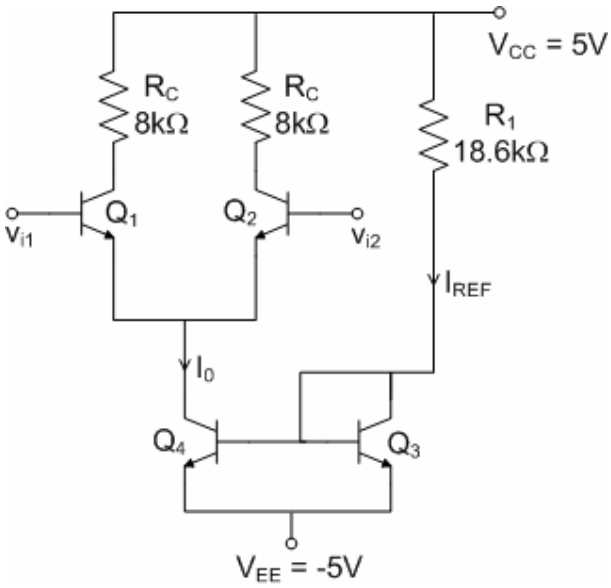
ELE311
EXAMPLES

1. For the circuit shown below, determine the differential and common mode input resistances calculate R_{id} and R_{ic} respectively. (2002 Midterm I)



$Q_1 \equiv Q_2$

$h_{fe} = h_{FE} = 100$

$V_{BE} = 0.7V$

$1/h_{oe1} = 1/h_{oe2} = 400k\Omega$

$1/h_{oe4} = 200k\Omega$

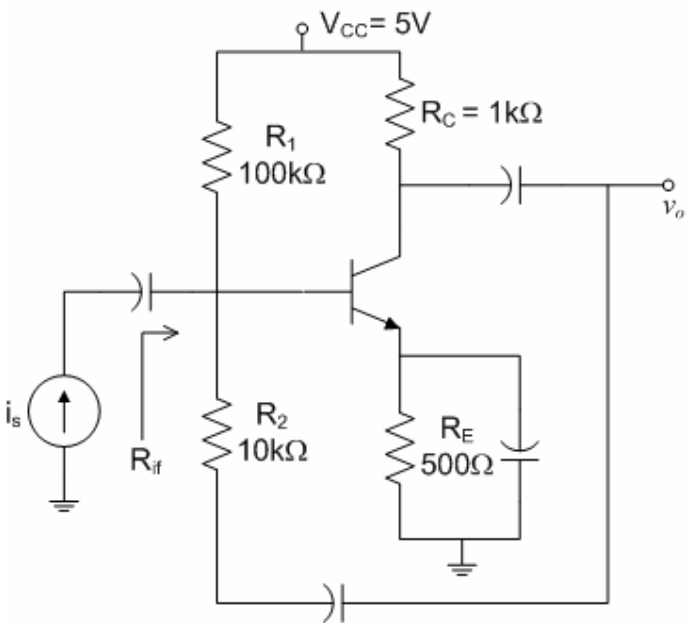
ANSWER:

$I_0 = I_{REF} = (V_{CC} - V_{BE} - V_{EE}) / R_1 = (5\text{-}0.7\text{+}5)/18.6k = 0.5mA$
$I_{E1} = I_{E2} = I_0 / 2 = 0.25mA$
$h_{ie} \cong (h_{fe} + 1)\, V_T / I_{EQ} = 101 \times 26mV / 0.25mA = 10.8k\Omega$

In the differential mode, i.e. $v_{i2} = -v_{i1}$.
$R_{id} = 2h_{ie} = 2\ (10.4k) = \underline{21.6k\Omega}$

In the differential mode, i.e. $v_{i2} = v_{i1}$.
Let us define $r_{o1} = 1/h_{oe1}$, $r_{o2} = 1/h_{oe2}$, $r_{o4} = 1/h_{oe4}$
$R_{ic} = (h_{fe}+1)(r_{o4} \parallel r_{o1} \parallel r_{o2}) = (100 + 1)(200k \parallel 400k \parallel 400k) = \underline{10.1\ M\Omega.}$

2. For the circuit shown below,
   a) Identify the type of feedback
   b) Find input resistance R_{if}
   c) Find the gain $A_f = v_o / i_s$. (2002 Midterm I)



$h_{fe} = h_{FE}$ =100

V_{BE} = 0.7V

ANSWER:

a) Voltage-parallel feedback

b) Let us find first I_{EQ}

$V_{CC} - V_{BE} = I_{EQ}R_E + I_{BQ}R_B$

$I_{EQ} = (5 - 0.7) / (500 + 100k/(50+1)) = 1.75mA$

$h_{ie} \cong (h_{fe}+1)V_T / I_{EQ} = 51 \times 26mV / 1.75mA = 758\Omega$

Let write down, the open-loop (i.e. without feedback) input resistance R_i

$R_i = R_1 \parallel R_2 \parallel h_{ie} = 10k \parallel 100k \parallel 758 = 700\ \Omega$,

the open-loop gain A

$A = v_o/i_s$ (open-loop)

$= -(R_C \parallel R_2)\ h_{fe}\ i_b / [h_{ie}\ i_b / R_i]$

$= -909 \times 50 / (758 / 700)$

$= -42\ k\Omega$

and the feedback gain β

$\beta = i_f / v_o = -1/R_2 = -100\ \mu\Omega^{-1}$

$R_{if} = R_i / (1+\beta A) = 700 / (1 + 100\mu \times 42k) = 700 / 5.2 = \underline{135\Omega}$

c) $A_f = A / (1+\beta A) = -42k / (1 + 100\mu \times 42k) = 42k / 5.2 = -\underline{8.08k\Omega}$