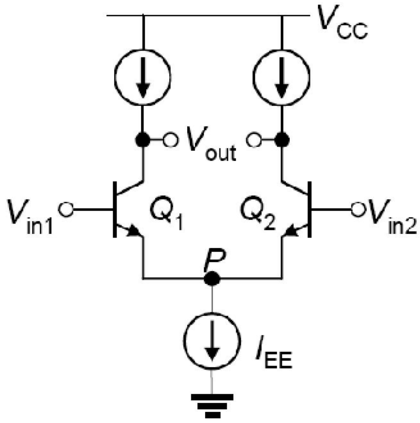
Quiz 1	Subject	Professor	Student ID#	Student Name	Score
Date: 2009.09.09	Microelectronics 2	Jong-Ho Lee			

1. Assume that bipolar transistors Q_1 and Q_2 are symmetric in the circuit shown below. The transistors have an output resistance r_o due to a finite Early voltage V_A. Answer for the following questions.



(a) Compute the differential gain of the circuit, where ideal current sources are used as loads to maximize the gain.

Answer)

The output impedance of the ideal current source is infinite. So Rout $= r_o(=r_{o1}= r_{o2})$, using half-circuit analysis.

Av = -gm r_o

(b) Repeat (a), but assume the output impedance of the ideal current sources for loads has a finite impedance r_o (not ideal).

Answer)

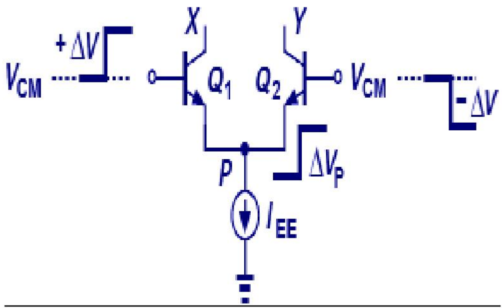
Rout $= r_o \,//\, r_o = \frac{ro}{2}$

Av = -gm$\frac{ro}{2}$

(c) Show that the node P is virtual ground.

Answer)

Method1.



$\triangle V_{BE1} = \triangle V - \triangle V_P$

$\triangle V_{BE2} = -\triangle V - \triangle V_P$

$g_{m1} = g_{m2} = g_m$

$\triangle I_{c1} = g_m(\triangle V - \triangle V_P)$

$\triangle I_{c2} = -g_m(\triangle V + \triangle V_P)$

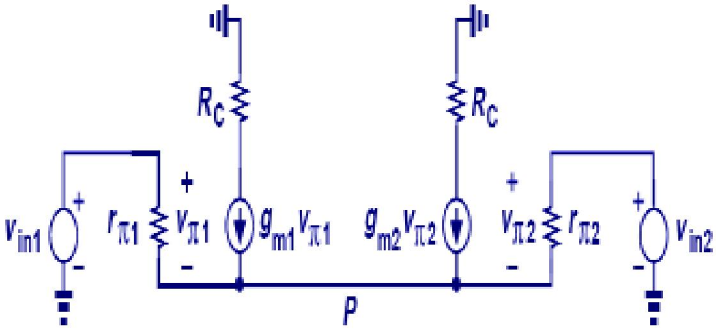
$\triangle I_{c1} + \triangle I_{c2} = 0$

$g_m(\triangle V - \triangle V_P) = g_m(\triangle V + \triangle V_P)$

Therefore, $\triangle V_P = 0$

For small changes at inputs, the gm's are the same, and the respective increase and decrease of IC1 and IC2are the same, node P must stay constant to accommodate these changes. **Therefore, node P can be viewed as AC ground.**

Method2.



$v_{in1} - v_{\pi1} = v_p = v_{in2} - v_{\pi2}$

$\frac{v_{\pi1}}{r_{\pi1}} + g_{m1}v_{\pi1} + \frac{v_{\pi2}}{r_{\pi2}} + g_{m2}v_{\pi2} = 0$

With $r_{\pi1} = r_{\pi2}$, and $g_{m1} = g_{m2}$, $v_{\pi1} = -v_{\pi2}$

Since $v_{in1} = -v_{in2}$, $2v_{in1} = 2v_{\pi1}$

$\mathbf{V_p = v_{in1} - v_{\pi1} = 0}$

There can be many other solutions for this problem.

Use front side only