L-4/T-2/EEE **Date: 28/3/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **EEE 411** (Power System 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** questions.

Assume reasonable value for any missing data.

1. (a) Derive the condition for the economic distribution of load between two units within a power plant. **(5)**

(b) Derive the general expression of transmission loss equation of a power system having K number of generating units. **(15)**

(c) Explain the classical economic dispatch process of thermal power plants incorporating transmission losses. **(15)**

2. (a) What is reactive power margin and Fast Voltage Stability Index (FVSI)? Derive an analytical expression of FVSI. **(15)**

(b) What is voltage unbalance? Describe the sources and effects of voltage unbalance. **(10)**

(c) What is harmonics? How are harmonic power loss and total current harmonic distortion (THD_I) calculated? **(10)**

3. (a) Explain the roles of inertial response and governor response for the frequency control of a power system. **(10)**

(b) Describe a step-wise procedure to find the frequency response index (in MW/0.1 Hz) of a power system. How will this index be affected for high renewable power penetration? **(15)**

(c) What is load frequency relief (LFR)? From exponential load models, derive a mathematical expression of LFR. **(10)**

4. (a) Why is reactive power compensation required? How can the power flow through a transmission line be controlled? **(5)**

(b) Briefly explain the working principles of STATCOM, TCSC, UPFC and IPFC. **(20)**

(c) A 400 kV transmission line has a reactance of 0.05 pu on 100 MVA base. The voltage at the sending end is $1.02\angle 2^\circ$ pu and that of the receiving end is $1.0\angle 0^\circ$ pu. What is the voltage that should be injected in quadrature with the sending end voltage to increase the power transfer across the line by 20%? **(10)**

Contd P/2

EEE 411

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE** questions.
Symbols have their usual meaning.

5. The figure in Fig. 5(a) represents a generator connected at bus 1 supplying power through a transmission line. Here E_1' and E_2' represent the transient internal voltage of a generator and motor respectively. Derive the power angle equation for the system. **(15)**

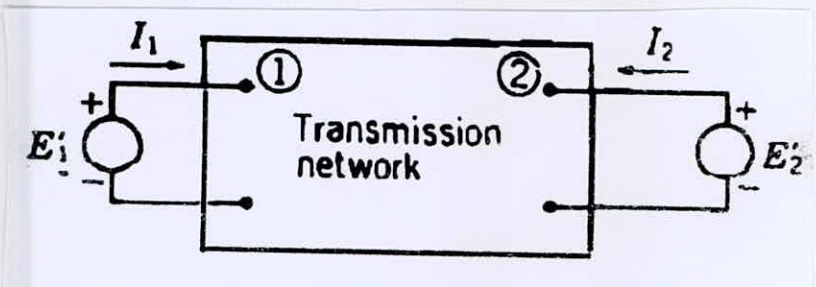

Fig . 5(a)

(b) Derive a second order differential swing equation governing the incremental rotor angle variation when mechanical power input is fixed. **(15)**

(c) What is synchronizing power co-efficient? Explain the significance of power co-efficient through the equation derived in Q. 5(b). **(5)**

6. (a) The single line diagram in Fig. 6(a) shows a generator connected through a parallel transmission line to a infinite bus. The machine is delivering 0.8 per unit power and both the terminal voltage and infinite bus voltage are 1.0 per unit. Determine the power angle equation for the given system operating condition. Also find the initial rotor angle. **(15)**

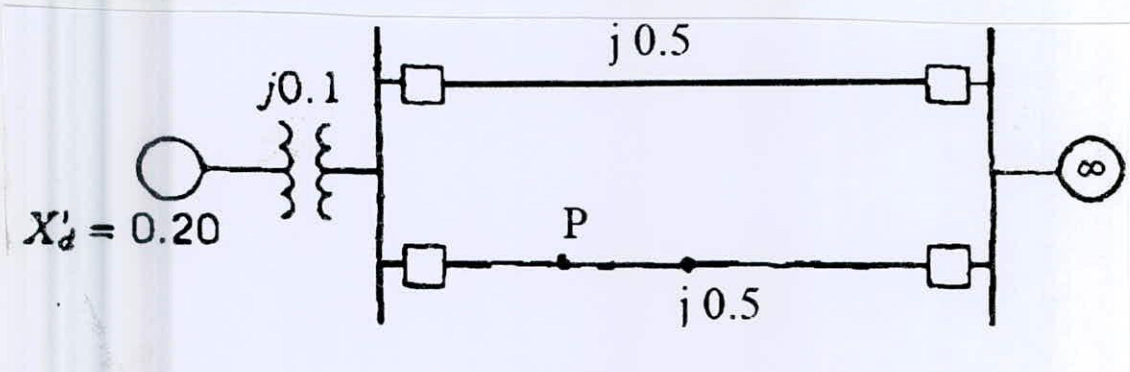

Fig. 6(a)

(b) A three phase fault occurs on the power system of question 6(a) at point P at a distance of 30% of the length away from the sending end terminal of the line. H = 5.0 MJ/MVA. Determine the following in the faulted condition. **(20)**

(i) the power angle and swing equation.

(ii) initial accelerating power

(iii) initial acceleration.

7. (a) A 50-Hz, 230-kV transmission system shown in Fig. 7(a) has two generators of finite inertia and an infinite bus. A three-phase fault occurs on line (4) –(5) near bus (4). Using the prefault power-flow solution given in Table 7(a) (i), and the faulted Ybus given in Table 7(a) (ii) determine the power angle and swing equation for machine 2 during the fault period. The generators have reactances and H values expressed on a 100-MVA base as follows: **(20)**

Generator 1: 400 MVA, 20 kV, Xd = 0.067 per unit, H = 11.2 MJ/MVA

Generator 2: 250 MVA, 18 kV, Xd = 0.10 per unit, H = 8.0 MJ/MVA

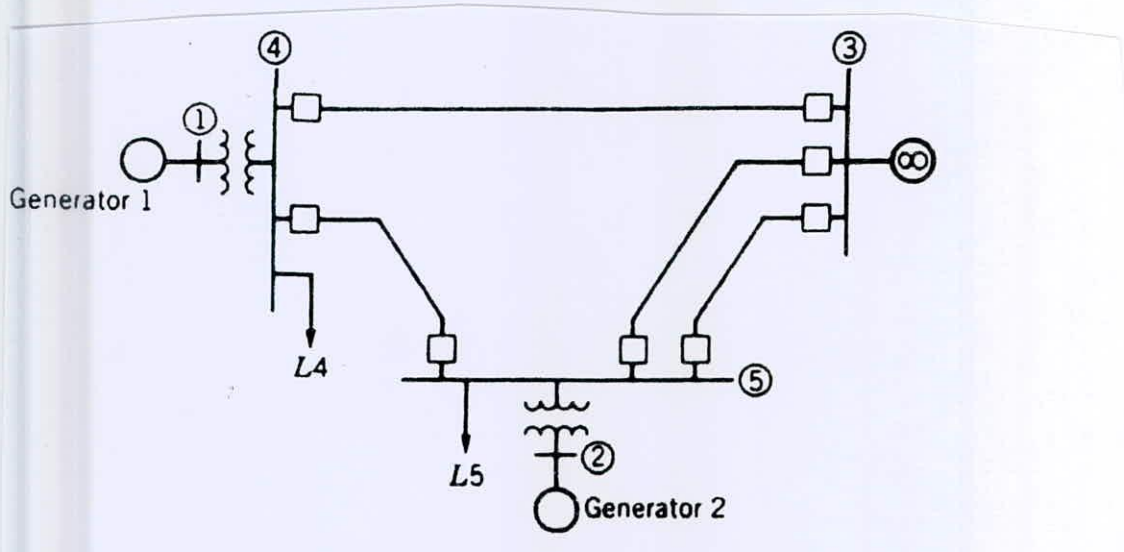

Fig 7(a)

Bus data and prefault load-flow values†

Bus	Voltage	Generation P	Generation Q	Load P	Load Q
①	$1.030\angle 8.88^\circ$	3.500	0.712		
②	$1.020\angle 6.38^\circ$	1.850	0.298		
③	$1.000\angle 0^\circ$	—	—		
④	$1.018\angle 4.68^\circ$	—	—	1.00	0.44
⑤	$1.011\angle 2.27^\circ$	—	—	0.50	0.16

†Values are in per unit on 230-kV, 100-MVA base.

Table 7(a)(i)

EEE 411

Contd... Q. No.7

Table 7(c)(ii) Faulted network Ybus			
Bus	①	②	③
①	0.0000 − j11.2360 (11.2360∠ −90°)	0.0 + j0.0	0.0 + j0.0
②	0.0 + j0.0	0.1362 − j6.2737 (6.2752∠ −88.7563°)	−0.0681 + j5.1661 (5.1665∠ 90.7552°)
③	0.0 + j0.0	−0.681 + j5.1661 (5.1665∠ 90.7552°)	5.7986 − j35.6299 (36.0987∠ −80.7564°)

(b) Prepare a table showing the steps required to determine δ (swing angle) of machine 2 for the fault mentioned in Question 7(a). Show the data only from t = 0s up to fault clearing time. The fault is cleared at 0.225s by simultaneously opening the circuit breakers at the end of faulted line (4)-(5). Given that, Δt = 0.05 s. **(15)**

8. (a) Develop the equivalent circuit of a salient pole synchronous generator. **(20)**

(b) A 14-pole, Y-connected three-phase, water-turbine-driven generator is rated at 120 MVA, 13.2 kV, 0.8 PF lagging, and 50 Hz. Its direct-axis reactance is 0.62Ω and its quadrature-axis reactance is 0.40Ω. All rational losses may be neglected. **(15)**

(i) What internal generated voltage would be required for this generator to operate at the rated conditions?

(ii) What is the voltage regulation of this generator at the rated conditions?

(iii) Sketch the power versus torque-angle curve for this generator. At what angle δ is the power of the generator maximum?

L-4/T-2/EEE **Date : 09/04/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub : **EEE 425** (Biomedical Signals, Instrumentations and Measurement)

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) Define biometrics. Briefly explain the biometric design factors. Name the problems normally encountered in measuring biological signals. (15)

   (b) Name the major physiological systems of human. With neat sketches, briefly describe the human nervous system with emphasis on signal generation and conduction. (15)

   (c) With neat diagram, describe the anatomical planes of human body. (5)

2. (a) Write the general and ionic characteristics of human cell. With neat sketches, describe the formation of bioelectric potential in human cells. (15)

   (b) Define electrode and classify it. Name the basic properties of a good biopotential electrode. With neat sketches, describe the construction and operation of an Ag/AgCl electrode. (15)

   (c) Write the basic requirements of a bioelectric amplifier. (5)

3. (a) Define ECG lead. "For a complete ECG-based diagnosis, 12 leads are necessary", – Explain. Explain the wave shapes of normal E
CG in different leads. (15)

   (b) Name the factors that changes the normal shapes of ECG. With neat sketches, explain the changes in ECG due to ventricular fibrillation and bundle branch block. (15)

   (c) Write a short note on ERG. (5)

4. (a) Define EMG. Briefly describe the measurement, significance and uses of different types of EMG. Describe the changes in EMG with voluntary efforts. (15)

   (b) Define natural and artificial pacemakers. Briefly describe different types of pacing methods and modes of pacemaker operation. (15)

   (c) Write a short note on automated external defibrillator. (5)

SECTION – B

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

5. (a) A cardiologist used a stethoscope and measured a mixture of heart, lung and friction sound. What will be considered noise in the measurement? Is it an in-vivo of in-vitro measurement? Define in-vivo and in-vitro measurements with suitable examples. (12)

   (b) What is the input impedance of a biomedical sensor or instrument? If we want to measure voltage or current, do we prefer low or high input impedance? Justify your answer. (10)

Contd P/2

EEE 425

Contd … Q. No. 5

(c) A thermocouple has an output voltage V that depends on temperature T (in K) as follows: (13)

$$V(T) = a + bT + cT^2$$

where, $a = 5$, $b = -0.01$, $c = 10^{-5}$

Is it a linear system? What is the sensitivity of the voltage output at nominal body temperature $T_0 = 310$ K?

6. (a) Using Einthoven's triangle, write the lead voltages I, II, III, aVR, aVL and aVF in terms of the electrode voltage RA, LA, and LL. Suppose your 12-lead ECG machine is broken and you can only measure leads I and III. How can you obtain the other four leads given only the leads I and III. (15)

(b) Suppose you have a graphical display of blood pressure monitor readings as follows: (10)

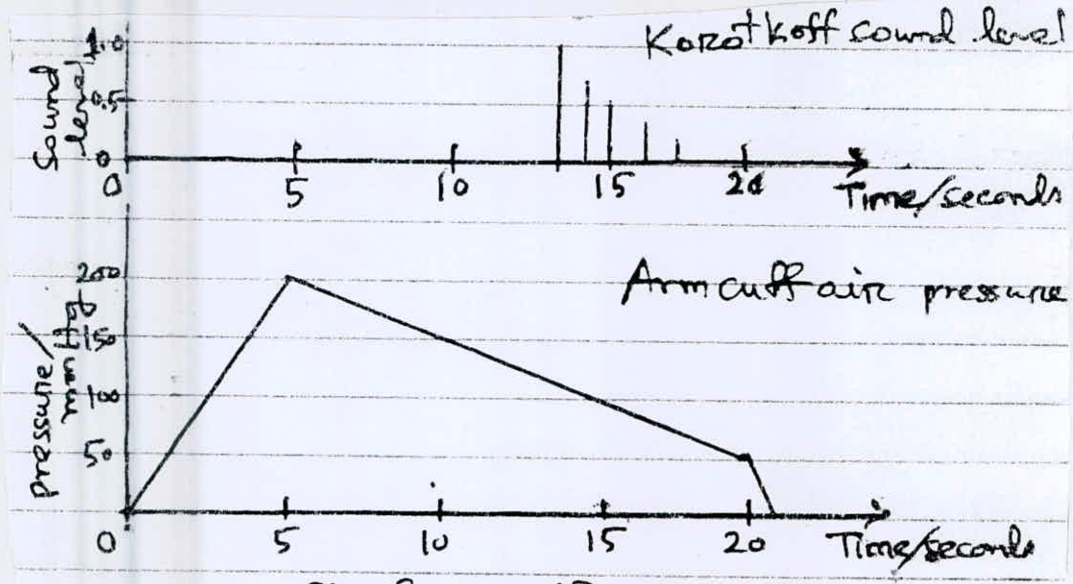

Fig. for Q 6(b)

What is the systolic and diastolic blood pressure according to the above graphs?

(c) For analog to digital conversion of an ECG signal, what is the minimum sampling rate for 160 BPM assuming that ± 1 BPM is allowed? (10)

7. (a) What is photoplethysmography? Describe the working principle of pulse oximeter. (15)

(b) What is a spirometer? What are the different types of spirometers used for measurement of respiratory parameters? (10)

(c) What is a flame photometer? How does it help in blood test? (10)

8. (a) What is the difference between imaging and image processing? How does the frequency of ultrasound wave influence axial resolution, lateral resolution and penetration of ultrasound imaging? (12)

(b) Describe the backprojection technique for CT image reconstruction. How does the filtered backprojection technique overcomes the limitation of simple backprojection? (12)

(c) Explain the principle of Position Emission Tomography (PET)? (11)

L-4/T-2/EEE **Date: 20/3/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

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**.

All the symbols have their usual meanings. Assume reasonable values for missing data.

1. (a) A process *x(n)* is formed by passing white noise *w(n)* through an AR system *H(z)* according to Fig for Q. 1(a). **(15)**

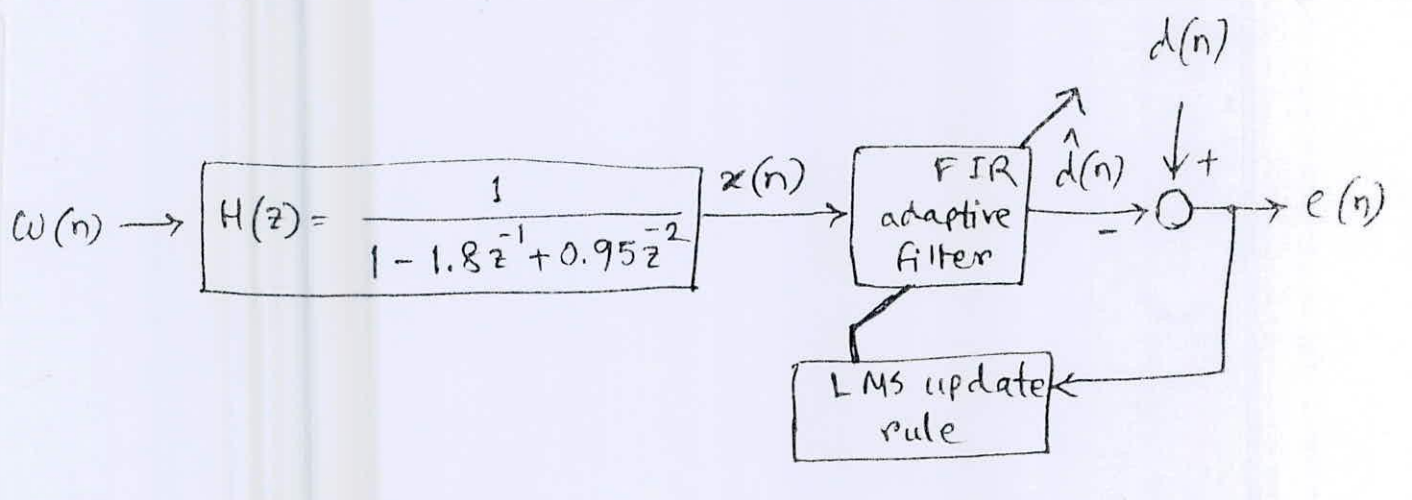

Fig. for Q. 1(a)

The variance of *w(n)* is known to be $\sigma_w^2 = 0.01$. The LMS algorithm (consider a 2-tap linear-phase FIR filter) is used to estimate a process *d(n)* from *x(n)*. Find the maximum value of the step size μ, in order for the LMS algorithm to converge in the mean.

(b) The electroencephalogram (EEG) signals are often corrupted with ocular artifacts. Show an adaptive filtering setup to reduce these ocular artifacts from the EEG signal and also write down the error in terms of the filter coefficients. Assume that reliable estimate of electrooculogram (EOG) can be obtained from 4 sensors placed around the eye. **(12)**

(c) Describe the Normalized LMS (NLMS) algorithm and write down the weight update equation. What are its benefits over LMS? **(8)**

2. (a) Consider a 3-tap Wiener filter with the following statistics: **(12)**

$$E\{d^2(n)\} = 10, \quad R = \begin{bmatrix} 1 & 0.5 & 0.25 \\ 0.5 & 1 & 0.5 \\ 0.25 & 0.5 & 1 \end{bmatrix}, \quad P = \begin{bmatrix} 3 \\ 1 \\ 0 \end{bmatrix}$$

(i) Evaluate the tap-weights of the Wiener filter.

(ii) What is the MMSE produced by the Wiener filter?

Contd P/2

EEE 431

Contd... Q. No.2

(b) Consider the system identification problem shown in Fig. for Q. 2(b). A 3rd order linear phase FIR filter $H_a(z)$ has been used to approximate the plant transfer function $H_p(z)$. Summarize the RLS algorithm for the given system identification problem. Define all necessary parameters and initial conditions as appropriate. **(15)**

(c) Explain the effect of using a smoothing constant (λ) in the cost function of the RLS adaptive filtering algorithm. **(8)**

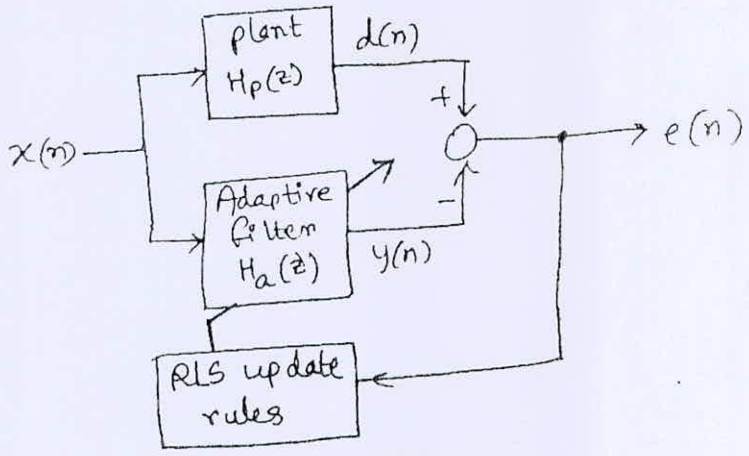

Fig. for Q. 2(b)

3. (a) Let $H(z)$ represent an FIR filter of length 10 with impulse response coefficients $h(n) = \left(\frac{1}{3}\right)^n$ for $0 \le n \le 9$. Find the polyphase components $G_o(z)$ and $G_1(z)$. **(12)**

(b) Consider the following specifications of a 50-fold decimation filter: **(15)**

Passnband edge frequency	70Hz
Stopband edge frequency	80Hz
Input sampling frequency	8 kHz
Passband ripple	0.01
Stopband ripple	0.01

Design a two stage decimator with the given specifications. Compute the multiplications per second (MPS) and total storage requirement (TSR) of the designed two stage decimator and compare them with that of a single stage implementation.

(c) Verify the equivalence of the cascade configurations given in Fig. for Q. 3(c). **(8)**

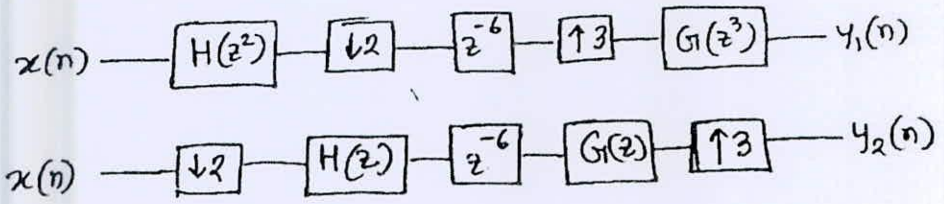

Fig. for Q. 3(c)

EEE 431

4. (a) Show that the following linear-phase FIR transfer function is a half-band filter: **(8)**

$$H(z) = 4 + 12z^{-2} + 11z^{-3} + 19z^{-4} - 9z^{-6}$$

(b) Consider the multi-rate structure shown in Fig. for Q. 4(b) alongside the frequency domain representation of the input signal and filters. **(17)**

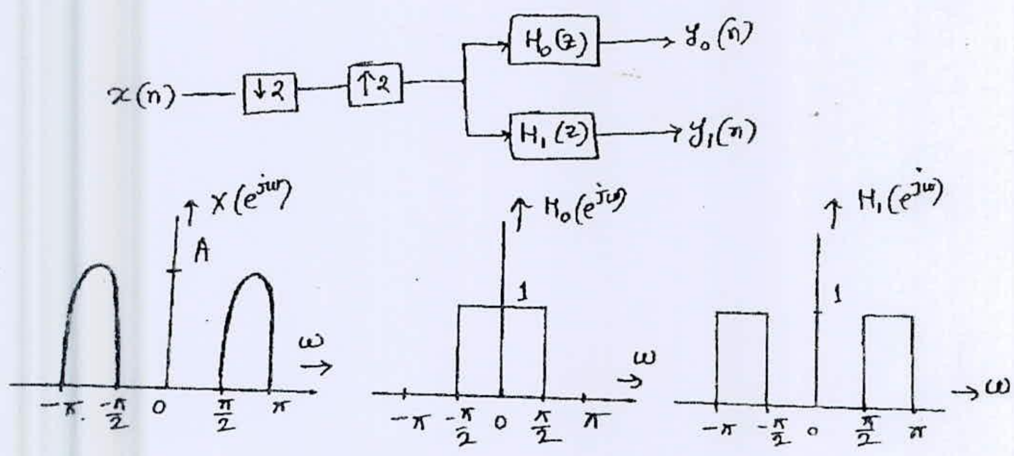

Fig. for Q. 4(b)

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

(c) Develop an expression for the output signal $y(n)$ as a function of the input signal $x(n)$ for the multi-rate structure given in Fig. for Q. 4(c). **(10)**

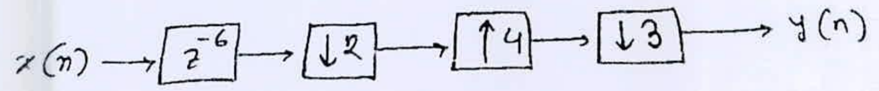

Fig. for Q. 4(c)

SECTION – B

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

5. (a) If $x(n)$ is a white Gaussian noise with $P_x(e^{j\omega}) = 1$, then show that the variance of the periodogram is independent of the data length. **(20)**

(b) Consider an all-pole system with the system function $H(z) = \dfrac{1}{1 + \sum a_p(k) z^{-k}}$, where the sum is evaluated for $k = 1, 2, \ldots, p$. Draw the lattice structure for this system. **(15)**

EEE 431

Contd... Q. No.6

6. (a) Derive the expression of the expected value of the periodogram estimate using Welch's method and show that Welch's method is an asymptotically unbiased estimate of the power spectrum. **(20)**

(b) Let *x(n)* be an AR(1) random process with an autocorrelation $r_x(k) = \frac{1}{1-\alpha^2}\alpha^{|k|}$, where $|\alpha| < 1$. Derive the expression for the minimum variance (MV) spectral estimate. **(15)**

7. (a) Let *x(n)* be an AR(1) random process with an autocorrelation $r_x = \frac{\sigma^2{}_w}{1-\alpha^2}\left[1, \alpha, \alpha^2, ..., \alpha^P\right]^T$. Derive the expression of reflection coefficient associated with this vector of autocorrelations. Here W(n) represents white Gaussian input with variance $\sigma^2{}_w$. **(20)**

(b) Briefly describe how audio signal compression can be performed using wavelets. **(15)**

8. (a) With necessary equations, describe the Pisarenko method for harmonic decomposition. Assume that the minimum eigenvalue of the autocorrelation matrix is $\lambda_{min} = \sigma^2{}_w$. Here W(n) represents white Gaussian input with variance $\sigma^2{}_w$. **(20)**

(b) Write the expressions for 1-level Haar wavelets. Express the detail coefficients in terms of the wavelets and the input signal vector. **(15)**

L-4/T-2/EEE **Date: 28/3/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **EEE 437** (Wireless Communications)

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** questions.

All symbols have their usual meanings.

1. (a) Starting from the received signal of each branch, derive the expressions of average SNR and outage probability for selection combining of M branches. **(12)**

(b) Assume that the required SNR and the average SNR per branch are equal. For MRC, **(10)**

(i) show that the outage probability is zero if the number of antennas is infinity and

(ii) determine the minimum number of required antennas to achieve an outage probability less than 10%.

(c) Explain the operation of OFDM with a block diagram. Also state and justify the bounds on the block length of OFDM. **(13)**

2. (a) Starting from the input-output relation of flat fading MIMO channel, show that the maximum capacity of a full rank MIMO channel is M times than that of a SISO channel if channel matrix is unknown to transmitter but known to receiver, where M is the number of transmit as well as receive antennas. **(18)**

(b) Derive the expression of the upper bound of the average symbol error probability under high SNR regime for M received signals with MRC if the M channel gains are independent and ZMCSCG random variables with unit variance. Then derive the upper and lower bound of the average symbol error probability for MIMO channel with transmit antenna diversity if the channel is known to the transmitter and the receiver. **(17)**

3. (a) Distinguish among coding gain, diversity gain and spatial multiplexing. Briefly describe the D-BLAST encoding technique for spatial multiplexing. **(18)**

(b) Briefly describe the rate adaptation, ICIC and carrier aggregation features of LTE. **(17)**

4. (a) The channel bandwidth of an FDD cellular system with LTE is 5 MHz. Suppose, the downlink to uplink bandwidth allocation ratio is 3:2, the total number of users is 100, and data transmission rate for each resource block is 10 Mbps. Determine (i) the number of resource elements in the system with normal CP, (ii) the maximum number of users for uplink and downlink that can be supported in one frame, and (iii) the average throughput capacity of each user under round robin scheduling. **(15)**

Contd P/2

EEE 437
Contd... Q. No.3

(b) Consider a 3-user CDMA uplink cellular system with chip sequences of user-1, user-2 and user-3 are C1 = [-1, 1, -1, 1], C2 = [-1, -1, 1, 1] and C3 = [-1, 1, 1, -1], respectively. The received amplitudes from the user-1, user-2 and user-3 are 60 V, 100 V and 80 V, respectively. The chip-wise received signal (voltage) value at the receiver is found to be [-40, 250, -80, 110] V for a bit duration, where it is assumed that the signal level does not change in a chip duration. Determine the decoded bits of the users under (i) linear decorrelator detector and (ii) SIC detector. **(20)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE** questions.
Answer in brief and to the point. Make reasonable assumptions on any missing information.

5. (a) Explain the three mechanisms of radio wave propagation. **(9)**

(b) Derive the expression of received power at a receiver in a wireless communication system considering two-way ground reflection model. **(12)**

(c) In a wireless communication system, a transmitter transmits a power of 10W. Antenna gains of the transmitter and the receiver are 6 dB and 4 dB, respectively. Received power at a reference distance of 50m is 0.5W. Path-loss exponent is equal to 4. Shadow-fading is log normally distributed with a mean of zero dB and a standard deviation of 8dB. The receiver is located at a distance equal to 1.5 km from the transmitter. Consider a shadow fading effect equal to -10dB. The receiver requires a minimum power of -30dBm for proper communication. Calculate the (i) received power at the receiver, and (ii) the probability that the received power is less than the required minimum power. **(14)**

6. (a) Explain what you understand by the terms "Frequency selective fast fading channel" and "Frequency selective slow fading channel". **(8)**

(b) The joint probabilities of inputs and outputs of a channel is given by the following matrix. **(12)**

$$P(X,Y) = \begin{matrix} & y_1 & y_2 \\ x_1 & 0.5 & 0.25 \\ x_2 & 0 & 0.125 \\ x_3 & 0.0625 & 0.0625 \end{matrix}$$

Calculate the – (i) joint entropy, (ii) mutual information, and (iii) channel capacity. If the sampling rate of the communication system is 8kHz, calculate the channel capacity in bits/second.

(c) The power delay profile of a wireless channel is shown in Fig. for Q. No 6(c). Transmitted signal over this channel has a bandwidth of 180 kHz. Calculate the – (i) average delay spread, (ii) RMS delay spread, and (iii) coherence bandwidth. Also, comment on the type of small-scale fading that will be faced by the transmitted signal. **(15)**

EEE 437

Contd... Q. No.6(c)

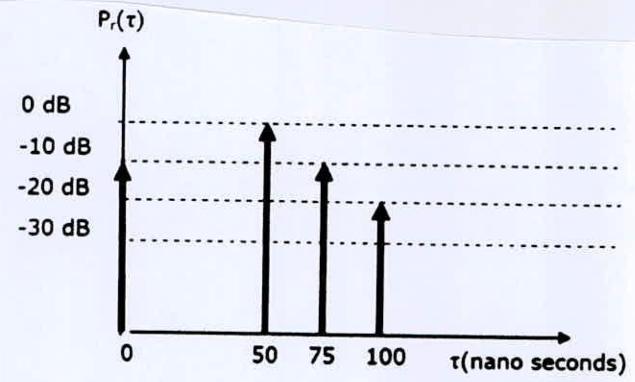

Fig. for Q. No. 6(c)

7. (a) Define the channel capacity of a wireless flat fading channel with a constraint of transmit power where both CDI and CSI are known at both the transmitter and the receiver. Now explain in details how this channel capacity can be achieved. **(15)**

(b) Consider a flat-fading channel with i.i.d. channel gain g_i, which can take on three possible values: $g_1 = 0.05$, with probability $p_1 = 0.1$, $g_2 = 0.5$ with probability $p_2 = 0.5$, and $g_3 = 1$ with probability $p_3 = 0.4$. CDI is known at both the transmitter and the receiver. However, the knowledge of CSI is only available at the receiver. The transmit power is 10 mW, the noise power spectral density is $N_0 = 10^{-9}$ W/Hz, and the channel bandwidth is 30 KHz. Find the capacity versus outage for this channel, and find the average rate correctly received for outage probabilities $p_{out} < 0.1$, $p_{out} = 0.1$ and $p_{out} = 0.6$. **(20)**

8. (a) Name three performance criteria for characterizing the symbol error probability of digital modulations in fading channels. Define them and discuss their appropriateness in different channel scenarios. **(15)**

(b) First, derive the exact expression of symbol error rate for QPSK modulation. Then, derive the expression of average symbol error rate for QPSK modulation considering a Rayleigh fading channel. **(20)**

L-4/T-2/EEE **Date: 20/3/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **EEE 441** (Telecommunication 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**.

All the symbols have their usual meanings. Assume reasonable values for missing data.

1. (a) What is side tone and why is it necessary for telephone circuit? With necessary figures explain how side tone is maintained in a telephone circuit. **(10)**

(b) Distinguish between pulse dialing and tone dialing. Briefly discuss the five design considerations for touch tone signaling. **(17)**

(c) Draw a telephone circuit and state what will happen during on-hook condition and off-hook condition. **(8)**

2. (a) In a telephone network, Subscriber A is connected to Subscriber B through a local exchange using 2-wire lines. How is it possible to achieve duplex communication between subscribers? What are the functions of local exchange here? Now, consider both subscribers are connected to respective local exchange and the two local exchanges are connected through trunk exchanges. Draw the connection diagram and show how the 2-wire line and 4-wire line can be used here and explain why two types of lines are used and how the conversion is done. **(15)**

(b) A step-by-step switching exchange consists of selector hunters and group selectors. Suppose the calling subscriber is dialing the called party's telephone number (4651), draw the corresponding trunking diagram for the connection (four-digit exchange) and briefly state what happen when the calling party goes off-hook and starts dialing from first digit and stops at last digit. **(10)**

(c) Write the benefits of SPC in telephone switching system naming the major control functions. Draw a typical centralized SPC system and comment on how to ensure better availability and reliability. **(10)**

3. (a) Single-stage space switch is strictly non-blocking but inefficient – justify the statement mentioning other limitations also of single-stage switch. Explain how the grading or multi-stage switching technique can overcome these limitations. **(8)**

(b) Draw a three-stage space switch with N number of inlets and N number of outlets. Derive the expression of minimum number of crosspoints for a non-blocking three-stage switching matrix. This non-blocking switch is not feasible for a large number of lines, why and explain how to reduce the number of crosspoints. **(15)**

Contd P/2

EEE 441

Contd... Q. No. 3

(c) Consider a three-stage space switch with total number of 1204 inlets which are sub-divided into 32 blocks, calculate the total number of crosspoints for single-stage switch and strictly non-blocking three-stage switch. If the probability of engagement of each inlet (inlet utilization) is 20%, and the concentration factor (or space expansion factor) is 0.3125, calculate the probability that an interstage link is busy, the blocking probability of this network, and the total number of crosspoints for the network. **(12)**

4. (a) Find out the basic differences between space division switching and (analog and digital) time division switching. With a neat sketch briefly describe the operation of a digital memory switch. **(15)**

(b) Why is two-dimensional switching required? Show how multistage two-dimensional switches can be achieved and write about their advantages. **(10)**

(c) Write short notes on (Any one): (i) FSO Communication, (ii) Distributed SPC. **(10)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE** questions.
All the symbols have their usual meanings.

5. (a) Distinguish among lost call cleared system, lost call held system and delay system in terms of functionalities, application scenarios and performance metrics. **(12)**

(b) Consider a group of 12 subscribers generates 30 calls during the busy hour in a buffer less telecommunication system of 4 lines/channels. The average holding time of a call is 3 minutes. A call is cleared immediately if it does not have service. Determine the blocking probability of the system. **(12)**

(c) Briefly explain how a DTH system works. **(11)**

6. (a) Distinguish between basic user interface and primary user interface of ISDN. **(12)**

(b) Briefly describe the signaling mechanism of ISDN. **(12)**

(c) With necessary diagram(s), describe the switching mechanism of ATM. **(11)**

7. (a) Draw the ATM protocol stack and briefly describe the functions of each layer. **(17)**

(b) Briefly describe the differences between PDH and SDH. **(18)**

8. (a) What are RTP and RTCP? Why these protocols are used in VoIP and why they are used on the top of UDP, not TCP? **(8)**

(b) Mention the components of a VoIP network and briefly describe the functions of each component. **(15)**

(c) Briefly describe the operation of PON with architecture. **(12)**

L-4/T-2/EEE **Date: 03/4/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **EEE 443** (Radar and Satellite Communications)

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** questions.

Answer in brief and to the point. Symbols and abbreviations have their usual meanings.

1. (a) What is a radar? **(2+8+7=17)**

Draw the most common type of radar pulse signal and show the typical values of peak power, pulse width, target return power, average power, PRI, f_p, and its duty cycle. Also, calculate the duty cycle of a continuous wave (CW) radar.

Determine the range equation for a radar. Define the maximum unambiguous range and derive its equation. Using the derived equation, plot the maximum unambiguous range versus the pulse repetition frequency, f_p. (Use a linear scale and plot for f_p = 1,000 Hz, 1,500 Hz and 2,000 Hz only).

(b) Define monostatic and bistatic radars. Draw the block diagram of a modern monostatic radar system, and with brief statements, describe the basic principle of its operation. **(7+3+8=18)**

What is the basic purpose of using modulation in a radar pulse? Name the various pulse-modulated waveforms that can be used as radar pulses.

Describe the pulse compression technique used in radar target detection and mention its advantages over the other methods.

2. (a) Write down the expression for the power density at a distance R from a directive antenna transmitting a power of P_t watts. Assuming a monostatic radar, also, derive the ultimate received power, P_r, at the receiving antenna received from a target at a distance R, in terms of the relevant parameters, G, A_e, and σ. Mention the typical levels of radar cross-section (σ) for three common targets. Sketch the received power versus range in a radar receiver embedded in noise and define the following terms: Detection threshold (S_{min}), False alarm, Detected target, Missed target and rms Noise level. **(8+2+7=17)**

(b) Define an antenna, and antenna pattern. What is a standard dipole? For such a dipole, draw the antenna pattern in polar and linear plots. **(6+5+7=18)**

Draw the electric field lines inside, before, and after a horn antenna, as it accomplishes radiation from a source to free space.

Contd P/2

EEE 443

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

Sketch a parabolic reflector antenna and show its feed and azimuth angle. Plot the gain of such an antenna as a function of its aperture for various values of wavelength and explain the curves.

3. (a) Classify radars in terms of their applications. **(5+7+8=20)**

Define a polarimetric radar. What are Jones vector and polarimetric scattering matrix $\vec{S}$? Write down the S-matrix for a linearly polarized radar system and explain the various terms used.

With a neat sketch, describe the principle of a TDM-MIMO radar with three Tx and three Rx antennas. Show the resulting Rx-Tx combinations and explain the corresponding channel matrix, H_{mn}.

(b) Answer each of the following questions in brief. **(6×2½=15)**

(i) What are the benefits of using a dual-polarization radar for weather forecasting applications?

(ii) What is the synthetic aperture radar (SAR)? With neat sketches, define the unfocused and focused SARs.

(iii) Name the various propagation effects on radar performance.

(iv) How can a modern radar distinguish between a stationary object and a moving target?

(v) What is a phased array antenna? What is the added advantages of using such an antenna?

(vi) What are the purposes of coherent and non-coherent integration of radar pulses?

4. (a) Draw the simplified diagram of a C/A code generator used on GPS satellites and mention the function of each block. **(6+9=15)**

Also, draw the simplified block diagram of a single channel correlator used for the GPS receiver, and explain how it extracts the 50 bps navigation signal correctly.

(b) Consider the case where 10 GPS satellites are visible at any given time and interference with the wanted signal is limited to nine overhead CDMA signals. The received power level for a typical C/A signal from an early GPS satellite is shown in the following table. **(20)**

Table for Q.4(b): Downlink budget for GPS C/A code signal.

Satellite EIRP	26.8 dBW
Path loss	186.8 dB
Receive antenna gain	0 dB
Received power, P_r	-160.0 dBW

Contd P/3

EEE 443

Contd... Q. No.4(b)

(i) Compute the CNR without and with the interference from the nine overlaid CDMA signals, and comment on the corresponding CNR values.

(ii) Next, compute the CNR for one GPS C/A code signal with the nine interfering signals.

(iii) Assuming an ideal correlator compute the SNR of the correlated C/A signal in a bandwidth of 1 kHz.

(iv) Determine the effective SNR, when the BPSK filter bandwidth is reduced towards 50 Hz, after acquiring the GPS satellite signal. Comment on the bit errors in a 50 bps navigation signal.

Assume: For BPSK modulation, the bit rates of the C/A code = 1.023 MHz; the receiver IF noise bandwidth = 2 MHz, System Noise Temperature = 273°K, and the signals are all received with equal power.

SECTION – B

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

All the symbols have their usual meanings. Assume reasonable values for missing data.

5. (a) What is communication satellite? What is the tactic of launching a satellite and how does it stay in orbit? Why is station-keeping necessary? **(10)**

   (b) Draw the block diagram of a satellite communication subsystem and briefly describe its operation. **(10)**

   (c) With suitable examples compare among communication satellite, navigation satellite and weather satellite. **(15)**

6. (a) Name the components/equipment of a satellite and explain why it requires reaction wheels, star trackers, thermal control and propulsion system. **(10)**

   (b) With neat sketches define the elevation angle, coverage angle, look angle, the subsatellite point and the satellite footprint. **(12)**

   (c) What is escape velocity? Derive the equation of escape velocity of an object (satellite) on earth. Also, derive the expression of velocity of an orbiting satellite and calculate its altitude considering it as geostationary satellite. **(13)**

EEE 443

7. (a) According to altitude of satellites, classify the satellite orbits with a neat figure identifying Van Allen radiation belts. Briefly comment on the relative advantages and disadvantages of those satellites in terms of altitude wise position. **(15)**

(b) Draw the basic functional block diagram of a digital earth station and explain the operation of reception side only. **(10)**

(c) An earth station antenna has a diameter of 30 m, an aperture efficiency of 70%, and is used to receive a signal at 4150 MHz. At this frequency, the LNA noise temperature is 50°K, clear air atmospheric gaseous absorption is 1 dB, and rain causes 1 dB attenution when the antenna points at the satellite at an elevation angle of 28°. What is the earth station G/T ratio under these conditions? Also calculate the noise power increased due to rain. Assume 90% coupling of sky noise into antenna noise and the temperature of the medium to be 270°K. **(10)**

8. (a) Draw the simplified diagram of a transponder of communication satellite for C band and explain its operation. **(9)**

(b) What is GMSPCS and what type of satellite is used for that? Briefly describe the mobile satellite communication network: INMARSAT or MobileSet. **(11)**

(c) A C-band satellite at a distance of 37,600 km from a point on the earth's surface transmits a power of 20 W with an antenna having a gain of 20 dB in the direction of the receiver. The satellite operates at a frequency of 6.0 GHz. The receiving antenna has an effective area of 20 m^2. Consider the attenuation of atmosphere as 5 dB and miscellaneous loss as 1 dB. Calculate the path loss (in dB) and the received power (in dBW). If the noise bandwidth is 30 MHz and system noise temperature is 100 °K at the receiver, calculate the C/N in dB. **(15)**

L-4/T-2/EEE **Date: 03/4/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

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** questions.

Symbols have their usual meanings. Assume any values, if missing.

1. (a) Describe, in detail, the Deal-Grove model for oxidation. Briefly explain, how you can calculate the activation energies of A and B. What is the significance of τ? **(17+4+4)**

   (b) Draw the full schematic diagram of a dry oxidation system. **(10)**

2. (a) A wafer is implanted with sulfur at an energy of 100 KeV and a dose of 1×10^{13} cm^{-2}. The water has a 500Å-thick layer of AlGaAs on top of GaAs-bulk substrate. Assuming the epi-layer AlGaAs behaves just like conventional GaAs-bulk, calculate the following- **(25)**

   (i) the depth of the maximum sulfur concentration. [assume R_p = 750Å , ΔR_p = 400 Å]

   (ii) the concentration at that peak point.

   Will most of the sulfur remain in AlGaAs-epi or GaAs-bulk? Plot the log of concentration versus depth and answer why.

   (b) Explain the diffusion of zinc in GaAs, and its "kink-behaviour" with proper diagram. **(10)**

3. (a) Explain how thermal annealing improves the crystal quality in p-doping of GaN. **(12)**

   (b) Explain briefly, why the redistribution of impurities at high temperatures is often undesirable. How do rapid thermal processes help in this regard? Why a big-sized oven is not suitable for this situation? How would you design an RTA chamber? **(7+3+3+7)**

   (c) Why has little research done on rapid thermal oxidation in wet ambient? **(3)**

4. (a) Discuss, in detail, the thermodynamics of vapor phase growth. How does the growth rate depend on temperature (R vs. $1/T$)? **(17+3)**

   (b) Discuss the issues of temperature measurement under vacuum conditions (e.g. MBE, RTP). **(15)**

EEE 451

SECTION – B

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

The notations have their usual meanings.

5. (a) Compare between wet etching and dry etching. **(10)**

(b) How does selectivity affect etchant choices? Why anisotropic etching is preferred? **(12)**

(c) Compare between two techniques of residual removal after etching – wet chemical versus dry RIE. **(13)**

6. (a) Discuss APCVD with proper figures. **(15)**

(b) Suppose a company BANGLAFAB has its R & D lab at ECE building, West Palashi Campus, BUET. You are the manager. A second company from Darjeeling, BIMAL, hires you to run their APCVD facility. You find several problems in running the facility as you did with similar equipment with BANGLAFAB. List the issues you think those are creating the problems and explain why. **(10)**

(c) How does LPCVD offer better alternatives to APCVD? **(10)**

7. (a) Explain how "resolution" depends on the choice of developer solution and photoresist. What other things can be done to improve resolution? **(15)**

(b) What are the cleanroom contaminants? **(8)**

(c) Make some comments on hotspot detection using neural networks as is used in lithography. **(12)**

8. (a) Write a short note on fabrication issues related to CMOS and MEMS as two different realms. **(15)**

(b) Write a short note on non-optical lithography techniques that extend the conventional UV and deep-UV methods of exposure. **(10)**

(c) How does MBE differ from MOCVD? **(10)**

L-4/T-2/EEE **Date: 28/3/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **EEE 457** (VLSI Circuits and Design 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** questions.
All symbols have their usual meanings. Assume reasonable values for missing data.

1. (a) Explain how dynamic voltage and frequency scaling are used to reduce power dissipation of a digital device. **(5)**

(b) A digital chip is fabricated in a 65 nm process with a supply voltage of 1.0 V and it contains 1 billion transistors of which 50 million are logic transistors and the rest are memory transistors. Average width of logic transistors are 12λ with activity factor 0.1 while average width of memory transistors are 4λ with activity factor 0.02. Two types of threshold voltage are available: nominal V_t and high V_t. High V_t transistors are used in all memories and 95% of the logic gates. Subthreshold leakage of nominal V_t transistors are 100 nA/μm and high V_t transistors are 10 nA/μm. Gate leakage of all transistors are 5 nA/μm. All transistors have gate capacitance of 1 fF/μm and diffusion capacitance of 0.8 fF/μm. Calculate the static and dynamic power dissipation of the chip. **(20)**

(c) Draw the cross-sectional diagram of a CMOS inverter showing NMOS and PMOS transistors in a twin well sub-micron CMOS process. Identify the LDD, side wall spacer, Shallow trench isolation, NWELL, PWELL, Metal1, via and Metal2. **(10)**

2. (a) Explain the following terms of static timing analysis: (i) Positive unate, (ii) Negative unate, (iii) Non-unate **(4)**

(b) The circuit in Fig. for Q. 2(b) shows the source clock pin CLK which supplies clock signal to three different destinations viz. CLKA, CLKB and CLKC. The rise latency and fall latency of each buffer and inverter connected in the path is shown in the Fig. for Q. No. 2(b). All timing parameters are in ns. **(15)**

(i) Calculate the minimum, maximum and average clock latency

(ii) Calculate the clock skew between CLKA, CLKB and CLKC for both rising and falling case of the source clock CLK.

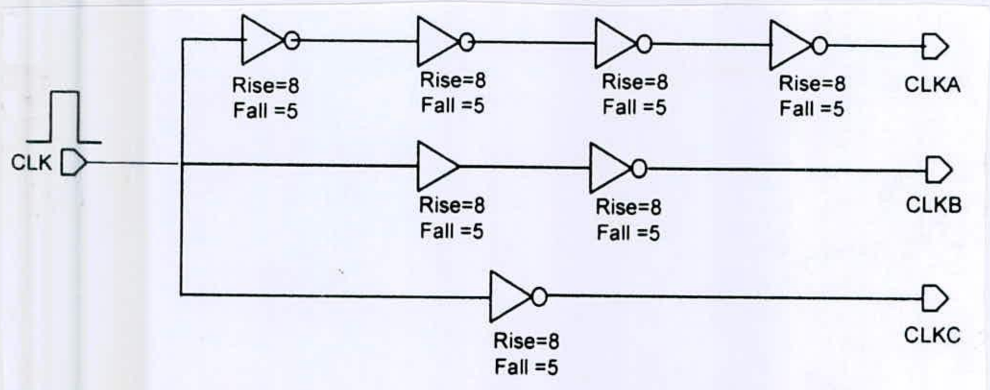

Fig. for Q No. 2(b)

Contd P/2

EEE 457
Contd... Q. No.2

(c) A register-transfer level circuit shown in the Fig. for Q.No.2(c). Calculate setup slack and hold slack. The following data are given: **(16)**

Max data path delay = 13.002 ns
Min data path delay = 0.802 ns
Setup time constraint of FF = 0.046 ns
Hold time constraint of FF = 1.046 ns

Source clock signal timing parameters:
Max Edge = 2.002 ns
Min Edge = 8.002 ns
Max clock path delay = 0.002 ns
Min clock path delay = 0.002 ns

Destination clock Signal timing parameters:
Max Edge = 2.020 ns
Min Edge = 20.02 ns
Max clock path delay = 0.500 ns
Min clock path delay = 0.500 ns

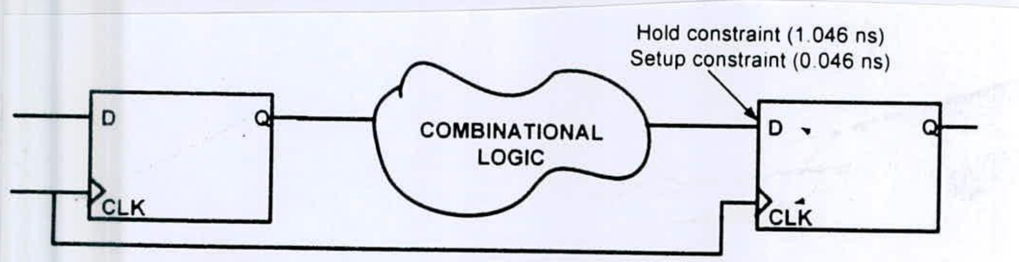

Fig. for Q No. 2 (c)

3. (a) Explain the difference between Data Types Logic, Reg and Wire in System Verilog. **(6)**

(b) A counter counts 0,2,4,7,0,2 and so on. **(14)**

(i) Write Verilog code of flat testbench of the counter finite state machine.

(ii) Suppose that you have to write a layered test bench of the counter. Write interface construct of the counter FSM incorporating Modport and Clocking block.

(c) The following shows a Universal Verification Methodology (UVM) sequencer code **(15)**

```
Class mem_sequencer extends uvm_sequencer#(mem_seq_item)
   uvm_sequencer_utils(mem_sequencer)
  function new (string name, uvm_component parent);
    super.new (name, parent);
  endfunction : new
 endclass
```

In the above code

(i) What is the relationship between `mem_sequencer` and `uvm_sequencer`?

(ii) What does the keyword `uvm_sequencer_utils` indicates?

(iii) Why the keyword super is used here? What does it indicate?

EEE 457

4. (a) The figure below (Fig. for Q. No. 4) shows a multicycle MIPS microarchitecture. Consider the instruction: **(20)**

Add $1 $2 $3

Explain the step by step operation performed by the hardware to implement the above instruction with specifically mentioning the followings:

(i) What are the values of control signals generated by the control unit for this instruction?

(ii) Which resources (blocks) perform a useful function for this instruction? Which resources produce no output for this instruction?

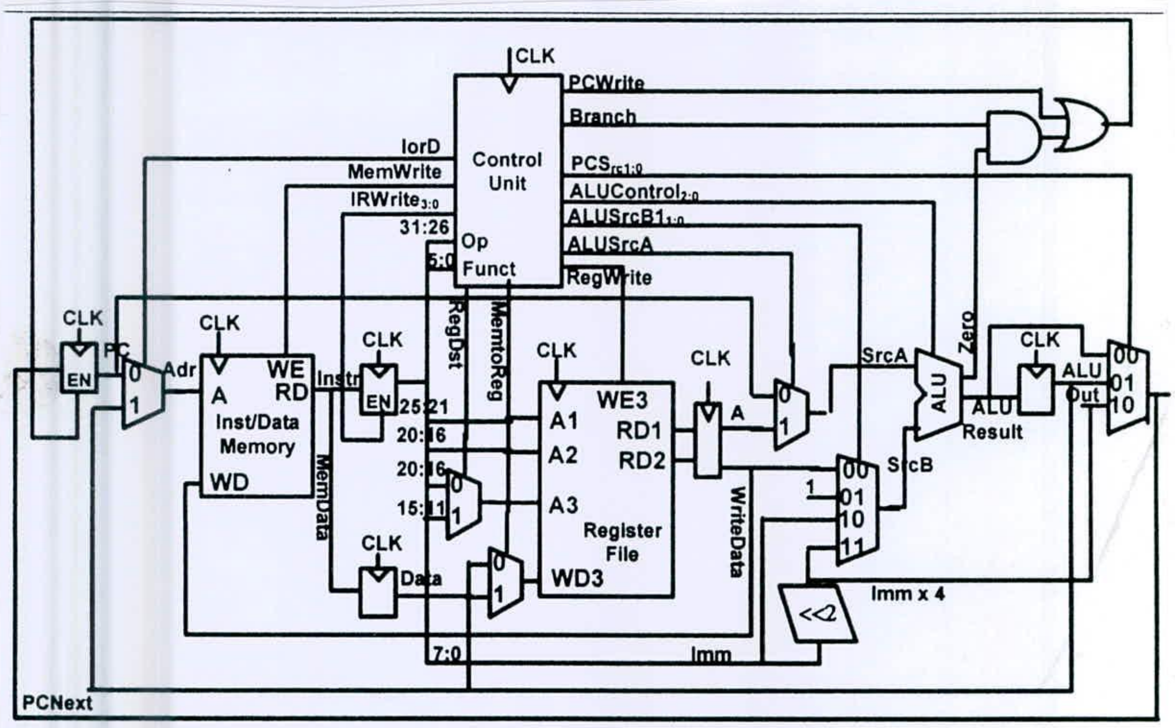

Fig. for Q. No. 4

(b) Different execution units and blocks of digital logic have different latencies. In Fig. for Q. No. 4 there are six kind of major blocks. Latencies of blocks along the critical path for an instruction determine the minimum latency of that instruction. Assume the following resource latencies **(15)**

Inst/Data Memory	Mux (2 input, 4 input)	Register File	ALU	Control Unit	FF
400 ps	30 ps	200 ps	120 ps	100 ps	25 ps

(i) What is the critical path for a MIPS ADD instruction? What is the latency of the instruction?

(ii) What is the critical path for a MIPS LOAD instruction? What is the latency of the instruction?

EEE 457

SECTION – B

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

All the symbols have their usual meanings. Assume reasonable values for missing data.

5. (a) Discuss about the monotonicity condition of dynamic logic gates. Mention how this condition can be addressed by domino and dual-rail domino gates. **(15)**

(b) The path from the data cache to the register file of a microprocessor involves 500 ps of gate delay and 500 ps of wire delay along a interconnect wire. The transistors are scaled using constant filed scaling and the wires with ideal scaling (scaled in both lateral and vertical dimensions) to a new process generation with a scaling factor of 2. **(20)**

(i) Estimate the gate and wire delays of the path. By how much did the overall delay improve?

(ii) If the switching (dynamic) power dissipation of the microprocessor was 10 W before scaling, what would be the switching power dissipation after scaling?

(iii) What would be the switching power dissipation density after scaling?

6. (a) The Figure for Q. 6(a) shows a multistage logic network built with different types of gates. Estimate the minimum delay of the path from A to B and choose gate sizes (x and y) to achieve this effect. **(15)**

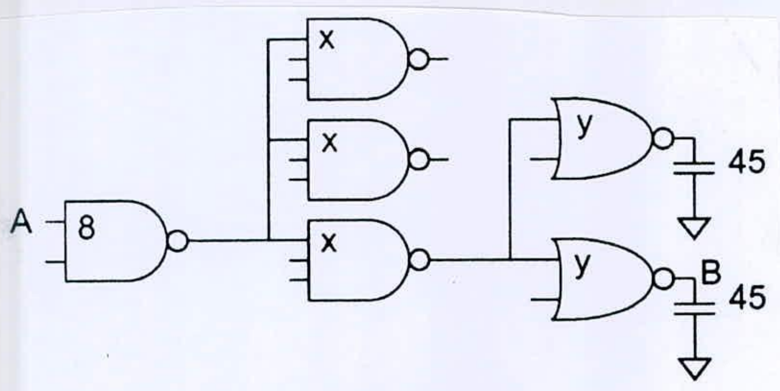

Figure for Q. 6(a)

(b) Consider two positive binary numbers A = $[1101]_2$, B = $[1000]_2$ are to be multiplied using modified both algorithm. Show the partial products and then compute the result of the multiplication. Show the modified Booth algorithm control circuit implementation. **(20)**

7. (a) Explain how progressive sizing and input re-ordering can help in the design of fast complex gates. **(15)**

(b) Explain the write and read operations of 6 transistors CMOS SRAM memory cell and discuss the significance of including sense amplifier blocks in the architecture. **(20)**

8. (a) Prove that for the minimum-size repeaters to be useful for improving wire delay, the RC constant of the wire must be at least seven times the delay of a minimum-size buffer. **(15)**

Contd P/5

EEE 457

Contd... Q. No.8

(b) Suppose an ALU self-bypass path is modified to use two-phase transparent latches where a mid-cycle $\phi 2$ latch is placed after the adder, as shown in the Figure for Q. 8(b). The delay contributions of different circuit elements are shown in the Table for Q. 8(b). Assume the early bypass multiplexer is not on the critical path. The latches have a setup time of 40 ps, a hold time of 5 ps, a clk-to-Q propagation delay of 82 ps and contamination delay of 52 ps, and a D-to-Q propagation delay of 82 ps. **(20)**

(i) Compute the minimum cycle time for the path.

(ii) How much time is borrowed through the mid-cycle latch at this cycle time? If the cycle time is increased to 2000 ps, how much time is borrowed?

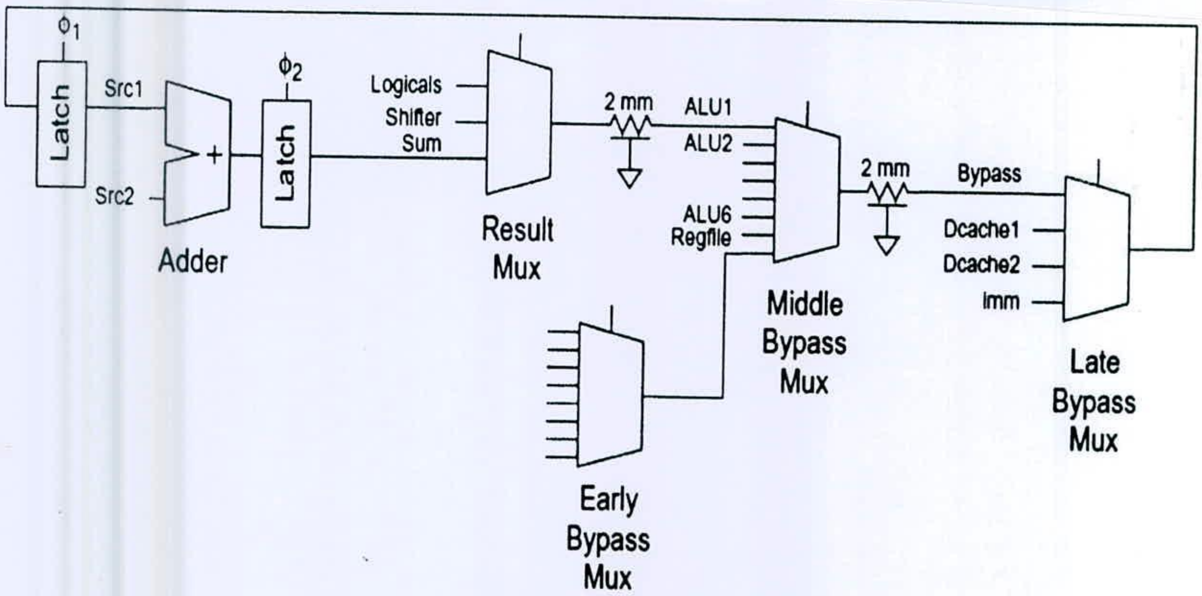

Figure for Q. 8(b)

Element	Propagation Delay	Contamination Delay
Adder	590 ps	100 ps
Result Mux	60 ps	35 ps
Early Bypass Mux	110 ps	95 ps
Middle Bypass Mux	80 ps	55 ps
Late Bypass Mux	70 ps	45 ps
2-mm Wire	100 ps	65 ps

Table for Q. 8(b)

L-4/T-2/EEE **Date : 17/04/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub : **EEE 459** (Optoelectronics)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

The symbols have their usual meanings. Make necessary assumptions

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) Draw PL spectral measurement set-up of semiconductors and explain PL spectra of GaAs and GaP semiconductors. With necessary diagrams, discuss the procedures to estimate the band gap of these semiconductors from absorption and PL spectra. Compare the accuracy of the band gap obtained from the two different methods. (20)

   (b) Draw quantum efficiency and peak emission wavelength versus alloy composition for $GaAs_{1-x}P_x$ with and without isoelectronic impurity. Why do quantum efficiency and wavelength modify with isoelectronic trap centre? Explain. (15)

2. (a) Discuss transitions in an ideal four level laser system and write the rate equations. Draw and explain the population inversion and laser power output as a function of pump rate. Show the emission pattern below, above and at threshold condition. (20)

   (b) An InGaAsP DFB laser operates at 1550 nm. Suppose that the effective refractive index $n \approx 3.5$ and the cavity length is 60 μm. What should be the corrugation period Λ for a first order grating, $q = 1$? What is Λ for a second-order grating, $q = 2$? How many corrugations are needed for a first order grating? How many corrugations are there for $q = 2$? (15)

3. (a) Draw and explain optical gain curve as a function of photon energy for an InGaAsP (1550 nm) active layer with different amounts of injected carrier concentration. What happens to the peak gain as the LD current (and hence the injected carrier concentration) is increased? Compare the current at transparency and threshold condition in laser diode.

   (b) What is Birefringence? Explain Pockels effect? (20)

   Suppose that we have a glass rectangular block of thickness (d) 50 μm and length (L) 20 mm and we wish to use the Kerr effect to implement a phase modulator in a fashion illustrated in Fig. for Q. 3(b). Note that d is the sample dimension along z, the applied field, and L is the sample length along y, the direction of light propagation. The input light has been polarized parallel to the applied field E_a direction, along the z-axis. Assume that the glass medium has a Kerr coefficient, $K = 3 \times 10^{-15}$ m V^{-2}. What is the applied voltage that induces a phase change of $\pi/2$ (quarter-wave length)? (15)

Contd P/2

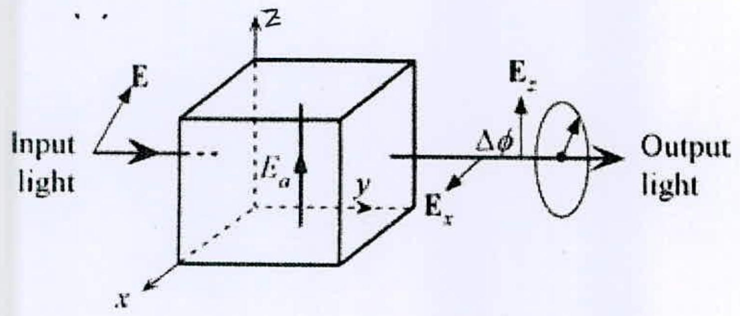

Fig. for Ques. No. 3 (b): A Kerr cell phase modulator.

4. (a) With suitable diagram explain various factors those affect solar cell efficiency. Design a heterojunction solar cell using GaAs and Si semiconductors. Draw energy band diagram and explain the merits and demerits of such structures in terms of expected efficiency, FF, and V_{oc} performance parameters. (20)

   (b) A solar cell under an illumination of 300 W m^{-2} has a short circuit current I_{SC} of 60 mA and an open circuit output voltage V_{OC} of 0.60 V. What are the short circuit current and open circuit voltage when the light intensity is 600 W m^{-2}? Assume $\eta = 1$. (15)

SECTION – B

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

5. (a) Design a double-heterostructure (DH) light emitting diode (LED) structure that emits red light. With necessary band diagrams, describe the operation of your designed DH LED and explain the significance of different layers used in the structure. How the drawbacks of homojunction LED are overcome in DH LED? (20)

   (b) The Varshni constants for GaAs are $E_{go} = 1.520$ eV, $A = 5.41 \times 10^{-4}$ eV K^{-1}, $B = 204$ K. (15)

   (i) What is the peak emission wavelength from a GaAs LED at 25°C?

   (ii) Find the shift in the peak wavelength emitted from this LED when it is cooled down from 25°c to –35°C.

   (iii) What are the linewidths between half intensity points at temperatures 25°C, 0°C, and 35°C?

EEE 459

6. (a) Draw the schematic of DH edge emitting LED (ELED) structure. Discuss the properties of typical materials used in confining and cladding layers of these LEDs. Write down the advantages of ELED over surface emitting LED. With necessary diagrams, discuss two kind of lens systems that can be used to couple emitted radiation from ELED into a fiber. (20)

(b) A particular 890 nm IR LED for use in instrumentation has a AlGaAs chip. The active region is doped p-type with 4×10^{17} cm^{-3} of acceptors and the nonradiative lifetime is ~60 ns. At a forward current of 52 mA, the voltage across it is 1.4 V, and the emitted optical power is 10 mW. Calculate (i) radiative efficiency, (ii) external quantum efficiency, (iii) extraction efficiency, and (iv) power conversion efficiency. For AlGaAs, the coefficient for band-to-band recombination, $B_r \approx 1\times10^{-16}\ m^3s^{-1}$. (15)

7. (a) Propose two device structures that improves light extraction ratio in LED. Describe your proposed structures with necessary schematics. (10)

(b) Draw the band diagrams and I-V characteristics of a *pn* junction for (i) photovoltaic and (ii) photodiode mode of operations. What are advantages of Schottky junction photodiodes over *pn* and *pin* photodiodes? (13)

(c) A Si *pin* photodiode has an active light receiving area of diameter 0.5 mm. When radiation of wavelength 720 nm and intensity 0.1 mWcm^{-2} is incident, it generates a photo current of 60 nA. What are the responsivity and the external quantum efficiency of the photodiode at 720 nm? (12)

8. (a) With necessary schematic and band diagrams, describe the operation of a SAGM APD. What is advantages of SAGM APD over SAM APD? Discuss the merits and demerits of super lattice APDs. (15)

(b) A Si APD hasd a QE of 60% at 800 nm in the absence of multiplication. The APD is biased to operate with a multiplication of 100. If the incident optical power is 20 nW, what is the photocurrent? (7)

(c) What is noise equivalent power (NEP) of a photodiode? A Si *pin* photodiode has NEP of 2×10^{-13} WHz$^{-1/2}$. What optical signal power it needs for a signal to noise ratio (SNR) of 1 if the bandwidth of operation is 4 GHz? (13)

L-4/T-2/EEE **Date : 20/03/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub : **EEE 461** (Semiconductor and Nano Device)

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) What happens to the initial energy and momentum of an electron after it is scattered by an interface defect between two materials? (8)

(b) Derive an expression for the net exchange of energy due to interactions between electron and phonon. (15)

(c) Compare silicon and gallium arsenic materials in designing detectors. (12)

2. (a) Why does an absorption spectrum broaden when electrons make transitions between two subbands in the conduction band? How does temperature affect broadening of a transition spectrum? (10)

(b) How is the light absorption spectrum used to determine the internal electronic structure of materials? Explain. (13)

(c) Derive the electron transition rate from an initial state *i* to *a* final state *f* due to a perturbing potential given by $V_0\cos\omega t$. (12)

3. (a) Can the electronic transport between source and drain in a graphene nano-ribbon FET be ballistic? Explain. (10)

(b) An electron is in the ground state of a GaAs quantum well of width 30 nm, which can be treated as an infinitely deep one-dimensional system. Suddenly the middle 10 nm becomes 120 meV deeper. Use the golden rule to derive an expression for the rate at which electron scatters into the second, third and fourth states. (12)

(c) Define oscillator strength of an electron transition due to light. How the oscillator strength of a quantum well can be increased? (13)

4. (a) How data can be stored in a flash memory device for a sufficiently long time? (10)

(b) Explain how sub-atomic imaging resolution is achieved using a tunneling electron microscope. (12)

(c) Derive the transmission coefficient of a double barrier structure. What is the condition for resonance? (13)

Contd P/2

EEE 461

SECTION – B

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

The symbols have their usual meanings.

5. (a) For a diatomic molecule, obtain the expression of E-K relation in one dimension applying tight binding model. Based on your derivation, show that the parabolic nature of E-K relation is retained near to the bottom of the band. (20)

(b) Consider an 1-D chain of atom where the lattice vibration is characterized by an elastic constant of 2.2×10^5 cm-s^{-1}. The lattice constant and mass of the atoms are 5.4 A^0 and 28 amu respectively, where 1 amu = 1.665×10^{-27} kg. In the dispersionless propagation regime, what is the velocity of wave propagation in the medium? Also calculate the frequency above which the propagation of phonon vibrational modes is strongly attenuated in the medium. Do you expect to observe the Reststrahlen effect in this medium? (15)

6. (a) Consider a diatomic molecule AB where masses of the elements A and B are m_A and m_B, respectively where $m_A > m_B$. Derive the phonon dispersion relation for this system. Based on your derivation, obtain the expression of the velocity of sound in this medium. Also calculate the frequency of phonon vibration near the edge of the Brillouin zones. (20)

(b) Consider the time dependent Shrodinger equation in three-dimension. For a free particle, show the solution of this equation is a plane wave propagating in free space. How is this solution modified when the particle resides in a crystal lattice? (15)

7. (a) Consider a GaAs-AlGaAs based single quantum-well which has a single energy state E_1 and a corresponding wavefunction ψ_1. Suppose this quantum-well is brought under the influence of a small electric field E_x. Based on time-independent perturbation theory, derive the expression of the second order corrected energy state and wavefunction for this system. Also show that the energy state and wavefunction reduce to their unpertubed values when the applied field is set to zero. (20)

(b) Consider the following experimental observations where light having wavelengths ranging from 20-100 μm is incident onto three different crystals of diatomic molecules. (15)

- No strong reflection of light occurs from the sample of molecule AB
- Weak reflection of light occurs from the sample of molecule CD
- Very strong reflection of light occurs from the sample of molecule EF

Based on your knowledge of lattice vibration, comment on the ionicity of the molecules AB, CD and EF. From the measured results, is it possible to obtain the elastic constant of the material?

Contd P/3

EEE 461

8. (a) Based on the harmonic oscillator model, derive the expression of internal energy and specific heat of a material. Also define Einstein's temperature based on your derivation and comment on the validity of the model in the low and high temperature limits. (20)

(b) 'In the degenerate limit, distribution of electrons can be approximated as a step function' – do you agree with this statement? Provide necessary justification of your answer. Also comment on the nature of the distribution function in the non-degenerate limit. (15)

L-4/T-2/EEE **Date : 17/04/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub : **EEE 483** (High Voltage 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**.

All the symbols have their usual meanings. Assume reasonable values for missing data.

1. (a) John Townsend studied variation of gas current measured between two parallel plate electrodes as a function of applied voltage. Discuss his findings and observations. Why did he introduce an ionization coefficient? What is the relationship between the ionization coefficient and mean free path of electron? **(17)**

(b) Discuss various ionization and deionization process in gas and how these affect high voltage breakdown of gas. **(18)**

2. (a) Current due to increased ionization in gases can be represented by the following, **(15)**

$$I = I_0 \, e^{\alpha d}.$$

A graph of current against gap length (d) should yield a straight line of slope α at constant pressure and field strength. However, when measuring current in parallel plate gaps Townsend observed that at higher voltages current increased more rapidly, as shown in Fig. 2(a). Write down the current equation as modified by Townsend. What was Townsend's explanation of the non-linearity at higher voltages? What is the weakness of Townsend's explanation?

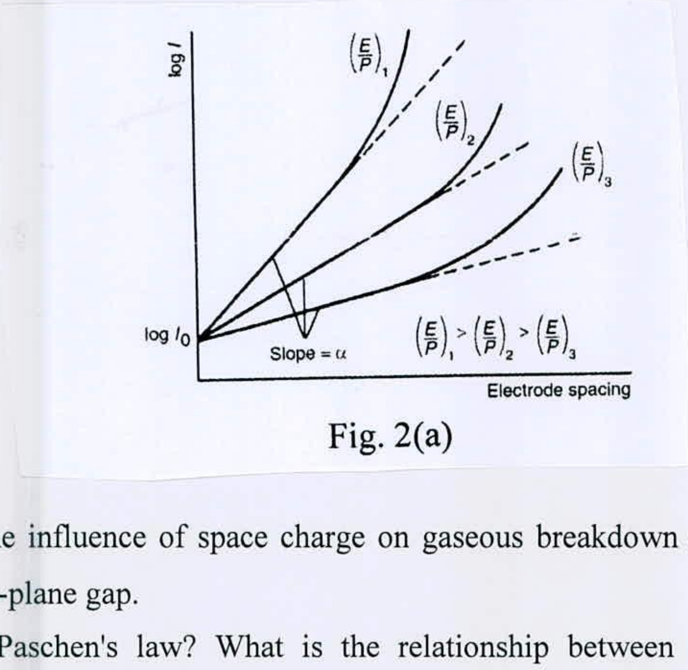

Fig. 2(a)

(b) Discuss the influence of space charge on gaseous breakdown for both positive and negative point-plane gap. **(12)**

(c) What is Paschen's law? What is the relationship between Paschen's curve and Townsend breakdown criterion? **(8)**

Contd P/2

EEE 483

3. (a) Explain the use of sphere gap as a high voltage measurement device. Why it cannot be used as an RMS measurement device? What principle would you suggest for a HV rms measuring device? **(13)**

   (b) Why geometry of a spark gap is a decisive factor for its application? When and why irradiation used in sphere-gap voltage measurements? What factors influence sphere-gap breakdown voltage? **(10)**

   (c) Write briefly on the principal sources of errors in Chubb-Fortescue method of high voltage measuring circuit. **(12)**

4. (a) What is insulation coordination? Discuss the statistical approach to insulation coordination. **(20)**

   (b) How would you correlate between insulation level and protection level, and assess insulation failure risk? **(15)**

SECTION – B

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

The symbols have their usual meanings.

5. (a) With neat diagram, describe the working principle of Cockcroft-Walton type multiplier circuit arrangement for generation of HVDC. Find the ripple of this circuit. **(20)**

   (b) A Cockcroft-Walton type voltage multiplier has eight stages with capacitance, all equal to 0.05 μF. The supply transformer secondary voltage is 125 kV at a frequency of 150 Hz. If the load current to be supplied is 5 mA, find **(15)**

      (i) the percentage ripple

      (ii) the regulation

      (iii) the optimum number of stages for minimum regulation on voltage drop

6. (a) Draw the basic circuit of cascaded transformers for high AC voltage generation and explain the operation in brief. **(17)**

   (b) Describe the working principle of a single-stage impulse generator by deriving the expression for voltage, the time for voltage rise to peak value, and the voltage efficiency of the generator. **(18)**

Contd P/3

EEE 483

7. What are the factors that influence breakdown in pure liquid dielectrics and in commercial liquid dielectrics? Explain in brief the suspended particle mechanism and cavity breakdown mechanism for liquid dielectrics. **(10+13+12)**

8. (a) Explain edge breakdown and treeing mechanism in case of solid dielectrics. **(10)**

(b) Describe how electromechanical breakdown occurs in solid dielectrics. **(10)**

(c) A solid dielectric specimen of dielectric constant 4.0 shown in the Fig. for Q. 8(c) has an internal void of thickness 1.1 mm. The specimen is 1 cm thick and is subjected to a voltage of 90 kV (rms). If the void is filled with air and the breakdown strength of air can be taken as 30 kV (peak)/cm, find the voltage at which internal discharge can occur. **(15)**

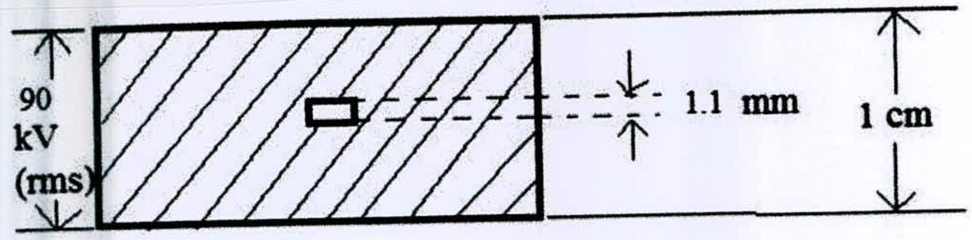

Fig. for Q. 8(c)

L-4/T-2/EEE **Date: 03/4/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **EEE 487** (Nuclear Power 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** questions.

All the symbols and abbreviations have their usual significance.

1. (a) Describe the various steps of spent fuel management in the back end of a closed-loop nuclear fuel cycle. **(15)**

(b) Given that the rate of fission in terms of fuel mass is 1.11 g/MWt/day in a 1000 MWe nuclear power plant with 33% efficiency. If the density of the resulting waste (fission products) is 10,000 kg/m^3 estimate the volume of the waste generated due to one year's operation of the plant. **(10)**

(c) Explain SWU (Separative Work Unit) in relation to the enrichment process of natural uranium. **(10)**

2. (a) Explain fuel criticality and neutron criticality in order to sustain a chain reaction. If in a reactor the neutron production, absorption and leakage rate for a fuel assembly are respectively 5.2×10^5 n/s, 4.0×10^5 n/s and 6×10^4 n/s, calculate the value of reactivity of the reactor. Is the value acceptable? **(12)**

(b) What is auxiliary system of an NPP? List various components of the auxiliary system. **(10)**

(c) What is I&C system of an NPP? What are its main functions? **(8)**

(d) What are the various power sources that are usually deployed in a Class 1E subsystem? **(5)**

3. (a) Discuss various factors that require a reliable grid system for connecting an NPP. **(20)**

(b) In a power system with a peak demand of 10,000MW, a 1000 MWe nuclear power plant is running along with other generators. The total capacity of other generators is 10,000 MW. What are the provisions that exist and what more are required so that the system will remain stable in case the NPP trips? Explain qualitatively. **(15)**

4. (a) Using a schematic diagram describe the operation of a typical ECCS. **(17)**

(b) Which parts of an ECCS work during normal or emergency shutdown of an NPP and which parts work during an accident likely to cause core meltdown? **(5)**

(c) Explain how the Chernobyl NPP reactor accident did happen. **(13)**

Contd P/2

EEE 487

SECTION – B

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

5. (a) Show a comparison chart between nuclear fission and nuclear fusion. **(5)**

(b) Explain the nuclear reaction process using the concept of transmutation of elements. What is binding energy? **(15)**

(c) What are the differences between electrostatic and nuclear forces? The decay constant of radium (atomic mass = 226.095) is 1.3566×10^{-11} s^{-1}. Find the half-life and initial activity of 1 g of radium-226. **(15)**

6. (a) What is thermal reactor criticality and neutron flux? **(5)**

(b) Describe the process of electrical power production in a nuclear power plant. **(15)**

(c) What are the usages of waste heat from a nuclear power plant? Discuss in detail the district heating mechanism using the waste heat. **(15)**

7. (a) What is Generation IV nuclear reactor? Write down the key features of various types of Generation IV reactors. **(15)**

(b) Describe the factors to ascertain the economic feasibility of a nuclear power plant. **(10)**

(c) What is small modular reactor (SMR)? Briefly mention the different design concepts of SMR. **(10)**

8. (a) Explain the nexus between hydrogen and electricity. State the role of next generation reactors in hydrogen economy. **(10)**

(b) With necessary illustration, describe the utilization of very high temperature reactor for hydrogen production. **(15)**

(c) Draw the basic layouts of BWR type and PWR type nuclear power plants. What are the main differences between these two reactors? **(10)**

L-4/T-2/EEE **Date: 20/3/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **EEE 489** (Smart Grid)

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** questions.

All the symbols and abbreviations have their usual meanings.

1. (a) A wind turbine driven and gear coupled synchronous generator rated 2 MW and 1800 rpm having the characteristics shown below is used as a DER. The generator is interfaced with the grid through back to back VSCs. It was operating at point "A" in a wind speed of 11 m/s. Due to a high frequency on the network, the grid operator requests a reduction of the wind turbine output by 20 per cent so that new operating point could be either "B" or "C". Which one should be selected as the new operating point and why? If at rated speed the frequency modulation index of the wind turbine side VSC is 30, determine the modulation index required to reduce the wind turbine power output? **(20)**

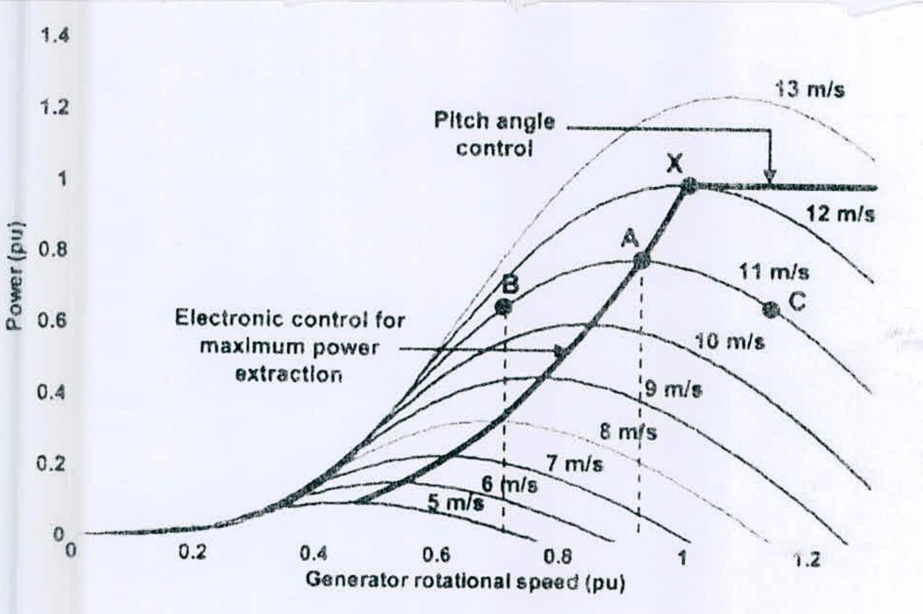

Fig. for Q. 1(a)

(b) What are "Prosumers"? Discuss their impacts on grid operation. **(15)**

2. (a) A distribution substation has 3 outgoing feeders. The feeder wise customer number, annual outage frequency and outage duration (minutes) are respectively (1000, 2, 100), (750, 1, 60) and (500, 3, 125). Determine SAIFI, SAIDI and ASAI in appropriate units for this substation. Will these indices improve if the number of feeders is increased either at planning stage or through auto-reconfiguration or sectionalization at operating stage keeping the total number of customers served by the substation same? Why? **(20)**

(b) What is grid hardening and how can it be implemented? **(15)**

Contd P/2

3. (a) What are "net metering" and "feed in tariff metering". **(5)**
(b) In the context of smart grid define the scope of HAN, NAN, SCADA and Utility WAN. List the communication technologies that can be deployed in each of these? **(20)**
(c) Briefly discuss the PLC technology. **(10)**

4. (a) Briefly discuss the application areas of the following protocols in a power system or smart grid. **(15)**
IEC 62056, IEC 61850, ANSI C12.22, Modbus, DNP3
(b) Explain the important factors for assessment of communication protocols for smart meeting. **(12)**
(c) How does a DCU operate in a smart grid? **(8)**

SECTION – B

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

5. (a) Define a smart grid. **(5)**
(b) What are the operational constraints in a traditional grid? What are the solutions to these constraints? How can a smart grid help achieving these solutions? **(15)**
(c) Provide an overview of the technologies required for the implementation of a smart grid. **(15)**

6. (a) With a functional block diagram, briefly describe the operation of a smart meter. What are the major differences between conventional prepayment meter and the visionary smart meter? **(10)**
(b) What is AMI? How does it work together with customer system for demand side management? **(10)**
(c) How do battery energy storage systems mitigate the uncertainties of variable renewable generation? Write down the key features of commonly used battery energy storage systems. **(15)**

7. (a) Define demand-side management, demand response, demand-side participation and demand-side integration (DSI). What is the relationship between DSI and smart metering? **(10)**
(b) With necessary illustration, explain the major services provided by DSI. **(10)**
(c) Describe the various schemes for price-based and incentive-based DSI implementations. **(15)**

8. (a) Describe the factors that affect the charging speed of EV batteries. **(10)**
(b) How can DSI support in the frequency control of a smart grid? **(5)**
(c) With a block diagram, describe the hierarchical control and islanded mode operation of a typical microgrid. **(20)**
