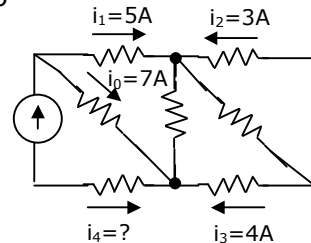


SECTION - A

1. For each of the following questions (1.1 – 1.11), four alternatives (A, B, C and D) are given. Indicate the correct answer by writing the letter (A, B, C or D) against the corresponding question number. All parts of this question must be attempted strictly in order.

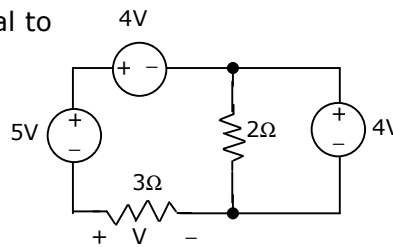
- 1.1 The current i_4 in the circuit of Fig.1.1 is equal to

- (a) 12 A
(b) -12 A
(c) 4A
(d) None of the above



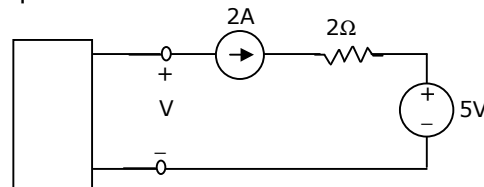
- 1.2 The voltage V in Fig.1.2 is equal to

- (a) 3V
(b) -3V
(c) 5V
(d) None of the above



- 1.3 The voltage V in Fig.1.3 is always equal to

- (a) 9V
(b) 5V
(c) 1V
(d) None of the above



- 1.4 The function $f(t)$ has the Fourier Transform $g(\omega)$. The Fourier Transform $ff(t)g(t) = \left(= \int_{-\infty}^{\infty} g(t) e^{-j\omega t} dt \right)$ is

- (a) $\frac{1}{2\pi} f(\omega)$
(b) $\frac{1}{2\pi} f(-\omega)$
(c) $2\pi f(-\omega)$
(d) None of the above

- 1.5 The Fourier Transform of $e^{at} \cos(\alpha t)$ is equal to

- (a) $\frac{(s - \alpha)}{(s - \alpha)^2 + \alpha^2}$
(b) $\frac{(s + \alpha)}{(s - \alpha)^2 + \alpha^2}$
(c) $\frac{1}{(s - \alpha)^2}$
(d) None of the above

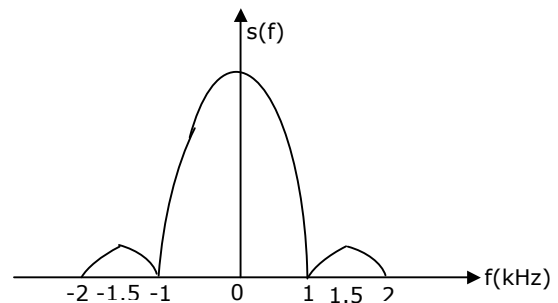
- 1.6 A transmission line of 50Ω characteristic impedance is terminated with a 100Ω resistance. The minimum impedance measured on the line is equal to
 (a) 0Ω (b) 25Ω (c) 50Ω (d) 100Ω
- 1.7 A rectangular air-filled wave-guide has cross section of $4\text{ cm} \times 10\text{ cm}$. The minimum frequency, which can propagate in the wave-guide, is
 (a) 1.5 GHz (b) 2.0 GHz (c) 2.5 GHz (d) 3.0 GHz
- 1.8 The line code that has zero dc component for pulse transmission of random binary data is
 (a) Non-return to zero (NRZ) (b) Return to zero (RZ)
 (c) Alternate Mark Inversion (AM) (d) None of the above

- 1.9 A probability density function is given by $p(x) = Ke^{-\frac{x^2}{2}}$ $-\infty < x < \infty$. The value of K should be

- (a) $\frac{1}{\sqrt{2\pi}}$ (b) $\sqrt{\frac{2}{\pi}}$ (c) $\frac{1}{2\sqrt{\pi}}$ (d) $\frac{1}{\pi\sqrt{2}}$

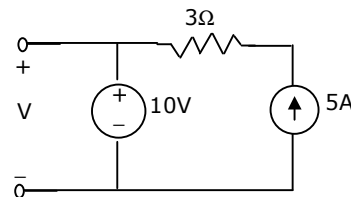
- 1.10 A deterministic signal has the power spectrum given in Fig.1.10. The minimum sampling rate needed to completely represent this signal is

- (a) 1 kHz
 (b) 2 kHz
 (c) 3 kHz
 (d) None of the above



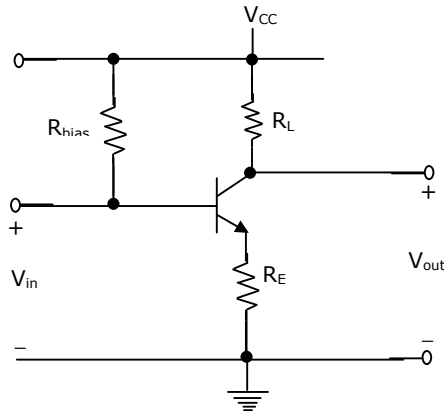
- 1.11 The voltage V in Fig.1.11 is

- (a) 10 V
 (b) 15 V
 (c) 5 V
 (d) None of the above



2. For each of the following questions (2.1 – 2.10), four alternatives (A, B, C and D) are given. Indicate the correct answer by writing the letter (A, B, C or D) against the corresponding question number. All parts of this question must be attempted strictly in order.

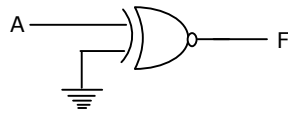
- 2.1 In the BJT amplifier shown in Fig.2.1, the transistor is biased in the forward active region. Putting a capacitor across R_E will



- (a) decrease the voltage gain and decrease the input impedance
 (b) increase the voltage gain and decrease the input impedance
 (c) decrease the voltage gain and increase the input impedance
 (d) increase the voltage gain and increase the input impedance
- 2.2 A cascade amplifier stage is equivalent to
- (a) a common emitter stage followed by a common base stage
 (b) a common base stage followed by an emitter follower
 (c) an emitter follower stage followed by a common base stage
 (d) a common base stage followed by a common stage
- 2.3 For a MOS capacitor fabricated on a p-type semiconductor, strong inversion occurs when
- (a) surface potential is equal to Fermi potential
 (b) surface potential is zero
 (c) surface potential is negative and equal to Fermi potential in magnitude
 (d) surface potential is positive and equal to twice the Fermi potential
- 2.4 In a common emitter BJT amplifier, the maximum usable supply voltage is limited by
- (a) Avalanche breakdown of Base-Emitter junction
 (b) Collector-Base breakdown voltage with emitter open (BV_{CBO})
 (c) Collector-Emitter breakdown voltage with base open (BV_{CBO})
 (d) Zener breakdown voltage of the Emitter-Base junction

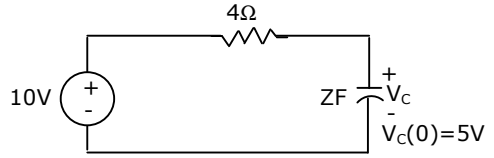
- 2.5 Each cell of a static Random Access Memory contains
- 6 MOS transistors
 - 4 MOS transistors and 2 capacitors
 - 2 MOS transistors and 4 capacitors
 - 1 MOS transistor and 1 capacitor
- 2.6 A 2 bit binary multiplier can be implemented using
- 2 inputs ANDs only
 - 2 input XORs and 4 input AND gates only
 - Two 2 inputs NORs and one XNOR gate
 - XOR gates and shift registers
- 2.7 In standard TTL, the 'totem pole' stage refers to
- the multi-emitter input stage
 - the phase splitter
 - the output buffer
 - open collector output stage
- 2.8 The inverter 74 ALS04 has the following specifications:
 $I_{OH\max} = -0.4mA$, $I_{OL\max} = 8mA$, $I_{iH\max} = 20mA$, $I_{iL\max} = -0.1mA$,
 The fan out based on the above will be
- 10
 - 20
 - 60
 - 100

- 2.9 The output of the logic gate in Fig.2.9 is



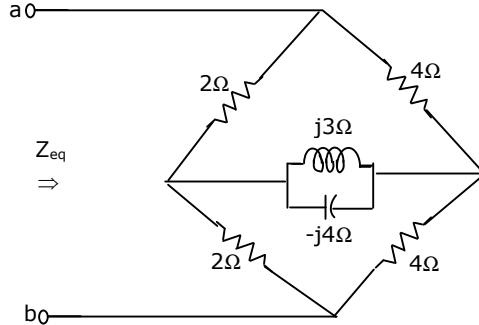
- 0
 - 1
 - A
 - F
- 2.10 In an 8085 μ P system, the RST instruction will cause an interrupt
- only if an interrupt service routine is not being executed
 - only if a bit in the interrupt mask is made 0
 - only if interrupts have been enabled by an EI instruction
 - None of the above
3. For each of the following questions (3.1 – 3.11), four alternatives (A, B, C and D) are given. Indicate the correct answer by writing the letter (A, B, C or D) against the corresponding question number. All parts of this question must be attempted strictly in order.

- 3.1 In the circuit of Fig.3.1 the energy absorbed by the 4Ω resistor in the time interval $(0, \infty)$ is
 (a) 36 Joules (b) 16 Joules
 (c) 256 Joules (d) None of the above



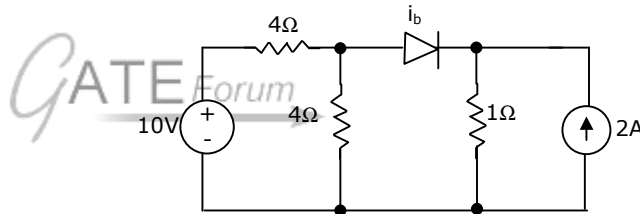
- 3.2 In the circuit of Fig.3.2, the equivalent impedance seen across terminals a,b is

- (a) $\left(\frac{16}{3}\right)\Omega$
 (b) $\left(\frac{8}{3}\right)\Omega$
 (c) $\left(\frac{8}{3} + 12j\right)\Omega$
 (d) None of the above



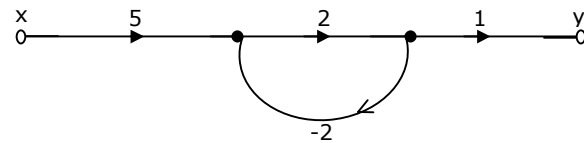
- 3.3 In the circuit of Fig.3.3, the current i_D through the ideal diode (zero cut in voltage and forward resistance) equals

- (a) 0 A
 (b) 4 A
 (c) 1 A
 (d) None of the above



- 3.4 In the signal flow graph of Fig.3.4, $\frac{y}{x}$ equals

- (a) 3 (b) $\frac{5}{2}$
 (c) 2 (d) None of the above



- 3.5 A certain linear time invariant system has the state and the output equations given below

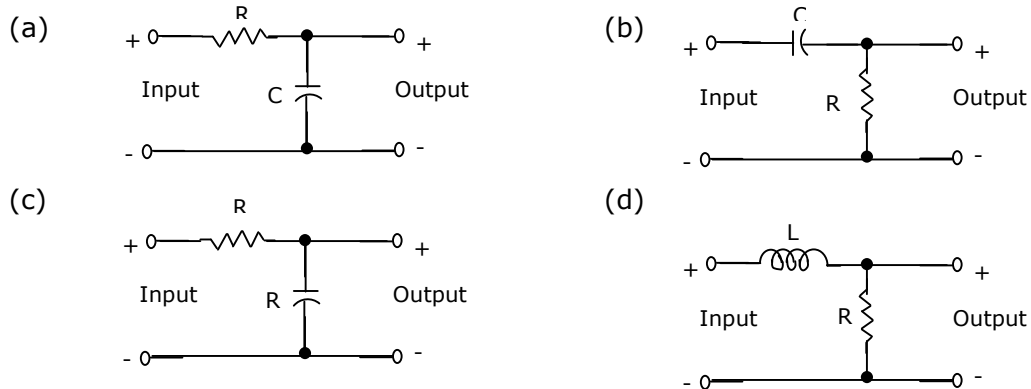
$$\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \end{bmatrix} = \begin{bmatrix} 1 & -1 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

$$y = \begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix}$$

If $X_1(0) = 1, X_2(0) = -1, u(0) = 0$, then $\frac{dy}{dt}|_{t=0}$ is

- (a) 1 (b) -1
 (c) 0 (d) None of the above

- 3.6 A communication channel has first order low pass transfer function. The channel is used to transmit pulses at a symbol rate greater than the half-power frequency of the low pass function. Which of the network shown in Fig.3.6 can be used to equalize the received pulses?

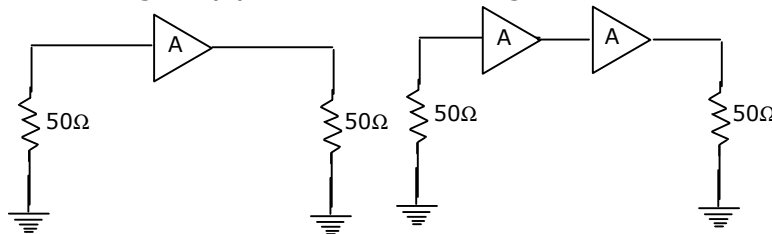


- 3.7 The power spectral density of deterministic signal is given by $\left[\frac{\sin(f)}{f^2} \right]$ where f is frequency.

The autocorrelation function of this signal in the time domain is

- (a) a rectangular pulse (b) a delta function
(c) a sine pulse (d) a triangular pulse

- 3.8 An amplifier A has 6 dB gain and 50Ω input and output impedances. The noise figure of this amplifier as shown in Fig.3.8(a) is 3 dB. A cascade of two such amplifiers as in Fig.3.8(b) will have a noise figure of



- (a) 6 dB (b) 8 dB
(c) 12 dB (d) None of the above

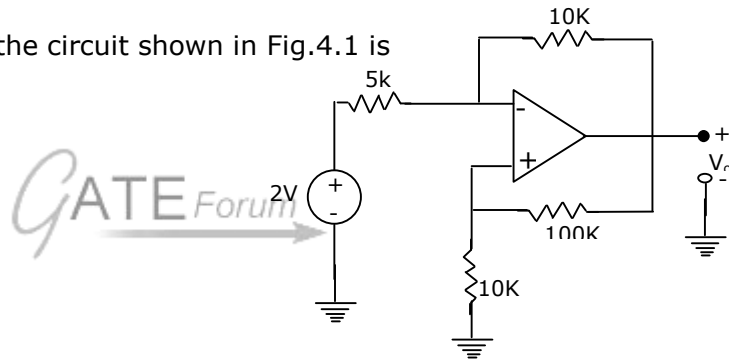
- 3.9 A parabolic dish antenna has a conical beam 2° wide, the directivity of the antenna is approximately

- (a) 20 dB (b) 30 dB (c) 40 dB (d) 50 dB

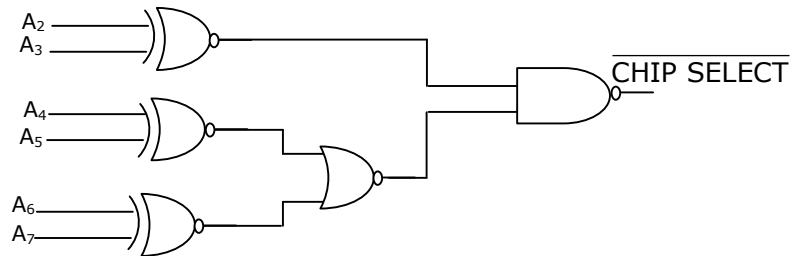
- 3.10 A very lossy, $\frac{\lambda}{4}$ long, 50Ω transmission line is open circuited at the load end. The input impedance measured at the other end of the line is approximately
- (a) 0 (b) 50Ω
(c) ∞ (d) None of the above
- 3.11 The skin depth at 10 MHz for a conductor is 1 cm. The phase velocity of an electromagnetic wave in the conductor at 1,000 MHz is about
- (a) $6 \times 10^6 m/sec$ (b) $6 \times 10^7 m/sec$ (c) $3 \times 10^8 m/sec$ (d) $6 \times 10^8 m/sec$
4. For each of the following questions (4.1 – 4.10), four alternatives (A,B, C and D) are given. Indicate the correct answer by writing the letter (A,B,C or D) against the corresponding question number. All parts of this question must be attempted strictly in order.

- 4.1 The output voltage V_o of the circuit shown in Fig.4.1 is

- (a) -4V
(b) 6V
(c) 5V
(d) -5.5V



- 4.2 The decoding circuit shown in Fig.4.2 has been used to generate the active low chip select signal for a microprocessor peripheral. (The address lines are designated as A0 to A7 for I/O addresses).



The peripheral will correspond to I/O addresses in the range

- (a) 60 H to 63 H (b) A4 to A 7H
(c) 30 H to 33 H (d) 70 H to 73 H

4.3 The following instructions have been executed by an 8085 μ P

ADDRESS (HEX)	INSTRUCTION
6010	LXI H, 8A, 79 H
6013	MOV A, L
6015	ADDH
6016	DAA
6017	MOV H, A
6018	PCHL

From which address will the next instruction be fetched?

- (a) 6019 (b) 6379
(c) 6979 (d) None of the above
- 4.4 A signed integer has been stored in a byte using the 2's complement format. We wish to store the same integer in a 16-bit word. We should
- (a) copy the original byte to the less significant byte of the word and fill the more significant with zeros
(b) copy the original byte to the more significant byte of the word and fill the less significant with zeros
(c) copy the original byte to the less significant byte of the word and make fit of the more significant byte equal to the most significant bit of the original byte
(d) copy the original byte to the less significant byte as well as the more significant byte of the word
- 4.5 A half wave rectifier uses a diode with a forward resistance R_f . The voltage is $V_m \sin \omega t$ and the load resistance is R_L . The DC current is given by
- (a) $\frac{V_m}{\sqrt{2}R_L}$ (b) $\frac{V_m}{\pi(R_f + R_L)}$ (c) $\frac{2V_m}{\sqrt{\pi}}$ (d) $\frac{V_m}{R_L}$
- 4.6 The intrinsic carrier density at 300 K is $1.5 \times 10^{10} / \text{cm}^3$, in silicon. For n-type silicon doped to $2.25 \times 10^{15} \text{ atoms} / \text{cm}^3$, the equilibrium electron and hole densities are
- (a) $n = 1.5 \times 10^{15} / \text{cm}^3, p = 1.5 \times 10^{10} / \text{cm}^3$
(b) $n = 1.5 \times 10^{10} / \text{cm}^3, p = 2.25 \times 10^{15} / \text{cm}^3$
(c) $n = 2.25 \times 10^{15} / \text{cm}^3, p = 1.0 \times 10^5 / \text{cm}^3$
(d) $n = 1.5 \times 10^{10} / \text{cm}^3, p = 1.5 \times 10^{10} / \text{cm}^3$

5. In the following questions (5.1 – 5.6), match each of the items 1,2 on the left with the most appropriate item a,b,c or d on the right.
[e.g. If you feel 1 matches with b and 2 with c, write (1,b) (2,c)].

5.1 In the case of a linear time invariant system

- | | |
|--|------------------------------------|
| (1) Poles in the right half plane implies | (a) Exponential decay of output |
| (2) Impulse response zero for $t \leq 0$ implies | (b) System is casual |
| | (c) No stored energy in the system |
| | (d) System is unstable |

5.2 If the Fourier Transform of deterministic signal $g(t)$ is $G(f)$, then

- | | |
|--|--------------------------|
| (1) The Fourier Transform of $g(t-2)$ is | (a) $G(f)e^{-j(4\pi f)}$ |
| (2) The Fourier Transform of $g(t/2)$ is | (b) $G(2f)$ |
| | (c) $2G(2f)$ |
| | (d) $G(f - 2)$ |



5.3

- | | |
|--|---|
| (1) An 8-bit wide 5 word sequential memory will have | (a) 8 Fixed 'AND' gates and 4 programmable 'OR' gates |
| (2) A 256×4 EFROM has | (b) Eight 4 bit shift registers |
| | (c) 4 words of 32 bits each |
| | (d) 8 address pins and 4 data pins output |

5.4

- | | |
|----------------------|-----------------------------|
| (1) Wave tilt | (a) Under-water propagation |
| (2) Faraday Rotation | (b) Ground wave propagation |
| | (c) Space wave propagation |
| | (d) Ionospheric propagation |

5.5 While moving data between registers of the 8085 and the stack

- | | |
|------------------------|---------------------------------------|
| (1) a PUSH instruction | (a) Pre increments the stack pointer |
| (2) a POP instruction | (b) Post increments the stack pointer |
| | (c) Pre decrements the stack pointer |
| | (d) Post decrements the stack pointer |

5.6 Negative feedback in

- | | |
|----------------------------------|--------------------------------|
| (1) Voltage series configuration | (a) increase input impedance |
| (2) Current shunt configuration | (b) decrease input impedance |
| | (c) increases closed loop gain |
| | (d) leads to oscillation |

6.

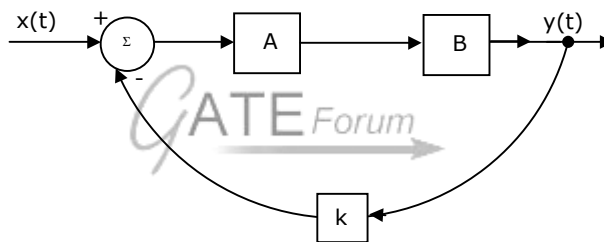


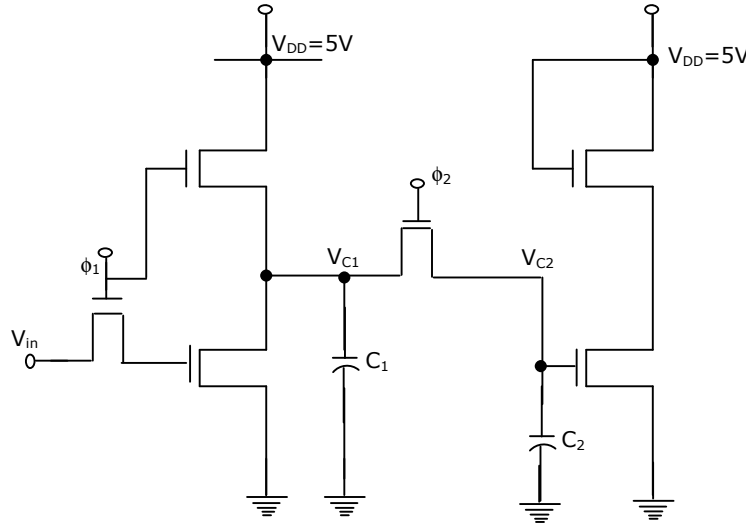
Fig.6

Fig.6 shows the block diagram representation of control system. The system in block A has an impulse response $h_A(t) = e^{-t}u(t)$. The system in block B has an impulse response $h_B(t) = e^{-2t}u(t)$. The block 'K' amplifies its inputs by a factor k. For the overall system with input $x(t)$ and output $y(t)$

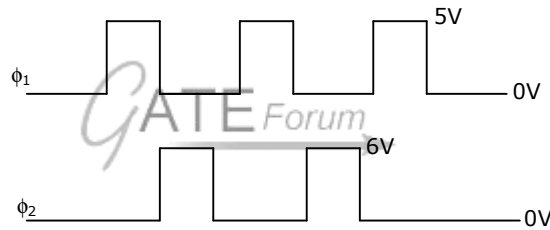
- (a) Find the transfer function $\frac{Y(s)}{X(s)}$ when $k = 1$
- (b) Find the impulse response when $k = 0$
- (c) Find the values of k for which the system becomes unstable

Note: $u(t) = 0$ $1 \leq 9$
 $= 1$ $t > 0$

7. Circuit shown in Fig.7(a) is an NMOS shift register. All transistors are NMOS enhancement type with threshold voltage $V_T = 1V$. Supply used is $V_{DD} = 5V$



Two non-overlapping clocks ϕ_1 and ϕ_2 are as shown in Fig.7(b) and have large pulse widths.



All capacitors are initially discharged and the input $V_{in} = 0$ volts is applied. If values of capacitors are $C_1 = 2pf$ and $C_2 = 1pf$, find out voltage V_{C2} on capacitor C_2 after ϕ_2 goes low.

Neglect body-effect on V_T in your evaluation.

8. The transistor in the circuit shown in Fig.8 is so biased (dc biasing network is not shown) that the dc collector current $I_c = 1mA$. Supply is $V_{CC} = 5V$.

The network components have following values:

$$R_C = 2k\Omega$$

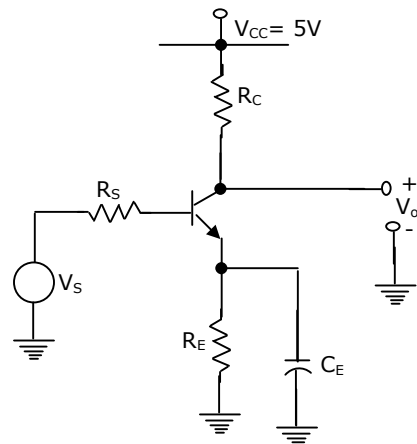
$$R_S = 1.4k\Omega$$

and $R_E = 100\Omega$

The transistor has specifications.

$\beta = 100$ and base spreading resistance

$$r_{bb} = 100\Omega .$$

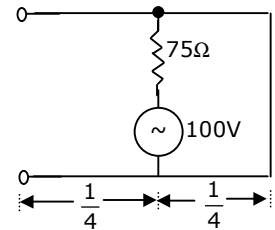


Assume $\frac{kT}{q} = 25mV$.

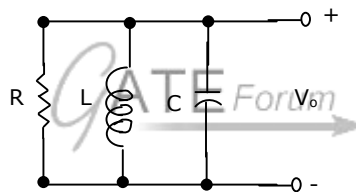
Evaluate small signal Voltage Gain A_{V_S} at a frequency of 10 kHz, and Input Resistance R_i for two cases:

- (a) CE, the bypass capacitor across R_E is 25 μF .
 (b) The bypass capacitor C_E is removed leaving R_E unbypassed

9. A $\frac{\lambda}{2}$ section of 600Ω transmission line, short circuited at one end and open circuited at the other end, is shown in Fig.9. A 100 V/ 75Ω generator is connected at the mid point of the section as shown in the figure. Find voltage at the open circuited end of the line.



10. In the circuit of Fig.10, $R=100\Omega$, $L = 20nH$ and $C = 32 pF$.

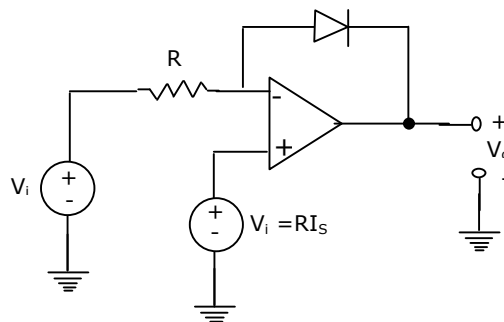


The circuit is maintained at a temperature of 300K. Derive and plot the power spectral density of the voltage V_o . Mark all the relevant points on the plot with numerical values. (The Boltzmann constant $k = 1.28 \times 10^{-23} J / K$)

SECTION - B

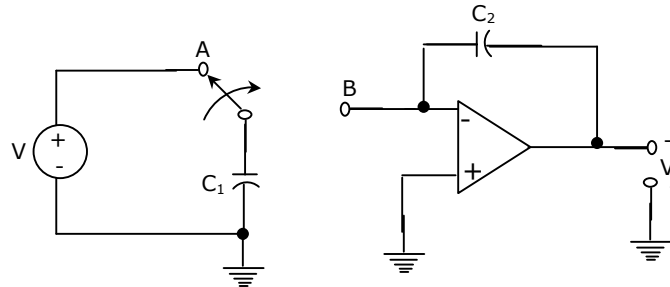
Attempt ANY TEN questions from this section. (Each question carries 5 marks)

11. Consider the circuit given in Fig.11, using an ideal operational amplifier.



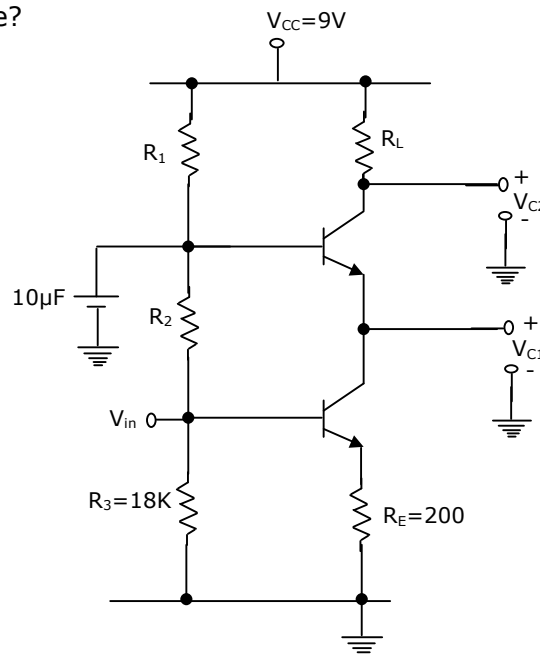
The characteristics of the diode are given by the relation $I = I_S \left(\frac{V}{e^{kT}} - 1 \right)$ where V is the forward voltage across the diode.

- (a) Express V_o as function of V_i assuming $V_i > 0$
- (b) If $R = 100\text{k}\Omega$, $I_S = 1\mu\text{A}$ and $\frac{kT}{q} = 25\text{mV}$, find the input voltage V_i for which $V_o = 0$.
12. In the circuit shown in Fig.12, assume that the operational amplifier is ideal and that $V_o = 0\text{V}$ initially. The switch is connected first to 'A' charging C_1 to the voltage V . It is then connected to the point 'B'. This process is repeated f times per second.



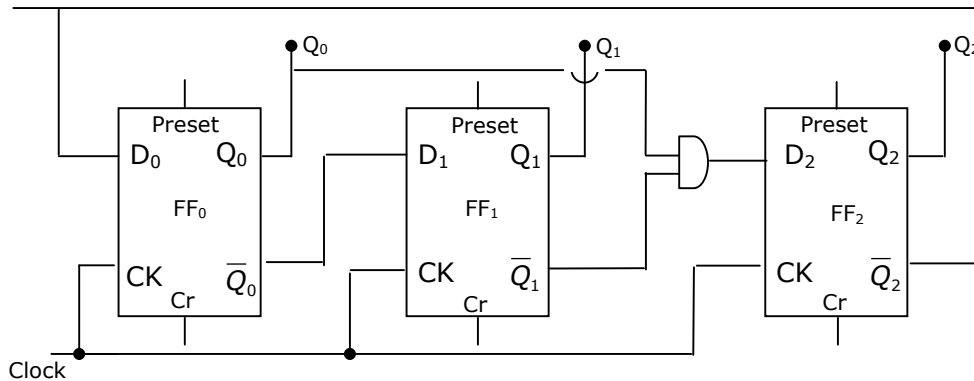
- (a) Calculate the charge transferred per second from node A to node B.
- (b) Derive the average rate of change of the output voltage V_o .
- (c) If the capacitor and the switch are removed and a resistor is connected between points A and B, find the value of the resistor to get the same average rate of change of the output voltage?
- (d) If the repetition rate of the switching action is 10^4 times per second, $C_1 = 100\text{pF}$, $C_2 = 10\text{pF}$ and $V = 10\text{mV}$. What is the average of change of the output voltage?

13.



In the cascade amplifier circuit shown in Fig.13, determine the values of R_1, R_2 and R_L such that the quiescent current through the transistors is 1 mA and the collector voltages are $V_C = 3V$ and $V_{C2} = 6V$, take $V_{BE} = 0.7V$, transistor β to be high and base currents to be negligible.

14. A sequence generator is shown in Fig.14. The counter status (Q_0, Q_1, Q_2) is initialized to 010 using preset/clear inputs.

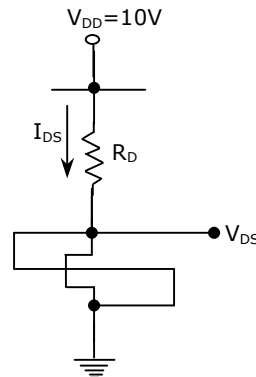


The clock has a period of 50 ns and transitions take place at the rising clock edge.

- (a) Give the sequence generated at Q_0 till it repeats.
 (b) What is the repetition rate of the generated sequence?
15. Given an NMOS circuit as shown in Fig.15. The specifications of the circuit are:

$$V_{DD} = 10, \beta = K = \mu_n C_{ox} (W/L) = 10^{-4} \text{ Amp} / V^2, V_T = 1V \text{ and } I_{DS} = 0.5mA.$$

Evaluate V_{DS} and R_D for the circuit. Neglect body - effect for V_T .



16. Find Static Noise-Margins for a BJT inverter shown in Fig.16. Transistor used is an n-p-n type with specifications as follows:

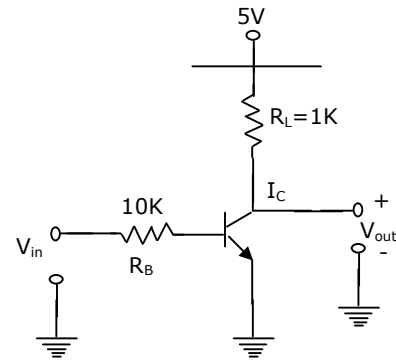
$$\beta_F = 70$$

$$V_{BEON} = 0.7V$$

$$V_{BESAT} = 0.8V$$

$$V_{CESAT} = 0.1V.$$

Also $R_L = 1k\Omega$; $R_B = 10k\Omega$ and supply $V_{CC} = 5V$.



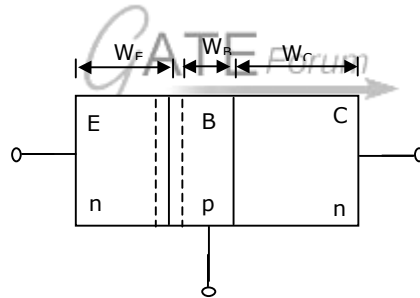
17. For a typical n-p-n transistor, as shown in Fig.17, we have the following data available:

(a) $W_C = 20\mu m$ and Collector doping = $5 \times 10^{18}/cc$

(b) $W_E = 1\mu m$ and Emitter doping = $10^{19}/cc$

(c) Base doping = $5 \times 10^{15}/cc$

(d) Minority carrier life time in the Base region is $\tau_n = 5\mu sec$.



Under Punch-through condition the $V_{BC} = 10V + V_{bi}$ volts.

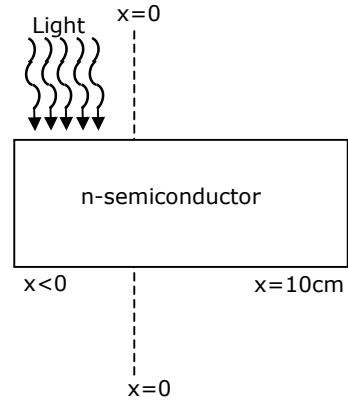
Here V_{bi} is the built in potential of Base-collector junction. Emitter Injection efficiency can be assumed as 1 for this transistor.

Evaluate Base Width W_B and the current gain α .

[Standard data for this question is: $q = 1.6 \times 10^{-19}$ coulombs; $\frac{KT}{q} = 25mV$

For silicon at $T = 300 K$, $D_n = 30cm^2 / sec$; $K_S \epsilon_0 = 10^{-12} F / cm$; $n_i = 1.5 \times 10^{10} / cc$]

18. An n-type silicon bar is doped uniformly by phosphorous atoms to a concentration $4.5 \times 10^{13}/\text{cc}$. The bar has cross-section of 1 mm^2 and length of 10 cm . It is illuminated uniformly for region $x < 0$ as shown in Fig.18. Assume optical generation rate 10^{21} Electron-Hole pairs per cm^3 per second, for this case. The hole lifetime and electron lifetime are equal, and equal to $1 \mu\text{sec}$.



Evaluate the hole and electron diffusion currents at $x = 34.6 \mu\text{m}$.

Following expressions and data can be used in this evaluation:

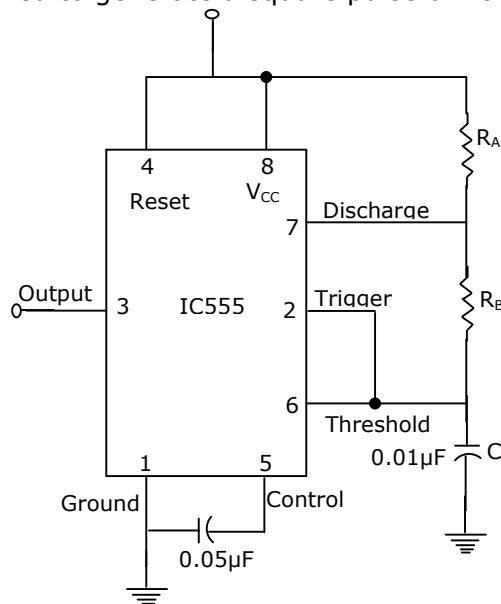
$$J_p = qD_p \frac{dp}{dx}; \quad J_n = qD_n \frac{dn}{dx}$$

where,

$$D_p = 12 \text{ cm}^2 / \text{sec}; \quad D_n = 30 \text{ cm}^2 / \text{sec}.$$

$$q = 1.6 \times 10^{-19} \text{ coulombs } (kt/q) = 26 \text{ mV}.$$

19. An IC 555 chip has been used to construct a pulse-Generator. Typical pin connections with components is shown below in Fig.19, for such an application. However it is desired to generate a square pulse of 10 kHz .



Evaluate values of R_A and R_B if the capacitor C has the value of $0.01 \mu\text{F}$ for the configuration chosen. If necessary you can suggest modification in the external circuit configuration.

20. An 8085 μP uses a 2 MHz crystal. Find the time taken by its to execute the following delay subroutine, inclusive of the call instruction in the calling program.

Calling program	DELAY:	PUSH PSW
.....		MVI A, 64 H
CALL	DELAYLOOP:	NOP
.....		DCR A
		JNZLOOP
		POP PSW
		RET

You are given that a CALL instruction takes 18 cycles of the system clock, PUSH requires 12 cycles and a conditional jump takes 10 cycles if the jump is taken and 7 cycles if it is not. All other instructions used above take $(3n + 1)$ clock cycles, where n is the number of accesses to the memory, inclusive of the opcode fetch.

- 21.

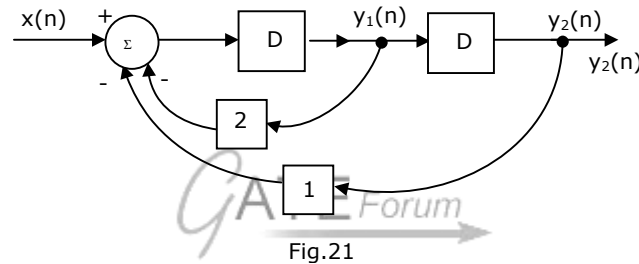
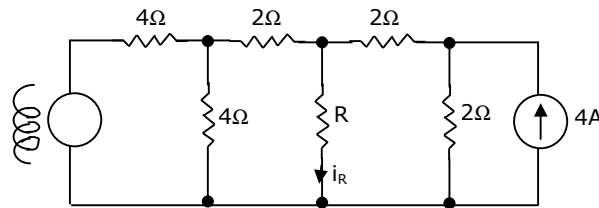


Fig.21

In Fig.21, a linear time invariant discrete systems is shown. Blocks labeled D represent unit delay elements. For $n < 0$, you may assume that $x(n)$, $y_1(n)$, $y_2(n)$ are all zero.

- (a) Find the expression for $y_1(n)$ and $y_2(n)$ in terms of $x(n)$.
- (b) Find the transfer function $\frac{Y_2(z)}{X(z)}$ in the z-domain.
- (c) If $x(n) = 1$ at $n = 0$
 $= 0$ otherwise,
 Find $y_2(n)$.

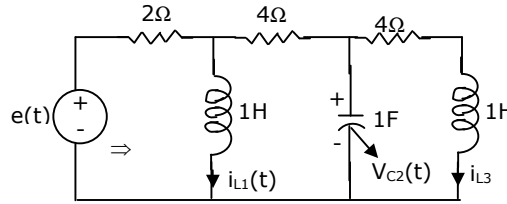
- 22.



In the circuit of Fig.22 when $R = 0\Omega$, the current i_R equals 10A

- (a) Find the value of R for which it absorbs maximum power
- (b) Find the value of ϵ
- (c) Find V_2 when $R = \infty$ (open circuit)

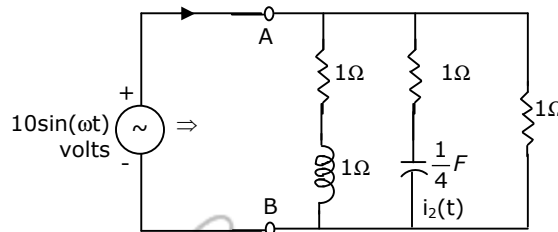
23.



In the circuit of Fig.23, all currents and voltages are sinusoids of frequency ω rad/sec.

- (a) Find the impedance to the right of (A,B) at $\omega = 0$ rad/sec and $\omega = \infty$ rad/sec.
- (b) If $\omega = \omega_0$ rad/sec and $i_1(t) = I \sin(\omega_0 t) A$, where I is positive $\omega_0 \neq 0, \omega_0 \neq \infty$ then find I, ω_0 and $i_2(t)$

24.



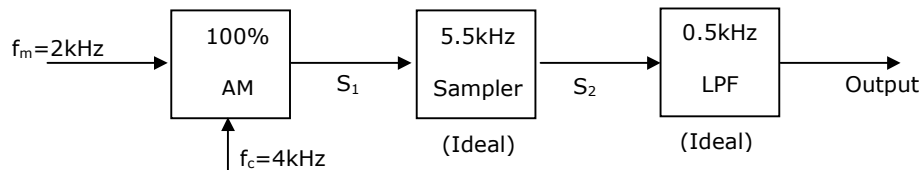
For the circuit shown in Fig.24, choose state variables X_1, X_2, X_3 , to be $i_{L1}(t), V_{C2}(t), i_{L3}(t)$

- (a) Write the state equations

$$\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \\ \dot{X}_3 \end{bmatrix} = A \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} + B [e(t)]$$

- (b) If $e(t) = 0, t \geq 0, i_{L1}(0) = 0, V_{C2}(0) = 0, i_{L3}(0) = 1A$, then what would the total energy dissipated in the resistors in the interval $(0, \infty)$ be?

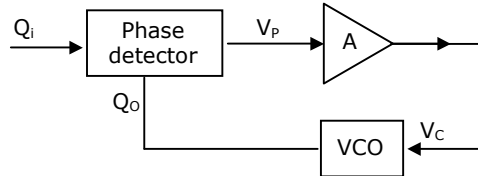
25. A block diagram of a system is shown in Fig.25. Draw the spectrum of the output signal with relative aptitudes of the frequencies.



26. Find the mean of a function $X(T) = \sin^2(\alpha T)$, where α is a constant, and T is a random variable.

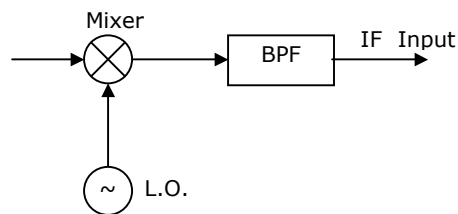
$$\begin{aligned} \text{The pdf of } T \text{ is given by, } f(T) &= e^{-T} && \text{for } T \geq 0 \\ &= 0 && \text{for } T < 0 \end{aligned}$$

27. Fig.27 shows the block diagram of phase-locked-loop (PLL) in the locked condition.



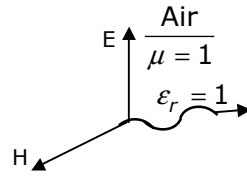
The output voltage of the phase detector is given by $V_p = K_d (\phi_i - \phi_o)$, where ϕ_i is phase of the input signal, and ϕ_o is the phase of the output Voltage Controlled Oscillator (VCO). The value of K_d is 1 Volt/radian, the frequency deviation of the VCO output is $\Delta f_o = K_f V_c$, where V_c is input voltage of the VCO, and $k_f = 159.15 \text{ Hz / volt}$. The amplifier A is a buffer with a voltage gain of unity.

- (a) Derive the transfer function $\frac{\phi_o(s)}{\phi_i(s)}$.
- (b) Let the loop to be locked for time $t < 0$ and $\Phi_i(t) = u(t)$ radian, where $u(t)$ is the unit step function. Determine $\Phi_o(t)$ for $t > 0$.
28. Fig.28 shows the first stage of a super heterodyne receiver. The desired input signal is at a frequency of 700 MHz. The local oscillator (L.O) frequency is 1 GHz. The mixer is an ideal multiplier with a gain independent of frequency. A band-pass filter (BPF) is used to select the Intermediate Frequency (IF) output at 300 MHz.



- (a) What is the image frequency of the desired input?
- (b) A Low Pass Filter (LPF) can be used before the mixer to reject the image frequency. If a perfect rejection (zero transmission) of the image is desired, what type of LPF should be employed?
- (c) The input in Fig.28 is corrupted by an undesired 750 MHz signal, which has the same amplitude as those of the desired signal at 700 MHz. Let the BPF be of second order. At the BPF output, the undesired signal should be 20 dB below the desired signal. Calculate the Q required for the BPF.

29. A uniform plane wave is normally incident from air on an infinitely thick magnetic material with relative permeability 100 and relative permittivity 4 (see Fig.29). the wave has an electric field of 1V, meter (rms). Find the average pointing vector inside the material.



$$\text{Magnetic material} \\ m_r = 100 \epsilon_r = 4$$

30. A dipole antenna has a $\sin \theta$ radiation pattern where the angle θ is measured from the axis of the dipole. The dipole is vertically located above an ideal ground plane (Fig.30). What should be the height of the dipole H in terms of wave length so as to get a null in the radiation pattern at an angle of 45° from the ground plane? Find the direction of maximum radiation also.

