Analog Electronic Circuits (EC2.103) : Endsem exam
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Date : 17^{th} June, 2023, Duration : 3 Hours, Max. Marks : 30

Instructions:
- Clearly write your assumptions (if any)
- Refrain from copying
- You can use own handwritten short notes (maximum 3 A-4 sheets both sides) in the exam hall
- Use of mobile phone and computers are not allowed during this exam

1. Consider the scheme shown in Fig. 1, where $m(t)$ and $x(t)$ are two periodic signals with fundamental frequencies $\omega_m = 2\pi f_m$ and $\omega_0 = 2\pi f_0$, respectively. It is given that $f_m = 10\ kHz$, $f_0 = 100\ MHz$, $R = 1\ k\Omega$, $R_1 = 10.61\ k\Omega$ and $C_1 = 1\ nF$.

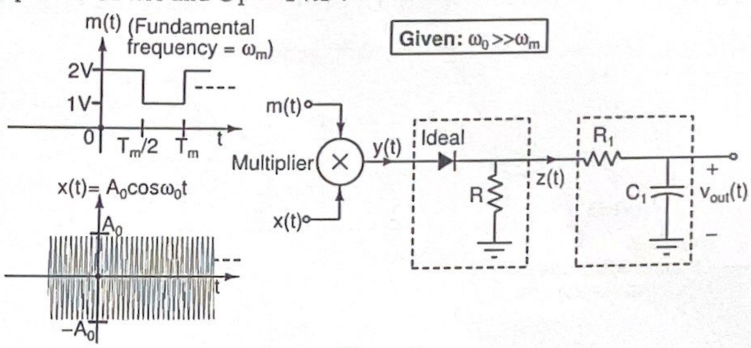

Figure 1

   (a) Briefly explain and plot $y(t)$, $z(t)$ by clearly marking the amplitude and time scales. [2 Mark]
   (b) Briefly explain and plot $v_{out}(t)$ by clearly marking the amplitude and time scales. [2 Mark]
   (c) Plot spectrum of $v_{out}(t)$ with proper frequency (X-axis) labels. [2 Mark]

2. Answer the following:
   (a) Consider the circuits shown in figure 2. It is given that the cut-in voltage of the diode is 0.7 V, thermal voltage $V_T = 25$ mV, $V_{IN} = 10\ V$, $v_{in} = sin(\omega_0 t)\ V$ and $R = 10\ k\Omega$. As shown in the figure, find v_{OUT}. [2 Mark]

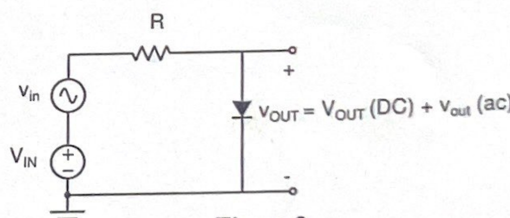

Figure 2

   (b) As shown in Fig. 3(a), the overall transconductance of the combination of N identical devices is g_m. Find the transconductance of the single transistor shown in Fig. 3(b) for same voltages (V_{BE}, V_{CC}). Clearly show all the steps. [2 Mark]

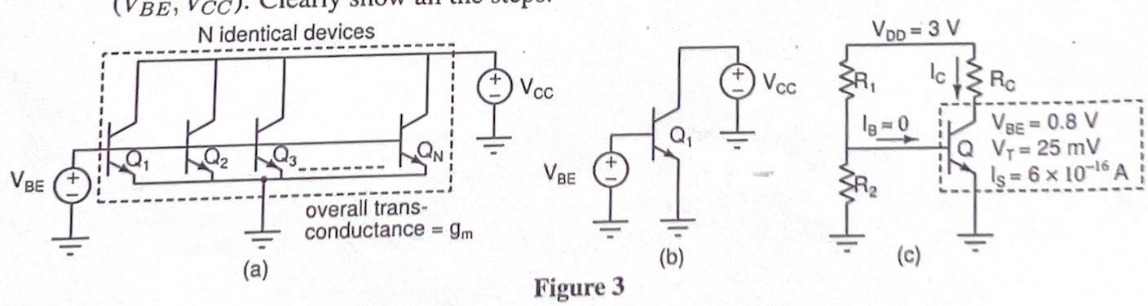

Figure 3

   (c) For the circuit shown in Fig. 3(c), find the % change in I_C if V_{BE} increases by 1%. [2 Mark]

3. (a) Plot I_D Vs V_{IN} for the circuit shown in Figure 4(a) when V_{IN} is swept from 0 *to* $1.2\ V$. Clearly mark the mode(s) of operation of the MOSFET on your graph. [2 Mark]

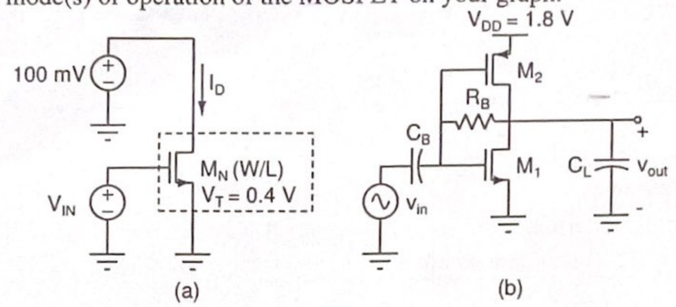

Figure 4

(b) For the circuit shown in Fig. 4(b), derive the small signal voltage gain transfer function $\frac{v_{out}(s)}{v_{in}(s)}$. Find DC gain of the circuit. Give Bode magnitude and phase plots for the transfer function. It is given that $R_B >> g_m$ and C_B is big enough to pass extremely low frequencies. [4 Mark]

4. (a) As shown in Fig. 5(a), derive R_{OUT} of the voltage follower. [3 Mark]

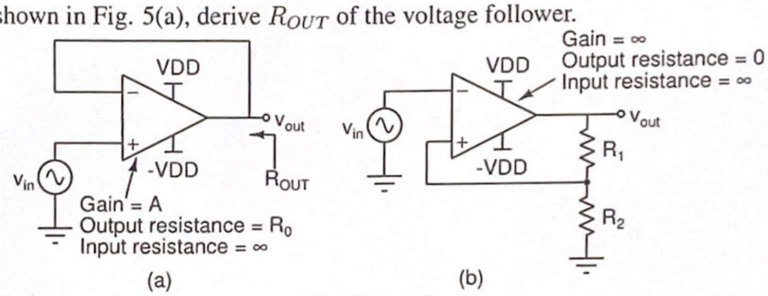

Figure 5

(b) Draw voltage transfer characteristics of the circuit shown in Fig. 5(b) by sweeping v_{in} from -VDD to +VDD. Clearly show the voltage levels (input and output) on the plot. [3 Mark]

5. Consider the circuits shown in Figures 6(a) and 6(b), where V_{os} depicts the offset voltage of the opamp.

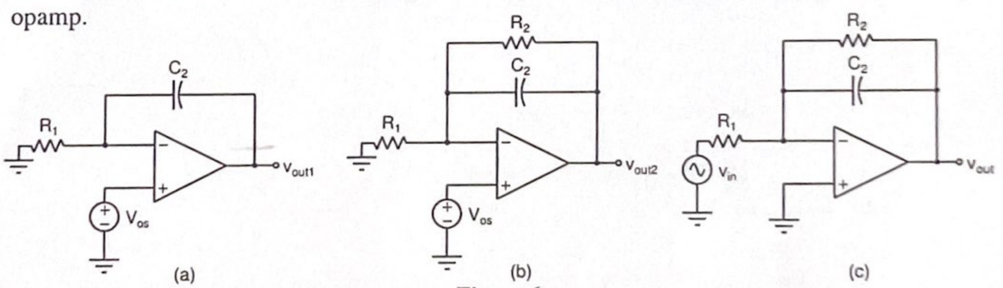

Figure 6

(a) Derive the transfer functions $H_1(s) = \frac{v_{out1}}{V_{os}}(s)$ and $H_2(s) = \frac{v_{out2}}{V_{os}}(s)$. Find pole locations and DC gains from the two transfer functions. [2 Mark]

(b) For a given value of $V_{OS} = 2$ mV, plot v_{out1} and v_{out2} with respect to time by clearly showing the steady state values. [1 Mark]

(c) For circuit shown in Fig. 6(c), derive the transfer functions $H(s) = \frac{v_{out}}{v_{in}}(s)$. Give Bode magnitude plot for $H(s)$. For what frequency, this circuit behaves as a good integrator (transfer function will have pole at origin). It is given that $v_{in}(t) = Asin(2\pi f_0)t$ V, $R_2 = 1\ k\Omega$, $C_2 = 1\ \mu$F. Give approximate plots of $v_{out}(t)$ for (i) $f_0 = 10\ kHz$ and (ii) $f_0 = 50\ Hz$. [3 Mark]

Good luck !!