ECSE-2050

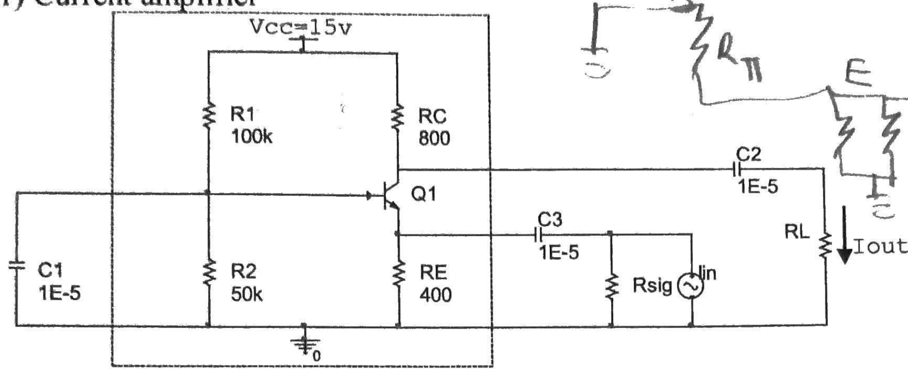
Introduction to Electronics
Summer 2020 **Name** ______________________

Homework 18

In all BJT problems, you may assume that $V_{CEsat} \sim 0.2V$, $V_{BE} \sim 0.7V$ and $r_o \to \infty$ when the transistor is in the forward active region. Also, the thermal voltage is Vth = 26mV.

C

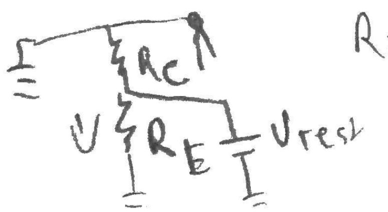
Problem 1) Current amplifier



Same DC bias circuit as problem 1 in HW16.

a) Determine the input resistance 'seen by' the current source, Iin.
b) Determine the output resistance 'seen by' the current load.
c) Determine the short circuit current gain, A_{Io}, when Rsig $\to \infty$ and RL $\to 0$.
d) Based on your above answer, what familiar name can you call this amplifier?

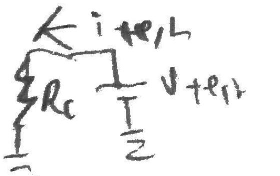
A:



$R_{in} = R_E \| R_e = 4.37\,\Omega$

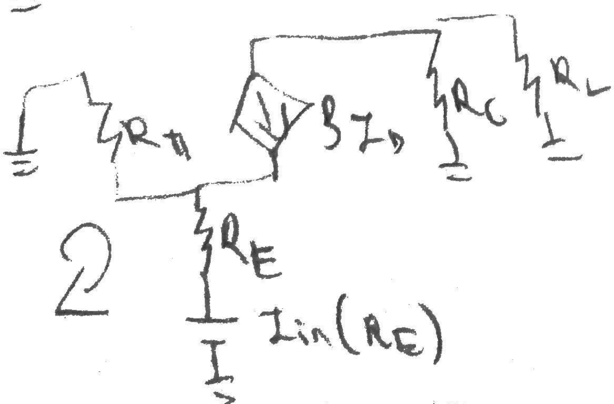
D: inverting amplifier
current inverter

B:



$R_{out} = R_C = 800\,\Omega$

C:



$I_{in}(R_E) - I_E R_E - I_B R_\pi - 0$

$400 I_{in} - (19 \cdot 400) I_B - .026 = 0$

$I_{in} = \frac{2.381}{400} = 5.953\,mA$

$\frac{I_{out}}{I_{in}} = \frac{5.95 \times 10^{-3}}{5.83 \times 10^{-3}} = -1.021$

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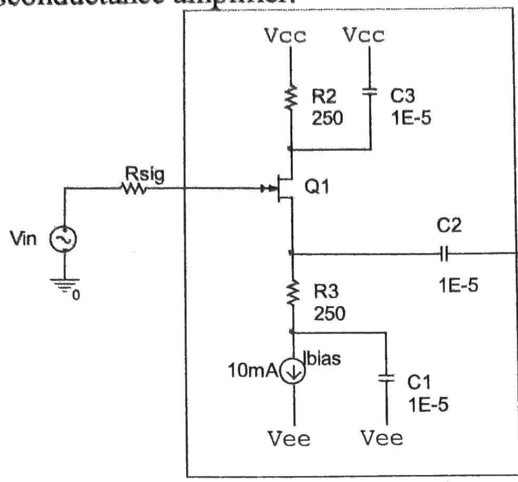
Problem 2) Transconductance amplifier.

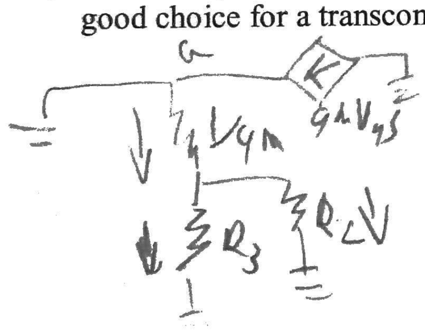


D: It's not a good choice because the gain is entirely dependent on DC bias which isn't a good idea. The gain is also small.

The NMOSFET in the above circuit has characteristics VTN = 2.2V, and Kn = 40 mA/V^2 (Same DC bias circuit as HW13)

a) Determine the input resistance 'seen by' the voltage source, Vin.
b) Determine the output resistance 'seen by' the current load.
c) Determine the short circuit transconductance gain, A_{Go}, when Rsig → 0 and RL → 0.
d) Based on your above answers, why is the common collector configuration not a good choice for a transconductance amplifier.

A:



$R_{in} = \frac{1}{g_m} + R_3 \| R_L$

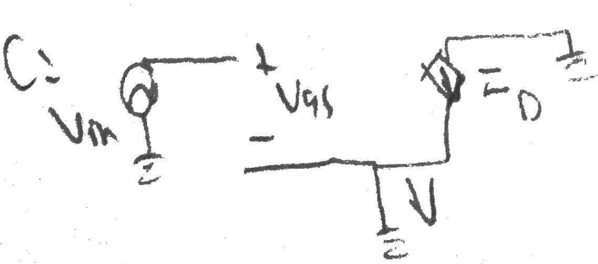
$g_m = 0.0283$ $\quad \underline{R_{in} = 35.4}$

B:

$I_{test} = \frac{V_{TEST}}{1/g_m} + \frac{V_{TEST}}{R_3}$ $\quad R_{out} = R_3 \| 1/g_m$

$\underline{= 31.01}$

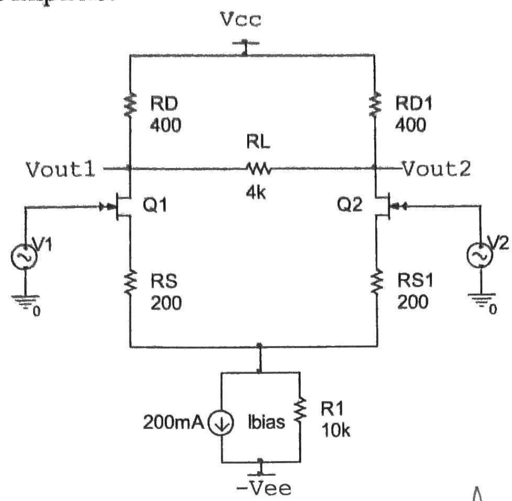
C:



$i_{out} = I_D = I_S$ $\quad \frac{I_D}{\frac{I_D}{g_m}} = g_m = \underline{A_{go} = 0.0283}$

$V_{in} = V_{gs}$

Problem 3) Differential Amplifier

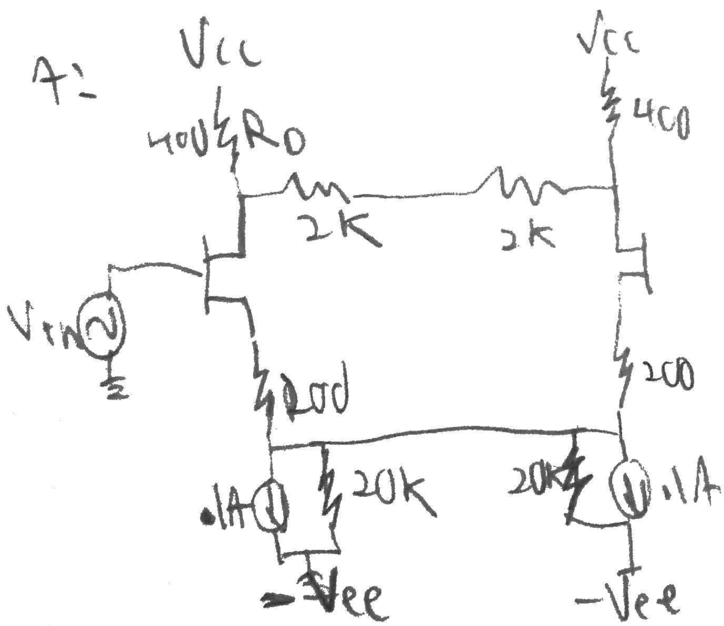


D: $V_{out} = I_D \cdot R_D$
$= .1 \cdot 400 = 40$
$V_1 = V_{gs} + I_s(R_s + 20k)$
$= V_{gs} + 2020$
$g_m V_{gs} = I_D = I_s = .1$
$V_{gs} = .707$; $V_1 = 2020.707$
$A_{CMHC} = \frac{V_{out}}{V_1} = \underline{.0198}$

In the above circuit, Kn = 0.1A/V^2,

a) Redraw the above circuit symmetrically, such that the 'left' and the 'right' sides are mirror images of each other.
b) Determine the small signal transconductance, g_m, for the transistors.
c) Using superposition and the symmetric characteristics for common mode inputs (V1=V2), draw the small signal half circuit.
d) Determine the half circuit common mode gain, A_{CMHC}.

A:



B: $g_m = \sqrt{2K_n I_D} = .1414$

C: