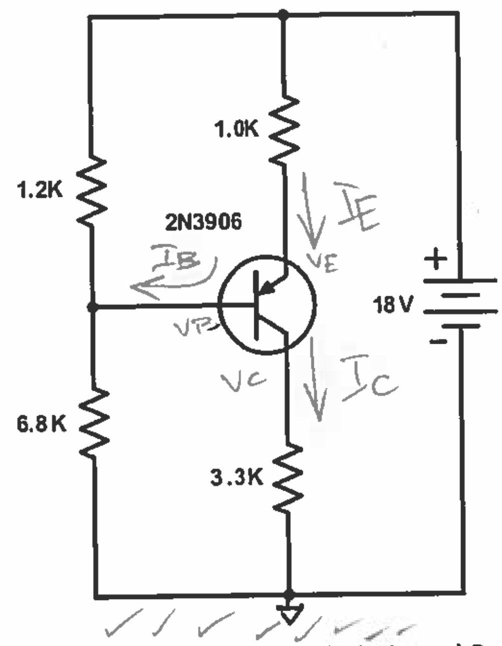
BME-ISE 3512 • Exam V • 6 April 2018 NAME SOLUTION

1) Refer to the following circuit:



Compute V_B, V_C, V_E, V_{BE}, V_{CE}, I_B, I_C, I_E, and P_{diss} if β = 250. Compute V_B assuming base current is small compared to the current in the biasing resistors. Also verify that the transistor is operating in the active region.

$$V_B = 18\left[\frac{6.8}{1.2+6.8}\right] = 15.3\text{V} \quad (+2)$$

$$V_{BE(ON)} = -0.7\text{V} \quad (\text{PNP}) \quad (+1)$$

$$\therefore \quad V_E = V_B - V_{BE} \quad (+1)$$

$$= 15.3 - -0.7 = 16\text{V} \quad (+1)$$

$$I_E = \frac{18 - V_E}{1k} = \frac{18-16}{1k} = 2\text{mA} \quad (+1)$$

$$I_B = \frac{I_E}{\beta+1} = \frac{2\text{mA}}{250+1} = 0.008 \text{ mA}$$

or 8 μA (+1)

ok to compute from I_C instead

$$I_C \approx I_E \quad (+1)$$

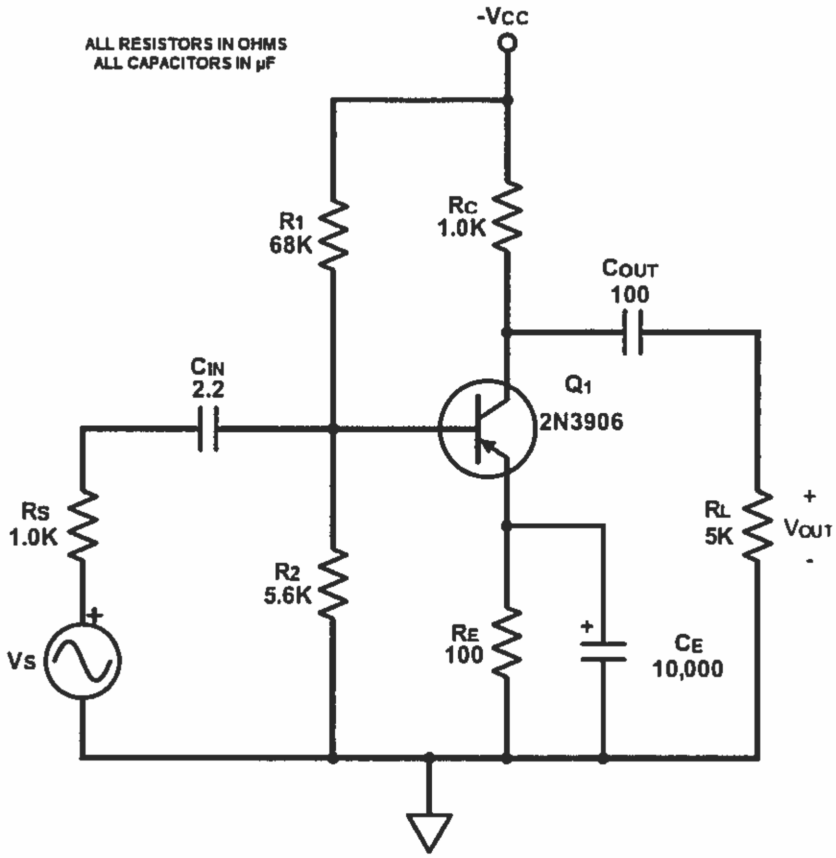
$$V_C \therefore= I_C \cdot 3.3K = 6.6\text{V} \quad (+2)$$

$$V_{CE} = V_C - V_E = 6.6 - 16 = -9.4\text{ V} \quad (+2)$$

yes, active region (+1)

$$P_{diss} = V_{CE} \cdot I_C = 9.4 \cdot 2 = 18.8 \text{ mW} \quad (+2)$$

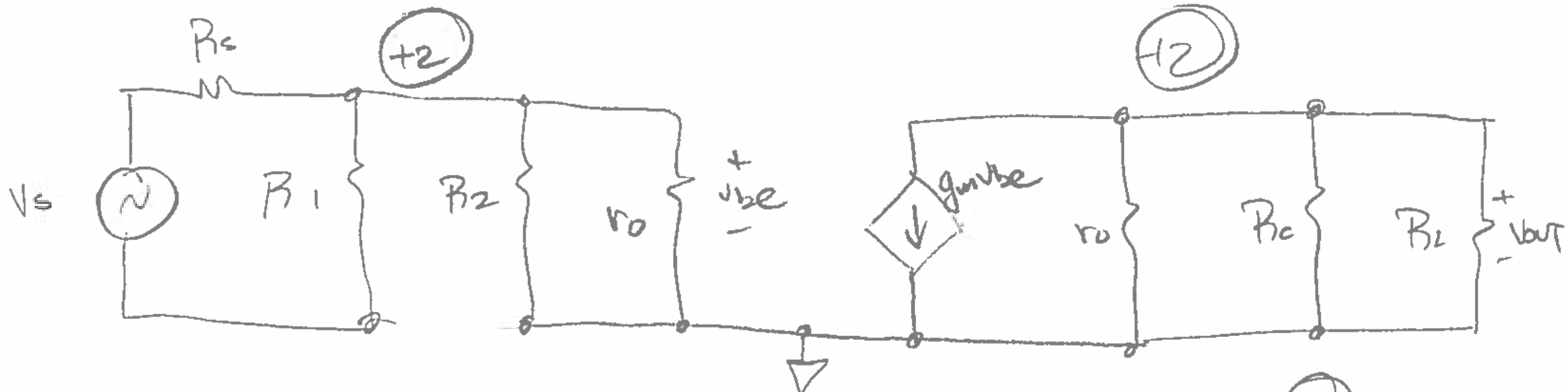
2) What amplifier configuration is this?



common - emitter (+1)

Draw the mid-frequency small-signal model. Calculate the dynamic parameters g_m, r_b, and r_o if I_C = 8 mA and $|V_A|$ = 80 V. Include a unit with each answer.

$\beta = 250$



$g_m = 35\, I_C = 35 \cdot 8 = 280$ mA/V

(+1) eqn. (+1) unit

$r_b = \dfrac{\beta}{g_m} = \dfrac{250}{280} = 0.893$ kΩ

(+1) eqn. (+1) unit

$r_o = \dfrac{|V_A|}{I_C} = \dfrac{80}{8} = 10$ kΩ

(+1) eqn.

$= 68k \parallel 5.6k \parallel 0.843k = 0.762 \, k\Omega$

Determine the mid-frequency gain A_V.

$= 10k \parallel 1k \parallel 5k = 0.769 \, k\Omega$ +1

$V_{OUT} = -g_m V_{be} [r_o \parallel R_C \parallel R_L]$ +1

$V_{OUT} = -280 \cdot V_{be} \cdot .769 = -215.32 \, V_{be}$ +1

$V_{be} = V_s \dfrac{R_1 \parallel R_2 \parallel r_\pi}{R_1 \parallel R_2 \parallel r_\pi + R_S}$ +1

$V_{be} = V_s \dfrac{.762}{.762 + 1} = 0.432 \, V_s$ +1

~~Draw the high-frequency small-signal model. Determine the input and output capacitances using Miller's Theorem if $C_{BC} = 6$ pF and $C_{BE} = 22$ pF.~~

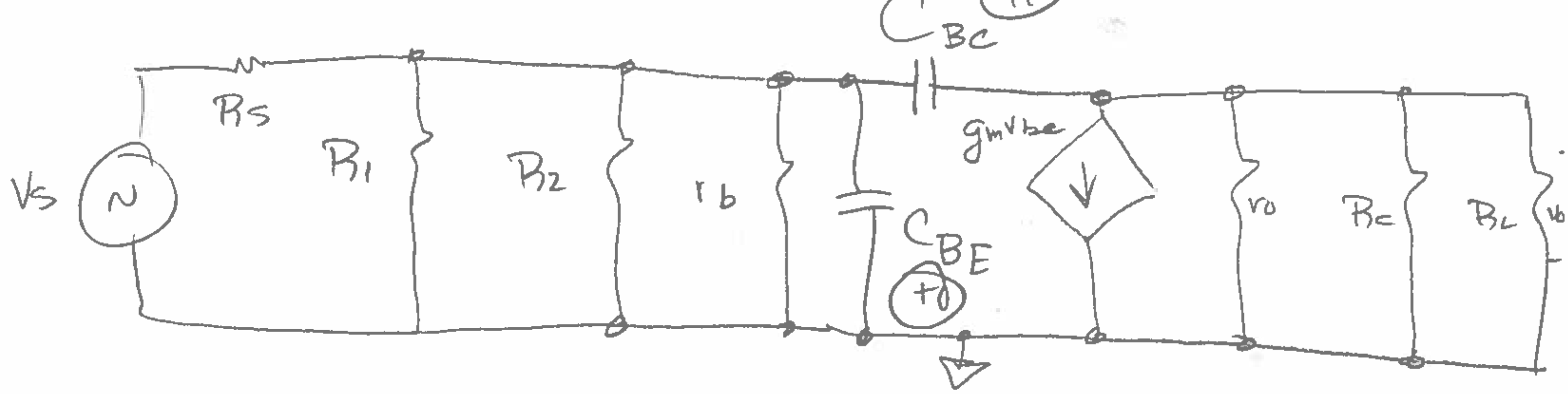
$V_{OUT} = -215.32 \cdot .432 \, V_s$

$\therefore A_V = \dfrac{V_{OUT}}{V_S} = -93.1$ +1

OR 39 dB inverting
+1 +1

~~Compute the input and output HF cutoff frequencies and the approximate overall high-frequency cutoff, f_H.~~

Draw the high-frequency small-signal model. Determine the input and output capacitances using Miller's Theorem if C_{BC} = 6 pF and C_{BE} = 22 pF.



$$C_{BC(IN)} = C_{BC}(1 - A_V) = 6 \cdot (1 - -93) = \underline{564} \text{ pF} \quad +1$$

$$\therefore C_{IN} = C_{BC(IN)} + C_{BE} = 564 + 22 = \underline{586} \text{ pF} \quad +1$$

$$C_{OUT} = C_{BC(OUT)} = C_{BC}\left(1 - \frac{1}{A_V}\right) \approx \underline{6} \text{ pF} \quad +1$$

Compute the input and output HF cutoff frequencies and the approximate overall high-frequency cutoff, f_H.

$$f_{H(IN)} = \frac{1}{2\pi \cdot C_{IN}(R_S \| R_1 \| R_2 \| r_b)} \quad +1$$

$$= .762k \| 1k = \underline{432\,\Omega} \quad +1$$

$$= \frac{1}{2\pi \cdot 586 \times 10^{-12} \cdot 432}$$

$$f_{H(IN)} = 628.7 \text{ kHz} \quad +1$$

$$f_{H(OUT)} = \frac{1}{2\pi \cdot C_{OUT}(r_o \| R_C \| R_L)} \quad +1$$

$$f_{H(OUT)} = \frac{1}{2\pi \cdot 6 \times 10^{-12} \cdot .762k}$$

$$f_{H(OUT)} = 34.8 \text{ MHz} \quad +1$$

$f_{H(IN)} \lll f_{H(OUT)}$

$\therefore$ $f_{H(IN)}$ dominates +1

$$f_H \approx 628.7 \text{ kHz} \quad +1$$