

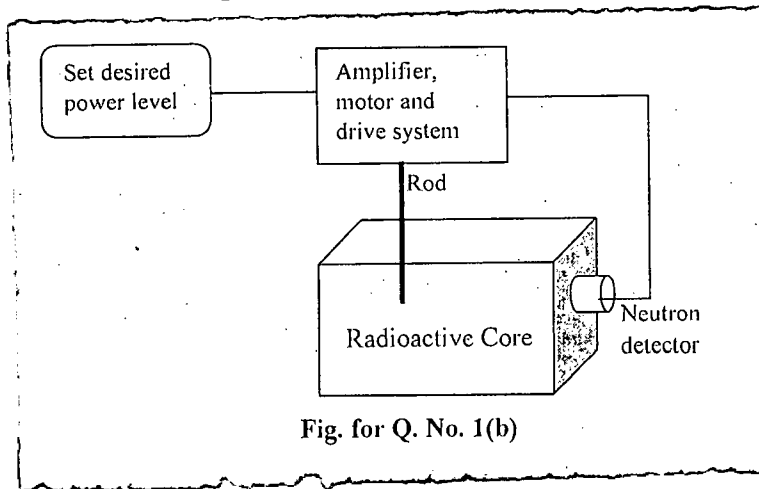
SECTION – A

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

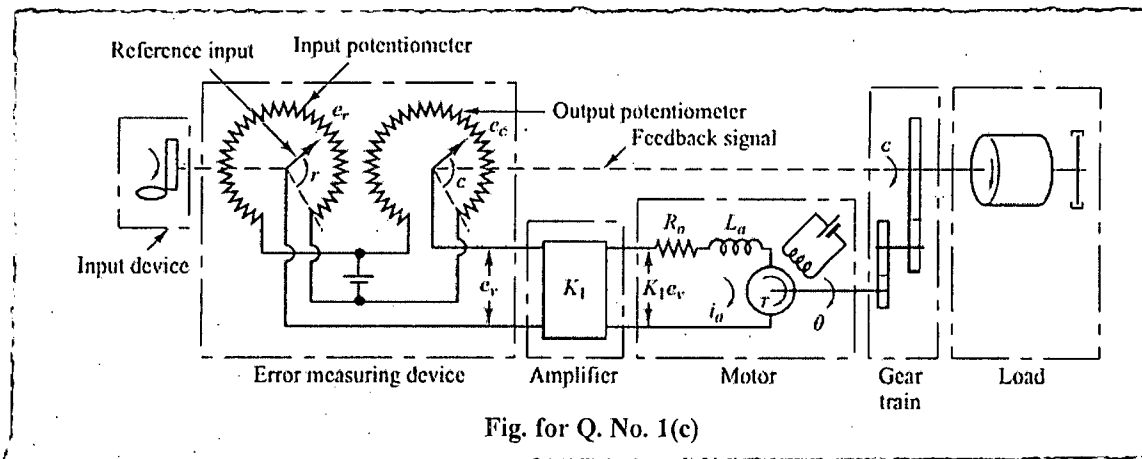
The symbols have their usual meanings.

1. (a) Show the design process of a control system using block diagrams. (6)

(b) In a nuclear power plant, heat from a reactor is used to generate steam for turbines. The rate of fission reaction in the reactor determines the amount of heat generated, and this rate is controlled by rods inserted into the radioactive core. The rods regulate the flow of neutrons. If the rods are lowered into the core, the rate of fission will diminish; if the rods are raised, the fission rate will increase. By automatically controlling the position of the rods, the amount of heat generated by the reactor can be regulated. Draw a functional block diagram for the nuclear reactor control system shown in the Fig. for Q. No. 1(b). Show all blocks and signals. (9)

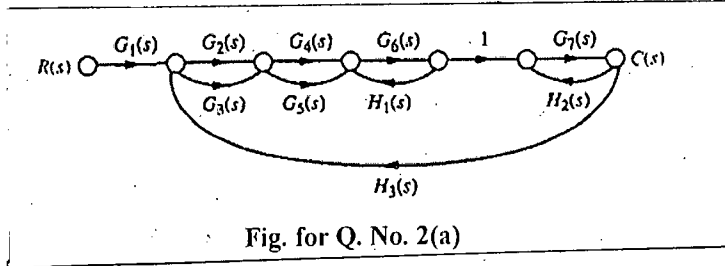


(c) The schematic diagram of a servo motor system is shown in the Fig. for Q. No. 1(c). r and c , shown in the figure, are reference input and controlled output, respectively. Draw the block diagram for the system and find its closed-loop transfer function. Given: J_0 and b_0 are the moment of inertia and viscous friction coefficient, respectively, of the combination of the motor, load, and gear train referred to the motor shaft. (10+10)



EEE 401

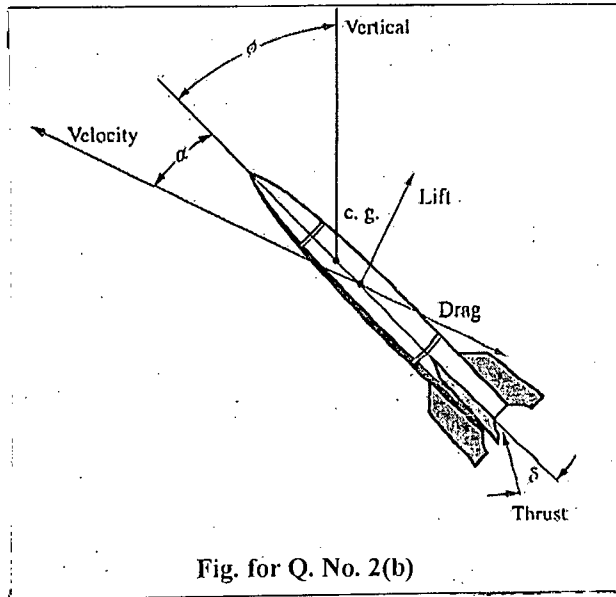
2. (a) Using Mason's rule, find the transfer function, $T(s) = C(s)/R(s)$, for the system shown in the Fig. for Q. No. 2(a). (15)



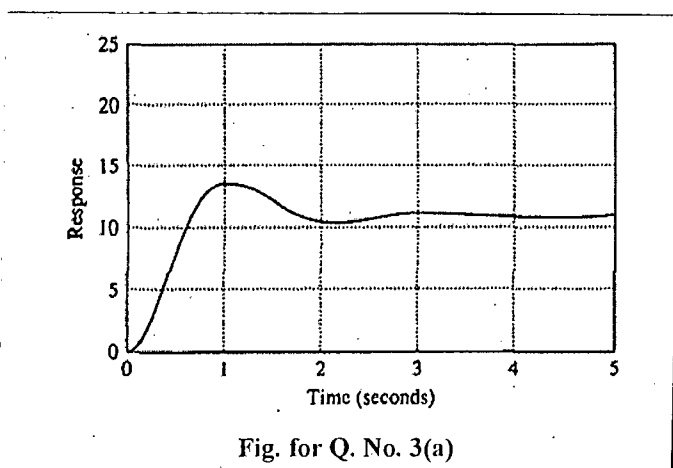
- (b) A missile in flight, as shown in Fig. for Q. No. 2(b), is subject to several forces: thrust, lift, drag, and gravity. The missile flies at an angle of attack, α , from its longitudinal axis, creating lift. For steering, the body angle from vertical, ϕ , is controlled by rotating the engine at the tail. The transfer function relating the body angle, ϕ , to the angular displacement, δ , of the engine is of the form: (10+10)

$$\frac{\Phi(s)}{\delta(s)} = \frac{K_a s + K_b}{K_3 s^3 + K_2 s^2 + K_1 s + K_0}$$

Represent the missile steering control in state space in phase-variable canonical form. Also draw the corresponding signal flow graph.



3. (a) The unity step response of a control system is found to be as shown in Fig. for Q. No. 3(a). Find the transfer function of the system. (10)



EEE 401

Contd ... Q. No. 3

(b) A second-order control system has the closed-loop transfer function $T(s) = Y(s)/R(s)$.

The system specifications for a step input follow:

Percent overshoot, %OS ≤ 5

Settling time, $T_s < 4s$

Peak time, $T_p < 1s$

Show the permissible area for the poles of T(s) in order to achieve the desired response.

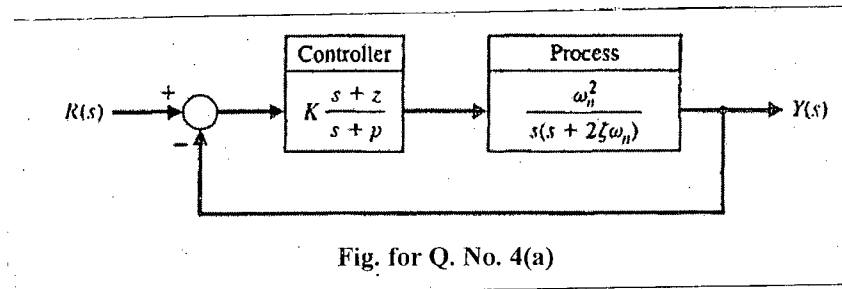
(c) An industrial robot, used to move 55-pound bags of salt pellets, uses a vacuum head to lift the bags before positioning. The robot can move as many as 12 bags per minute. The transfer function of the swivel controller and the plant of the robot is given by,

$$G(s) = \frac{\omega_0(s)}{V_i(s)} = \frac{k}{(s+10)(s^2 + 4s + 10)}$$

where $\omega_0(s)$ is the Laplace transform of the robot's output swivel velocity and $V_i(s)$ is the voltage applied to the controller.

Evaluate percent overshoot, settling time and peak time of the response of the swivel velocity to a step-voltage input.

4. (a) Consider the system shown in the Fig. for Q. No. 4(a). Determine the conditions on K, p, and z that must be satisfied for closed-loop stability. Assume that $K > 0$, $\zeta > 0$, and $\omega_n > 0$.

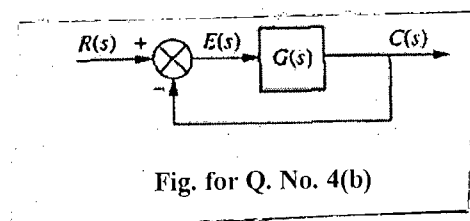


(b) Using the Routh-Hurwitz criterion and the system shown in the Fig. for Q. No. 4(b)

with $G(s) = \frac{k}{s(s+1)(s+2)(s+5)}$,

(6+6+6)

- (i) find the range of K for stability.
- (ii) find the value of K for marginal stability.
- (iii) Find the frequency of oscillation when the system is marginally stable.



EEE 401**SECTION – B**

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

Use semi-log graph paper for Q. 6(b). Attach it with answer script.

5. (a) The steady-state error in velocity of a system is defined to be (20)

$$e_{ss, \text{ velocity}} = \lim_{t \rightarrow \infty} \left(\frac{dr}{dt} - \frac{dc}{dt} \right),$$

where r is the system input, and c is the system output. Find the steady-state error in velocity for an input of $t^3 u(t)$ to a unity gain negative feedback system with a forward transfer function of

$$G(s) = \frac{100(s+1)(s+2)}{s^2(s+3)(s+10)}.$$

- (b) For a unity gain negative feedback control system with open loop transfer function (15)

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

find the steady state error with unit-step input. Also the sensitivity of steady state error to changes in parameter K .

6. (a) For a unity gain negative feedback control system with open loop transfer function (18)

$$G(s) = \frac{K(s+2)(s+3)}{(s^2 - 2s + 2)},$$

sketch the root locus. Also, find the angle of departure from complex poles, and break-in point.

- (b) Consider a unity gain negative feedback control system with open loop transfer function (17)

$$G(s) = \frac{100K}{s(s+36)(s+100)},$$

find the value of gain, K , to yield a 9.5% overshoot in the transient response for a step input. Use frequency response method only, Relation between phase margin, ϕ_M and damping ratio, ζ is given by,

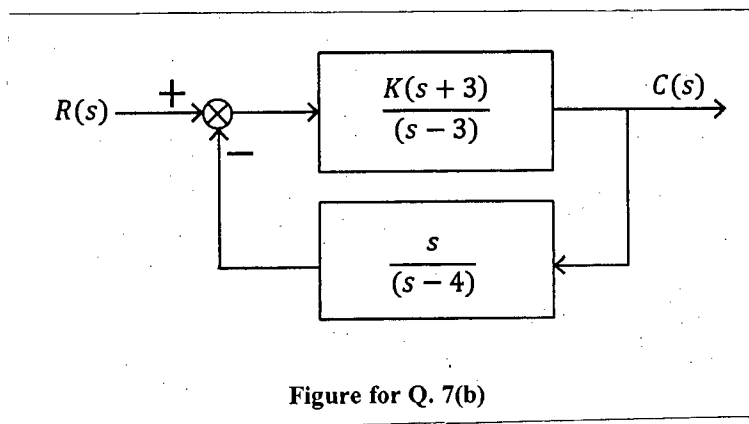
$$\phi_M = \tan^{-1} \frac{2\zeta}{\sqrt{-2\zeta^2 + \sqrt{1 + 4\zeta^4}}}.$$

Use semi-log graph paper for bode plot and attach it with answer script.

EEE 401

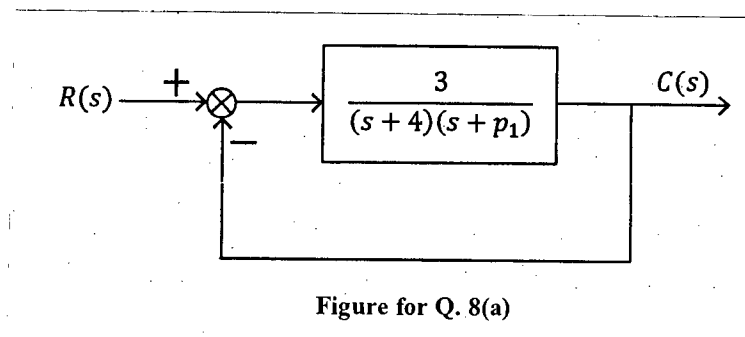
7. (a) Derive the equations for constant M and N circles. Roughly sketch them also. (15)

(b) Consider the following system shown in Figure 7(b), (20)



- (i) Draw Nyquist diagram for $K = 1$. Is this system stable?
- (ii) Find the range of stability for K .

8. (a) Draw the root locus for the system shown in Figure 8(a) with p_1 as a parameter. (10)



(b) Consider a unity gain negative feedback system with forward transfer function, (25)

$$G(s) = \frac{K}{(s+2)(s+4)(s+6)(s+8)}$$

Find the transfer function of a lag-lead compensator that will yield a settling time 0.5 second shorter than that of the uncompensated system, with a damping ratio of 0.5, and improve the steady-state error by a factor of 30. Choose the lead compensator's zero to be at -5 . Also, find the compensated system's gain. [Assume, second order approximation is valid, and you don't need to check.]

SECTION – A

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

All the symbols have their usual meanings.

1. (a) An unknown semiconductor has $E_g = 1.1$ eV and $N_c = N_v$. It is doped with 10^{15} cm⁻³ donors, where the donor level is 0.2 eV below E_c . Given that E_F is 0.25 eV below E_c , calculate n_i and the concentration of electrons and holes in semiconductor at 300 K. Also calculate the concentration of ionized donors. (25)
- (b) For a Si conductor of length 5 μm, doped n-type at 10^{15} cm⁻³, calculate the current density for an applied voltage of 2.5 V across its length. How about for a voltage of 2500 V? The electron and hole mobilities are 1500 cm²/V-s and 500 cm²/V-s, respectively, in the ohmic region for electric fields below 10⁴ V/cm. For higher fields, electrons and holes have a saturation velocity of 10⁷ cm/s. (10)
2. (a) Derive the expressions of the recombination rates and the lifetimes of excess carriers considering defect states within the forbidden-energy bandgap of a semiconductor. (20)
- (b) An n-type Si slice of a thickness L is inhomogeneously doped with phosphorus donor whose concentration profile is given by $N_D(x) = N_0 + (N_L - N_0) (x/L)$. $N_{0(L)}$ is the concentration at the front (back) surface. Derive the expression for the electric potential difference between the front and the back surfaces when the sample is at thermal and electric equilibria. (15)
3. (a) A Si sample with 10^{16} /cm³ donors is optically excited such that 10^{19} /cm³ electron-hole pairs are generated per second uniformly in the sample. The laser causes the sample to heat up to 450 K. Find the quasi-Fermi levels and change in conductivity of the sample upon shining the light. Electron and hole lifetimes are both 10 μs. $D_p = 12$ cm²/s; $D_n = 36$ cm²/s; $n_i = 10^{14}$ cm⁻³ at 450 K. (15)
- (b) A diffused silicon pn junction has a linearly graded junction on the p side with $a = 2 \times 10^{19}$ cm⁻⁴ and a uniform doping of 10^{15} cm⁻³ on the n side. If the depletion width on the p side is 0.7 μm at zero bias, find the total depletion width, built-in potential, and maximum electric field at zero bias. Also plot the potential function through the junction. (20)
4. (a) For a silicon pn junction at T = 300 K, assume $\tau_{p0} = 0.1 \tau_{n0}$ and $\mu_n = 2.4 \mu_p$. The ratio of electron current crossing the depletion region to the total current is defined as the electron injection efficiency. Determine the expression for the electron injection efficiency as a function of N_d/N_a and the ratio of n-type conductivity to p-type conductivity. (15)

EEE 413

Contd ... Q. No. 4

(b) The cross-sectional area of a silicon pn junction is 10^{-3} cm^2 . The temperature of the diode is $T = 300 \text{ K}$ and the doping concentrations are $N_d = 10^{16} \text{ cm}^{-3}$ and $N_a = 8 \times 10^{15} \text{ cm}^{-3}$. Assume minority carrier lifetime of $\tau_{n0} = 10^{-6} \text{ s}$ and $\tau_{p0} = 10^{-7} \text{ s}$. Calculate the total number of excess electrons in the p region and the total number of excess holes in the n region for $V_a = 0.4 \text{ V}$.

(20)

SECTION – B

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

The symbols have their usual meanings.

Assume reasonable values for any missing data.

5. (a) What is the main difference between ohmic and Schottky contacts? Draw the energy band diagrams of metal-semiconductor (n-type) ohmic and Schottky contacts and explain their operational principles.

(20)

(b) The excess electron concentration in the base of an npn transistor is given by

(15)

$$\delta n_B(x) = \frac{n_{B_0} \left\{ \left[\exp\left(\frac{eV_{BE}}{KT}\right) - 1 \right] \sinh\left(\frac{x_B - x}{L_B}\right) - \sinh\left(\frac{x}{L_B}\right) \right\}}{\sinh\left(\frac{x_B}{L_B}\right)}$$

If $\delta n_{B_0}(x)$ is the linear approximation of excess minority carrier in the base region, determine

$$\frac{\delta n_{B_0}(x) - \delta n_B(x)}{\delta n_{B_0}(x)} \times 100\%$$

at $x = x_B/2$ for (i) $x_B/L_B = 0.1$ and (ii) $x_B/L_B = 1$.

Assume $V_{BE} \gg KT/e$. Comment on the results.

6. (a) A silicon npn bipolar transistor at 300 K has the following parameters:

(20)

$$\begin{aligned} D_E &= 10 \text{ cm}^2/\text{s}, D_B = 25 \text{ cm}^2/\text{s}, x_B = 0.7 \text{ } \mu\text{m}, x_E = 0.5 \text{ } \mu\text{m} \\ \tau_{E0} &= 10^{-7} \text{ s}, \tau_{B0} = 5 \times 10^{-7} \text{ s}, N_E = 10^{18} \text{ cm}^{-3}, N_B = 10^{16} \text{ cm}^{-3} \\ J_{r0} &= 5 \times 10^{-8} \text{ A/cm}^2, V_{BE} = 0.65 \text{ V} \end{aligned}$$

Calculate the

- (i) emitter injection efficiency
- (ii) base transport factor
- (iii) recombination factor and
- (iv) common-emitter current gain.

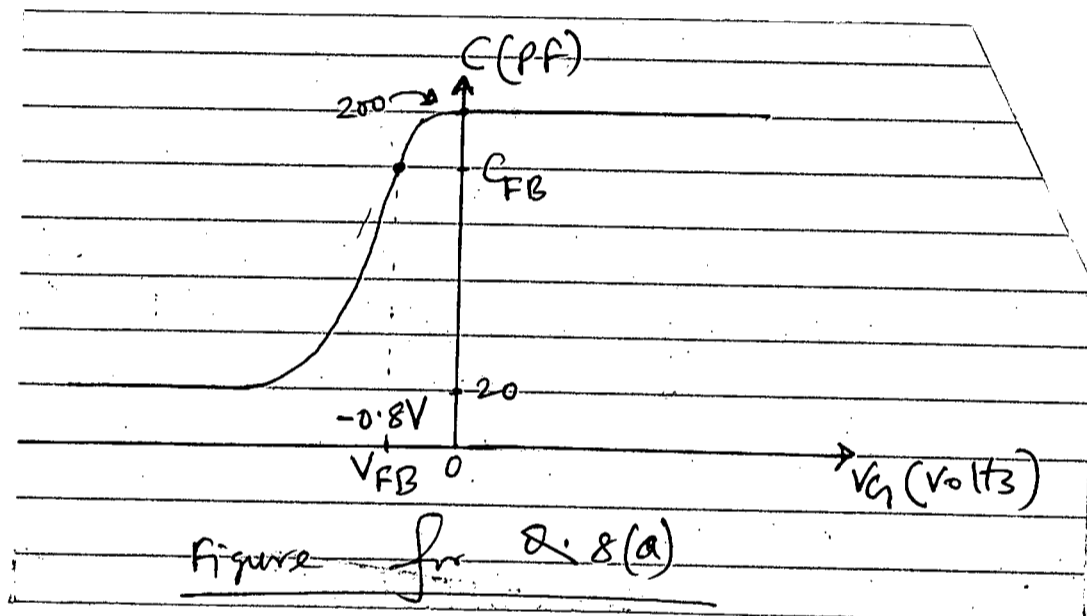
(b) Draw the Ebers-Moll equivalent circuit model for bipolar junction transistor and explain its different components.

(15)

EEE 413

7. (a) An n-channel Si MOSFET with an n+ polysilicon gate has a substrate doping of $N_A = 10^{15} \text{ cm}^{-3}$ and a oxide (SiO_2) thickness of 500 \AA . The equivalent fixed oxide charge is $Q'_{SS} = 10^{10} \text{ cm}^{-2}$. Assuming, the n-channel thickness is equal to the maximum induced space charge width, (20)
- (i) determine the channel thickness and
 - (ii) calculate the threshold voltage.
- (b) Draw energy band diagrams of a pMOS structure for the following conditions: (15)
- (i) at equilibrium
 - (ii) positive voltage at the metal and
 - (iii) negative voltage at the metal

8. (a)



The high frequency C-V characteristics curve of a MOS capacitor is shown in Figure for Q. 8(a). The area of the device is $2 \times 10^{-3} \text{ cm}^2$. The metal semiconductor workfunction difference is $\Phi_{ms} = -0.5 \text{ V}$. The oxide is SiO_2 . The semiconductor is Si and doped with $2 \times 10^{16} \text{ cm}^{-3}$. (20)

- (i) Is the semiconductor n or p type?
 - (ii) What is the oxide thickness?
 - (iii) What is the equivalent trapped oxide charge density?
 - (iv) Determine the flat band capacitance.
- (b) Consider a p-channel Si MOSFET with SiO_2 thickness $t_{ox} = 600 \text{ \AA}$ and $N_D = 5 \times 10^{15} \text{ cm}^{-3}$. Determine the body to source voltage V_{BS} which will shift the threshold voltage by -1.5 V . (15)

SECTION – A

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

1. (a) State the merits of an optical fiber over conventional waveguides. Classify optical fibers and state their relative merits and applications. (10)
- (b) Define the parameter which represents the light guiding capacity of a fiber and find its expression as a function of relative refractive index difference. (10)
- (c) Explain the various phenomenon which are responsible for power attenuation in a silica fiber. Draw and explain the attenuation characteristics of a silica fiber showing all the loss components and the transmission windows for optical fiber communications. (15)

2. (a) Explain the mechanism of intramodal and intermodal dispersion in a multimode fiber. (10)
- (b) Define the parameter used to measure the effect of dispersion at the output of a fiber and find its expression considering a single mode fiber. How does it relate to bandwidth of the fiber? (10)
- (c) A multimode is used for a short-hand transmission link at a wavelength of 1310 nm. The material dispersion of the core is defined as $\left| \frac{d^2 n_1}{d\lambda^2} \right| = 0.05 \mu\text{m}^{-2}$. The wavelength dispersion coefficient is -100 ps/km-nm . The refractive index of the core is 1.56 and relative index difference is 4 percent. The source is an LED with a FWHM linewidth of 10 nm. Determine: (15)
 - (i) material dispersion coefficient in ps/km-nm;
 - (ii) rms pulsewidth at the output of 10 km fiber only due to intra-modal dispersion;
 - (iii) overall rms pulsewidth at 10 km output of fiber;
 - (iv) bandwidth of 1 km fiber;
 - (v) bandwidth-distance product of the fiber.

3. (a) What are the limitations induced by dispersion on the performance of a fiber optic communication link? What is meant by bandwidth-distance product (B-L) of a fiber? Compare the B-L of SMF and MMF. (10)
- (b) What are the following fibers? (12)
 - (i) DSF (ii) NZ-DSF (iii) DCF (iv) DFF

Comment on their usefulness in a fiber-optic link.
- (c) What are the methods used for compensating dispersion in a fiber-optic link using DCF? Discuss with necessary system block diagrams. (13)

EEE 435

4. (a) An SMF link consists of ten fiber spans of length 25 km which are connected by connectors of loss 1 dB each. The link is an IM direct detection link with a receiver with sensitivity -60 dBm. The source is laser of linewidth 0.1 nm. The required loss margin is 6 dB. The source to fiber and fiber to detector couplers have loss of 1.5 dB each. Determine required laser power in mW. Assume the fiber attenuation coefficient as 0.2 dB/km. (10)
- (b) Classify the different types of WDM multi/demultiplexers. Find the transfer function of a Mach-Zehnder interferometer (MZI) and show how it can be used as a 2-ch WDM MUX/DMUX. (10)
- (c) Write short notes on (Any two): (15)
- (i) Fiber Bragg Grating (FBG)
 - (ii) Optical Couplers
 - (iii) Fiber Non-linear Effects

SECTION – B

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

5. (a) Why do lasers must operate away from thermal equilibrium? With necessary figures explain how stimulated emission and laser oscillation are occurred in a semiconductor laser diode. (13)
- (b) Compare the input-output characteristics and spectral characteristics of laser with LED. Which one is suitable for single-mode fiber and why? (12)
- (c) State the advantages and limitations of LED and laser. Also mention their applications in context of optical communication. (10)
6. (a) State the limitations of a p-n photodiode. Explain how p-i-n photodiode is more advantages than p-n photodiode. Which one is suitable for current lightwave system among Si, Ge and InGaAs p-i-n photodiodes and why? (10)
- (b) Explain how APD offers high responsivity illustrating its cross-section and electric field distribution under reverse bias. What are the merits and limitations of an APD compared to p-i-n photodiode? (12)
- (c) Derive the expression of the signal to noise ratio (SNR) at the output of an APD receiver. In case of shot noise limit, show that its SNR is reduced by excess noise factor (F_A) compared to p-i-n receiver. (13)

EEE 435

7. (a) Distinguish between IM/DD and coherent lightwave transmission systems. Why is PSK modulation preferable to OOK modulation for high speed optical fiber transmission? (11)
- (b) What is dense WDM (DWDM)? How is the huge capacity of optical fiber utilized by WDM technology? What are the limiting factors of WDM transmission system? (11)
- (c) An IM/DD optical transmission system is operating at a data rate of 100 Mbps with an APD at the receiver. The quantum efficiency of the photodiode is 80% at the operating wavelength of 1300 nm. An output current of 10 μ A is achieved for the APD after avalanche gain with a multiplication factor of 200. The receiver has an amplifier with a noise figure of 4 dB and the post-detection bandwidth of the receiver is equal to data rate. The dark current in the device is negligible and the load resistance is 2 k Ω at the operating temperature of 27°C. The excess noise factor of the APD is 4. Calculate: (13)
- (i) the SNR at the output of the receiver,
- (ii) the receiver sensitivity corresponding to a BER of 10^{-9} .
8. (a) What are the different types of optical amplifiers? State the basic concept of each of them with corresponding schematic diagram. (11)
- (b) Discuss the pumping scheme of EDFA. Compare the gain spectra of EDFA with those of SOA and state their applications. (12)
- (c) Compare the operating principle of EOM with that of EAM. Briefly explain how phase modulated signal can be generated using EOM. (12)
-

SECTION – A

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

The questions are of equal value.

1. (a) With a block diagram explain the operation of a coal fired steam power plant.
(b) Considering the environmental factor along with others, describe the criteria for selecting the location of a thermal power station.
2. (a) Explain how the shaft speed, steam and heat flow are controlled when real power varies on a steam power plant.
(b) How the reactive power (VAR) transfer takes place between two alternators operating in parallel and connected to an infinite bus?
3. (a) Discuss the merits and demerits of a hydro-electric power plant. Explain with a neat sketch the operation of a Kaplan turbine.
(b) A hydro-electric power station is supplied from a reservoir of capacity $3 \times 10^7 \text{ m}^3$ at a height of 150 m. Determine the total energy available in kWh, if the overall efficiency of the plant is 75%. Density of water is 1000 kg/m^3 .
4. (a) Discuss the private sector power generation policy of Bangladesh.
(b) Name the subsidiaries of BPDB. Is there any grid interconnection between Bangladesh and neighbouring country? What are the advantages of interconnection?

SECTION – B

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

The figures in the margin indicate full marks.

5. (a) With necessary diagrams equations and explain the nuclear fission reaction and how energy is released in such a reaction? Why it is the easiest in heavy elements? Where does the energy come from? (18)
- (b) Explain with diagram the operation of a Sodium-Graphite Reactor (SGR). What are its advantages? (17)

EEE 475

6. (a) Explain with a block diagram the operation of a closed cycle gas turbine plant. (14)
 (b) Present a comparison between closed cycle and open cycle gas turbine. (7)
 (c) Briefly explain the operation of a combined cycle power plant, with an appropriate diagram showing the major components. (14)
7. (a) What are the energy-rate objectives? Present the general rate form for electrical energy. (12)
 (b) Discuss how electricity rates are adjusted. (10)
 (c) A residential consumer in Dhaka city uses 460 units of electricity in a month. The tariff rates are given in the table below; consider existing slab structure. Sanctioned load of the consumer is 3 kW. Demand and service charges are BDT 15/kW of sanctioned load and 10 BDT/month respectively. VAT is 5% of the bill. Calculate the monthly electricity bill of the consumer. Minimum charge is BDT 115/month. (13)

Table: Tariff rate for Dhaka city

Step	Rate, BDT/kWh
1	3.80
2	5.14
3	5.36
4	5.63
5	8.70
6	9.98

8. (a) Explain the mathematical load forecasting method considering economic parameters. (16)
 (b) A generating system will have a total capacity of 300 MW. Investigate the probable forced outages when the capacity is supplied by three 100 MW units; four 75 MW unit. The operating probabilities of all units are $P = 0.98$, and the forced outage is $Q = 0.02$. Comment on the capacity outage probability values calculated. (19)

SECTION – A

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

Symbols have their usual meanings. Make necessary assumptions.

1. (a) Draw energy band structure of Si and GaAs semiconductors and show optical transitions in such semiconductors. Explain differential negative mobility in GaAs from E-K diagram. How certain elements act as amphoteric dopants in compound semiconductors? (20)
- (b) Discuss the significance of critical thickness in epitaxial growth. Show variation of critical thickness with $\text{In}_x\text{Ga}_{1-x}\text{As}$ composition for epitaxy of InGaAs on GaAs substrate. Describe hole band dispersions for biaxial tensile and compressive strain in GaAs. (15)
2. (a) Compare J-V characteristics of pn junction diode and Schottky barrier diode. Sketch energy-band diagram of a metal-semiconductor junction with an interfacial layer and interface states. Show that Fermi level becomes 'pinned' for high surface state density. (20)
- (b) For a Schottky diode, following parameters are given: (15)

$$\phi_m = 5.2 \text{ V}, \phi_n = 0.10 \text{ V}, \phi_0 = 0.60 \text{ V}$$

$$E_g = 1.43 \text{ eV}, \delta = 25 \text{ \AA}, \epsilon_i = \epsilon_0$$

$$\epsilon_s = (13.1)\epsilon_0, \chi = 4.07 \text{ V}$$

$$N_d = 10^{16} \text{ cm}^{-3}, D_{it} = 10^{13} \text{ eV}^{-1} \text{ cm}^{-2}$$

Determine

 - (i) barrier height without interface states,
 - (ii) barrier height with interface states.
3. (a) Sketch basic Ebers-Moll equivalent circuit and define the parameters used in the model. Elaborate that nonideal effects are taken into account in the Gummel-Poon model. What is Gummel number? (20)
- (b) For an npn Si BJT following parameters are given at 300 K: (15)

$$I_E = 0.5 \text{ mA}, C_{je} = 0.8 \text{ pF}, x_B = 0.7 \text{ \mu m}, x_{dc} = 2.0 \text{ \mu m},$$

$$C_S = C_\mu = 0.08 \text{ pF}, r_c = 30 \text{ \Omega}, \beta = 60, D_n = 30 \text{ cm}^2/\text{s}$$

Calculate

 - (i) the transit time factors
 - (ii) the cutoff frequency and
 - (iii) the beta cutoff frequency

EEE 455

4. (a) Explain why polysilicon emitter is used in Si BJT. With necessary diagrams, discuss that collector current and current gain are improved if Ge is incorporated in the base of Si BJT. (20)
- (b) Compare Kirk effect to that of base width modulation in BJT. How performance degradation due to Auger recombination and Kirk effect are reduced in HBTS? With neat sketch, describe basic operation mechanism of TEBT. (15)

SECTION – B

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

5. (a) A **narrow bandgap n-type** and a **wide bandgap p-type** material are used to form a heterojunction. The band diagram of the system before the materials are brought into contact is shown in Fig. 5(a). Draw the energy band diagram of the heterojunction at thermal equilibrium. With necessary assumptions, derive expression for: (18)
- (i) Electric field in both regions
 - (ii) Electrostatic potential along the junction
 - (iii) Space charge width in both regions

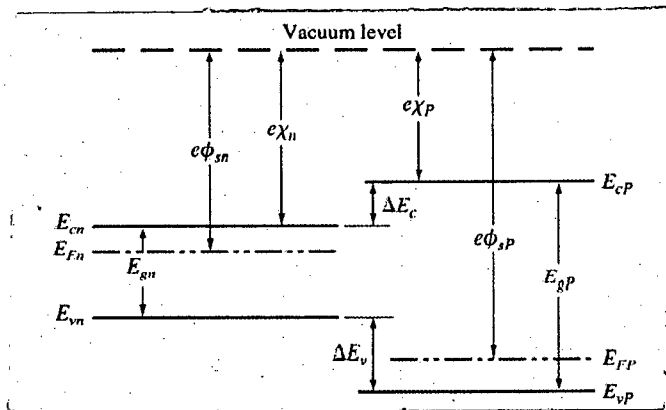


Fig. 5(a)

- (b) Suppose, a thin layer of intrinsic GaAs is sandwiched between a layer of **n-Al_{0.3}Ga_{0.7}As** and **p-Ga_{0.49}In_{0.51}P** as shown in Fig. 5(b). The middle GaAs layer is 50 μm thick. The top and bottom layers each have thickness of 100 μm. The doping density at AlGaAs and GaInP regions are 10¹⁶ cm⁻³ and 10¹⁷ cm⁻³, respectively. The material parameters at each layer is given in the following table: (17)

Parameters	Material		
	Ga _x In _{1-x} P	GaAs	Al _x Ga _{1-x} As
Bandgap (eV)	1.34+0.92x	1.424	1.424+1.247x eV(x<0.45)
Dielectric Constant	12.5-1.4x	12.9	12.90-2.84x
Electron Affinity (eV)	4.38-0.58x	4.07	4.07-1.1x (x < 0.45)
Conduction Band Density of States (cm ⁻³)	1.8×10 ¹⁹ (0.0317+0.9683x)	4.7×10 ¹⁷	2.5×10 ¹⁹ (0.063+0.083x) ^{3/2}
Valance Band Density of States (cm ⁻³)	1.9×10 ¹⁹ (0.5689+0.4311x)	9×10 ¹⁸	2.5×10 ¹⁹ (0.51+0.25x) ^{3/2}

Draw the thermal equilibrium energy band diagram of the system.

EEE 455

Contd ... Q. No. 5(b)

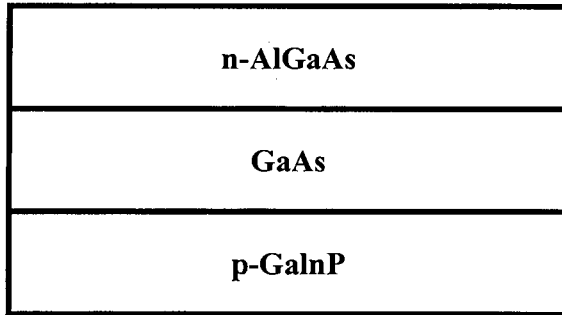


Fig. 5(b)

6. (a) Draw the energy band diagrams of metal-semiconductor non-rectifying junctions under ideal conditions at thermal equilibrium. Draw diagrams for both n-type and p-type semiconductors. (10)

(b) Draw the small signal equilibrium circuit of a p⁺n JFET. What are the frequency limiting factors of such devices? With necessary assumptions, show that the maximum cutoff frequency, $f_{T,max}$ of such a device can be given by the following expression: (18)

$$f_{T,max} = \frac{g_{m,max}}{2\pi C_{G,min}}$$

where,

$g_{m,max}$ = Maximum transconductance

$C_{G,min}$ = Minimum gate capacitance

(c) An n-channel silicon JFET is operating with a maximum cutoff frequency of 3.5 GHz. Assume that, n-type doping density is 10^{16} cm^{-3} , gate length is 5 μm and channel thickness is 0.6 μm . Determine the device width. The relative permittivity of silicon is 11.7. Use the information given in Fig. 6(c). (7)

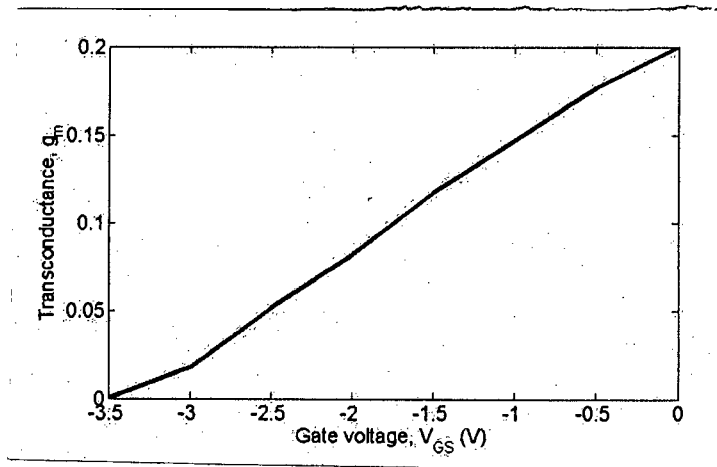


Fig. 6(c)

EEE 455

7. (a) Draw the channel space charge region profiles of a single gate n-channel JFET for the following operating regions:

(10)

- (i) $V_g > V_p$ and $V_d = 0V$
- (ii) $V_g > V_p$ and $V_d < V_{d,sat}$
- (iii) $V_g > V_p$ and $V_d \approx V_{d,sat}$
- (iv) $V_g > V_p$ and $V_d > V_{d,sat}$

where, V_g = Applied gate voltage
 V_p = Pinchoff voltage
 V_d = Drain voltage
 $V_{d,sat}$ = Drain voltage at the onset of saturation

(b) Write short notes on any three of the following topics:

(15)

- (i) 2 DEG
- (ii) Velocity saturation in JFET
- (iii) Subthreshold conduction in JFET
- (iv) HEMT

(c) An Al/Al_{0.35}Ga_{0.65}As/GaAs HEMT is fabricated with Al_{0.35}Ga_{0.65}As layer doped n-type to 10^{18} cm^{-3} and having a thickness of 500 Å. Assume the undoped spacer layer to be negligible and GaAs layer is undoped. The barrier height at Al/Al_xGa_{1-x}As junction is given in the Fig 7(a). Determine the carrier density per unit area in the HEMT channel at $V_g = 0.1 \text{ V}$. If necessary, use the information given in the energy band diagram of a AlGaAs/GaAs HEMT at threshold voltage in Fig. 7(b). The Al_xGa_{1-x}As system has the following parameters:

(10)

Material Parameters	
Bandgap (eV)	$1.424 + 1.247x \text{ eV } (x < 0.45)$
Dielectric Constant	$12.90 - 2.84x$
Electron Affinity (eV)	$4.07 - 1.1x \text{ (} x < 0.45 \text{)}$

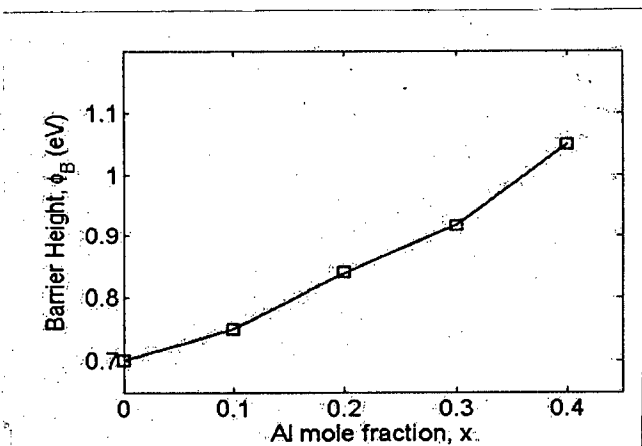


Fig. 7(a)

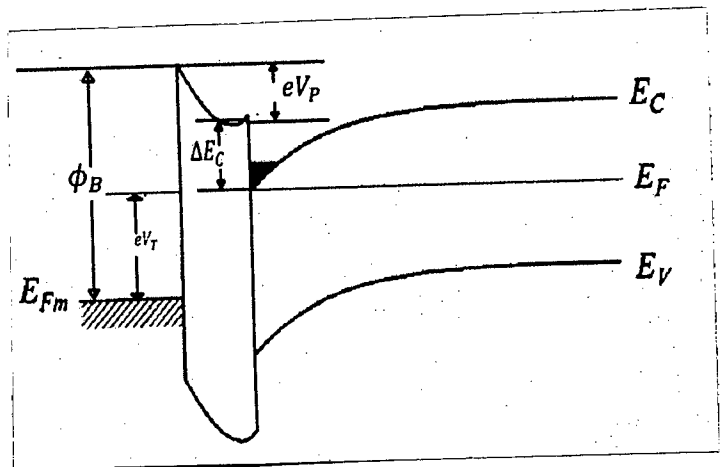


Fig. 7(b)

EEE 455

8. (a) Show that, for a single gate JFET, the DC current in saturation region can be expressed by the following expression: (23)

$$I_D = I_{p1} \left\{ 1 - 3 \left(\frac{V_{bi} - V_{GS}}{V_{p0}} \right) \left[1 - \frac{2}{3} \sqrt{\frac{V_{bi} - V_{GS}}{V_{p0}}} \right] \right\}; \quad I_{p1} \equiv \frac{\mu_n (eN_d)^2 W a^3}{6 \epsilon_s L}$$

where,

- μ_n = mobility of the channel material
- N_d = channel doping density
- W = device width
- a = channel thickness
- L = gate length
- ϵ_s = dielectric constant
- V_{bi} = Junction built-in voltage
- V_{p0} = Internal pinch-off voltage
- V_{GS} = Gate voltage

- (b) For a silicon p⁺n JFET, the following parameters are given: (12)

Relative permittivity	11.7	Channel mobility	1000 cm ² /v/s
Channel thickness	0.75 μm	Doping in p ⁺ region	10 ¹⁸ cm ⁻³
Channel width	30 μm	Doping in n region	10 ¹⁶ cm ⁻³
Gate length	10 μm	Intrinsic carrier density	1.5 × 10 ¹⁰ cm ⁻³

Calculate the following quantities:

- (i) The maximum drain current in the device.
- (ii) Internal pinch-off voltage
- (iii) Drain current at $V_{GS} = -0.2$ V

Important Equations

Students may use the following equations of pn junction electrostatics if necessary:

$$x_n = \left\{ \frac{2\epsilon_s V_{bi}}{e} \left[\frac{N_a}{N_d} \right] \left[\frac{1}{N_a + N_d} \right] \right\}^{1/2}$$

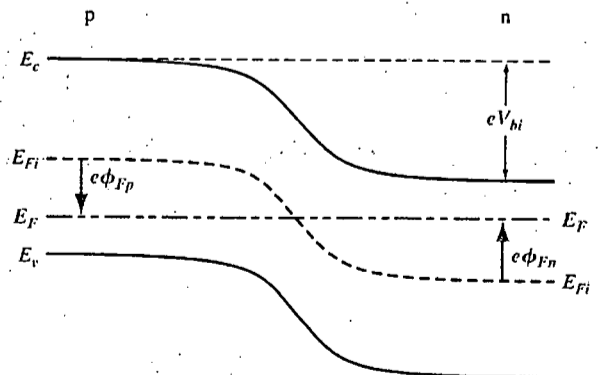
$$x_p = \left\{ \frac{2\epsilon_s V_{bi}}{e} \left[\frac{N_d}{N_a} \right] \left[\frac{1}{N_a + N_d} \right] \right\}^{1/2}$$

$$W = x_n + x_p$$

$$W = \left\{ \frac{2\epsilon_s (V_{bi} + V_R)}{e} \left[\frac{N_a + N_d}{N_a N_d} \right] \right\}^{1/2}$$

$$V_{bi} = \frac{kT}{e} \ln \left(\frac{N_a N_d}{n_i^2} \right) = V_t \ln \left(\frac{N_a N_d}{n_i^2} \right)$$

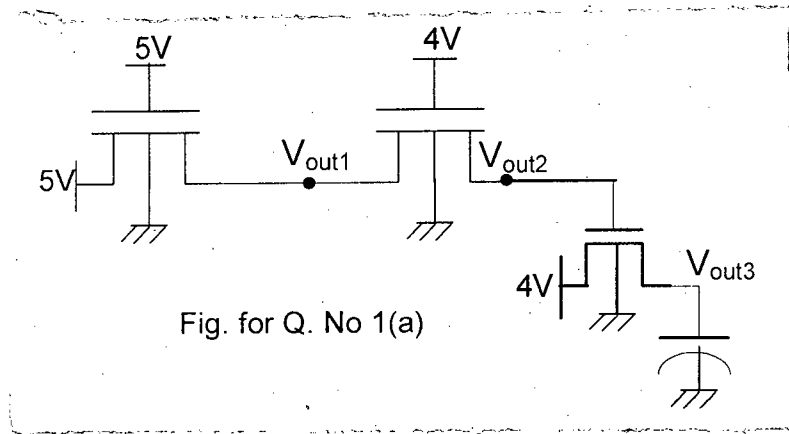
Here, symbols have their usual meaning.



SECTION – AThere are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Derive an expression showing the influence of the source-body voltage on the threshold voltage of a NMOS transistor. (9+3×3)

For the following NMOS pass transistor circuit find the output voltage V_{out1} , V_{out2} and V_{out3} . Assume $V_{t0} = 1$ V, $\gamma = 0.5$ and neglect ϕ_f .



- (b) A pseudo NMOS inverter is designed such that the output voltage becomes 0.25 V when the input voltage is 5 V. The following data are given: $\mu_n C_{ox} = 120 \mu A/V^2$, $\mu_p C_{ox} = 50 \mu A/V^2$, $V_{ton} = 1$ V, $V_{top} = -1$ V, $V_{DD} = 5$ V, $\gamma = 0.5$. Assume that the body of the NMOS transistor is connected with the ground and the body of the PMOS transistor is connected with V_{DD} . (2+8+7)

- (i) Draw the circuit diagram of the inverter.
 (ii) Calculate the inverter ratio i.e., the ratio of driver transistor (W/L) to the load transistor (W/L).
 (iii) What will be the output voltage if the input voltage is held at 0.25 V? Explain your answer.
2. (a) A 3 input NAND gate is driving 15 similar NAND gates. The following data are given: Gate oxide capacitance = $35 \text{ fF}/\mu\text{m}^2$. Source/Drain capacitance = $15 \text{ fF}/\mu\text{m}^2$, NMOS aspect ratio $(W/L)_n = 10 \mu\text{m}/1 \mu\text{m}$, PMOS aspect ratio $(W/L)_p = 25 \mu\text{m}/1 \mu\text{m}$, Drain/source length for both NMOS = $15 \mu\text{m}$, $\mu_n C_{ox} = 120 \mu A/V^2$, $\mu_p C_{ox} = 50 \mu A/V^2$, $V_{DD} = 5$ V. (6×3)

EEE 453

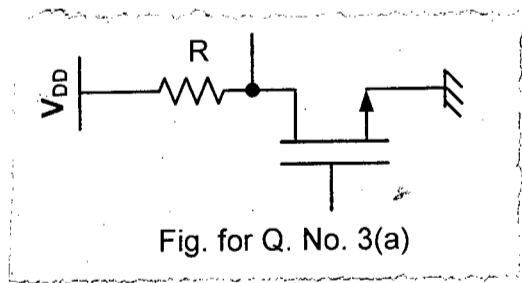
Contd ... Q. No. 2(a)

- (i) Derive expression for rise time, fall time and dynamic power dissipation of the NAND gate in the worst case in terms of device and circuit parameters.
 - (ii) Calculate the rise time and fall time of the NAND gate in the worst case.
 - (iii) What is the maximum operating frequency of the gate in the worst case and what is the dynamic power dissipation of the gate at this frequency?
- (b) A clock signal from the PLL is routed by a minimum size inverter to 1500 locations in an IC where the clock is received by the same size inverter in each location. The following data are given: Gate oxide capacitance = $25 \text{ fF}/\mu\text{m}^2$, Source/Drain capacitance = $20 \text{ fF}/\mu\text{m}^2$, NMOS aspect ratio of minimum sized inverter $(W/L)_n = 10 \mu\text{m}/1 \mu\text{m}$, PMOS aspect ratio of minimum sized inverter $(W/L)_p = 25 \mu\text{m}/1 \mu\text{m}$, Drain/source length for both NMOS and PMOS of minimum sized inverter = $10 \mu\text{m}$, $\mu_n C_{ox} = 120 \mu\text{A}/\text{V}^2$, $\mu_p C_{ox} = 50 \mu\text{A}/\text{V}^2$, $V_{DD} = 5 \text{ V}$.

(5+12)

- (i) Calculate the average propagation delay of the driving inverter.
 - (ii) Design a buffer chain such that the delay of the signal through the buffer chain becomes minimum. What is the value of n (factor by which aspect ratio of each gate in the chain is larger than that of the preceding gate) and m (number of stages in the chain) of the buffer chain? What is the average propagation delay of the buffer chain?
3. (a) Show the process sequence of fabricating the following circuit in a PWELL NMOS process technology. Clearly show the mask used and the device cross-sectional diagram after each step.

(25)



- (b) Explain briefly the necessity of the following design rules:
- (i) Poly overlap diffusion = 2λ
 - (ii) Floating NWELL not allowed
 - (iii) Metall width = 3λ
 - (iv) N-difusion to P-diffusion spacing = 6λ
 - (v) Maximum metall area = $1200 \mu\text{m}^2$.

(10)

EEE 453

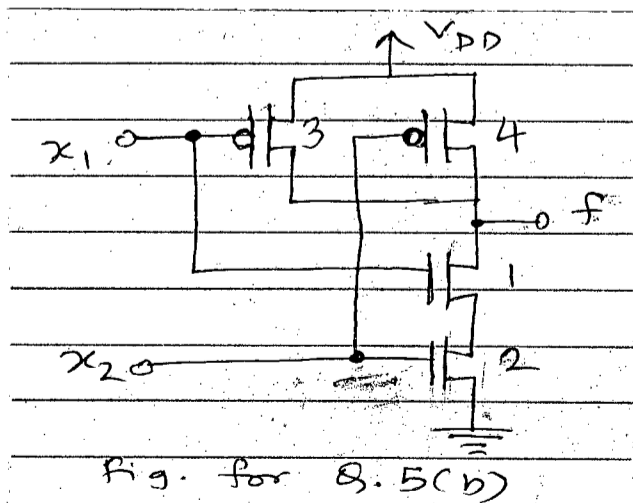
4. (a) A process use aluminum conductor for which electromigration related maximum current density is $2 \text{ mA}/\mu\text{m}^2$. How many NMOS 8:1 inverter can be driven by a minimum size conductor assuming λ -based rule and 180 nm process technology? The following data are given: conductor width = 3λ , conductor thickness = $1 \mu\text{m}$, $V_{DD} = 1.8\text{V}$ and on-resistance of the 8:1 pull down transistor is $10 \text{ k}\Omega$. (10)
- (b) A 4-input NOR gate is designed such that the gate has equal rise and fall time in the best case. If mobility of electron is 2.5 times that of hole, calculate the width of the PMOS transistor in terms of the width of the NMOS transistor. Assume that both NMOS and PMOS transistor has the same gate length. (10)
- (c) A room has three doors with a switch beside each door and a light bulb at the center of the room. You have to design a control circuit such that anyone entering into the room from any of the door can turn the light ON or OFF. Write the truth table, the Boolean equation of the control circuit and show the implementation of the circuit in (i) NMOS, (ii) P_{seudo} NMOS, (iii) Static CMOS and (iv) Footed dynamic CMOS technology. (15)

SECTION – B

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

If any question has missing data, make a reasonable assumption and state it in your solution.

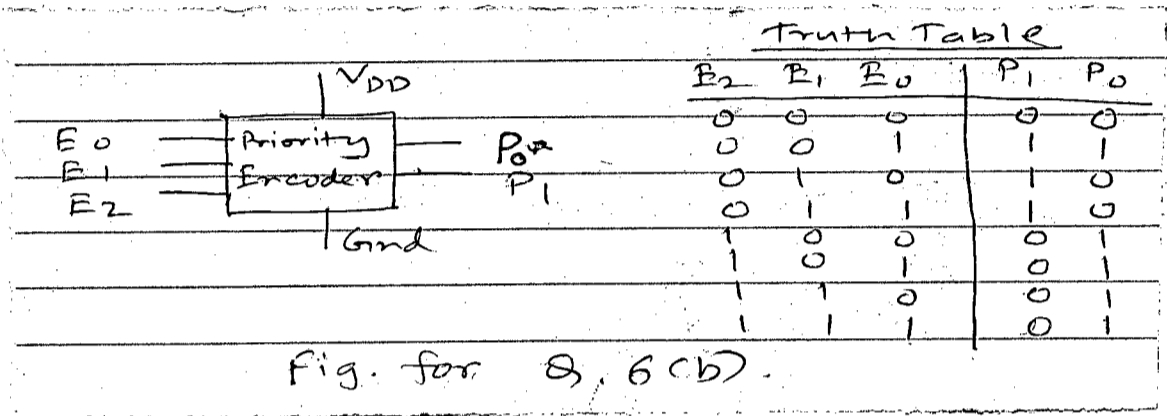
5. (a) What is the significance of 'design for testability' for a VLSI system? Discuss the different criteria which are used for fault classification in a VLSI system. Mention the differences between stuck-open and stuck-on faults. (17)
- (b) A two input static CMOS NAND gate is presented in Fig. for Q. 5(b). Determine a test vector or a two-pattern test for the system for the following fault conditions: (18)
- (i) a stuck-at1 fault on the line fed by input x_2 ,
 - (ii) a stuck-open fault in transistor 1,
 - (iii) a stuck-on fault in transistor 4 assuming that current monitoring is done.



EEE 453

6. (a) Explain the operation of a four bit dynamic shift register with the help of clear diagrams. The stick diagrams for shift register cells need to be presented. (18)

(b) A priority encoder is a combinational circuit in which each input is assigned a priority with respect to the other inputs and the output generated at any time depends on the highest priority input then present. If such a structure is described in the Fig. for Q. No. 6(b), design a stick diagram to realize the structure. (17)



7. (a) Explain the operation of a 4x4 barrel shifter. Mention its practical applications. Devise the stick diagram for such a barrel shifter. (18)

(b) Write and explain the verilog code for a Mealy type finite state machine with the help of state diagrams. (17)

8. (a) Discuss the differences between NMOS and CMOS realizations of a parity generator with the help of stick diagrams. Explain why buffer sections could be required during the realization of bus arbitration logic circuits. (20)

(b) Design the layout of a four way n-switch based multiplexer showing the position of the standard cells. (15)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2014-2015

Sub : **EEE 473** (Power Electronics)

Full Marks : 210

Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – AThere are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Draw a DC chopper circuit and explain how can it be adopted for controlling variable voltage output supplied to a load having back EMF. (20)
 (b) A permanent magnet dc motor is controlled from a DC chopper. The total series resistance in the chopper (including the motor armature resistance) is 1.5Ω . The motor back EMF is proportional to motor speed and maintains the following relation: (15)

$$E_{back} = 0.25 N$$
 Where N is the motor speed in RPM. If the input supply to the chopper is 400V DC and motor speed is 1000 RPM, determine the duty required for the chopper to supply a motor current of 25A DC.

2. (a) What are the differences between a DC chopper and a switching regulator? (5)
 (b) With a neat diagram explain the operation of a switching buck-boost regulator. Derive the necessary equations to explain the buck-boost operation. (15)
 (c) Design a switching Buck regulator that would limit the maximum current ripple to 10mA and maximum voltage ripple to 5mV. Consider an input supply voltage of 48V Dc and input maximum supply current of 10A. (15)

3. (a) Draw a single full bridge voltage source inverter and explain (with necessary diagrams) how it can be controlled for fixed output frequency and variable output using Sine Pulse Modulation. Draw a typical spectrum of the FOURIER components and show how the index of modulation affects the spectrum considering a fixed carrier frequency. (20)
 (b) A single phase full bridge voltage source inverter is used in an Uninterruptible Power Supply. The input supply of the inverter is a Battery having a nominal voltage of 96V DC. If the inverter is operated in single pulse per half cycle mode, determine the fundamental RMS output voltage for an index of modulation of 0.8. (15)

EEE 473

4. (a) Draw a three phase full bridge voltage source inverter and explain how it can be controller to provide 120° shifted three phase output voltage considering 180° conduction. (15)
- (b) With a neat diagram explain the operating regions of an AC motor drive. Explain why v/f control is necessary to operate the motor in constant torque region. (10)
- (c) An induction motor is run in v/f control mode from a three phase voltage source inverter operating with Sine Pulse Width Modulation control. If the supply DC voltage to the inverter is 400V DC, what should be the modulation index to have a fundamental output voltage of 170V RMS? (10)

SECTION – B

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

5. (a) Draw the power circuit of a single phase full wave controlled rectifier and explain its operation. Draw the waveforms of gate pulses and input current and output voltage corresponding to input voltage for a firing angle α for 2 cycle. Determine input power factor. (10+6+8=24)
- (b) Draw the power circuit of a single phase half wave uncontrolled rectifier (for inductive load). Draw the waveforms of output voltage and input current corresponding to input voltage. Explain mathematically why output voltage becomes negative for a brief period of time for inductive load. (11)
6. (a) Draw the power circuit of three phase half wave uncontrolled rectifier with resistive load. Draw the waveforms of input current and output voltage. Determine average output voltage. (12)
- (b) Draw the power circuit of a three phase full wave controlled rectifier with resistive load for a firing angle of $\alpha = 90^\circ$. Draw the waveforms of input currents and output voltage corresponding to the input voltage and also show the gate pulses. (23)
7. (a) Draw the power circuit of a single phase Dual converter. Explain how the circuit operates to drive a DC motor in both direction. Show the gate pulses corresponding to the input voltage. (18)
- (b) Draw the power circuit of a $3\phi - 1\phi$ cyclo-converter and explain its operation with gate pulses. (17)
8. Draw the power circuit of a three phase voltage controller. Show the gate pulses for a firing angle $\alpha = 120^\circ$. Draw the waveforms of line to neutral and line to line voltage and input currents for $\alpha = 120^\circ$ corresponding to input voltage. Show calculations for determining the waveforms of voltages. (6+6+12+11)
-

SECTION – A

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

Use appropriate diagram if necessary. Smith Transmission line chart is supplied.

1. (a) For sinusoidal voltage on an ideal transmission line, prove that $Z_{\max} = Z_0 S$ and $Z_{\min} = Z_0/S$, where symbols have their usual meaning. (7)
- (b) With proper diagram derive and explain the equations of constant resistance and reactance curves of the Smith transmission line chart. (14)
- (c) Suppose an ideal transmission line with $Z_0 = 50$ ohm is 30 m long and operates at 2 MHz signal frequency with a phase velocity 1.8×10^8 m/s. The line is terminated with a load $Z_L = 60 + j40$ ohm. Using Smith transmission line chart determine input impedance Z_{in} of the line (Smith transmission line chart is supplied). (14)

2. (a) Suppose that the distributed impedance of a lossless transmission line is formed by inductance and capacitance in series and only capacitance in parallel. Then derive the equation of propagation constant in terms of the cutoff frequency and other line parameters. Explain its behaviour when $\omega < \omega_c$ and $\omega > \omega_c$. (8)
- (b) For low loss lines show that the attenuation constant can be expressed as, (9)

$$\alpha = \frac{1}{2} \left[GZ_0 + \frac{R}{Z_0} \right] \text{ Np/m}$$

where symbols have their usual meaning.
- (c) Consider an Aluminum thin film parallel plate transmission line with a signal of 18 GHz. Given: (18)
 - Metal thickness = 2.0 μm
 - Dielectric thickness = 2.0 μm
 - Width of each conductor = 10 μm
 - Relative permittivity of dielectric material = 3.8 and assumed to be lossless
 - Surface impedance of Aluminum = $3.26 \times 10^{-7} \sqrt{f}$ (1 + j1) ohm, and
 - Skin depth of Aluminum = $0.0826/\sqrt{f}$ m.

Assuming negligible shunt conductance determine characteristics impedance Z_0 and attenuation constant α .

EEE 433

3. (a) Starting from Maxwell's equations, prove that for a source free waveguide, (10+2)

$$E_x = -\frac{1}{\gamma^2 + k^2} \left(\gamma \frac{\partial E_z}{\partial x} + j\omega\mu \frac{\partial H_z}{\partial y} \right)$$

where symbols have their usual meaning. Then re-write the equation for attenuation free propagation.

- (b) For TE and TM waves in a parallel plate waveguide derive the equation for attenuation constant due to dielectric loss. (8)

- (c) For TE₁₀ wave in a rectangular waveguide the field equations are: (15)

$$H_z = B \cos k_x x$$

$$E_y = -\frac{j\omega\mu B}{k_x} \sin k_x x$$

$$H_x = \frac{j\beta B}{k_x} \sin k_x x$$

$$E_x = H_y = E_z = 0$$

Where symbols have their usual meaning. Considering these equations and other parameters of the waveguide derive the equation for attenuation constant due to conductor loss.

4. (a) Derive the field equations for TM waves in perfectly conducting parallel plates. (12)

- (b) For the same wave mentioned in (a) derive the equations of propagation constant, cut-off frequency, phase velocity, group velocity, guide wavelength and wave impedance. (18)

- (c) Plot ω vs. propagation constant (β , α) found in (b) and explain it. (5)

SECTION – B

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

5. (a) What types of waves are supported by a microstrip transmission line? How the phase velocity and the propagation constant of the supported wave are expressed? (6)

- (b) Explain the types of losses usually occur in a microstrip transmission line. What are the advantages and disadvantages of using microstrip line in microwave integrated circuits? Also, show the field distribution over a cross-sectional geometry of a microstrip line. (9)

- (c) Using the electrostatic solution technique, find an expression of static capacitance per unit length of a microstrip transmission line. Explain how can you obtain the effective dielectric constant and the characteristic impedance of the microstrip transmission line from the electrostatic solutions. (20)

EEE 433

6. (a) What are cavity resonators? What are their most desirable properties? Are the field patterns in a cavity resonator travelling waves or standing waves? How do they differ from those in a waveguide? (8)

(b) The fields of the lowest order mode (TE₁₀₁) in a rectangular waveguide resonator are given by (18)

$$E_y = E_0 \sin \frac{\pi x}{a} \sin \frac{\pi z}{d},$$

$$H_x = -j \frac{E_0}{\eta} \frac{\lambda}{2d} \sin \frac{\pi x}{a} \cos \frac{\pi z}{d},$$

$$H_z = j \frac{E_0}{\eta} \frac{\lambda}{2a} \cos \frac{\pi x}{a} \sin \frac{\pi z}{d},$$

(symbols and letters have their usual meaning)

Show that the quality factor (Q) of a cubical resonator can be expressed by

$$Q = 0.742 \frac{\eta}{R_s}$$

(c) A cubical cavity resonator made of copper is to be designed to operate at 10 GHz for the lowest order mode. Find the dimensions of the cavity, its quality factor, and its bandwidth. (9)

7. (a) What are far fields of an antenna? Find the expressions of far fields for a Hertzian dipole carrying current $I = I_0 \cos \omega t$. Show the two-dimensional sketches of E-plane and H-plane radiation patterns of a Hertzian dipole. (20)

(b) Explain the terms "Directive Gain" and "Power Gain" of an antenna. (8)

(c) Evaluate the Directivity of an antenna with normalized radiation intensity (7)

$$U(\theta, \phi) = \begin{cases} \sin \theta, & 0 \leq \theta \leq \frac{\pi}{2}, \quad 0 \leq \phi \leq 2\pi \\ 0, & \text{otherwise} \end{cases}$$

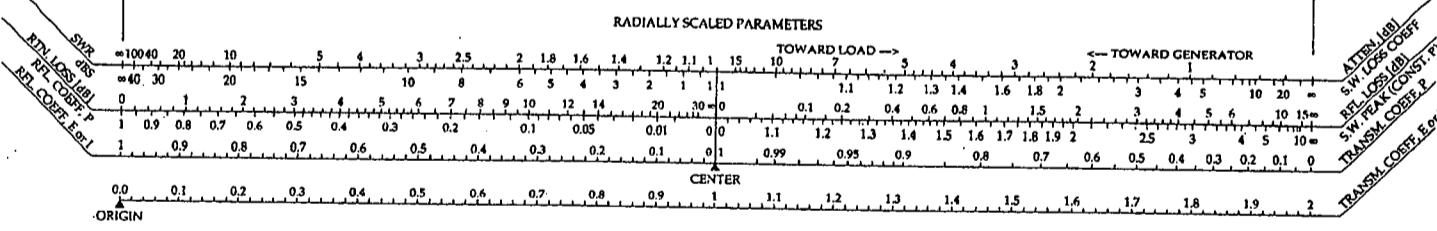
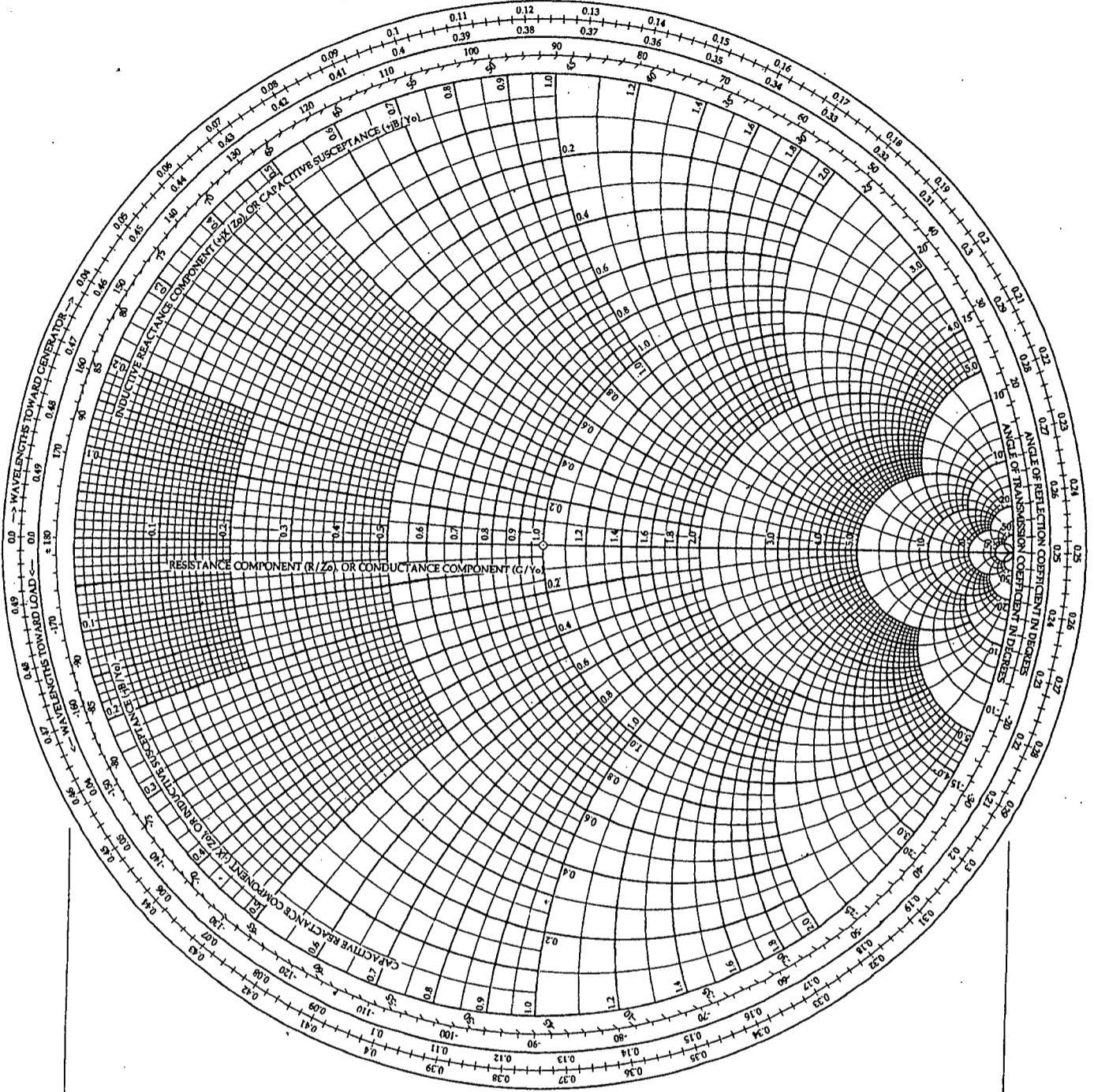
8. (a) What are the major advantages of antenna arrays compared to a single element antenna fed with the same input power? Explain the principle of "Pattern Multiplication" using a two element array. (15)

(b) A certain antenna with an efficiency of 95% has maximum radiation intensity of 0.5 W/Sr. Calculate its directivity when (i) the input power is 0.4 W, (ii) the radiated power is 0.3 W. (10)

(c) Describe various elements of a typical Yagi-Uda antenna. What are the merits and demerits of Yagi-Uda antenna? (10)

The Complete Smith Chart

Black Magic Design



BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2014-2015

Sub : **EEE 451** (Processing and Fabrication Technology)

Full Marks : 210

Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – AThere are **FOUR** questions in this Section. Answer any **THREE** questions.

Answers should be to the point.

1. (a) "Wet etching is a cheap process" – explain the technological implications behind this assertion. Why diffusion is so ubiquitous a process in fabrication? (8+10)
- (b) A 1000-Å gate oxide is required for some process step. How long will it take for the oxidation to be done, if done in a dry-O₂ environment? Compare that value with that done in a wet-O₂ environment. The necessary parameters are given below, the symbols have their usual meaning and proper units: (17)
- | | | |
|--------|--------|-------|
| | dry | wet |
| A | 0.165 | 0.226 |
| B | 0.0117 | 0.287 |
| τ | 0.37 | x |
2. (a) Compare contact and proximity aligners. Discuss the effects of surface reflections and standing waves. (15)
- (b) Thermal annealing helps activate impurities. Explain this phenomena specially in the exciting case of doping GaN. (15)
- (c) What is the use of a primer solution in photoresist spinning? (5)
3. (a) Describe various techniques of physical vapor deposition. (20)
- (b) Describe the differences in resolution and chemical composition of positive and negative photoresists. (15)
4. (a) Describe the process of ion implantation, using appropriate figures and detailed description of the equipment. (20)
- (b) Discuss the relative merits of the two models that explains thin oxidation results ($t_{ox} < 300 \text{ \AA}$). (15)

EEE 451

SECTION – B

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

5. (a) Discuss the main features of CMOS advances during the 1990's and 2000's. Can you identify the key differences in the processing technologies of these two decades? (15)
- (b) Describe the chip characteristics that affect packaging processes. (10)
- (c) Comment on the different enclosure techniques of the packages. (10)
6. (a) What are the major yield-limiters in wafer fabrication business? Describe in detail. (18)
- (b) Describe the use of Al in wire-bonding technologies of packaging. (10)
- (c) Write down the expression for overall process-yield and briefly explain the yield-vs-time profile. (7)
7. (a) Describe in detail the effects of major contamination sources in a cleanroom. Comment on how to control them. (20)
- (b) Why CMOS has become so popular and mature as a technology-explain the key processing advantages that this process offers over other competing processes. (15)
8. Write short notes on: (35)
- (a) Fabrication of organic solar cells
- (b) MBE
- (c) Ohmic Contact
- (d) Dopant activation energy.
-

SECTION – A

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

1. (a) “In a permanent magnet dc motor two processes cause reduction of air gap flux
 (i) reduction due to cross-magnetization when brushes are on mechanical neutral position
 (ii) demagnetization resulting from a brush shift and change of armature pole orientation”
 – discuss in detail. (20)
- (b) Explain how torque is developed in a reluctance motor. Discuss the torque speed characteristics of such a motor. (15)

2. (a) Discuss the dc- and ac-torque-speed characteristics of a universal motor. (10)
- (b) Explain why a chopper drive control universal motor gives higher efficiency, less acoustic noise and better EMC behavior than those of a phase-angle driven universal motor. (10)
- (c) Present a sketch of an ion-membrane fuel cell and explain its operation. Comment on the efficiency of a fuel cell and compare it with the Carnot-cycle efficiency. (15)

3. (a) Explain the following with reference to a switched reluctance motor (SRM). (18)
 - (i) At least two phases required to guarantee starting.
 - (ii) At least three phases required to ensure starting direction;
 - (iii) Number of rotor poles and stator poles must differ to ensure starting.
- (b) “Design of firing angles in an SRM involves resolution of two conflicting concerns- maximizing torque output or maximizing efficiency” – explain. (17)

4. (a) Classify power electronic interfaces for grid-connected PV systems. (5)
- (b) What are the major factors that influence the electrical design of solar array? Discuss the shadow effect on solar PV array and how it is addressed. (15)
- (c) Present the incremental conductance-based maximum power point tracking technique. (15)

EEE 471

SECTION – B

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

5. (a) How does a Magneto Hydrodynamic Generator (MHO) differ from a conventional ac generator involved in electricity generation in most power plants? (10)
- (b) With a neat diagram explain the operation of a typical MHD based power plant that can supply power to an ac grid system. (25)
6. (a) What are the operational differences between windmill and wind turbines in respect to electric power generation? (10)
- (b) Why induction generators are used in wind turbines? (5)
- (c) With a neat diagram explain the necessary of a power electronic converter in wind turbine generators to supply power to a mini grid system. (20)
7. (a) What are the constructional and functional differences between an AMPLIDYNE and a METADYNE generator? Cite an example of the use of an AMPLIDYNE generator. (15)
- (b) With a neat diagram explain how a power electronic converter can mimic an AMPLIDYNE and propose an application that could replace an AMPLIDYNE. (10)
- (c) Explain the construction and operation of an acyclic generator. (10)
8. (a) Propose a noise free refrigeration system using semiconductor technology utilizing thermo electric effects. (20)
- (b) With a neat diagram explain the principle of operation of a thermo electric DC conduction pump. (15)
-

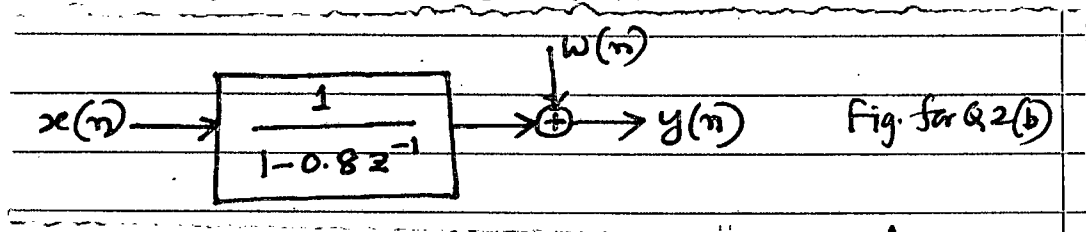
SECTION – A

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

1. (a) Draw the schematic diagram of a proto type Wiener filtering set up. Show that the error signal of the Wiener filter is orthogonal to the filter output. (12)
- (b) Consider a cost function $J = h^2 - 40h + 28$. We search for the minimum of J using the Steepest-descent algorithm. Write the expression of the update equation. Determine the value of step-size parameter that will give fastest convergence to the desired solution. (12)
- (c) What are the algorithmic differences between Steepest-descent and LMS algorithms? Based on these differences, discuss the advantages of LMS algorithm. (11)

2. (a) Write the conditions for the LMS algorithm to be convergent in the mean and mean-squared sense. Which condition gives more conservative estimate of the step-size parameter? (10)

- (b) Consider an AR system as shown in Fig. for Q. 2(b). (13)

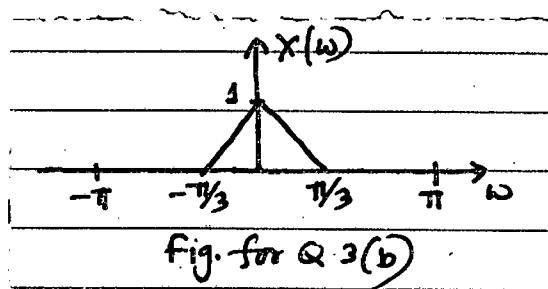


The input $x(n)$ and additive noise $w(n)$ are white random process with variances σ_x^2 and σ_w^2 , respectively. Determine the optimum coefficients of a two-tap filter $B(z) = b_0 + b_1z^{-1}$ that can compensate the AR system.

- (c) Discuss how the step-size parameter of LMS algorithm should be suitably chosen at different stages of iterations and time-varying condition. (12)

3. (a) Discuss the influence of weighting factor a forgetting factor λ on the solution of RLS algorithm. (11)

- (b) Consider a signal $x(n)$ with Fourier transform $X(\omega)$ as shown in Fig. for Q. 3(b) (13)



EEE 431

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

The signal is applied to a decimator that reduce the rate by a factor of 2. Sketch the output spectrum. Can we reconstruct the original signal again? How?

(c) Discuss how decimation of a signal can be done using a polyphase filter and a commutator. (11)

4. (a) Consider a system $T\{\cdot\}$ that given fractional delay to the input signal as

$$y(n) = T\{x(n)\} = x\left(n - \frac{2}{3}\right).$$

Describe the multirate implementation of system $T\{\cdot\}$.

(b) Derive the polyphase structure of uniform DFT filter banks. (11)

(c) The analysis filter $H_0(z)$ in a two channel QMF has the transfer function. (13)

$$H_0(z) = 1 + z^{-1}$$

Determine the analysis filter $H_1(z)$, synthesis filter $G_0(z)$ and $G_1(z)$. Sketch the entire two channel QMF based on polyphase filters. Show that the QMF bank results in perfect reconstruction.

SECTION – B

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

5. (a) The input-output relationship of an AR(P) system is given by

$$x(n) = -\sum_{i=1}^P a_i x(n-i) + u(n)$$

where a_i are the AR parameters and $u(n)$ is the zero-mean stationary white noise input to the system. Determine the AR parameters that minimize the cost function. (18)

$$J = \sum_{n=N_1}^{N_2} |e(n)|^2$$

where $e(n) = x(n) + \sum_{i=1}^P a_i x(n-i)$, $N_1 = P + 1$ and $N_2 = N$ is the length of $x(n)$.

(b) Consider the AR(3) process generated by the equation (3+6+8)

$$x(n) = \frac{14}{24}x(n-1) + \frac{9}{24}x(n-2) - \frac{1}{24}x(n-3) + u(n)$$

where $u(n)$ is a stationary white noise process with variance σ_u^2 .

(i) Determine the coefficients of the optimum $p = 3$ linear predictor

(ii) Determine the auto correlation sequence $r_{xx}(m)$, $1 \leq m \leq 4$, when $r_{xx}(0) = 4.93$.

(iii) Determine the reflection coefficients corresponding to the $p = 3$ linear predictor.

Is the AR system stable?

EEE 431

6. (a) Show that a uniform filter bank with a bank of M analysis filters can be implemented in a computationally more efficient way using polyphase filters as compared to that of realizing each analysis filter as a separate filter. (10)

(b) The sampling rate of an audio signal $x(n)$ is to be reduced, by two-stage decimation, from 240 kHz to 8 kHz. The highest frequency of interest in the data after decimation is 3.4 kHz. Assume that an optimal FIR filter is to be used, with an overall passband ripple, $\delta_p = 0.05$, and stopband ripple, $\delta_s = 0.01$. Design an efficient decimator. Your answer must indicate a suitable pair of decimation factors, with appropriate detailed analysis of computational and storage complexities to justify your choice. Specify the sampling frequencies at the input and output of each stage of decimation, and the following parameters for each of the decimation filters in your design: (25)

- (i) the bandedge frequencies
- (ii) the normalized transition width
- (iii) passband and stopband ripples
- (iv) filter length

7. (a) Show that the Bartlett estimate of the power spectral density is asymptotically unbiased, that the variance of the estimate decreases with the number of data sections, and that the spectrum estimates are consistent. What effect does the modified periodogram method have on the frequency resolution? (15)

(b) The 3×3 autocorrelation matrix of a harmonic process is

$$\mathfrak{R}_x = \begin{bmatrix} 3 & -j & -1 \\ j & 3 & -j \\ -1 & j & 3 \end{bmatrix}$$

Using the MUSIC algorithm, find the complex exponential frequencies and the variance of the white noise. (20)

8. (a) Show that the short-time Fourier transform (STFT) can be implemented using a filter bank. (12)

(b) Explain with neat diagram why a scaling function is used in wavelet transform. (5)

(c) The wavelet and subband transform theories have significant linkages-explain with mathematical details. (18)
