L-4/T-1/EEE **Date: 17/02/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2016-2017

Sub: **EEE 401** (Control System I)

Full Marks: 210 Time: 3 Hours

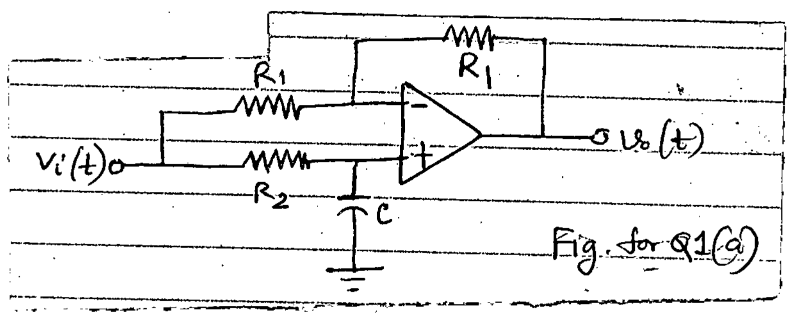
The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

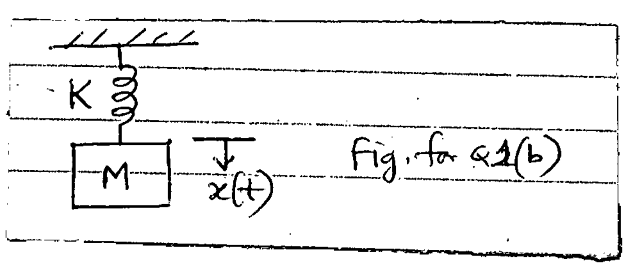
SECTION – A

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

1. (a) An operational amplifier circuit is shown in Fig. for Q1(a). Determine the transfer function of the circuit, assuming an ideal op-amp. **(12)**

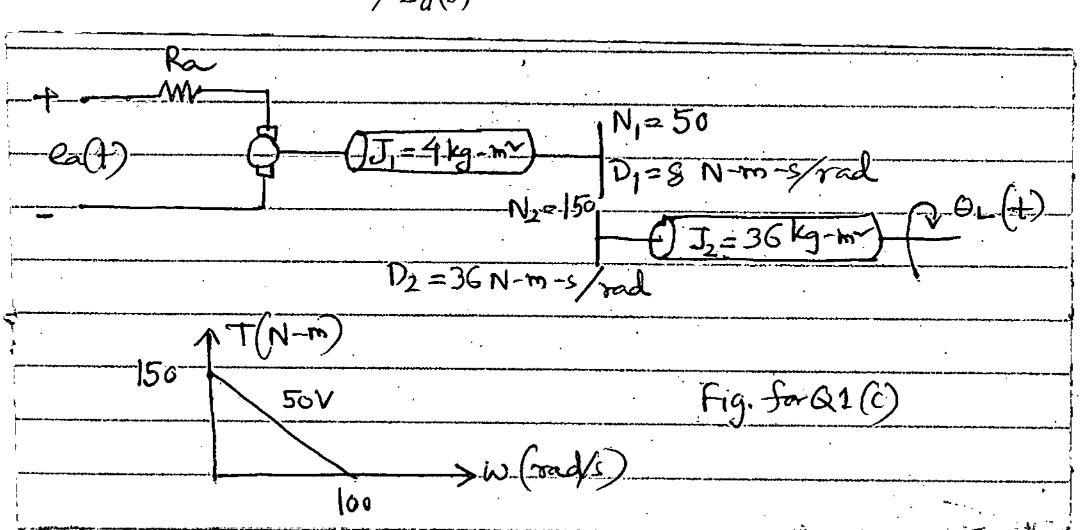


(b) Consider the mass and spring system shown in Fig. for Q1(b). **(10)**



Assuming initial conditions $x(0)=x_0$ and $x(0)=x_1$, write a Laplace transform expression for X(s). Find x(t) by obtaining the inverse Laplace transform. What will be the oscillation frequency for this system?

(c) For the motor, load, and torque-speed curve shown in Fig. for Q1(c), find the transfer function, $G(s)=\theta_L(s)/E_a(s)$. **(13)**



Contd P/2

EEE 401

2. (a) Represent the following transfer function in state space model. Write your answer in vector-matrix form. **(11)**

$$T(s)=\frac{s(s+2)}{(s+1)(s^2+2s+5)}$$

(b) An RLC network is shown in Fig. for 2(b). Identify a suitable set of state variables. Obtain the state differential equation. **(12)**

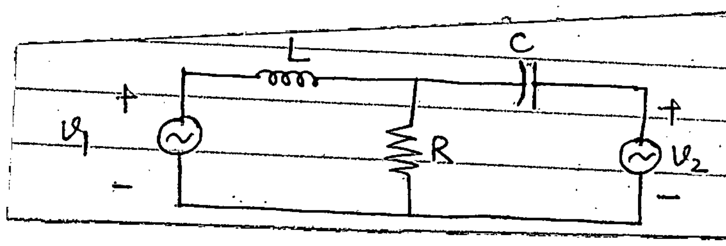


Fig. for Q2(b)

(c) Sketch the step response of the non-minimum phase system **(12)**

$$G(s)=\frac{s-2}{s^2+3s+36}$$

Comment on the transient and steady-state response of the system with respect to a minimum phase system.

3. (a) A position control system has the closed loop transfer function **(12)**

$$T(s)=\frac{11.1(s+18)}{(s+20)(s^2+4s+10)}$$

Plot the poles and zeros of the system and discuss the dominance of the complex poles. What overshoot for a step input do you expect?

(b) A second order control system has the following specification for a step input: **(12)**

(i) $\%os \le 5\%$ (ii) $T_s < 4s$ (iii) $T_p < 1s$

Show the permissible area of the poles in order to achieve the desired response.

(c) Sketch the general shape of the root locus for the open loop pole-zero plots shown in Fig. for Q3(c). **(11)**

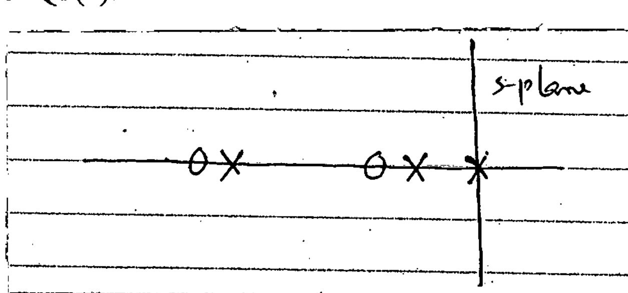


Fig. for Q.3(c)

EEE 401

4. (a) A position control system has unity feedback and loop transfer function **(12)**

$$G(s)H(s) = \frac{10}{s(s+1)(s+p)}$$

Sketch the root locus as a function of p. The roots of the polynomial $(s^3 + s^2 + 10)$ are –2.54, 0.77 + j1.83 and 0.77–j1.83.

(b)A unity feedback control system has the loop transfer function **(10)**

$$G(s)H(s) = \frac{K(s^2 + 10s + 30)}{s^2(s+10)}$$

The system is required to operate at complex roots $s = -3.56 \pm j3.56$. Find the gain K to satisfy this condition. What is the damping ratio of the dominant roots at this gain?

(c) A feedback control system is shown in Fig. for Q4(c). **(13)**

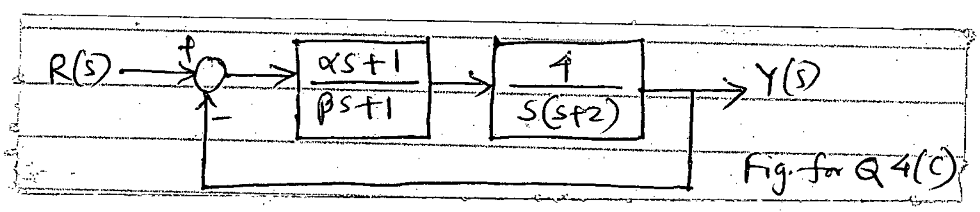


Fig. for Q 4(c)

Using root locus method, find the suitable values of α and β so that settling time is less than 4s and the damping ratio of the dominant roots is greater than 0.6.

SECTION – B

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

5. (a) A feedback control system has the structure shown in Fig. for Q. No. 5(a). Find the closed-loop transfer function, $T = \frac{C(s)}{R(s)}$ by (i) block diagram manipulation, and (ii) by using a signal flow graph and Mason's rule. (iii) Select the gains K_1 and K_2 so that the closed-loop response to a step input is critically damped with two poles at s = –10. (iv) Plot the unit step response and find the time required for the response to reach 90% of its final value? **(20)**

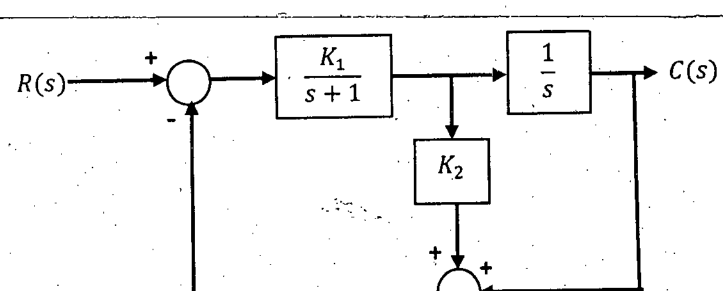


Fig. for Q. no. 5(a)

EEE 401

Contd... Q. No. 5

(b) For the closed-loop system shown in Fig. for Q. No. 5(b), find the state-space representation in 'Parallel' form. **(15)**

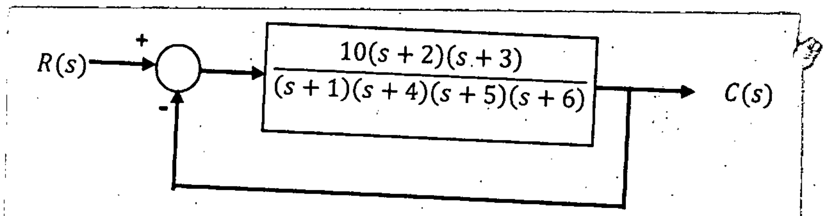


Fig. for Q. no. 1 (b)

6. (a) The circuit diagram of a phase shift oscillator is shown in Fig. for Q. No. 6(a). The transfer function for the passive network can be expressed as, **(18)**

$$\frac{V_2(s)}{V_1(s)} = \frac{-1}{\left(1+\frac{1}{sRC}\right)\left(2+\frac{1}{sRC}\right)^2 - 3 - \frac{2}{sRC}}$$

Find the characteristic equation of the oscillator (assume $K = \frac{R_2}{R_1}$). Use the Routh-Hurwitz criterion to obtain the oscillation condition and the oscillation frequency of this circuit.

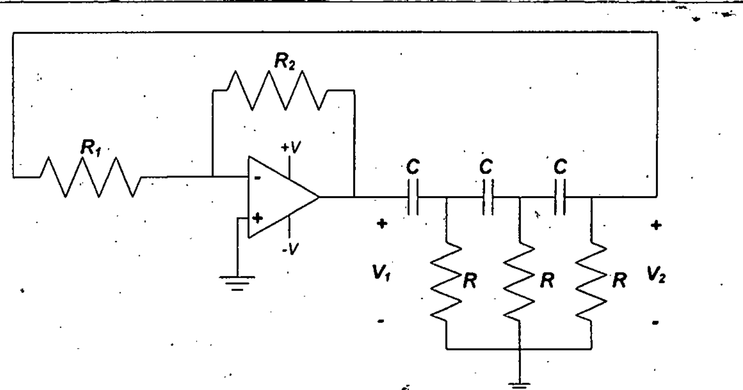


Fig. for Q. no. 2 (a)

(b) The steady-state velocity error of a system is defined as **(17)**

$$e_{ss} = \lim_{t\to\infty}\left(\frac{dr}{dt} - \frac{dc}{dt}\right)$$

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

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

EEE 401

7. (a) Consider the system shown in Fig. for Q. No. 7(a). draw Nyquist Diagrams and comment on the stability of this system for $K = 0.3$ and $K = 0.4$. **(18)**

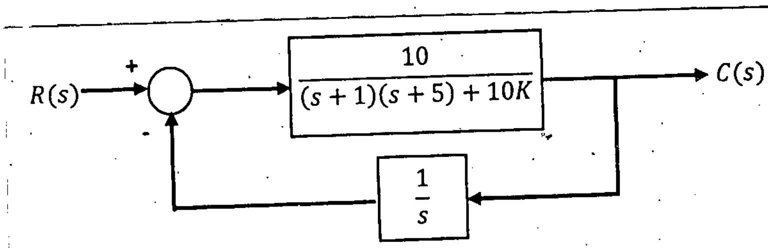


Fig. for Q. no. 7 (a)

(b) NASA is planning many Mars missions with rover vehicles. A typical rover is a solar-powered vehicle which will see where it is going with TV cameras and will measure distances to objects with laser range finders. It will be able to climb a 30° slope in dry sand and will carry a spectrometer to determine the chemical composition of surface rocks. It will be controlled remotely from the Earth. For the model of the position control system used for a typical rover as shown in Fig. for Q. No. 7(b), draw the Bode plots and determine the gain K that maximizes the gain margin. Determine the overshoot for a step input with the selected gain. **(17)**

Use semi-log graph paper for Bode plots and attach the plots with the answer script.

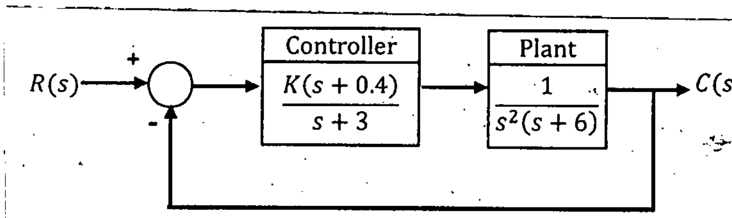


Fig. for Q. no. 7 (b)

8. (a) With necessary illustration and derivation, show how steady-state errors can be found from Bode magnitude plots for different types of systems. **(10)**

(b) For the closed-loop control system shown in Fig. for Q. No. 8(b), use only frequency response methods to - **(10+15)**

(i) find the value of gain K that yields a 9.5% overshoot in its step transient response.

(ii) design a lag compensator to yield a 10-fold improvement in the steady-state error over the gain-compensated system, while keeping the overshoot within 9.5%.

EEE 401

Contd... Q. No. 8(b)

Use semi-log graph papers for Bode plots and attach the plots with the answer script.

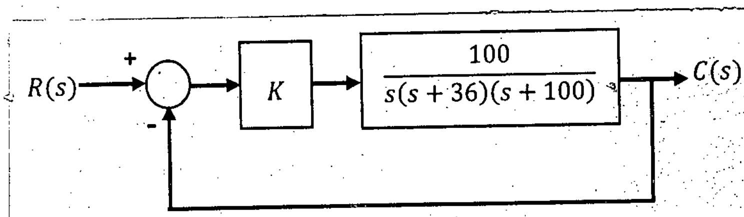


Fig. for Q. No. 4(b) 8

L-4/T-1/EEE **Date : 22/02/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2016-2017

Sub : **EEE 433** (Microwave Engineering)

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**.

Smith's Chart supplied.

1. (a) Using necessary diagrams derive the one-dimensional wave equations of voltage and current for a two conductor ideal transmission line. **(12)**

   (b) Determine the solutions of the wave equations for voltage and current found in Q. No. 1(a). **(11)**

   (c) Determine the equations of characteristic impedance and wave velocity for a lossless co-axial line. **(12)**

2. (a) Derive equations of reflection coefficient and transmission coefficient when an ideal transmission line of characteristics impedance Z_0 is terminated with a load resistance, R_L, What will happen if $R_L = Z_0$? **(12)**

   (b) Consider two computers are interconnected by a co-axial cable of 100 m long whose characteristic impedance is 50 Ohm and velocity of propagation is 2×10^8 m/s. Consider a potion of digitally coded signal generated by PC-1 as shown in Fig. for Q. No. 2(b). With proper diagram explain what will happen to these pulses when they will reach PC-2 whose input impedance is 100 Ohm. What will happen when the pulses come back to PC-1 whose input impedance is (i) equal to 50 Ohm, and (ii) not equal to 50 Ohm. **(12+2)**

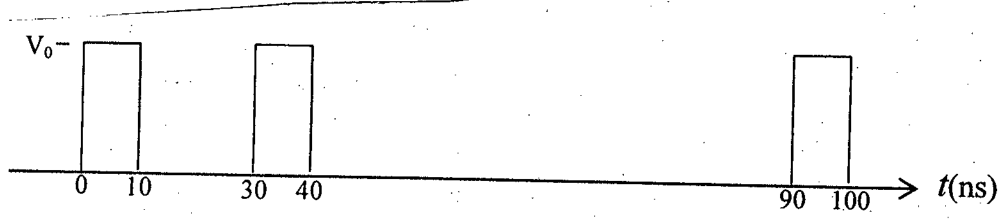


Fig. for Ques. 2(b)

   (c) A 77 mm long open ended ideal transmission line is charged to a dc voltage of 9 V and then connected to a 51.64 Ohm resistor in one end. Draw the wave shape of voltage across the resistor showing all the voltage levels and time. Show calculation for two cycles, where in each cycle the incident wave travels to the end of the open circuited line and comes back to the resistor. Given: Transmission line parameters are: L = 0.2 μH/m and C = 300 pF/m. **(9)**

3. (a) For sinusoidal voltage on an ideal transmission line, prove that, $Z_{max} = Z_0S$ and $Z_{min} = Z_0/S$, where symbols have their usual meaning. **(6)**

(b) With proper diagram derive and explain the equations of constant resistance and reactance curves of the Smith transmission line chart. **(14)**

(c) A load impedance of $Z_L = 20 + j20\ \Omega$ is to be matched to a $Z_0 = 50\ \Omega$ line for 10 GHz signal using a shorted stub tuner of characteristic impedance 100 Ω. Using admittance chart determine the nearest distance from the load where the stub must be placed in parallel with the line and the length of the stub. Assume that the phase velocity of the above signal in both the lines is equal to 2×10^8 m/s. (Use the Smith's chart provided with this question paper and attach it with your answer script.) **(15)**

4. (a) Starting from Maxwell's equations, prove that for a source free waveguide,

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

where symbols have their usual meaning. Then re-write the equation for attenuation free propagation. **(10+2)**

(b) For TM wave in a perfectly conducting parallel plates separated by a distance 'a' the field equations are:

$$E_x = -\frac{j\beta a A}{m\pi} cos \frac{m\pi}{a} x; \quad H_y = -\frac{j\omega\varepsilon a A}{m\pi} cos \frac{m\pi}{a} x \ \text{ and } E_y = H_x = 0.$$

where symbols have their usual meaning. Considering these equations and other parameters of the guide, derive the equation of attenuation constant due to conductor losses. (15)

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

EEE 433

SECTION – B

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

The symbols have their usual meaning.

5. (a) Explain various modes supported by a rectangular waveguide with perfectly walls and filled with lossless material. **(8)**

(b) Write the expressions of Electric and Magnetic fields in a rectangular waveguide and obtain the general expression of attenuation due to conductor loss for TM modes. **(15)**

(c) A rectangular waveguide with dimensions a = 2.5 cm and b = 1.0 cm is to operate at 15 GHz. Calculate the cutoff frequency, phase constant, and phase velocity of TE_{10} and TM_{11} modes. **(12)**

6. (a) What are cavity resonators? Derive an expression of the Quality Factor (Q-factor) of a rectangular cavity in terms of its dimensions. **(17)**

(b) From the general field equations of a circular waveguide, Obtain the expressions of fields for TE_{01} mode and hence show that the attenuation per unit length is given by **(18)**

$$\alpha_c = \frac{K_c^2 Z_{TE} R_s}{\omega^2 \mu^2 a}$$, where the symbols have their usual meaning.

7. (a) Explain the terms Directive Gain, Directivity, and power Gain of an antenna. A half-wave dipole is fed at its centre by a sinusoidal source. Give a sketch of current distribution along the dipole. **(15)**

(b) A vertically oriented Hertzian dipole has a uniformly distributed sinusoidally time varying current of amplitude 25 A at 60 MHz. It is located in free- space with its mid-point at the origin of spherical coordinates. The length of the dipole is 3 cm. Find (i) the radiation electric and magnetic field intensities at (150 m, 90°, 0°), (ii) total radiated power, (iii) maximum and average values of radiation intensity, and (d) radiation efficiency of the antenna, if the radius and conductivity of the antenna wire are 1.5 mm and 57×10^6 S/m, respectively. **(12)**

8. (a) State the differences between a broadside array and an endfire array of antennas. Also, state and explain the principle of "Pattern Multiplication". **(12)**

EEE 433

(b) Find the expressions of far fields for a small filamentary circular loop antenna carrying a uniform current I_0 coswt. **(13)**

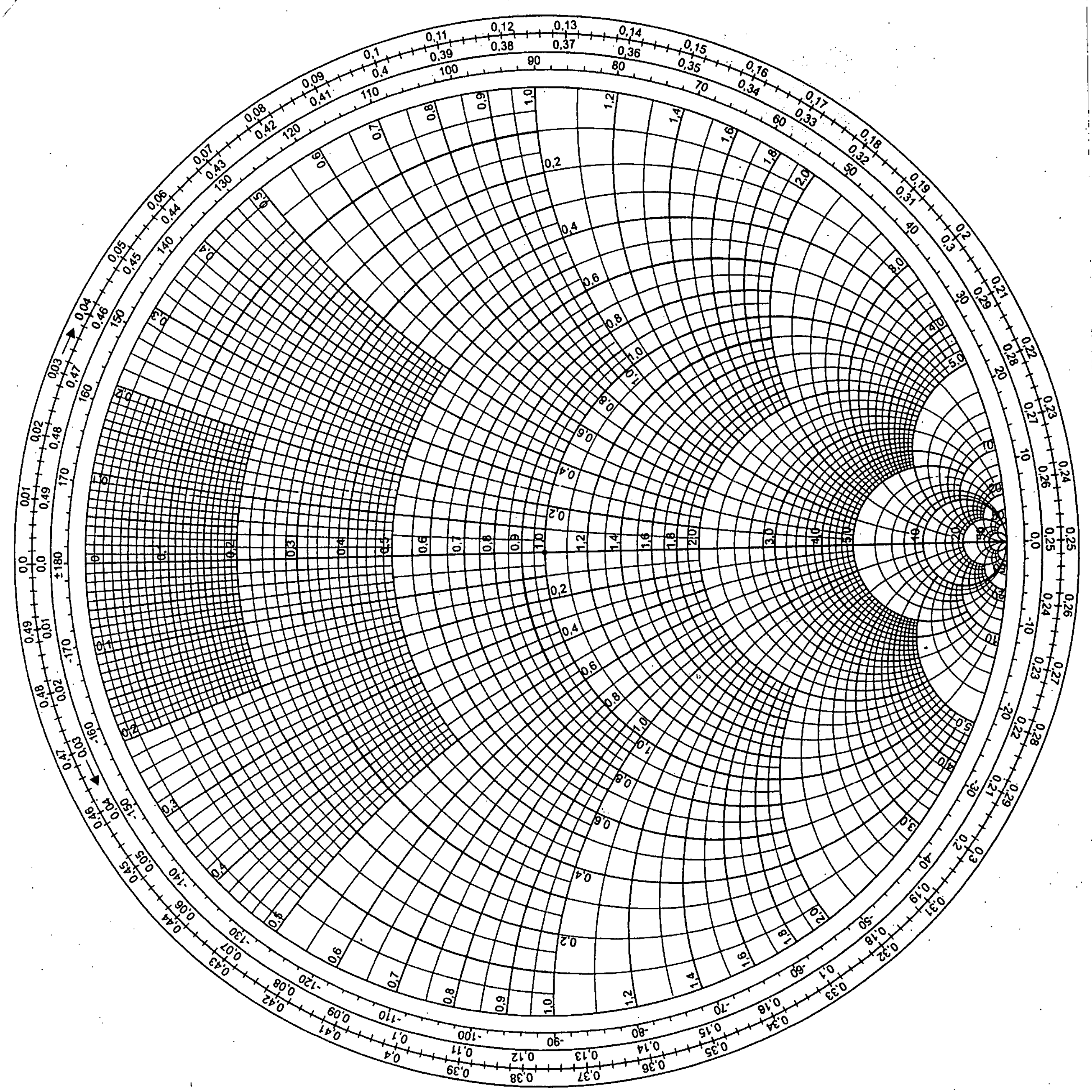
(c) A magnetic field strength of 5 μA/m is required at a point on $\theta = \pi/2$, which is 2 km from an antenna in air. Neglecting Ohmic loss, how much power must the antenna transmit if it is a 10-turn loop antenna of radius $\rho_0 = \frac{\lambda}{20}$? **(10)**

EEE 433

=5=

Smith's Transmission Line Chart

(Please attach this chart with your answer script)



L-4/T-1/EEE **Date: 22/02/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2016-2017

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 – A

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

1. (a) For a single phase full-bridge diode rectifier supplied from a sinusoidal voltage source, show that the input power factor becomes 90% lagging when the load is highly inductive (i.e., solenoid or dc motor). **(18)**

(b) A dc shunt motor is run from a single-phase full-bridge controlled rectifier as shown in Fig. 1. The supply voltage is **(17)**

$$v_{in} = 339\sin(314t) \text{ volt.}$$

If the motor needs a dc voltage (v_a) of 150 V and draws an armature current (I_a) of 10 A dc, determine

(i) Firing angle α,

(ii) Input power factor.

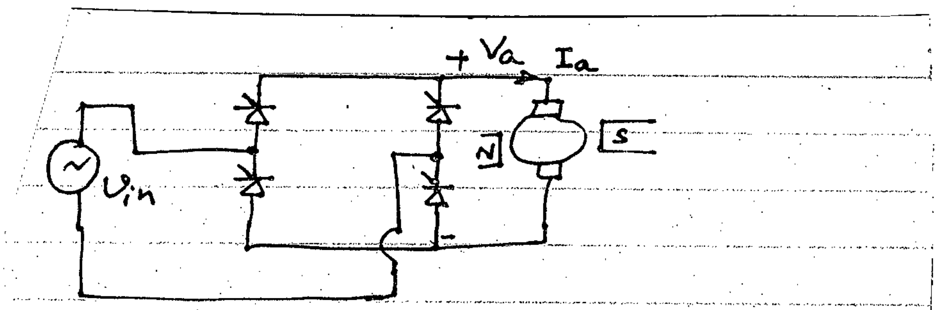


Fig. 1 [for Q. 1(b)]

2. (a) In a 3-phase full bridge diode rectifiers show analytically that the dc output voltage is given by **(15)**

$$V_{dc} = \frac{3\sqrt{3}\,V_m}{\pi}$$

where, V_m is the peak (maximum) value of the line to neutral voltage. Assume sinusoidal input supply.

(b) A battery stack of 110 V dc is charged from a 3-phase SCR based controlled rectifier. **(20)**

The battery charging circuit has a limiting resistance of 1.5 Ω, 500 W connected in series. If the input supply voltage is 415 V (rms) line to line, determine the firing angle α to have an average charging current of 100 A.

[consider a balance sinusoidal input of 3-phase source]

EEE 473

3. (a) Define Total Harmonic Distortion (THD). **(5)**

(b) For a single-phase full-bridge voltage source inverter, determine the THD of the output voltage when the inverter is run in square wave mode. **(15)**

(c) A single phase full-bridge voltage source inverter is run with sine pluse width modulation (SPWM). The modulation index (M) is set to 0.8. If the RMS value of the fundamental output voltage is 220 V, determine the inverter supply dc voltage. **(15)**

4. (a) Draw a 3-phase voltage source inverter and explain with necessary control and output waveforms the operation of the inverter in 180° conduction mode. Consider a 3-phase star connected load. **(20)**

(b) A 3-phase full bridge SCR converter is operated in inversion mode to supply power from a 400 kV dc source to a 3-phase 400 kV ac transmission line as shown in Fig. 2. **(15)**

(i) Determine the SCR firing angle α,

(ii) If the power fed to the ac line is 450 MW

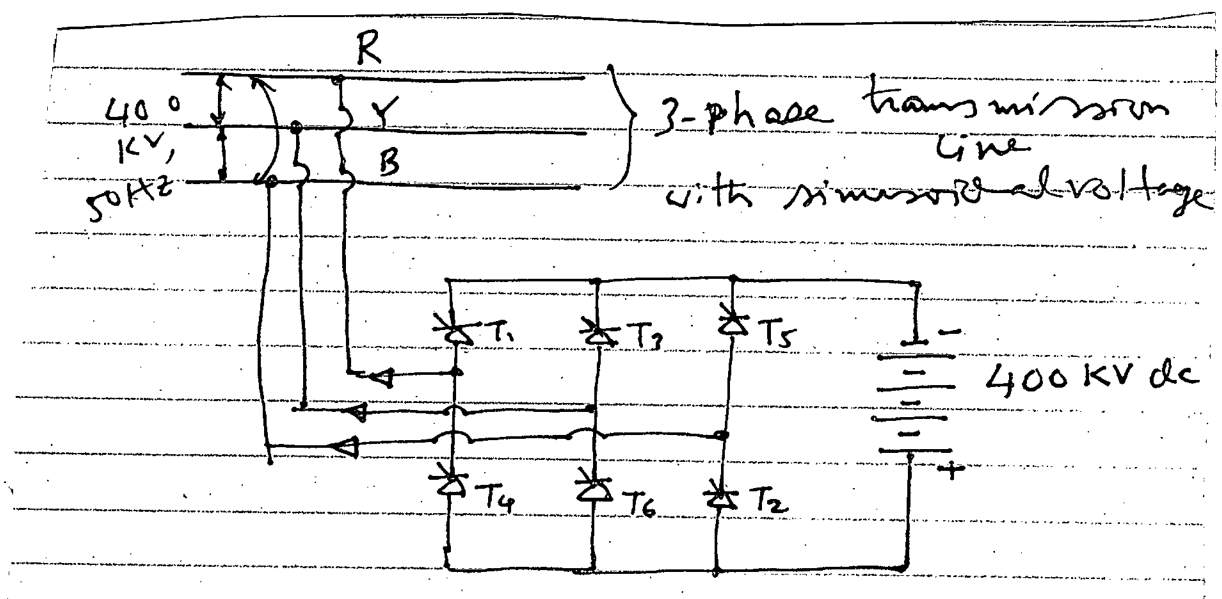


Fig. 2 for Q. 4(b)

determine the average current through each SCR.

EEE 473

SECTION – B

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

Make necessary assumptions. Symbols their usual meanings.

5. Draw the circuit diagram of SEPIC dc-dc converter and explain its operation showing the direction of current flow when switch is ON and when switch is OFF. Derive the relation between output voltage and input voltage. From the waveforms of current through both the inductors, find the minimum values of the inductors required to keep the operation in continuous Conduction Mode. **(12+12+11)**

6. (a) For CuK converter find the value of filter capacitor required for a specified value of output voltage ripple, switching frequency, duty cycle and inductor used. **(12)**

   (b) What is holding current and latching current of an SCR. **(5)**

   (c) Explain (i) Self commutation, (ii) Complementary commutation and (iii) External pulse commutation with suitable example. Draw the waveforms of currents and voltages required for your explanation. **(18)**

7. (a) For a single phase AC-AC voltage converter with resistive load find the equation of input power factor in terms of firing angle 'α'. **(12)**

   (b) Draw the circuit diagram of a single phase to single phase cycloconverter and show the gate pulses applied for an output frequency of one-third of the input frequency. **(10)**

   (c) Draw the circuit diagram of a three phase to single phase cycloconverter and show the gate pulses applied. **(13)**

8. Draw the circuit diagram of a three phase voltage controller. Show the gate pulses for firing angle $\alpha = 120°$. Determine the line to neutral and line to line voltages with proper calculations and draw the waveforms of line to neutral and line to line voltages neatly for $\alpha = 120°$. **(6+6+13+10)**

L-4/T-1/EEE **Date : 22/02/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2016-2017

Sub : **EEE 453** (VLIS I)

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) A designer designed a NMOS pass transistor circuit shown below. Calculate the output voltages V_{out1}, V_{out2} and V_{out3}. Assume V_{to} = 1 V, γ = 0.5 and that the initial voltage at all the above nodes were zero. **(17)**

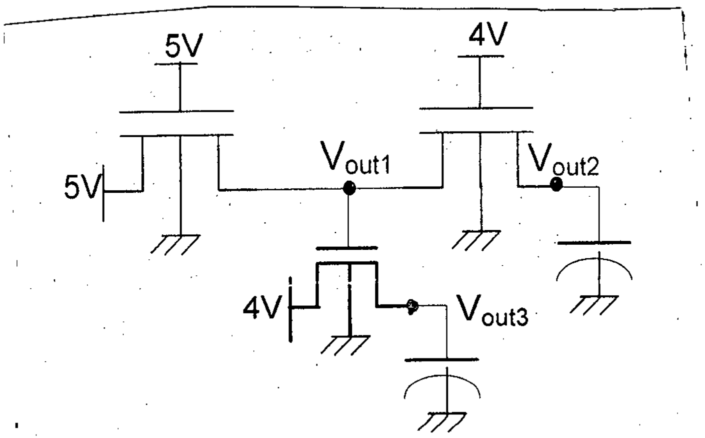


Fig. for Q. No 1(a)

(b) The layout of a circuit in 180 nm CMOS process is shown in Fig. for Q. 1(b). **(18)**

(i) Draw the Schematic diagram of the circuit and then clearly mark the length and width of each of the transistor.

(ii) Find the current flowing through each of the transistors.

(iii) If the transistors are to be replaced by an equivalent single transistor, calculate the (W/L) ratio of the equivalent transistor.

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

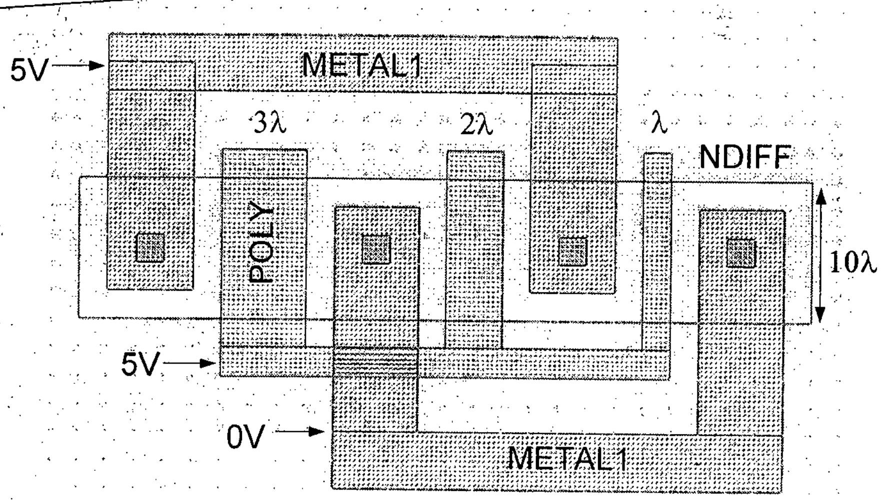


Fig. for Q1(b)

Contd P/2

EEE 453

2. (a) Show that circuit diagram of a NMOS inverter with a PMOS load (Pseudo NMOS Inverter). The inverter is designed such that the output voltage becomes 0.2 V, when the input voltage is High (5 V). Calculate the inverter ratio (i.e. the ratio of driver transistor aspect ratio to load transistor aspect ratio). The following data are given: $\mu_n C_{ox} = 120\ \mu A/V^2$, $\mu_p C_{ox} = 40\ \mu A/V^2$, $V_{to} = 1$ V, $V_{DD} = 5$ V, $\gamma = 0.5$. Assume that the body of the NMOS transistor is connected with the ground and that of the PMOS transistor is connected with V_{DD}. **(20)**

(b) Derive the equiation of rise time, fall time and dynamic power consumption of a CMOS inverter in terms of load capacitance (C_L), power supply voltage (V_{DD}), frequency of operation (f) and transistor parameters. **(17)**

3. (a) Sketch a 3-input NAND gate with transistor widths chosen to achieve worst case effective rise and fall resistance equal to a unit inverter. Let C and R be the gate/diffusion capacitance and resistance, respectively of a unit NMOS transistor ($W_n = W_{min}$ and $L_n = L_p = L_{min}$). Assume $\mu_n = 3\ \mu_p$ and that standard layout practice was followed. **(20)**

(i) Show the layout of the above NAND gate.

(ii) Sketch the transistor level schematic of the gate. In this schematic diagram append (show) capacitance at each node of the circuit as calculated from the layout.

(iii) Compute the worst case rising and falling propagation delay of the NAND gate driving 'h' identical NAND gate using Elmore delay model.

(iv) If C = 2 fF/μm and R = 2.5 KΩ.μm for NMOS in a 180 nm process, what is the delay of the above fan-out of 3 NAND gate.

(b) A ring oscillator is constructed from an odd number of inverters. Use the linear delay model to estimate the frequency of an N-stage ring oscillator. Assume the inverters are constructed in a 65 nm process with $\tau = 3$ps. **(15)**

4. (a) Show with mask and device cross-sectional diagram, the fabrication sequence of an NWELL CMOS process. Briefly explain each step. **(20)**

(b) A process uses aluminum conductor for which electromigration related maximum current density is 2 mA/μm². 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 μm, $V_{DD} = 1.8$ V and on-resistance of the 8 : 1 pull down transistor is 10 kΩ. **(15)**

Contd P/3

EEE 453

SECTION – B

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

5. (a) An 8-bit adder is to be designed that will perform serial addition, dealing with a pair of bits in one clock cycle. Using Finite State Machine (FSM) approach, show the implementation of the adder. **(20)**

(b) Write a Verilog code for the FSM described above. **(15)**

6. (a) (i) Show that the SVM output of a one bit full adder can be expressed as

$$S_i = A_i B_i C_{i-1} + \overline{C_i}.(A_i + B_i + C_{i-1})$$ **(10)**

where the symbols have their usual meaning.

(ii) Show that transistor level circuit implementation of the above SVM output in (a) CMOS, (b) Pseudo NMOS and (c) CaS code voltage switch logic. **(9)**

(b) Draw the circuit diagram of a 2 × 2 bit six transistor Static Random Access Memory array. Show clearly the row select, column select, Pre-charge, sense amplifier and the I/O signal lines. Explain how read operation is performed and the role of the sense amplifier in the read operation. **(16)**

7. (a) Show the transistor level implementation of the following logic function in a NOR-NOR Programmable Logic Array (PLA). **(15)**

$$Z_1 = \overline{X}_2 X_4 + X_1 \overline{X}_2 X_4 + X_1 X_2 \overline{X}_3 \overline{X}_4$$
$$Z_2 = \overline{X}_2 X_4 + X_1 X_2 \overline{X}_3 \overline{X}_4 + \overline{X}_3 \overline{X}_4$$
$$Z_3 = X_1 \overline{X}_2 X_4 + X_1 X_2 \overline{X}_3 \overline{X}_4 + \overline{X}_3 \overline{X}_4$$

(b) A 4-bit datapath consists of register, ALU and a shifter. Show two possible bus architectures of the system such that an addition operation of two operand stored in the register and storing the result back in the register can be computed in at most 2 clock cycles. **(16)**

EEE 453

8. (a) Using a structured design approach, develop a bus arbitration logic for n-line bus such that access is given to the highest priority line. If priority is given according to ascending order (line N highest priority) draw the circuit diagram and the layout diagram of the basic leaf cell. **(18)**

(b) (i) The input capacitance of an inverter is used as a dynamic storage cell in a certain circuit. Given that the input capacitance is 0.03 pF and leakage current across the channel to substrate reverse-biased diode is 0.36 nA, calculate the minimum operating frequency of the refresh circuit. Assume V_{DD} = 5 V and make necessary assumptions. **(6)**

(ii) Using the above dynamic storage cell as a building block, show the construction of a 4-bit serial-in serial-out dynamic shift register. **(5)**

(iii) You are asked to use two phase non-overlapping clock in the above circuit. Design a circuit to generate the two phase non-overlapping clock from a master clock signal. What are the advantages of such clocked sequential circuit over single phase clocked circuit? **(6)**

L-4/T-1/EEE **Date: 27/02/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2016-2017

Sub: **EEE 413** (Solid State Devices)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks.

The symbols have their usual meanings. Assume reasonable values for any missing data.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) A new semiconductor material is to be "designed". The semiconductor has to be p type and doped with 5×10^{15} cm^{-3} acceptor atoms. Assume complete ionization and $N_D = 0$. The effective density of states functions are $N_C = 1.2\times10^{19}$ cm^{-3} and $N_V = 1.8\times10^{19}$ cm^{-3} at $T = 300$ K and vary as T^2. A special semiconductor device fabricated with this material requires that the hole concentration be no greater than 5.08×10^{15} cm^{-3} at $T = 350$ K. What is the minimum bandgap energy required in this new material? **(20)**

(b) A semiconductor has electron and hole mobilities of 1350 cm^2/V-s and 480 cm^2/V-s, respectively with an intrinsic concentration of 2×10^{10} cm^{-3}. When the conductivity is considered as a function of the hole concentration p_0, find **(15)**

(i) the hole concentration at which minimum value of conductivity will occur,
(ii) the value of intrinsic conductivity and
(iii) the minimum value of conductivity.

2. (a) In silicon, the electron concentration is given by $n(x) = 10^{15}e^{-x/L_n}$ cm^{-3} for $x \geq 0$ and the hole concentration is given by $p(x) = 5\times10^{15}e^{+x/Lp}$ cm^{-3} for $x \leq 0$. The parameter values are $L_n = 2\times10^{-3}$ cm and $L_p = = 5\times10^{-4}$ cm. The electron and hole diffusion coefficients are $D_n = 25$ cm^2/s and $D_p = 10$ cm^2/s, respectively. Calculate the total current density. **(20)**

(b) Germanium at 300 K is uniformly doped with donor impurity atoms to a concentration of 4×10^{13} cm^{-3}. The excess carrier lifetime is found to be $\tau_{p0} = 2\times10^{-6}$ s and $n_i = 2.4\times10^{13}$ cm^{-3}, $\mu_n = 3900$ cm^2/V-s, $\mu_p = 1900$ cm^2/V-s. Determine, **(15)**

(i) the ambipolar diffusion coefficient and mobility.
(ii) the electron and hole lifetimes.

3. (a) A pn junction has the doping profile shown in Figure for Q. 3(a). Assume that $x_n > x_0$ for all reverse-biased voltages. **(20)**

(i) What is the built-in potential across the junction?
(ii) For the abrupt junction approximation, sketch the charge density through the junction.

Contd P/2

EEE 413

Contd... Q. No. 5(a)

(iii) Derive the expression of the electric field through the space charge region.

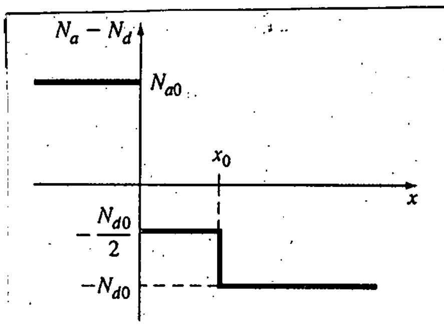


Figure for Q. 3(a)

(b) Consider the following equation of SRH recombination rate- **(15)**

$R = \frac{C_n C_p N_t (np - n_i^2)}{C_n(n+n') + C_p(p+p')}$ and the definitions of τ_{p0} and τ_{n0} by $\frac{1}{C_p N_t}$ and $\frac{1}{C_n N_t}$, respectively. Let, $n' = p' = n_i$. Assume that in a particular region of a semiconductor, $n = p = 0$. Determine the recombination rate R and explain what this result means physically.

4. (a) A silicon pn junction diode is to be designed to operate at T = 300 K such that the diode current is I = 10 mA at a diode voltage of V_D = 0.65 V. The ratio of electron current to total current is to be 0.10 and the maximum current density is to be no more than 20 A/cm^2. **(20)**
($N_A = N_D = 10^{16}$ cm^{-3}, D_n = 25 cm^2/s, D_p = 10 cm^2/s, $\tau_{p0} = \tau_{no} = 5 \times 10^{-7}$ s)
Determine the diode's doping levels.

(b) For a uniformly doped pn junction having $N_A >> N_D$, the $\left|\frac{1}{C'}\right|^2$ versus V_R characteristic shows that the curve intercept the x-axis at V_R = –0.725 V and the slope is 6.15 × 10^{15} (F/cm^2)$^{-2}$V^{-1}. Determine the impurity doping concentration of p and n sides. **(15)**

SECTION – B

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

5. (a) Draw the energy band diagram (in the semiconductor region) of an ideal MOS (n-type) capacitor when the device is biased in the accumulation, depletion and inversion mode. **(15)**

(b) Determine the metal-semiconductor work function difference in an MOS structure with p-type silicon when the gate is aluminum. The metal work function is 4.3 eV, the oxide electron affinity is 0.9 eV and the semiconductor electron affinity is 4 eV. Let $N_a = 10^{15}$ cm^{-3}. **(20)**

EEE 413

6. (a) An Al-silicon dioxide-silicon MOS capacitor has an oxide thickness of 450 Å and a doping of $N_a = 10^{15}$ cm^{-3}. The oxide charge density is 3×10^{11} cm^{-2}. Calculate the flat-band voltage and the threshold voltage. Sketch the electric field through the structure at the onset of inversion. Use the Figure for Q. No. 6 in your calculation. **(15)**

(b) The flat-band capacitance for an MOS capacitor is 5.03×10^{-8} F/cm^2. Consider a p-type silicon substrate at T = 300 K. The oxide is silicon dioxide with a thickness of 550 Å and the gate is aluminum. If the threshold voltage is –0.34 V, calculate the fixed oxide charge density. Use Figure for Q. No. 6 in your calculation. **(20)**

7. (a) A uniformly doped silicon pnp transistor is biased in the forward- active Mode. The doping concentrations are $N_E = 10^{18}$ cm^{-3}, $N_B = 5 \times 10^{16}$ cm^{-3}, and $N_C = 10^{15}$ cm^{-3}. Calculate the values of n_{E0}, p_{B0}, n_{C0}. For V_{EB} = 0.650 V, determine p_B at x = 0 and n_E at $x' = 0$. Sketch the minority carrier concentrations through the device and label each curve. **(25)**

(b) Draw the energy band diagram of an npn bipolar transistor operating in the inverse-active mode. **(10)**

8. (a) A Schottky diode with n-type GaAs at T = 300 K yields the $1/C'^2$ versus V_R plot shown in Figure for Q. No. 8(a), where C' is the capacitance per cm^2. **(20)**

Determine $V_{bi}, N_d, \phi_n, \phi_{B0}$.

(b) A metal, with a work function $\phi_m = 4.2$ V, is deposited on an n-type silicon semiconductor with χ_s = 4.0 V and E_g = 1.12 eV. Assume no interface states exist at the junction. Let T = 300 K. Sketch the energy-band diagram at zero bias for the case when no space charge region exists at the junction. Determine N_d so that the condition mentioned above is satisfied. What is the potential barrier height seen by electrons in the metal moving into semiconductor? **(15)**

Contd ------ P/4

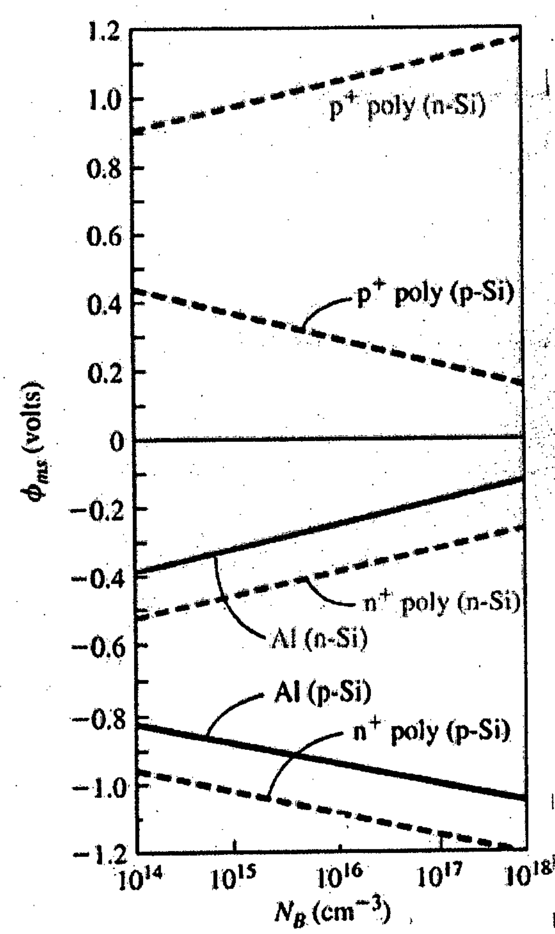


Figure for Q. No. 6

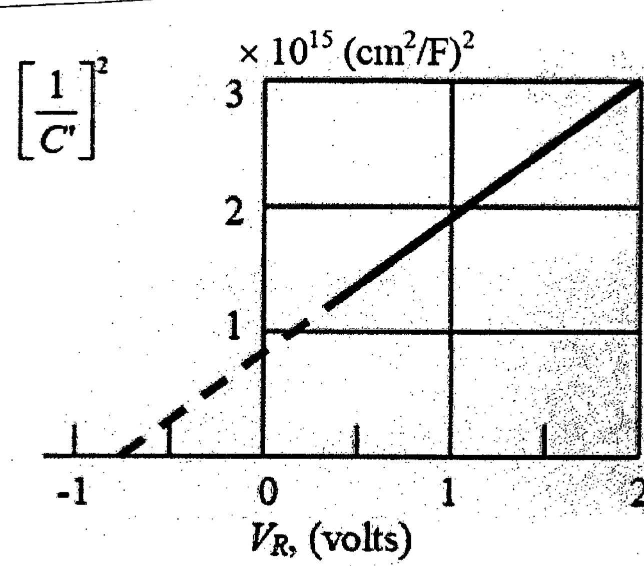


Figure for Q. No. 8 (a)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2016-2017

Sub: **EEE 475** (Power Plant Engineering)

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. Discuss the essential factors which influence the choice of site for Hydro-electric power plants. What are the various elements of Hydro-electric power plants? Describe them briefly. Explain the principle of operation of a pumped storage power plant. **(35)**

2. Why the thermal efficiency of a steam power plant is quite low? **(35)**
How is thermal efficiency of a steam power plant improved?
Why steam power plants are always suited by the side of a river or lake?

3. Enumerate the advantages and disadvantages of a Nuclear Power Plant as compared to Conventional Power Plants. **(35)**
Explain with neat diagram the working of a nuclear power station.
Describe Atomic Fuels.

4. "Diesel Power Plants are used as standby units in a grid connected system" – Discuss. **(35)**
Draw a layout of a modern Diesel Power Plant showing the following systems:
    (a) Air intake system
    (b) Cooling system
    (c) Fuel supply system and
    (d) Exhaust system
Explain what is combined Heat and Power generation (CHP). Explain its advantages.

SECTION – B

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

5. (a) Define load factor and diversity facor. Discuss the effect of diversity factor on load factor of a power plant. **(13)**
(b) Explain how use factor and capacity factor effects the choice of the size of a generation plant. **(10)**

Contd P/2

EEE 475

Contd... Q. No. 5

(c) The peak load on a power station is 30 MW. The loads having maximum demands of 25 MW, 10 MW, 5 MW and 7 MW are connected to the power plant. The capacity of the power station is 40 MW and annual load factor is 50%. Find, **(12)**

(i) Average load on the power station

(ii) Energy supplied per year

(iii) Demand factor

(iv) Diversity factor.

6. (a) Why load forecasting is necessary for economical operation of power plants? Discuss the time series method of load forecasting. **(18)**

(b) Discuss the considerations on which location of a power plant generally depends. **(17)**

7. (a) Define heat rate and incremental heat rate for a power plant. Discuss in details the significance of incremental heat rate? **(20)**

(b) An input-output curve of a 10 MW power station is expressed as, **(15)**

$$I = 10^6\left(10 + 8L + 0.4L^2\right)$$

where I is in kcal per hour and L is in MW.

Find the load at which the maximum efficiency occurs.

8. (a) Discuss the economic division of loads between two generating units in a power station. **(18)**

(b) Describe a typical switchyard for a power plant. **(17)**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2016-2017

Sub : **EEE 455** (Compound Semiconductor and Hetero-Junction Devices)

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**.

Make necessary assumptions. The symbols have their usual meanings.

1. (a) Why the effective mass of electrons in GaAs is different to that in Si? Which semiconductor has higher electron mobility? Discuss the variation of electron mobility in these semiconductors with electric field. **(20)**

   (b) Estimate InAs mole fraction, x, in a ternary compound $In_x Ga_{1-x} As$, such that this compound will be lattice matched to InP. Also calculate the critical thickness of estimated $In_x Ga_{1-x} As$ epitaxial layer on GaAs and InAs substrates. **(15)**

   [Assume a linear variation of the lattice constant with the mole fraction and assume that the lattice constants of InP, GaAs and InAs are 5.868Å, 5.653Å and 6.058Å, respectively]

2. (a) Why is the Schottky-barrier diode much faster in switching, than the pn-diode? Draw energy-band diagram of a metal-semiconductor junction with an interfacial layer and interface states. Also, discuss how does Ferni level 'pinned' at the surface. **(20)**

   (b) A Schottky barrier diode contains interface states and an interfacial layer. Assume the following parameters: **(15)**

   $\varphi_m = 4.75$ V $\quad \varphi_n = 0.164$ V $\quad \varphi_o = 0.230$ V

   $E_g = 1.12$ eV $\quad \delta = 20$ Å $\quad \epsilon_i = \epsilon_o$

   $\epsilon_s = (11.7)\,\epsilon_o$ $\quad \chi = 4.01$ V $\quad N_d = 5 \times 10^{16}$ cm^{-3}

   $D_{it} = 10^{13}$ eV^{-1} cm^{-2}.

   (i) Determine the theoretical barrier height Φ_{BO}, without interface states and
   (ii) Determine the barrier height with interface states.

Contd P/2

EE 455

3. (a) What is the mechanism of Schottky barrier lowering? Show that

$$\Delta\varphi = \sqrt{\frac{eE}{4\pi \in_s}}$$ **(20)**

where the symbols have their usual meanings.

(b) Determine ΔE_v, ΔE_c and ΔV_{bi} for an n-Ge to p-GaAs heterojunction using the electron affinity rule. Consider an n-type Ge doped with $N_d = 2 \times 10^{16}$ cm^{-3} and p-type GaAs doped with $N_a = 3 \times 10^{16}$ cm^{-3}. Let T = 300 K so that $n_i = 2.4 \times 10^{13}$ cm^{-3} for Ge and 1.8×10^{6} cm^{-3} for GaAs. Given that $N_v = 7.0 \times 10^{18}$ cm^{-3} for GaAs and 6.0×10^{18} cm^{-3} for Ge. **(15)**

4. (a) Draw and explain an idealized energy-band diagram of the substrate- channel-metal in the n-channel MESFET.

Show that, $$V_{po} = \frac{ea^2 N_d}{2 \in_s}$$ **(20)**

where the symbols have their usual meanings.

(b) The Schottky barrier height, ϕ_{Bn}, of a metal-n GaAs MESFET is 0.90 volt. The channel doping is $N_d = 1.5 \times 10^{16}$ cm^{-3}, and the channel thickness is a = 0.5 μm, for T = 300 K **(15)**

(i) Calculate the internal pinch off voltage

(ii) Calculate the threshold voltage and

(iii) Determine whether the MESFET is depletion type or enhancement type. For GaAs,

given: $\in_s = (13.1) \in_0$

$N_c = 4.7 \times 10^{17}$ cm^{-3}

$N_v = 7.0 \times 10^{17}$ cm^{-3}

EEE 455

SECTION – B

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

5. (a) Draw the schematic of a "normal" and "invested" AlGaAs/GaAs HEMT showing the position of gate, source and drain and all the layers. Also show the current path through the device. **(9)**

   (b) Draw the energy band diagram for a depletion mode and enhancement mode HEMT showing the movement of Fermi level with the application of gate voltage. **(8)**

   (c) Consider an abrupt N $Al_{0.3}Ga_{0.7}As$ intrinsic GaAs heterojunction HEMT. The N-AlGaAs is doped with $N_d = 2\times10^{18}$ cm^{-3}. The Schottky barrier height is 0.85 volt and heterojunction conduction band edge discontinuity is $\Delta E_C = 0.22$ eV. Determine the thickness of AlGaAs layer so that $V_{off} = -0.3$ volt. Also find the channel electron concentration for $V_g = 0$. Is this device depletion or enhancement type? ε_r for $Al_{0.3}Ga_{0.7}As$ is 12.2. **(18)**

6. (a) Show that for an HBT, the ratio of J_{nE} and J_{PE} can be expressed as

$$\frac{J_{nE}}{J_{PE}} = \frac{N_{DE}}{N_{AB}} \cdot \frac{W_E}{W_B} \cdot \frac{D_{nB}}{D_{pE}} exp\left(\frac{\Delta E_g}{kT}\right)$$

   Where the symbols used have their usual meanings. **(10)**

   (b) Describe the advantages of HBT over BJT. **(10)**

   (c) A uniformly doped silicon epitaxial *npn* bipolar transistor is fabricated with a base doping of $N_B = 3\times10^{16}$ cm^{-3}and a heavily doped collector region with $N_C = 5\times10^{17}$ cm^{-3}. The neutral base width is $X_B = 0.7$ μm when $V_{BC} = V_{BE} = 0$. Determine V_{BC} at which punch through occurs. **(15)**

7. (a) Find the expression for electron current density in base, J_n and hole current density in emitter, J_p for an *npn* transistor as described in Gammel-Poon model. What are Base Gummel number and emitter Gummel number? Where is Gummel-Poon model used? **(18)**

   (b) Consider a uniformly doped silicon bipolar transistor at T = 300°K with a base doping $N_B = 5\times10^{16}$ cm^{-3} and a collector doping $N_C = 2\times10^{15}$ cm^{-}3. Assume the metallurgical base width is 0.7 μm. Calculate the change in neutral base width as the C – B voltage changes from 2 to 10 V. **(17)**

EEE 455

8. (a) What is high level injection in BJT? Mention the effects of high level injection in BJT. Also describe the kirk effect. **(18)**

   (b) For an npn transistor, assume the emitter doping has been increased from 10^{18} cm^{-3} to 10^{19} cm^{-3}. Calculate the change in P_{EO} value (i) without and (ii) with the effect of bandgap narrowing. Assume, T = 300°K. Here, P_{EO} = Hole density in the emitter under thermal equilibrium. **(12)**

   (c) Briefly describe the operation of a Tunneling Emitter Bipolar Transistor (TEBT), and show the appropriate schematic. **(5)**

L-4/T-1/EEE **Date: 05/03/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2016-2017

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

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks.

Symbols and abbreviations have their usual meanings.

USE SEPARATE SCRIPTS FOR EACH SECTION

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 limitations. **(10)**

(b) What is meant by numerical aperture (NA) of a fiber? Find the expression of NA. A fiber has core index of 1.55 and numerical aperture of 0.40. Find the value of the acceptance angle and relative index difference. **(10)**

(c) What are the phenomenons responsible for attenuation in a fiber? Explain briefly. Draw the loss characteristics of a silica fiber and show the operating windows. **(15)**

2. (a) What is dispersion in a fiber? Explain intramodal and intermodal dispersion that occur in a MMF. What are the limitations due to dispersion? **(10)**

(b) Derive an expression for the rms pulse width at the output of an SMF and explain the parameters involved. **(10)**

(c) An MMF link has a fiber length of 20 km using a source of FWHM linewidth 5 nm at a wavelength of 1300 nm. The material dispersion coefficient of the fiber is 16 ps/km-nm at this wavelength. The core refractive index is 1.55 and relative index difference is 4 percent. Determine: **(15)**

(i) rms pulsewidth at the output of the fiber due to intramodal dispersion only;

(ii) overall rms pulsewidth at the output of the fiber due to both intramodal and intermodal dispersion;

(iii) Bandwidth of the fiber link;

(iv) Bandwidth of 1 km of such fiber link.

3. (a) Discuss the principles of operation and applications of the following: **(10)**

(i) Fiber fused biconical taper (FBT) coupler,

(ii) Electro-Optic directional coupler,

(iii) Star coupler,

(iv) Optical (4×4) switch.

Contd P/2

EEE 435

Contd... Q. No. 3

(b) Discuss the principles of optical FDM and WDM. Distinguish between them. **(10)**

(c) Explain the principles of operation of WDM multi-/demultiplexers (MUX/DMUX), based on the followings: (15)

(i) Mach-Zehnder Interferometer (MZI)

(ii) Fiber Bragg Grating (FBG)

4. (a) Discuss the methods of compensation for dispersion in a fiber-optic link. **(15)**

(b) An SMF link consists of ten number of fiber segments of length 25 km each and connected by connectors of loss 1.5 dB per connector. The source is a LD of FWHM linewidth of 0.05 nm at the operating wavelength of 1550 nm. The PD is of PIN type with minimum detectable powr of –90 dBm. The source to fiber and fiber-to-detector couplings are made of couplers of loss 2 dB each. The loss coefficient of the fiber is 0.2 dB/km. Determine: **(20)**

(i) Total loss from source to detector;

(ii) Minimum power (mW) required for the LD to have reliable communication over the link;

(iii) Dispersion limited transmission rate through the link for NRZ data if the fiber material dispersion coefficient is 17 ps/km-nm.

SECTION – B

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

5. (a) Show that spontaneous emission is a dominant mechanism at thermal equilibrium. Explain how thermal non-equilibrium can be achieved and lasing action can be created in a semiconductor diode. (Assume any data if necessary) **(13)**

(b) What are the necessary conditions of laser oscillation? Show that the threshold gain condition for laser oscillation is given by **(12)**

$$g_{th} = \alpha_{eff} + \frac{1}{2L}\ln\left(\frac{1}{R_1 R_2}\right)$$

(c) With necessary figure, define ILD. Show the input-output characteristics and spectral characteristics of ILD and LED. Why is LED not suitable for high speed long-haul communication? **(10)**

6. (a) With necessary graphs and data, compare the characteristics of Si, Ge and InGaAs p-i-n photodiodes. Which one is suitable for 4G lightwave system and why? **(11)**

Contd P/3

EEE 435

Contd... Q. No. 6

(b) Draw the block diagram of a typical phase-modulated optical communication system. Briefly discuss its performance compared to the IM/DD system. **(11)**

(c) An optical fiber link is carrying intensity modulated data at a rate of 10 Gbps with an APD receiver for direct detection. The quantum efficiency of the photodiode is 90% at the operating wavelength of 1550 nm. The dark current of the device is negligible at the operating temperature of 290 K and the load resistance is 4 kΩ. Determine the minimum incident optical power which can yield an SNR of 20 dB. In case of shot noise limit, how many number of photons are required per "1" bit to achieve this SNR? (Multiplication factor of APD is 20 and excess noise factor is 10, receiver amplifier noise figure is 4 dB.) **(13)**

7. (a) Classify the optical amplifiers. Compare EDFA with FRA in terms of operating principle, basic configuration, pumping scheme and gain spectra. **(15)**

(b) Making necessary assumptions prove that SNR is degraded by 3 dB for an ideal optical amplifier. **(10)**

(c) Explain why Raman gain efficiency is higher for DCF compared to SSMF and DSF showing their Raman gain spectra. Why is DCF not popular as the main fiber for fiber-optic communication though it is much suitable for Raman amplification? **(10)**

8. (a) With appropriate figures explain how OOK modulation is done using a semiconductor laser (directly) and using Lithium niobate modulator (indirectly). State the relative merits and demerits of them. **(14)**

(b) Compare EOM with EAM in terms of basic principle and structure. What are the advantages of EAM over EOM? **(8)**

(c) How is the huge potential bandwidth of an optical fiber utilized using WDM technology? Draw a typical WDM network and define different types of topology and components used in the network **(13)**

L-4/T-1/EEE **Date: 11/03/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2016-2017

Sub: **EEE 471** (Energy Conversion III)

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) Write down the expression for the power output from a wind turbine. What does the power coefficient factor signify? Comment on the spatial and temporal variations of wind speed. **(15)**

   (b) What is 'Tip Speed Ratio'? Why is it so important? How is it maintained in a doubly fed induction generator (DFIG)? **(20)**

2. (a) Explain the working principle of reluctance motor. Why there is no rotor copper loss in this motor? **(15)**

   (b) "Current in SRM can be controlled to any desired value at low-speed but not at high speed" — Explain. **(10)**

   (c) Discuss the torque ripples in an SRM and strategies to reduce it. **(10)**

3. (a) Why is the commutator brushes of a permanent magnet DC (PMDC) motor shifted away from the mechanical neutral axis? — Explain with reference to armature reaction. **(18)**

   (b) Discuss in detail the 'reactance voltage' in a PMDC motor. **(17)**

4. (a) What are the differences between reluctance torque and hysteresis torque? Present a mathematical analysis of the starting and running torque in a hysteresis motor. **(15)**

   (b) Explain why a hysteresis motor can synchronize any load it can accelerate. What application you perceive for such a motor? **(10)**

   (c) Compare the performance of unipolar and bipolar operation of stepper motor. Comment on resonance in stepper motor. **(10)**

Contd P/2

SECTION – B

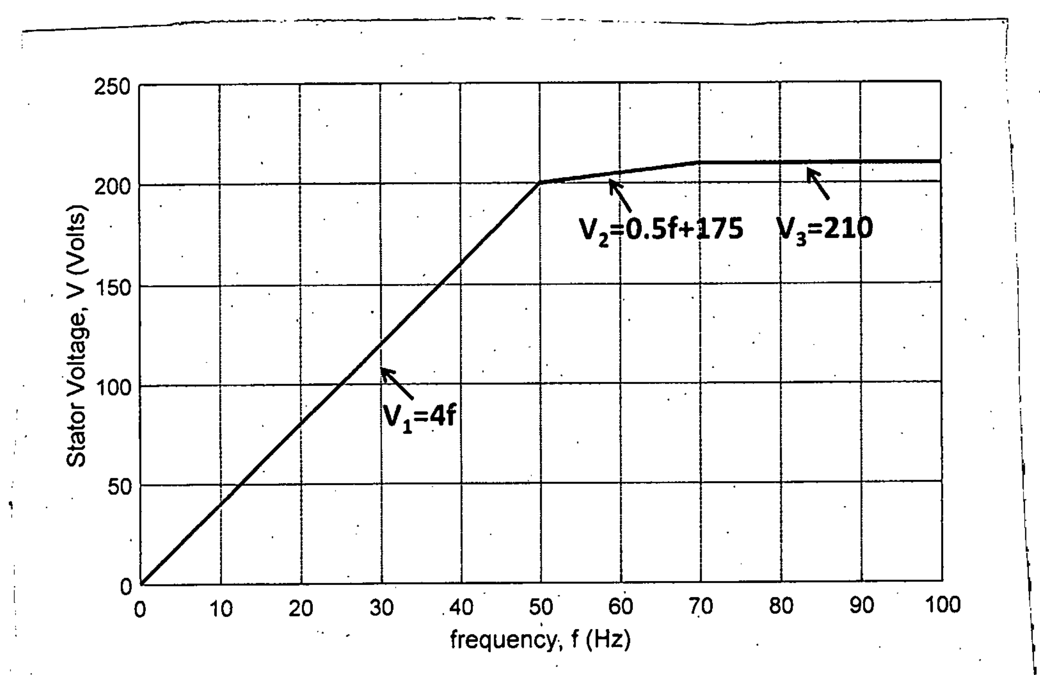
There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Describe the working principle of the followings: **(10+10=20)**
   (i) Shaded pole motor. Mention particularly: how a rotating flux is generated and how to reverse the direction of rotation.
   (ii) Van de Graaff generator. Mention one application.

   (b) Describe in brief the principle of operation of fuel cells with the necessary chemical reactions. What are the differences between batteries and fuel cells? Mention one main advantage and disadvantage of fuel cells. **(6+4+5=15)**

6. (a) What is V/f speed control of induction motors? Why is closed-loop V/f control more accurate than its open-loop counterpart? **(4+4=8)**

   (b) The speed of an induction motor is being controlled by open-loop V/f control scheme. The motor stator voltage has frequency of 50 Hz and the rotor speed is 1500 rpm in this case. Assume, in all cases, the rotor slip is near zero. The V vs. f (stator voltage vs. frequency) curve is given below: **(9+12+6=27)**



Now, answer the followings:
   (i) What will be the stator voltage if the motor is to operate at 1480 rpm?
   (ii) What will be the input frequency if the motor is to operate at 1600 rpm? Determine the percentage drop of flux in this case compared to 1500 rpm case.
   (iii) Will the induction motor be able to provide the same torque in this case? If yes/no, why?

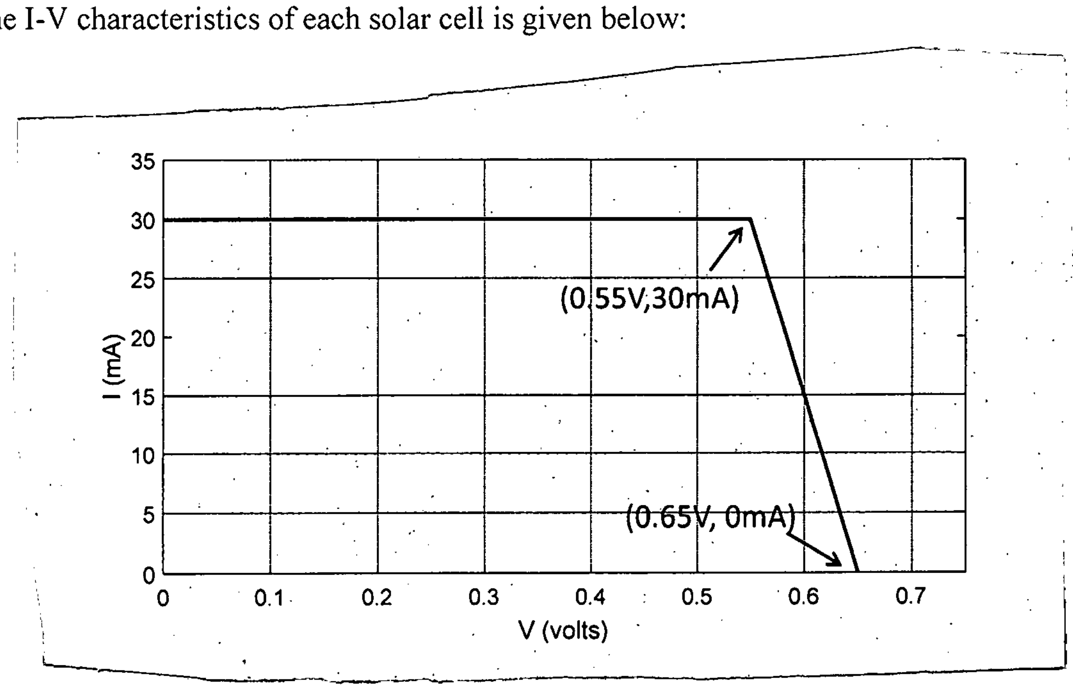
7. (a) Explain, with the help of a neat diagram, the principle of operation of a p-n junction solar cell. Mention why light having any frequency cannot generate photovoltaic current. **(11+4=15)**

(b) What is maximum power point of a solar cell? How does it vary with solar irradiance? Derive the expression of current generated from a p-n junction solar cell with the help of an equivalent circuit. **(4+4+12=20)**

8. (a) What is by-pass diode in the context of photovoltaic arrays? What are the different topologies for connecting by-pass diodes? **(5+5=10)**

(b) A solar panel is composed of 6 (six) strings connected in parallel. Each string has 20 (twenty) solar cells connected in series. **(7+9+9=25)**

The I-V characteristics of each solar cell is given below:



(i) Draw the I-V characteristics of the entire solar panel.

(ii) If the voltage across the solar panel is to be maintained at 11.6 V, what will be the operating point (voltage and current) of each solar cell?

(iii) Again, the voltage across the solar panel is to be maintained at 11.6 V. Now, one solar cell in one string becomes fully shaded. Approximate this shaded cell with a 5Ω resistor. What will be the operating point of each cell in this string now? (Hint: appropriate answer is acceptable, mention the method of getting to the answer)

L-4/T-1/EEE **Date: 11/03/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2016-2017

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 – A

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

1. (a) Compare between diffusion and ion implantation techniques. Given an in-detail description of the operation of various parts of an ion implanter machine. **(5+20)**

   (b) What are the stopping mechanisms for a high-speed ion in a crystal? Give a short description of the various mathematical models. **(10)**

2. (a) What are the basic differences of epitaxy and CVD growth process? Which one is more industry friendly and why? **(10+5)**

   (b) What is linear growth regime and diffusion-limited regime in oxidation process? Describe the Deal-Grove model of oxidation and explain the above two regimes. **(5+15)**

3. (a) Describe the six properties affecting oxidation rate. What do you mean by thermal budget? **(10+5)**

   (b) Explain in which respect float-zone technique is better than CZ method of wafer growth. Explain how CMOS technology accomplishes current reduction. What is high-numerical aperture immersion lithography? **(6+7+7)**

4. (a) Briefly explain the different components of photoresist. What is photosolubilization? How does a photoresist react to deep UV as opposed to extreme UV? **(8+5+7)**

   (b)What points should be considered while selecting a proper aligner? What are the different types of aligner available? What is a TMAH solution? **(6+6+3)**

SECTION – B

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

5. (a) What key requirements a metal system must meet? What are the solutions to mitigate the problem of A1-Si eutectic formation? **(10+10)**

   (b) "All current circuits are being developed with Cu metallization and low-k dielectrics" — Explain. Describe the functions of IMD. **(10+5)**

Contd P/2

6. (a) Describe the different package sealing techniques. **(20)**

   (b) "A dominant chip characteristic is the extreme vulnerability of its surface to physical abuse" — what are the chip characteristics that affect packaging? **(10)**

   (c) What is wedge-bonding? **(5)**

7. (a) Describe, in detail, the major problem caused by metallic ions to wafer fabrication. What are the contamination sources in a cleanroom? **(5+15)**

   (b) Describe the two methods of wire bonding. **(15)**

8. Write short notes on the following topics: **(9+9+9+8)**

   (a) Non-optical photolithography

   (b) Proximity effect in E-beam lithography

   (c) Holographic lithography

   (d) Quadruple patterning

L-4/T-1/EEE **Date : 11/03/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2016-2017

Sub : **EEE 431** (Digital Signal Processing II)

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) Consider the random process

$$x(n) = g\,v(n) + w(n), \quad n = 0, 1, \dots, M-1$$

where v(n) is a known sequence, g is a random variable with $E[g] = 0$, $E[g^2] = G$, and is also uncorrelated with w(n). The process w(n) is a white noise sequence with $r_{ww}(m) = \sigma\omega^2\delta(m)$. Determine the coefficients (h(n)) of the linear estimator for g, that is,

$$\hat{g} = \sum_{n=0}^{M-1} h(n)x(n)$$

that minimize the mean-square error (MSE) $J = E\left[(g-\hat{g})^2\right]$ **(17)**

(b) Given the DSP system for the noise cancellation application using an adaptive filter with two coefficients shown in Fig. for Q. 1(b): **(18)**

(i) Set up the LMS algorithm for the adaptive filter (define the cost function and calculate its gradient, write down the update equation)

(ii) Perform adaptive filtering to obtain outputs e(n) for n = 0, 1, 2 given the following inputs and outputs:

x(0) = 1, x(1) = 1, x(2) = – 1, d(0) = 2, d(1) = 1, d(2) = – 2 and initial weights, ω(0)= ω(1) = 0, convergence factor is set to be μ = 0.1.

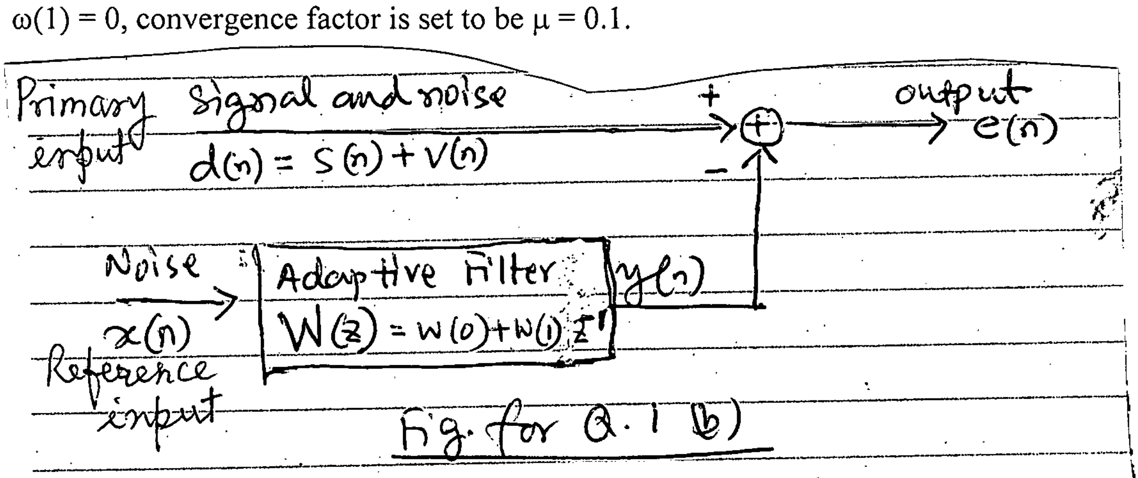


Fig. for Q. 1 (b)

Contd P/2

EEE 431

2. (a) The prototype filter in a four-channel uniform DFT filter bank is characterized by the transfer function $H_0(z) = 1 + z^{-1} + 3z^{-2} + 4z^{-3}$ **(17)**

(i) Determine the transfer function of the filters $H_1(z)$, $H_2(z)$, and $H_3(z)$ in the analysis section.

(ii) Determine the transfer function of the filters in the synthesis section.

(iii) Sketch the analysis and synthesis sections of the uniform DFT filter bank.

(b) Show that the following FIR transfer function is a power-symmetric function: (18)

$$H_0(z) = \frac{1}{2} - z^{-1} + \frac{21}{2}z^{-2} - \frac{27}{2}z^{-3} - 5z^{-4} - \frac{5}{2}z^{-5}$$

Using $H_0(z)$ as one of the analysis filters, determine the remaining three filters of the corresponding two-channel orthogonal filter bank. Show that the filter bank is alias-free and satisfies the perfect reconstruction condition.

3. (a) An efficient implementation of two separate single-input, single-output LTI discrete-time systems with an identical transfer function H(z) by a single two-input, two-output multi-rate discrete-time system is obtained using the pipelining/interleaving (PI) technique as shown in Fig. for Q. 3(a). Show that the system of this figure is time-invariant and determine the transfer functions from each input to each output. **(15)**

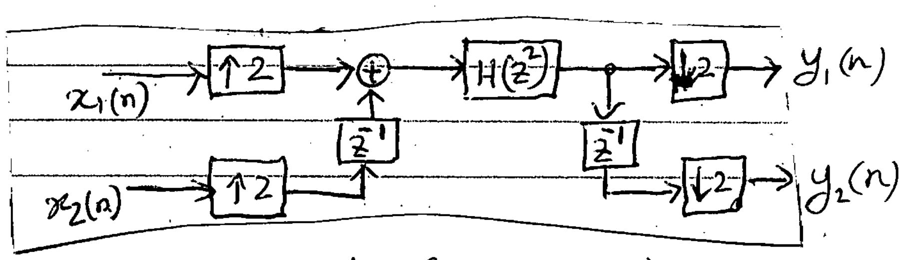


Fig. for Q. 3(a)

(b) The block diagram of EOG noise canceller from contaminated EEG using adaptive filtering is shown in Fig. for Q. 3(b), where h(m) represents an FIR filter of length M. Define all the signals in the diagram and then derive the RLS algorithm to compute the filter coefficients. Make assumptions as necessary. **(20)**

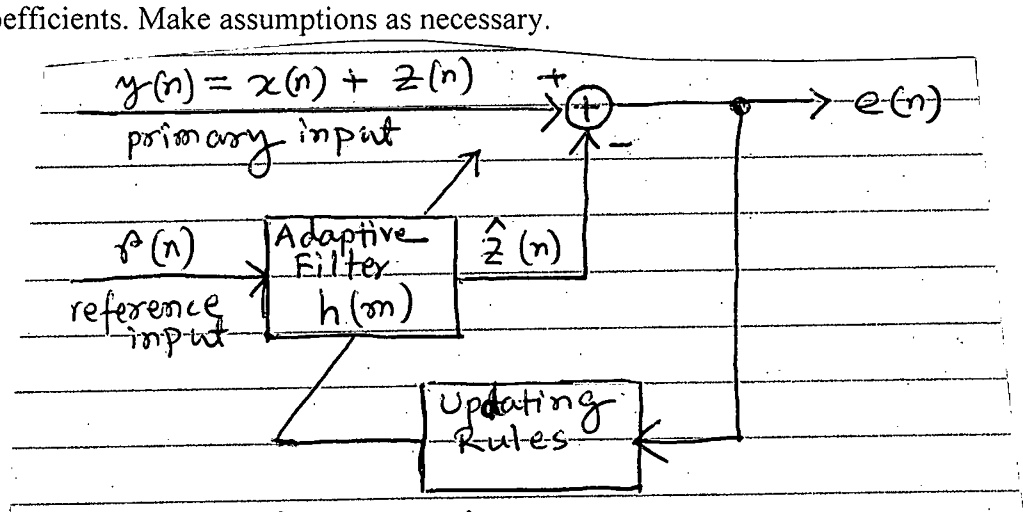


Fig. for Q. 3(b)

EEE 431

4. (a) The sampling rate of a signal x(n) is to be reduced, by decimation, from 96 kHz to 1 kHz. The highest frequency of interest after decimation is 450 Hz. Assume that an optimal FIR filter is to be used, with an overall passband ripple, $\delta_p = 0.01$, and passband deviation, $\delta_s = 0.001$. Design one-stage and two-stage ($M_1 = 32$, $M_2 = 3$) decimators for this problem. Which one is efficient? Draw the block diagram and filter sepecification(s) for each case. **(18)**

(b) How does the fixed step-size affect the stability and convergence of the LMS adaptive filter? Derive a variable step-size LMS algorithm. **(17)**

SECTION – B

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

Symbols have their usual meaning.

5. (a) An MA(2) process is described by the difference equation x(n) = ω(n) + 0.81 ω(n–2) where ω(n) is a white noise process with variance σ_ω^2. Determine the parameters of the AR(2) model that provide a minimum mean-square error fit to the data x(n). **(12)**

(b) Consider the linear system described by the difference equation

y(n) = 0.8y (n–1) + x(n) + x(n–1) where x(n) is a wide-sense stationary random process with zero mean and autocorrelation **(23)**

$$\gamma_{xx}(m) = \left(\frac{1}{2}\right)^{|m|}$$

(i) Determine the power density spectrum of the output y(n)

(ii) Determine the autocorrelation $\gamma_{yy}(m)$ of the output

(iii) Determine the variance σ_y^2 of the output

6. (a) Barlett's method is used to estimate the power spectrum of a process from a sequence of N = 2000 samples. What is the minimum length L that may be used for each sequence, if the resolution Δf = 0.005? Explain why it would not be advantageous to increase L beyond this value. **(12)**

(b) A random process is known to consist of a single sinusoid in white noise given by

$$x(n) = A\cos(n\omega_0 + \phi) + v(n)$$

Thus, the autocorrelation sequence for $x(n)$ is,

$$r_x(k) = \frac{1}{2}A^2\cos(kw_0) + \sigma_v^2\delta(k)$$

(i) If $\omega_0 = \frac{\pi}{4}$, $A = \sqrt{2}$ and $\sigma_v^2 = 1$, find the spectrum of the AR(2) process. **(23)**

EEE 431

Contd ... Q. No. 6(b)

(ii) Determine the location of the poles of the spectrum.

(iii) Does the peak of the spectrum provide an accurate estimate of ω_0?

7. (a) The autocorrelation of a sequence consisting of a sinusoid with random phase in noise is given by $\gamma_{xx}(m) = P\cos 2\pi f_1 m + \sigma_\omega^2 \delta(m)$ **(17)**

where f_1 is the frequency of the sinusoidal, P is its power, and σ_ω^2 is the variance of the noise.

(i) Determine the optimum coefficients of the AR(2) model as a function of σ_ω^2 and f_1 by using the Levinson-Durbin algorithm.

(ii) Determine the reflection coefficients k_1 and k_2.

(b) The signal y(n) consists of complex exponentials in white noise. Its autocorrelation matrix is

$$\Gamma_{yy} = \begin{bmatrix} 2 & -j & -1 \\ j & 2 & -j \\ -1 & j & 2 \end{bmatrix}$$

Use the MUSIC algorithm to determine the frequencies of the exponentials and their power levels. **(18)**

8. (a) Let a discrete signal be f = (2, 2, 4, 6, 8, 10). Find the first-level Haar wavelet coefficients in the approximate band a^1 and detailed band d^1. Compute the percentage of compaction of the energy in terms of $\frac{\varepsilon_{a^1}}{\varepsilon_f}$. **(12)**

(b) Write the basic steps of signal denoising using wavelet-based thresholding method. **(10)**

(c) Explain the filter-bank implementation of STFT. **(13)**
