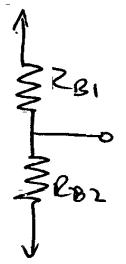
SOLUTIONS

Midterm Examination II
304-330A
November 15th 2001

Question 1

a)



$\Longrightarrow$

$$V = \left(\frac{R_{B2}}{R_{B1}+R_{B2}} \times 10\right) - 5 = -1.67\,V$$

$R_{B1} || R_{B2}$
$= 13.3\,k\Omega$

Using KVL:

$$-1.67 - I_B(13.3K) - \underbrace{0.7}_{V_{BE}=0.7} - \underbrace{100\,I_B}_{I_E=(\beta+1)I_B} R_{E1} = -5$$

$$\Longrightarrow I_B = 0.01\,mA$$

$$I_E = 1\,mA$$

$$V_E = 5 - R_C I_C = 5 \cdot 0.99 \quad 4.01\,V$$

b) $R_{IN} \Leftarrow R_{B1} || R_{B2} || (\beta+1)[r_e + R_E || R_{E2}]$

$= 11.29\,k\Omega$

c) $R_{OUT} = R_C = 1k\Omega$

d) $$\frac{V_{OUT}}{V_S} = \frac{R_{IN}}{R_{IN}+R_S} \times \frac{-\alpha\, R_C || R_L}{r_e + R_E || R_{E2}}$$

$$= -0.1645\ V/V$$

e) Condition required

$$|v_{be}| < 10\,mV$$

$$\frac{v_{be}}{v_s} = \frac{R_{IN}}{R_{IN}+R_s} \times \frac{-r_e}{r_e + R_{E1}||R_{E2}}$$

$$= 6.232\ mV/V$$

$$v_{be} < 10mV \Rightarrow |v_s| < 1.6\ V$$

Answers for Test #2.

1 → (a) $R_{i3} = (\beta+1)(r_{o3} \,//\, R_L + r_{e3})$

2 → (b) $R_{o3} = r_{o3} \,//\, \left(\frac{r_{o4}}{\beta+1} + r_{e3}\right)$

3 → (c) $\frac{v_o}{v_{b3}} = \frac{(R_L // r_{o3})}{(R_L // r_{o3}) + r_{e3}}$

4 → (d) $R_{in2} = (\beta+1)(r_{e2} + R_{E2})$

$v_{b3} = g_{m2} v_{eb} (r_{o4} // R_{i3})$

where $v_{eb} = -\frac{r_{e2}}{r_{e2} + R_{E2}} v_{b2}$ & $R_{i3} =$

(e) $\Rightarrow \frac{v_{b3}}{v_{b2}} = +g_{m2} \frac{r_{e2}}{r_{e2}+R_{E2}} (r_{o4} // R_{i3})$ (+ sign)

where $r_{e2} = \frac{\alpha_2}{g_{m2}} \Rightarrow g_{m2} = \frac{\alpha_2}{r_{e2}}$

$= -\frac{\alpha}{r_{e2}+R_{E2}} (r_{o4} // R_{i3}) = -\frac{\beta}{R_{in2}} (r_{o4} // R_{i3})$

$$v_{b2} = -g_m v_{be} (R_{C1} /\!/ R_{in2})$$

where $v_{be} = \ominus v_{e1}$

$$\Rightarrow \frac{v_{b2}}{v_{e1}} = g_m (R_{C1} /\!/ R_{in2}) = \frac{\alpha}{r_e} (R_{C1} /\!/ R_{in2})$$ (f)

$$R_{i1} = r_{e1} /\!/ R_{E1}$$ (g)

$$\frac{v_{e1}}{v_s} = \frac{R_{i1}}{R_{i1} + R_s}$$ (i)

$$R_{o1} = R_{C1}$$ (h)

#3 a)

(1) $\frac{V_S}{250} - \frac{5 - V_D}{250}$

(2) Assume saturation

$\frac{1}{2} k_n \left(\frac{W}{L}\right)(V_{GS} - V_t)^2 (1 + \lambda V_{DS}) = \frac{V_S}{250}$

$50\mu (20)(V_G - 1)^2 = \frac{V_S}{250}$

$\frac{1m}{0.25} V_G^2 = 1$

$\Rightarrow V_G = \pm 4$ $\quad V_G = 2 \pm 2$

$V_G = 0 \quad V_G = 4$

(3) Need $V_G - V \geq V_t$

$V_G - \geq$

$V_G \geq 2 \Rightarrow \boxed{V_G = 4}$

(4) $\frac{V_S}{250} \quad 250 \Rightarrow \boxed{I_D = 4mA}$

(5) $V_D \quad 5 - 4mA \; 250\Omega \Rightarrow \boxed{V_D = 4V}$

(6) Verify saturation

$V_D \geq V_G - V_t$

$4 \geq 4$ yes $\Rightarrow$ saturation ✓ OK

assumption

3. b.)

① $V_s = 250 \cdot 2mA = 0.5V$

② For saturat^n or triode, need

$$-V_s \geq V_t$$

$$3 - 0.5 \geq 1 \quad \text{(OK)}$$

③ Saturation $\Rightarrow$ $V_D \geq V_G - V_t$

Triode $\Rightarrow$ $V_D \leq V_G - V_t$

Edge $\Rightarrow$ $V_D = V_G - V_t$

$= 3 - 1$

$\Rightarrow \boxed{V_D = 2V}$

④ $R_D = ?$:

$$R_D = \frac{5V - 2V}{2mA} \Rightarrow \boxed{R_D = 1.5k\Omega}$$