L-4/T-1/EEE Date : 25/09/2022

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **EEE 415** (Microprocessor and Embedded Systems)

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. Question No. 1 is compulsory to answer and has 45 marks. Answer Q. No. 1 and any **TWO** questions from Question No. 2-4.

1. (a) Design a single cycle processor to implement LSL, ADC and TEQ commands. You should design a single processor data-path that can implement all the commands. Neatly sketch the data-path for your design. Write the main and ALU decoder truth tables for your design. (Use Complete Single Cycle Processor, Decoder and Conditional Logic part of Control unit, Main Decoder Truth Table, ALU Decoder Truth Table given in Appendix 1(a) as reference design and modify data paths to accommodate all functions. Description for Different assembly commands are given in Appendix 2. Also note, all three commands should be implemented in a single processor). **(15)**

(b) Death Star Corporation claims to have patent on a three-ported register file. Rather than fighting Death Star Corporation in court, Obi Wan Kenobi designs a new register file that has only a single read/write port (like the combined instruction and data memory). Redesign the ARM multicycle data-path and controller to use his new register file. (Use Complete Multicycle Processor, Decoder and Conditional Logic part of Control unit, Main Decoder Truth Table, ALU Decoder Truth Table and FSM Diagram of Main Decoder which are given in Appendix 1(b).) **(15+5)**

(i) Now, neatly sketch the new Datapath, control unit with added control signals and state diagram for your designed system.

(ii) What is the CPI of the redesigned multicycle ARM processor for SPECINT2000 bench mark (25% loads, 10% stores, 13% branches, and 52% data-processing instructions)?

(c) Consider building a pipelined processor by chopping up the single-cycle processor into N stages. The single-cycle processor has a propagation delay of 740 ps through the combinational logic. The sequencing overhead of a register is 90 ps. Assume that the combinational delay can be arbitrarily divided into any number of stages and that pipeling hazard logic does not increase the delay. A five-stage pipeline has a CPI of 1.23. Assume that each additional stage increases the CPI by 0.08 because of branch mispredictions and other pipeline hazards. How many pipeline stages should be used to make the processor execute programs as fast as possible? **(10)**

Contd P/2

EEE 415

2. (a) The following code is a machine code output from ARM v7 A compiler. Decompile the code into assembly language. (The first hexadecimal number in each line is a memory address, and the second hexadecimal number is a machine code) **(15)**

```
0x00000000   E3A0000F
0x00000004   E3A03004
0x00000008   EB000002
0x0000000C   E0800103
0x00000010   E1A00000
0x00000014   EAFFFFFD
0x00000018   E2833002
0x0000001C   E1A0F00E
```

(b) Consider the ARM assembly code below. func1, func2, and func3 are non-leaf functions. func4 is a leaf function. The code is not shown for each function, but the comments indicate which registers are used within each function. **(10)**

```
0x00091000 func1 ...      ; func1 uses R4-R10
0x00091020 BL func2
. . .
0x00091100 func2 ...      ; func2 uses R0-R5
0x0009117C BL func3
. . .
0x00091400 func3 ...      ; func3 uses R3, R7-R9
0x00091704 BL func4
. . .
0x00093008 func4 ...      ; func4 uses R11-R12
0x00093118 MOV PC, LR
```

Sketch the stack after func4 is called. Clearly indicate which registers are stored where on the stack and mark each of the stack frames. Give values where possible. How many words are in the stack frames of each function?

(c) What are the target markets and applications for ARM A, R and M architectures? **(5)**

EEE 415

3. (a) What is superscalar processing? Briefly explain how a 2 bit branch predictor works. **(5+5)**

(b) What is Internet-of-Things (IoT)? What are the challenges of implementing IoT? What are the constraints/design challenges of an embedded system? **(2+4+4)**

(c) Write a short assembly code snippet that has the following functionality: R0 = R1 NAND R2. Use as few instructions as possible. **(5)**

(d) For a SAR of 24-bit ADC with a clock speed of 180MHz, if sample time is 10 cycles, what is the ADC conversion time? **(5)**

4. (a) For the STM32F103 board shown in Fig. for Q. 4(a), from top right , pin 2 is GND, pin 3 is 5V, pin 6 is PB7 (SDA), pin 7 is PB6 (SCK). Draw the circuit diagram to interface a PCF8574 LCD controller and TC74 temperature sensor with the STM32 board. **(10)**

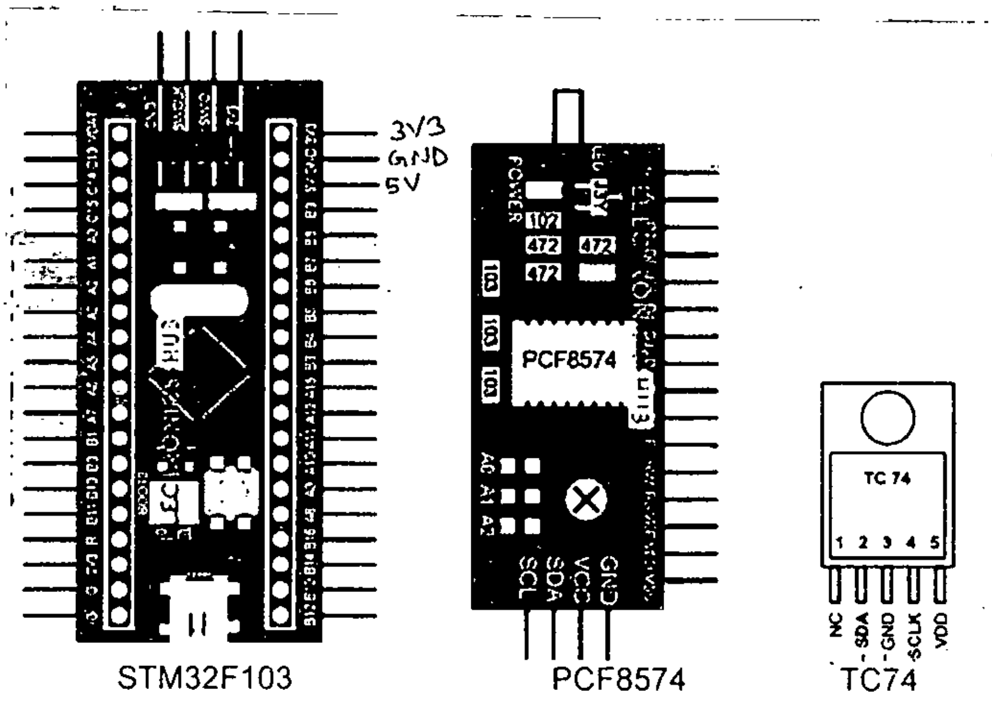


Fig for Q.4(a)

(b) Briefly explain the differences between Harvard and Von Neumann architecture. **(5)**

(c) For an STM32 processor UART communication, if the APB frequency is 180MHz, and Baud Rate is 9600, what value needs to be put in the Baud Rate Register (BRR) in hexadecimal? **(5)**

(d) Fig for Q. 4(d) shows the analog voltage sampled in an ADC channel. Briefly explain with a sketched wave form, how ADC Successive Approximation (SAR) Digital Quantization can convert this signal to its digital output. **(5)**

EEE 415

Contd... Q. 4(d).

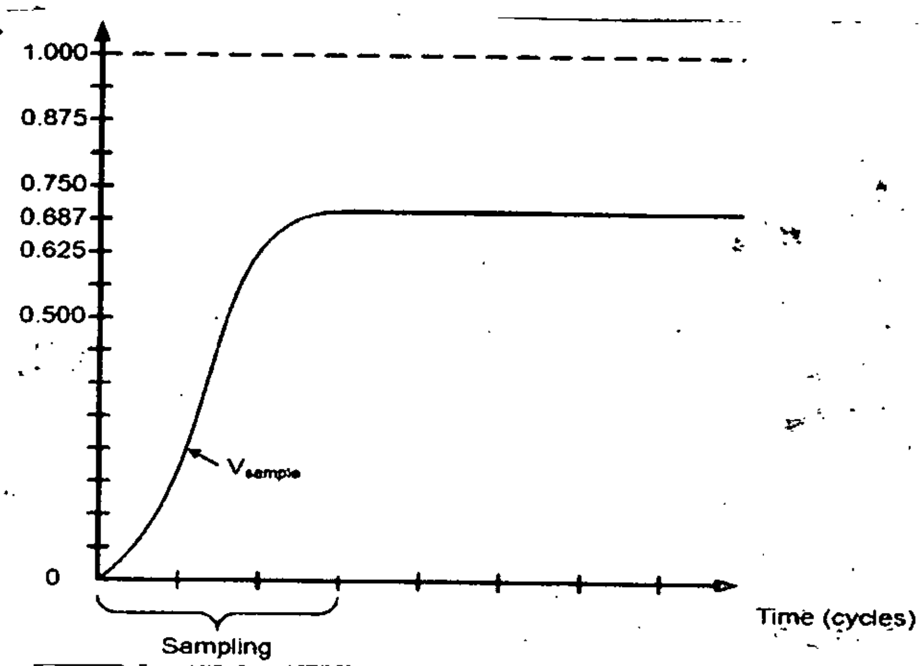


Fig. for Q. 4(d)

(e) Draw a circuit diagram to connect the STM32L4 and L3GD20 Gyroscopic sensor shown in Fig. for Q. 4(e) in SPI mode. **(5)**

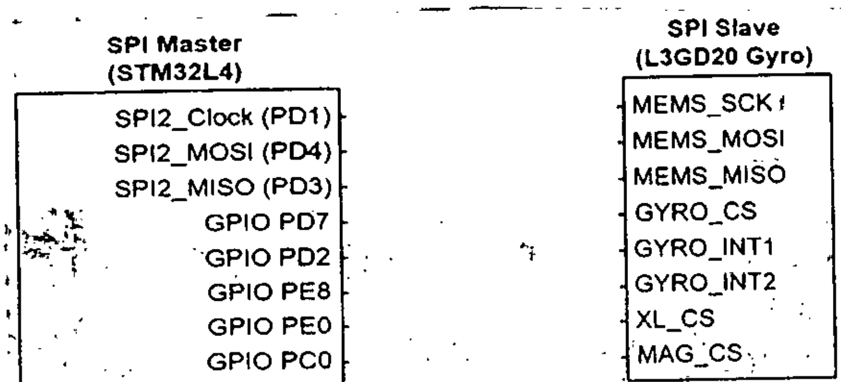


Fig for Q. 4(e)

SECTION – B

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

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

5. (a) Explain Open Drain Output type for a GPIO pin and mention one of its advantages. Complete the code shown in Fig. for Q. No. 5(a)(i), given separately, to toggle an LED if a Push Button is Pressed. Use polling method to check if Push Button has been pressed. The LED is connected to Port A pin 5, and the Push Button to Port C pin 13. The Push Button has an external Pull-down resistor. The GPIO pins are hardware debounced, so software debouncing are not required. GPIO registers are described in Fig. for Q. No. 5(a)(ii), given separately. **(18)**

Contd P/5

EEE 415

Contd...Q. No. 5

(b) Explain the differences between polling and Interrupt. Why two external interrupts connected to PA1 and PB1 cannot be enabled simultaneously? Perform the same tasks as those in Q. 5(a) using interrupt. You do not have to initialize the GPIO pins. Code template and Register descriptions are given in Fig. for Q. No. 5(b)(i) and Fig. for Q. No. 5(b)(ii), given separately. **(17)**

6\. (a) What is an update event (UEV)? Draw the waveform of an up-counting timer showing UEV signal if ARR = 3, RCR (Repetition counter register) = 1. **(6)**

(b) As a part of a festival lighting system, you need to turn on 2 LEDs sequentially and periodically as shown in Fig. for Q. No. 6(a). Duration of each state is one second. System clock frequency is 16 MHz. Relevant part of the STM board datasheet and timer modes are shown in Fig. for Q. No. 6(b), separately. **(12)**

(i) Draw the waveforms for each LED. Which pins will you connect the two LEDs to? In which mode will you initialize the timer/s? Justify your answer briefly.

(ii) Calculate relevant register values to get the desired period. Assume the pre-scaler to be 159,999.

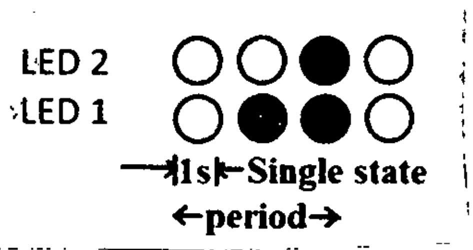


Fig. for Q. No. 6(a).

(c) Suppose you have to design a 2-bit binary dice for a board game, which displays a number among 00,01,10,11 when a push button is pressed. Two LEDs are used for display, one for LSB and the other for MSB. You chose to generate the bit patterns by timer counters, which would be frozen when the push button is pressed. The bit patterns would be generated at a high frequency (00 to 11 within 1 ms) so that the user cannot predict the pattern at which the LEDs would freeze when the push button is pressed. The system clock frequency is 8MHz. Relevant part of the STM board datasheet and timer modes are shown in Fig. For Q. No. 6(b). **(17)**

(i) Draw the waveforms for the MSB and LSB. Comment on their frequency ratio. Which pins will connect the two LEDs? Justify your answer briefly.

(ii) In which mode will you initialize the timers? Show the Timer CNT and OCREF wave form along with the MSB-LSB waveform. Which mode will you use to freeze them?

Contd P/6

EEE 415

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

(iii) Calculate the ARR for LSB and MSB to get the desired frequency. Assume the pre-scaler to be 7.

(iv) Suppose the functions to initialize the timers and GPIO pins are already written and called in the main function. Write the forever loop in which, if a button press is detected, the LEDs would be frozen. [OC1M and OC2M are, in bit 4~6 and 12~14 of CCMR1, respectively].

7. (a) Answer the following short questions: **(18)**

(i) Describe briefly what happens when an interrupt occurs.

(ii) What is preemption? Illustrate with an example.

(iii) How does SysTick work? Mention a suitable application of SysTick.

(b) You have to implement a stopwatch on the STM32F board, which displays the time elapsed between two consecutive presses of a push-button in an LCD display. The push button is connected to PB6, which has TIM4_CH1 Connected to it as AF2. The timer will operate in input capture mode. DIER and SR register maps are shown in Fig. for Q. No. 7(b), given separately. **(17)**

(i) Which edge will you set up for interrupt activation? Which interrupts will you enable in the DIER register?

(ii) Write the ISR called TIM4_IRQHandler() which stores the difference of counter values for two consecutive button press in a global volatile int type variable 'time'. ARR is initialized as 0xFFFF. You may declare more global variable if necessary.

8. (a) The Loop shown in Fig. for Q. No. 8(a) is being executed on a 16-word 2-way associative cache. Each block is 2-word. Word size is 4 bytes. **(25)**

(i) Calculate the no. of Set, and tag size (address size is 32 bit).

(ii) Which Locality/ies has/have been utilized in this design? Draw the cache block diagram.

(iii) Show that contents of the cache in the block diagram after executing the following code. Calculate the miss rate.

```
MOV R0, #3
MOV R1, #0
LOOP CMP R0, #0
BEQ DONE
LDR R2, [R1, #0x20]
LDR R3, [R1, #0x24]
LDR R4, [R1, #0x40]
SUB R0, R0, #1
ADD R1, R1, 4
B LOOP
DONE
```

Fig. for Q. No. 8(a)

Continued... P7

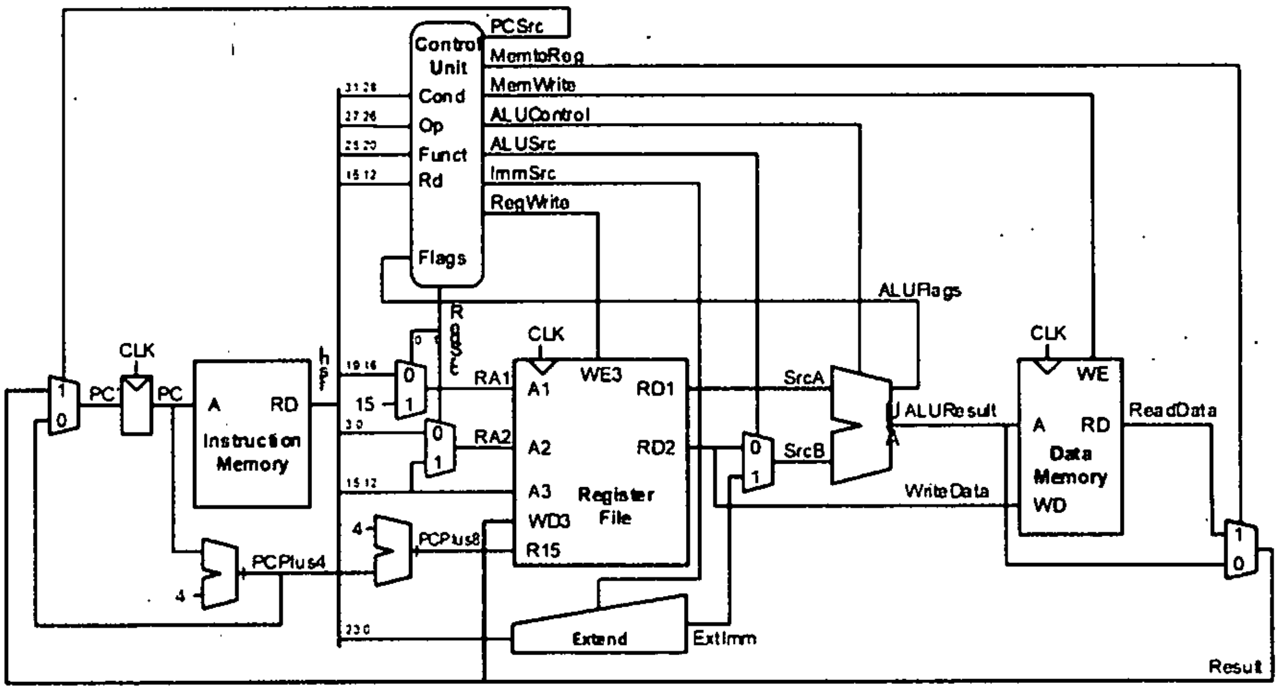
EEE 415
Contd...Q.No. 8

(b) Suppose a program has 2000 data access instructions (loads or stores), and 1250 of these requested data are found in the cache. The other 750 data are supplied to the processor by the main memory. If the access time of the cache and main memory are 1 and 100 cycles respectively, calculate the Average Memory Access Time. **(10)**

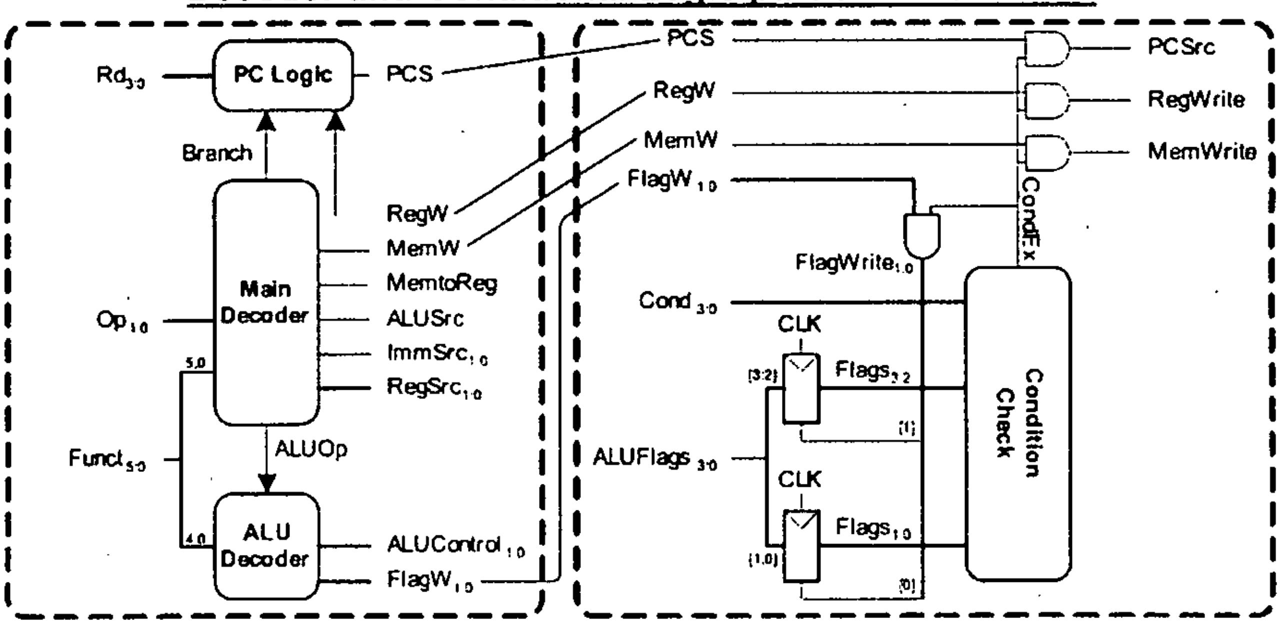
= Page 8 =

Appendix 1(a) - Single Cycle Arm Processor

Complete Single Cycle Processor



Decoder and Conditional Logic part of Control unit



= Page 9 =

Main Decoder Truth Table

Op	$Funct_5$	$Funct_0$	Type	Branch	MemtoReg	MemW	ALUSrc	ImmSrc	RegW	RegSrc	ALUOp
00	0	X	DP Reg	0	0	0	0	XX	1	00	1
00	1	X	DP Imm	0	0	0	1	00	1	X0	1
01	X	0	STR	0	X	1	1	01	0	10	0
01	X	1	LDR	0	1	0	1	01	1	X0	0
10	X	X	B	1	0	0	1	10	0	X1	0

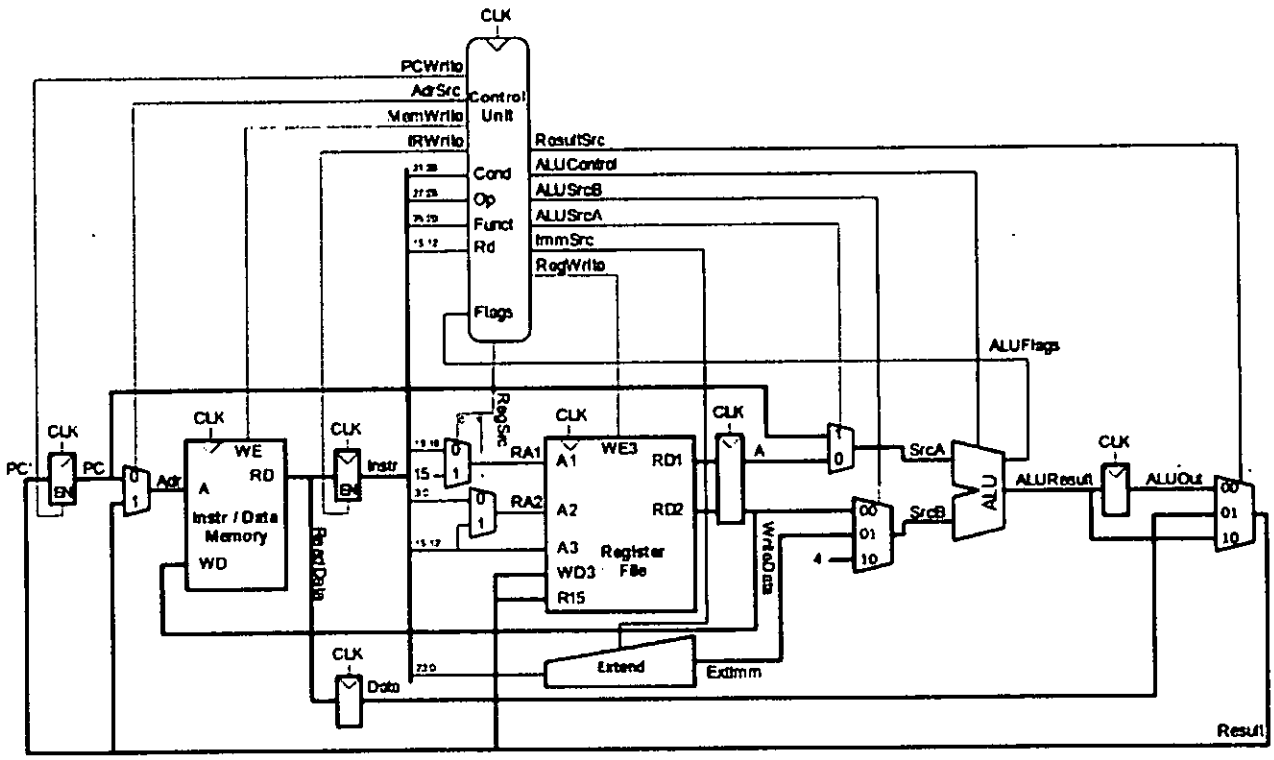
ALU Decoder Truth Table

ALUOp	$Funct_{4:1}$ (cmd)	$Funct_0$ (S)	Type	$ALUControl_{1:0}$	$FlagW_{1:0}$
0	X	X	Not DP	00 (Add)	00
1	0100	0	ADD	00 (Add)	00
		1			11
	0010	0	SUB	01 (Sub)	00
		1			11
	0000	0	AND	10 (And)	00
		1			10
	1100	0	ORR	11 (Or)	00
		1			10

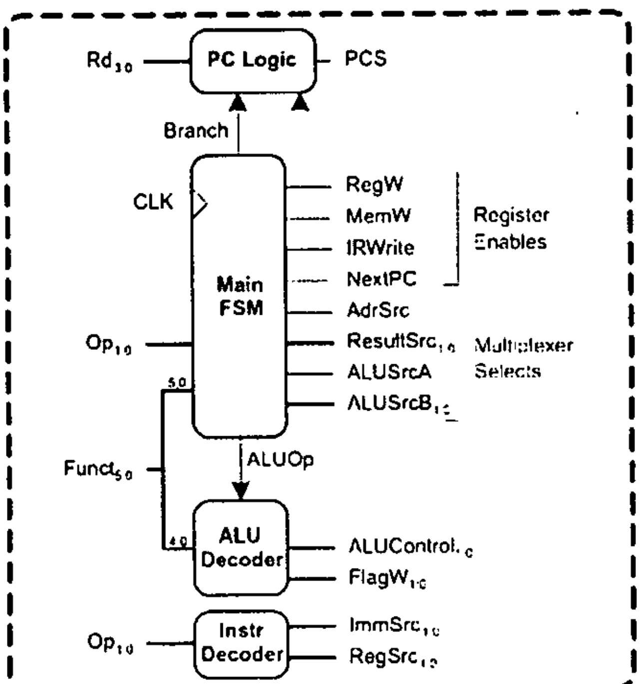
= Page 10 =

Appendix 1(b) - Multi-Cycle Arm Processor

Complete Multi-Cycle Processor

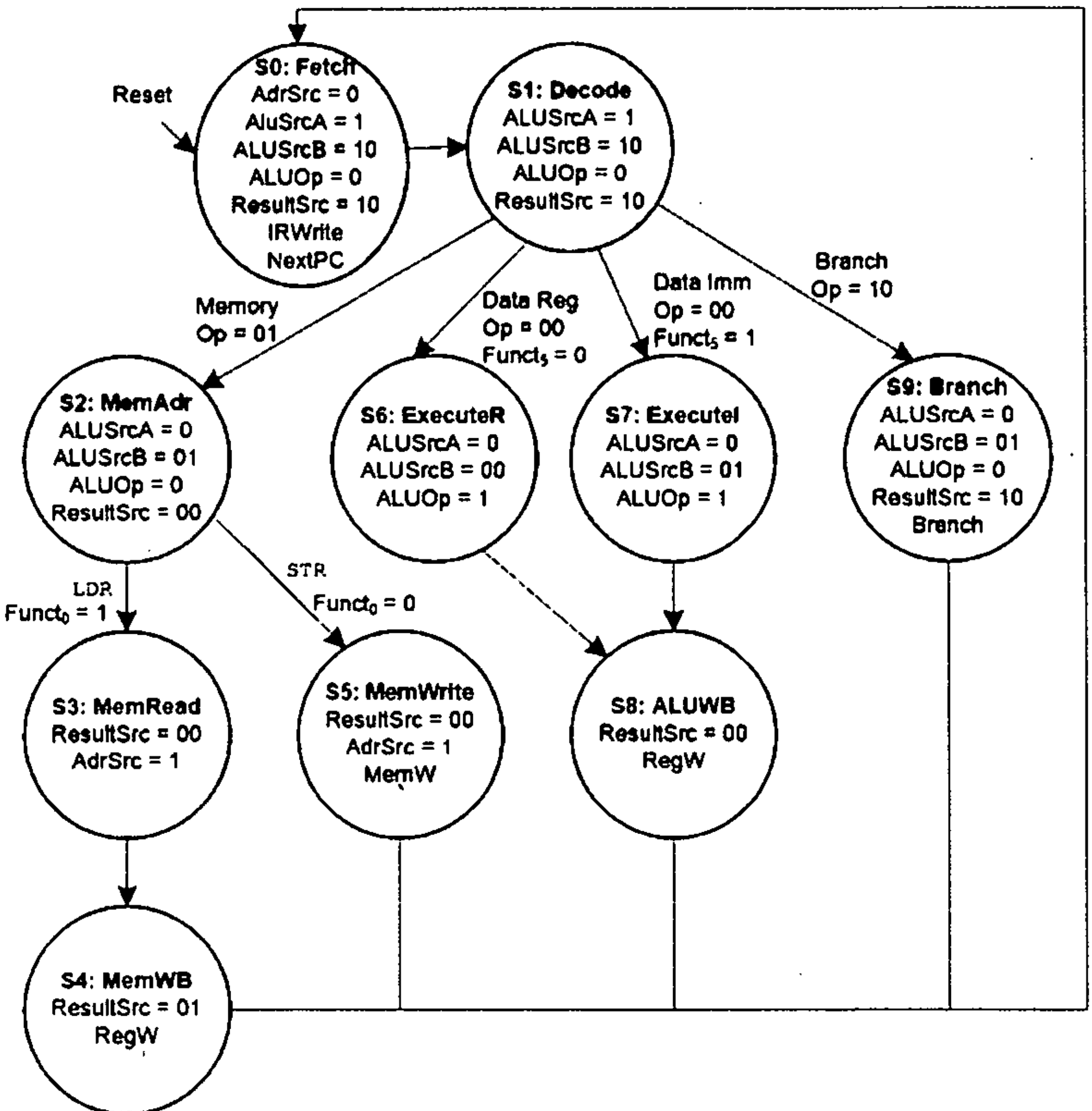


Main Decoder:



Note: ALU Decoder and PC Logic same as single-cycle

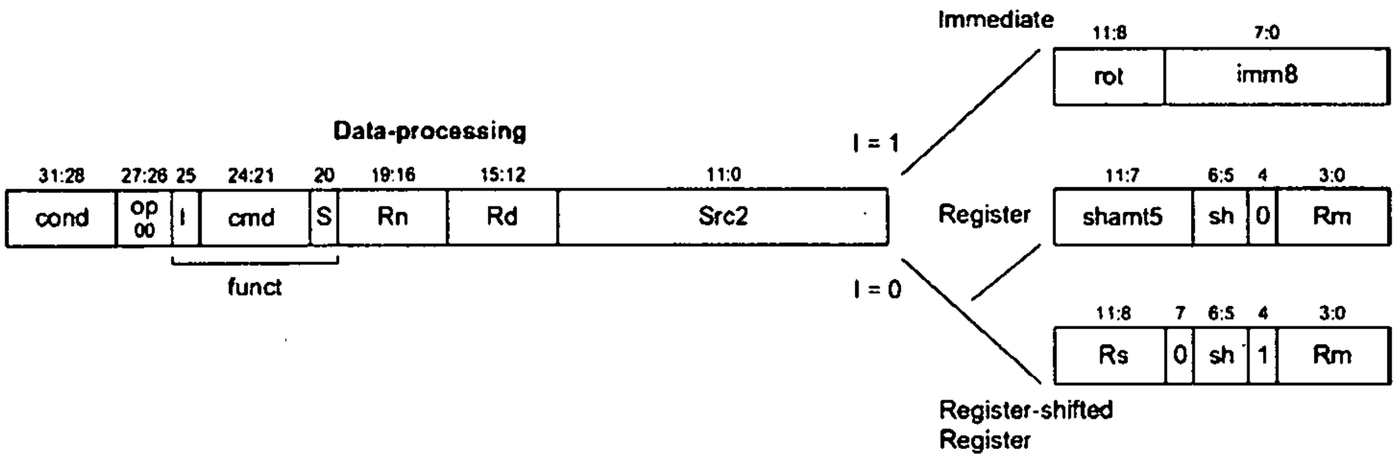
Multicycle Main Decoder FSM (Finite State Machine):



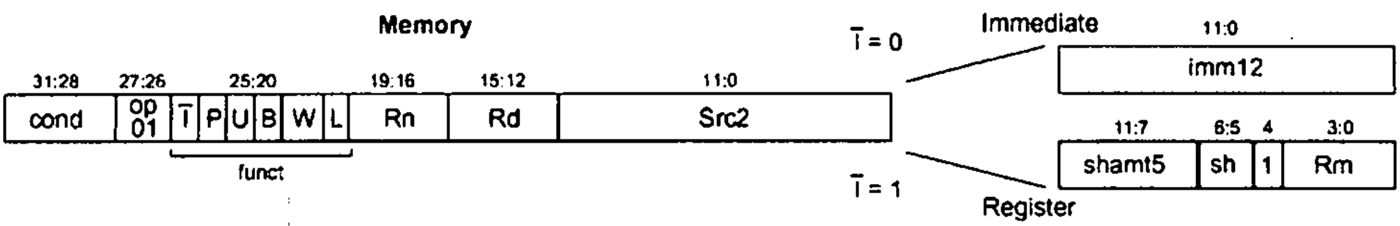
= Page 12 =

Appendix 2 - ARM v7a Instruction Format

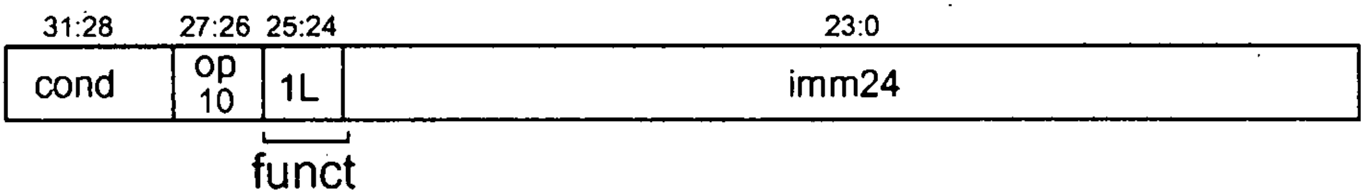
Data-processing



Memory



Branch



= Page 13 =

Data Processing Instructions and CMD field

cmd	Name	Description	Operation
0000	AND Rd, Rn, Src2	Bitwise AND	Rd ← Rn & Src2
0001	EOR Rd, Rn, Src2	Bitwise XOR	Rd ← Rn ^ Src2
0010	SUB Rd, Rn, Src2	Subtract	Rd ← Rn - Src2
0011	RSB Rd, Rn, Src2	Reverse Subtract	Rd ← Src2 - Rn
0100	ADD Rd, Rn, Src2	Add	Rd ← Rn+Src2
0101	ADC Rd, Rn, Src2	Add with Carry	Rd ← Rn+Src2+C
0110	SBC Rd, Rn, Src2	Subtract with Carry	Rd ← Rn - Src2 - $\bar{C}$
0111	RSC Rd, Rn, Src2	Reverse Sub w/ Carry	Rd ← Src2 - Rn - $\bar{C}$
1000 ($S = 1$)	TST Rd, Rn, Src2	Test	Set flags based on Rn & Src2
1001 ($S = 1$)	TEQ Rd, Rn, Src2	Test Equivalence	Set flags based on Rn ^ Src2
1010 ($S = 1$)	CMP Rn, Src2	Compare	Set flags based on Rn - Src2
1011 ($S = 1$)	CMN Rn, Src2	Compare Negative	Set flags based on Rn+Src2
1100	ORR Rd, Rn, Src2	Bitwise OR	Rd ← Rn | Src2
1101	Shifts:		
$I = 1$ OR ($instr_{11:4} = 0$)	MOV Rd, Src2	Move	Rd ← Src2
$I = 0$ AND ($sh = 00$; $instr_{11:4} \neq 0$)	LSL Rd, Rm, Rs/shamt5	Logical Shift Left	Rd ← Rm << Src2
$I = 0$ AND ($sh = 01$)	LSR Rd, Rm, Rs/shamt5	Logical Shift Right	Rd ← Rm >> Src2
$I = 0$ AND ($sh = 10$)	ASR Rd, Rm, Rs/shamt5	Arithmetic Shift Right	Rd ← Rm>>>Src2
$I = 0$ AND ($sh = 11$; $instr_{11:7,\ 4} = 0$)	RRX Rd, Rm, Rs/shamt5	Rotate Right Extend	{Rd, C} ← {C, Rd}
$I = 0$ AND ($sh = 11$; $instr_{11:7} \neq 0$)	ROR Rd, Rm, Rs/shamt5	Rotate Right	Rd ← Rn ror Src2
1110	BIC Rd, Rn, Src2	Bitwise Clear	Rd ← Rn & ~Src2
1111	MVN Rd, Rn, Src2	Bitwise NOT	Rd ← ~Rn

NOP (no operation) is typically encoded as 0xE1A000, which is equivalent to MOV R0, R0.

<pre>void **init_LED_PIN**(void){ // Enable the clock to GPIO Port A RCC->AHB1ENR |= RCC_AHB1ENR_GPIOAEN; **// Write rest of the code to initialize PA 5** **// for LED** } void **init_Button_PIN**(void){ // Enable the clock to GPIO Port C RCC->AHB1ENR |= RCC_AHB1ENR_GPIOCEN; **// Write rest of the code to initialize PC 13** **// for Push Button** } void **main**(void){ init_LED_PIN(); init_Button_PIN(); while(1){ **// write code here to toggle LED if Button pressed** } }</pre>	**MODER**: 2 bits per pin, 32 bits for 16 pins are sequentially located. 00 = digital input, 01 = digital output, 10 = alternate function, 11 = analog (default) **OTYPER**: 1 bits/pin, sequentially located. 0 = push-pull, 1 = open-drain **OSPEEDR**: 2 bits/pin, sequentially located. 00 = low speed, 01 = medium 10 = Fast speed, 11 = High Speed **PUPDR**: 2 bits/pin, sequentially located 00 = no pull-up, no pull-down 01 = pull up 10 = pull down 11 = reserved **IDR, ODR**: input and output data register, 1 bits/pin, sequentially located
Fig. for Q. No. 5(a)(i)	Fig. for Q. No. 5(a)(ii)

<pre>void config_EXTI(void) { // Connect External Line to the GPIO RCC->APB2ENR |= RCC_APB2ENR_SYSCFGEN; // SYSCFG external interrupt configuration registers SYSCFG->EXTICR[3] &= ~SYSCFG_EXTICR4_EXTI13; // select port C SYSCFG->EXTICR[3] |= SYSCFG_EXTICR4_EXTI13_PC; **// complete the function** } void EXTI15_10_IRQHandler(void) { **// write the ISR here** } int main(void){ init_LED_PIN(); init_Button_PIN(); config_EXTI(); while(1); }</pre>	**RTSR**: rising trigger selection, 1 bit/EXTI, sequentially located 0: rising trigger disabled 1: rising trigger enbled **FTSR**: falling trigger selection, similar to RTSR **IMR**: Interrupt mask register, 1 bit/EXTI, sequentially located 0: masked 1: unmasked **PR**: Pending register, 1 bit/EXTI, sequentially located 0: No trigger request occurred 1: trigger request occurred **Relevant Functions:** NVIC_EnableIRQ(), NVIC_SetPriority(), NVIC_DisableIRQ()
Fig. for Q. No. 5(b)(i)	Fig. for Q. No. 5(b)(ii)

GPIO Pin Connection			Timer Output Mode	
Circuit Component	Pin No.	Alternate Function	Output compare mode (OCM)	Timer Reference Output (OCREF)
TIM1_CH1	PA8	AF1	Timing mode (000)	Frozen
TIM1_CH2	PA9	AF1	Toggle mode (011)	Logic High if CNT = CCR
TIM4_CH1	PB6	AF2	PWM mode1 (110)	Logic High if CNT < CCR
Push Button	PC13		PWM mode2 (111)	Logic High if CNT ≥ CCR

Fig. for Q. No. 6 (b).

Register	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
TIMx_DIER																		TDE	COMDE	CC4DE	CC3DE	CC2DE	CC1DE	UDE	BIE	TIE	COMIE	CC4IE	CC3IE	CC2IE	CC1IE
Reset value																		0	0	0	0	0	0	0	0	0	0	0	0	0	0
TIMx_SR																				CC4OF	CC3OF	CC2OF	CC1OF		BIF	TIF	COMIF	CC4IF	CC3IF	CC2IF	CC1IF
Reset value																				0	0	0	0		0	0	0	0	0	0	0

Fig. for Q. No. 7(b).

L-4/T-1/EEE   Date : 01/10/2022

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **EEE 417** (Random Signals and Processes)

Full Marks : 210   Time : 3 Hours

The figures in the margin indicate full marks.

All 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**.

Symbols have their usual meanings. A table of Φ function is attached.

1. (a) The amount of impurity in a batch of chemical product is a random variable with a mean of 4 gm and standard deviation of 1.5 gm. If N batches of the product are independently prepared, find the probability that the amount of impurity is between 3.5 gm and 3.8 gm for N = 30, 50, 100 and 150. Analyze your results and comment. **(20)**

   (b) Define Hazard rate. Is a system with constant hazard rate memoryless? Explain. What is the physical significance of hazard rate citing suitable examples? **(15)**

2. (a) Consider the random process $X(t) = A\cos(\omega_o t + \theta)$ where θ ~ u(0, π) and A~ u(−1, 1). Is X(t) a WSS process? If not, then find the condition to make X (t) WSS. If WSS or WSS under the condition, then will it be strict-sense stationary? Justify. **(20)**

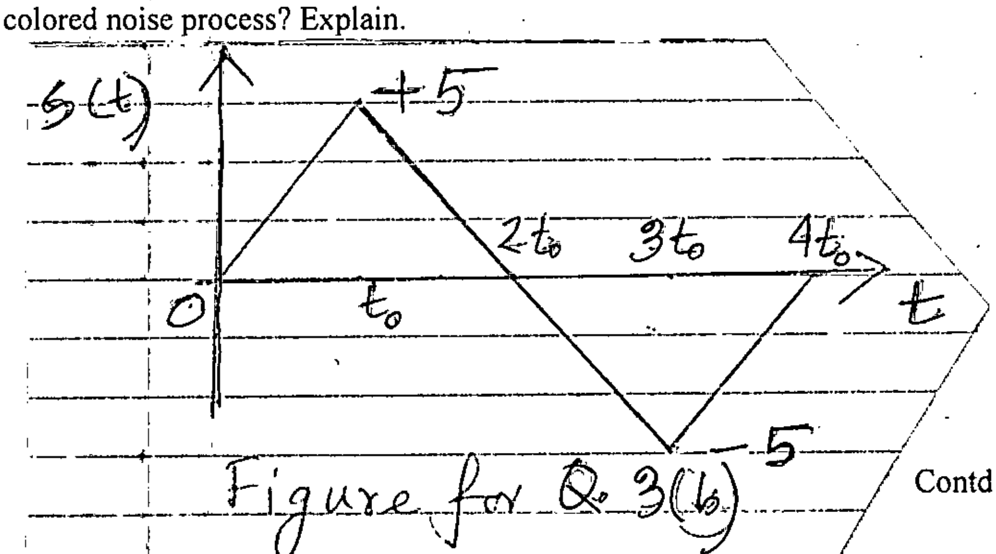
   (b) The random process X(t) has the autocorrelation function given by

   $$R_{xx}(\tau) = \sigma^2 e^{-\alpha\tau^2} \quad -\infty < \tau < \infty$$

   Does the process has derivative and integral in mean-square sense? Verify. Is the process uncorrelated and orthogonal? Explain. **(15)**

3. (a) The input to a parallel RLC network is X(t) = A $\cos(\omega_0 t + \theta)$ + N(t), where θ~ u(0, π); N(t) is a zero – mean WSS white nose process with variance σ_n^2. Assume that N is independent of θ and A is an arbitrary constant. Find the power spectrum of the output across the network. **(20)**

   (b) Find the impulse response of the filter that maximizes the SNR at the output of the filter at t = t_o. The input to the filter is y(t) where y(t) = s(t) + n(t); s(t) being a deterministic signal and n(t) a WSS white noise with power spectral density $N_o/2$. The waveshape of s(t) is shown in Figure for Q. 3(b). What should be done if n(t) is a WSS colored noise process? Explain. **(15)**



Contd P/2

EEE 417

4. (a) A wide – sense stationary (WSS) process $X_C(t)$ has the following autocorrelation function: $R_{X_C X_C}(\tau) = 20e^{-4|\tau|} \quad -\infty < \tau < \infty$

The discrete-time random process $X(n) = X_c(nT)$. Find $S_{xx}(\Omega)$ for T = 10s, 20s and 30s. Sketch $S_{xx}(\Omega)$ and comment on your results. **(20)**

(b) X and Y are i.i.d. normal random variables with zero mean. Determine $f_z(z)$ using the auxiliary variable method where

$$Z = X/Y.$$

Explain the physical significance of your result. **(15)**

SECTION – B

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

5. (a) State the three axioms of probability. Show that $Pr(\overline{A}) = 1 - Pr(A)$ using these axioms. **(8)**

(b) A missile can be accidentally launched if two relays A and B both have failed. The probability of A and B failing are known to be 0.01 and 0.04, respectively. It is also known that B is more likely to fail (probability 0.06) if A has failed. **(15)**

(i) What is the probability of an accidental missile launch?

(ii) What is the probability that A will fail if B has failed?

(c) A submarine attempts to sink an aircraft carrier. It will be successful only if two or more torpedoes hit the carrier. If the submarine fires three torpedoes and the probability of a hit is 0.4 for each torpedo, what is the probability that the carrier will be sunk? **(12)**

6. (a) What are the properties of a cumulative distribution function (CDF)? Determine if the following function can be the CDF of a random variable. **(11)**

$$F_X(x) = \begin{cases} \frac{1}{2}e^{x}, & x < 0 \\ 1 - \frac{1}{2}e^{-x}, & x \geq 0 \end{cases}.$$

(b) A Gaussian random variable has a probability density function of the form

$$f_X(x) = c\,exp\left(-\left(2x^2 + 3x + 1\right)\right)$$

Find the value of constant c. Find the values of the parameters m and σ for this Gaussian random variable. **(11)**

(c) The lifetime of a system expressed in weeks is a Rayleigh random variable X for which

$$f_X(x) = \begin{cases} (x/200)e^{-x^2/400}, 0 \leq x \\ 0 \qquad , \qquad x < 0 \end{cases}$$ **(15)**

EEE 417

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

(i) What is the probability state the system will not last for a week?

(ii) What is the probability that the system lifetime will exceed one year?

7. (a) A random variable has a PDF given by

$$f_X(x) = be^{-bx}u(x)$$

Find the mean, variance, coefficient of skewness and coefficient of kurtosis of X. **(12)**

(b) A random variable X is uniformly distributed on the interval (–5, 15). Another random variable $Y = e^{-X/5}$ is formed. Find E[Y]. **(11)**

(c) Consider a source that emits symbols from a four-letter alphabet, $X \in \{a, b, c, d\}$. Let $P_a = 1/2$, $P_b = 1/4$, $P_c = P_d = 1/8$ be the probability of each of the four symbols. If the symbols are represented as a = '0', b = '10', c = '110', d = '111', determine the average codeword length. Does this code produce the most efficient representation? **(12)**

8. (a) A pair of random variables has a joint PDF specified by

$$f_{X,Y}(x,y) = d\,exp\left(-\left(ax^2 + bxy + cy^2\right)\right).$$

(i) Find the constant d in terms of a, b, and c. Also find any restrictions needed for a, b, and c themselves for this to be a valid PDF.

(ii) Find the marginal PDFs, $f_X(x)$ and $f_Y(y)$.

(iii) Find Pr(X>Y). **(12)**

(b) Let X and Y be random variables with mean μ_x and μ_y, variances σ^2_X and σ^2_Y and correlation coefficient $\rho_{X,Y}$.

(i) Find the value of the constant a which minimizes $E[(Y - aX)^2]$.

(ii) Find the value of $E[(Y - aX)^2]$ when a is given as determined in part (i). **(12)**

(c) A pair of random variable X and Y are uniformly distributed over the unit circle as

$$f_{X,Y}(x,\ y) = \begin{cases} \frac{1}{\pi}, & x^2 + y^2 \le 1; \\ 0, & otherwise \end{cases}$$

Determine if X and Y are independent or not. **(11)**

Table of Φ function

= Page 4 =

Table 1 Area Φ(x) Under the Standard Normal Curve to the Left of x

x	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767

Table 1 (Continued.)

x	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998	0.9998
3.5	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998
3.6	0.9998	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999
3.7	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999
3.8	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	1.0000	1.0000	1.0000

L-4/T-1/EEE Date : 20/10/2022

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **EEE 435** (Optical 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 Question No. 1 (Mandatory) and any TWO from the rest of the questions.**

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

1. (a) Briefly compare the guided modes, leaky modes and radiation modes in an optical fiber. How is mode determined in an optical waveguide? Define some modes in a fiber corresponding to skew rays and meridional rays. **(10)**

(b) Find the cut-off condition of a mode in a fiber and hence find the equation of normalized frequency and normalized propagation constant. Draw the plot of normalized propagation constant as a function of normalized frequency for a few low-order fiber modes and show the single-mode condition and multimode condition. **(17)**

(c) A step-index fiber has a core diameter of 8 μm, a core refractive index of 1.465, and a relative refractive index difference of 0.8%. A light of wavelength 1.55μm is used to excite modes in the fiber. Determine the number and name of the mode(s) to be guided by the fiber using the plot in Q. 1(b). If it is not a single-mode fiber, show how to make it or operate it as a single-mode fiber. **(8)**

2. (a) Draw and label the attenuation characteristics and chromatic dispersion characteristics of SSMF, DSF, and DFF on the same or different graph and mention their attenuation and dispersion vales at popular wavelengths. Why are single-mode fiber and 1550 nm wavelength preferred? **(10)**

(b) With necessary block diagram and/or figure, distinguish between (i) FSO communication and fiber-optic communication, (ii) intramodal dispersion and intermodal dispersion, and (iii) chromatic dispersion (CD) and polarization mode dispersion (PMD). Briefly explain how CD and PMD affect the optical fiber communication. **(16)**

(c) A typical single-mode fiber has a zero-dispersion wavelength at 1.31 μm and it offers total chromatic dispersion of –2.8 ps/nm/km at a wavelength of 1.28 μm. Determine the total chromatic dispersion in the fiber at a wavelength of 1.57 μm. If material dispersion and profile dispersion at the latter wavelength are, 14.1 ps/nm/km and 0.3 ps/nm/km, respectively, determine the waveguide dispersion at this wavelength. **(9)**

Contd P/2

EEE 435

3\. (a) What are the mechanisms of the Kerr effects and inelastic scattering effects in optical fibers? For a two-channel optical transmission system, determine the nonlinear phase shift due to SPM and XPM and comment on their impact on the system. **(13)**

(b) Identify some key attributes of SBS and SRS and justify the statement 'SRS is detrimental for multichannel system but SBS is not'. **(12)**

(c) A 1550 nm fiber-optic transmission link is of 100 km length without repeater with a single-mode fiber having loss of 0.25 dB/km and dispersion of 20 ps/nm/km. The fiber is jointed every five-kilometer with connectors which give an attenuation of 0.5 dB each. The transmitter to fiber and fiber to photodiode couplers incur a loss of 1 dB each. Determine the minimum average power which should be launched into the fiber from the transmitter to maintain an average optical power level of 0.5 μW at the receiver. Design a DCF to compensate the accumulated dispersion fully for the total length of the fiber. **(10)**

4\. (a) Prove that 'all lasers must operate away from thermal equilibrium'. Write all the necessary conditions for achieving lasing action and with necessary figures show how laser oscillation can be obtained from a semiconductor diode. **(16)**

(b) Draw the typical input-output and spectral characteristics for LED and semiconductor laser. Why LED is not suitable for long-haul fiber-optic communication and FSO communication? **(9)**

(c) A GaAs injection laser has an active optical cavity of length 600 μm and width 200 μm. At normal operating temperature the gain factor (β) is 20×10^{-3} cm/A and the loss coefficient (α) is 20 cm^{-1}. Determine the total loss due to Fresnel reflection, threshold gain per unit length (g_{th}), threshold current density (J_{th}) and threshold current (I_{th}) for the device. The refractive index of GaAs may be taken as 3.6 (For stimulated emission, threshold gain is directly related to threshold current density through the gain factor. Assume that the cleaved mirrors are uncoated and the current is restricted to the optical cavity). **(10)**

SECTION – B

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

All the symbols have their usual meanings. Use necessary assumptions.

5\. (a) Explain different types of loss in fiber joints with reasons. **(12)**

(b) Briefly describe the construction of different types of optical coupler that use FBT method. **(12)**

(c) Explain the effects of width, drift velocity, parasitic capacitance, internal series resistance and load resistance on the performance of a photodetector. **(11)**

Contd P/3

EEE 435

6. (a) The width and absorption coefficient of a photodetector operating at 1.3 μm are 5 μm and 0.4/μm, respectively. Determine (i) the responsivity of the photodetector at 1.3 μm, (ii) the received optical power if the mean photo current is 2 μA, and (iii) the number of received photons. **(12)**

   (b) Compare between *p-i-n* photo diode and APD in terms of operation, limitations, advantages, disadvantages, and performance. **(12)**

   (c) Describe the operating principle of EDFA. Also mention the basic differences between EDFA and FRA. **(11)**

7. (a) The quantum efficiency of a *p-i-n* photo detector operating at 0.9 μm is 0.8. The noise figure, load resistance and operating temperature are 3 dB, 4 kΩ and 27°C, respectively. Determine the SNR in dB if the applied optical power to the detector and the post detection signal bandwidths are 5 μW and 20 MHz, respectively. Assume negligible dark current. **(17)**

   (b) Describe the operating principles of MZM and EOM. Also mention the advantages of EAM compared to EOM. **(18)**

8. (a) Briefly describe the operation of WDM system. Also compare between CDWM and DWDM. **(12)**

   (b) In a 100 km long haul 1.3 μm single mode optical fiber system, the required mean power at the receiver is −40 dBm for data transmission rate 400 Mbps. Fiber loss and splices loss are 0.2 dB/km and 0.05 dB/km, respectively. Connector losses at the transmitter and receiver are 1 dB each. Determine the mean power needed to be launched from the transmitter. **(12)**

   (c) Provide an architectural overview on various access and backbone optical networks. **(11)**

L-4/T-1/EEE **Date : 16/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **EEE 439** (Communication Systems II)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

All 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**.

Answer in brief and to the point.

1. (a) Define a matched filter, Describe its properties with brief statements and equations. Also, mention its purpose of use in telecommunication systems. **(10)**

(b) Part (i) of **Fig. for Q. No. 1(b)** shows the input signal $g(t)$, and part (ii) the corresponding output signal, $y(t)$, of its matched filter. **(15)**

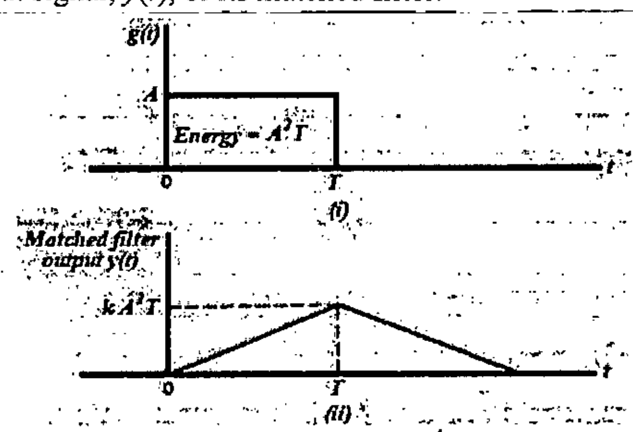


Fig. for Q. No. 1(b)

(i) Draw the impulse response, $h(t)$, of the matched filter for the input signal, $g(t)$.

(ii) Mention where (at what instant) you should sample the output signal for optimum detection of the transmitted bit in presence of white noise, and why.

(iii) Suggest how you can design an equivalent matched filter that takes a rectangular pulse as an input and produces the required portion of the output y(t). as shown in Fig. Q. No. 1(b).

(c) For a binary symmetric channel, write down the final expression for probability of bit error P_e. Sketch the P_e vs E_b/N_0 curve for a binary PCM receiver. Also, explain its significance. **(10)**

2. (a) What is ISI? Mention the two main causes of ISI. **(5)**

Draw the (frequency domain) amplitude response, P(f), of the overall channel (ideal Nyquist channel) and the corresponding output pulse, p(t), to be received by the receiver for achieving zero ISI. With these diagrams, explain the basic principle of achieving zero ISI. **(13)**

Also, mention the two practical difficulties with an ideal Nyquists Channel.

Contd P/2

Contd...Q. No. 2

(b) Comment with a neat diagram, how the said difficulties can be overcome using a modified frequency domain channel characteristic with various roll-off factor α or r. Also, plot the time responses for those roll-off factors. What is the price paid for overcoming the difficulties in such a scheme? **(12)**

A binary PAM wave is to be transmitted over a baseband channel with an optimum bandwidth of 75 kHz. The bit duration is 10 μs. Find a raised cosine spectrum that satisfies these requirements. **(5)**

3. (a) Answer the following questions: **(13)**

   (i) Draw the complete block diagram of the duobinary transmitter with a precoder.

   (ii) Draw the appropriate detector for the above transmitter with decision threshold.

   (iii) Determine the output at each stage of the transmitter for the binary data sequence: $\{\mathbf{b_k}\} = \mathbf{1\ 1\ 0\ 1\ 0\ 0\ 1\ 0}$. Assume $\mathbf{d_k} = \mathbf{1}$ as an initial value.

   (iv) Using the detector in part (ii), determine the received output corresponding to the given $\{\mathbf{b_k}\}$

   (b) What is an optical Fibre? With a neat diagram, describe the principle of light wave communication through an optical fibre. Can we transmit optical signal with the core layer only?

   Name two optical sources and two optical detectors used popularly in practical applications. **(12)**

   (c) Define link power budget. Draw the block diagram of an optical power loss model used for optimizing the link power budget and label each component. An optical transmitter has an output power of 0.1 mW. It is used with a fibre having NA = 0.25, attenuation of 6 dB/km and length 0.5 km. The link contains two connectors of 2 dB average loss. The receiver has a minimum acceptable power (sensitivity) of –35 dBm. The designer has allowed a 4 dB margin. Calculate the link power budget and comment on the performance of the proposed link. **(4+6)**

4. (a) What is a satellite? Mention the basic principle of how a satellite stays in its geostationary orbit. **(3)**

   Draw the block diagram of a satellite earth station and describe the functions of each block from both the transmitter and receiver sides. **(8)**

   Name two popular earth station antennas. With a neat diagram, briefly describe the operations of any one of them during signal transmission and reception. **(6)**

   (b) What is attenuation or fade margin in a satellite link? Write down the satellite link equation for its uplink. **(4)**

   Draw the block diagram of a satellite transponder and briefly describe the function of each block. **(8)**

   An earth station operating at 12 GHz with a 10° elevation angle has a 47-dB gain and a 2.5dB loss from the antenna feed to the input of the LNA. The sky noise is 25° K developing an antenna noise temperature of 240° K. The noise figure of the LNA is 1.5 dB. Calculate the gain over noise temperature, G/T. **(6)**

Contd P/3

EEE 439

SECTION – B

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

5. (a) Draw a block diagram of passband data transmission system. **(4)**

(b) (i) Define Q function. Write the probability density function of a Gaussian random variable. Express the cumulative density function of a Gaussian random variable in terms Q function. **(2+2+2+6)**

(ii) The signal space diagram for BPSK scheme is shown in Fig. for Q. No. 5(b). Determine the decision regions and the error probability P_{eM} of the optimum receiver as a function of E_b/N_o for an AWGN channel (noise mean and variance 0 and $N_0/2$ respectively).

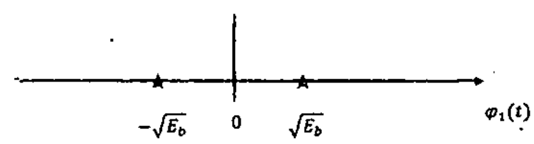


Fig. for Q. No. 5(b)

(c) (i) Draw the bit error rate (BER) vs. E_b/N_o curve for M-PSK scheme with M=2, 4, 8, 16 in the one plot and for M-FSK scheme with M=2, 4, 8, 16 in another plot.

(ii) Explain both set of the curves for change in E_b/N_o and M. **(8+4+2+5)**

(iii) Explain the reason why QPSK has same bit error rate as BPSK. What is the specialty of QPSK?

(iv) Draw block diagrams of QPSK transmitter and coherent QPSK receiver.

6. (a) A source emits sixteen equiprobable messages, which are assigned QAM signals s_1, $s_2 \ldots s_{16}$, as shown in Fig. for Q. No. 6(a). Determine the decision regions and the error probability P_{eM} of the optimum receiver as a function of E_b/N_0, where E_b is average bit energy and the channel is AWGN channel (noise mean and variance are 0 and $N_0/2$, respectively). **(20)**

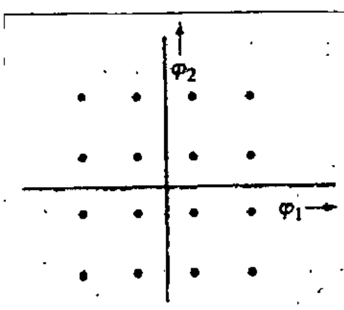


Fig. for Q. No. 6(a)

(b) Explain very briefly the conflict free and non-conflict free multiple access techniques with suitable examples. **(8)**

Contd P/4

EEE 439

Contd...Q.No. 6

(c) Suppose a cellular system in which the one-way bandwidth of the system is 12.5 MHz, the channel spacing is 30 kHz, and the guard band at each boundary of the spectrum is 10 kHz. If the cell area is 6 km^2, the frequency reuse factor is 7, and 21 the available channels are used to handle control signaling, calculate the system spectral efficiency in units of channels/MHz/km^2. **(7)**

7\. (a) Consider a (7, 4) Hamming code with a Generator matrix given by **(18)**

$$G = \begin{pmatrix} 1101000 \\ 0110100 \\ 1110010 \\ 1010001 \end{pmatrix}$$

(i) What are the possible codewords of this code?

(ii) Comment on the coder error detection and correction capacity.

(iii) What is the parity check matrix H for this code?

(iv) Create a syndrome table, with errors in one column and syndromes in the other.

(v) Explain if and how the channel decoder corrects e = (0001000).

(b) Define a computer network and mention some of its major applications. With neat diagrams, briefly describe the various network topologies. What is a firewall and how is it accomplished in practice? **(17)**

8\. (a) (i) Mention two impacts of multipath wireless propagation channel on digital transmission. **(4+6+8)**

(ii) Explain very briefly large scale and small scale fading.

(iii) Describe channel modeling Schemes used for small scale multipath fading.

(b) (i) Explain cell, cluster and frequency reuse terms in cellular communications. **(6+4+7)**

(ii) Derive the capacity expansion expression obtained by using frequency reuse and explain its different variations.

(iii) Consider a cellular system in which there are a total of 1001 radio channels available for handling traffic. Suppose the area of a cell is 6 km^2 and the area of the entire system is 2100 km^2. Calculate the system capacity if the cluster size is 7. Calculate the system capacity if the cluster size is 4. Does decreasing the cluster size increase the system capacity? Explain the results with respect to part (ii) observation.

L-4/T-1/EEE **Date : 01/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **EEE 455** (Compound Semiconductor Devices)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

All 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**.

Use Figure 1, if necessary.

1. (a) Explain the significance of critical thickness in thin film growth technology. Calculate critical thickness of Ge on Si substrate and draw variation of critical layer thickness of Ge_xSi_{1-x} composition for epitaxy Ge_xSi_{1-x} grown on Si substrate. Show energetically favorable growth phenomenon for below and above critical thickness. Justify your answer. **(20)**

   (b) Draw schematic hole band dispersion for 1 nm thick GaAs film grown on Si substrate and InP substrate separately. Explain dispersion diagrams with justification. **(15)**

2. (a) With necessary diagrams, differentiate between the staggered, straddling and broken gap heterojunctions. **(20)**

   Sketch the energy-band diagrams of an abrupt $Al_{0.35}Ga_{0.65}As$-GaAs heterojunction for N-AlGaAs, p-GaAs. Assume $E_g = 1.9$ eV for $Al_{0.35}Ga_{0.65}As$ and assume $\Delta E_c = 2/3\ \Delta E_g$.

   (b) Draw energy-band diagram for modulation-doped superlattice structure of GaAs and $Al_{0.35}Ga_{0.65}As$. With necessary diagrams, discuss the mobility as a function of temperature for bulk GaAs and modulation-doped superlattice structure. **(15)**

3. (a) Sketch the cross section of an n-channel GaAs MESFET and draw corresponding idealized energy-band diagram of the substrate-channel-metal in the n-channel MESFET. Explain how source resistance affects transconductance and transistor gain of JEFT/MESFET. **(20)**

   (b) An n-channel GaAs MESFET at T=300 K has the following parameters:
   ϕ_{Bn} =0.90 V, N_d =5 $\times 10^{16}$ cm^{-3}, μ_n=7500 cm^2/V-s, a=0.30 μm, W =5 μm and L =1.2 μm. Calculate the cutoff frequency using (a) the constant mobility model and (b) the saturation velocity model. If required, make necessary assumptions. **(15)**

4. (a) Deign a resonant tunneling diode (RTD) and draw a schematic energy-band diagram of structure in thermal equilibrium and when bias is applied. Show and discuss I-V characteristics at different biasing conditions. **(20)**

Contd P/2

EEE 455
Contd...Q. No. 4

(b) A symmetric GaAs/AlAs resonant-tunneling diode (RTD) has a barrier width of 10 Å and a well width of 20 Å. Draw schematic I-V characteristics of RTD. Redraw the schematic I-V characteristics of the RTD if the emitter layer thickness is increased by 5 Å. Explain with proper justification. **(15)**

SECTION – B

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

5. (a) Estimate the common-emitter current gain of a silicon npn bipolar transistor at T = 300 K given the following parameters: $D_B = 25\ cm^2/s$, $D_E = 10\ cm^2/s$, W = 0.7 μm, $x_E = 0.7$ μm, $N_B = 10^{16}/cm^3$, $N_E = 10^{18}/cm^3$. **(10)**

   (b) A silicon pnp bipolar transistor at T = 300 K has uniform dopings of $N_E = 10^{18}\ /cm^3$, $N_B = 10^{16}/cm^3$, $N_C = 10^{15}/cm^3$. The metallurgical base width is 1.2 μm. Let $D_B = 10\ cm^2/s$ and $V_{EB} = 0.625$ V. Determine the hole diffusion current density in the base for $V_{BC} = 5$ V, $V_{BC} = 10$ V, and $V_{BC} = 15$ V. Also estimate the Early voltage. **(25)**

6. (a) A silicon pnp bipolar transistor at T = 300 K is to be designed so that the Emitter injection efficiency is 0.996. Assume that $x_E = x_B$, $L_E = L_B$, $D_E = D_B$, and $N_E = 10^{19}/cm^3$. Determine the maximum base doping taking into account bandgap narrowing. If bandgap narrowing were neglected, what would be the maximum base doping required? **(20)**

   (b) Explain the effects occur in a bipolar transistor at high injection levels. **(15)**

7. (a) A uniformly doped silicon epitaxial npn bipolar transistor is fabricated with a base doping of $N_B = 3 \times 10^{16}/cm^3$ and a heavily doped collector region with $N_C = 5 \times 10^{17}/cm^3$. The neutral base width is 0.70 μm when $V_B = V_{BC} = 0$. Determine V_{BC} at which punch-through occurs. **(20)**

   (b) What is SiGe-base transistor? What are effects of SiGe-base transistor compared to a Si-base transistor? **(15)**

8. (a) Consider an N-$Al_{0.3}Ga_{0.7}As$-intrinsic GaAs abrupt heterojunction. Assume that the AlGaAs is doped to $10^{18}/cm^3$ and has a thickness of 500 Å. Assume an undoped spacer layer of 20 Å, $\varphi_B = 0.85$ V, and $\Delta E_c/q = 0.22$ eV. The relative dielectric constant of $Al_{0.3}Ga_{0.7}As$ is 12.2. Determine the 2-D electron concentration. **(15)**

   (b) Consider a silicon npn transistor at T = 300 K. Calculate the emitter-to-collector transit time and the cutoff frequency assuming the following parameters: $I_E = 1mA$, $C_{je} = 1$ pF, $x_B = 0.5μm$, $x_{dc} = 2.4$ μm, $D_n = 25\ cm^2/s$, $r_c = 20\ \Omega$, $C_\mu = 0.1$ pF, $C_s = 0.1$ pF. **(20)**

= Page 3 =

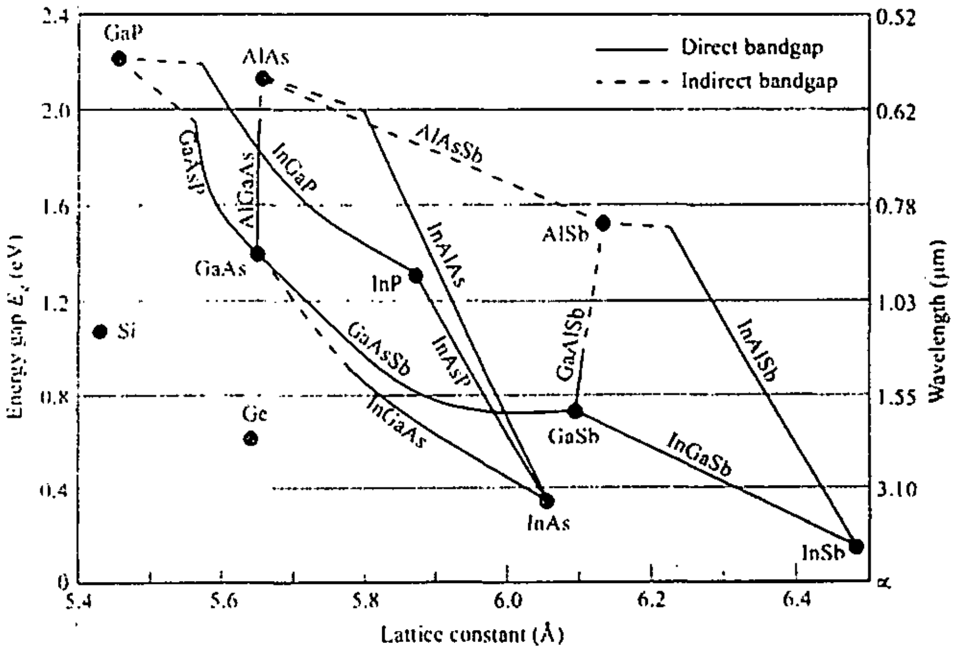


Figure 1: Energy gap vs. lattice constant for some common compound semiconductors.

L-4/T-1/EEE Date : 20/10/2022

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **EEE 463** (Nano-electronics and Nanotechnology)

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) Discuss the importance of nanotechnological innovations in daily life. **(15)**

   (b) Describe some important nanotools that has revolutionized our conception of the nano-world. Explain briefly their significances. **(20)**

2. (a) Define surface tension. Describe some nano-applications for surface tension. Define spreading coefficients S, and explain what S= 0, S > 0, S < 0 conditions signify. **(25)**

   (b) Explain how TEM improves optical resolution of images. **(10)**

3. (a) Describe, with necessary diagrams, the operation of scanning tunneling microscope. **(20)**

   (b) "A weak spring can have a high resonant frequency if its mass is small enough" – explain this in relation to atomic force microscopy. **(15)**

4. Write short notes on- **(35)**

   (a) Dip-pen nanolithography,

   (b) Nano grafting,

   (c) Langmuir-Blodgett methology,

   (d) Quantum dots

SECTION – B

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

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

5. (a) Describe the operation of Molecular Beam Epitaxy. Explain why MBE is so successful in nano-growth. **(17)**

   (b) Compare between dry and wet etching techniques. **(10)**

   (c) Name the five major classes of contamination. **(8)**

6. (a) Describe with proper band diagrams, the operation of RTD. Briefly discuss the importance of Tsu-Esaki equation in this regard. Give examples of materials which can be used in making RTDs. **(12+5+5)**

   (b) What are molecular electronics? Describe with some examples. **(13)**

Contd P/2

EEE 463

7. (a) Derive the expression for the fundamental/quantum value of conductance and resistance. What are these values? Describe why in your measurements in labs you can measure resistances in the range of micro-ohms while fundamental/quantum of resistance has a much higher value. **(6+6+6)**

   (b) Derive the Landauer formula and discuss its significance in nano transport. **(17)**

8. (a) Derive the transmission probability of a simple rectangular barrier under 3 cases of $E<V_0$; $E>V_0$ and $E=V_0$ where E is the energy of the incident electron and V_0 is the height of the potential barrier. Draw the qualitative transmission probability curve as a function of distance for the $E=V_0$ case. **(20)**

   (b) How can you realize a quantum point contact in a practical system? Explain with specific examples. **(15)**

L-4/T-1/EEE Date : 26/10/2022

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **EEE 465** (Analog Integrated Circuits and Design)

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**.

The symbols have their usual Meanings.

1. (a) Explain why – "if the gate source voltage of a MOSFET is precisely defined, then its drain current is not!" **(8)**

(b) For the circuit shown in Fig. for Q. No. 1(b) find the small signal voltage gain of the circuit in terms of device parameters. Use the data provided in the figure where the symbols have their usual meaning. **(12)**

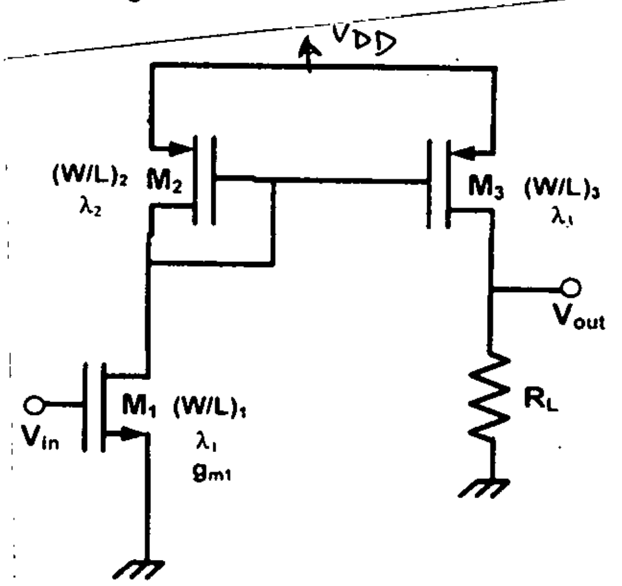


Fig. for Q. No. 1(b)

(c) Fig for Q. No. 1(c) shows a cascade current mirror where the reference current source I_{REF} require 0.5 V to operate as a current source. What is the maximum value of the reference current I_{REF}. The following data are given: $\mu_n c_{ox}$ = 120 $\mu A/V^2$, V_{THN}=0.7 V, V_{DD}=3 V, $(W/L)_0$=20/0.5, $(W/L)_1$=50/0.5, $(W/L)_3 = (W/L)_2$ = 25/0.5 **(15)**

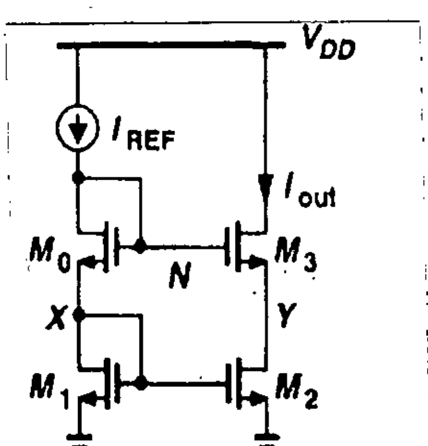


Fig. for Q. No. 1(c)

Contd P/2

EEE 465

2\. (a) The common source stage shown in Fig. for Q. No. 2(a), is designed with $(W/L)_1$=50/0.5, R_S = 1 kΩ and R_D = 2 kΩ. If I_{D1} = 1 mA, determine the poles and zero of the circuit. The following data are given λ= 0.1 /V, $\mu_n c_{ox}$ = 120 μA/V², V_{THN}=0.7 V, C_{GS}=54 fF, C_{GD}=20 fF, C_{DB}=27 fF, V_{DD}=3 V **(20)**

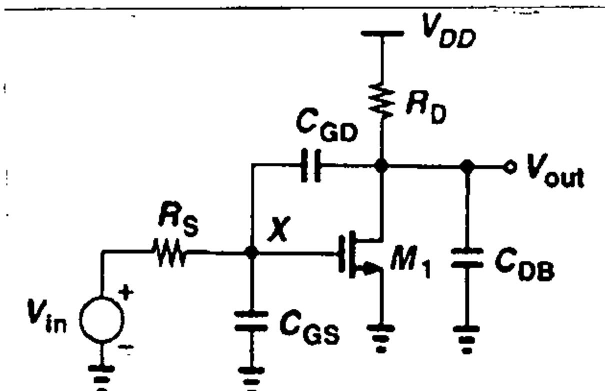


Fig. for Q. No. 2(a)

(b) The circuit shown in Fig. for Q. No. 2(b) is an implementation of a feedback configuration. Calculate the closed loop gain and the output resistance of the amplifier at relatively low frequency. The following parameters are given: C_1= 3 fF, C_2= 15 fF, for all NMOS λ =0.1 /V, $\mu_n c_{ox}$ = 120 μA/V², for all PMOS λ=0.05 /V, $\mu_p c_{ox}$ = 60μA/V². Again, I_{D1}=I_{D2}=0.5 mA and all NMOS has (W/L)=50/0.5, while all PMOS has (W/L)=100/0.5. **(15)**

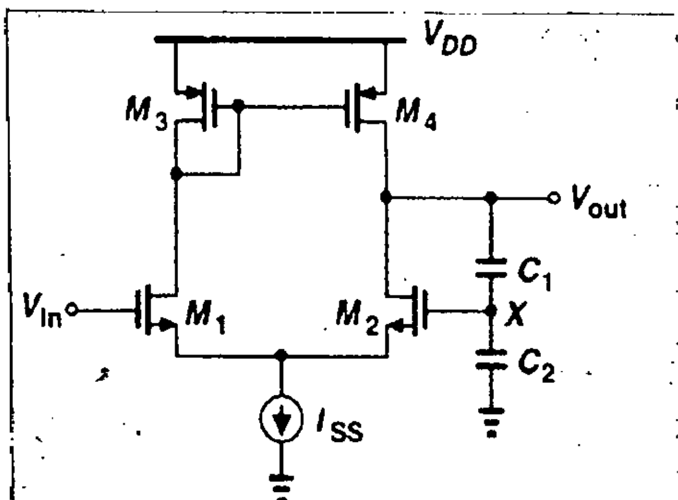


Fig. for Q. No. 2(b)

3\. (a) If V_{TH1}=V_{TH2} and λ=0, prove that the current I_{out} produced by the circuit shown in Fig. for Q. No. 3(a) does not depends on power supply. Why do we need a startup circuit to operate this system? Draw a suitable start-up for this circuit. **(15)**

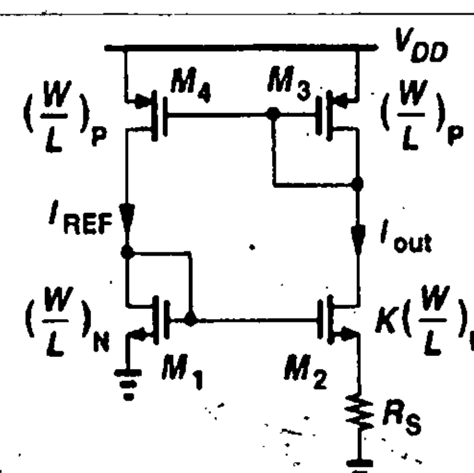


Fig. for Q. No. 3(a)

Contd P/3

EEE 465
Contd...Q. No. 3

(b) Explain how a positive-TC voltage and a negative-TC voltage can be obtained in a process having bipolar transistors and resistors in addition to MOS transistors. Show how these two voltages can be combined to obtain a temperature independent voltage reference. **(20)**

4. (a) Draw the circuit diagram of a two stage op-amp using NMOS different pair and PMOS current mirror load. Calculate the voltage gain of the op-amp assuming that it uses the 0.8 μm technology. The following data are given: Channel length of all transistors=0.8 μm, over voltage of all transistors $|V_{OV}|$ =0.2 V. For all NMOS V_{AN}=8.33 V/μm, $|V_{AP}|$ =16.66 V/μm. **(10)**

(b) Show that the gain bandwidth product of the two stage amplifier with compensating capacitor C_C can be approximated as $G_B = G_{m1}/C_C$. **(8)**

(c) Describe with neat sketch why a D-Flip can not be used as a frequency detector. **(7)**

(d) Starting from the block diagram and a timing diagram of a PFD, design a charge pump PLL and describe different modes of its operation. **(10)**

SECTION – B

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

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

5. (a) For the NMOS transistor biased as shown in Fig. for Q. 5 (a)(b)(c) the following transistor parameters are specified: $\mu_n C_{ox}$ = 120 μA/V^2, V_{t0} = 1 V, γ = 0.5, VA =1/λ = 30 V, $2\varphi_F$=0.7 V, W=1μm L = 100 nm. Calculate the **(15)**

   (i) drain source current (I_{DS})
   (ii) transconductance with respect to gate voltage (g_m)
   (iii) transconductance with respect to source-body voltage (g_{mb})
   (iv) output resistance (r_0)
   (v) intrinsic gain of the transistor.

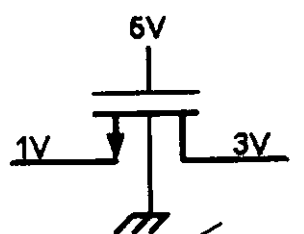


Figure for Q.5(a)(b)(c)

(b) In order to increase the intrinsic gain the designer connected the gate terminal to the drain terminal by keeping the gate voltage at 5V (i.e. $V_G = V_D$ = 5V, Vs=1V). What is the resulting gain now? **(5)**

(c) To further increase the gain, the designer doubles the channel length (i.e. L= 200 nm). What is the resulting gain now? **(5)**

Contd P/4

EEE 465

Contd...Q. No. 5

(d) Figure for Q. 5(d) shows the layout of a single stage amplifier in 100 nm CMOS technology. **(10)**

(i) Draw the transistor level circuit diagram including the channel length and width of each transistor.

(ii) Calculate the capacitance at node V_{in} and V_{out}. The following data are given: Gate oxide capacitance = 150 $fF/\mu m^2$, Source-drain junction capacitance C_j = 100 $fF/\mu m^2$, source-drain side wall capacitance C_{jsw} = 40 $fF/\mu m$.

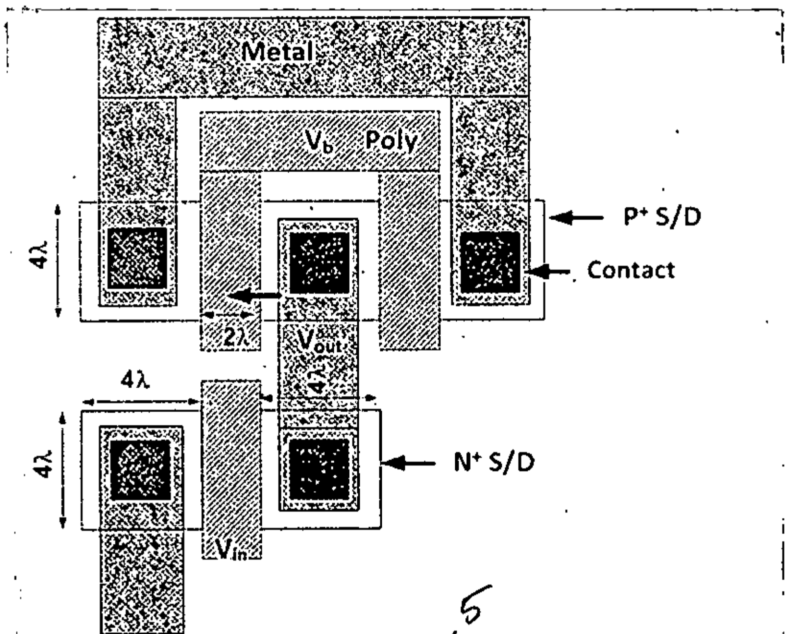


Figure for Q.5(d)

6. (a) Figure for Q. 6(a) shows a common source amplifier with PMOS diode connected load. The following parameters are given: $\mu_n C_{ox}$ = 120 $\mu A/V^2$, $\mu_p C_{ox}$ = 40 $\mu A/V^2$, $L_1 = L_2$=100 nm, W_1=12 μm, W_2=0.5 μm, V_{DD} = 3 V, $V_{TH1}=|V_{TH2}|$=0.5 V. Find **(20)**

(i) the voltage gain of the amplifier

(ii) the output voltage swing if the gate of M1 is biased with a dc source of 0.7 V superimposed with an ac source of peak voltage 50 mV.

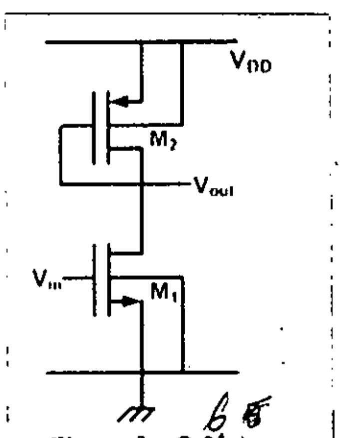


Figure for Q.6(a)

(b) To improve the gain while maintaining the output swing of the amplifier the designer decided to replace the diode connected load in Figure for Q. 6(a) with a current source load. In this context explain the following statement with proper argument and explanation: "*longer transistors yield a higher voltage gain, however, if width is not increased proportionately, output voltage swing suffers*" **(15)**

EEE 465

7. (a) To improve linearly a designer choose to use a common source amplifier with source degeneration. If a resistance R_D is used as load and the source degeneration resistance is R_S, calculate the voltage gain and output resistance of the amplifier in the presence of body effect and channel length modulation. **(25)**

(b) Calculate the voltage gain of the circuit shown in Fig. for Q. 7(b) considering body effect and channel length modulation. **(10)**

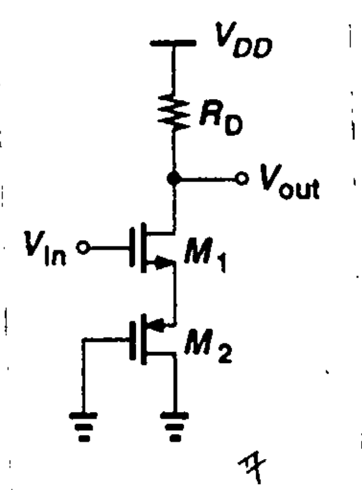


Figure for Q.7(b)

8. (a) Explain why in some applications differential amplifier is preferred over single ended amplifier? **(5)**

(b) Plot the input (ΔV_{in}) – output (ΔI_D) characteristics of a differential pair as the width and the tail current vary. Show the result graphically and analytically. **(15)**

(c) The differential pair of Fig. for Q. 8(c) is designed with $(W/L)_{1,2}$ = 50/0.5, $(W/L)_{3,4}$=10/0.5 and I_{SS}=0.5 mA. I_{SS} is implemented with an NMOS device having $(W/L)_{SS}$ = 50/0.5. The transistor parameters are as follows: μ_nC_{ox} = 120 $\mu A/V^2$, μ_pC_{ox} = 40 $\mu A/V^2$, V_{DD} = 3 V, V_{THN}=$|V_{THP}|$=0.7 V. Determine, **(15)**

(i) the differential gain of the amplifier

(ii) the minimum allowable input CM levels if the differential swings at the input and output are small.

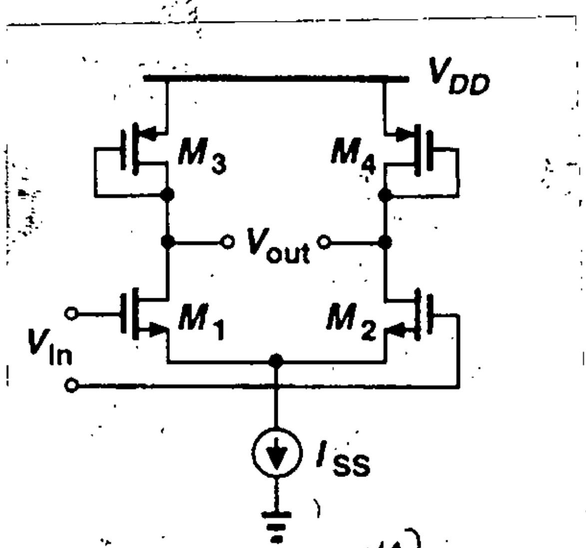


Figure for Q.8(c)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **EEE 477** (Power System Protection)

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 "dependability" and "security" in relation to protective relaying.
"As a relaying system becomes more dependable, its tendency to become less secure increases" – explain with reference to the Fig. for Q 1(a). **(12)**

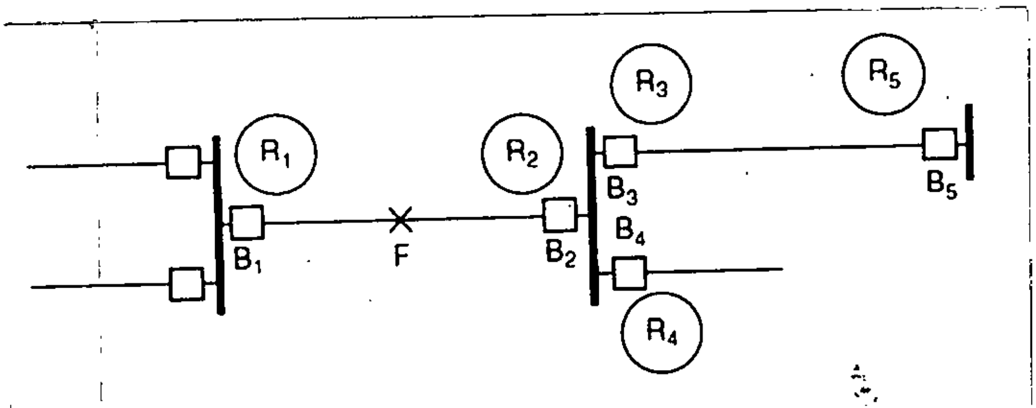


Fig. for Q 1(a)

(b) Assume that tripping of breakers was correct in Fig. for Q. 1(b). For the following cases where was the short circuit, and was there any failure of relaying, including breakers, and if so, which one(s) failed? **(12)**

Case	Breaker Tripped
A	3,4,5,6
B	1,4,5,6
C	3,7,8
D	4,5,7,8

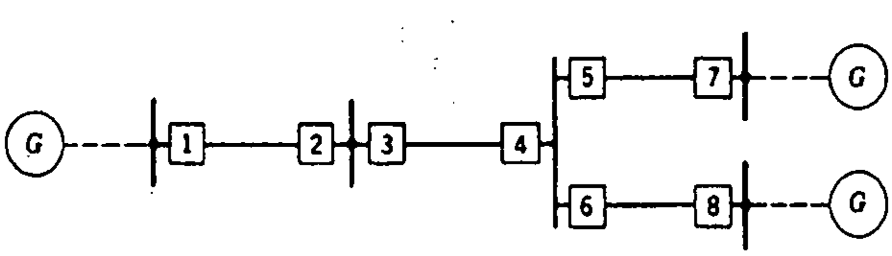


Fig. for Q 1(b)

(c) Why is a power system divided into protection zones? Why is zone overlap necessary? How it is typically achieved? Does zone overlap violate the principle of selectivity? **(11)**

Contd P/2

EEE 477

2. (a) Consider the inverse-time curves shown in Fig. for Q 2(a). What do they show? What type of relay do they represent? If multiple of pickup is 4, and no. 5 time –dial setting is used, **(17)**

(i) What is the time required to close the contact? (ii) What is the time required for the disc to travel a distance corresponding to 3.0 time-dial setting instead of 5.0?

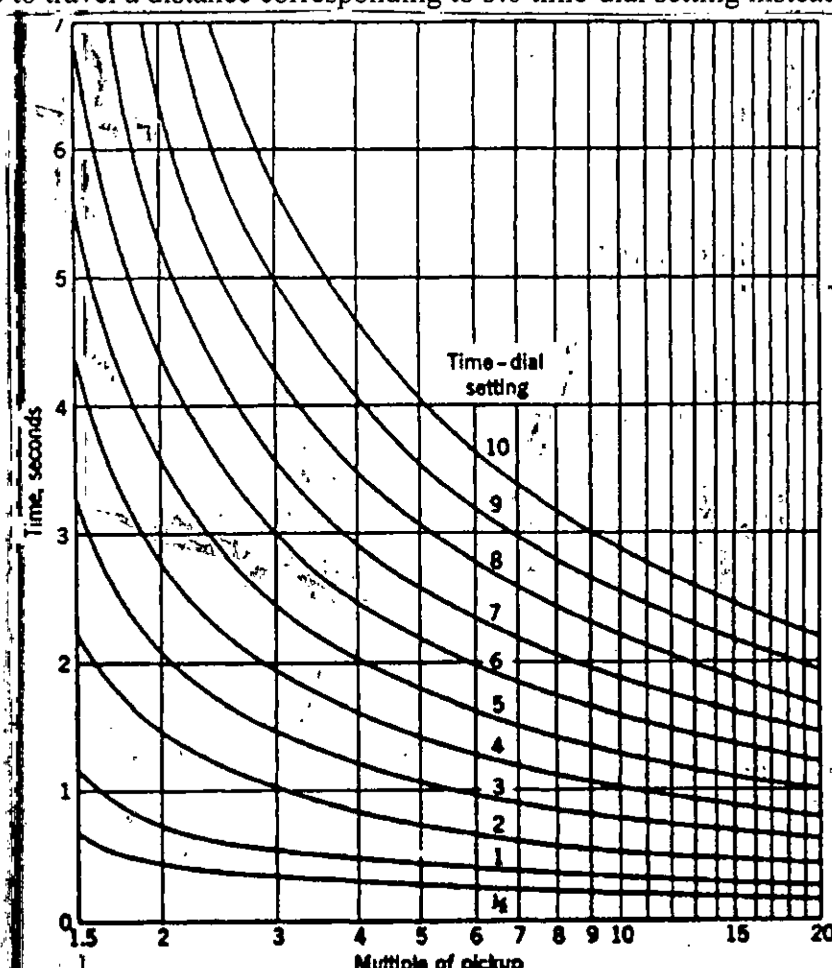


Fig. for Q 2(a)

(b) With reference to Fig. for Q. 2(b) discuss torque production in an induction type relay. Why is the relay free from vibration? Does no vibration mean the net force will always be the same? What effect does the angular separation between the two fluxes have on the relay? How is the direction of motion determined in this relay? **(18)**

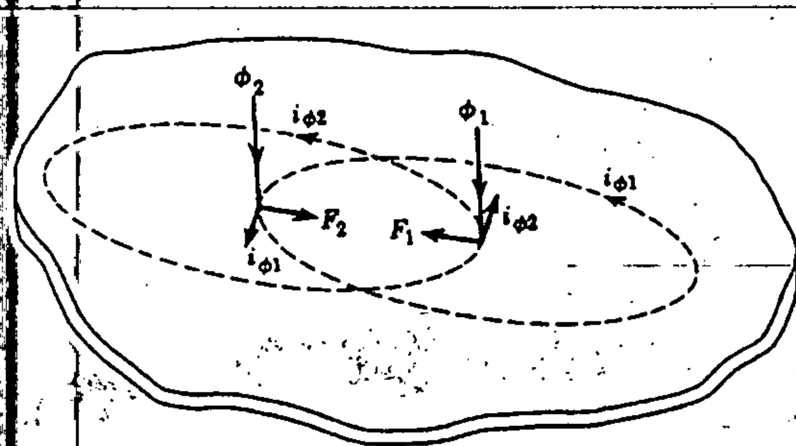


Fig. for Q 2(b)

EEE 477

3. (a) Consider a long radial transmission line. Comment on the reach of the distance relay for the line when the line is open at receiving end; when the line is heavily loaded. **(10)**

(b) Discuss the limitations of over-current protection of transmission line. **(8)**

(c) Show how residual current is used to identify ground fault in a transmission line. **(10)**

(d) Draw and briefly explain the trip contact circuit for three-stepped distance protection scheme. **(7)**

4. (a) Explain why and how DC component of current in a CT significantly affects its performance. **(12)**

(b) Sometimes a resistor in parallel with CB contacts is used – explain why. **(6)**

(c) With necessary derivation show that circuit with high natural frequency gives a high rate of rise of TRV. **(8)**

(d) A three phase 11 kV generator is connected to a circuit breaker. The inductive reactance up to the circuit breaker is 5 ohm per phase. The distributed capacitance up to circuit breaker between phase and neutral is 0.01 μF. Determine the following: **(9)**

(i) Peak restriking voltage across circuit breaker

(ii) Frequency of restriking voltage transient

(iii) Maximum RRRV.

SECTION – B

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

Symbols and abbreviations have their usual meanings.

5. (a) Explain the operating principle of percentage differential relay with harmonic restraint for single-phase transformer protection. **(15)**

(b) Describe the working principle of Buchholz relay. **(12)**

(c) What factors cause spill current on external fault in case of transformer differential protection? **(8)**

6. (a) What are the various faults and abnormal operating conditions to which an alternator is likely to be subjected? **(12)**

(b) Discuss the transverse differential protection scheme for inter-turn fault of generator winding. **(12)**

(c) What causes over-speeding of a generator? Explain the remedial action that needs to be taken to present over-speeding. **(11)**

EEE 477

7. (a) What are the causes of bus zone faults? Write down the desirable features of busbar protection. **(12)**

   (b) Discuss the behaviour of a CT in deep saturation. What are its implications for the busbar differential protection? **(11)**

   (c) Explain the high impedance busbar differential protection scheme. **(12)**

8. (a) Explain the trip law for reactance relay using universal torque equation. **(10)**

   (b) Discuss the performance of simple impedance relay during (i) normal load flow, and (ii) power swing condition. **(15)**

   (c) Explain the effect of arc resistance on Mho relay reach. **(10)**

L-4/T-1/EEE Date : 01/10/2022

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **EEE 481** (Power System Operation and Control)

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 and abbreviations have their usual meanings.

1\. (a) How a single period auction is administered in a spot electricity market? **(15)**

(b) In an electricity market for a certain period three GenCos submit on-line 'offers' and two DisCos submit on-line 'bids' respectively shown in Tables below. **(20)**

Offers	Unit 1			Unit 2			Unit 3		
Block	1	2	3	1	2	3	1	2	3
Power (MW)	5	12	13	8	8	9	10	10	5
Price ($/MWh)	1	3	3.5	4.5	5	6	8	9	10

Bids	Demand 1				Demand 2			
Block	1	2	3	4	1	2	3	4
Power (MW)	8	5	5	3	7	4	4	3
Price ($/MWh)	20	15	7	4	18	16	11	3

Using a graph determine the accepted offers and bids, the Market Clearing Price in $/MWh and the Social Welfare in $ for that particular hour. ***<u>The graph paper must be attached with your answer script.</u>***

2\. A power system shown in the Fig. for Q. 2 has the sensitivity matrix S_f when bus No. 5 is slack.

$$S_f = \begin{bmatrix} 0.4828 & -0.3448 & 0.4138 & 0.3448 \\ 0.1034 & 0.0689 & -0.4828 & -0.0689 \\ 0.4138 & 0.2759 & 0.0689 & -0.2759 \\ 0.4828 & 0.6552 & 0.4138 & 0.3448 \\ 0.1034 & 0.0689 & 0.5172 & -0.0689 \\ 0.5172 & 0.3448 & 0.5862 & 0.6552 \end{bmatrix}$$

(a) Determine the line flows in base case when the loads are 1000 MW each and generations at buses 3, 4, 5 are respectively 1000 MW, 750 MW and 250 MW. Base MVA is 100 MVA. **(10)**

(b) Determine the ranking index (RI) respectively for two separate contingencies: outages of G3 and L4. Assume that lost generation is picked up by slack bus generator. **(18)**

(c) Explain masking effect using the RIs obtained in (b). **(7)**

Contd P/2

EEE 481

Contd...Q. No. 2

Line i, j	P_f^{max} MW
L1 1-2	1000
L2 1-3	1000
L3 1-4	1000
L4 2-5	1000
L5 3-4	1000
L6 4-5	1000

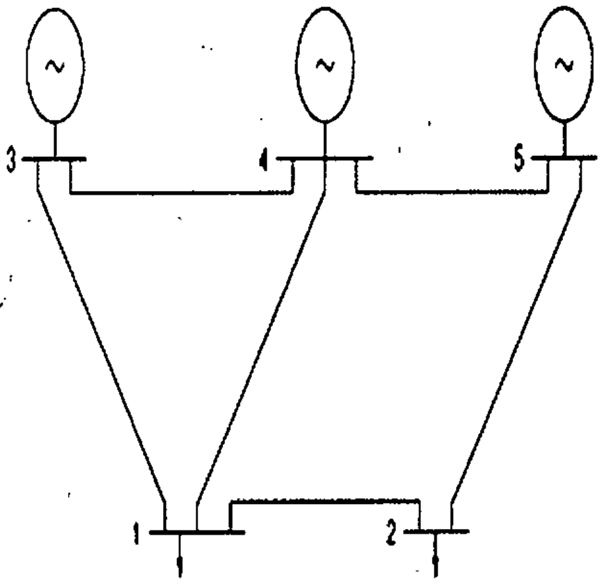


Fig. for Q. 2

3. (a) What are the differences between reliability, security and resilience? Derive an expression for the line outage distribution factors in terms of S_f matrix elements. **(18)**

(b) Form the AC OPF model for loss minimization in the following power system. **(17)**

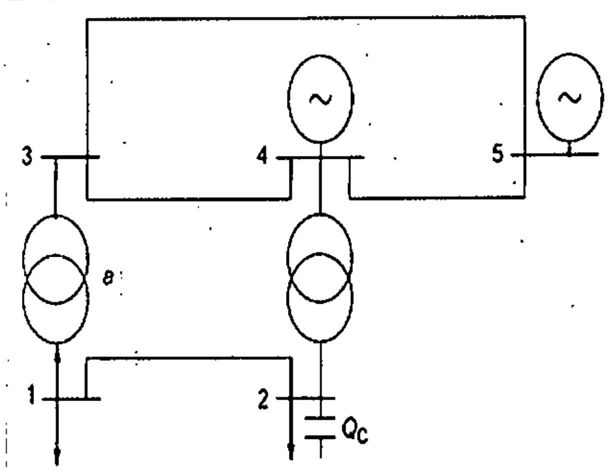


Fig. for Q. 3(b)

Each generator can produce 500 MW to 1500 MW and – 1000 MVAR to +1000 MVAR. Each line can carry a maximum of 1500 MVA. The capacitor bank can provide 0 to 200 MVAR. Bus voltages must be within 0.95 pu. to 1.05 pu. Transformer tap position is adjustable between 0.9 pu and 1.1 pu in step of 0.01. The generation costs are respectively G4 : 100 + 10.5 P_{G4} \$/MWh; G5: 100 + 10.0 P_{G5} \$/MWh. In base case each load is 1000 MW + j250 MVAR. Base MVA is 100 MVA.

4. (a) What are the various objective functions that are used in OPF corresponding to various states of a power system? **(9)**

(b) Suppose in a power system a line outage contingency needs to be tackled using generation scheduling in both preventive and corrective modes. Discuss two possible means to make sure that OPF solution will comprise both preventive and corrective generation scheduling. **(6)**

Contd P/3

EEE 481
Contd...Q. No. 4

(c) Form the DC OPF model for removing the overhead of lines through generation rescheduling and load shedding in the following power system. Load 1 can be shed more than load 2. Generation at bus 5 will have less preference for adjustment. Accordingly choose suitable weights for the generation and load adjustments. **(20)**

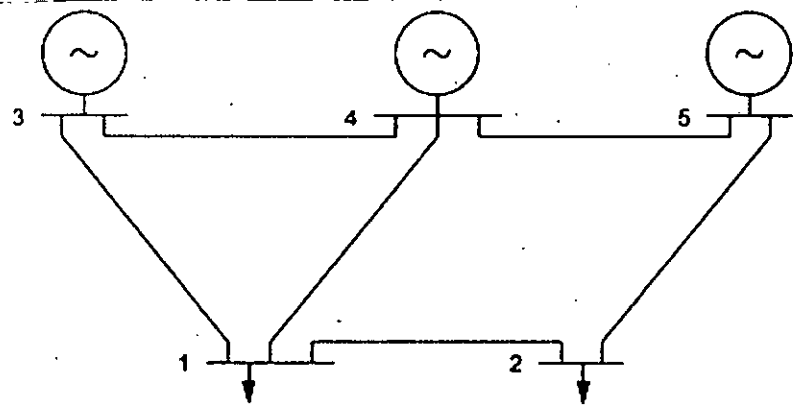


Fig. for Q. 4(c)

The line parameters and B matrix for the system are given below.

Line i, j	Resistance	Reactance	Shunt Susceptance	P_f^{max} MW
	pu (P_{base} = 100 MVA)			
L1 1-2	0.002	0.01	0.002	1000
L2 1-3	0.004	0.02	0.004	1000
L3 1-4	0.002	0.01	0.002	1000
L4 2-5	0.004	0.02	0.004	1000
L5 3-4	0.004	0.02	0.004	1000
L6 4-5	0.004	0.02	0.004	1000

$$B = \begin{bmatrix} 250 & -100 & -50 & -100 \\ -100 & 150 & 0 & 0 \\ -50 & 0 & 100 & -50 \\ -100 & 0 & -50 & 200 \end{bmatrix}$$

Base MVA is 100 MVA. Bus 5 is slack. Each generator can produce 250 MW to 1500 MW. In base case P_{L1}=2500 MW, P_{L2}=300 MW, P_{G3} = 1300 MW, P_{G4}=1250 MW, P_{G5}=250 MW.

5. (a) What is SCADA? With a block diagrams, describe the basic structure of a SCADA. What is the difference between SCADA and Substation Automation System (SAS)? **(15)**

(b) What is an Energy Management System (EMS)? With a block diagram, describe the basic model of an EMS. **(10)**

(c) Explain the concept of power system control in a deregulated environment. **(10)**

6. (a) What is the difference between load flow and state estimation? What is observability and how is it tested? **(10)**

(b) Derive the Weighted Least Square (WLS) criterion of state estimation. **(10)**

(c) Write down the 'accept' and 'reject' criteria for three commonly used bad data detection tests. What are the five necessary steps to identify bad data? **(15)**

Contd P/4

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **EEE 485** (Power Transmission and Distribution)

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 a group of *n* number of conductors. Derive an expression for flux linkage of one conductor in the group. **(12)**

(b) Why bundled conductors are preferred for high voltage power transmission? If we use quad conductor instead of single conductor having the same thermal limit what effect will have on surge currents due to lighting stroke? **(8)**

(c) A single-phase 50-Hz overhead power line is symmetrically supported on a horizontal cross arm. Spacing between the centers of the conductors is 2.5 m.A telephone line is also symmetrically supported on a horizontal cross arm 1.8 m directly below the power line. Spacing between the centers of these conductor is 1.0 m. **(15)**

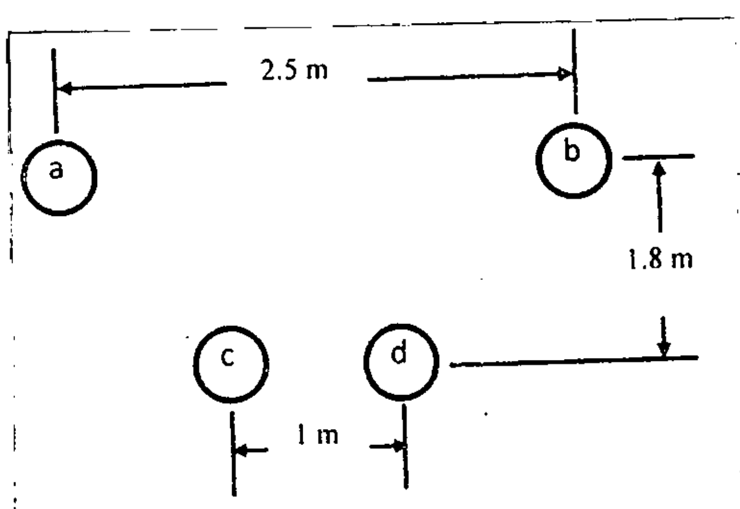


Fig. for Q 1(c)

(i) Using the equation derived in 1(a), show that the mutual inductance per unit length between the circuits is given by

$$4\times10^{-7}\, ln\sqrt{\frac{D_{ad}D_{bc}}{D_{ac}D_{bd}}}\, H/m \qquad \text{[D denotes the distance in meters]}$$

(ii) Hence, compute the mutual inductance per kilometer between the power line and the telephone line.

2. (a) Give a physical interpretation of 'string efficiency.' Why is this important for transmission line design? Why 100% string efficiency cannot be achieved? **(13)**

(b) With a simple diagram present the parameters that characterize suspension insulators for overhead transmission line. **(10)**

Contd P/2

EEE 485

Contd...Q. No. 2

(c) A 3-phase transmission line is being supported by three disc insulators. The potentials across top unit (i.e., near to the tower) and middle unit are 8 kV and 11 kV respectively. Calculate (i) the ratio of capacitance between pin and earth to the self-capacitance of each unit (ii) the line voltage and (iii) string efficiency. **(12)**

3. (a) Present the different busbar arrangement in a grid substation. **(15)**

(b) What is ground potential rise (GPR)? How does it relate to the criteria of different tolerable voltages in a substation? **(8)**

(c) Draw and discuss the diagram showing the information flow of system monitoring in a smart power distribution network. **(12)**

4. (a) What are the primary causes for corona development? You are assigned the task of designing a 400 kV transmission line. What design criteria would you consider for reducing corona in the line? **(12)**

(b) What are the different types of vibrations experienced by overhead transmission lines? How can these vibrations be minimized? **(11)**

(c) Discuss the loss reduction strategies used by distribution utilities. **(12)**

SECTION – B

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

5. (a) Deduce an expression for line to neutral capacitance for a 3-phase overhead transmission line considering the effect of earth and transposed unsymmetrically placed conductors. **(15)**

(b) Derive the following capacitive reactance between two conductors of a two-wire transmission line. **(10)**

$$X_c = \frac{5.724}{f} \times 10^9 \, ln \, D/r \, \Omega.m$$

(c) A 3-phase overhead transmission line has its conductors arranged at the corners of an equilateral triangle of 2 m side. Calculate the capacitance of each line conductor per km. Given diameter of each conductor is 1.25 cm. **(10)**

6. (a) What is a sag in overhead lines? Discuss the disadvantages of providing too small or too large sag on a line. **(08)**

(b) Deduce an approximate expression for sag in over-head transmission line when supports are at unequal levels. **(12)**

Contd P/3

EEE 485

Contd...Q. No. 6

(c) A transmission line has a span of 214 meters between level supports. The conductors have a cross sectional area of 3.225 cm^2. Calculate the factor of safety under the following conditions: **(15)**

Vertical sag = 2.35m; Wind pressure = 1.5 kg/m run; Breaking stress = 2540 kg/cm^2; wt. of conductor = 1.125 kg/m run.

7. (a) Explain the capacitance and inter sheath grading methods in cables. **(15)**

(b) Explain the Murray loop test method for locating earth fault in underground cable. **(10)**

(c) Find the most economical size of a single-core cable working on a 132 kV, 3-phase system, if a dielectric stress of 60 kV/cm can be allowed. **(10)**

8. (a) Explain the functions of different components used in HVDC transmission system. **(11)**

(b) Explain the monopolar, bipolar and homopolar arrangements for HVDC transmission system. **(12)**

(c) Assume one overhead AC and an overhead DC line have same line length, made of same size conductors, transmit same amount of power and have same total I^2R losses. Determine: (i) line-to-line DC voltage of V_d in terms of line-to-neutral AC voltage E_p. (ii) DC line current I_d in terms of AC line current I_L. (iii) Ratio of DC insulation level to AC insulation level. **(12)**

L-4/T-1/~~CSE~~ EEE **Date : 26/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **CSE 451** (Computer Networks)

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 is the role of Sequence number in each packet while flooding link state packets (by routers)? What would happen if

   (i) the sequence number gets corrupted?

   (ii) the router restarts?

   Explain possible solutions to the above-mentioned problems. **(5+5+5=15)**

   (b) In the following network topology (Figure: A1) 5 devices and 4 ethernet switches are connected. Labels on the wires indicate the port numbers. Initially, mac address tables of all four switches are empty. Find the mac address tables of the switches after ICMP message have been exchanged between the following pair of devices. **(10+5=15)**

   (i) PC-1 pings PC-2 and gets reply

   (ii) PC-5 pings PC-3 and gets reply

   (iii) PC-1 pings PC-3 and gets reply

   If PC-2, PC-3 and PC-4 send packet to PC-1 at the same time, will there be any collision? Explain briefly.

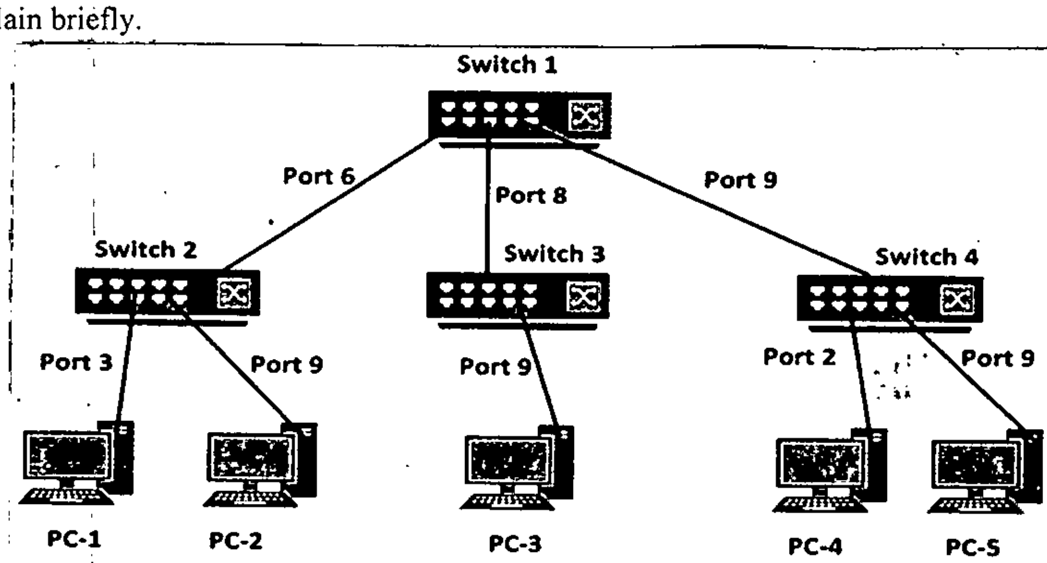


Figure: A1

   (c) Compare the advantages and disadvantages of Fiber Optics and Twisted pair cables. **(5)**

2. (a) A router has the following (CIDR) entries in its routing table: **(10)**

Contd P/2

CSE 451

Address/Mask	Next Hop
135.46.56.0/22	Interface 0
135.46.60.0/22	Interface 1
192.53.40.0/23	Interface 2
Default	Interface 3

For each of the following IP addresses, find the next hop.

(i) 135.46.63.10

(ii) 135.46.57.14

(iii) 135.46.52.2

(iv) 192.53.40.7

(v) 192.53.56.7

(b) Describe how CSMA/CD protocol works with binary exponential backoff and discuss how CSMA/CD solves the major drawbacks of slotted ALOHA protocol. **(10)**

(c) "By mapping multiple private IPv4 addresses to a single (or a few) public IPv4 address(s), NAT (Network Address Translator) can prevent depletion of IPv4 addresses" – do you agree or disagree with the above statement? Justify your answer with necessary figures and examples. **(15)**

3. (a) Illustrate how Transparent and Nontrasparent IP fragmentation/reassembly work with necessary examples. Is it possible to avoid fragmentation? Briefly explain your answer with necessary figures. **(10+5=15)**

(b) Suppose Host A wants to send a large file to Host B, The path from Host A to Host B has three links, of rates R1 = 512 kbps, R2 = 2 Mbps and R3 = 1 Mbps. **(5+5+5=15)**

(i) List the potential delay components in end-to-end delay.

(ii) What is the propagation delay between R1 and R2 if average packet size is 1200 bytes?

(iii) Assuming no other traffic in the network, what is the throughput for the file transfer?

(c) Draw the timing diagram of the messages that are exchanged between the server and the client in Dynamic Host Configuration Protocol (DHCP) and briefly mention the function of each message. **(10)**

4. (a) Alice have received a bit stream 11011011101 (8 data bits and 3 redundancy bits) where checksum has been calculated using standard CRC method. If generator polynomial G is 1011, detect whether the data received has been corrupted or not. **(10)**

(b) Draw a high-level Networking architecture of the Internet depicting global, regional and local ISPs and autonomous systems and show where Internet Exchanges (IX) are generally placed. **(10)**

(c) Consider the wireless topology below in Figure A2. The solid circles represent the transmission radius of nodes A and D, respectively, and the dashed circles represent the transmission range of B and C, respectively. Assume the two nodes' transmissions will interfere at a location if and only if they transmit at the same time and their transmission areas overlap. Also assume that losses only occur due to collisions.

Contd P/3

CSE 451

Now, answer the following questions with brief reasoning based on your observations.

(i) When node A transmits to node B, indicate the potential hidden terminals (in either direction – those who might clobber A's transmission or those whose transmission might get clobbered by A). **(3+2+5+5=15)**

(ii) Similarly find hidden nodes when B transmits to node C

(iii) Suppose A is sending data to B and C is sending data to D, both at a constant bit rate equal to the physical capacity ("as fast as they can") and no mechanism is being used to detect or avoid collisions. Measure the throughput of each transfer as a fraction of its sending rate

(iv) For the above problem in (iii), now assume that each node uses CSMA/CA. Measure the throughput of each transfer as a fraction of its sending rate.

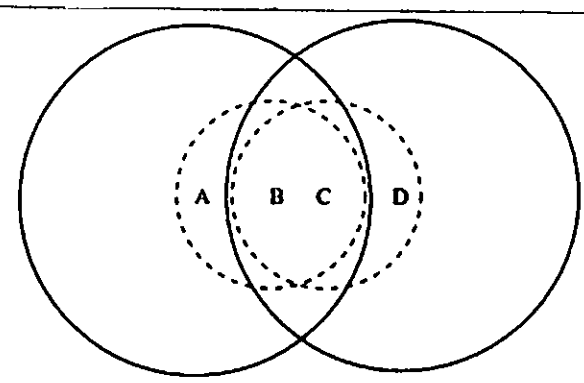


Figure: A2

SECTION – B

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

5. (a) What are the differences between message confidentially and message integrity? Can there be confidentially without integrity? Can there be integrity without confidentially? Justify your answer. **(12)**

(b) Consider an 8-block cipher. How many possible input blocks does this cipher have? How many possible mappings are there? If we view each mapping as a key, then how many possible keys does this cipher have? **(12)**

(c) Suppose N people want to communicate with one another using symmetric key encryption. All communications between any two people, i and j, is visible to all other people in this group of N, and no other person in this group should be able to decode their communication. How many keys are required in the system as a whole? Now, suppose that public key encryption is used. How many keys are required in this case? **(11)**

6. (a) Discuss advantages and disadvantages of a virtual private network. **(15)**

(b) What is the main difference between reverse proxy server and proxy server? **(10)**

(c) How can a reverse proxy server act as a load balancer? **(10)**

Contd P/4

CSE 451

7. (a) In the reliable transfer protocols, why did we need to introduce sequence numbers? **(10)**

   (b) Suppose that the roundtrip delay between sender and receiver is constant and known to the sender. Would a timer still be necessary in reliable data transfer protocols assuming that packets can be lost? Explain. **(10)**

   (c) Suppose a process in Host C has a UDP socket with port number 6789. Suppose both Host A and Host B individually send a UDP segment to Host C with destination port number 6789. Will both of these segments be directed to the same socket at Host C? If so, how will the process at Host C know that these two segments were originated from two different hosts? **(15)**

8. (a) List the four broad classes of services that a transport protocol can provide. For each of the service classes, indicate whether UDP or TCP (or both) provides such a service. **(16)**

   (b) List five nonproprietary Internet applications and the application-layer protocols that they use. **(10)**

   (c) Suppose you wanted to do a transaction from a remote client to a server as fast as possible. Would you use UDP or TCP? Why? **(9)**
