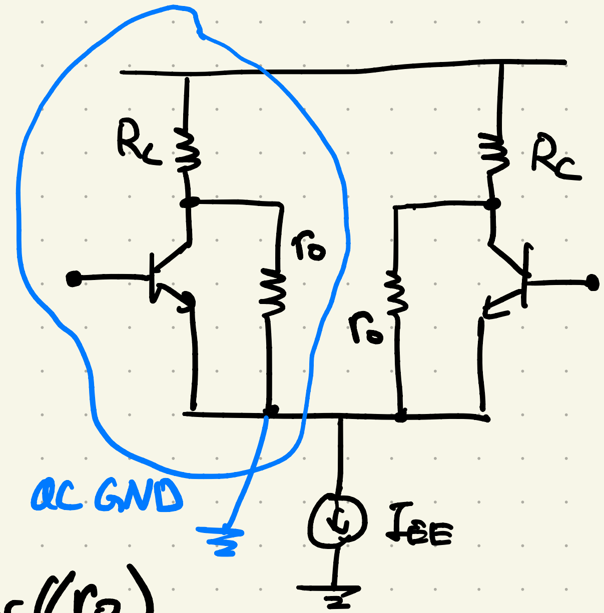
$$A_v = -g_m (R_C // \frac{R_L}{2})$$

Example



Example

$V_A < \infty$



$$A_v = -g_m (R_C // r_o)$$