

USE SEPARATE SCRIPTS FOR EACH SECTION

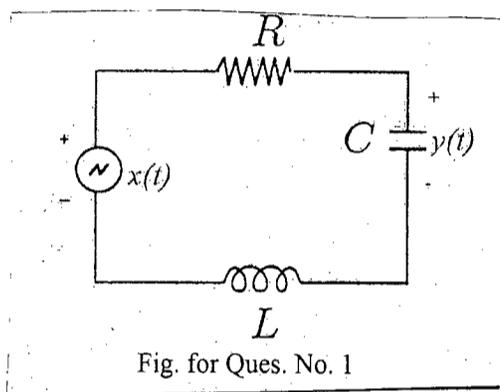
The figures in the margin indicate full marks.

The symbols have their usual meanings.

SECTION - A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Consider a RLC circuit shown in Fig. for Ques. No. 1. Find the output, $y(t)$ of the system when input is, $x(t)$ for (i) $R = 0$ and (ii) $R > 0$. Comment on the stability of the system for both cases. (15)



- (b) (i) Choose appropriate value of L and C in the system shown in Fig. for Ques. No. 1 such that the natural frequency of the system, $\omega_n = 100$ rad/s. (20)
- (ii) Is it possible to obtain sinusoidal output $y(t)$ with 200 rad/s frequency in steady state from this system with natural frequency, $\omega_n = 100$ rad/s, for (i) $R = 0$ and (ii) $R > 0$? Explain for both cases. If yes, what should be input?
2. (a) Assume $Q(s) = s^4 + 7s^3 + 15s^2 + (20 + K)s + 2K$ to be the denominator of the transfer function of a system. Find the range of values of K for which the system will be stable. (17)

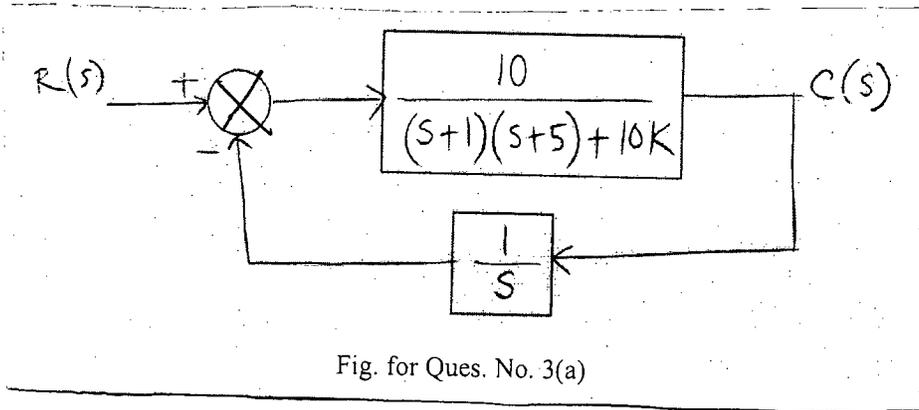
- (b) Open loop gain of a system is given by, (18)

$$G(s)H(s) = \frac{K(s+10)}{s(s-3)}$$

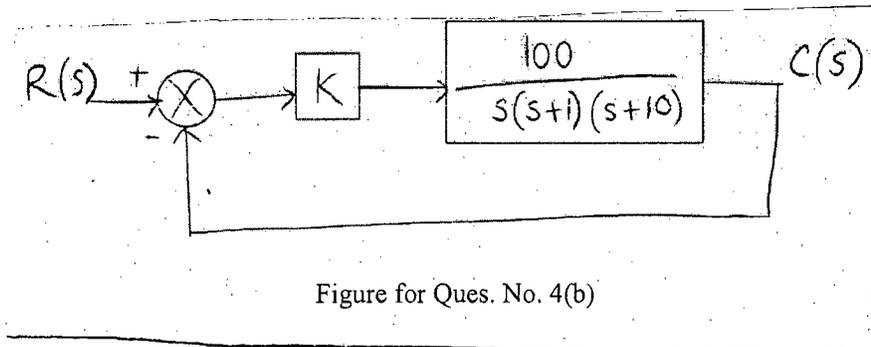
Find the value of K for which the system oscillates. Also find the frequency of oscillation.

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3. (a) Consider the system shown in Fig. for Ques. No. 3(a). Draw Nyquist Diagrams and comment on the stability of this system for $K = 0.3$ and $K = 0.4$. (20)



- (b) Derive the expression of M and N circles. What are the utilities of these diagrams? (15)
4. (a) Derive the expression relating phase margin and damping ratio. From this expression, find the phase margin required for a second order system to be critically damped. (15)
- (b) A unity feedback system is shown in Fig. for Ques. No. 4(b). Using Bode Plot, find the value of K such that the system response is critically damped. [Make necessary assumptions. Use semi-log graph paper and attach it to the answer script.] (20)



SECTION - B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Draw a signal flow graph for the following state space equation. Use Mason's rule to find the transfer function $\frac{Y(s)}{R(s)}$ from the signal flow graph. (20)

$$\dot{x}(t) = \begin{bmatrix} 7 & 1 & 0 \\ -3 & 2 & -1 \\ -1 & 0 & 2 \end{bmatrix} x(t) + \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix} r(t)$$

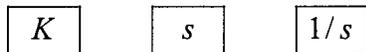
$$y(t) = [1 \quad 3 \quad 2]x(t)$$

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Contd... Q. No. 5

(b) Draw a block diagram that results in the transfer function $T(s) = \frac{s}{3s+K}$ using the following blocks:

(15)



You can use these blocks multiple times. Use as many summing junctions as necessary.

6. (a) A unity gain negative feedback system with forward transfer function

(20)

$$G(s) = \frac{K(s + \alpha)}{s(s + \beta)}$$

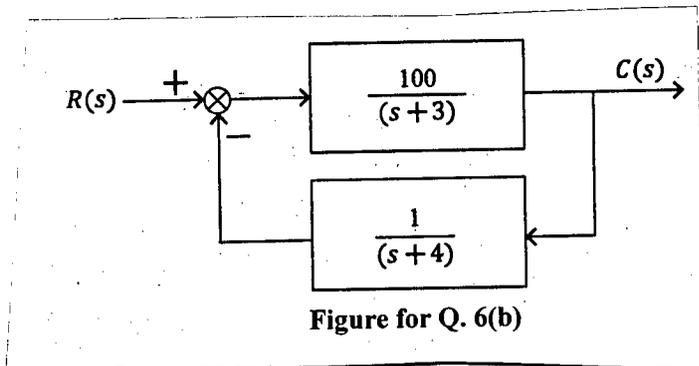
is to be designed to meet the following requirements:

- (i) The steady-state error for a unit ramp input equals $\frac{1}{10}$
- (ii) The closed-loop poles will be located at $-1 \pm j1$

Find K , α and β to meet the requirements.

(b) Find the steady state error, $e_{ss} = r(\infty) - c(\infty)$, for a unit step input for the following system shown in Fig. 6(b).

(15)



7. (a) For the negative unity gain feedback system, where

(20)

$$G(s) = \frac{K(s+3)(s+6)}{(s^2+2s+2)(s+2)(s+4)(s+5)}$$

- (i) Sketch the root locus
- (ii) Find $j\omega$ -axis crossing, and range of K for stability
- (iii) Find angles of departure from the complex poles

(b) A negative unity gain feedback system has a forward transfer function,

(15)

$$G(s) = \frac{K(s+3)(s+4)}{(s+1)(s+2)}$$

- (i) Find the break-in and break-away points
- (ii) Calculate gain K , at break-in and break-away points.

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8. (a) A negative unity gain feedback system with

(25)

$$G(s) = \frac{K}{(s+2)(s+4)}$$

is operating with an overshoot of 20%. Design a lag-lead controller (using root-locus technique) to reduce the settling time by a factor of 2, and tenfold improvement in the steady-state error while maintaining the same overshoot.

- (b) A negative unity gain feedback system with

(10)

$$G(s) = \frac{K}{(s+4)^3}$$

is operating with a settling time of 1.6 second. Find the percentage of overshoot of the system.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Silicon atoms, at a concentration of $7 \times 10^{15} \text{ cm}^{-3}$, are added to gallium arsenide. Assume that the silicon atoms act as fully ionized dopant atoms and that 5 percent of the concentration added replace gallium atoms and 95 percent replace arsenic atoms.

Let $T = 300 \text{ K}$.

- (i) Determine the donor and acceptor concentration. (20)
 (ii) Is the material n type or p type?
 (iii) Calculate the electron and hole concentration.
 (iv) Determine the position of the Fermi level with respect to E_{Fi} .

[GaAs has an intrinsic concentration of $1.8 \times 10^6 \text{ cm}^{-3}$.]

- (b) Assume that the donor concentration in an n-type semiconductor at $T = 300 \text{ K}$ is given by (15)

$$N_d(x) = 10^{16} - 10^{19} x \text{ (cm}^{-3}\text{)}$$

Where x is given in cm and ranges between $0 \leq x \leq 1 \text{ } \mu\text{m}$.

- (i) Determine the induced electric field in the semiconductor in thermal equilibrium.
 (ii) What is the potential difference between $x=0$ and $x=1 \text{ } \mu\text{m}$?

2. (a) An n-type silicon resistor has a length $L=150 \text{ } \mu\text{m}$, width $W = 7.5 \text{ } \mu\text{m}$, and thickness $t=1 \text{ } \mu\text{m}$. A voltage of 2 V is applied across the length of the resistor. The donor impurity concentration varies linearly through the thickness of the resistor with $N_d=2 \times 10^{16} \text{ cm}^{-3}$ at the top surface and $N_d=2 \times 10^{15} \text{ cm}^{-3}$ at the bottom surface.

Assume an average carrier mobility of $\mu_n = 750 \text{ cm}^2 / \text{V} \cdot \text{s}$. (20)

- (i) What is the electric field in the resistor?
 (ii) Determine the average conductivity of the silicon.
 (iii) Calculate the current in the resistor.
 (iv) Determine the current density near the top surface and the current density near the bottom surface.

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Contd ... Q. No. 2

(b) Germanium at $T = 300$ K is uniformly doped with donor impurity atoms to a concentration of $4 \times 10^{13} \text{ cm}^{-3}$. The excess carrier lifetime is found to be $\tau_{p0} = 2 \times 10^{-6} \text{ s}$. (15)

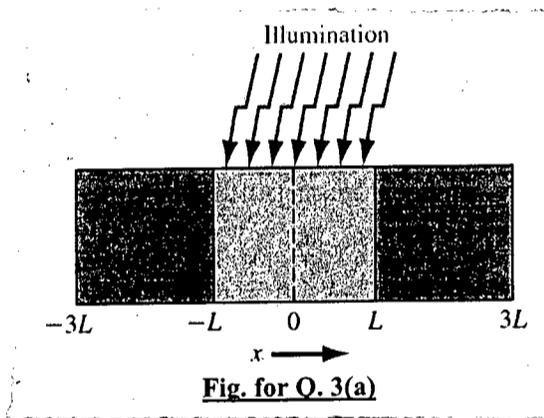
(i) Determine the ambipolar diffusion coefficient and mobility.

(ii) Find the electron and hole lifetimes.

[Ge has an intrinsic concentration of $2.4 \times 10^{13} \text{ cm}^{-3}$.

$\mu_n = 3900 \text{ cm}^2 / \text{V} \cdot \text{s}$ and $\mu_p = 1900 \text{ cm}^2 / \text{V} \cdot \text{s}$].

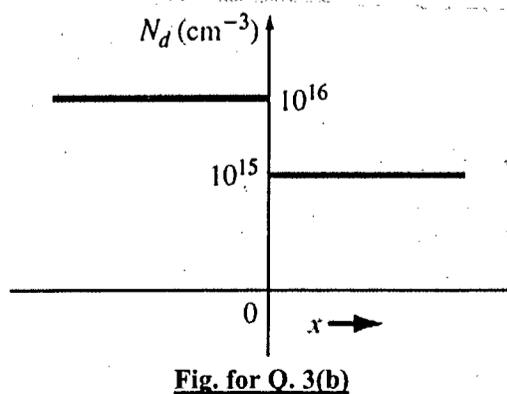
3. (a) Consider the n-type semiconductor shown in Fig. for Q. 3(a). Illumination produces a constant excess carrier generation rate, G_0 , in the region $-L < X < +L$. Assume that the minority carrier lifetime is infinite and the excess minority carrier hole concentration is zero at $x = -3L$ and at $x = +3L$. Find the steady-state excess minority carrier concentration versus x , for the case of low injection and zero applied electric field. (20)



(b) An “ isotype” step junction is one in which the same impurity type doping changes from one concentration value to another value. An n-n isotype doping profile for silicon is shown in Fig. for Q. 3(b). (15)

(i) Sketch the thermal equilibrium energy-band diagram of the isotype junction.

(ii) Using the energy-band diagram, determine the built-in potential of the junction.

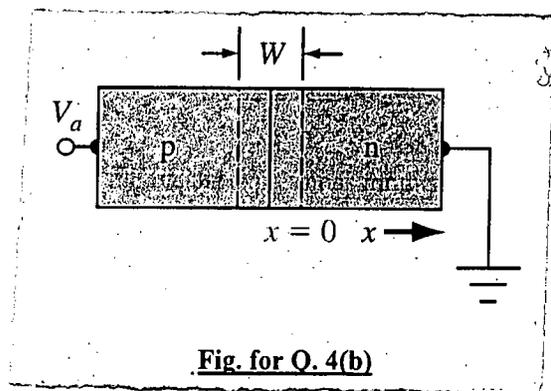


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4. (a) For a linearly graded junction, derive the expressions for the built-in potential barrier, electric field and potential distribution in the space charge region. (20)

(b) Consider the ideal long silicon p-n junction shown in Fig. for Q. 4 (b). $T = 300$ K. The n-region is doped with 10^{16} donor atoms per cm^3 and the p-region is doped with 5×10^{16} acceptor atoms per cm^3 . The minority carrier lifetimes are $\tau_{n0} = 0.05 \mu\text{s}$ and $\tau_{p0} = 0.01 \mu\text{s}$. The minority carrier diffusion coefficients are $D_n = 23 \text{cm}^2/\text{s}$ and $D_p = 8 \text{cm}^2/\text{s}$. The bias voltage is $V_a = + 0.610$ V. Calculate- (15)

- (i) the excess hole concentration as a function of x for $x \geq 0$,
- (ii) the hole diffusion current density at $x = 3 \times 10^{-4}$ cm, and
- (iii) the electron current density at $x = 3 \times 10^{-4}$ cm.



SECTION-B

There are **FOUR** questions in this section. Answer any **THREE**

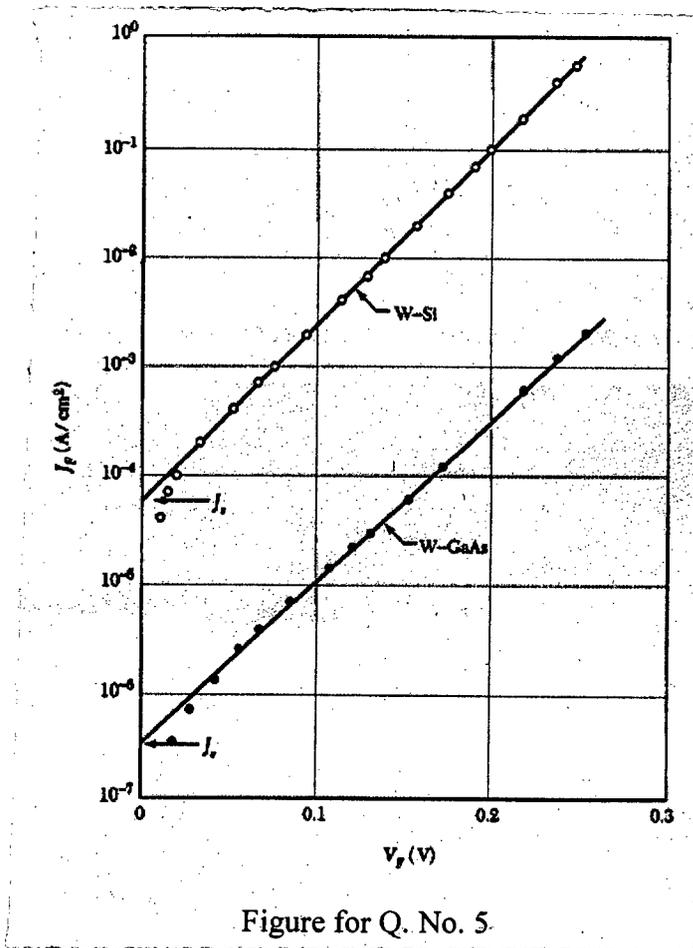
5. For a tungsten-silicon Schottky diode with $N_D = 10^{16} \text{cm}^{-3}$, find the barrier height and depletion layer width from Figure for Q. No. 5. Compare the saturation current J_s with J_{p0} assuming that the minority carrier lifetime and diffusion coefficient in Si are 10^{-6} and $10 \text{cm}^2/\text{s}$, respectively. Also determine the junction capacitance and the maximum electric field when a reverse bias of 4V is applied. (35)

6. The recombination current density, J_{r0} , in an npn silicon bipolar transistor at $T = 300$ K is $J_{r0} = 5 \times 10^{-8} \text{A}/\text{cm}^2$. The uniform dopings are $N_E 10^{18} \text{cm}^{-3}$, $N_B = 5 \times 10^{16} \text{cm}^{-3}$, and $N_C = 10^{15} \text{cm}^{-3}$. Other parameters are $D_E = 10 \text{cm}^2/\text{s}$, $D_B = 25 \text{cm}^2/\text{s}$, $\tau_{E0} = 10^{-8} \text{s}$ and $\tau_{B0} = 10^{-7} \text{s}$. Determine the neutral base width so that the recombination factor is $\delta = 0.995$ when $V_{BE} = 0.55$ V. If J_{r0} remains constant with temperature, what is the value of δ when $V_{BE} = 0.55$ V for the case when the temperature is $T = 400$ K? Use the previously determined value of neutral base width. (35)

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7. An Al- gate MOS capacitor has an oxide thickness of 100 Å and an oxide charge density of $3 \times 10^{11} \text{ cm}^{-2}$. The charge is positive. Calculate (a) the flat band voltage, (b) the turn-on voltage. Also, draw the energy band diagram, qualitative charge density, and electric field profile of the structure at the onset of inversion. $N_a = 5 \times 10^{15} \text{ cm}^{-3}$. The work function of Al is 4.1 eV, the electron affinity for SiO_2 is 0.9 eV, and that of Si is 4.15 eV. (35)

8. An ideal MOS capacitor with an Al-gate has an oxide thickness of 400 Å on an n-type silicon substrate doped with a donor concentration of $N_d = 5 \times 10^{14} \text{ cm}^{-3}$. An equivalent fixed oxide charge is 10^{11} cm^{-2} . Determine oxide capacitance, flat-band capacitance, minimum capacitance, and gate capacitance at strong inversion at (a) $f = 1 \text{ Hz}$ and (b) $f = 1 \text{ MHz}$. Also determine V_{FB} and V_T . Sketch C'/C_{ox} versus V_G for parts (a) and (b). The work function of Al is 4.1 eV, the electron affinity for SiO_2 is 0.9 eV, and that of Si is 4.15 eV. (35)



SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Derive the expressions of emitter injection efficiency factor and base transport factor in a BJT. Explain the rationale for keeping base width as low as possible from your derived result. Assume excess minority carrier concentration in the base and emitter to be respectively, (20)

$$\delta n_B(x) = \frac{n_{BO}}{x_B} \left\{ \left[\exp\left(\frac{eV_{BE}}{kT}\right) - 1 \right] (x_B - x) - x \right\} \text{ and}$$

$$\delta p_E(x') = \frac{p_{EO}}{x_E} \left[\exp\left(\frac{eV_{BE}}{kT}\right) - 1 \right] (x_E - x')$$

- (b) Consider an npn Silicon BJT with the following parameters: (15)

$D_B = 25 \text{ cm}^2/\text{s}$	$D_E = 10 \text{ cm}^2/\text{s}$
$\tau_{bo} = 10^{-7} \text{ s}$	$\tau_{EO} = 5 \times 10^{-8} \text{ s}$
$N_B = 10^{16} \text{ cm}^{-3}$	$x_E = 0.5 \text{ } \mu\text{m}$

The recombination factor, $\delta = 0.998$.

Common emitter current gain, $\beta = 120$

Base transport factor and emitter injection efficiency factor are equal. Calculate the maximum base width x_B and minimum emitter doping N_E to achieve these specifications.

2. (a) What are the reasons behind early effect and current crowding in a BJT? Explain with necessary figures. (17)

(b) Derive the electron current density in the base region of an npn BJT in terms of base Gummel number. (18)

Explain how Gummel-Poon model can account for various non-idealities in a BJT.

3. (a) Explain how 2D electron gas is formed in an $\text{Al}_x\text{Ga}_{1-x}\text{As}$ -GaAs heterojunction. Discuss how mobility is affected in this structure. (10)

(b) Explain transistor performance of a “normal” AlGaAs-GaAs MODFET in depletion mode. Draw its energy band diagram in ON and OFF state. (12)

(c) Consider an N $\text{Al}_{0.4}\text{Ga}_{0.6}\text{As}$ -i GaAs abrupt heterojunction. Assume that the AlGaAs is doped with a concentration of $N_d = 3 \times 10^{18} \text{ cm}^{-3}$ and has a thickness of $300 \text{ } \text{Å}$. Let $\phi_{BN} = 0.9 \text{ V}$ and $\Delta E_c = 0.24 \text{ eV}$. Relative dielectric constant is 12.7. (13)

Calculate (i) V_{off} and (ii) η_s for $V_g = 0 \text{ V}$.

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4. (a) Derive the formula of internal pinch-off voltage in an n-channel JFET. (10)
 (b) Prove that the base transit time in an npn BJT is proportional to the square of base width. (10)
 (c) What is Kirk effect? Explain how it reduces transistor gain when high collector current is drawn. (15)

SECTION-B

There are **FOUR** questions in this section. Answer any **THREE**

5. (a) For an experimental setup an epitaxial pseudomorphic layer of $\text{In}_x\text{Ga}_{1-x}\text{As}_y\text{Sb}_{1-y}$ is grown on InP substrate. If a light of wavelength less than 1243 nm passes through the epitaxial layer then it is absorbed in the film, otherwise it transmits through the layer. The lattice parameter of the unstrained InGaAsSb is 5.93 Å. By using data from Figure for Q. No. 5 (a), find x and y. Also determine the critical thickness for this system. (25)
 (b) Describe the possibility of the existence of the random alloys with the help of phase diagram of quaternary compound $\text{A}_x\text{B}_{1-x}\text{C}_y\text{D}_{1-y}$. (10)
6. (a) Define monocrystalline, polycrystalline and amorphous materials. (6)
 (b) Why is lattice constant of semiconductor important for heterostructured devices? Discuss the effect of biaxial compression on opto-electronic devices. (17)
 (c) Explain differential negative resistance in GaAs and velocity saturation in Si. (12)
7. (a) What is effective mass? Explain a method with mathematical verification to determine effective mass from E-K diagram. (7)
 (b) Explain complete ionization of the acceptor atoms and freeze-out of donor atoms. Derive the equation of charge neutrality for the condition of complete ionization. (16)
 (c) A silicon device with n-type material is to be operated at $T = 550$ K. At this temperature, the intrinsic carrier concentration must contribute no more than 5 percent of the total electron concentration. Determine the minimum donor concentration required to meet this specification. (12)
8. (a) Define staggered, straddling and broken gap heterojunctions. Give one example of each type. (9)
 (b) Consider an n- $\text{In}_{0.8}\text{Ga}_{0.2}\text{As}$ and P-Gap heterojunction with $N_{\text{DN}} = 0.3 \times 10^{19} \text{ cm}^{-3}$ and $N_{\text{AP}} = 0.1 \times 10^{20} \text{ cm}^{-3}$ has following parameters given in table for Q. No. 8 (b). (26)
 (i) Draw the thermal equilibrium energy band diagram of the system with proper dimension.
 (ii) Determine ΔE_c , ΔE_v , V_{bi} , x_n and x_p for this system and show them in the energy band diagram.

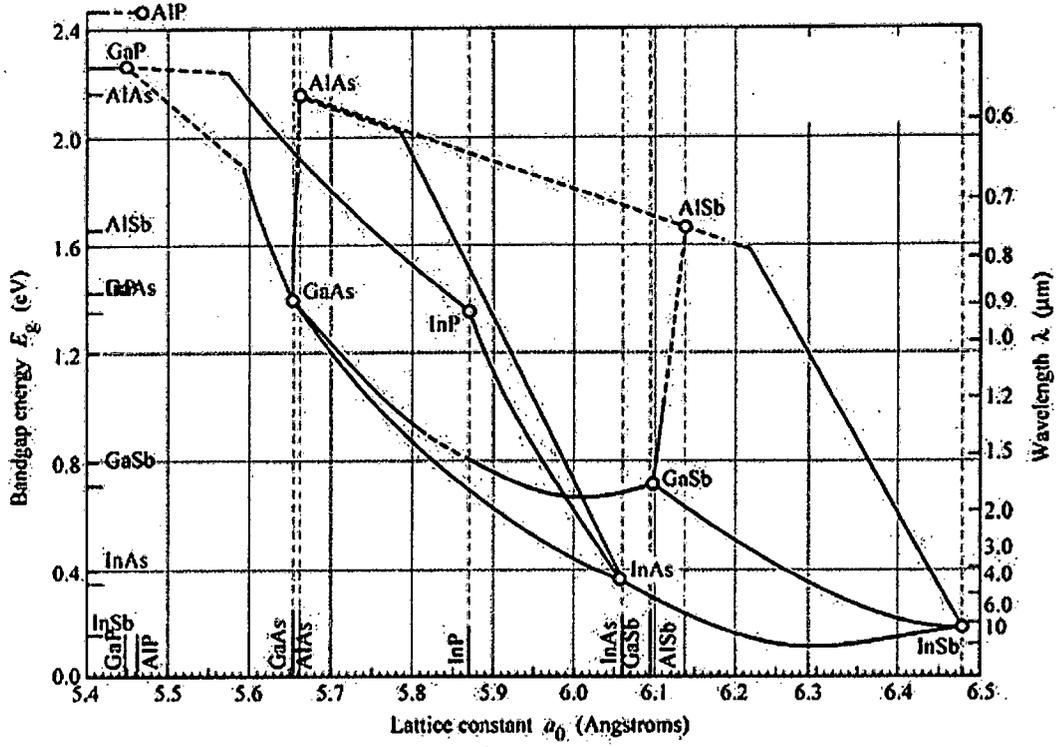


Figure for Q. No. 5(a)

Table for Q. No. 8(b)

Parameter	In _{0.8} Ga _{0.2} As	GaP
Electron Affinity(eV)	4.0	2.04
Bandgap(eV)	0.55	2.26
Conduction Band Density of States, N _c (cm ⁻³)	0.137×10 ¹⁸	0.186×10 ²⁰
Valance Band Density of States, N _v (cm ⁻³)	0.659×10 ¹⁹	0.123×10 ²⁰
Dielectric Constant	15.15	11.1

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2015-2016

Sub : **EEE 475** (Power Plant Engg.)

Full Marks: 210

Time : 3 Hours

The questions are of equal value

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Why the forecasting of (Electrical) Loads and Electrical Energy Requirement are necessary? Discuss in detail.
(b) What are the standard methods that are used for Load-Forecasting or estimates of future demand of electrical energy?
Explain in-detail the procedure of “Electrical Load-Forecasting” by using “Sectional Methods or Load Survey Methods.”
2. (a) “To determine the capacity of a power plant”, explain in-detail the procedure of uninterrupted power supply to meet the peak/ maximum load-demand.
(b) What are the factors to be considered while selecting the site/ location of the “Thermal Power Plants”? Explain them in-detail.
3. (a) Describe the general objectives of electric energy rate. With simple curves, describe between Block-Meter Rate and Hopkinson Demand Rate.
(b) A Wright demand rate is quoted as follows:
For energy purchased monthly, the equivalent of
 - (i) The first 50hr. use of max^m demand at 10.00 taka per KWhr.
 - (ii) The next 50hr. use of max^m demand at 8.00 taka per KWhr.
 - (iii) The next 100hr. use of max^m demand at 6.00 taka per KWhr.
 - (iv) The next 200hr. use of max^m demand at 4.00 taka per KWhr.
 - (v) All energy in-excess of foregoing blocks at 2.00 taka per KWhr.
 (A) Compute the bill for a monthly energy consumption of 4,32,000 KWhr with a maximum demand of 1600 KW. Compute the unit energy cost corresponding.
(B) Find the lowest possible bill for this energy consumption and the corresponding unit energy cost for a 30-day month.
4. (a) With very brief history of the development of Bangladesh Power Development Board, discuss on “Long Term Power Policy” of the Present Government of Bangladesh.
(b) Discuss on “Challenges in Power Sector Development”. How the government will be able to overcome those challenges/ limitations?

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SECTION-B

There are **FOUR** questions in this section. Answer any **THREE**

5. (a) Define the terms Demand Factors, Group Diversity Factor, Peak Diversity Factor, Load Factor and Utilization Factor.
 (b) Determine the maximum demand for the group of energy consumers shown in the table-1.

Table-1

Class of Service	Total Connected load, KW	Demand Factor in Percentage	Group Diversity Factor	Peak Diversity Factor
Apartments	2,000	55	4.0	1.20
Hospital	400	45	1.5	1.05
Foundry	7,000	80	1.1	1.05
Boiler Factory	8,000	90	1.1	1.05
Motor Factory	10,000	75	1.1	1.05

6. (a) Explain in-brief the performance of generating plants. Show that “ The Heat Rate (HR) of a continuous input-output is at a minimum when it equals the Incremental Rate (IR)”.
 (b) The input-output curve of a 30 MW generating station is defined by

$$I = 30 + 0.6L + 0.75 I^2$$

where, I is in millions of Btu per hour and L is in megawatts. Find the average heat-rate of this station for a day when it is operating:

at a load of 30 MW for 12 hours and

at a load of 0 MW for remaining 12 hours

Compare this average heat-rate with the heat rate that would be obtained if the same energy were produced for the day at a constant 24 hour load.

7. (a) Discuss the merits and demerits of hydro-electric power plant. Describe the criterion for site selection of this type of power plant.
 (b) Draw the schematic layout of hydro-electric power station and explain (i) Dam, (ii) Spill-way and (iii) Tail race.
8. (a) With a simple diagram show the different components of a Nuclear Power Station. Discuss them in very brief.
 (b) What are different types of Nuclear Reactors? Discuss them in brief. Which one is the best reactor? Why?

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2015-2016

Sub : **EEE 435** (Optical Fiber Communication)

Full Marks: 210

Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Classify the optical fibers in terms of refractive index, mode and material. Which type of fiber is suitable for high bit rate long haul optical fiber communication and why? (10)
- (b) Why is cabling necessary for optical fibers? Discuss the elements required for cable design. Draw the structure of a stranded loose tube cable with aluminum and steel tape plus non-metallic central strength member. (14)
- (c) What is the physical significance of numerical aperture of an optical fiber? The numerical aperture of a single-mode step index fiber is given as 0.095 and relative refractive index difference is 0.2%. Determine the core diameter required for the fiber to permit its operation over the wavelength range 1.48 to 1.60 μm . Calculate the new fiber core diameter to enable single-mode transmission at a wavelength of 1.3 μm . Also calculate the range of propagation constant for guided mode at this wavelength. (11)
2. (a) Define different optical fiber modes. How is a mode in a fiber uniquely determined? What are the hybrid modes and linearly polarized modes? (11)
- (b) Deduce the expressions of normalized frequency, V and normalized propagation constant, b and plot b as a function of V for a few low order fiber modes. Also show the condition of single-mode and multimode. (12)
- (c) With necessary figure define DGD and PMD. Distinguish between chromatic dispersion and PMD. Why PMD is detrimental for high bit rate systems for both coherent and non-coherent communication? (12)
3. (a) Draw the attenuation profile of silica fiber and show different low loss windows. What are the dominant factors of fiber loss? (10)
- (b) Why dispersion management is necessary? With necessary figures explain how dispersion management is done. (11)
- (c) Show the dispersion characteristics of SSMF, DSF, NZDSF and DFF, and mention their relative advantages and disadvantages with regard to optical fiber communication. (14)

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Contd... Q. No. 3(c)

A step index single-mode fiber exhibits material dispersion of 6 ps/nm/km at an operating wavelength of 1.55 μm. Assume the core refractive index as 1.45 and relative refractive index difference as 0.5%. Calculate the diameter of the core needed to make the total dispersion of the fiber zero at this wavelength. Given the following empirical formula

$$V \frac{d^2(bV)}{dV^2} \approx 0.080 + 0.549(2.834 - V)^2$$

where the symbols have their usual meanings.

4. (a) A digital single-mode optical fiber system is designed for operation at a wavelength of 1.55 μm and a transmission rate of 560 Mb/s over a distance of 50 km without repeaters. The rms pulse broadening over the total distance is 800 ps. The single-mode injection laser is capable of launching a mean power of -12 dBm into the fiber cable which exhibits a loss of 0.205 dB/km. In addition, average splice losses are 0.1 dB at 1 km intervals. The connector loss at the transmitter and receiver is 0.5 dB each and the receiver sensitivity is -40 dBm. Finally, an extinction ratio penalty of 1 dB is predicted for the system. Perform an optical power budget for the system and hence determine its viability. (11)
- (b) Distinguish between SBS and SRS and comment on their impact on multichannel transmission system. (10)
- (c) Write short notes on (Any Two): (14)
- (i) AWG
 - (ii) FBT coupler
 - (iii) OADM.

SECTION-B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Draw the cross-section of double heterojunction (DH) LED with the energy band diagram and explain its operational principle. (10)
- (b) Distinguish between spontaneous emission and stimulated emission. Explain the operational principle of an injection laser diode and find the following expression of the threshold current density for lasing. (15)

$$J_{th} = \frac{1}{\beta} \left[\bar{\alpha} + \frac{1}{2L} \ln \left(\frac{1}{r_1 r_2} \right) \right]$$

where symbols have their usual meanings.

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Contd... Q. No. 5

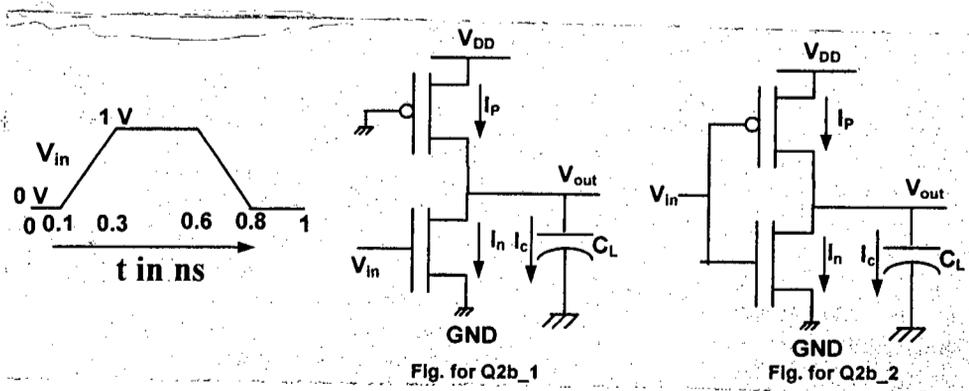
- (c) Define the differential external quantum efficiency and internal quantum efficiency of a laser diode and their relationship. (5)
- (d) Compare the spectral characteristics of an LED and ILD. (5)
6. (a) What are the different types of photodiodes? Discuss with a cross-section the principle of operation of the Avalanche photodiode (APD). (10)
- (b) What are the different noise components that arise during photodetection using PIN and APD? Write the expression for the signal to noise ratio (SNR) at the output of a direct detection receiver using a PIN photodiode. (15)
- (c) A silicon PIN photodiode has a quantum efficiency of 85 percent at an operating wavelength of 1310 nm. The PIN photodiode is used in a direct detection receiver with a load resistance of 50 ohm at an operating temperature of 27 degree Celsius. The data rate of transmission is 560 Mbps using intensity modulation with a received optical intensity of 300 μ w. Determine: (10)
- (i) Responsivity of the PD
 - (ii) RMS noise current at the output of the receiver
 - (iii) SNR at the output of the receiver
 - (iv) Bit Error Rate (BER)
- Given: $erfc(x) = exp(-x^2)$.
7. (a) Draw the block diagram of a coherent optical receiver. Find the expression of the output signal and noise currents considering a PIN photodiode with homodyne and heterodyne detection schemes. (15)
- (b) Explain the operational principle of Mach-Zohuder Intensity modulator with a schematic diagram. (10)
- (c) Explain the relative merits and limitations of an opto-electronic amplifier and an optical amplifier. Draw the schematic of an EDFA and its gain spectra. State its merits over SOA. (10)
8. Write short notes: (Any Three) (35)
- (i) Acousto-Optic Modulator
 - (ii) Electro-Optic Phase Modulator (EOPM)
 - (iii) Wavelength Division Multiplexing (WDM)
 - (iv) Febry Perot Amplifier (FPA)
-

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Explain the meaning of the following MOS model parameters: (10)
 - (i) K_p (ii) γ (iii) c_{jsw} (iv) m_{jsw} (v) u_0
- (b) Show the device cross-sectional diagram of the NMOS and PMOS transistor of a Pseudo NMOS inverter fabricated on a n-type Si wafer. Clearly indicate the source, drain, body contacts, interconnects and the bias connection of the back-gate. Explain why the back-gate of the transistors are not kept floating? (15)
- (c) Show that the resistance of a square sheet of interconnect material is same irrespective to the area of the sheet. (10)

2. (a) A CMOS inverter is designed such that the current carrying capacity of NMOS and PMOS transistor is equal i.e. ($\beta_n = \beta_p$). Assume that the supply voltage is 5 V and $V_{tn} = 1V$ and $V_{tp} = -1V$. Draw the transfer curve of the CMOS inverter and show the inversion voltage. From the transfer curve show the equation of high level noise margin and low level noise margin. Explain each parameter used in your equation graphically. What will happen to the low level noise margin and high level noise margin if $\beta_n \gg \beta_p$? (15)
- (b) Draw the approximate wave shape of V_{out} , I_p , I_n , I_c , P_n ($I_n \times V_{out}$), P_p ($I_p \times (V_{DD} - V_{out}t)$), P_c ($I_c \times V_{out}$) and $P_{V_{DD}}$ ($I_p \times V_{DD}$) for both the circuit shown in Fig. for Q 2b_1 and Fig. for Q 2b_2. (20)



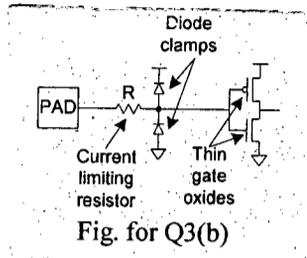
3. (a) Describe all the steps of photolithography to pattern a gate polysilicon layer in a CMOS inverter. (10)
- (b) An ESD protection circuit shown below needs a resistor, diode and MOS transistors. All of these devices have to be built in standard CMOS process. Show the

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Contd... Q. No. 3 (b)

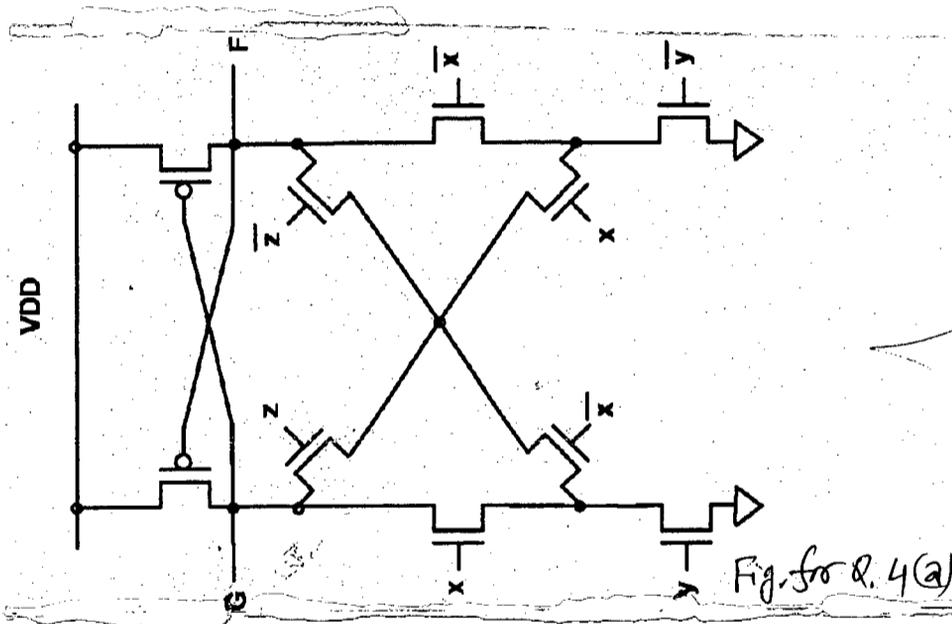
possible fabrication sequence of the circuit on a p-type COMS process. In each step show the mask and the cross-section of the circuit up to that step. For clarification you have to draw the composite layout first. The pad in the figure can be built from any metal layer.

(25)



4. (a) What are the function of F and G in the following diagram? Just write down the logic function without the need of logic minimization.

(10)



(b) You have to design a car alarm system in which the alarm will ring (Y=1) if any one of the following condition is satisfied. (i) {The key is in (K=1), the Seat belt is fasten (B=1) and the door is open (D=0)} or (ii) {The key is in, Door is closed and Seat belt is not fasten}. Write the Truth table, the Boolean equations and show the implementation of the circuit in (i) static CMOS, (ii) NMOS, (iii) Pseudo NMOS, (iv) Footed dynamic CMOS and (v) Un-footed dynamic CMOS.

(10)

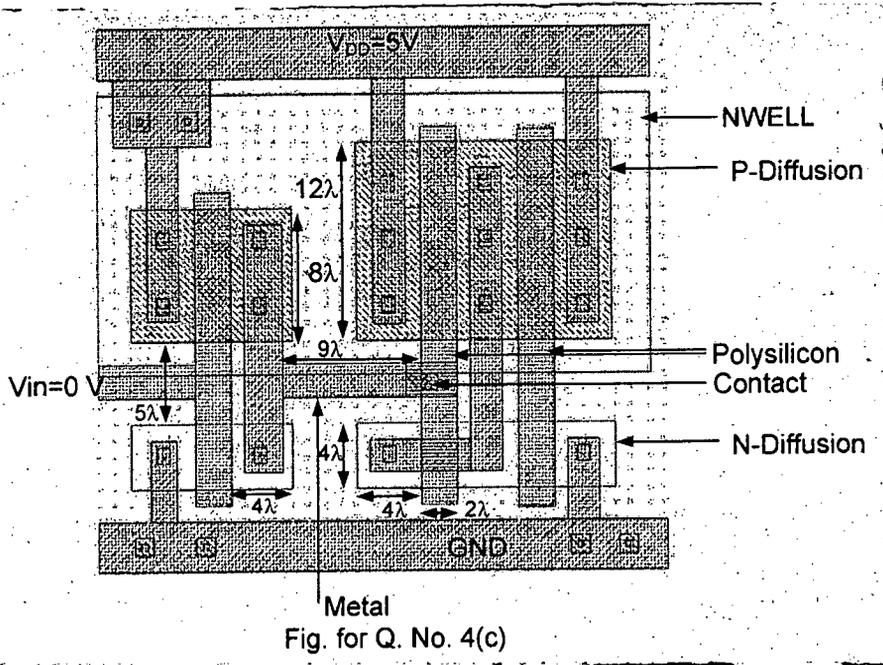
(c) Draw the schematic diagram of the circuit shown below. Calculate the rise time, fall time and power dissipation of the driver circuit. The following data are given:

(15)

Gate oxide capacitance = 35 fF/μm². Source/Drain bottom Junction capacitance = 15 fF/μm², Source/Drain side wall junction capacitance = 10 fF/μm, Poly-substrate capacitance = 5 fF/μm², metal-substrate capacitance = 3 fF/μm², μ_nC_{ox}=120 μA/V², μ_pC_{ox}=50 μA/V², V_{DD}=5V and f=20 MHz. Assume 100 nm process and all gate lengths are of 2λ.

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Contd... Q. No. 4 (c)



SECTION-B

There are **FOUR** questions in this section. Answer any **THREE**.

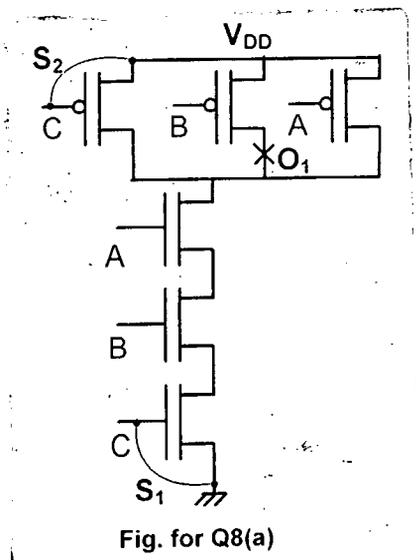
- 5. (a) Show the construction of a 4/1 mux using NMOS pass transistor. How would you connect the input if the mux is to be used as a 2 input XOR gate? (10)
- (b) What are the advantages of using 2-phase non-overlapping clock in a synchronous digital system? Show a suitable circuit which can be generated such a clock from a single source of master clock. (10)
- (c) The following diagram shows the truth table of a 3-bit Gray to Binary Converter. You have to design the hardware of the converter in a structured modular expandable way such that number of bits can easily be increased. Show the design of the unit cell and the connection of the 3-bit cell. Draw the layout of the unit cell in such a way that the cells can be easily connected together. (15)

Gray Code			Binary code		
G2	G1	G0	A2	A1	A0
0	0	0	0	0	0
0	0	1	0	0	1
0	1	1	0	1	0
0	1	0	0	1	1
1	1	0	1	0	0
1	1	1	1	0	1
1	0	1	1	1	0
1	0	0	1	1	1

Table for Q. 5(c)

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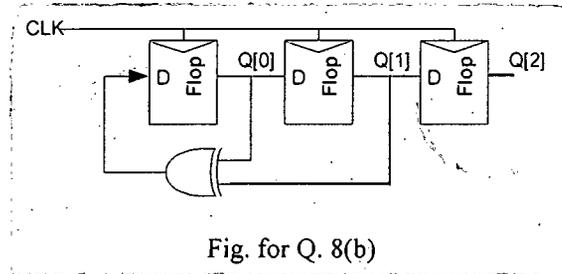
6. (a) Draw the circuit diagram of a 2×2 bit Six transistor Static Random Access Memory array. Show clearly the row select, column select, Precharge, Sense amplifiers and the I/O signal lines. Explain how a read and a write operation is done by assuming that the second row and second column cell is the target cell to write and read from. **(15)**
- (b) Draw the circuit diagram of the 1T DRAM cell and explain how read and write operation is performed in this cell. Draw a cross-sectional diagram of the memory cell and explain how the cell saves silicon area. **(10)**
- (c) A metal line of $100 \mu\text{m}$ long and 100 nm wide is used as a bit line. Capacitance from metal line to substrate is $100 \text{ aF}/\mu\text{m}^2$, and a memory cell is connected in every 400 nm . Each memory cell is connected through an NMOS device to the bit line having a source or drain implant capacitance of 0.4 fF , and a typical value for the memory bit capacitance, C_{mbit} is 20 fF and V_{DD} is 1 V . If the bit line was pre-charged to $V_{\text{DD}}/2$, calculate the change in bit line voltage when accessing the memory cell. (Note: $a = 10^{-18}$, $f = 10^{-15}$) **(10)**
7. A sequence detector produces a '1' for each occurrence of the input sequence '1001' at its input.
- (a) (i) Draw the state-transition diagram of the FSM realizing the sequence detector. **(20)**
- (ii) Obtain state table from the state transition diagram.
- (iii) Realize the FSM using D FFs and combinational logic.
- (b) Show the complete design of a modulo-8 counter using Finite State Machine approach and show the implementation of the circuit using D FFs and combinational logic. **(15)**
8. (a) A three input CMOS NAND gate is shown in figure below. The circuit has three faults S_1 , S_2 , and O_1 as shown in the figure. Considering one fault at a time find appropriate test vector(s) to detect each of the faults. **(15)**



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Contd... Q. No. 8

(b) A pseudo random sequence generator (PRSG) is built with the linear feedback shift register shown below. Assuming the circuit reset to 111, find the pseudo random sequence generated by the circuit. (10)



(c) What is built-in Logic Block Observer (BILBO)? Show how a BILBO circuit can be constructed from a PRSG and signature analyzer to check the functionality of a logic block and explain how the circuit works. (10)

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Draw a dc/dc chopper circuit and explain how can it be controlled using pulse width modulation. (18)
 (b) A dc/dc chopper is used to drive a dc motor having a permanent magnet field. The switching frequency of the chopper is 1 kHz. The dc source voltage is 400 V dc. At full load the motor draws a dc current of 50 A. The chopper switch has conduction resistance of 0.85Ω and loss per switching of 0.5 W. The freewheeling diode has a conduction voltage drop of 1.5 V at 50 A. (17)
 (i) Determine the chopper efficiency
 (ii) What would be the chopper efficiency when the motor draws 40 A dc current?
 For (i) Consider chopper duty cycle = 0.8 and for (ii) Consider chopper duty cycle= 0.7
2. (a) Explain with a neat diagram and necessary equations the buck-boost operation of a fly back switching regulator. (18)
 (b) Design a switching Buck regulator where the worst case current ripple should be limited to 15 mA and output voltage ripple limited to 10 mV. Choose a switching frequency in the range of 40 kHz to 50 kHz. (17)
3. (a) Draw and explain the operation of a single phase full bridge voltage source inverter. (12)
 (b) A single phase full bridge inverter is driven from a voltage source and is operated in square wave mode. If the peak magnitude of the 3rd harmonic component of the output voltage is 50 V, determine (12)
 (i) Inverter supply voltage Vs
 (ii) RMS value of fundamental of the output voltage.
 (c) What is dead time as referred to voltage source inverter? Explain the impacts of dead time is VSI. (11)
4. (a) With a neat diagram, explain the construction and operation of a resonant inverter. Also cite a specific application of resonant inverter with reasoning. (10)

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Contd... Q. No. 4

- (b) Draw a three phase VSI and explain with necessary gating waveforms how 3- ϕ output can be obtained using 180⁰ conduction schedule. Consider a 3- ϕ star connected balanced load. (15)
- (c) A three phase VSI running in square wave mode with 180⁰ conduction needs to output a line to line fundamental output voltage of 415 V (RMS). Determine the inverter dc supply voltage (V_s). (10)

SECTION-B

There are **FOUR** questions in this section. Answer any **THREE** questions.

5. (a) Describe the operation of SCR using the two transistor model. (12)
- (b) Define latching current and holding current of SCR. (5)
- (c) Why volts/hertz control is applied in induction motor? Briefly explain with the torque speed characteristics of induction motor. (18)
- Explain any two possible circuit arrangements for obtaining variable voltage and frequency.
6. Draw the power circuit of a three phase voltage controller. Show the gate pulses for firing angle $\alpha = 60^0$. Draw the waveforms of line to neutral and line to line voltages for $\alpha = 60^0$, corresponding to input voltage. Show calculations for determining the waveforms of voltages. (6+6+12+11)
7. (a) Draw the power circuit of single phase full wave controlled rectifier. Explain its operation by drawing the waveforms of gate pulses, input current and output voltage, corresponding to input voltage. Derive the expression of rms output voltage. (12)
- (b) Prove that , the average output voltage of single phase full wave controlled rectifier is twice of average output voltage of half wave controlled rectifier (8)
- $$V_{o,avg} (\text{Full wave}) = 2 V_{o,avg} (\text{Half wave})$$
- (c) Design an efficient circuit to produce an average voltage of 40V across a 100 Ω load resistor from a 120 V rms 60 Hz ac source. Determine the power absorbed by resistance and input power factor. (15)
8. (a) Draw the circuit of a three phase SCR controlled rectifier (full wave/ six pulse). With proper input V_{LN} , V_{LL} , gate pulses of 6 SCRs, output voltage waveform and input currents of three phases, explain the operation of rectifier for resistive load with firing angle $\alpha = 60^0$. (24)

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Contd... Q. No. 8

(b) The following figure shows dc transmission line, where ac voltage to each of the bridges is 230 kV rms line to line. The total line resistance is 10Ω , and the inductance is large enough to consider the dc current to be ripple free. The objective is to transmit 100 MW to ac system 2 from ac system 1 over the dc line. Given that $V_{o2} = -200$ kV. Find the firing angle for converter 1 and converter 2. Also determine the power loss in the line.

(11)

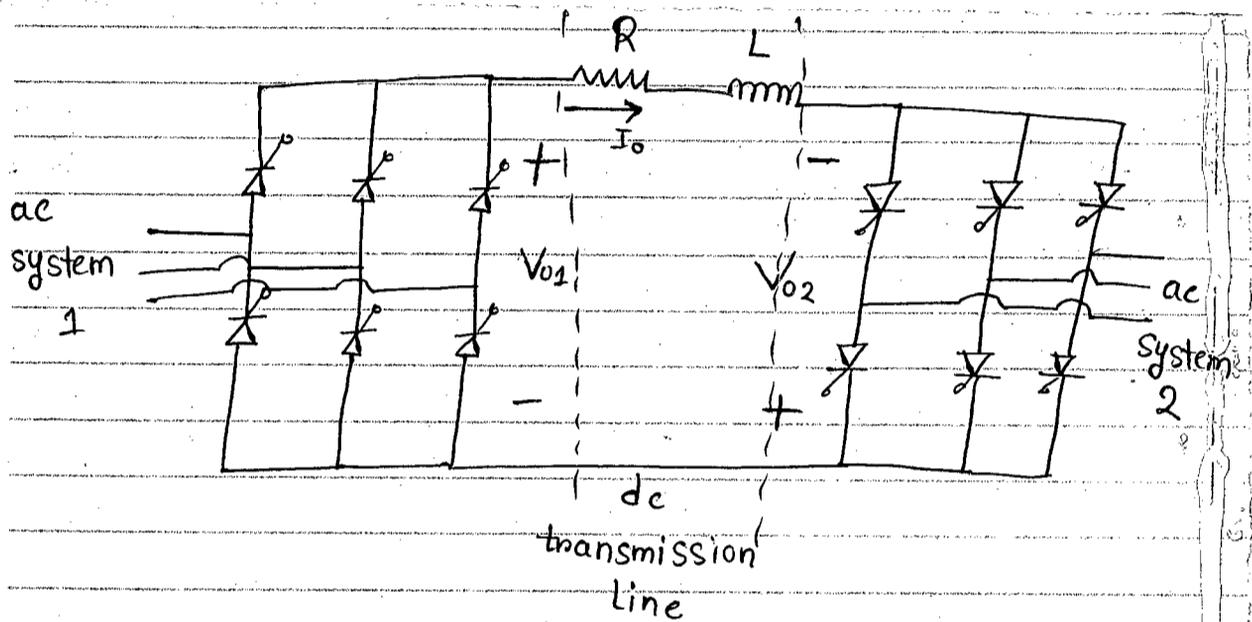


Fig for Q.No 8(b)

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Develop a simplified expression for developed torque in a switched reluctance motor (SRM). What does this expression tells us about the basic SRM control strategy? **(15)**
 (b) What is the essential difference between switched reluctance motor and stepped motor? Why and where PWM technique is applied in SRM? **(12)**
 (c) Explain why increasing number of SRM phases reduces torque ripple? **(8)**

2. (a) Consider a phase-angle drive system for a universal motor. A triac is used as the switch controlled by a microcontroller. What subroutines would you propose to meet the following requirements for the control system? **(18)**
 - (i) Generate pulses for the triac
 - (ii) Match firing pulse time of the triac in relation with zero crossing of line voltage
 - (iii) Speed measured by a tachometer and A/D converter
 - (iv) Protection for the motor when the shaft is blocked
 - (v) Include START and STOP command.
 (b) Describe the operation of a simple 3-phase unipolar-operated brushless DC motor having optical sensors as position detectors. Draw a diagram showing the switching sequence and rotation of stator's magnetic field. **(17)**

3. (a) Discuss the demagnetization effect on air gap flux in a permanent magnet DC (PMDC) motor. **(20)**
 (b) "In the cases of both under commutation and over commutation, high brush current densities cause excessive heating and wear in a PMDC"– explain. **(15)**

4. (a) Explain the operating principle of the conduction pump and hence its difference with the induction pump. **(13)**
 (b) Present a schematic drawing of an amplidyne follow-up system and briefly explain its operation **(12)**
 (c) Show mathematically that the hysteresis component of torque in a hysteresis motor is constant at all rotor speeds. **(10)**

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SECTION-B

There are **FOUR** questions in this section. Answer any **THREE**

5. (a) What are the components of a Magneto Hydrodynamic Generator (MHD). Cite applications of MHD in power generation. **(10)**
(b) What are the limitations of MHD? Can we replace the conventional thermal power plants with MHD? Give justification to your answer. **(25)**

 6. (a) Draw the characteristics of a wind turbine and explain how it can be utilized for running with high efficiency. **(15)**
(b) Explain with a neat diagram how wind turbine can be utilized to supply power to a high voltage DC grid system. **(20)**

 7. (a) What is an acyclic generator? How does it differ from a conventional ac power generator? **(10)**
(b) Explain the functionalities of Amplidyne and Metadyne generators. Cite one application example for each of the Amplidyne and Metadyne generators. **(15)**
(c) Devise a system that would utilize thermo electric effects as the conversion technology and charge a battery in a desert area. **(10)**

 8. (a) With necessary functional blocks and diagram explain the principle of operation of a thermo electric DC conduction pump. **(15)**
(b) Design an isolated grid power system having non conventional generators but operating from geo-thermal, wind and solar sources. **(20)**
-

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Many commercial Fourier analyzers continuously update the estimate of the power spectrum of a process $x(n)$ by exponential averaging periodograms as follows, (17)

$$\hat{P}_i(e^{j\omega}) = \alpha \hat{P}_{i-1}(e^{j\omega}) + \frac{1-\alpha}{N} \left| \sum_{n=0}^{N-1} x_i(n) e^{-jn\omega} \right|^2$$

where $x_i(n) = x(n + Ni)$ is the i th sequence of N data values. This update equation is initialized with $\hat{P}_{-1}(e^{j\omega}) = 0$.

(i) Qualitatively describe the philosophy behind this method, and discuss how the value for the weighting factor α should be selected.

(ii) Assuming that successive periodgrams are uncorrelated and $0 < \alpha < 1$, find the mean of $\hat{P}_i(e^{j\omega})$ for a Gaussian random process.

- (b) The second-order AR spectrum of a process $x(n)$ is (18)

$$\hat{P}_{AR}(e^{j\omega}) = \frac{2}{|1 - 0.5e^{-j\omega} + 0.25e^{-2j\omega}|^2}$$

What is the second-order minimum variance spectrum?

2. (a) Consider a signal $x(n) = S(n) + w(n)$, where $S(n)$ is an AR(1) process that satisfies the difference equation (17)

$$S(n) = 0.8 S(n-1) + v(n)$$

where $v(n)$ is a white noise sequence with variance $\sigma_v^2 = 0.49$ and $w(n)$ is a white noise sequence with variance $\sigma_w^2 = 1$. The process $v(n)$ and $w(n)$ are uncorrelated.

(i) design a Wiener filter of length $M = 2$ to estimate $S(n)$.

(ii) Determine the MMSE for $M = 2$.

- (b) To illustrate the relationship between excess mean square error and step-size of the LMS algorithm, consider an adaptive filter of order $M = 1$ with the following input and desired output: (18)

$$x(n) = 2\cos(0.5\pi n) + v(n)$$

$$d(n) = \sin(0.5\pi n)$$

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Contd... Q. No. 2(b)

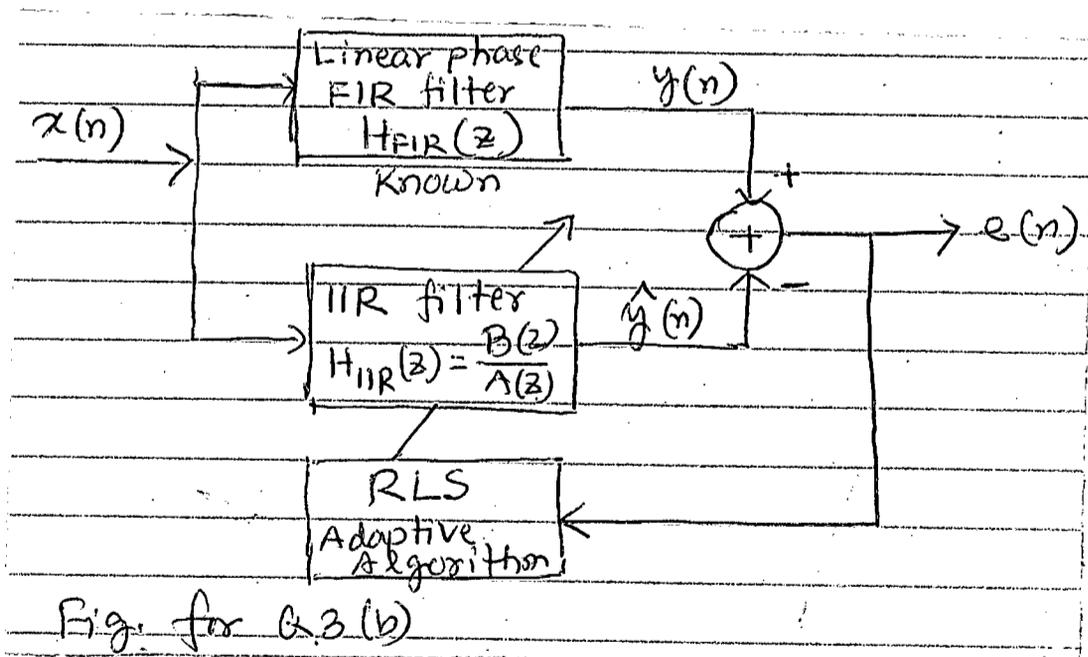
Here, $v(n)$ represents white noise uniformly distributed over the interval $[-0.5, 0.5]$ that is statistically independent of $2\cos(0.5\pi n)$. Determine the range of the step-size μ and the misadjustment factor M_f . How does the step-size affect the convergence speed and steady-state accuracy of the LMS algorithm?

3. (a) Determine the frequency and power of a single real sinusoid in additive white noise using the root MUSIC method. The noisy signal correction function is given by (18)

$$r_{yy}(m) = \begin{cases} 3, & m = 2 \\ 0, & m = 1 \\ -2, & m = 2 \\ 0, & |m| > 2 \end{cases}$$

Compare the results with those of the Pisarenko harmonic decomposition method. Comment if they are different.

- (b) An approximately linear phase IIR filter is to be designed using the system identification approach shown in Fig. for Q. 3(b). Assuming that the linear phase FIR filter $H_{FIR}(z)$ is known, summarize the RLS algorithm (beginning with the definition of the cost function) for this design problem. Choose the filter order and initial conditions as appropriate. (17)



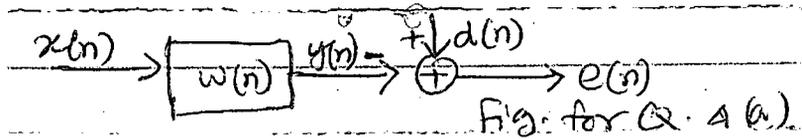
4. (a) For the block diagram shown in Fig. for Q. 4 (a), the unknown M -th order FIR filter coefficients are to be estimated using the leaky LMS algorithm. Show that the gradient based iterative minimization of the cost function (15)

$$J(n) = |e(n)|^2 + \alpha \|\omega(n)\|^2$$

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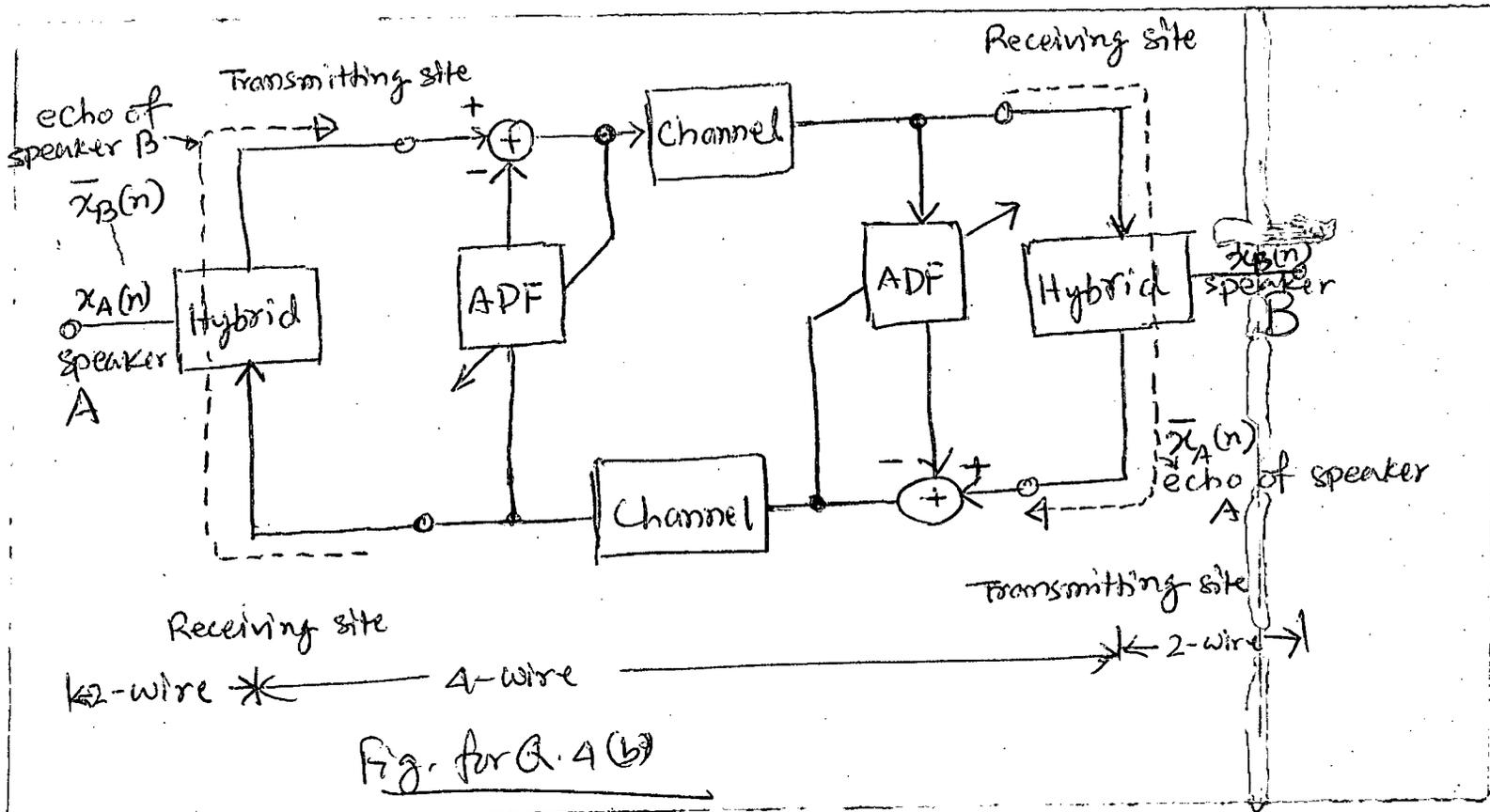
Contd... Q. No. 4(a)

with respect to the filter coefficient vector $w(n)$ would serve the purpose. Here α is a constant and $\| \cdot \|$ denote the l_2 -norm.



(b) Given an application of the echo cancellation shown in Fig. for Q. 4 (b). (20)

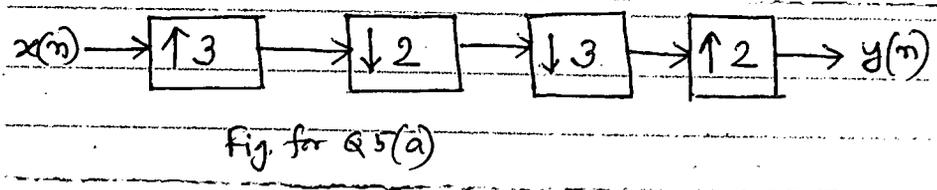
- (i) Explain the concepts and benefits of using the echo canceller;
- (ii) Explain the operations of the adaptive filter at the speaker B site;
- (iii) Determine all difference equations including the cost function and parameter update equation to implement the adaptive filter at the speaker A site.



SECTION-B

There are **FOUR** questions in this section. Answer any **THREE**

5. (a) For the system shown in Fig. for Q. 5(a), find an expression of $y(n)$ in terms of $x(n)$. Simplify the expression as much as possible. (12)



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Contd... Q. No. 5

(b) Let $H(z)$ represent an FIR filter of length 10 with impulse response coefficients $h(n) = \left(\frac{1}{2}\right)^n$ for $0 \leq n \leq 9$. (10)

Find the polyphase components $P_0(z)$ and $P_1(z)$.

(c) Consider the following specification of a 50 fold decimation filter: (13)

Passband edge: 70 Hz

Stopband edge: 80 Hz

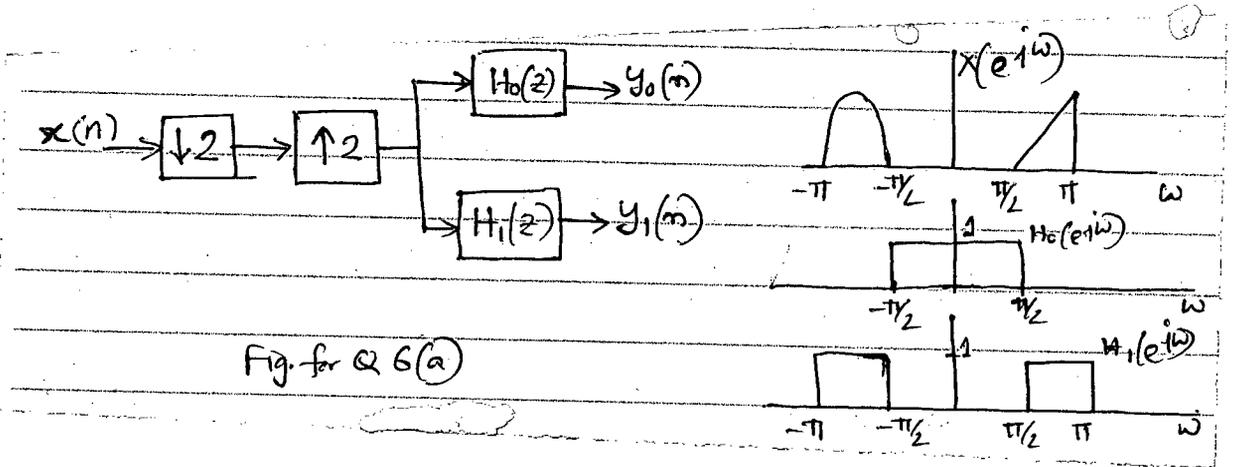
Ripple: $\delta_1 = 0.01, \delta_2 = 0.01$

Input sampling rate: 8kHz

What is the advantage of a two-stage decimation instead of single stage implementation. You may calculate the filter order using:

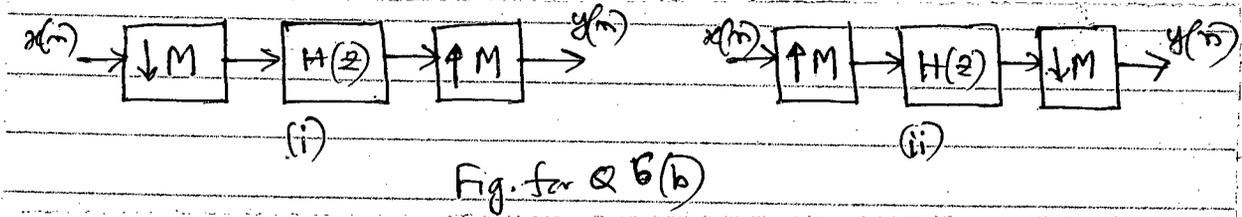
$$\hat{M} = \frac{-10 \log_{10} \delta_1 \delta_2 - 13}{14.6 \Delta f} + 1$$

6. (a) Consider the structure shown in Fig. for Q. 6(a), with the frequency-domain representation of input signal and the filter as (13)



Sketch the spectra $Y_0(e^{j\omega})$ and $Y_1(e^{j\omega})$.

(b) Find the following systems are linear time invariant (LTI) or not. (12)



Note that for an LTI system with input $x(n)$ and output $y(n)$, $Y(z) = G(z) X(z)$.

(c) Why is a two channel QMF bank that results in perfect reconstruction not a good choice for sub-band coding? What is more desirable filter response in this respect? (10)

7. (a) What is the advantage of using model based method for spectrum estimation as compared to non-parametric method? (7)

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Contd... Q. No. 7

(b) Consider an autoregressive process, $u(n)$, described by the difference equation (23)

$$u(n) = u(n-1) - 0.5u(n-2) + v(n)$$

where $v(n)$ is white-noise process of zero mean and variance 0.5.

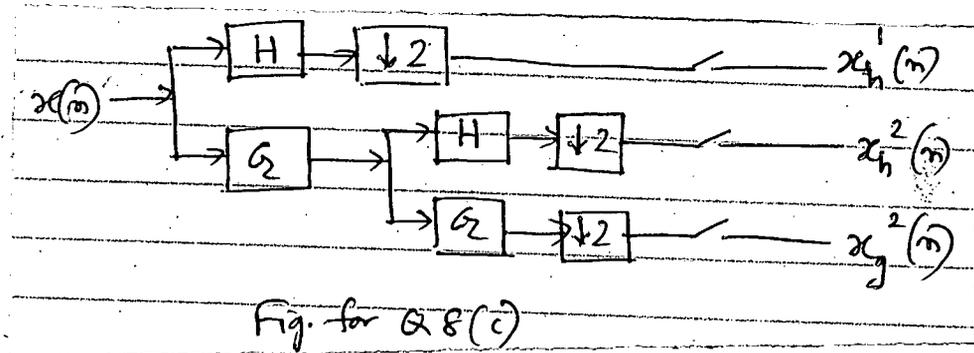
- (i) Find the power spectrum of $u(n)$.
- (ii) Write the Yule-Walker equation for the process and solve these equations to find the autocorrelation values $r_{uu}(1)$, $r_{uu}(2)$.
- (iii) Find the variance of $u(n)$.

(c) What is the relationship between poles and zeros of an ARMA process and its estimated power spectrum? (5)

8. (a) For the signal $x(n) = \{2, 2, 2, 4, 4, 4\}$, find its first level Haar transform. Compute signal $\hat{x}(n)$ by inverse transforming the compressed Haar transform obtained by setting all the fluctuation values equal to zero. (12)

(b) Explain how wavelet transform can be applied for denoising a noisy signal. (11)

(c) Consider the following 2-level DWT tree on the analysis part (12)



Assume for a specific input sequence $x(n)$, you get the following wavelet and scaling coefficients

$$x_n^1(n) = \{\dots, 0, 0, 1, -1, 1, -1, 2, 0, 0, 0, \dots\}$$

$$x_n^2(n) = \{\dots, 0, 0, -1.5, 1.5, -1.5, 1.5, 0, 0, 0, \dots\}$$

$$x_g^2(n) = \{\dots, 0, 0, 2, -1.5, 0.5, -0.5, 0.5, 0, 0, 0, \dots\}$$

If you can select only one of the switches and see the output after the synthesis, closing which one will give the best approximation of the input in the l_2 sense?