Electronics III final exam

date: 2008/01/15

1. (a) For the circuit in Fig. 1, find the close loop gain $L(j\omega)$, the frequency for zero phase, and the condition for oscillation. (15%)
   (b) Given that $R_1 = R_2 = R_3 = 10\ \text{k}\Omega$ and $C_1 = C_2 = C_3 = 10$ nF in Fig. 1, find the oscillation frequency. (5%)
   (c) What is the phase and frequency relation between the waveforms at V_A and V_B? (5%)

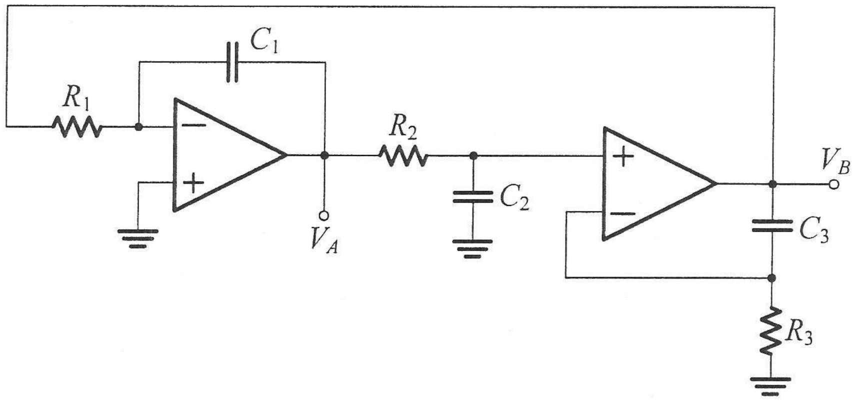


Fig. 1

2. For the circuit shown in Fig. 2, A_1 and A_2 are ideal op amps with an output voltage ranging from 0 to V_{DD}. The op-amp output will be at either 0 or V_{DD} if saturated. The input signal, V_{in}, is a DC voltage.
   (1) If $R_1 = 2R_2$, $R_3 = R_4$, plot the waveforms for signal V_a and V_b (please denote key parameters). (12%)
   (2) If $R_1 = 2R_2$, $R_3 = R_4$, what are the period and duty cycle for signal V_a? (8%)
   (3) If you use this circuit to generate a 20% duty-cycle square wave, how would you choose the resistors (i.e. ratios between R_1, R_2, and R_3, R_4)? (5%)

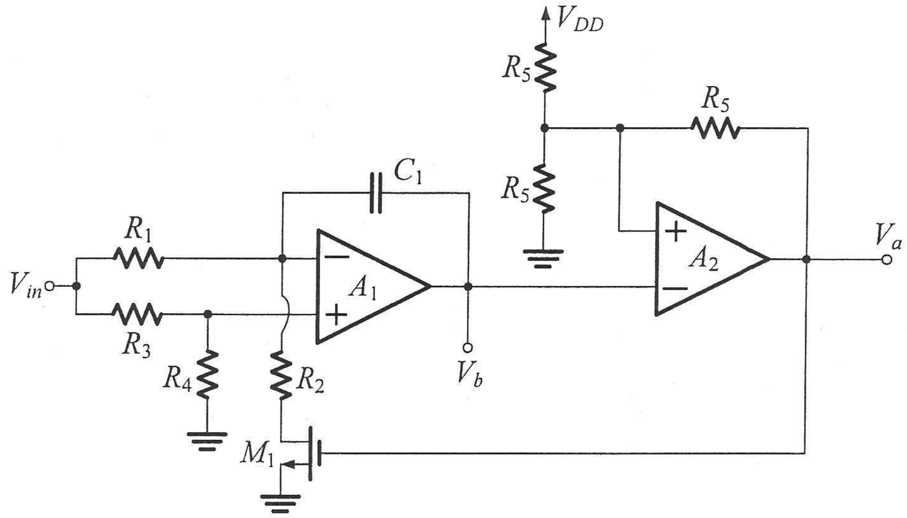


Fig. 2

3. (25%) Derive the relationship between v_O and v_I for the circuit shown in Fig. 3 which functions as a logarithmic amplifier by applying I_S and n as the diode parameters and V_T as the thermal voltage. Since the output voltage is proportional to the logarithm of the input voltage, the circuit is known as a logarithmic amplifier. Such amplifiers find application in situations where it is desired to compress the signal range.

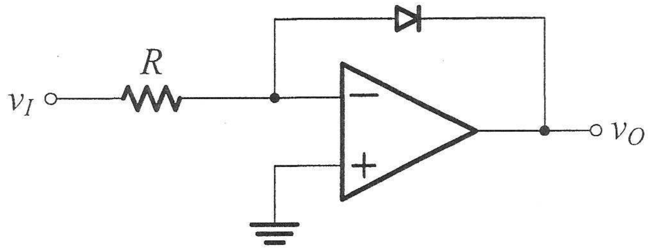


Fig. 3

4. Consider the circuit in Fig. 4(a). Neglect the on resistance of the inverters and other parasitic capacitances. The inverters have switching threshold of $V_{DD}/2$.

(a) Sketch the steady-state waveforms of V_A, V_B, V_C, and V_D and mark important points. (6 %) Does the circuit oscillate? If so, determine the oscillation period. (3 %)

(b) Now two ideal diodes D_1, D_2 are added to node A as shown in Fig. 4(b). Repeat part (a). (4 %) (3 %)

(c) For the circuit in Fig. 4(c), repeat part (a). Diode D_3 is ideal. (4 %) (3 %) What kind of damage would the devices possibly suffer from? (2 %)

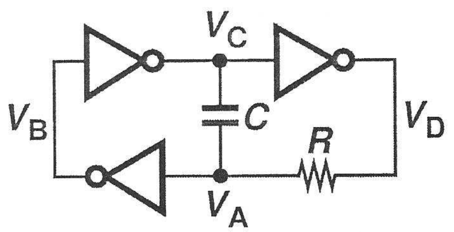


Fig. 4(a)

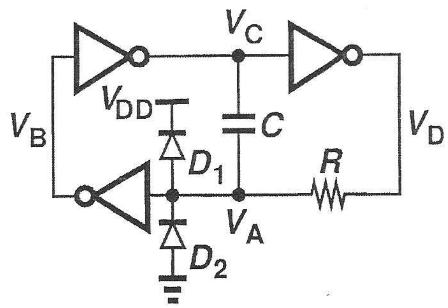


Fig. 4(b)

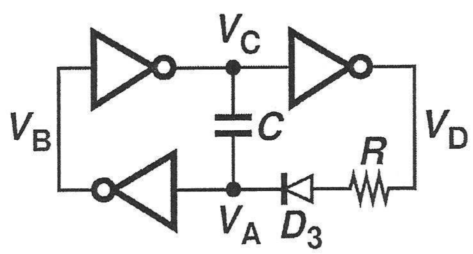


Fig. 4(c)

1.
$$V_{+,com2} = V_B \cdot \frac{R_3}{R_3 + \frac{1}{j\omega C_3}}$$

$$V_A = V_{+,com2} + I_{C2}R_2 = V_B \cdot \frac{R_3}{R_3 + \frac{1}{j\omega C_3}} \cdot [1 + j\omega R_2 C_2]$$

$$V_X = -V_A \cdot j\omega C_1 \cdot R_1 = -V_B \cdot \frac{R_3}{R_3 + \frac{1}{j\omega C_3}} \cdot [1 + j\omega R_2 C_2]\, j\omega R_1 C_1$$
(The outopen node)

$$\frac{V_X}{V_B} = \frac{-j\omega R_3 C_3 [1 + j\omega R_2 C_2]\, j\omega R_1 C_1}{1 + j\omega R_3 C_3} = \frac{j\omega^3 R_1 C_1 R_2 C_2 R_3 C_3 + \omega^2 R_1 C_1 R_3 C_3}{1 + j\omega R_3 C_3}$$

$$= \frac{\omega^2 R_1 C_1 R_3 C_3 + \omega^4 R_1 C_1 R_2 C_2 R_3^2 C_3^2 + j(\omega^3 R_1 C_1 R_2 C_2 R_3 C_3 - \omega^3 R_1 C_1 R_3^2 C_3^2)}{1 + \omega^2 R_3^2 C_3^2}$$

要 oscillates，虛部 = 0. $\Rightarrow R_2 C_2 = R_3 C_3$ $\quad = \frac{\omega^2 R_1 C_1 R_2 C_2 \cancel{(1 + \omega^2 R_2^2 C_2^2)}}{\cancel{1 + \omega^2 R_2^2 C_2^2}}$

gain = 1 $\Rightarrow \omega_0 = \frac{1}{\sqrt{R_1 C_1 R_2 C_2}}$

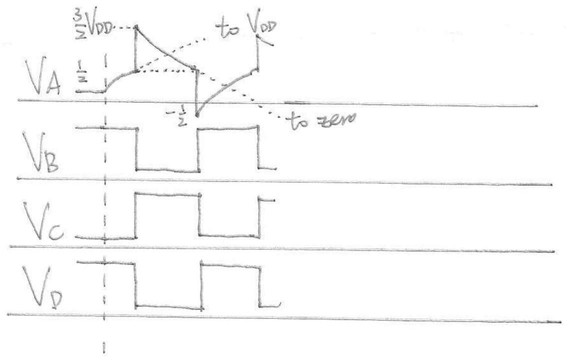
$$\frac{V_A}{V_B} = \left(\frac{V_X}{V_B}\right) \div (-j\omega R_1 C_1) = \frac{\omega^2 R_1 C_1 R_2 C_2}{-j\omega R_1 C_1} = j\omega R_2 C_2$$

for the case, V_A is 90° ahead V_B, $f_A = f_B$ 頻率相同.

4.

VA 通過 R 進行充放電 (與 V_D)

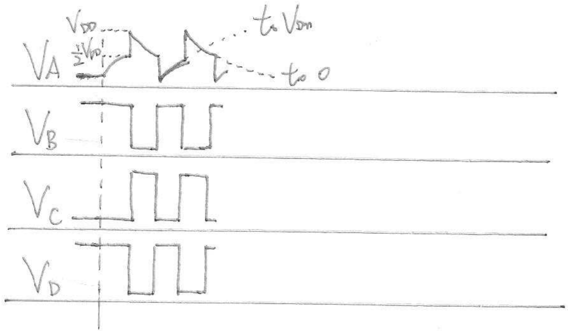
(a).



$V_A(t)$ at falling $= \frac{3}{2} V_{DD} e^{-t/RC}$

$V_A(t)$ at rising $= V_{DD} - \frac{3}{2} V_{DD} e^{-t/RC}$

period $= 2RC\ln 3$.

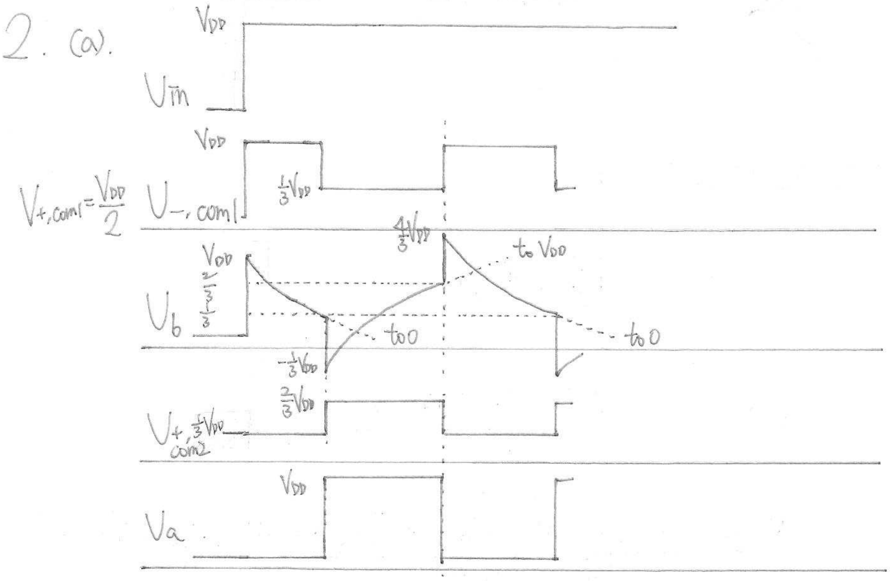


$V_A(t)$ at falling $= V_{DD} e^{-t/RC}$

$V_A(t)$ at rising $= V_{DD} - V_{DD} e^{-t/RC}$.

period $= 2RC\ln 2$

2. (a).

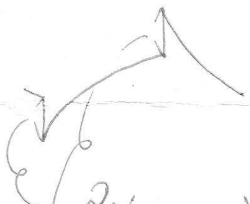


(b). $v_b(t)$ at falling $= \frac{4}{3}V_{DD}e^{-t/R_1C_1}$ terminal : $\frac{1}{3}V_{DD} \Rightarrow T_f = R_1C_1\ln 4$

$v_b(t)$ at rising $= V_{DD} - \frac{4}{3}V_{DD}e^{-t/R_1C_1}$ terminal : $\frac{2}{3}V_{DD} \Rightarrow T_r = R_1C_1\ln 4$

duty cycle $= R_1C_1\ln 4$, period $= 2R_1C_1\ln 4$.

(c). wish a $\frac{1}{5}R_1C_1\ln 4$ duty cycle.



$$\underbrace{\frac{2}{3}}V_{DD} = \Delta V_{-,com1} = V_{DD} - \frac{R_2}{R_1+R_2}V_{DD}$$

The magnitude $= \frac{R_1}{R_1+R_2}$

$v_b(t)$ at rising $= V_{DD} - \left(1+\frac{1}{3}-\frac{R_1}{R_1+R_2}\right)V_{DD}e^{-t/R_1C_1}$

at rising end : $\frac{2}{3}V_{DD} = V_{DD} - \left(1+\frac{1}{3}-\frac{R_1}{R_1+R_2}\right)V_{DD}e^{-t/R_1C_1}$

$$+\frac{1}{3} = \left(\frac{4}{3}-\frac{k}{k+1}\right)e^{-t/R_1C_1}$$

duty cycle $= R_1C_1\ln\left(1+3\frac{1}{k+1}\right)$.

$1-3\frac{1}{k+1} = 4^{\frac{1}{5}} \Rightarrow k = 8.38944$.