

Analog Electronic Circuits (EC2.103) : Endsem exam
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 Date : 17th 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 $f_m = 10 \text{ kHz}$, $f_0 = 100 \text{ MHz}$, $R = 1 \text{ k}\Omega$, $R_1 = 10.61 \text{ k}\Omega$ and $C_1 = 1 \text{ nF}$.

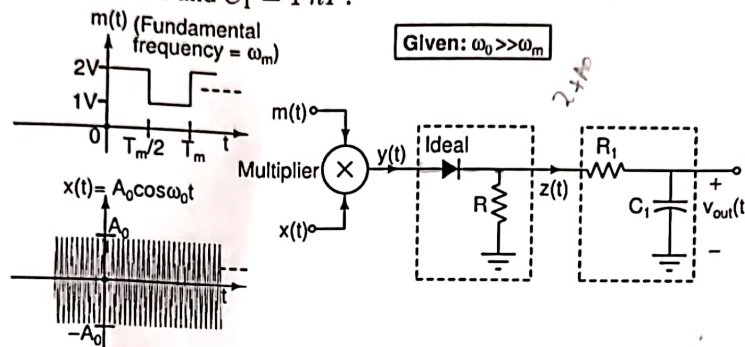


Figure 1

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

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

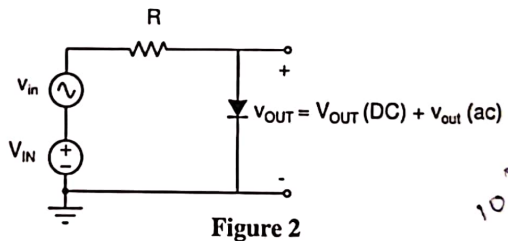


Figure 2

- 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]

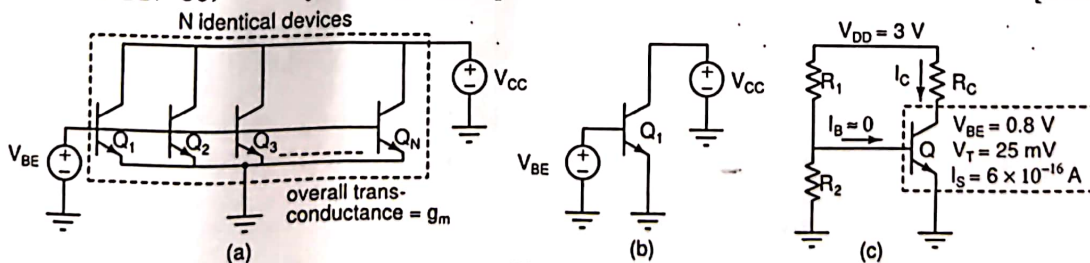


Figure 3

- 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]

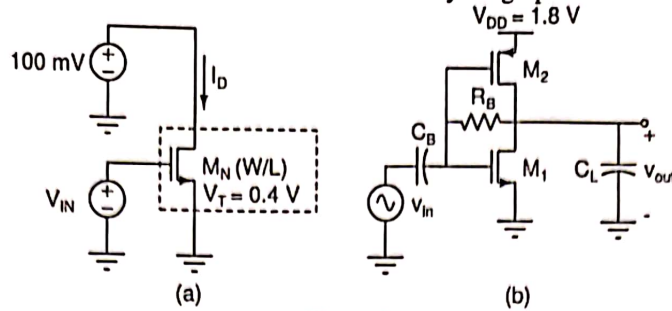


Figure 4

- (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 $R_B \gg g_m$ 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]

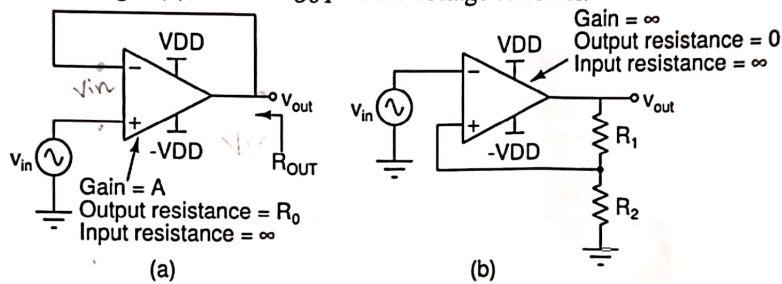


Figure 5

- (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.

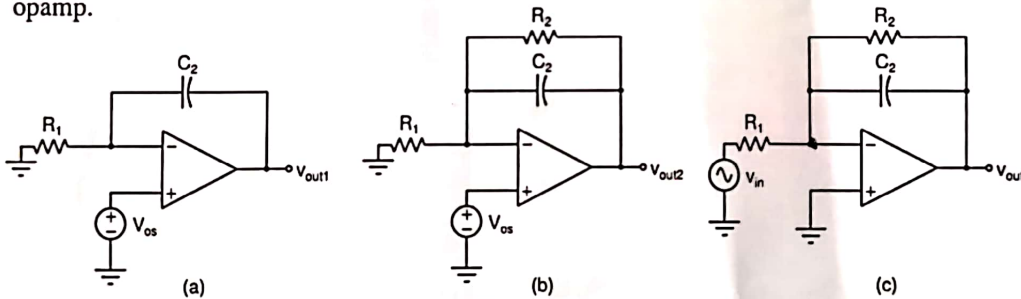


Figure 6

- (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 $v_{in}(t) = A \sin(2\pi f_0)t$ V, $R_2 = 1$ k Ω , $C_2 = 1$ μ F. Give approximate plots of $v_{out}(t)$ for (i) $f_0 = 10$ kHz and (ii) $f_0 = 50$ Hz. [3 Mark]

Good luck !!

$$1 + \frac{R_2}{(1+sR_2C)R_1}$$

$$V_{out} =$$

2

$$V \times =$$

$$R_2 \parallel \frac{1}{sC}$$

$$\frac{R_2}{sC} \parallel (1+sR_2C)$$