

# GATE - 2000

## Electronics And Communication Engineering

Time : Three hours

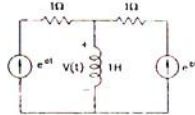
Maximum Marks : 150

### SECTION A (100 Marks)

1. This question consists of 25 (Twenty Five) multiple choice questions, each carrying one mark. For each question (1.1 – 1.25), four alternatives (a, b, c and d) are given, out of which only one is correct. Write the correct answers in the boxes corresponding to the questions only on the FIRST sheet of the answer book. (1 × 25 = 25)

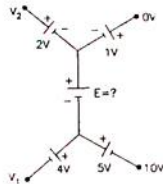
1.1. In the given circuit, the voltage  $v(t)$  is

- (a)  $e^{at} - e^{bt}$
- (b)  $e^{at} + e^{bt}$
- (c)  $ae^{at} - be^{bt}$
- (d)  $ae^{at} + be^{bt}$



1.2. In the given circuit, the value of the voltage source E is

- (a) -16 V
- (b) 4 V
- (c) -6 V
- (d) 16 V



1.3. Given that

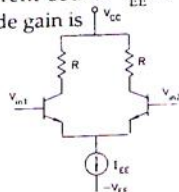
$$\mathcal{L}\{f(t)\} = \frac{s+2}{s^2+1}, \quad \mathcal{L}\{g(t)\} = \frac{s^2+1}{(s+3)(s+2)}$$

$$h(t) = \int_0^t f(\tau)g(t-\tau)d\tau. \quad \mathcal{L}\{h(t)\} \text{ is}$$

- (a)  $\frac{s^2+1}{s+3}$
- (b)  $\frac{1}{s+3}$
- (c)  $\frac{s^2+1}{(s+3)(s+2)} + \frac{s+2}{s^2+1}$
- (d) None of these

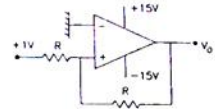
1.4. In the differential amplifier of the figure, if the source resistance of the current source  $I_{EE}$  is infinite, then the common-mode gain is

- (a) zero
- (b) infinite
- (c) indeterminate
- (d)  $\frac{V_{m1} + V_{m2}}{2V_T}$



1.5. In the given circuit,  $V_o$  is

- (a) -1 V
- (b) 2 V
- (c) +1 V
- (d) +15 V



1.6. Introducing a resistor in the emitter of a common amplifier stabilizes the dc operating point against variations in

- (a) only the temperature
- (b) only the  $\beta$  of the transistor
- (c) both temperature and  $\beta$
- (d) none of these

1.7. The current gain of a bipolar transistor drops at high frequencies because of

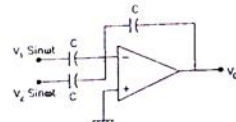
- (a) transistor capacitances
- (b) high current effects in the base
- (c) parasitic inductive elements
- (d) the Early effect

1.8. An amplifier with resistive negative feedback has two left half plane poles in its open-loop transfer function. The amplifier

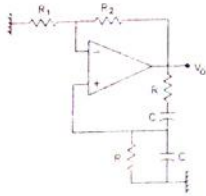
- (a) will always be unstable at high frequencies
- (b) will be stable for all frequencies
- (c) may be unstable, depending on the feedback factor
- (d) will oscillate at low frequencies

1.9. If the op-amp in figure is ideal, then  $v_o$  is

- (a) zero
- (b)  $(V_1 - V_2) \sin \omega t$
- (c)  $-(V_1 + V_2) \sin \omega t$
- (d)  $(V_1 + V_2) \sin \omega t$



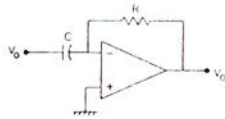
1.10. The configuration of given figure is a



- (a) precision integrator
- (b) Hartley oscillator
- (c) Butterworth high pass filter
- (d) Wien-bridge oscillator

1.11. Assume that the op-amp of the figure is ideal. If  $v_i$  is a triangular wave, then  $v_o$  will be

- (a) square wave
- (b) triangular wave
- (c) parabolic wave
- (d) sine wave



1.12. The Fourier Transform of the signal  $x(t) = e^{-3t^2}$  is of the following form, where A and B are constants

- (a)  $Ae^{-B|f|}$
- (b)  $Ae^{-Bf}$
- (c)  $A + B|f|^2$
- (d)  $Ae^{-Bf^2}$

1.13. A system with an input  $x(t)$  and output  $y(t)$  is described by the relation  $y(t) = tx(t)$ . This system is

- (a) linear and time-invariant
- (b) linear and time varying
- (c) non-linear and time-invariant
- (d) non-linear and time-varying

1.14. The amplitude modulated wave form  $s(t) = A_c[1 + K_a m(t)] \cos \omega_c t$  is fed to an ideal envelope detector. The maximum magnitude of  $K_a m(t)$  is greater than 1. Which of the following could be the detector output?

- (a)  $A_c m(t)$
- (b)  $A_c^2 [1 + K_a m(t)]^2$
- (c)  $|A_c [1 + K_a m(t)]|$
- (d)  $A_c [1 + K_a m(t)]^2$

1.15. An 8 bit successive approximation analog to digital converter has full scale reading of 2.55V and its conversion time for an analog input of 1V is 20  $\mu$ s. The conversion time for a 2V input will be

- (a) 10  $\mu$ s
- (b) 20  $\mu$ s
- (c) 40  $\mu$ s
- (d) 50  $\mu$ s

1.16. The number of hardware interrupts (which require an external signal to interrupt) present in an 8085 microprocessor are

- (a) 1
- (b) 4
- (c) 5
- (d) 13

1.17. The most commonly used amplifier in sample and hold circuits is

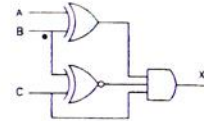
- (a) a unity gain inverting amplifier
- (b) a unity gain non-inverting amplifier
- (c) an inverting amplifier with a gain of 10
- (d) an inverting amplifier with a gain of 100

1.18. The number of comparators in a 4 bit flash ADC is

- (a) 4
- (b) 5
- (c) 15
- (d) 16

1.19. For the logic circuit shown in the figure is the required input condition (A, B, C) to make the output (X) = 1 is

- (a) 1, 0, 1
- (b) 0, 0, 1
- (c) 1, 1, 1
- (d) 0, 1, 1



1.20. In the 8085 microprocessor, the RST6 instruction transfers the program execution to the following location:

- (a) 30 H
- (b) 24 H
- (c) 48 H
- (d) 60 H

1.21. The magnitudes of the open-circuit and short-circuit input impedances of a transmission line are 100  $\Omega$  and 25  $\Omega$  respectively. The characteristic impedance of the line is,

- (a) 25  $\Omega$
- (b) 50  $\Omega$
- (c) 75  $\Omega$
- (d) 100  $\Omega$

1.22. A TEM wave is incident normally upon a perfect conductor. The E and H fields at the boundary will be, respectively,

- (a) minimum and minimum
- (b) maximum and maximum
- (c) minimum and maximum
- (d) maximum and minimum

1.23. The frequency range for satellite communication is

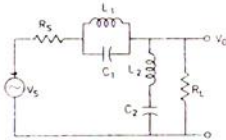
- (a) 1 kHz to 100 kHz
- (b) 100 kHz to 10 MHz
- (c) 10 MHz to 30 MHz
- (d) 1 GHz to 30 GHz

1.24. If the diameter of a  $\frac{\lambda}{2}$  dipole antenna is increased

from  $\frac{\lambda}{100}$  to  $\frac{\lambda}{50}$ , then its

- (a) bandwidth increases
- (b) bandwidth decreases
- (c) gain increases
- (d) gain decreases

1.25. The circuit of the figure represents a



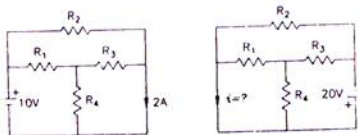
- (a) low pass filter
- (b) high pass filter
- (c) band pass filter
- (d) band reject filter

2. This question consists of 25 (Twenty Five) multiple choice questions, each carrying two marks. For each question (2.1 - 2.25), four alternatives (a, b, c and d) are given, out of which only one is correct. Write the correct answers in the boxes corresponding to the questions only on the SECOND sheet of the answer book. ( $25 \times 2 = 50$ )

2.1. The eigen values of the matrix  $\begin{bmatrix} 2 & -1 & 0 & 0 \\ 0 & 3 & 0 & 0 \\ 0 & 0 & -2 & 0 \\ 0 & 0 & -1 & 4 \end{bmatrix}$  are

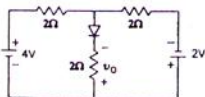
- (a) 2, -2, 1, -1
- (b) 2, 3, -2, 4
- (c) 2, 3, 1, 4
- (d) None of these

2.2. Use the data of the figure. The current  $i$  in the circuit of the figure is



- (a) -2 A
- (b) 2 A
- (c) -4 A
- (d) +4 A

2.3. For the circuit in the figure, the voltage  $v_o$  is



- (a) 2 V
- (b) 1 V
- (c) -1 V
- (d) None of these

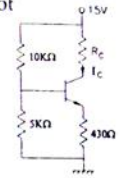
2.4. A linear time invariant system has an impulse response  $e^{2t}$ ,  $t > 0$ . If the initial conditions are zero and the input is  $e^{3t}$ , then output for  $t > 0$  is

- (a)  $e^{3t} - e^{2t}$
- (b)  $e^{5t}$
- (c)  $e^{3t} + e^{2t}$
- (d) None of these

2.5. In the circuit of the figure, assume that the transistor is in active region. It has a large  $\beta$  and its base-emitter voltage is 0.7 V. The value of  $I_c$  is

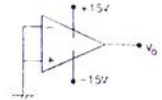
(a) Indeterminate since  $R_b$  is not given

- (b) 1 mA
- (c) 5 mA
- (d) 10 mA

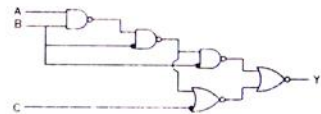


2.6. If the op-amp in given figure, has an input offset voltage of 5 mV and an open-loop voltage gain of  $10^5$ , then  $v_o$  will be

- (a) 0 V
- (b) 5 mV
- (c) +15 V or -15 V
- (d) +50 V or -50 V

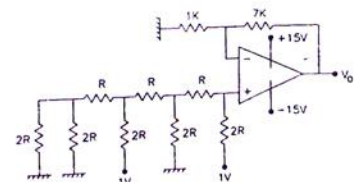


2.7. For the logic circuit shown in, the simplified Boolean expression for the output Y is



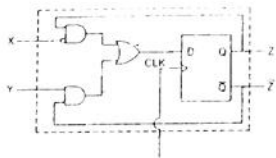
- (a)  $A + B + C$
- (b) A
- (c) B
- (d) C

2.8. For the 4 bit DAC shown, the output voltage  $v_o$  is



- (a) 10 V
- (b) 5 V
- (c) 4 V
- (d) 8 V

- 2.9. A sequential circuit using D Flip-Flop and logic gates is shown in figure, where X and Y are the inputs and Z is the output. The circuit is

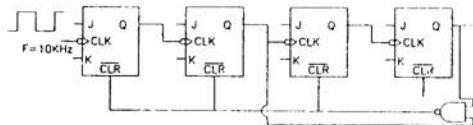


- (a) S - R Flip-Flop with inputs X = R and Y = S  
 (b) S - R Flip-Flop with inputs X = S and Y = R  
 (c) J - K Flip-Flop with inputs X = J and Y = K  
 (d) J - K Flip-Flop with inputs X = K and Y = J

- 2.10. The contents of Register (B) and Accumulator (A) of 8085 microprocessor are 49H and 3AH respectively. The contents of A and the status of carry flag (CY) and sign flag (S) after executing SUB B instructions are

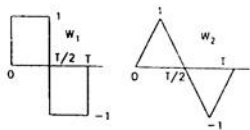
- (a) A = F1, CY = 1, S = 1  
 (b) A = 0F, CY = 1, S = 1  
 (c) A = F0, CY = 0, S = 0  
 (d) A = 1F, CY = 1, S = 1

- 2.11. In given figure, the J and K inputs of all the four Flip-Flops are made high. The frequency of the signal at output Y is



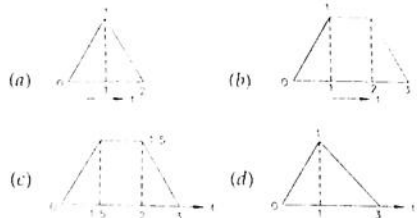
- (a) 0.833 kHz      (b) 1.0 kHz  
 (c) 0.91 kHz      (d) 0.77 kHz

- 2.12. One period (0, T) each of two periodic waveforms  $W_1$  and  $W_2$  are shown in figure. The magnitudes of the  $n$ th Fourier series coefficients of  $W_1$  and  $W_2$  for  $n \geq 1$ ,  $n$  odd, are respectively proportional to



- (a)  $n^{-3}$  and  $n^{-2}$       (b)  $n^{-2}$  and  $n^{-3}$   
 (c)  $n^{-1}$  and  $n^{-2}$       (d)  $n^{-4}$  and  $n^{-2}$

- 2.13. Let  $u(t)$  be the step function. Which of the waveforms in given figure, (a)-(d) corresponds to the convolution of  $u(t) - u(t-1)$  with  $u(t) - u(t-2)$ ?



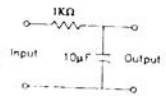
- 2.14. In given figure, the steady state output voltage corresponding to the input voltage  $3 + 4 \sin 100t$  V is

(a)  $3 + \frac{4}{\sqrt{2}} \sin(100t - \frac{\pi}{4})$  V

(b)  $3 + 4\sqrt{2} \sin(100t - \frac{\pi}{4})$  V

(c)  $\frac{3}{2} + \frac{4}{\sqrt{2}} \sin(100t + \frac{\pi}{4})$  V

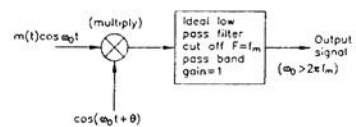
(d)  $3 + 4 \sin(100t + \frac{\pi}{4})$  V



- 2.15. In a digital communication system employing Frequency Shift Keying (FSK), the 0 and 1 bit are represented by sine waves of 10 kHz and 25 kHz respectively. These waveforms will be orthogonal for a bit interval of

- (a) 45 μsec      (b) 200 μsec  
 (c) 50 μsec      (d) 250 μsec

- 2.16. A message  $m(t)$  bandlimited to the frequency  $f_m$  has a power of  $P_m$ . The power of the output signal in given figure is



- (a)  $\frac{P_m \cos \theta}{2}$       (b)  $\frac{P_m}{4}$   
 (c)  $\frac{P_m \sin^2 \theta}{4}$       (d)  $\frac{P_m \cos^2 \theta}{4}$

- 2.17. The Hilbert transform of  $\cos \omega_1 t + \sin \omega_2 t$  is

- (a)  $\sin \omega_1 t - \cos \omega_2 t$       (b)  $\sin \omega_1 t + \cos \omega_2 t$   
 (c)  $\cos \omega_1 t - \sin \omega_2 t$       (d)  $\sin \omega_1 t + \sin \omega_2 t$



- 2.18. A system has a phase response given by  $\phi(\omega)$ , where  $\omega$  is the angular frequency. The phase delay and group delay at  $\omega = \omega_0$  are respectively given by

(a)  $-\frac{\phi(\omega_0)}{\omega_0}, -\frac{d\phi(\omega)}{d\omega}\bigg|_{\omega=\omega_0}$

(b)  $\phi(\omega_0), -\frac{d^2\phi(\omega_0)}{d\omega^2}\bigg|_{\omega=\omega_0}$

(c)  $\frac{\omega_0}{\phi(\omega_0)}, -\frac{d\phi(\omega)}{d(\omega)}\bigg|_{\omega=\omega_0}$

(d)  $\omega_0\phi(\omega_0), \int_{-\infty}^{\omega_0} \phi(\lambda)d\lambda$

- 2.19. A system described by the transfer function

$$H(s) = \frac{1}{s^3 + \alpha s^2 + ks + 3}$$

is stable. The constraints on  $\alpha$  and  $k$  are

- (a)  $\alpha > 0, \alpha k < 3$       (b)  $\alpha > 0, \alpha k > 3$   
 (c)  $\alpha < 0, \alpha k > 0$       (d)  $\alpha > 0, \alpha k < 0$

- 2.20. In an FM system, a carrier of 100 MHz is modulated by a sinusoidal signal of 5 kHz. The bandwidth by Carson's approximation is 1 MHz. If  $y(t) = (\text{modulated waveform})^3$ , then by using Carson's approximation, the bandwidth of  $y(t)$  around 300 MHz and the spacing of spectral components are, respectively.

- (a) 3 MHz, 5kHz      (b) 1 MHz, 15kHz  
 (c) 3 MHz, 15 kHz      (d) 1 MHz, 5 kHz

- 2.21. A uniform plane wave in air impinges at  $45^\circ$  angle on a lossless dielectric material with dielectric constant  $\epsilon_r$ . The transmitted wave propagates in a  $30^\circ$  direction with respect to the normal. The value of  $\epsilon_r$  is

- (a) 1.5      (b)  $\sqrt{1.5}$   
 (c) 2      (d)  $\sqrt{2}$

- 2.22. For an 8 feet (2.4 m) parabolic dish antenna operating at 4 GHz, the minimum distance required for far field measurement is closest to

- (a) 7.5 cm      (b) 15 cm  
 (c) 15 m      (d) 150 m

- 2.23. A rectangular waveguide has dimensions  $1 \text{ cm} \times 0.5 \text{ cm}$ . Its cut-off frequency is

- (a) 2 dB      (b) 5 dB  
 (c) 8 dB      (d) 12 dB

- 2.24. A rectangular waveguide has dimensions  $1 \text{ cm} \times 0.5 \text{ cm}$ . Its cut-off frequency is

- (a) 5 GHz      (b) 10 GHz  
 (c) 15 GHz      (d) 20 GHz

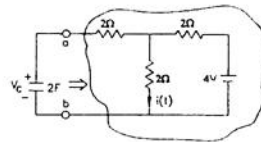
- 2.25. Two coaxial cables 1 and 2 are filled with different dielectric constants  $\epsilon_{r1}$  and  $\epsilon_{r2}$  respectively. The ratio of the wavelengths in the two cables,  $(\lambda_1/\lambda_2)$  is

- (a)  $\sqrt{\epsilon_{r1}/\epsilon_{r2}}$       (b)  $\sqrt{\epsilon_{r2}/\epsilon_{r1}}$   
 (c)  $\epsilon_{r1}/\epsilon_{r2}$       (d)  $\epsilon_{r2}/\epsilon_{r1}$

### SECTION B (75 Marks)

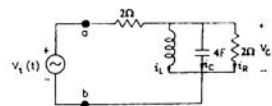
The section consists of TWENTY questions of FIVE marks each. ANY FIFTEEN out of them have to be answered. If more number of questions are attempted, score off the answers not to be evaluated, else only the first fifteen unscored answers will be considered. (5 × 15 = 75)

3. For the circuit in given figure,



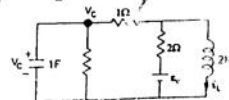
- (a) Find the Thevenin equivalent of the sub circuit faced by the capacitor across the terminals  $a, b$ .  
 (b) Find  $v_c(t), t > 0$ , given  $v_c(0) = 0$ .  
 (c) Find  $i(t), t > 0$ .

4. For the given circuit, which is in steady state

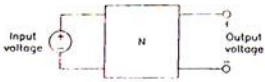


- (a) Find the frequency  $\omega_0$  at which the magnitude of the impedance across terminals  $a, b$  reaches a maximum.  
 (b) Find the impedance across  $a, b$  at the frequency  $\omega_0$ .  
 (c) If  $v_s(t) = V \sin(\omega_0 t)$ , find  $i_L(t), i_R(t)$ .

5. For the given circuit, write the state equations using  $v_c$  and  $i_L$  as state variables.

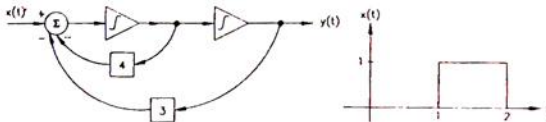


6. The network N in given figure consists only of two elements: a resistor of  $1 \Omega$  and an inductor of L Henry. A 5 V source is connected at the input at  $t = 0$  seconds. The inductor current is zero at  $t = 0$ . The output voltage is found to be  $5e^{-3t}$  V, for  $t > 0$ .



- Find the voltage transfer function of the network.
- Find L, and draw the configuration of the network.
- Find the impulse response of the network.

7. For the linear, time-invariant system whose block diagram is shown in figure with input  $x(t)$  and output  $y(t)$ ,



- Find the transfer function.
- For the step response of the system [i.e. find  $y(t)$  when  $x(t)$  is a unit step function and the initial conditions are zero.]
- Find  $y(t)$ , if  $x(t)$  is as shown in figure and the initial conditions are zero.

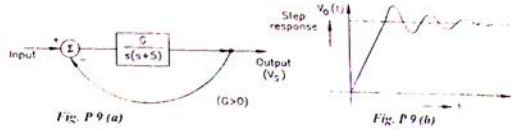
8. A certain linear, time-invariant system has the state and output representation shown below:

$$\begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \end{pmatrix} = \begin{pmatrix} -2 & 1 \\ 0 & -3 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} + \begin{pmatrix} 1 \\ 0 \end{pmatrix} u$$

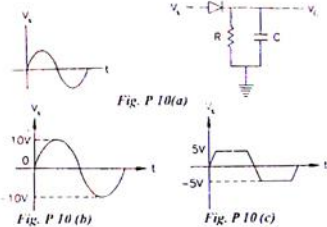
$$y = (1 \ 1) \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$$

- Find the eigenvalues (natural frequencies) of the system.
- If  $u(t) = \delta(t)$  and  $x_1(0_+) = x_2(0_+) = 0$ , find  $x_1(t)$ ,  $x_2(t)$  and  $y(t)$ , for  $t > 0$ .
- When the input is zero, choose initial conditions  $x_1(0_+)$  and  $x_2(0_+)$  such that  $y(t) = Ae^{-2t}$  for  $t > 0$ .

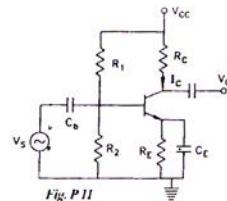
9. The block diagram of a feedback system is shown in the figure.



- Find the closed loop transfer function.
  - Find the minimum value of G for which the step response of the system would exhibit an overshoot, as shown in figure.
  - For G equal to twice this minimum value, find the time period T indicated in the figure.
10. (a) For given figure, Plot  $v_o$  under steady state conditions, with and without C. Assume that the diode is ideal.
- (b) Design a circuit using two ideal diodes, one resistor and two voltage sources that would convert the input voltage of figure is to the output voltage of fourth figure. The resistor value need not be specified.

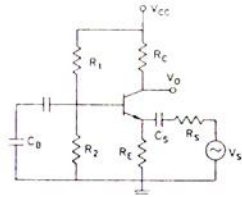


11. For the amplifier of given figure,  $I_C = 1.3 \text{ mA}$ ,  $R_C = 2 \text{ k}\Omega$ ,  $R_E = 500 \Omega$ ,  $V_T = T/q = 26 \text{ mV}$ ,  $\beta = 100$ ,  $V_{CC} = 15 \text{ V}$ ,  $v_s = 0.01 \sin(\omega t)$  V and  $C_b = C_c = 10 \mu\text{F}$ .



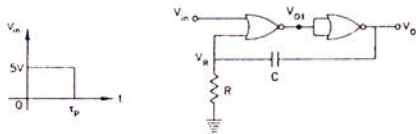
- (a) What is the small-signal voltage gain,  $A_v = v_o/v_i$ ?
- (b) What is the approximate  $A_v$  if  $C_c$  is removed?
- (c) What will  $v_o$  be if  $C_b$  is short circuited?

12. For a feedback amplifier, the open loop transfer function has three poles at  $100 \text{ k rad/s}$ ,  $1 \text{ M rad/s}$  and  $10 \text{ M rad/s}$ . The low frequency open loop gain is  $1000$  and the feedback factor ( $\beta$ ) is  $1$ . Use Bode plots to determine the phase margin of the amplifier. Is the amplifier stable?
13. The figure shows a common base amplifier.



- (a) Write expressions for the time-constants associated with the capacitors,  $C_b$  and  $C_s$ .
- (b) What is the approximate lower cut-off frequency of the amplifier?

14. For the CMOS monostable multivibrator of given figure,  $R = 50 \text{ k}\Omega$ ,  $C = 0.01 \mu\text{F}$ ,  $V_{DD} = 5\text{V}$ , and the CMOS NOR gates have a threshold voltage ( $V_T$ ) of  $1.5 \text{ V}$ .  $v_{in}$  is a trigger pulse ( $\tau_p \ll RC$ ) as shown in the figure.



- (a) Plot  $v_{A1}$  and  $v_R$  as functions of time.
- (b) Write the equation for  $v_R(t)$ , for  $t > 0$ .
- (c) Find the time period of the output pulse.

15. The operating conditions (ON = 1, OFF = 0) of three pumps ( $x, y, z$ ) are to be monitored.  $x = 1$  implies that pump X is on. It is required that the indicator (LED) on the panel should glow when a majority of the pumps fail.

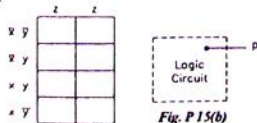


Fig. P 15(a)

Fig. P 15(b)

- (a) Enter the logical values in the K-map in the format shown in figure. Derive the minimal Boolean sum-of-products expression whose output is zero when a majority of the pumps fail.
- (b) The above expression is implemented using logic gates, and point P is the output of this circuit, as shown in given figure, P is at  $0 \text{ V}$  when a majority of the pumps fails and is at  $5 \text{ V}$  otherwise. Design a circuit to drive the LED using this output. The current through the LED should be  $10 \text{ mA}$  and the voltage drop across it is  $1\text{V}$ . Assume that P can source or sink  $10 \text{ mA}$  and a  $5 \text{ V}$  supply is available.

16. A one-bit full adder is to be implemented using 8-to-1 multiplexers (MUX).

- (a) Write the truth table for sum (S) and carry to the next stage ( $C_N$ ) in terms of the two bits (A, B) and carry from the previous stage ( $C_p$ ). The truth table should be in the ascending order of (A, B,  $C_p$ ), i.e. (000, 001, 010, ... etc.).
- (b) Implement S and  $C_N$  using 8-to-1 multiplexers.

17. (a) The program and machine code for an 8085 microprocessor are given by

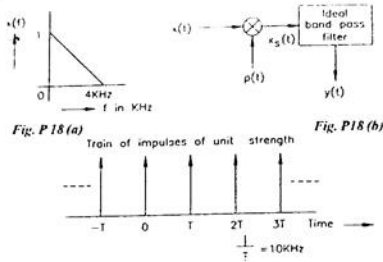
3E	MVI	A	C3
C3			
00	NOP		
80	ADD	B	
3D	DEC	A	
C2	JNZ	800A	
0A			
80			
C3	JMP	800C	
0C			
80			
D3	OUT	10	
10			
76	HLT		

The starting address of the above program is  $7\text{FFF H}$ . What would happen if it is executed from  $8000 \text{ H}$ ?

- (b) For the instructions given below, how many memory operations (read/write) are performed during the execution in an  $8085 \mu\text{P}$ ?
- (i) Call  $2000 \text{ H}$
- (ii) LDA  $2000 \text{ H}$
- (c) Write an instruction which takes the minimum possible time to clear the accumulator of the  $8085$ .

18. A bandlimited signal  $x(t)$  with a spectrum  $X(f)$  as

shown in first figure is processed as shown in second figure is  $p(t)$  is a periodic train of impulses as in third figure. The ideal bandpass filter has a passband from 26 kHz to 34 kHz.



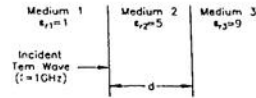
- (a) Calculate the Fourier series coefficients  $C_n$  in the Fourier expansion of  $p(t)$  in the form

$$p(t) = \sum_{n=-\infty}^{+\infty} C_n \exp(jn2\pi t/T)$$

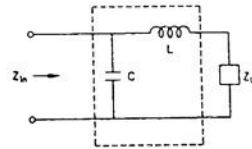
- (b) Find the Fourier Transform of  $p(t)$ .  
 (c) Obtain and sketch the spectrum of  $x_s(t)$ .  
 (d) Obtain and sketch the spectrum of  $y(t)$ .
19. Zero mean white Gaussian noise with a two-sided power spectral density of 4 W/kHz is passed through an ideal lowpass filter with a cut-off frequency of 2 kHz and a passband gain of 1, to produce the noise output  $n(t)$ .

- (a) Obtain the total power in  $n(t)$ .  
 (b) Find the autocorrelation function  $E[n(t)n(t+\tau)]$  of the noise  $n(t)$  as a function of  $\tau$ .  
 (c) Two noise samples are taken at times  $t_1$  and  $t_2$ . Find the spacing  $|t_1 - t_2|$  so that the product  $n(t_1)n(t_2)$  has the most negative expected value and obtain this most negative expected value.

20. Given  $E = 10e^{-j(4x - kt)} \hat{y}$  V/m in free space.  
 (a) Write all the four Maxwell's equations in free space.  
 (b) Find  $\nabla \times E$ .  
 (c) Find H.
21. The three regions shown in figure are all lossless and non-magnetic. Find.



- (a) Wave impedance in mediums 2 and 3.  
 (b)  $d$  such that medium 2 acts as a quarter wave ( $\lambda/4$ ) transformer.  
 (c) Reflection coefficient ( $\Gamma$ ) and voltage standing wave ratio (VSWR) at the interface of the mediums 1 and 2, when  $d = \lambda/4$ .
22. Design a lossless impedance matching network shown in figure to transform  $Z_L = 10 + j10 \Omega$  to  $Z_{in} = 50 \Omega$ . Find the values of  $L$ ,  $C$  and quality factor (Q) of the circuit at  $f = 1$  GHz.



## ANSWERS

1. 1 (d)    1. 2 (a)    1. 3 (b)    1. 4 (b)    1. 5 (c)    1. 6 (c)    1. 7 (a)    1. 8 (b)    1. 9 (c)    1. 10 (d)
1. 11 (a)    1. 12 (d)    1. 13 (d)    1. 14 (c)    1. 15 (b)    1. 16 (a)    1. 17 (b)    1. 18 (c)    1. 19 (d)    1. 20 (a)
1. 21 (b)    1. 22 (a)    1. 23 (d)    1. 24 (b)    1. 25 (c)    2. 1 (b)    2. 2 (c)    2. 3 (d)    2. 4 (a)    2. 5 (d)
2. 6 (d)    2. 7 (c)    2. 8 (b)    2. 9 (d)    2. 10 (a)    2. 11 (a)    2. 12 (c)    2. 13 (b)    2. 14 (a)    2. 15 (b)
2. 16 (d)    2. 17 (a)    2. 18 (a)    2. 19 (b)    2. 20 (d)    2. 21 (c)    2. 22 (a)    2. 23 (c)    2. 24 (c)    2. 25 (b)