Solution Set 6

Exercises 4.3, 4.4, 4.8, 4.9, 4.12, 4.14, 4.16, 4.19, 4.32, 4.33, 4.36, 4.39, 9.3, 9.7, 9.27, 9.30

4.3 FROM THE LEFT SIDE OF THE CIRCUIT

$$i_1 = \frac{10}{R_1} = \frac{10}{10K} = 1mA$$

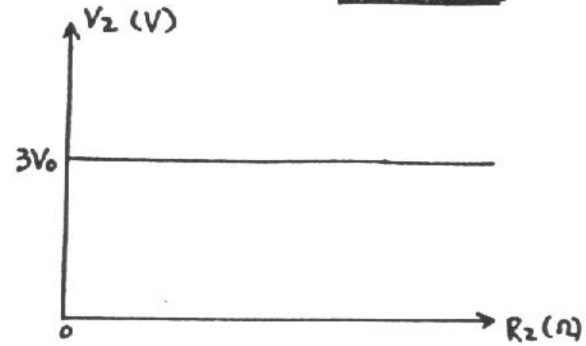
FROM THE RIGHT SIDE OF THE CIRCUIT

$$i_2 = \beta i_1 = 100(1mA)$$
$$= \underline{100mA}$$

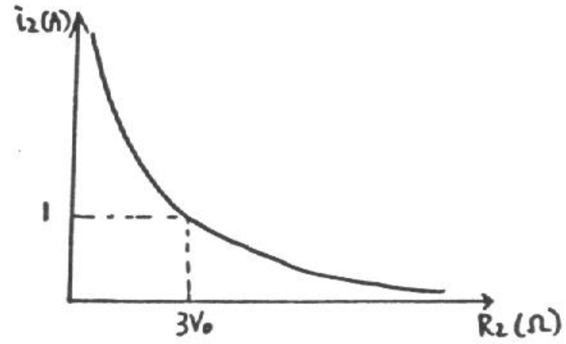
4.4 OBVIOUSLY, FROM THE RESULT OF LAST PROBLEM, $i_2 = 1A$

$$\therefore V = i_2 R_2 = 1000(1)V$$
$$= \underline{\underline{1000V}}$$

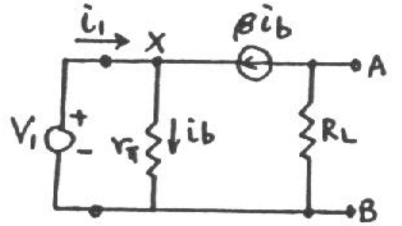
4.8 (a) $V_2 = \mu V_1 = \mu V_0 = \underline{3V_0 \text{ VOLTS}}$



(b) $i_2 = \frac{\mu V_1}{R_2} = \frac{3V_0}{R_2}$ A



4.9



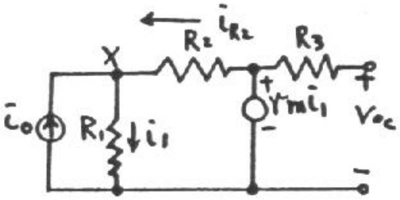
KCL AT X

$i_1 = i_b - \beta i_b$

$= i_b(1-\beta)$

$= \frac{V_1}{r_\pi}(1-\beta) = \frac{2}{2500}(1-100) = \underline{\underline{-79.2\,mA}}$

4.12 (i) FOR V_{oc}



$V_{oc} = r_m i_1$

KCL AT NODE X

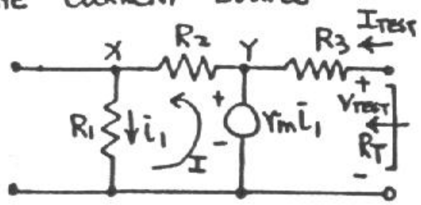
$i_o - i_1 R_1 + i_{R2} = 0$

$\Rightarrow i_o - i_1 R_1 + \frac{r_m i_1 - i_1 R_1}{R_2} = 0$

$\Rightarrow i_1 = \frac{i_o R_2}{R_1 + R_2 - r_m}$

$\Rightarrow V_{oc} = \frac{i_o r_m R_2}{R_1 + R_2 - r_m}$

(ii) FOR R_T, ZERO THE CURRENT SOURCE (INDEPENDENT).



KVL AROUND LOOP I

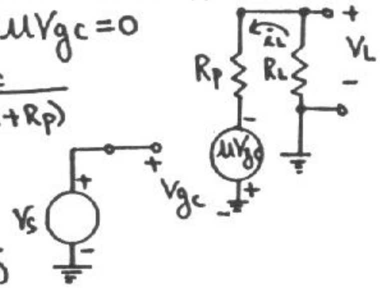
$r_m i_1 = (R_1 + R_2) i_1$

IF $r_m \neq R_1 + R_2$ IS ASSUMED, i_1 MUST BE ZERO.

THEREFORE Y IS EFFECTIVELY GROUNDED.

4.14 THE COMPLETE CIRCUIT IS SHOWN BELOW.

KVL FOR THE RIGHT SECTION:



$-i_L(R_L + R_p) - \mu V_{gc} = 0$

$\Rightarrow i_L = \frac{-\mu V_{gc}}{(R_L + R_p)}$

$V_{gc} = V_s$

$\Rightarrow i_L = -\frac{\mu V_s}{(R_L + R_p)}$

$\Rightarrow V_L = -i_L R_L$

$= \underline{\underline{\frac{\mu R_L V_s}{R_L + R_p}}}$

4.16 (a)

$V_1 = Z_{11} i_1 + Z_{12} i_2$

$V_2 = Z_{21} i_1 + Z_{22} i_2$

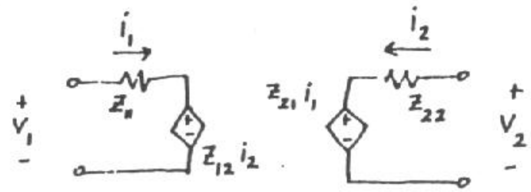
FOR FIG 4.9 (b)

$V_1 = i_1 R_i$

$V_2 = i_2 R_o + A i_1 R_i$

THIS CAN BE PUT INTO THE DESIRED FORM IF $Z_{11} = R_i$, $Z_{12} = 0$, $Z_{21} = A R_i$, $Z_{22} = R_o$.

(b)



(4.19) THIS IS GIVEN BY LAST PROBLEM

$V_i = V_{TEST}$ AND $i = I_{TEST} = \dfrac{V_i}{R_o + (1+A)R_i}$

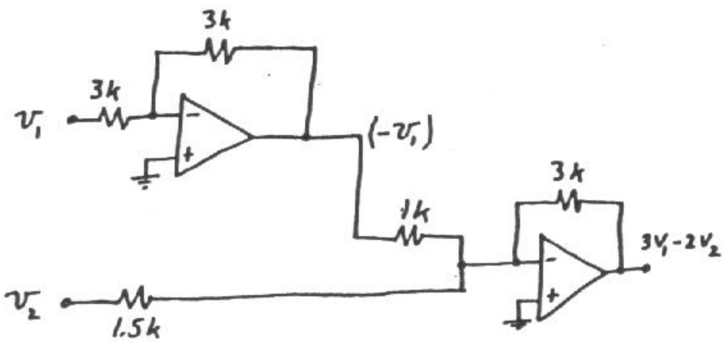
$\therefore$ INPUT RESISTANCE R_i'

$$= \frac{V_{TEST}}{I_{TEST}} = \frac{V_i}{V_i / [R_o + (1+A)R_i]}$$

$$= R_o + (1+A)R_i$$

∎

(4.32) USE AN INVERTING AMP FOLLOWED BY A SUMMING AMP:



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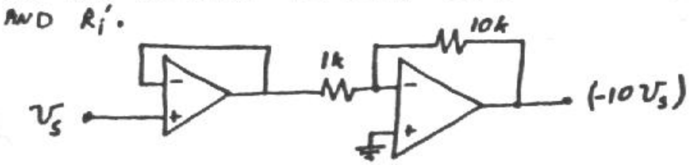
(4.33) WE HAVE TO PROVIDE A HIGH INPUT RESISTANCE OR VOLTAGE WILL BE LOST IN THE VOLTAGE DIVIDER COMPOSED OF R_T AND R_i'.



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(4.36) TO FIND V_{OUT}, THE IDEAL OP-AMP TECHNIQUE MAY BE USED.

NODE EQ. AT A (ASSUMING $V_{(-)} = V_{(+)}$ AND NO CURRENT FLOWS INTO THE (-) TERMINAL:

$$\frac{V_S}{R_1} + \frac{V_S - V_B}{R_{F1}} = 0 \Rightarrow V_B = \left[\frac{1}{R_1} + \frac{1}{R_F}\right] R_{F1} V_S$$

NODE EQ. AT C (ASSUMING NO CURRENT FLOWS INTO (-) TERMINAL):

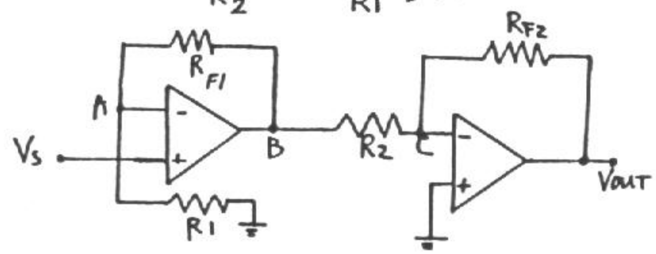
$$\frac{V_C - V_B}{R_2} + \frac{V_C - V_{OUT}}{R_{F2}} = 0$$

BY THE IDEAL OP-AMP ASSUMPTIONS, $V_C = V_{(-)} = V_{(+)} = 0$

THUS $V_B = -\dfrac{R_2}{R_1} V_{OUT}$

THEN, EQUATING THE TWO EXPRESSIONS FOR V_B AND SOLVING FOR V_{OUT},

$$V_{OUT} = -\frac{R_{F2}}{R_2}\left[1 + \frac{R_{F1}}{R_1}\right] V_S$$



∎

(4.39) SUMMING CURRENTS ENTERING THE (−) NODE,

$$I_0 e^{qV_{OUT}/kT} + V_{IN}/R_1 = 0$$

(WHERE WE HAVE USED THE FACT THAT $V_{(-)} = 0$, DUE TO IDEAL OP-AMP ASSUMPTIONS.) HENCE

$$V_{OUT} = \frac{kT}{q} \ln\left(-\frac{V_{IN}}{I_0 R_1}\right)$$

THIS USEFUL CIRCUIT IS CALLED A "LOGARITHMIC AMPLIFIER."

(9.3) (a)

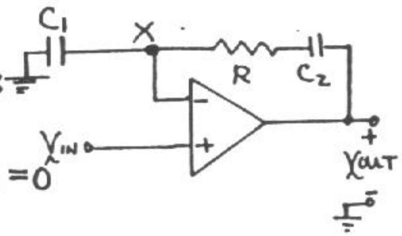
$$\underset{\sim}{A}' = -\frac{10^5(1000)}{(10^5+1)(1000)+1000} = -0.9999800$$

(b)

$$\underset{\sim}{A}' = -\frac{(1.1\cdot 10^5)(1000)}{(1.1\cdot 10^5+1)(1000)+1000} = -0.9999818$$

(c) THE POINT IS THAT THANKS TO THE FEEDBACK, THE AMPLIFICATION OF THE CIRCUIT IS ALMOST COMPLETELY UNAFFECTED $(1.8\times 10^{-4}\ \%)$ BY A 10% VARIATION IN $\underset{\sim}{A}$.

(9.7) NODE EQT. AT X:



$$j C_1 \omega \underset{\sim}{V}_X - (\underset{\sim}{V}_{OUT} - \underset{\sim}{V}_X)\left[1/(R + \tfrac{1}{j\omega C_2})\right] = 0$$

SINCE $\underset{\sim}{V}_{(+)} = \underset{\sim}{V}_{(-)} = \underset{\sim}{V}_{IN} = \underset{\sim}{V}_X$,

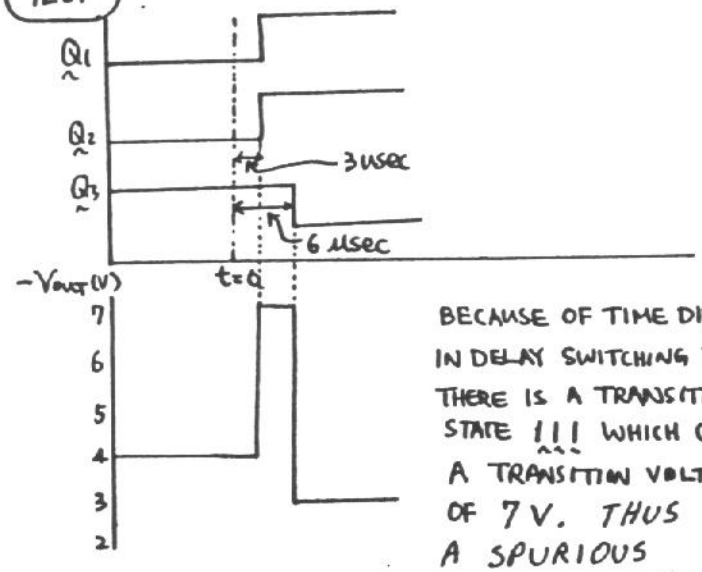
$$\underset{\sim}{V}_{IN}\left[j\omega C_1 + 1/(R + \tfrac{1}{j\omega C_2})\right] = \underset{\sim}{V}_{OUT}/(R + \tfrac{1}{j\omega C_2})$$

$$\Rightarrow \underset{\sim}{V}_{OUT} = \underset{\sim}{V}_{IN}\left[1 + j\omega C_1 (R + \tfrac{1}{j\omega C_2})\right]$$

$$= V_0\left[1 + j\omega C_1 (R + \tfrac{1}{j\omega C_2})\right]$$

■

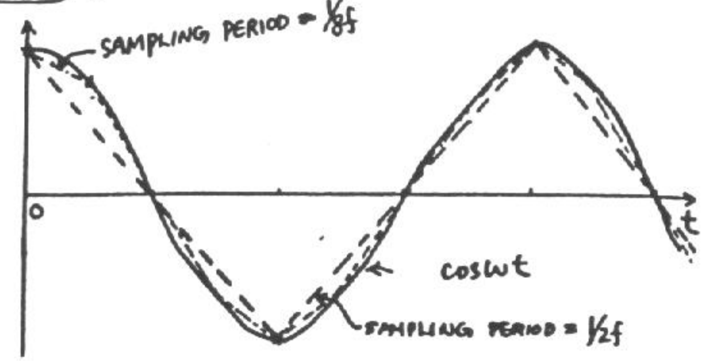
12.27



BECAUSE OF TIME DIFFERENCE IN DELAY SWITCHING TIME, THERE IS A TRANSITION STATE !!! WHICH CREATES A TRANSITION VOLTAGE OF 7 V. THUS A SPURIOUS 7-V PULSE APPEARS IN THE OUTPUT.

THIS SPURIOUS OUTPUT IS KNOWN AS A "GLITCH". ■

12.30 (a) ASSUME THE THE COSINE FUNCTION IS $\cos\omega t$



(b) THE GREATEST ERROR OCCURS AT THE PLACE THE CURVATURE (2^{ND} DERIVATIVE) IS LARGEST. FOR THE COSINE THIS IS NEAR $\theta = 0$. LET THE SAMPLING INTERVAL BE $\frac{2\pi}{NF}$. THE MAX ERROR IS THEN AT THE TIME $\frac{\pi}{NF}$:

$$\text{ERROR} = \cos\frac{\pi}{N} - \left[\frac{1+\cos\frac{2\pi}{N}}{2}\right]$$

USING $\cos\epsilon \cong 1 - \frac{1}{2}\epsilon^2$ (VALID FOR $\epsilon \ll 1$) THIS BECOMES

$$\text{ERROR} \cong \frac{\pi^2}{2N^2} = 3.9 \cdot 10^{-3}$$

FROM WHICH

$$N \cong 36$$

■