

**EE232-INTRODUCTION TO ELECTRONICS-FALL 2009**  
**EXERCISE-BJT2**

**P1** In the amplifier circuit shown in Figure-1,  $|V_{BE}| \cong 0.6V$ ,  $V_T \cong 26mV$  and  $\beta_F = 200$  are given for the transistors.

a)  $V_O$  is required "0V" in DC case when  $V_i = 0V$ .

Find  $R_{C3}$ . (10Points)

**A-1a**

$V_O = 0V$  has been given for  $V_i = 0V$ .

From the circuit topology;

$$I_{RC2} = I_{RC1} \cong \frac{I_K}{2} = 1mA \quad (I_{RK} \text{ can be neglected})$$

Then,

$$I_{RC2} \times R_{C2} = V_{RE3} + V_{EB} = I_{E3} \times R_{E3} + V_{EB}$$

$$1mA \times 2.2k = I_{E3} \times 1k + 0.6V \Rightarrow I_{E3} = 1.6mA \cong I_{C3}$$

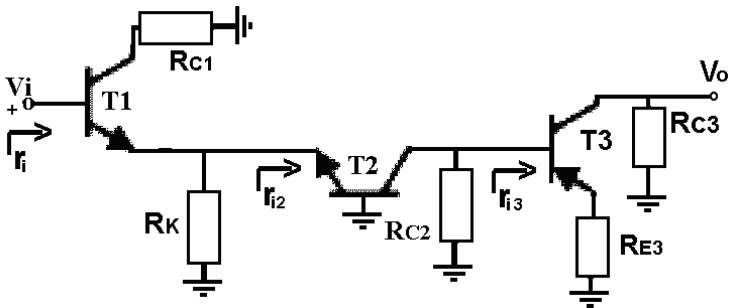
$$V_{RC3} = I_{C3} \times R_{C3} = V_O - V_{ss} = 0 - (-12V) = 12V$$

$$R_{C3} = 7.5k\Omega$$

$R_{C3} = 7.5k$  is obtained.

b) Find ac gain ( $v_o/v_i$ ) of the circuit.(10Points)

**A-1b**



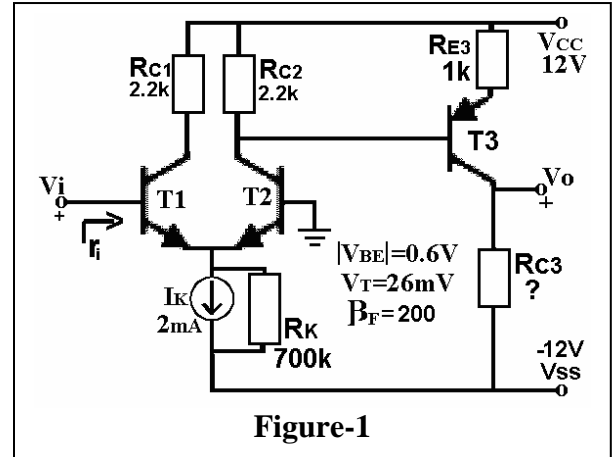
ac case of the circuit

**T1: emitter-follower:**  $\frac{v_{e1}}{v_i} = \frac{g_{m1}R_{e1}}{1 + g_{m1}R_{e1}} = \frac{g_{m1}(R_K // r_{i2})}{1 + (R_K // r_{i2})}$

$$r_{i2} = \frac{1}{g_{m2}} + \frac{R_{b2}}{\beta_F} = \frac{1}{g_{m2}} + \frac{0}{\beta_F} = \frac{1}{g_{m2}}$$

**T2: common-base:**  $\frac{v_{c2}}{v_{e2}} = \frac{g_{m2}R_{c2}}{1 + g_{m2}\frac{R_{b2}}{\beta_F}} = \frac{g_{m2}(R_{c2} // r_{i3})}{1 + g_{m2}\frac{0}{\beta_F}} = g_{m2}(R_{c2} // r_{i3})$

$$r_{i3} = \beta_F \left( \frac{1}{g_{m3}} + R_{e3} \right) = \beta_F \left( \frac{1}{g_{m3}} + R_{E3} \right)$$



**Figure-1**

**T3: common-emitter:**  $\frac{v_{c3}}{v_{b3}} = -\frac{g_{m3}R_{c3}}{1 + g_{m3}R_{e3}} = -\frac{g_{m3}R_{C3}}{1 + g_{m3}R_{E3}}$

$$g_{m1} = \frac{I_{C1}}{V_T} \quad g_{m2} = \frac{I_{C2}}{V_T} = g_{m1} \quad g_{m3} = \frac{I_{C3}}{V_T}$$

$$\frac{v_o}{v_i} = \frac{v_{e1}}{v_i} \times \frac{v_{c2}}{v_{e2}} \times \frac{v_{c3}}{v_{b3}} = \frac{1}{2} \times 88 \times (-7.38) = -325$$

**c)** Find CMRR of the circuit. (10Points)

**A-1c**

$$CMRR = \frac{1}{2} + g_{m1}R_{EE} = \frac{1}{2} + g_{m1}R_K = 0.5 + \frac{1}{25}700k \cong 28000$$