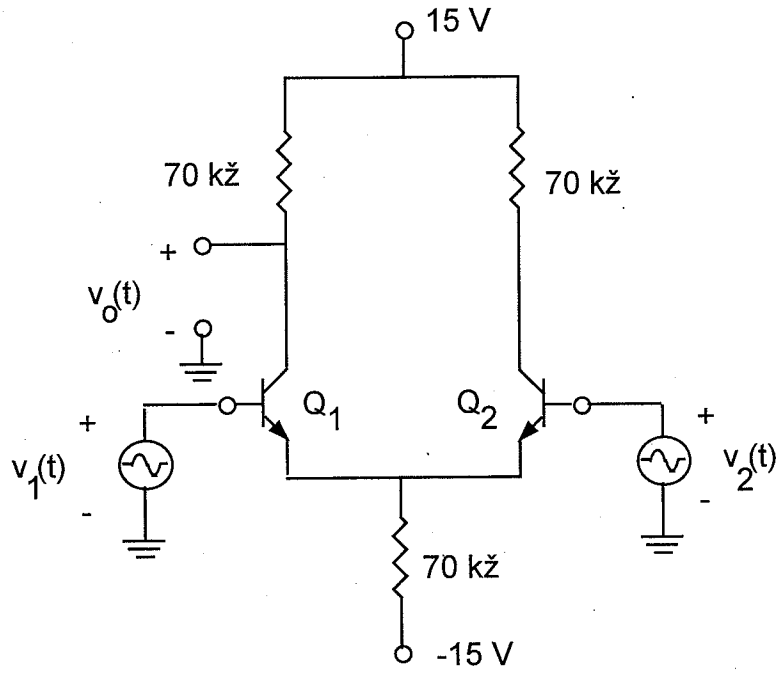
Electronics Problem – Fall 2006 ECE Qualifying Exam

Consider the amplifier shown below. The BJT characteristics are also given.



Silicon BJT

Beta = 100
Early Voltage = 100 V
f_T = 100 MHz
C_π = 3 pF
C_μ = 2 pF

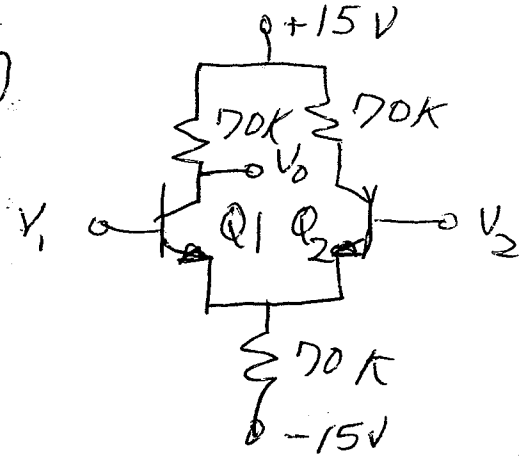
1. Determine the voltage gain $\dfrac{v_o}{(v_1 - v_2)}$.

2. Determine the common mode rejection ratio.

3. Add negative feedback to the amplifier to produce a closed-loop amplifier with a single-ended input (ground-referenced input) having an input resistance of 1 MΩ. Show the feedback circuit on the amplifier circuit diagram including values of the feedback circuit elements.

4. What is closed-loop voltage gain of the amplifier?

Qual. Exam Electronics Prob. Solution

① 

$$I_{C1} = \frac{(15-0.7)}{70K} \times \frac{1}{2}$$

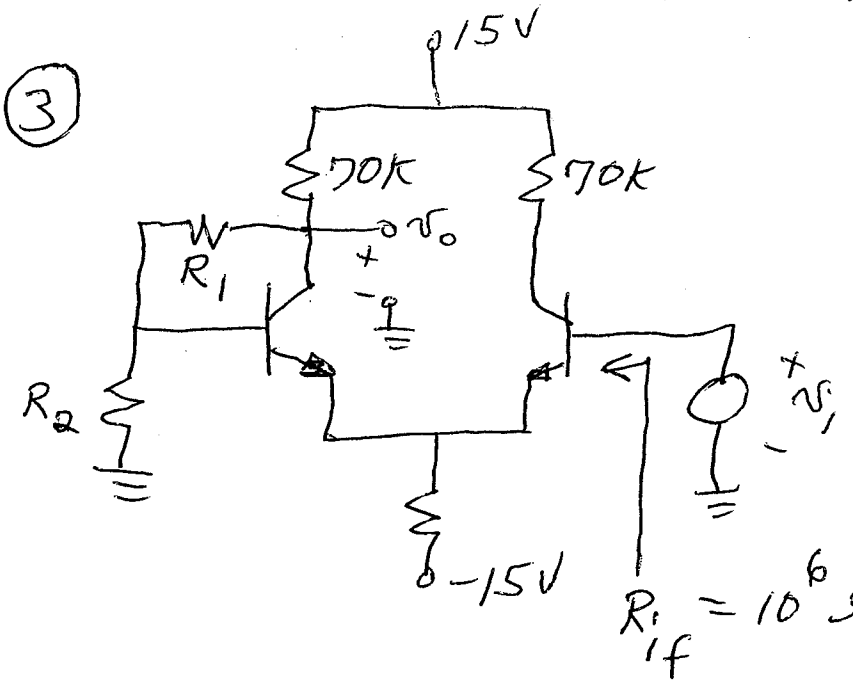
$$I_{C1} \simeq 0.1mA$$

$$\frac{v_o}{(v_1 - v_2)} = \frac{g_m R_C}{2}$$

$$g_m = \frac{0.1mA}{0.025V} = 4 \times 10^{-3}\ \mho$$

$$\frac{v_o}{v_1 - v_2} = \frac{(4\times10^{-3})(7\times10^{4})}{2} = \boxed{140}$$

② $$CMRR = \frac{R_E}{2R_C} \sim \frac{70K}{(2)(70K)} \simeq \frac{1}{2}$$

③ 

Assume R_1-R_2 feedback ckt does not load open-loop amplifier

$R_1 + R_2 >> 70K$

$$R_{if} = 10^6\ \Omega = R_i(1 + A_o\beta)$$

R_i = open-loop amp. input impedance $= 2r_\pi$

$$r_\pi = \frac{25\times10^{-2}\,V}{(10^{-4}A)/(100)} = 25k\Omega;\ R_i = 50k$$

$$10^6 = 5\times10^4(1+A_0\beta)$$

$$A_0\beta + 1 = 20$$

$$A_0\beta = 19\ ;\ A_0 = 140$$

$$\beta = \frac{19}{140} \cong 0.14 = \frac{R_2}{(R_1+R_2)}$$

$$.14R_1 + .14R_2 = R_2$$

$$R_1 = \frac{0.86}{0.14}R_2 = 6.14R_2$$

Set $R_1 + R_2 = 10^6\,\Omega$

$$6.14R_2 + R_2 = 10^6$$

$$R_2 = \frac{10^6}{7.14} = \boxed{140k\Omega = R_2;\ R_1 = 860k\Omega}$$

(4) $$A_f = \frac{140}{1+19} = \boxed{7 = A_f}$$