JEPPIAAR
INSTITUTE OF TECHNOLOGY
"Self-Belief | Self Discipline | Self Respect"

QUESTION BANK

Regulation	:	2017
Year/Semester	:	III
Semester	:	05
Batch	:	2017-2021

DEPARTMENT OF
ELECTRONICS AND COMMUNICATION ENGINEERING

Vision of the Institution

Jeppiaar Institute of Technology aspires to provide technical education in futuristic technologies with the perspective of innovative, industrial and social application for the betterment of humanity.

Mission of the Institution

- To produce competent and disciplined high-quality professionals with the practical skills necessary to excel as innovative professionals and entrepreneurs for the benefit of the society.
- To improve the quality of education through excellence in teaching and learning, research, leadership and by promoting the principles of scientific analysis, and creative thinking.
- To provide excellent infrastructure, serene and stimulating environment that is most conducive to learning.
- To strive for productive partnership between the Industry and the Institute for research and development in the emerging fields and creating opportunities for employability.

To serve the global community by instilling ethics, values and life skills among the students needed to enrich their lives.

DEPARTMENTVISION

To enhance and impart futuristic and innovative technological education for the excellence of Electronics and Communication Engineering with new ideas and innovation to meet industrial expectation and social needs with ethical and global awareness reinforced by an efficiency through research platform for the advancement of humanity.

MISSION

M1: To produce competent and high quality professional Engineers in the field ofElectronics and Communication Engineering for the benefit of the society globally.

M2: To provide a conducive infrastructure and environment for faculty and students with enhanced laboratories, to create high quality professionals

M3: To provide Prerequisite Skills in multidisciplinary areas for the needs of Industries, higher education and research establishments and entrepreneurship

M4: To handle Socio Economic Challenges of Society by Imparting Human Values and Ethical Responsibilities.

Program Educational Objectives (PEOs)

PEO 1: Graduate Engineers will have knowledge and skills required for employment and an advantage platform for lifelong learning process.

PEO 2: Graduate Engineers willbe provided withfuturistic education along with the perspective research and application based on global requirements.

PEO 3: Graduate Engineers will have effective communication skills and work in multidisciplinary team.

PEO 4: Graduate Engineers will develop entrepreneurship skills and practice the profession with integrity, leadership, ethics and social responsibility.

Program Specific Outcomes (PSOs)

PSO 1 : Ability to develop and utilize novel, compact and power efficient coherent theoretical and practical methodologies in the field ofanalog and digital electronics.

PSO 2: Ability to implement analog, digital and hybrid communication Protocol to aspect the challenges in the field ofTelecommunication and Networking.

BLOOM'S TAXONOMY

Definition:

Bloom's taxonomy is a classification system used to define and distinguish different levels of human cognition like thinking, learning and understanding.

Objectives:

- To classify educational learning objectives into levels of complexity and specification. The classification covers the learning objectives in cognitive, affective and sensory domains.
- To structure curriculum learning objectives, assessments and activities.

Levels in Bloom's Taxonomy:

- **BTL 1 – Remember** - The learner recalls, restate and remember the learned information.
- **BTL 2 – Understand** - The learner embraces the meaning of the information by interpreting and translating what has been learned.
- **BTL 3 – Apply** - The learner makes use of the information in a context similar to the one in which it was learned.
- **BTL 4 – Analyze** - The learner breaks the learned information into its parts to understand the information better.
- **BTL 5 – Evaluate** - The learner makes decisions based on in-depth reflection, criticism and assessment.
- **BTL 6 – Create** - The learner creates new ideas and information using what has been previously learned.

TABLE OF CONTENT

EC8501 **DIGITALCOMMUNICATION** **L TPC 3 0 03**

OBJECTIVES:

- To know the principles of sampling &quantization
- To study the various waveform codingschemes
- To learn the various baseband transmissionschemes
- To understand the various Band pass signalingschemes
- To know the fundamentals of channelcoding

UNITI INFORMATION THEORY 9

Discrete Memoryless source, Information, Entropy, Mutual Information - Discrete Memoryless channels – Binary Symmetric Channel, Channel Capacity - Hartley - Shannon law - Source coding theorem - Shannon - Fano & Huffman codes.

UNITII WAVEFORMCODING& REPRESENTATION 9

Prediction filtering and DPCM - Delta Modulation - ADPCM & ADM principles-Linear Predictive Coding- Properties of Line codes- Power Spectral Density of Unipolar / Polar RZ & NRZ – Bipolar NRZ - Manchester

UNITIII BASEBAND TRANSMISSION& RECEPTION 9

ISI – Nyquist criterion for distortion less transmission – Pulse shaping – Correlative coding - Eye pattern – Receiving Filters- Matched Filter, Correlation receiver, Adaptive Equalization

UNITIV DIGITAL MODULATION SCHEME 9

Geometric Representation of signals - Generation, detection, PSD & BER of Coherent BPSK, BFSK & QPSK - QAM - Carrier Synchronization - Structure of Non-coherent Receivers - Principle of DPSK.

UNITV ERROR CONTROL CODING 9

Channel coding theorem - Linear Block codes - Hamming codes - Cyclic codes - Convolutional codes - Viterbi Decoder.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of the course, students will be able to

- Design PCMsystems
- Design and implement base band transmissionschemes
- Design and implement band pass signaling schemes
- Analyze the spectral characteristics of band pass signaling schemes and their noiseperformance
- Design error control codingschemes

TEXT BOOK:

1. S. Haykin, “Digital Communications”, John Wiley, 2005

REFERENCES:

1. B. Sklar, “Digital Communication Fundamentals and Applications”, 2nd Edition, Pearson Education, 2009.
2. B.P. Lathi, “Modern Digital and Analog Communication Systems” 3rd Edition, Oxford University Press 2007.
3. H P Hsu, Schaum Outline Series - “Analog and Digital Communications”, TMH2006.
4. J.G Proakis, “Digital Communication”, 4th Edition, Tata McGraw Hill Company,2001.

Subject Code:EC8501 Year/Semester: III /05
Subject Name: DIGITAL COMMUNICATIONSubject Handler: Mrs. M.Benisha& Ms. Rubala

UNIT I - INFORMATION THEORY

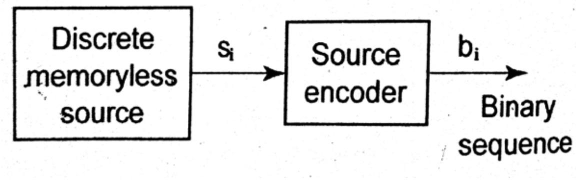
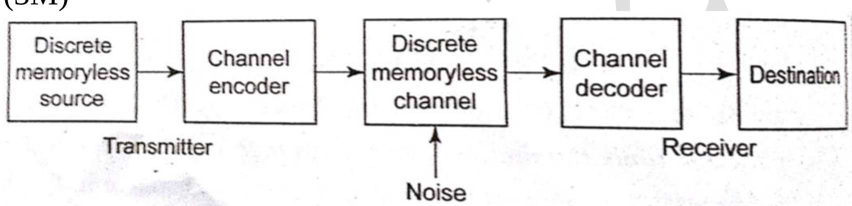
Discrete Memory less source, Information, Entropy, Mutual Information - Discrete Memoryless channels – Binary Symmetric Channel, Channel Capacity - Hartley - Shannon law - Source coding theorem - Shannon - Fano & Huffman codes.

PART * A

Q.No.	Questions
1.	**State Shannon's capacity theorem for power and band limited channel. (Nov/Dec2016)** BTL1 The information capacity of a continuous channel of BW B Hz perturbed by a AWGN of PSD No/2 and limited to BW B is given by $C=\log_2[1+(P/NoB)]$ .where P is the average transmitted power
2	**Define entropy. (May/June 2015)(Nov/Dec 2017)** BTL1 Entropy is the measure of the average information content per second. It is given by the expression, $H(X)=\sum_I P(xi)\log_2 P(xi)$ bits/sample.
3	**Give the relation between the different entropies.** BTL 4 H(X,Y) = H(X)+H(Y/X) = H(Y)+H(X/Y) H(X)- entropy of the source(Y/X),H(X/Y)-conditional entropy H(Y)-entropy of destination H(X,Y)- Joint entropy of the source and destination
4	**Define information rate.** BTL1 If the time rate at which source X emits symbols is r symbols per second. The information rate R of the source is given by R=r H(X) bits/second H(X)- entropy of the source.
5	**State the property of entropy. (May/June 2015)** BTL1 • $\log M \geq H(x) \geq 0$ • H(X) = 0 if all probabilities are zero $H(X) = \log_2 M$ if all probabilities are equal
6	**What is differential entropy?** BTL 2 The average amount of information per sample value of x(t) is measured by ∞ $H(X)= - _{\infty}\int f_x(x)\log f_x(x)dx$ bit/sample H(X) –differential entropy of X.
7	**What is source coding and entropy coding?** BTL 2 A conversion of the output of a DMS into a sequence of binary symbols is called source coding. The design of a variable length code such that its average cod word length approaches the entropy of the DMS is often referred to as entropy coding.
8	**State Shannon Hartley theorem.** BTL1 The capacity 'C' of a additive Gaussian noise channel is $C=B \log_2 (1+S/N)$ 1. B= channel bandwidth, S/N=signal to noise ratio.
9	**What is information theory?** BTL 2 1. Information theory deals with the mathematical modeling and analysis of a communication system rather than with physical sources and physical channels

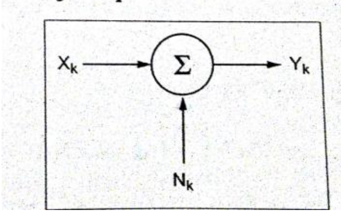
10	**Why is Huffman code is called as minimum redundancy coding? (May/June 2014)** BTL 4 The term "redundancy" has been defined by Shannon as a property of codes. A "minimum-redundancy code" will be defined here as an ensemble code which, for a message ensemble consisting of a finite number of members, N, and for a given number of coding digits, D, yields the lowest possible average message length. In order to avoid the use of the lengthy term "minimum-redundancy", this term will be replaced here by "optimum" It will be understood then that, in this paper, "optimum code" means "minimum-redundancy code"
11	**Explain Shannon-Fano coding. (May/June 2015)** BTL1 An efficient code can be obtained by the following simple procedure, known as Shannon- Fano algorithm. • List the source symbols in order of decreasing probability. • Partition the set into two sets that are as close to equiprobable as possible, and sign 0 to the upper set and 1 to the lower set. Continue this process, each time partitioning the sets with as nearly equal probabilities as possible until further partitioning is not possible.
12	**Find the entropy for the given sequence : ½,1/4,1/8,1/16,1/16** BTL 3 Given the probabilities .Find the entropy using the below formula $H = -\sum_{k=1}^{6} P_k.\log_2 P_k$ **=**([1/2log10(1/2)+1/4log10(1/4)+1/8log(1/8)+1/16log(1/16)+1/16log(1/16)]) = -(-1/2-1/2-3/8-4/16-4/16) =1.875bits/symbol. Given the probabilities P1=1/8,P2=3/8,P3=3/8,P4=1/8. [1/8.log10(1/8)+3/8.log10(3/8)+1/8.log10(1/8)+3/8.log10(3/8)]) H=1.81125bits/symbol
13	**Calculate the entropy of four possible messages {Q1, Q2, Q3, Q4} which is transmitted with probabilities {1/8, 3/8, 3/8, 1/8}?(Nov 2017)** BTL 3 $H(s) = \sum_{i=1}^{3} p_i \log_2 \frac{1}{p_i}$ $= \frac{1}{2}\log_2(2) + \frac{1}{4}\log_2(4) + \frac{1}{4}\log_2(4) = 1.5 \text{ bits/symbol}$
14	**Consider a discrete memory less source with source alphabet (S_0, S_1, S_2) and with their respective probabilities ($P_0 = \frac{1}{4}, P_1 = \frac{1}{4}, P_2 = 1/2$) entropy of the source. (May 2017) (Nov 2016)** BTL 3 $H(s) = \sum_{i=1}^{3} p_i \log_2 \frac{1}{p_i}$ $= \frac{1}{2}\log_2(2) + \frac{1}{4}\log_2(4) + \frac{1}{4}\log_2(4) = 1.5 \text{ bits/symbol}$

15	**Define mutual information and mention its properties. (May 2017) (May 2015)**BTL 1 Mutual information I(X,Y) of a channel is defined by I(X,Y)=H(X)-H(X/Y) bits/symbol H(X)- entropy of the source, H(X/Y)- conditional entropy of Y. **Properties:** i) I(X,Y)=I(Y,X) ii) I(X,Y)>=0 iii) I(X,Y)=H(Y)-H(Y/X) I(X,Y)=H(X)+H(Y)-H(X,Y).
16	**An event has six possible outcomes with probabilities ½, ¼,1/8, 1/16, 1/32. Find the entropy of the system. (May 2015)** BTL 3 H = $\Sigma p_k log_2 {}^{1}/_{p_k}$ = (½)$log_2$2 + (¼)$log_2$4 + (1/16) $log_2$16 + (1/32) $log_2$32 + (1/32) $log_2$32 = 1.5625.
17	**Explain Shannon-Fano coding.** BTL 1 An efficient code can be obtained by the following simple procedure, known as Shannon-Fanoalgorithm. i) List the source symbols in order of decreasing probability. ii) Partition the set into two sets that are as close to equi probable as possible, and sign 0 to the upper set and 1 to the lower set. 3. Continue this process, each time partitioning the sets with as nearly equal probabilities as possible until further partitioning is not possible.
18	**When is the average information delivered by a source of alphabet size 2, maximum?**BTL 2 Average information is maximum, when the two messages are equally likely i.e., p1 = p2 = 1/2. Then the maximum average information is given as, Hmax = 1/2 $log_2$2 + 1/2 $log_2$2 = 1 bit / message.
19	**What is the channel capacity of a BSC and BEC?** BTL 1 For BSC the channel capacity C=1+plog_2 p +(1-p) log_2 (1-p). For BEC the channel capacity C=(1-p).
20	**State the channel coding theorem for a discrete memory less channel.**BTL 1 Given a source of Mequally likely messages, with M>>1, which is generating information at rate R. Given channel with capacity C. Then if, R ≤ C
	PART * B
1	**What is source coding? Discuss source coding theorem procedure, with an example source code. (May/June 2017) (13M)**BTL 2 **Answer : Page : 637 - H Taub, D L Schilling** **SHANNON'S THEORMS :** **TYPES :** (2M) Shannon's first theorem or source coding theorem Shannon's second theorem or channel coding theorem Shannon's third or capacity theorem or Shannon'sHartley theorem **Shannon's first theorem or source coding theorem:** Codeword -encoder- binary Source code - unique

	 (3M) Average code length $\bar{L} = \sum_{i=0}^{N-1} pi\ l\ i$ (2M) Coding efficiency $\eta = \frac{L_{min}}{\bar{L}}$ (2M) DMS- average code word length $\bar{L}$- bounded $\bar{L} \geq$ H(S) (2M) **Efficiency :** $\boldsymbol{\eta = \frac{H(S)}{\bar{L}}}$(1M) **Code redundancy $\boldsymbol{\gamma = 1 - code\ efficency}$ = 1- $\boldsymbol{\eta}$**(1M)
2	**What is source coding? Discuss Shannon's second theorem .(13M)**BTL 2 **Answer : Page : 637 - H Taub, D L Schilling** **Shannon's second theorem or channel coding theorem** **Need for channel coding :** (3M) Presence -noise- discrepancies – output and input data sequence Error probability- 9 out of 10- transmitted bits are received- level of reliability Probability error= 10^{-6} – even lower- channel coding Increase – resistance -digital communication system -channel (3M)  **Code rate :** r $= \frac{k}{n} = \frac{No\ of\ messages\ bits\ in\ a\ block}{no.of\ bits\ in\ code\ word} < 1$ (1M) **Average information rate :** (1M) $= \frac{H(S)}{T_S}$ bits/sec **Channel capacity per units :** (1M) $= \frac{C}{T_C}$ bits/sec **Statement :** $\frac{H(S)}{T_S} \leq \frac{C}{T_C}$ (source output -transmitted – over -channel-reconstructed-small probability error)(2M) $\frac{H(S)}{T_S} > \frac{C}{T_C}$ (no possibility -transmission- reconstructed-small probability error) (2M)
3	**What is source coding? Discuss Shannon'sthird theorem. (13M)**BTL 2

Answer : Page : 63 -H Taub, D L Schilling
SHANNON'S THEORMS :
TYPES : (1M)
Shannon's first theorem or source coding theorem
Shannon's second theorem or channel coding theorem
Shannon's third or capacity theorem or Shannon'sHartley theorem
Shannon's third or capacity theorem or Shannon'sHartley theorem:
Information capacity theorem (2M)
Band limited – power limited- Gaussian channel

No. of samples K = 2BT



(2M)

Channel capacity of a Gaussian channel (1M)

$C = B\log_2\left[1+\frac{S}{N}\right]$ bits /sec

Signal power : $P = \int_{-B}^{B} Power\ spectral\ density$ (1M)

Noise power :

$N = \int_{-B}^{B} \frac{N_0}{2}$ df $= N_0$B

(1M)

Channel capacity depends on : (3M)
Bandwidth
Signal to noise ratio
Noise spectral density

$C = B\log_2\left[1+\frac{P}{N_{0B}}\right]$ bits /sec (2M)

4 **A discrete memory less source has an alphabet of seven symbols whose probabilities of occurrence are as described here**

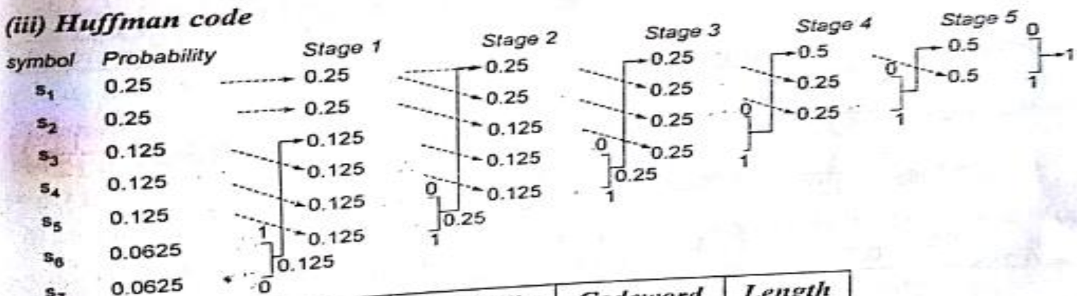
Symbol	S1	S2	S3	S4	S5	S6	S7
Probability	**0.25**	**0.25**	**0.125**	**0.125**	**0.125**	**0.0625**	**0.0625**

Compute i) Shannon fano coding ii) Huffman coding iii) calculate the efficiency(May-June 2014)(13M) BTL3
Answer: Page. : 13.26 - K.MuraliBabu
Shannon fano coding &Huffman coding : (6M)

(ii) Shannon Fano Code

Symbols	Probability	Stage 1	Stage 2	Stage 3	Stage 4	CW	Length
s_1	0.25	0	0			00	2
s_2	0.25	0	1			01	2
s_3	0.125	1	0	0		100	3
s_4	0.125	1	0	1		101	3
s_5	0.125	1	1	0		110	3
s_6	0.0625	1	1	1	0	1110	4
s_7	0.0625	1	1	1	1	1111	4

(iii) Huffman code



Symbol	*Probability*	*Codeword*	*Length*
s_1	0.25	10	2
s_2	0.25	11	2
s_3	0.125	001	3
s_4	0.125	010	3
s_5	0.125	011	3
s_6	0.0625	0000	4
s_7	0.0625	0001	4

$\bar{L} = \sum_{i=1}^{N} p_i L_i$ **(p1L1+ ---p7L7)** (3M)

$\bar{L}$ **=2.625bits /symbols**

Entropy :

$H(S) = \sum_{i=1}^{N} p_i \log_2\left(\frac{1}{p_i}\right)$(3M)

$H(S)$ **= 2.625 bits/ sec**

Efficiency : (1M)

$\eta = \frac{H(S)}{\bar{L}}$

$$\eta = 100\%$$

5	**Draw in detail about the procedure for Shannon-Fano Coding Scheme. (8M) (Nov/Dec 2015)** BTL 3 **Answer : Page. : 632 HTaub, D L Schilling** **Code word length** (3M)

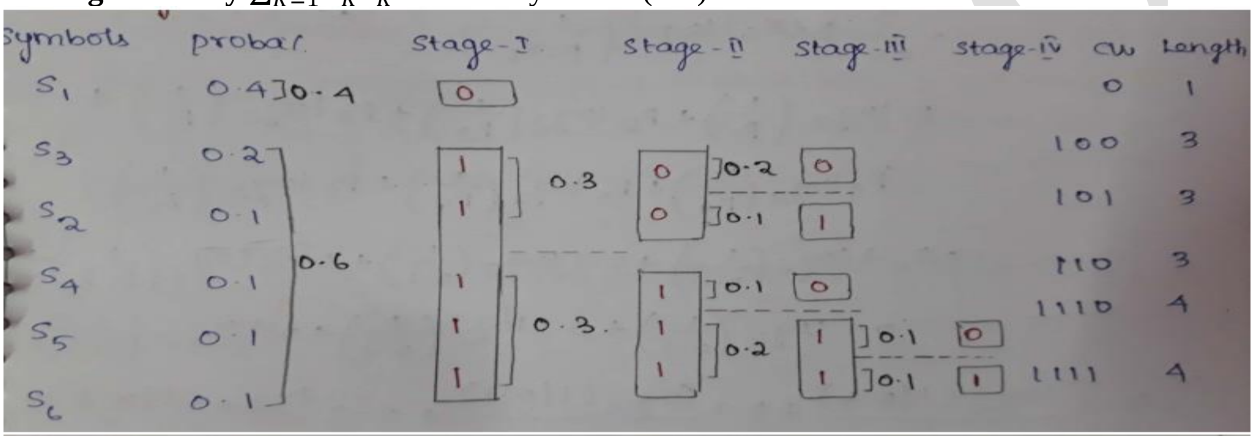
	$\bar{L}=\sum_{i=1}^{N} p_i L_i$ **Entropy** (3M) $$H(S)=\sum_{i=1}^{N} p_i \log_2\left(\frac{1}{p_i}\right)$$ **Efficiency** (2M) $\eta=\frac{H(S)}{\bar{L}}$
6	**Brief the properties of entropy. (4) (ii) Five symbols of the alphabet of DMS and their probabilities are given below. S={So,S1,S2,S3,S4}** **P(S)= {0.4,0.2,0.2,0.1,0.1}.Code the symbols using Huffman coding.(12) . (Nov 2010).** **Code word length** (3M) $\bar{L}=\sum_{i=1}^{N} p_i L_i$ **Entropy** (3M) $$H(S)=\sum_{i=1}^{N} p_i \log_2\left(\frac{1}{p_i}\right)$$ **Efficiency** (2M) $\eta=\frac{H(S)}{\bar{L}}$
7	**(i) Discuss the BSC and BEC with their channel diagram and transition matrix.(12) (ii) Consider that a source is transmitting equiprobable 1/0 at the rate of 10^3bits/sec and the probability of error is p_e = 1/16. Determine the rate of transmission.. (Nov 2010)** **Codeword length** (3M) $\bar{L}=\sum_{i=1}^{N} p_i L_i$ **Entropy** (3M) $$H(S)=\sum_{i=1}^{N} p_i \log_2\left(\frac{1}{p_i}\right)$$ **Efficiency** (2M) $\eta=\frac{H(S)}{\bar{L}}$
8	**State the properties of mutual information (7M) NOV-DEC-17 BTL1** Properties of Mutual information Mutual information of a channel is symmetric. I(x;y)=I(y;x)I(x;y)=I(y;x) (1M) Mutual information is non-negative. I(x;y)≥0I(x;y)≥0 (1M) Mutual information can be expressed in terms of entropy of the channel output. I(x;y)=H(y)−H(y|x)I(x;y)=H(y)−H(y|x) (2M) Where H(y|x)H(y|x) is a conditional entropy Mutual information of a channel is related to the joint entropy of the channel input and the channel output. I(x;y)=H(x)+H(y)−H(x,y)I(x;y)=H(x)+H(y)−H(x,y) (2M)

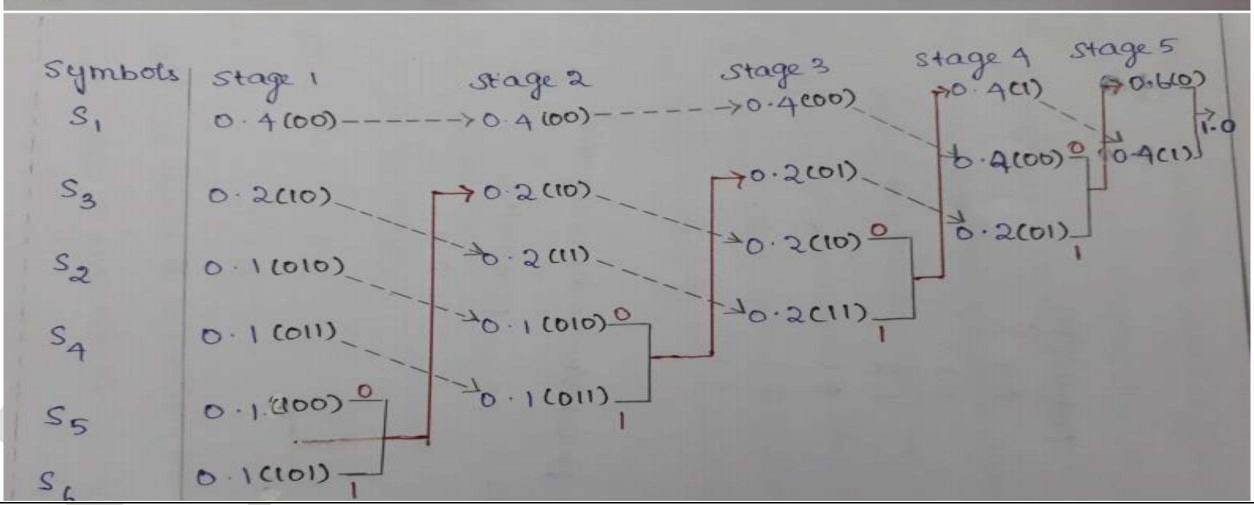
Where the joint entropy H(x,y)H(x,y) is defined by
H(x,y)=∑j=0j−1∑k=0k−1p(xj,yk)log2(1p(xi,yk)) (1M)

9

Five source messages are probable to appear as m1 =0.4, m2= 0.1, m3 = 0.2, m4 = 0.1, and m5 = 0.1, m6 =0.1. Determine the coding efficiency for
1) Shannon-Fano coding
2) Huffman coding (13M) (Nov 2017)BTL 3
Answer: Page:187&193- Notes

Explanation: Arrange - given probabilities - decreasing order. (1M)
Perform calculation. (8M)
Coding efficiency:$\sum_{K=1}^{K} P_K L_K$=2.4 bits/symbol . (4M)





10

Derive the expression for mutual information and channel capacity. (Nov 2017) (7M) BTL 2
Answer: Page:5.87- Chitode

Mutual information: Information gain amount-per- received signal.
I(X;Y)= H(X)-H(X/Y) (1M)
Channel capacity: C= max I(X;Y) (1M)
Expression and properties of mutual information:(2M)
Symmetric

	Non negative Related to joint entropy -channel input - channel output **Types of channel capacity :**(3M) Noise free channel Symmetric channel Binary symmetric channel Cascaded channel Binary erasure channel.
11	**Five source messages are probable to appear as m1=0.4, m2=0.15, m3=0.15, m4=0.15 and m5=0.15. Find coding efficiency for** **i) Shannon-Fano coding** **ii) Huffman coding. (13M)(Nov 2016)**BTL 3 **Answer: Page:187&193- Notes** **Explanation**: Arrange - given probabilities - decreasing order. (1M) Perform calculation. (8M) **Coding efficiency**:$\sum_{K=1}^{K} P_K L_K$=2.4 bits/symbol (4M)
12	**Describe the concept of channel capacity. (7M) (Nov 2014)**BTL 2 **Answer: Page:5.120-chitode** **Channel capacity**: Represents uncertainty-about channel input - resolved by observing -channel output. (2M) C=max I(X;Y), over all (p(x_1), $p(x_2), \ldots, p(x_m)$) **Explanation**:Channel capacity per second Capacities of Special channel Lossless Channel Deterministic Channel Noiseless Channel Binary Symmetric Channel(5M)
	PART * C
1	**Construct Shannon-Fano code for the given symbols {x1, x2….x6} with probabilities {0.3, 0.25, 0.2, 0.1, 0.1, and 0.05}.Also find the average code word length and the entropy of the source.** **Code word length** (3M) $\bar{L} = \sum_{i=1}^{N} p_i L_i$ **Entropy** (3M) $$H(S) = \sum_{i=1}^{N} p_i \log_2 \left(\frac{1}{p_i}\right)$$ **Efficiency** (2M) $\eta = \frac{H(S)}{\bar{L}}$
2	**A discrete memory less source emits five symbols with probabilities [0.4, 0.1, 0.2, 0.1, and 0.2].Find Shannon-Fano code and its average length.**

	Code word length (3M) $\bar{L} = \sum_{i=1}^{N} p_i L_i$ **Entropy** (3M) $$H(S) = \sum_{i=1}^{N} p_i \log_2\left(\frac{1}{p_i}\right)$$ **Efficiency** (2M) $\eta = \frac{H(S)}{\bar{L}}$
3	**A discrete memory less source emits five symbols with probabilities [0.4, 0.1, 0.2, 0.1, and 0.2].Find Huffman code and its length by placing the combined symbol as high as possible.** **Code word length** (3M) $\bar{L} = \sum_{i=1}^{N} p_i L_i$ **Entropy** (3M) $$H(S) = \sum_{i=1}^{N} p_i \log_2\left(\frac{1}{p_i}\right)$$ **Efficiency** (2M) $\eta = \frac{H(S)}{\bar{L}}$

UNIT II – WAVEFORM CODING& REPRESENTATION	
Prediction filtering and DPCM - Delta Modulation - ADPCM & ADM principles-Linear Predictive Coding- Properties of Line codes- Power Spectral Density of Unipolar / Polar RZ & NRZ – Bipolar NRZ - Manchester	
PART * A	
Q.No.	**Questions**
1.	**What is meant by Delta modulation systems? (April 2018)** BTL 1 DM is the one bit or 2 level version of DPCM, it provides the staircase approximation to the oversampled version of input baseband signal with step size $\Delta=2\delta$. Δ – Absolute value of representation. Thus, it encodes one bit per samples.
2	**Why delta modulation is superior to differential pulse code modulation? (April 2018)** BTL 2 Delta modulation encodes one bit per samples. Thus, signaling rate is reduced in DM. Hence **delta modulation is superior to differential pulse code modulation**
3	**What is slope overload distortion in delta modulation systems? (Nov 2017)**BTL 1 When the slope of the input signal X(t) is maximum and if the step size does not satisfy the expression $\frac{\delta}{Ts} \geq max\left\|\frac{dX(t)}{dt}\right\|$, then the step size is found to be too small to follow the steer segment of the input waveform. Thus, the representation u(t) falls below the signal x(t). this is called slope overload distortion in delta modulation systems.
4	**What is meant by granular noise in a delta modulation system? How it can be avoided? (April 2017)** BTL 1 It occurs when the step size is too large relative to the local slope characteristics of the signal x(t), thereby causing u(t) to hunt around the flat segment of input waveform. This can be avoided by reducing the step size of the quantizer.
5	**What is a linear predictor? On what basis are the predictor coefficients determined? (April 2017)** BTL 2 Prediction is a special form of estimation; the future sample of the process is predicted using finite set of present and past samples of the stationary process. If it is linear combination of given samples of the process then it is called linear prediction. $$\widehat{Xn} = \sum_{k=1}^{M} h_{ok}.x_{n-k},$$ Where,$h_{o1,}h_{o2,}h_{o3},\ldots.h_{oM}$are the optimum predictor coefficients.
6	**What is the need of prediction filtering? (Nov 2016)** BTL 2 Prediction filtering is used mostly in audio signal processing and speech processing for representing the spectral envelopment of a digital signal of speech in compressed form, using the information of a linear prediction model.
7	**How to overcome the slope overload? (Nov 2016)** BTL 2 This can be avoided by increasing the step size of the quantizer. (by Adaptive delta modulation)
8	**What are the advantages of delta modulator? (June 2016)** BTL 4 1. Delta modulation transmits only one bit for one sample. Thus, the signalling rate and transmission channel bandwidth is quite small for delta modulation. 2. The transmitter and receiver implementation are very much simple for delta modulation. There is no analog to digital converter involved in delta modulation

9	**Define APF and APB.(Nov 2015)** BTL 1 Adaptive Prediction with Forward Estimation: Unquantized samples of the input signal are used to derive the estimate of predictor coefficient. Adaptive Prediction with Backward Estimation: Quantized samples of the input signal are used to derive the estimate of predictor coefficient.
10	**Write the limitations of delta modulation. (Nov 2015)** BTL 1 1. Slope of overload distortion. 2. Granular noise.
11	**List any three speech encoding procedures. (June 2014)** BTL 1 1. Temporal waveform coding 2. Spectral waveform encoding 3. Model based encoding
12	**Mention the merits of DPCM.** BTL 2 1. Bandwidth requirement of DPCM is less compared to PCM. 2. Quantization error is reduced because of prediction filter 3. Numbers of bits used to represent one sample value are also reduced compared to PCM.
13	**What is the main difference between DPCM and DM?** BTL 2 DM encodes the input sample by one bit. It sends the information about + δ or -δ, i.e. step rise or fall. DPCM can have more than one bit of encoding the sample. It sends the information about difference between actual sample value and the predicted sample value.
14	**Mention the use of adaptive quantizer in adaptive digital waveform coding schemes.** BTL 2 Adaptive quantizer changes its step size according variance of the input signal. Hence quantization error is significantly reduced due to the adaptive quantization. ADPCM uses adaptive quantization. The bit rate of such schemes is reduced due to adaptive quantization.
15	**What do you understand from adaptive coding?** BTL 2 In adaptive coding, the quantization step size and prediction filter coefficients are changed as per properties of input signal. This reduces the quantization error and number of bits to represent the sample value. Adaptive coding is used for speech coding at low bits rates.
16	**What is meant by adaptive delta modulation?** BTL 1 In adaptive delta modulation, the step size is adjusted as per the slope of the input signal. Step size is made high if slope of the input signal is high. This avoids slope overload distortion.
17	**Define ADPCM.**BTL 1 It means adaptive differential pulse code modulation, a combination of adaptive quantization and adaptive prediction. Adaptive quantization refers to a quantizer that operates with a time varying step size. The autocorrelation function and power spectral density of speech signals are time varying functions of the respective variables. Predictors for such input should be time varying. So adaptive predictors are used.
18	**What is called Prediction error?** BTL 1 The difference between original sample and the predicted sample value is called Prediction error.It is denoted by £n. £n =Xn -$\widehat{Xn}$ Variance of prediction error $\sigma_E^2 = E[£n^2]$
19	**Differentiate voiced and unvoiced sounds.** BTL 2

Voiced sound	Unvoiced sound

These are produced by forcing air through the glottis with the tension of vocal track adjusted , so that they vibrate in a relaxation osillator.	These are generated by forming constriction at some point in vocal track and forcing air through the constriction at high velocity to produce turbulance.
It can be generated by a Impulse train generator excited with pitch period f0.	It can be generated by a random noise generator.
Eg. A, E,O	Eg, S, Sh

20 **What is linear DM?** BTL 1

A DM whch is using fixed step size value is called Linear DM.

21 **State the advantages of adaptive DM.** BTL 2

1. One bit per sample
2. Because of variable step size, Dynamic range is wide.
3. Better SNR than DM

22 **What are the disadvantages of adaptive DM?** BTL 2

1. Quantisation noise and granular noise is present.
2. Complex circuits for dulation and demodulation

23 **What should be the minimum bandwidth required to transmit a PCM signal?** BTL 2

$B_T = \upsilon W$, Where , υ - Number of bits required to represend one pulse.

W- Maximum Signal Frequency

24 **Compare PCM and DPCM.** BTL 2

PCM	DPCM
Large BW required	Less BW required
Poor SNR	Good SNR
Suitable for video and audio telephony	Suitable for video and speech signal

25 **What do the various autocorrelation coefficients represent in the power spectral density expression of a line code? Given the values of R10, R8, R50 and R200 and arrange them in the increasing order (April 2018) (Nov 2017)**BTL2

R8, R10, R50, R200.

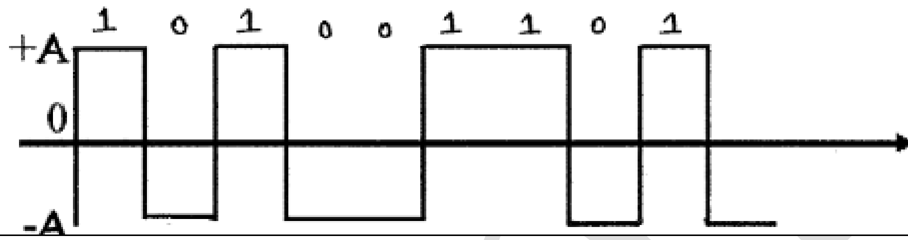
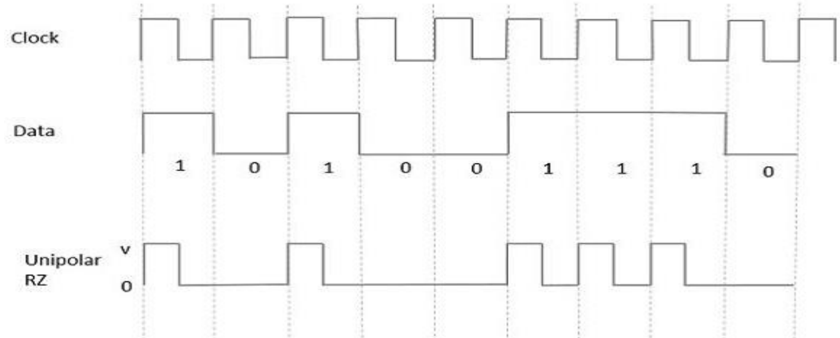
26 **State the desirable properties of line codes. (April 2017) (Dec-2012)**
What are the requirements of a line code? (June-2014)BTL1

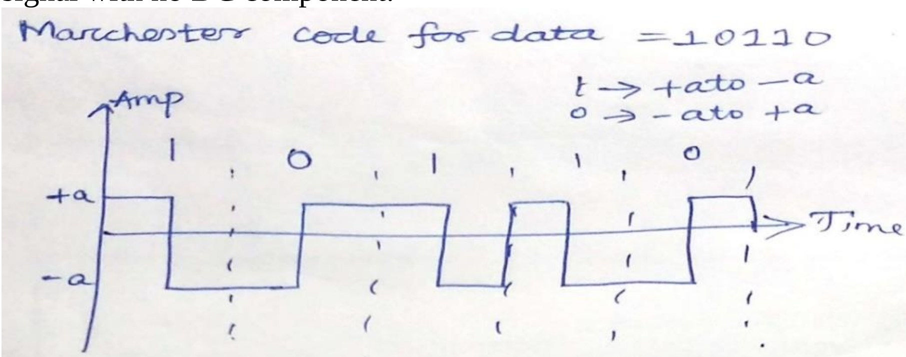
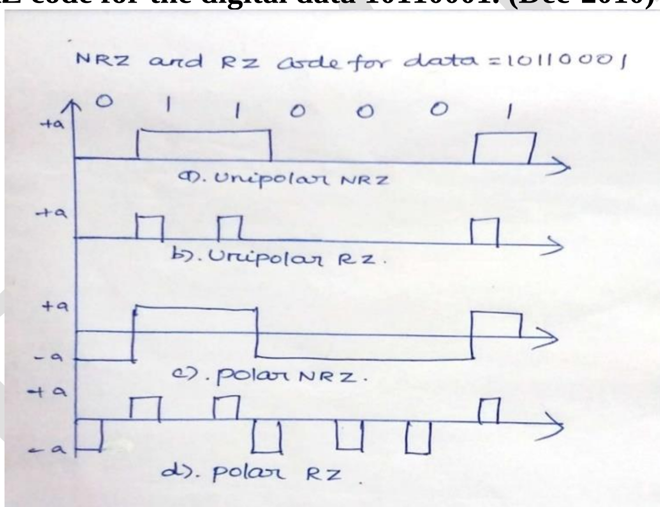
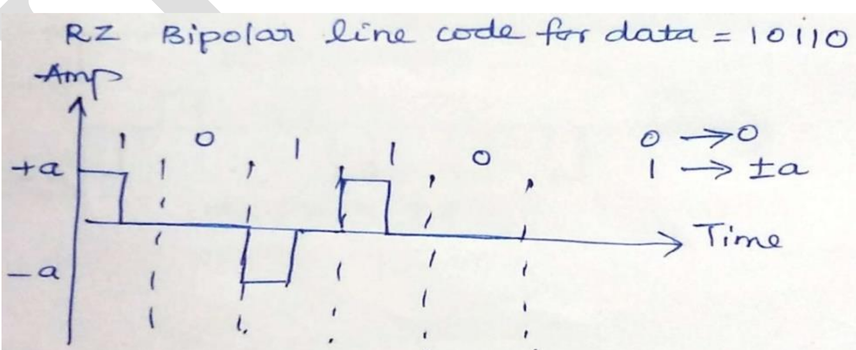
1. Error detection
2. Bandwidth compression
3. Noise immunity
4. Differential encoding
5. Transparency
6. DC Component

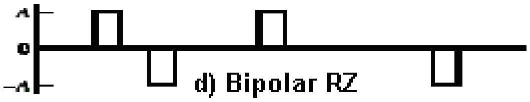
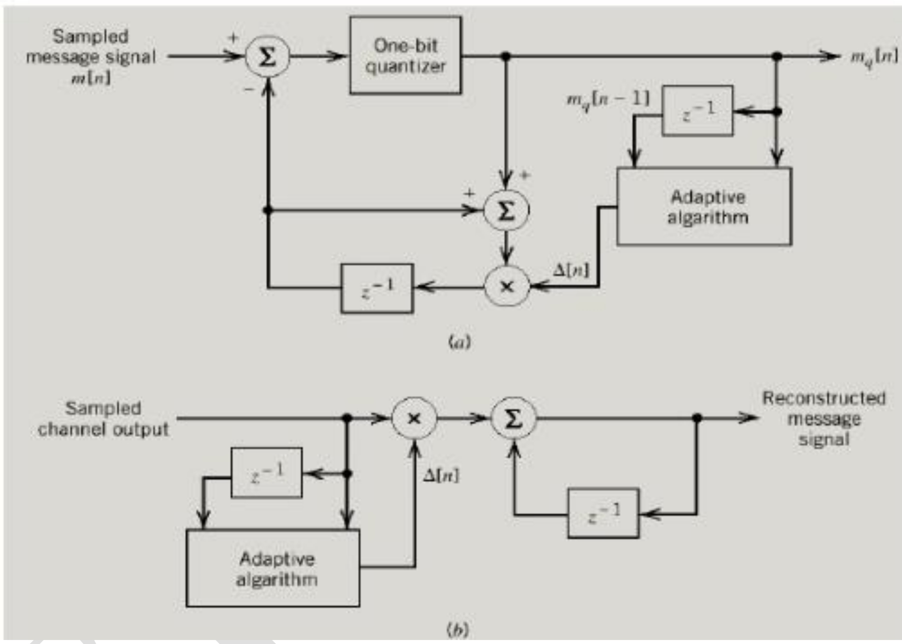
27 **Compare DM and ADM.** BTL 2

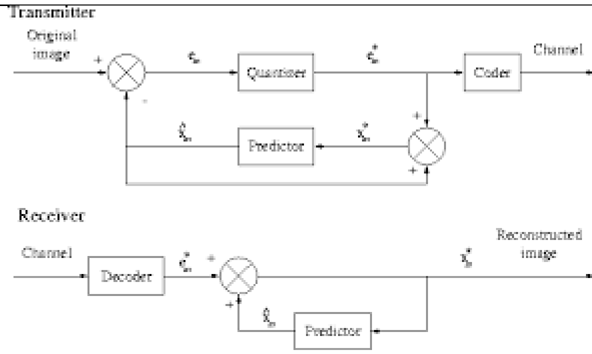
DM	ADM
It uses one bit per sample.	It uses one bit per sample.
Fixed step size	Variable step size
Less BW required.	Large BW required
Slope overload noise and granular noise is present.	Quantisation noise and granular noise is present.

	Simple circuits for modulation and demodulation.	Complex circuits for modulation and demodulation.

28	**Illustrate Polar NRZ type line coding for binary data transmission.**BTL1 When the pulse occupies full duration of the symbol, the unipolar format is said t be polar NRZ type. In this scheme signals are represented by, $S_1(t) = +a \quad 0 \le t \le T_b \quad for \quad Symbol\ 1$ $S_2(t) = -a \quad 0 \le t \le T_b \quad for \quad Symbol\ 0$ Example: 
29	**For the binary data 01101001 draw the unipolar RZ signal. (Nov 2016)**BTL6 
30	**What are line codes? Name some popular line codes. (June-2016) (Dec-2013)** BTL 1 A line code is a code chosen for use within a communications system for transmitting a digital signal down a line. Line coding is often used for digital data transport. Some line codes are digital baseband modulation or digital baseband transmission methods, and these are baseband line codes that are used when the line can carry DC components. NRZ–L, NRZ–M, RZ, Bipolar, Unipolar
31	**Define transparency of a line code. Give two examples of line codes which are not transparent. (June-2013) (May-2011)** BTL1 A line code should be so designed that the receiver does not go out of synchronization for any sequence of data symbols. A code is not transparent if for some sequence of symbols, the clock is lost. E.g. 1. Manchester Code 2. Bipolar code
32	**A 64-kbps binary PCM polar NRZ signal is passed through a communication system with a raised-cosine filter with roll-off factor 0.25. Find the bandwidth of the filtered PCM signal. (Dec-2012)** BTL3 Bit Rate (D) =64Kbps Roll off factor (α) =0.25

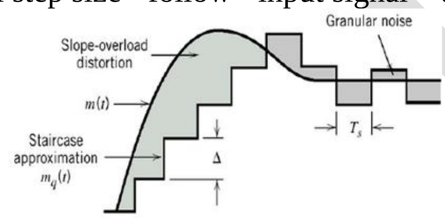
	Bandwidth W=1/2 *D(1+α) =40KHz.
33	**What is Manchester code? Draw the Manchester format for the data stream 10110. (May-2012)** BTL6 Manchester code (also known as Bi phase encoding,) is a line code in which the encoding of each data bit is either low then high, or high then low, for equal time. It is a self-clocking signal with no DC component. 
34	**Draw the NRZ and RZ code for the digital data 10110001. (Dec-2010)** BTL6 
35	**Draw RZ bipolar line code for the digital data 10110. (Dec-2011)** BTL6 
36	**Draw the RZ-Bipolar line code format for the information (01101001). (Dec 2011)** BTL6

	
	PART*B
1	**Explain the construction features and working of adaptive delta modulation. (13M)(April 2018)**BTL 1 **Answer: Page 208 - S. Haykin** **Definition**: Step size adapted - avoid slope overload distortion - granular noise. (2M) **Block Diagram**: Transmitter: One bit Quantizer- Adaptive Algorithm for step change (2M) Receiver: Reconstruction – Inverse adaptive algorithm (2M)  **Explanation:** (5M) $\delta min \leq \delta(nTs) \leq \delta max$ (2M) δmax- controls slope overload distortion δmin: controls granular noise
2	**Elucidate the DPCM system. Derive an expression of slope overload noise of the system.(13M)(April 2018)** BTL 2 **Answer: Page 200 - S. Haykin** **DPCM**: More than one bit - encode sample- Sends information - difference between actual sample values - predicted sample value. (2M) **Block Diagram:** (2M)



Explanation: Transmitter: Quantizer- Prediction filter- Encoder. Receiver: Decoder – Prediction Filter (5M)

Slope overload distortion: Small step size - follow - input signal – u(t) falls behind x(t) (2M)



Signal To Noise Ratio: Input to quantizer signal: e(nTs)=x(nTs)-$\hat{x}(nTs)$ (2M)

Output v(nTs)=e(nTs)+q(nTs)

3

Explain the noises in delta modulation systems. How to overcome this effect in Delta modulation? (8M) (June2012) BTL 2

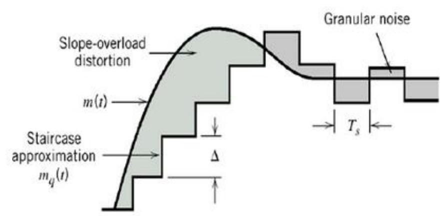
Answer: Page 199 - S. Haykin

Noises in delta modulation systems

Granular Noise – During constant input – step size – to be reduced (2M)

Slope overload distortion- During Steep slope- Step size- to be increased (2M)

Diagram: (2M)



Method to overcome Noises: Adaptive Delta Modulator – Variable step size – Based on Input – Step size – increased- steep slope – decreased – constant input. (2M)

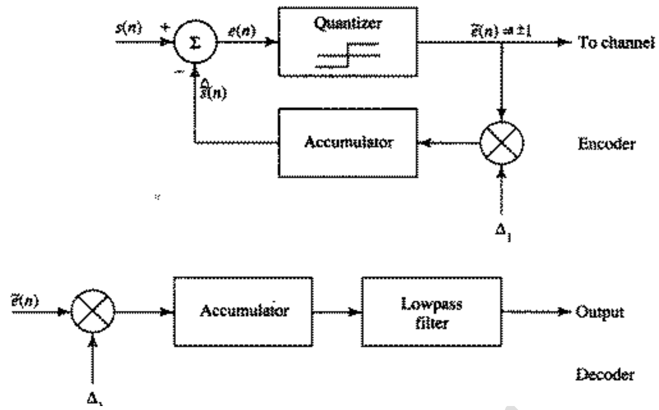
4

Describe delta modulation system in detail with a neat block diagram. Also, illustrate the two forms of quantization error in delta modulation.(13M) (Nov 2016)BTL 2

Answer: Page 198 - S. Haykin

Delta Modulator:One bit or 2 level DPCM version- provides staircase approximation - oversampled version of input baseband signal - step size Δ=2δ.(2M)

Block Diagram:(4M)



Explanation:Δ – Absolute value - representation- Encodes one bit per samples- Reduced signaling rate. (3M)

Quantization errors in DM:

Granular Noise – During constant input – step size – to be reduced (2M)

Slope overload distortion- During Steep slope- Step size- to be increased (2M)

5 **A delta modulator with affixed step size of 0.75v, is given a sinusoidal message signal. If the sampling frequency is 30 times the Nyquist rate, determine the maximum permissible amplitude of the message signal if slope overload is to be avoided. (13M) (April 2016)**BTL 3

Answer: Page 203 - S. Haykin

Step size = 0.75v

Sampling Frequency = 30* Nyquist Rate(4M)

Nyquist Rate (4M)

Maximum Permissible amplitude to avoid Slope overload distortion (5M)

6 **How the adaptive time domain coder codes the speech at low bit rates?Compare it with frequency domain coder.(13M) (Nov-2015)** BTL 3

Answer: Page 208 - S. Haykin

Adaptive time domain coder: Encoding – Time domain- Examples – Delta Modulation- Adaptive Delta Modulation- ADPCM, DPCM, PCM- Also Called- Temporal Waveform Coding. (5M)

Frequency domain coder: Encoding – Frequency domain- Sub band Coding. (5M)

Comparison: Frequency domain coding- Simpler- Easy to process. (3M)

7 **Describe the linear predictive coding technique in Speech encoding.(8M) (June-2014)**BTL 1

Answer: Page 109, 114 - S. Haykin

Definition: Prediction based - present input - past output values.(2M)

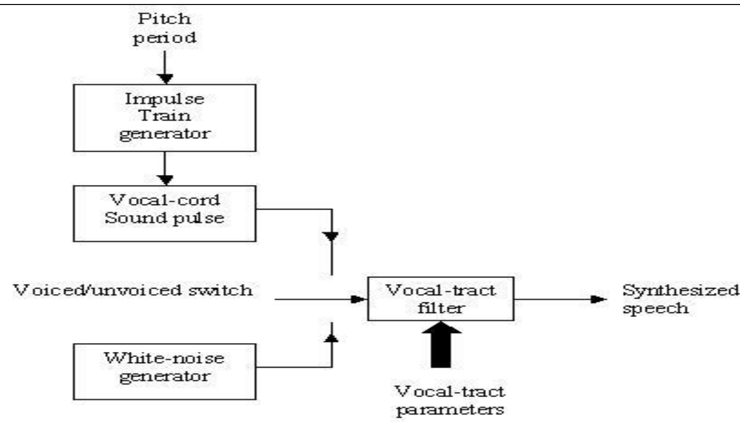
Speech encoding method: Linear Predictive Vocoders – Voiced – Unvoiced sound- difference (2M)

Filter coefficients: Vocal Tract Filter (2M)

Synthesis/analysis Block Diagram & Explanation: (2M)

Voiced Sound- Periodic- Pitch frequency- generated by- Impulse train generator.

Unvoiced Sound- Aperiodic – no pitch frequency-generated – White noise generator.



Block diagram of simplified model for the speech production process

8

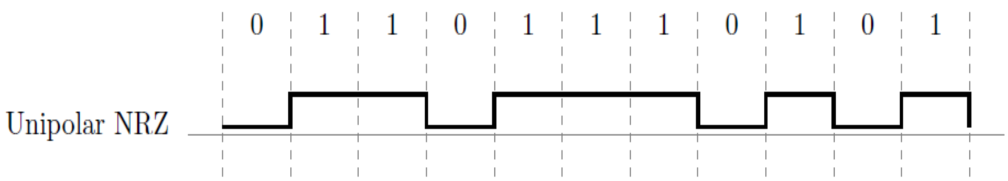
What is the need for line shaping of signals? Derive the PSD of a unipolar RZ and NRZ line code and compare their performance. (13M) (April 2018) (Nov 2017) (Dec-2016) BTL1
Determine the power spectral density for NRZ bipolar and unipolar formats. Assume that 1's and 0's in the input binary data occur with equal probability. (6M) (Dec-2015)
Answer: Page 239 - S. Haykin
Derive the expression for power spectral density of unipolar NRZ line code. Explain its characteristics. (15M) (Dec-2012) BTL2

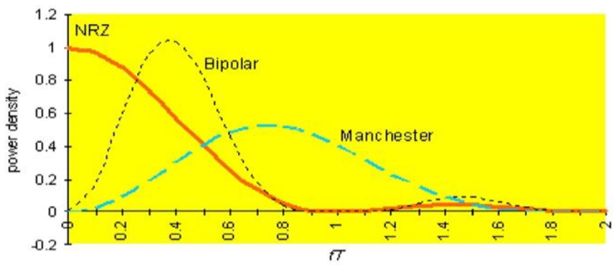
Need for line shaping methods: Suitable form – communication (4M)
Power spectral density: RZ - NRZ line code - graph – performance (4M)
PSD of unipolar NRZ Sx(f)=$\frac{a^2Tb}{4}sinc^2(fTb)+\frac{a^2}{4}\delta(f)$ (3M))
PSD of unipolar RZ Sx(f) =1/T$|v(f)|^2\sum_{n=-\infty}^{\infty}RA(n)\exp(-j2\pi nfT)$(2M)

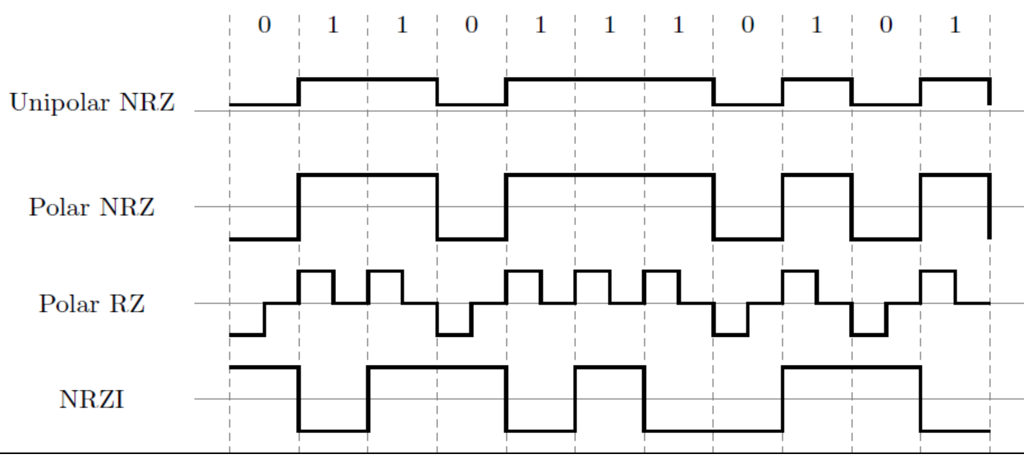
9

Derive the power spectral density of unipolar NRZ data format and list its properties. (13M) (April 2017) BTL4
Answer: Page 239 - S. Haykin

Definition: Unipolar NRZ – symbol 0 – 0 – symbol 1- Amplitude- 'a' (2M)
PSD of unipolar NRZ and Graph Sx(f)=$\frac{a^2Tb}{4}sinc^2(fTb)+\frac{a^2}{4}\delta(f)$ (4M+2M)
Properties of line codes: Transparency- Dc component -Differential encoding- self synchronization- BW Compression – Error detection- Noise immunity – Spectral Compatibility (3M)
Example: **(2M)**



<table>
<tr><td>10</td><td>
Sketch the power spectra of (a) Polar NRZ and (b) bipolar RZ signals (10) (May-2016) BTL6
Answer: Page 240 - S. Haykin
Definition (2M+2M)
1. Polar NRZ: binary 1‟s -represented - pulsep(t) - binary 0‟s - represented - negative -pulse -p(t)
2. Bipolar RZ: Alternate binary 1‟s -represented - pulsep(t) & negative - pulse -p(t) -binary0‟s - represented – 0.
Power spectral density:
For polar NRZ $Sx(f)=a^2TbSinc^2(fTb)$ (2M)
Bipolar RZ $Sx(f) = a^2TbSinc^2(fTb)sin^2(\pi fTb)$ (2M)
Graph: (2M)


</td></tr>
<tr><td>11</td><td>
Compute the various line coding techniques and list their merits and demerits. (13M) (May-2016) BTL6
Answer: Page 234 - S. Haykin
Definition of line coding: Transmitting - digital signal - down a line. Line coding - used - digital data transport. Some line codes - digital baseband modulation - digital baseband transmission methods. (2M)
Types: NRZ–L, NRZ–M, RZ, Bipolar, Unipolar. (1M)
Example Waveform: (2M)


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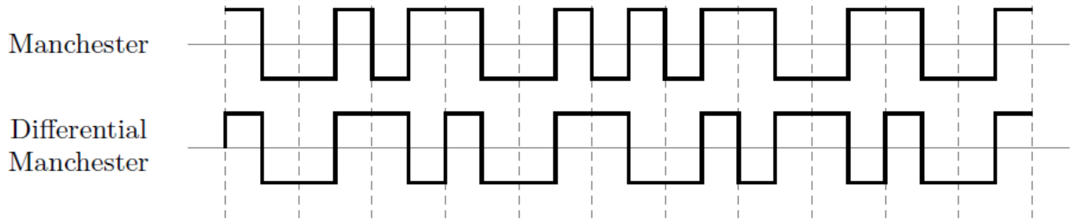


Unipolar – RZ and NRZ: (2M)

ADVANTAGES	DISADVANTAGES
1. Simplicity 2. No DC component	1. Can contain low-frequency components (leads to signal drooping) 2. No clocking component to synchronize to at receiver 3. No error correction capability

Polar – RZ and NRZ: : (2M)

ADVANTAGES	DISADVANTAGES
1. Simplicity 2. No DC component	1. Can contain low-frequency components (leads to signal drooping) 2. No clocking component to synchronize to at receiver 3. No error correction capability

Bipolar RZ: : (2M)

ADVANTAGES	DISADVANTAGES
1. No DC component 2. No signal droop problem	1. No clocking component to synchronize to at receiver 2. Limited error correction capability

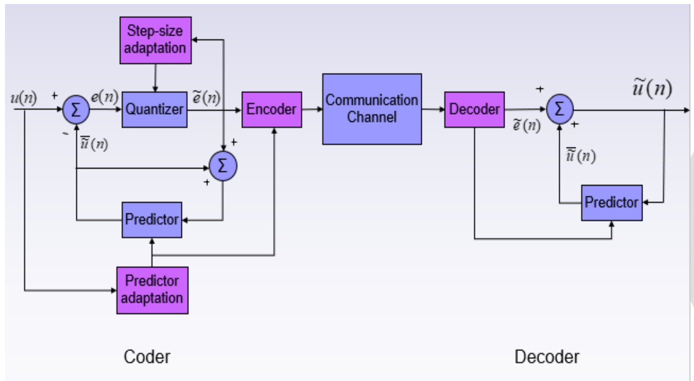
Manchester Coding: : (2M)

ADVANTAGES	DISADVANTAGES
1. No DC component 2. No signal droop problem 3. Easy to synchronize to the waveform	1. Greater bandwidth required for this waveform 2. No error correction capability

PART * C

1 **State in your own words the functioning of ADPCM system with block diagram.(15M) (April 2016)**BTL 2
Answer: Page. 211 - S. Haykin

ADPCM: Adaptive differential pulse code modulation- combination of adaptive quantization - adaptive prediction. - operates with a time varying step size.
Autocorrelation function - power spectral density - speech signals - time varying functions - the respective variables. Predictors - time varying – requireadaptive predictors.(4M)

<table>
<tr><td></td><td>Block Diagram& Explanation:(4M+7M)
Transmitter: Quantizer-Adaptive Predictor- Step size controller-Encoder.
Receiver: Decoder-Predictor- destination.

</td></tr>
<tr><td>2</td><td>In a single integration DM scheme the voice signal is sampled at a rate of 64Khz, the maximum signal amplitude is 1v, voice signal bandwidth is 3.5 KHz .
(i) Determine the minimum value of step size to avoid slope overload (5M)
(ii) Determine the granular noise (5M)
(iii) Assuming the signal to be sinusoidal, calculate the signal power and signal to noise ratio. (5M)BTL5
Answer: Page 203 - S. Haykin

Sampling Rate = 64KHz
Maximum signal Amplitude = 1v
Channel Bandwidth = 3.5KHz
Step size $\Delta=2\delta$
Nyquist Rate = sampling rate =64KHz (2M)
Slope overload amplitude avoided.(3M)
Granular Noise (5M)
Signal to Noise Ratio (5M)</td></tr>
<tr><td>3</td><td>A 1 KHz signal of voice channel is sampled at 4KHz using 12-bit PCM and a DM system. If 25 cycles of voice signal are digitized. Solve in each case.
(i) Signalling rate (5M)
(ii) Bandwidth required (5M)
(iii) No of bits required to be transmitted. (5M)BTL6
Answer: Page 203 - S. Haykin

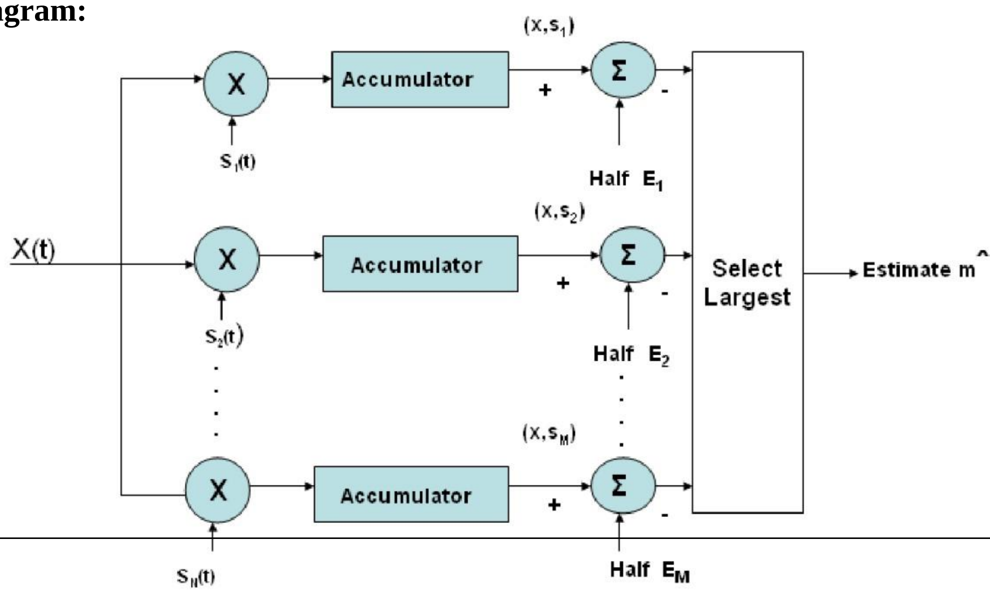
Sampling Rate = 4KHz
Voice Signal = 1KHz
PCM Bit = 12
Cycles digitized = 25
No of bits/sample (5M)
Signaling Rate (5M)
Bandwidth required (5M)</td></tr>
</table>

UNIT III – BASEBAND TRANSMISSION& RECEPTION	
ISI – Nyquist criterion for distortion less transmission – Pulse shaping – Correlative coding -Eye pattern - Receiving Filters- Matched Filter, Correlation receiver, Adaptive Equalization.	
PART * A	
Q.No.	**Questions**
1.	**State Nyquist second and third criteria to realize zero ISI. (April 2018) (Nov 2017)** **State Nyquist criteria for zero ISI. (Dec-2011)**BTL1 Zero ISI can be obtained if the transmitted pulse satisfies the following condition Time domain $$p[(i-k)Tb] = \begin{cases} 1, & i = k \\ 0, & i \neq k \end{cases}$$ Frequency Domain $$\sum_{N=-\infty}^{\infty} P(f - nfb) = Tb$$
2	**Define correlative level coding. (Nov 2016)**BTL1 Correlative level coding is used to transmit a baseband signal with the signaling rate of 2Bo over the channel of bandwidth Bo. This is made physically possible by allowing ISI in the transmitted in controlled manner. This ISI is known to receiver. The correlative coding is implemented by duo binary signaling and modified duo binary signaling.
3	**What is ISI and what are the causes of ISI? (June-2016) (Dec-2014) (June-2014)** BTL 1 In baseband binary PAM, symbols are transmitted one after another. These symbols are separated by sufficient time durations. The transmitter, channel and receiver acts as a filter to this baseband data. Because of the filtering characteristics, transmitted PAM pulses spread in time. The presence of outputs due to other bits interference with the output of required bit. This effect is called ISI. The receiving filter output y(t) sampled at time ti=iTb of a baseband system is $$y(t_i) = \mu \sum_{k=-\infty}^{\infty} a_k P(iT_b - kT_b)$$ $$= \mu a_i + \mu \sum_{\substack{k=-\infty \\ i \neq k}}^{\infty} a_k P(iT_b - kT_b)$$
4	**Give three applications of eye pattern. (June-2015)** **What is the information that can be obtained from eye pattern regarding the signal quality? (May-2012)** **What is the use of eye pattern? (Dec-2013)** **State any two applications of eye pattern. (Dec-2012) (May-2011)** BTL2 Eye pattern is used to study the effect of ISI in baseband transmission. 1. Width of eye opening defines the interval over which the received wave can be sampled without error from ISI. 2. The sensitivity of the system to timing error is determined by the rate of closure of the eye as the sampling time is varied. 3. Height of the eye opening at sampling time is called margin over noise.
5	**What is the function of an equalizing filter? (Dec-2014)** BTL1 Equalizing filter in the receiver cancels any residual ISI present in the received signal and

	presents an ISI free signal to the detector block
6	**'ISI can-not be avoided'. Justify the statement. (June-2013)** BTL2 One can combat noise by increasing signal power, but no one can combat with ISI by increasing signal energy over noise energy. The only way to mitigate ISI is to use the proper pulse shaping filters. Thus, ISI cannot be completely avoided but it can be controlled.
7	**State Roll off factor in raised cosine spectrum. BTL1** It specifies the ratio of extra BW required for the pulses compared to the minimum BW required by the sinc function. $r = \frac{\text{Excess Bandwidth}}{\text{Minimum Bandwidth}} = \frac{\omega_x}{\omega_b/2} = \frac{2\omega_x}{\omega_b}$.
8	**What is the necessity of equalization?** BTL1 When the signal is passed through the channel distortion is introduced in terms of 1) Amplitude 2) Delay this distortion creates problem of ISI. The detection of the signal also becomes difficult this distraction can be compensated with the help of equalizer.
9	**How does pulse shaping reducing inter symbol interference? (Dec-2010)** BTL1 The shape of the pulse is selected such that the instant of detection, the interference due to all other symbol is zero. The effect of ISI eliminates if the signal is sampled at Tb,2Tb,3Tb… and so on.
10	**How is eye pattern obtained on the CRO? (May 2009)** BTL2 Eye pattern can be obtained on CRO by applying the signal to one of the input channels and given an external trigger of 1/T*b* Hz. This makes one sweep of beam equal to T*b* seconds.
11	**Define Duo binary baseband PAM system**. BTL2 Duo binary encoding reduces the maximum frequency of the baseband signal. The word duo means to double the transmission capacity of the binary system. Let the PAM signal a_k represents kth bit. Then the encoder the new waveform as $C_k = a_k + a_{k-1}$ Thus, two successive bits are added to get encoded value of the kth bit. Hence C_k becomes a correlated signal even though $a_k$is not correlated. This introduces intersymbol interference in the controlled manner to reduce the bandwidth.
12	**What is an ideal Nyquist channel? (Nov 2006)** BTL1 For an ideal Nyquist channel, the transmission bandwidth (B0) is given by half the bit rate (Rb). The frequency function P(f) occupying the narrowest band is $P(f) = \frac{1}{2B_0} rect\left(\frac{f}{2B_0}\right)$
13	**Write the performance of data transmission system using eye pattern technique?** BTL1 The width of the eye opening defines the interval over which the received wave can be sampled without error from inter symbol interference. The sensitivity of the system to timing error is determined by the rate of closure of the eye as the sampling time is varied
14	**Why do you need adaptive equalization in a switched telephone network?** (Nov-Dec 2005) BTL2 In switched telephone network the distortion depends upon 1) Transmission characteristics of individual links.

	2) Number of links in connection. Hence fixed pair of transmit and receive filters will not serve the equalization problem. The transmission characteristics keep on changing. Therefore, adaptive equalization is used.
15	**What is meant by a matched filter?**BTL 2 Matched filter is used for detection of signal in base band and pass band transmission. A filter whose impulse response is a time reversed & delayed version of some signal, then it is said to be matched to correspondingly, the optimum receiver based on the detector is referred to as the matched filter receiver. A filter that maximizes the output signal to noise ratio is called matched filter.
16	**What is an optimum filter?**BTL 1 It is the filter which has minimum probability of error caused by noise.
17	**What is meant by coherent receiver?**BTL 1 Coherent detection is a technique in which the receiver is time synchronized with transmitter and assumed to be locked in phase with the transmitter. Such a receiver is known as coherent receiver.
18	**What is correlation receiver?**BTL 1 Consider a binary communication system in which the transmitter gives out one of the two signals Xo(t) and X1(t) whose waveforms are known completely. The receiver in which the received signal y(t) is cross correlated with the signals Xo(t) and X1(t) is known as correlation receiver.
19	**How the impulse response of the optimum filter is related to the input signal?** BTL 2 The impulse response is equal to the input signal displaced to a new origin at t=to and folded about this point so as to run backward. Hopt(t) = K x(to-t)
20	**What is equalizer?)Nov/Dec 13(---**BTL1 The device which equalizes the dispersive effect of a channel is referred to as an equalizer (or) to compensate the ISI
21	**Define adaptive equalizer.**BTL1 To combat ISI, the equalizer coefficients should change according to the channel status so as to track the channel variations. Such an equalizer is called an adaptive equalizer since it adapts to the channel variations.
22	**What are the operating modes available in an adaptive equalizer?**BTL1 Training and tracking modes.
23	**What is training mode in an adaptive equalizer?**BTL3 First, a known fixed length training sequence is sent by the transmitter, then the receiver's equalizer may adapt to a proper setting of minimum bit error rate detection, where the training sequence is pseudorandom binary signal or a fixed and prescribed bit pattern.
24	**What is tracking mode in an adaptive equalizer?**BTL1 Immediately following the training sequence, the user data is sent, and the adaptive equalizer at the receiver utilizes a recursive algorithm to evaluate the channel and estimate filter coefficients to compensate for the distortion created by multipath in the channel
25	**Write a short note on i(linear equalizers ii(non-linear equalizers.**BTL1 If the output is not used in the feedback path to adapt, then this type of equalizer is called linear equalizer. If the output is fed back to change the subsequent outputs of the equalizer, this type of equalizer is called nonlinear equalizers.
26	**Why nonlinear equalizers are preferred?** BTL1

	The linear equalizers are very effective in equalizing channels where ISI is not severe. The severity of ISI is directly related to the spectral characteristics. In this case there are spectral nulls in the transfer function of the effective channel; the additive noise at the receiver input will be dramatically enhanced by the linear equalizer. To overcome this problem, nonlinear equalizers can be used.
27	**What is the nonlinear equalization methods used?** BTL1 Decision feedback equalization)DFE(, Maximum likelihood symbol detection and Maximum likelihood sequence estimation)MLSE(.
28	**Write the basic algorithms used for adaptive equalization.**BTL 2 Zero forcing algorithm)ZF(, least mean square algorithm)LMS(and recursive least square algorithm)RLS(.
	PART*B
1.	**Explain correlator type receiving filter in detail. (100M)** **Answer: Page 243 - S. Haykin** **Introduction:**For an AWGN channel - when the transmitted signals - equally likely, the optimum receiver consists of **two subsystems** **(2M)** 1) Receiver consists of a bank of M product-integrator or correlatorsΦ1(t),Φ2(t) …….ΦM(t) orthonormal function (2M) 2)The bank of correlator operate on the received signal x(t) to produce observation vector x Implemented in the form of maximum likelihood detector that operates on observationvector x to produce an estimate of the transmitted symbol mi i = 1 to M, in a way that would minimize the average probability of symbol error. (2M) The N elements of the observation vector x are first multiplied by the corresponding N elements of each of the M signal vectors s1, s2… sM , and the resulting products are successively summed in accumulator to form the corresponding set ofInner products {(x, sk)} k= 1, 2 ..M. The inner products are corrected for the fact that the transmitted signal energies may be unequal. Finally,the largest in the resulting set of numbers is selected and a corresponding decision on the transmitted message made. The optimum receiver is commonly referred as a correlation receiver. (2M) **Block Diagram:** **(2M)**



Vector Receiver

2.

What is ISI and what are the various methods to remove ISI in communication system. Also, state Nyquist first criterion for zero ISI. (13M) (April 2018) BTL1
Answer: Page 243 - S. Haykin

Definition of ISI: Transmitted PAM pulses- spread in time. Presence - outputs - other bits interference with - output - required bit - ISI. Receiving filter output y(t) - sampled at time ti=iTb (2M)

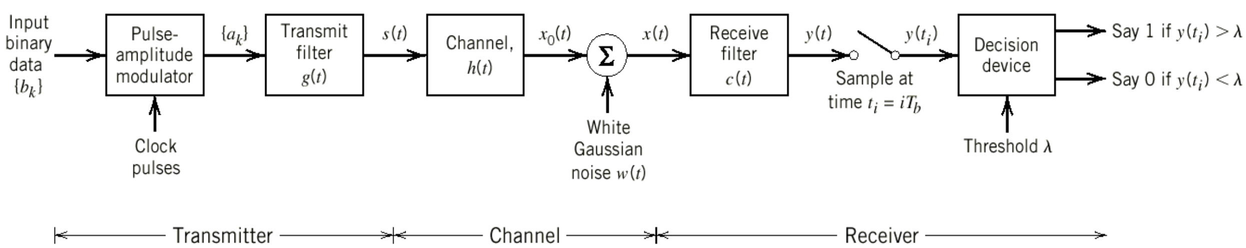
Expression for ISI:

$$y(t_i) = \mu \sum_{k=-\infty}^{\infty} a_k P(iT_b - kT_b)$$

$$= \mu a_i + \mu \sum_{\substack{k=-\infty \\ i \neq k}}^{\infty} a_k P(iT_b - kT_b)$$

(2M)

Block diagram (2M)



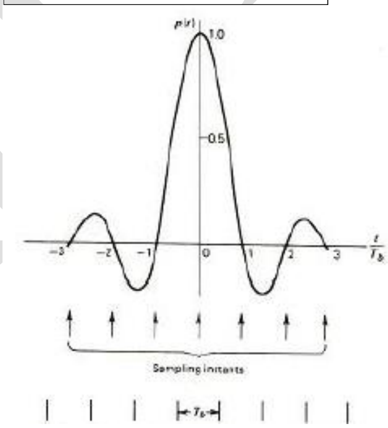
Methods to remove ISI-Nyquist Criterion: (2M)

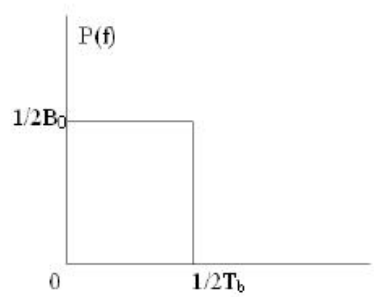
1. Ideal Solution
2. Practical Solution

Nyquist first criterion for zero ISI: (2M)

$$P(f)\begin{cases} \dfrac{1}{2W}, & -W < f < W \\ 0, & |f| > W \end{cases} = \frac{1}{2W} rect(\frac{f}{2W})$$

$$\sum_{n=-\infty}^{\infty} P(f - nR_b) = T_b$$





Amplitude Response

Explanation: (3M)

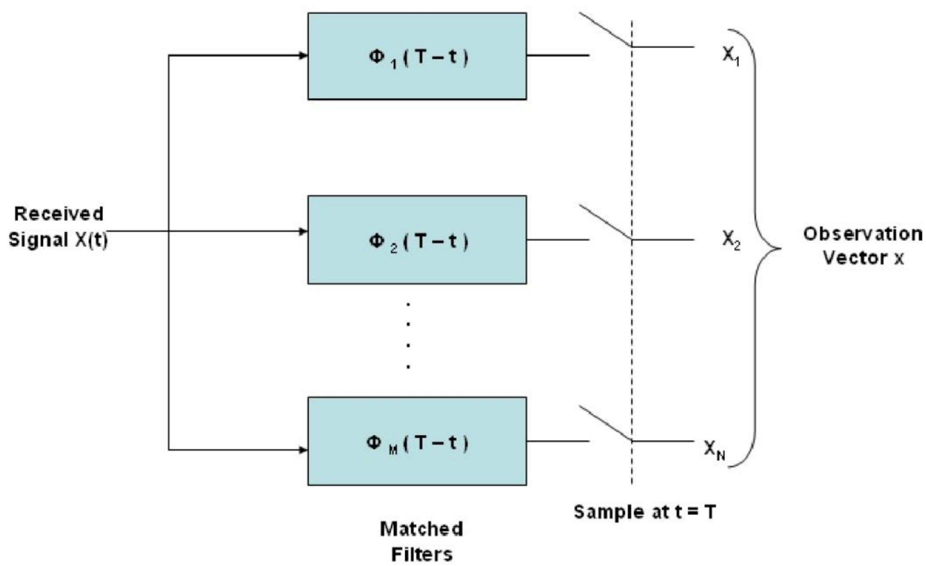
Pulse shaping- remove ISI – ideal solution- rectangular pulse- sinc function.

3

Explain Matched filter type receiving filter in detail.

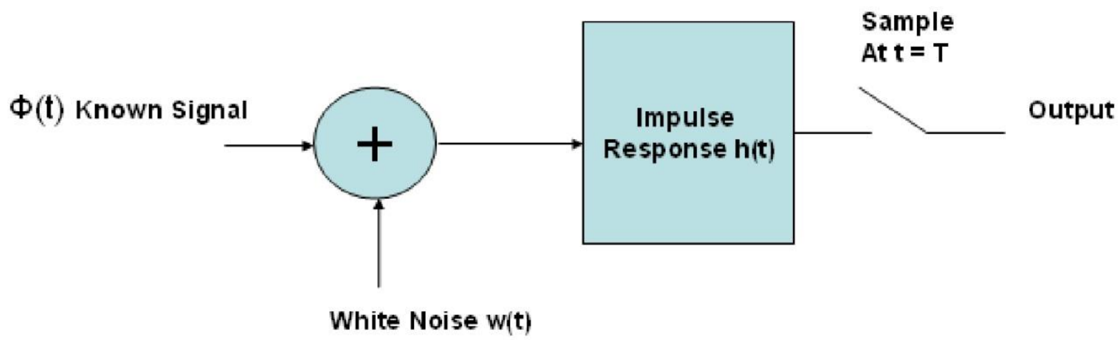
Definition: A filter whose impulse response is time reversed and delayed version of the input signal is said to be matched with the $\Phi_j(t)$ correspondingly. Then the filter is called as matched filter receiver. (2M)

Block Diagram: (2M)



Detector Part Of Matched Filter Receiver

Matched Filter: (2M)



$\Phi(t)$ = input signal; $h(t)$ = impulse response; $W(t)$ =white noise

Properties: (4M)

1. The spectrum of the output signal of a matched filter with the matched signal as input is,except for a time delay factor, proportional to the energy spectral density of the input signal.
2. The output signal of a Matched Filter is proportional to a shifted version of the

autocorrelation function of the input signal to which the filter is matched.

3. The output Signal to Noise Ratio of a Matched filter depends only on the ratio of the signal energy to the power spectral density of the white noise at the filter input
4. The Matched Filtering operation may be separated into two matching conditions; namely spectral phase matching that produces the desired output peak at time T, and the spectral amplitude matching that gives this peak value its optimum signal to noise density ratio.

4

What is “raised cosine spectrum”? Discuss how does it help to avoid ISI? (6M) (April 2017) BTL1

Answer: Page 245 - S. Haykin

Drawback of ideal solution: Sudden transition - Not possible practically - Ideal solution- Raised cosine spectrum needed. (2M)

Raised Cosine Spectrum: Design raised cosine filter - transfer function - flat portion - roll off portion - sinusoidal form.Bandwidth Bo=1/2Tb - adjustable - between Bo - 2Bo- to avoid ISI

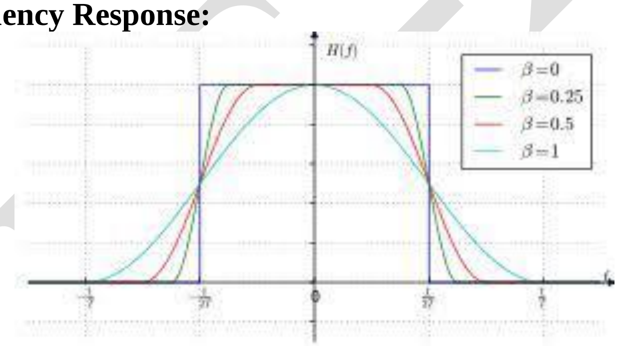
$$P(f)=\begin{cases}\dfrac{1}{2W}, & 0\le |f|<f_1\\[2mm] \dfrac{1}{4W}\left\{1-\sin\left[\dfrac{\pi(|f|-W)}{2W-2f_1}\right]\right\}, & f_1\le |f|<2W-f_1\\[2mm] 0, & |f|\ge 2W-f_1\end{cases}$$

(2M)

$$\alpha = 1-\frac{f_1}{B_0}$$

α is called the **roll off factor**

Frequency Response: (2M)



5

Describe how eye pattern is helpful to obtain the performance of the system in detail with a neat sketch. (10) (Dec-2016) (Dec-2015) (Dec-2014) Page 261 - S. Haykin BTL4

List the inferences made from eye pattern (4) (May-2014) BTL1

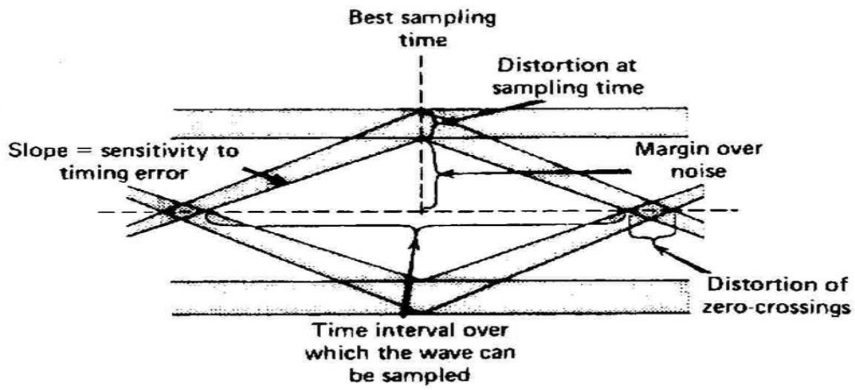
Answer: Page 261 - S. Haykin

Definition: Study - effect of ISI - baseband transmission. (2M)

Inferences made: (4M)

1. Width - eye opening - interval - received wave - sampled -without error - ISI.
2. The sensitivity - system - timing error - rate of closure - eye - sampling time is varied.
3. Height - eye opening -sampling time - margin over noise.

Diagram (4M)



Interpretation of the eye pattern.

6

Draw the block diagram of duo binary signaling scheme without and with precoder and explain. (13M) (May-2016) (May-2012) BTL6

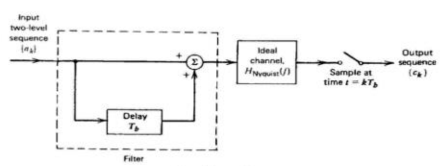
Answer: Page 252 - S. Haykin

Definition: Duobinary encoding - reduces - maximum frequency - baseband signal. Duo - double - transmission capacity. (1M)

Explanation:

PAM signal - ak represents -kth bit. Encoder - new waveform - C*k* =a*k* + ak-1. two successive bits -added - encoded value - kth bit. - Ck - correlated signal - a*k*is not correlated. - introducesintersymbol interference - controlled manner - reduce the bandwidth. (2M)

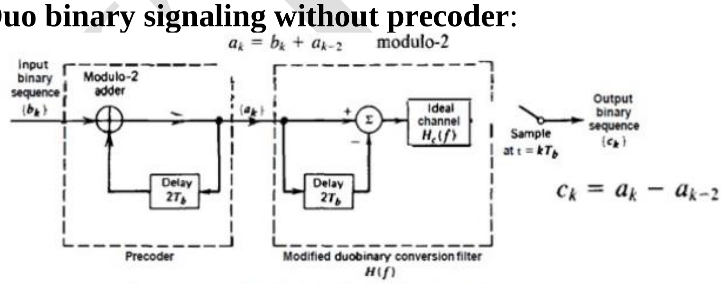
Block diagram: (2M)



Duobinary signaling scheme.

Ck=bk+bk-1 (2M)

Duo binary signaling without precoder: (2M)



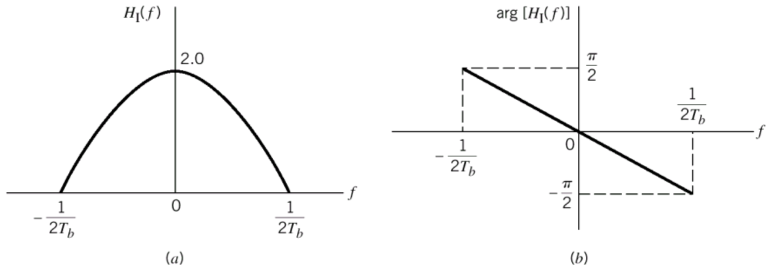
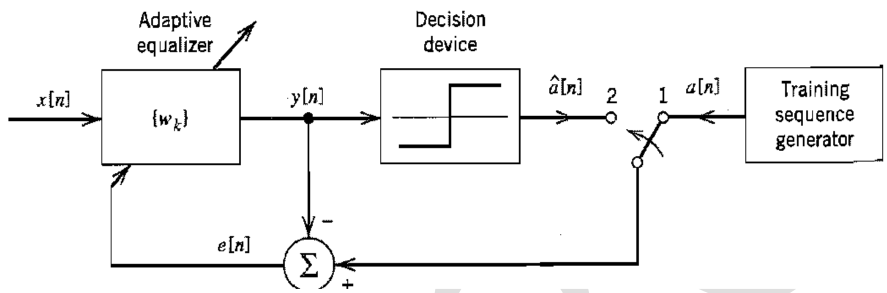
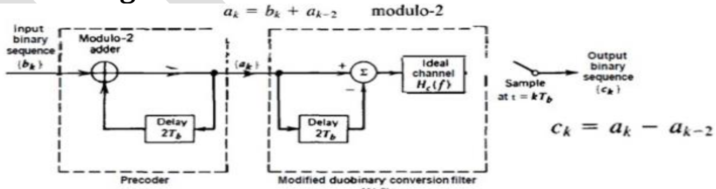
Modified duobinary signaling scheme.

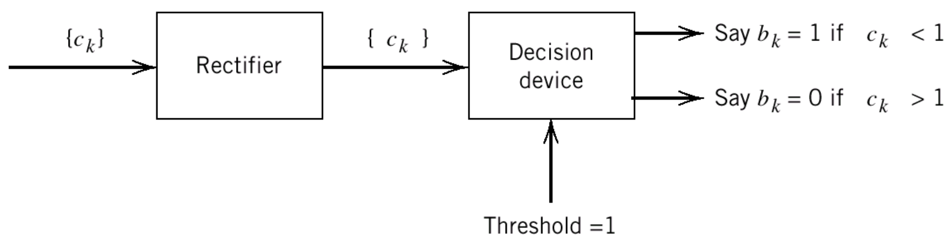
Ak=bk+ak-1 (Modulo-2) (1M)

Ck=ak+ak-1 (1M)

$$H_I(f) = \begin{cases} 2\cos(\pi f T_b)\exp(-j\pi f T_b), & |f| \le 1/2T_b \\ 0, & \text{otherwise} \end{cases}$$

(2M)

	
7	**Explain the adaptive equalization with the block diagram. (8M) (May-2016) (Dec-2015)**BTL1 **Answer: Page 263 - S. Haykin** **Definition:** Equalizing - vatiations -channel -adaptivelly. (2M) **Block diagram**: (2M)  e(nT)=b(nT)-y(nT) (1M) **Explanation**: (3M) **Two modes** 1. Training mode (position 1) – Decision made by receiver. 2. Decision-directed mode (position 2) - if μ - too large, high excess mean-square error - μ too small, a *too-slow tracking*
8	**Describe modified duo binary coding technique and its performance by illustrating its frequency and impulse responses. (13M) (Dec-2015)** **Draw the block diagram of modified duo binary signaling scheme without and with precoder and explain. (13M) (Dec-2012)** BTL2 **Answer: Page 257 - S. Haykin** **Definition**: Precoder - included to avoid error propagation. (2M) **Block diagram**: (3M) $a_k = b_k + a_{k-2}$ modulo-2  Modified duobinary signaling scheme. ak=bk+ak-1 (Modulo-2) (2M) ck=ak+ak-1 (2M) **Frequency and impulse response**: (2M) $\Rightarrow H_{MDuoB}(f) = 1 - \exp(-j4\pi f T_b)$

	$$\Rightarrow \begin{cases} \bar{S}_Y(f)/T_b = \text{sinc}^2(2fT_b), & \text{Duobinary} \\ \bar{S}_Y(f)/(4T_b) = \sin^2(2\pi fT_b)\text{sinc}^2(fT_b), & \text{Modified Duobinary} \end{cases}$$ $$c_k = a_k - a_{k-2}$$ $$= (2\tilde{b}_k - 1) - (2\tilde{b}_{k-2} - 1)$$ $$= 2\tilde{b}_k - 2\tilde{b}_{k-2} \qquad b_k = \tilde{b}_k \oplus \tilde{b}_{k-2}$$ **Receiver:** (2M) 
	PART * C
1	**Explain the working principles of equalizer and its types (15M) BTL1** **Answer : Page : (383-385) H Taub, D L Schilling** **Definition :** Dispersive effect -channel-compensate ISI – high speed data transmission wireless channel (2M) **Types :** (1M) • Zero facing • Mean square • Adaptive **Zero facing :** (1M) Channel -equalizer impulse response -zero Time delay= symbol duration Ts H_{ch}(f) H_{eq}(f) =1 **Block diagram** (1M) **Advantages** :(1M) Static channels -high SNR **Disadvantage :** (1M) High attenuation **Mean square**:(1M) minimize -MSE-desired equalizer output -actual equalizer output $\boldsymbol{e_k}$=$\boldsymbol{x_k}$ --$\boldsymbol{\hat{d}}_k$ (1M) Block diagram (1M) **Adaptive**: (2M)

Track -channel variations

Block diagram (1M)

Operating mode: (1M)

Training- fixed length training sequence-minimum BER -Pseudorandom binary signal

Tracking – recursive algorithm

Error signal : e(nTs)= b(nTs)- y(nTs) (1M)

2

The binary data 0010110 are applied to the input of a modified duo binary system.
a). Construct a modified duo binary encoder and decoder without precoder.
b). Suppose due to error during transmission, the level at the receiver input produced by the 3rd digit is reduced to 0. Construct the decoder output for the above case.
c). Construct a duo binary encoder and decoder with precoder.
Compare the results and show that error propagation is avoided with precoding. (15M)
BTL2

Answer: Page 245 - S. Haykin

Encoding: (3M)

Digit x_k	0	0	1	0	1	1	0
Bipolar amplitude	-1	-1	1	-1	1	1	-1
Combined amplitude		-2	0	0	0	2	0

Decision Rule: (3M)

$y_k = 2 \quad$ (decide $x_k = 1$)

$y_k = -2 \quad$ (decide $x_k = 0$)

$y_k = 0 \quad$ (decide opposite of previous decision)

Decoded Values: (2M)

Decoded values	-1	1	-1	1	1	-1
Decoded sequence	0	1	0	1	1	0

Precoding: (1M)

$b_k = x_k \oplus b_{k-1}.$

Precoding decision rule: (2M)

$y_k = \pm 2 \quad$ (decide $x_k = 0$)

$y_k = 0 \quad$ (decide $x_k = 1$).

With Precoding: (4M)

Digit x_k	0	0	1	0	1	1	0
Precoded sequence	0	0	1	1	0	1	1
Bipolar amplitude	-1	-1	1	1	-1	1	1
Combined amplitude		-2	0	2	0	0	2
Decoded sequence		0	1	0	1	1	0

3	**Describe any one method for ISI control. (15M) (May-2014)** BTL1 **Answer: Page 245 - S. Haykin** **Duo Binary/modified duo binary signaling** Ref Q.11 – Part B

UNIT IV – DIGITAL MODULATION SCHEME

Geometric Representation of signals - Generation, detection, PSD & BER of Coherent BPSK, BFSK & QPSK - QAM - Carrier Synchronization - structure of Non-coherent Receivers - Principle of DPSK.

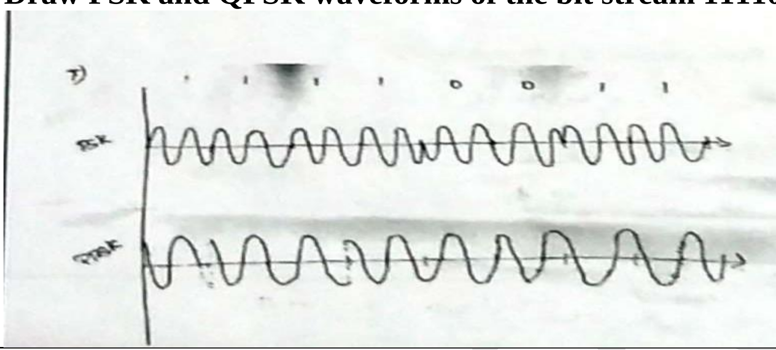
PART * A

Q.No.	Questions

1. Define non-coherent detection schemes.(April 2018) (April 2017) BTL1

In this method, the receiver carrier need not be phase locked with transmitter carrier. Hence it is called envelope detection.

2 Draw PSK and QPSK waveforms of the bit stream 11110011.(April 2018) (Nov 2017) BTL6



3 Differentiate between coherent and non-coherent detection schemes. (Nov 2017) (Nov 2016) (May 2016) BTL4

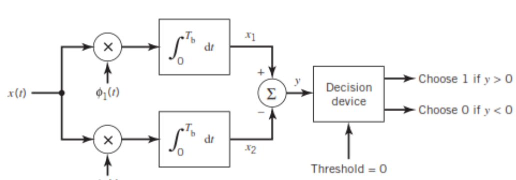
Coherent detection	Non-coherent detection
In this method the local carrier generated at the receiver is phase locked with the carrier at the transmitter.	In this method, the receiver carrier need not be phase locked with transmitter carrier.
Hence it is called synchronous detection	Hence it is called envelope detection.

4 What is QPSK? Write down an expression for the signal set. (April 2017) (May 2016) BTL1

QPSK is Quadri phase –shift keying. In QPSK the phase of the carrier takes on one of the four equally spaced values Such as π/4, 3π/4, 5π/4 and 7π/4.

In QPSK two successive bits in the data sequence are grouped together. This combination of two bits forms four distinct symbols. When symbols are changed to next symbol the phase of the carrier is changed by 45^0.

5 Draw a block diagram of coherent BFSK receiver. (Nov 2016) (Nov 2015) BTL1



6

Distinguish between BPSK and QPSK techniques.(Nov 2015) BTL4

Parameter	**QPSK**	**BPSK**
Bits per symbol	2	1
Symbol duration	2Tb	Tb
Detection Method	Coherent	Coherent
Bandwidth	fb	2fb

7

What are coherent and non-coherent receivers.(June 2015) (June 2013) (May-2012) BTL1

Coherent Receivers:

In this method the local carrier generated at the receiver is phase locked with the carrier at the transmitter.

Hence it is called synchronous detection and the receiver is called coherent receiver.

Non-coherent Receivers:

In this method, the receiver carrier need not be phase locked with transmitter carrier. Hence it is called envelope detection. and the receiver is called non-coherent receiver.

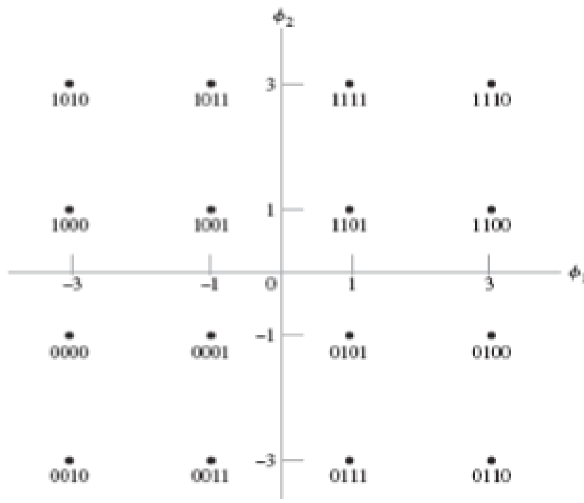
8

Draw constellation diagram of QAM.(Nov 2014)

What is QAM? (June 2013)

Define QAM and draw its constellation diagram.(Dec-2010) BTL6

A system which involves amplitude and phase shift keying which is called as Quadrature amplitude shift keying (QASK) or QAM.4QAM constellation is given below.



9

Mention the advantages of PSK systems. (Nov 2014) BTL1

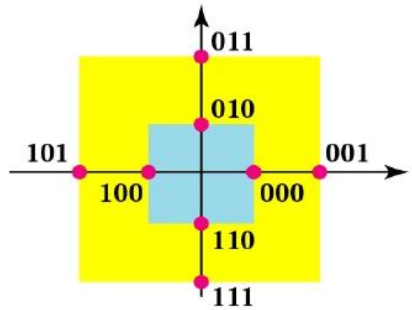
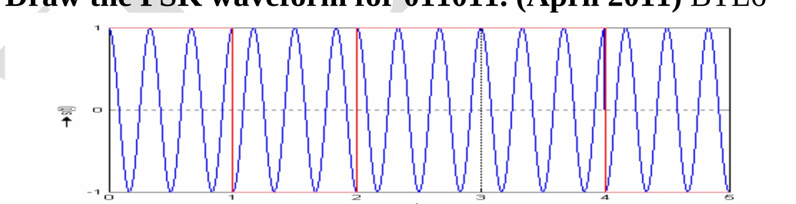
1. BPSK has a bandwidth which is lower than of BFSK is the best of all systems in the presence of noise.
2. It gives the minimum possibility of error and it has very good noise immunity.
3. Requires simple circuit for generation and detection

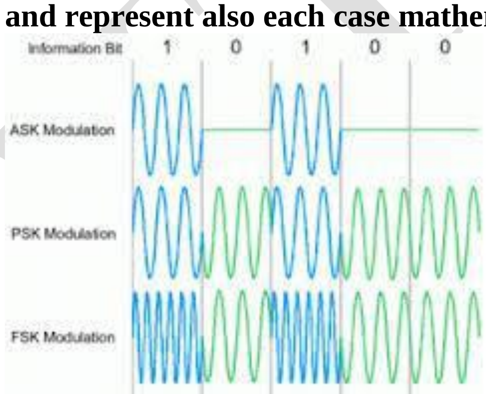
10

What are the advantages of QPSK over PSK.(June 2014) BTL1

Advantages of QPSK are for the same bit error, the bandwidth required by QPSK is reduced to half as compared to BPSK because of reduced bandwidth, the information transmission rate of QPSK is higher variation in offset QPSK amplitude is not much. Hence carrier power almost remains constant.

1. Bandwidth required by QPSK is reduced to half as compared to BPSK

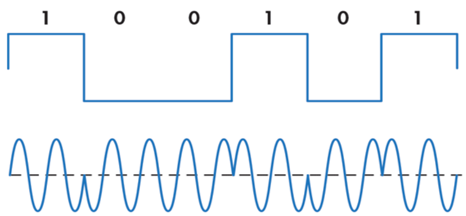
	2. No amplitude fluctuations, carrier power almost remains constant 3. Information transmission rate is higher because of reduced bandwidth
11	**Draw the signal space diagram for QAM signal for M=8. (June 2014)** BTL6  8-QAM 2 amplitudes, 4 phases
12	**Mention the drawbacks of amplitude shift keying. (Dec-2013)** BTL4 ASK has amplitude variations, hence noise interference is more
13	**What are the drawbacks of binary PSK system? (May-2012)** BTL1 It is difficult to detect +b(t) and –b(t) because of squaring in the receiver, Problem of ISI and inter channel interference are present.
14	**A BPSK system makes errors at the average rate of 1000 errors per delay. Data rate is 1 kbps. The single-sided noise power spectral density is 10-20 W/Hz. Assuming the system to be wide sense stationary, what is the average bit error probability? [Dec-12]** BTL3 24*60*60=86400sec $86.4*10^6$ Bir error probability $Pe=100/86.4*10^6$ $=1.1157*10^{-6}$
15	**Why is PSK always preferable over ASK in coherent detection. (Dec-2011)** BTL2 ASK has amplitude variations, hence noise interference is more, PSK method has less noise interference. It is always preferable.
16	**Draw the PSK waveform for 011011. (April 2011)** BTL6 
17	**A BFSK employs two signaling frequencies f1 and f2. The lower frequency f1 is 1200 Hz and signaling rate is 500 baud. Calculate f2. (Dec-2010)** BTL3 f1 = 1200 Hz. Signaling rate = 500 Baud, f2 = 1200 + 500 = 1700 Hz.
18	**Compare the probability of Error of PSK with that FSK.** BTL2 In PSK the probability of error Pe=1/2 erfc (square root (Eb/No) Where as in FSK Pe=1/2 erfc (square root (Eb/2No)

	Comparing these two equations in FSK the bit energy to noise density ratio has to be doubled to maintain the same bit error as in PSK. So FSK needs double the bandwidth of PSK. In PSK, the error probability is less whereas in FSK the error probability is high.
19	**Write the expression for bit error rate for Coherent Binary FSK. (Nov-Dec 2004)** BTL6 For coherent binary FSK, $P_e = \frac{1}{2} erfc \sqrt{\frac{E_b}{2N_0}}$ **or** $P_e = \frac{1}{2} erfc \sqrt{\frac{0.6E_b}{4N_0}}$
20	**What are Antipodal signals?** BTL1 Pair of sinusoidal waves that differs only in a relative phase shift of 180 degrees is referred as Antipodal signals.
21	**What are the advantages and disadvantages of binary FSK signals?** BTL2 Binary FSK has poorer error performance than PSK or QAM and consequently, is seldom used for high performance digital radio systems. Its use is restricted to low performance, low cost, asynchronous data modems that are used for data communications. The peak frequency deviation is constant and always at its maximum value
22	**Compare the Bandwidth Efficiency of M-ary PSK signals and M-ary FSK signals.** BTL2 The bandwidth efficiency of M-ary PSK signal is ρ=Rb/B=log2M/2 The bandwidth efficiency of M-ary ρ=Rb/B=2log2M/M
23	**What happens to the probability of error in M-ary FSK as the value of M increases? (Dec 2004)** BTL2 The probability of error will remain constant as the value of M increases $Pe \le 1/2(M-1)erfc(\left(\sqrt{E/2N_o}\right)$
24	**What are the advantages of M-ary signaling schemes? (Apr 2004)** BTL2 The main advantages of M-ary signaling is it increases or improves the spectral efficiency or bandwidth efficiency
25	**Sketch the waveform representation of ASK, FSK, PSK for an NRZ coded binary sequence and represent also each case mathematically.** BTL6 
	PART*B
1	**Calculate the BER for Binary Phase Shift Keying modulation from the first principles. (13M) (April-2018) (Nov-2017) (April 2016) (Dec 2013)** **Explain in detail the detection and generation of BPSK system. Derive the expression for its**

bit error probability. (13M)
Describe the generation and detection of coherent binary PSK signals. (13M) (Nov-2016), (Nov 2015) BTL5

Answer: Page 275 - S. Haykin

Definition of BPSK: Binary 1 - sending - signal -Binary 0 - not sending - signal. (2M)
Waveform of BPSK&Constellation Diagram(2M)



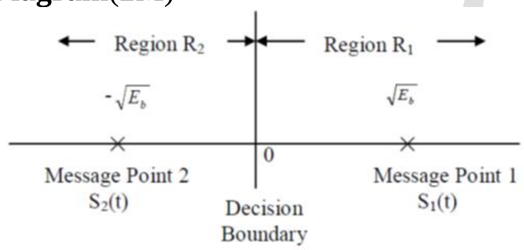
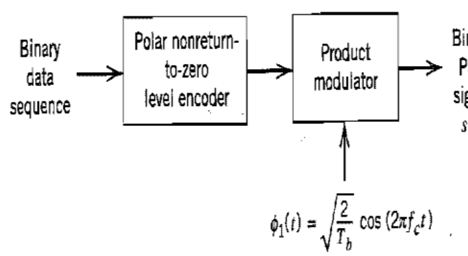
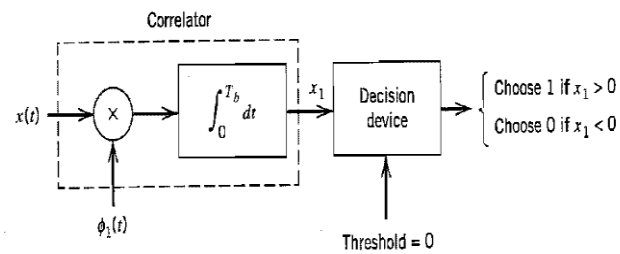


Fig. Signal Space Representation of BPSK

Error probability of BPSK: DerivationPe= ½ erfc(Eb/No)$^{1/2}$(3M)
Transmitter&Receiver:
(2M+2M)





Decision Rule:

If x1 > 0, receiver decides -favour- symbol 1.
If x1 < 0, receiver decides -favour- symbol 0.

Advantages: Less Error probability, Less noise interference (2M)

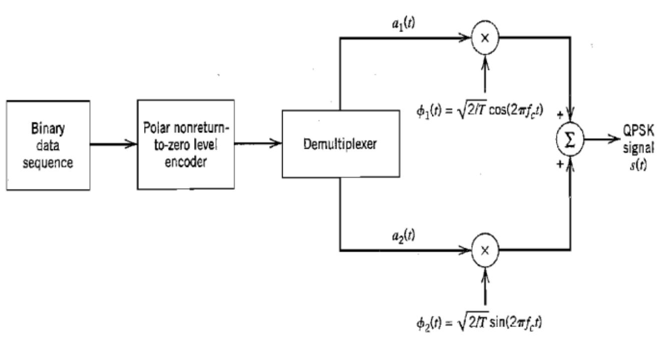
2 **Explain geometric representation of signals. (13M)** BTL2
Answer: Page 66 - S. Haykin

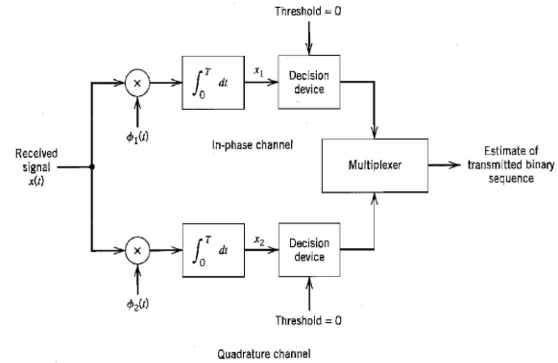
Signal space:complete set – signals. (1M)
Basis functions: Collection -minimum number- functions - represent - given signal-Independent-Orthogonal.
Dimension of the signal space: Minimum no. -basis functions. (1M)
Basis set: Collection - basis functions(1M)
Orthonormal basis set: Energy - basis functions - normalized -K_j = 1, basis set - called -

	orthonormal basis set. (1M) $s_1(t) = a_{11}\psi_1(t) + a_{12}\psi_2(t) + ... + a_{1N}\psi_N(t)$ $s_2(t) = a_{21}\psi_1(t) + a_{22}\psi_2(t) + ... + a_{2N}\psi_N(t)$ – – – $s_M(t) = a_{M1}\psi_1(t) + a_{M2}\psi_2(t) + ... + a_{MN}\psi_N(t)$ (2M) $s_k(t) = \sum_{j=1}^{N} a_{kj}\psi_j(t), \quad \mathrm{k = 1,2...,M; \quad j = 1,2....N}$ (2M) **Normalized energy:** (2M) $\mathrm{E_k = \sum_{j=1}^{N} a_{kj}^2}$ **Orthogonality:** (2M) $\int_0^T \psi_j(t)\,\psi_k(t)dt = K_j\delta_{jk}, \quad 0 \le \mathrm{t} \le \mathrm{T_j}, \quad \mathrm{k = 1,2,....N}$ $\delta_{jk} = \begin{cases} 1 & \mathrm{j = k} \\ 0 & \mathrm{otherwise} \end{cases}$ **To express signal in terms of orthogonal functions:** (1M) $s_k(t) = \sum_{j=1}^{N} a_{kj}\psi_j(t), \quad \mathrm{k = 1,2...,M; \quad j = 1,2....N}$ $a_{kj} = \frac{1}{K_j}\int_0^T s_k(t)\psi_j(t)dt, \quad \mathrm{k = 1,...M; \; j = 1,...N; \; 0 \le t \le T}$
3	**Draw and explain the Quadrature Receiver structure for coherent QPSK and derive the expression for bit error probability of a QPSK system (13M) (April-2018) (Nov-2017)** BTL6 **Draw the signal space diagram of a coherent QPSK modulation scheme and also find the probability of error if the carrier takes on one of four equally spaced values 0^o, 90^o, 180^o, 270^o (13M) (April-2018) (Nov-2017) (Nov 2016)** BTL6 **Illustrate the transmitter, receiver and signal space diagram of Quadrature Phase shift keying and describe how it reproduces the original sequence with the minimum probability of symbol error with neat sketch (13) (Nov-2015) (Nov 2014) (may 2015) (May 2013)** BTL6 **Answer: Page 284 - S. Haykin** **Definition of QPSK**: QPSK -Quadri phase –shift keying. Carrier Phase -take - one - equally spaced value - π/4, 3π/4, 5π/4 ,7π/4. Two successive bits - data sequence - grouped together - combination - two bits - four distinct symbols. When symbols- changed - next symbol - phase - carrier - changed -

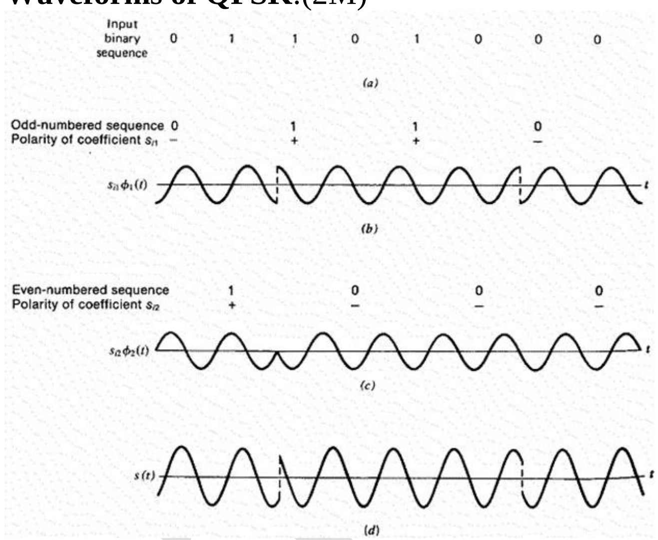
45^0 (3M)

Block diagram of QPSK Transmitter& Receiver: (2M+2M)





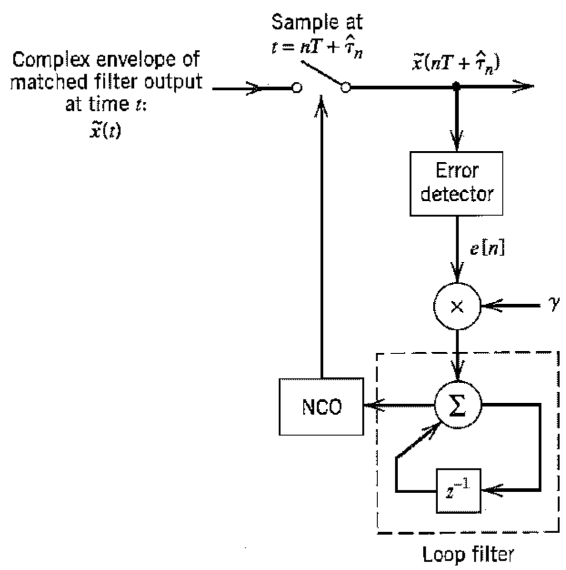
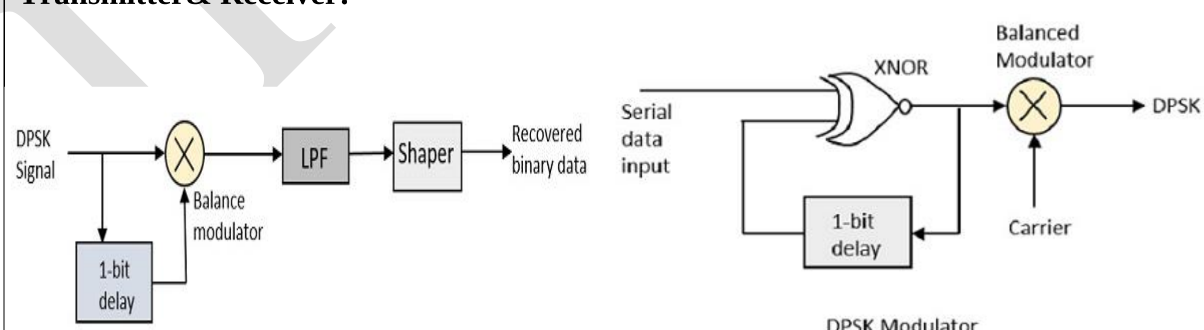
Waveforms of QPSK:(2M)



Coordinates of signal Points: (2M)

Index i	Phase of QPSK signal (radians)	Amplitudes of constituent binary waves: Binary wave 1 $a_1(t)$	Binary wave 2 $a_2(t)$	Input dibit $0 \le t \le T$
1	$\pi/4$	$+\sqrt{E/2}$	$-\sqrt{E/2}$	10
2	$3\pi/4$	$-\sqrt{E/2}$	$-\sqrt{E/2}$	00
3	$5\pi/4$	$-\sqrt{E/2}$	$+\sqrt{E/2}$	01
4	$7\pi/4$	$+\sqrt{E/2}$	$+\sqrt{E/2}$	11

Error probability of QPSK: DerivationPe= ½ erfc$(Eb/No)^{1/2}$(2M)

4	**Explain the principle of working of an "early late bit-synchronizer". (8M) (April-2017)** BTL1 **Answer: Page 347 - S. Haykin** **Definition:** Process – making – synchronous situation. (2M) **Types**: Carrier – symbol (2M) **Symbol Synchronization**: Time instants – modulation change happens – estimation- time instants. (2M) **Early-Late Bit Synchronization:** (2M) 
5	**Explain the principle of DPSK encoding. (8M) (April-2017)** BTL1 **Answer: Page 307 - S. Haykin** **Definition of DPSK**: Differential Phase Shift Keying (DPSK) - modulated signal- phase-shifted relative to - previous signal element.(2M) **Block diagram:**(2M+2M) **Transmitter& Receiver:**  **Operation of DPSK**:Example- binary data- differentially encoded- shifted- separate phase-compare phase- detect output.

(2M)

Binary Data		0	0	1	0	0	1	0	0	1	1
Differentially Encoded Data	1	0	1	1	0	1	1	0	1	1	1
Phase of DPSK	0	π	0	0	π	0	0	π	0	0	0
Shifted Differentially encoded Data d_{k-1}		1	0	1	1	0	1	1	0	1	1
Phase of shifted Data		0	π	0	0	π	0	0	π	0	0
Phase Comparision Output		-	-	+	-	-	+	-	-	+	+
Detected Binary Seq.		0	0	1	0	0	1	0	0	1	1

6 **Illustrate the power spectra of coherent binary FSK signal (13M) (Nov-2016)** BTL2

Answer: Page 279 - S. Haykin

Definition of BFSK: Symbol 1 - sending signal – frequency – f1- 0Symbol 0 - sending signal - frequency f2. (2M)

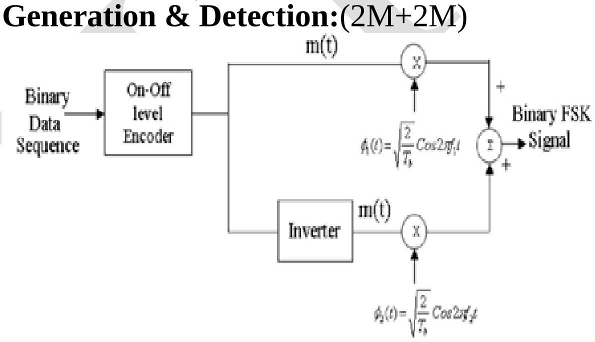
Signal Representation: (1M)

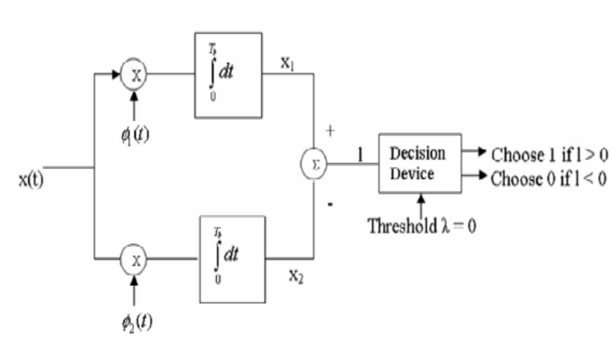
$$s_i(t) = \begin{cases} \sqrt{\dfrac{2E_b}{T_b}} \cos 2\pi f_i t, & 0 \le t \le T_b,\ i = 1, 2 \\ 0, & \text{elsewhere.} \end{cases}$$

Basis Function:(1M)

$$\varphi_i(t) = \sqrt{\frac{2}{T_b}} \cos 2\pi f_i t \quad ; \quad 0 \le t \le T_b \ \text{ and } \ j = 1,2$$

Generation & Detection:(2M+2M)



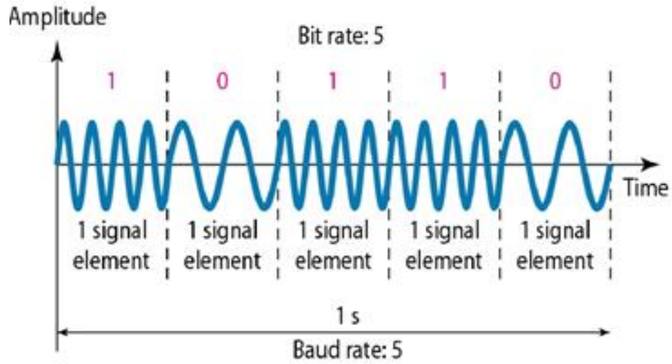
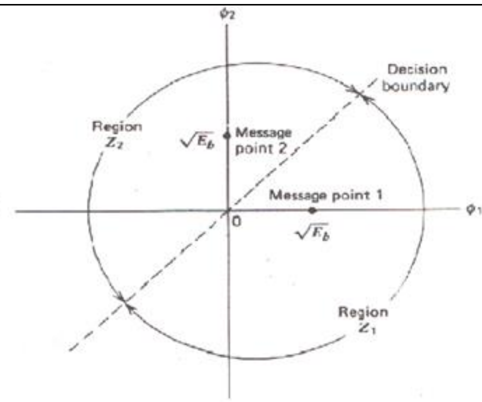


Decision Rule:(1M)

If l > 0, receiver decides -favour- symbol 1.

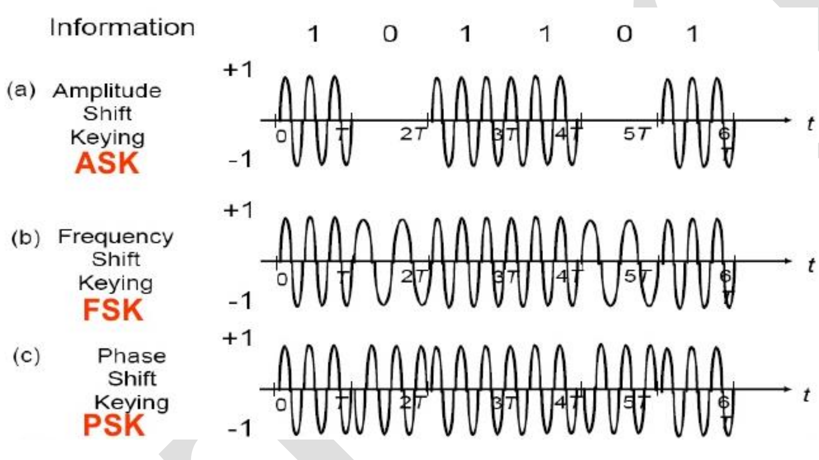
IF l < 0, receiver decides -favour - symbol 0.

Waveform of BFSK& signal space diagram: (2M)

	  **Power spectra of BFSK**: (1M) $$S_B(f)=\frac{E_b}{2T_b}\left[\delta(f-\frac{1}{2T_b})+\delta(f+\frac{1}{2T_b})\right]+\frac{8E_b\cos^2(\pi T_b f)}{\pi^2(4T_b^2f^2-1)^2}$$ **Bit error Probability:**(1M) **BER _fsk =** Pe= ½ erfc(Eb/2No)$^{1/2}$
7	**Derive the bit error probability of coherent ASK,FSK,PSK receivers. (6M) (May-2015)** BTL6 **Answer: Page 275,279 - S. Haykin** **Definition** **ASK**: 2 different amplitudes, **FSK**: 2 different frequencies, **BPSK**: 2 different phases. (3M) **Error probability**: Derivation (3M) **BER _ask =** Pe= ½ erfc(Eb/2No)$^{1/2}$ **BER _fsk =** Pe= ½ erfc(Eb/2No)$^{1/2}$ **BER _psk =** Pe= ½ erfc(Eb/No)$^{1/2}$
8	**Compare the performance of various digital modulation schemes (13M) (June-2014)** BTL2 **Answer: Page 284 - S. Haykin** **Definition** **ASK**: 2 different amplitudes, **FSK**: 2 different frequencies, **BPSK**: 2 different phases. (3M) **Comparison:** Detection method & BER(6M)

$Modulation$	$Detection Method$	$Bit Error Rate\,(P_b)$
$BPSK$	$Coherent$	$0.5erfc(\sqrt{\frac{E_b}{N_0}})$
$QPSK$	$Coherent$	$0.5erfc(\sqrt{\frac{E_b}{N_0}})$
$M-PSK$	$Coherent$	$\frac{1}{m}\,erfc\left(\sqrt{\frac{mE_b}{N_0}}sin(\frac{\pi}{M})\right)$
$M-QAM(m=even)$	$Coherent$	$\frac{2}{m}\left(1-\frac{1}{\sqrt{M}}\right)erfc(\sqrt{\frac{3mE_b}{2(M-1)N_0}})$
$D-BPSK$	$Non-coherent$	$0.5e^{-\frac{E_b}{N_0}}$
$D-QPSK$	$Non-coherent$	$Q_1(a,b)-0.5I_0(ab)e^{-0.5(a^2+b^2)}$ $where\ a=\sqrt{\frac{2E_b}{N_0}\left(1-\frac{1}{\sqrt{2}}\right)}$ $b=\sqrt{\frac{2E_b}{N_0}\left(1+\frac{1}{\sqrt{2}}\right)}$ $Q_1(a,b)=$ Marcum Q -function $I_0(ab)=$ Modified Bessel-function

Comparison: Waveform (2M)



Type of modulation scheme	Variable parameter	Definition of modulated wave $s_1(t)$ or $s_2(t)$, for $0 \le t \le T_b$	Phasor representation of modulated wave
1. Binary amplitude-shift keying (BASK)	$\begin{pmatrix}\text{Carrier amplitude}\\ A_c\end{pmatrix} = \begin{cases}\sqrt{\frac{2}{T_b}} & \text{for symbol 1}\\ 0 & \text{for symbol 0}\end{cases}$	$s_1(t)=\sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t)$ for symbol 1 $s_2(t)=0$ for symbol 0	Zero phasor for symbol 0; Phasor for symbol 1
2. Binary phase-shift keying (BPSK)	$\begin{pmatrix}\text{Carrier phase}\\ \phi_c\end{pmatrix} = \begin{cases}0 & \text{for symbol 1}\\ \pi & \text{for symbol 0}\end{cases}$	$s_1(t)=\sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t)$ for symbol 1 $s_2(t)=\sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t+\pi)$ for symbol 0	Phasor for symbol 0; Phasor for symbol 1
3. Binary frequency-shift keying (BFSK)	$\begin{pmatrix}\text{Carrier frequency}\\ f_c\end{pmatrix} = \begin{cases}f_1 & \text{for symbol 1}\\ f_2 & \text{for symbol 0}\end{cases}$	$s_1(t)=\sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_1 t)$ for symbol 1 $s_2(t)=\sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_2 t)$ for symbol 0	Phasor for symbol 0; Phasor for symbol 1

Notations
T_b = bit duration
E_b = transmitted signal energy per bit
Carrier: $c(t) = A_c\cos(2\pi f_c t + \phi_c)$
The carrier phase ϕ_c is set equal to zero for both BASK and BFSK.

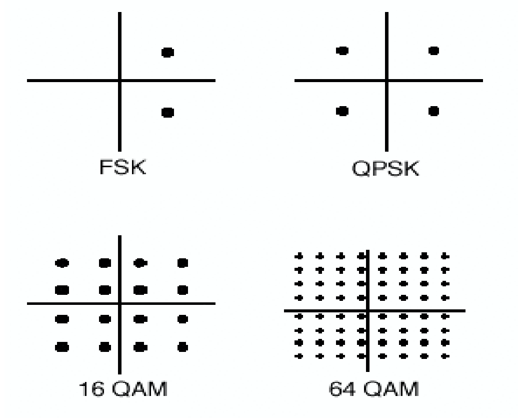
Comparison: Power Spectral Density (2M)

9 **Describe with signal space diagram quadrature amplitude modulation and its differences with respect to QPSK. (13M) (Dec-2013)** BTL2

Answer: Page 284 - S. Haykin

Refer Q.3

Difference between QAM & QPSK constellation:(3M)



10 **Explain the carrier synchronization methods with block diagrams. (13M)** BTL2

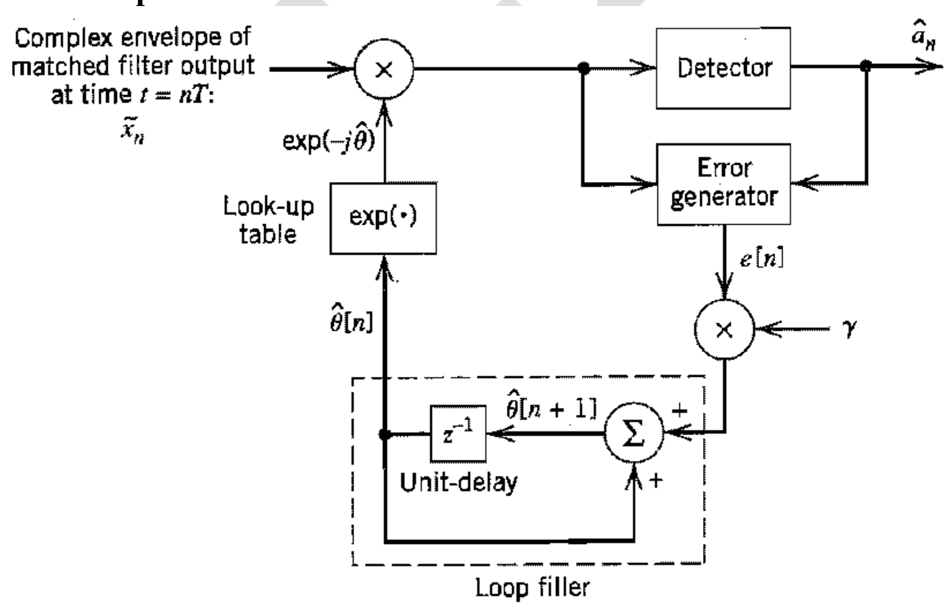
Answer: Page 344 - S. Haykin

Definition: Process – making – synchronous situation. (3M)

Types: Carrier – symbol (2M)

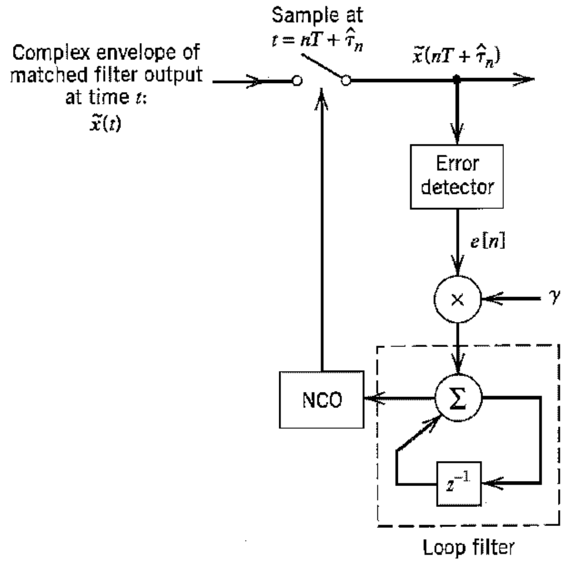
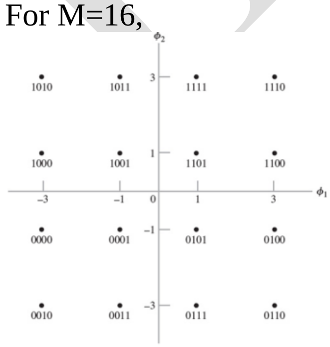
Carrier Synchronization: coherent Detection- Knowledge of frequency, phase-Estimation – carrier phase, frequency. (2M)

Costas Loop: (2M)

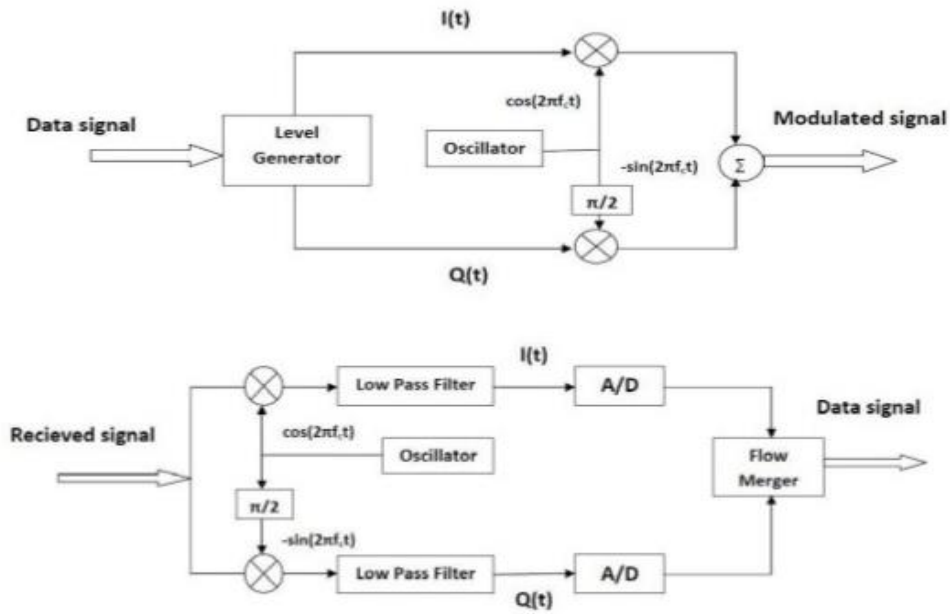


Symbol Synchronization: Time instants – modulation change happens – estimation- time instants. (2M)

Early-Late Bit Synchronization: (2M)

	
	PART *C
1	**Explain the PSD of QAM and derive its BER. State the advantages of QAM (15M) (Nov 2017)** BTL2 **Draw the functional block diagram of modulator for QAM and explain its operation. (May-2012)**BTL2 **Answer: Page 318 - S. Haykin** **Definition of QAM**: Shift in both amplitude and phase-combination - ASK – PSK. (4M) 12 different phases - combined - two different amplitudes. 4 phase angles - 2 different amplitudes, - total - 16 combinations – 16 signal combinations-each baud equals 4 bits - information (2 ^ 4 = 16). Minimum bandwidth requirement - same as ASK or PSK. $s_i(t) = \sqrt{\frac{2E_0}{T}} a_i \cos(2\pi f_c t) \quad i = 0,1,\ldots,M-1$ $s_i(t) = \sqrt{\frac{2E_0}{T}} a_i \cos(2\pi f_c t) - \sqrt{\frac{2E_0}{T}} b_i \sin(2\pi f_c t), \quad i = 0,1,\ldots, M-1, \quad 0 \le t \le T$ **Waveform &Signal space diagram of QAM**: (4M) M=4, 16, 32, 64, 128, 256 For M=16, 

Generation and Detection: (4M)



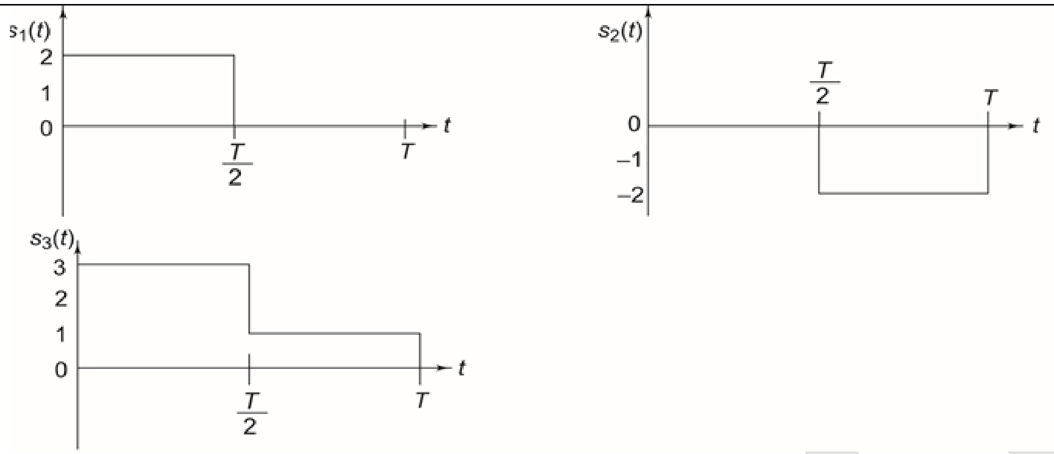
Power spectral density of QAM: With necessary equations (1M)
Error probability of QAM: With necessary equations (1M)
Advantages of QAM: Increased efficiency, Usage – both – amplitude-phase variations. (1M)

2 **A set of binary data is sent at the rate of R_b = 100kbps over a channel with 60 dB transmission loss and power spectral density η=10^{-12} W/Hz at the receiver. Determine the transmitted power for a bit error probabilty $P_e = 10^{-3}$ for the following modulation schemes.**

- **i) Coherent ASK**
- **ii) Non-coherent ASK**
- **iii) FSK**
- **iv) PSK**
- **v) DPSK**
- **vi) 16 QAM (15M) (Dec-2011)** BTL3

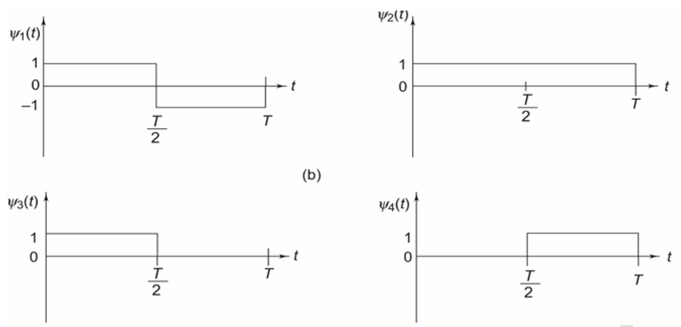
Answer: Page 284 - S. Haykin
Transmitted Power:(3M)
Data Rate: ρ = Rb/B (4M)
For each Scheme:(8M)

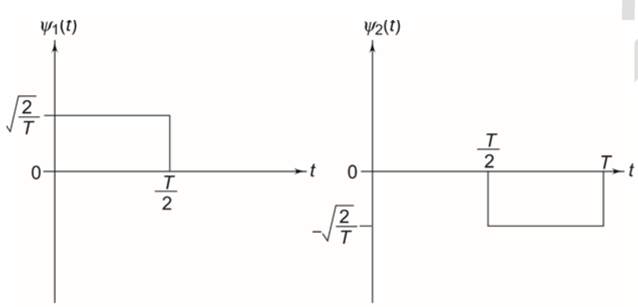
3 **A set three waveforms s_1(t), s_2(t) and s_3(t) are shown in the figure 2.1.**
(a) Demonstrate that these waveforms do not form an orthogonal set.
(b) Show that $\psi_1(t)$ and $\psi_2(t)$ form a basis set
(c) Express the signal set s_i(t) in terms of basis set
(d) Verify that $\psi_3(t)$ and $\psi_4(t)$ also form a basis set
(e) Express the signal set s_i(t) in terms of basis set (15M) BTL2



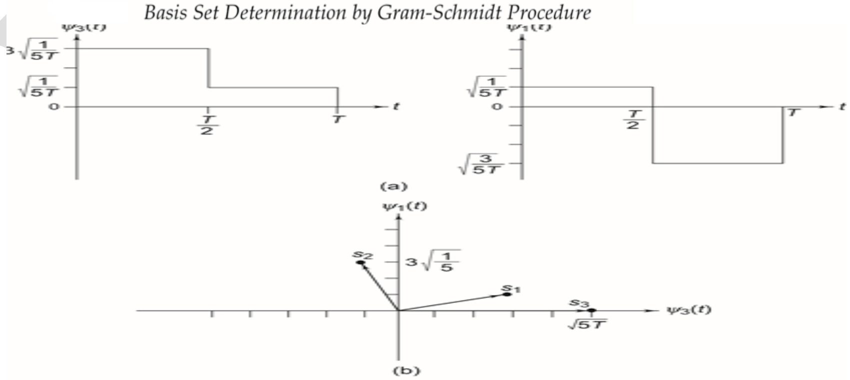
Answer: Page 64 - S. Haykin

Orthogonal Basis set: (4M)





Basis Set Determination by Gram-Schmidt Procedure



(a) Alternative Basis Set (b) Signal Space Diagram

(4M)

	First basis function: (2M) $$E_1 = \int_0^T s_1^2(t)\,dt$$ $$\psi_1(t) = \frac{s_1(t)}{\sqrt{E_1}}$$ **Second basis function:** (2M) $$c_{12} = \int_{-\infty}^{\infty} s_2(t)\psi_1(t)dt$$ $$\psi_2'(t) = s_2(t) - c_{12}\psi_1(t)$$ $$\psi_2(t) = \frac{\psi_2'(t)}{\sqrt{E_2}}$$ **Generally, the kth basis function:** (2M) $$\psi_k(t) = \frac{\psi_k'(t)}{\sqrt{E_k}}$$ $$\psi_k'(t) = s_k(t) - \sum_{i=1}^{k-1} c_{ik}\psi_i(t)$$ $$c_{ik} = \int_{-\infty}^{\infty} s_k(t)\psi_i(t)dt, \quad i = 1,2,3....k-1$$ **Energy:** (1M) $$s_k(t) = \sum_{n=1}^{N} s_{kn}\psi_n(t), \; k = 1,2...M$$ $$s_{kn} = \int_{-\infty}^{\infty} s_k(t)\psi_n(t)dt, \quad k = 1,2,3...M; \; n = 1,2..N;$$ $$\text{and } E_k = \int_{-\infty}^{\infty} [s_k(t)]^2\,dt = \sum_{n=1}^{N} s_{kn}^2 = \|s_k\|^2$$

UNIT V – ERROR CONTROL CODING	
Channel coding theorem - Linear Block codes - Hamming codes - Cyclic codes - Convolutional codes - Viterbi Decoder.	
PART * A	
Q.No.	**Questions**
1.	**What is meant by syndrome of linear block code? (April 2018) Nov 2017)** BTL1 The non-zero output of the productyH^T is called syndrome & it is used to detect errors in received code vector y. Syndrome is denoted by S & given as, $S=yH^T$
2	**Write the various techniques/algorithms used in encoding and decoding of convolutional code. (April 2018) (Nov 2017)** BTL4 The various techniques/algorithms used in encoding of convolutional code are 1. Time domain approach 2. Transform domain approach 3. State table/Code table 4. Code tree 5. State diagram/Transition Diagram 6. Trellis diagram. The various techniques/algorithms used in decoding of convolutional code are 1. Maximum likelihood detection – Viterbi algorithm
3	**What is the need of channel coding? (May-2017)** BTL1 We need channel coding for 2 reasons 1. Deal with errors since noise attack our information at the channel, how can we detect errors and recover them 2. Data compression, can we compress our information to save bandwidth.
4	**What are the different methods for describing the structure of a convolutional code? (May-2017)** BTL4 The different methods of describing the structure of a convolutional code are 1. State table/Code table 2. Code tree 3. State diagram/Transition Diagram 4. Trellis diagram.
5	**What is called block codes?** BTL1 The code which takes a block of "k" information bits and convert that into "n" code bits is called block codes. This can be represented by (n,k) block code.
6	**Define (State) channel coding theorem. (Dec-2016) (Dec-2015)** BTL1 $$\frac{H(S)}{T_s} \le \frac{C}{T_c}$$ It is possible to transmit information over the channel and reconstruct it with a an arbitrarily small probability of error $$\frac{H(S)}{T_s} > \frac{C}{T_c}$$ It is not possible to transmit information over the channel and reconstruct it with a an arbitrarily

	small probability of error.
7	**What is a linear code? (May-2016)** BTL1 A code which satisfies the Linear Property is called linear code. **Linearity property:** The sum of any two-code word is also a valid code word.
8	**What is meant by constraint length of a convolutional encoder? (May-2016) (May-2015)** BTL1 Constraint length is the number of shifts over which the single message bit can influence the encoder output. It is expressed in terms of message bits. K=M+1; where K- Constraint Length M- No of Memory elements
9	**What are the properties of cyclic codes? (Dec-2015) (Dec-2011)** BTL1 Cyclic codes are the subclasses of linear block codes. They have the property that a cyclic shift of one codeword produces another code word. **Properties:** 1) **Linearity**: The sum, of any 2 code words in the code is also a code word. 2)**Cyclic property**: Any cyclic shift of a code word in the code is also a code word.If X = (xn-1, xn-2…, x1, x0) Then X‟ = (xn-2, xn-3 ……, x1, x0, xn-1) which is another code vector.X‟‟‟= (xn-3, xn-4………., x1, x0, xn-1, xn-2) which is a valid code vector.
10	**Define Hamming distance and Hamming weight. (May-2015) (June-2014)** BTL1 **Hamming weight** of a code vector is defined as the number of non-zero elements in the code word or it is the distance between the code vector and all zero-code vector. **Hamming distance** is defined as the number of locations in which their respective elements differ or the minimum distance is defined as the smallest Hamming distance between any pair of code vectors in the code or the minimum distance is defined as the smallest Hamming weight of the non-zero code vectors in the code.
11	**What is the need for error control codes? (Dec-2014)** BTL 1 It builds redundancies in the signal so that the error caused by the channel is minimized or rectified. Thus, it needs 1. To fight with the channel noise 2. To give insurance to the transmitted signal against the corruption by channel noise.
12	**Define channel capacity. (Dec-2014)** BTL1 The "capacity" of a channel is the theoretical upper-limit to the bit rate over a given channel that will result in negligible errors. Channel capacity is measured in bits/s. Shannon's channel capacity is an equation that determines the information capacity of a channel from a few physical characteristics of the channel. The Shannon channel capacity, C, is measured in units of bits/sec and is given by the equation: $C=W \log_2 (1+SNR)$. C is the maximum capacity of the channel, W is the available bandwidth in the channel, and SNR is the signal to noise ratio.
13	**Define code and block rate. (May-2014) (Dec-2013)** BTL1 Code rate is defined as the ratio between No of bits in the message vector to the number of bits in the code vector. r=k/n.
14	**State the significance of minimum distance of a block code. (June-2013)** BTL4 Minimum distance of a block code is used to find error detecting and correcting capability of the code word.

	To detect up to "s" errors per word, dmin ≥ S+1 To correct up to "t" errors per word, dmin ≥ 2t +1
15	**Find the hamming distance between 101010 and 010101. If the minimum Hamming distance of a (n,k) linear block code is 3, what is its minimum hamming weight? (Dec-2012)** BTL3 Hamming distance between 101010 and 010101 is d(X,Y)= 6 (No of locations varying) By property of Linear Block Code, minimum Hamming distance of a (n,k) linear block code is equal to minimum hamming weight. Hence minimum hamming weight =3.
16	**What is convolutional code? How is it different from block codes? (May-2012)** BTL4 Block codes takes k number of bits simultaneously form n bit code vector. This code vector is also called block. Convolutional code takes one message bits at a time and generates two or more encoded bits. Thus, convolutional codes generate a string of encoded bits for input message string.
17	**Define hamming distance (May-2011)** BTL1 The Hamming distance between a pair of codewords d(x,y) is defined as the number of locations in which their respective elements differ. For example, let the two code words be, X = (11100) and Y= (11011) D= 2 These two code words differ in second and third bits. Therefore, the hamming distance between X and Y is two.
18	**Define hamming distance and calculate its value for two code words 11100 and 11011. (Dec-2010)** BTL3 The Hamming distance between a pair of codewords d(x,y) is defined as the number of locations in which their respective elements differ. Given: The two code words be, X = (11100) and Y= (11011) D= 2 These two code words differ in second and third bits. Therefore, the hamming distance between X and Y is two.
19	**What is BCH code? (May-June 2006)** BTL1 BCH codes are most extensive and powerful error correcting cyclic codes. The decoding of BCH codes is comparatively simpler. For any positive integer „m and „t (where t<2 m-1)there exists a BCH code with following parameters: Block length: n= 2m-1 Number of parity check bits : n-k<=mt Minimum distance: dmin>=2t+1
20	**What is RS code? (Apr-May 2005)** BTL1 These are non-binary BCH codes. The encoder for RS code operates on multiple bits simultaneously. The (n, k) RS code takes the groups of m- bit symbols of incoming binary data stream. It takes such „k number of symbols in one block. Then the encoder acts (n – k) redundant symbols to form the code word of „n symbols. RS code has: Block Length: n=2m-1 symbols Message size: K symbols Parity check size: n-k= 2t symbols Minimum distance: dmin=2t+1 symbol
21	**What are the advantages of convolutional codes?** BTL2 **Advantages:** 1. The decoding delay is small in convolutional codes since they operate on smaller blocks of data. 2. The storage hardware required by convolutional decoder is less since the block sizes

	are smaller. **Disadvantages:** 1. Convolutional codes are difficult to analyze since their analysis is complex. 2. Convolutional codes are not developed much as compared to block codes.
22	**Give the special features of Trellis codes. (Nov-Dec 2007)** BTL2 1. Code Trellis is more compact representation of code tree. 2. Decoding is little complex. 3. It is simpler to implement. 4. It shows the transition from current to next states.
23	**What is meant by systematic and non-systematic codes?** BTL1 In a Systematic block code, message bits appear first and then check bits. In the non-systematic code, message and check bits cannot be identified in the code vector.
24	**List the requirements of Passband transmission.** BTL1 1. Maximum data transmission rate. 2. Minimum probability of symbol error. 3. Minimum transmitted power.
25	**What is the error detection and correction capabilities of hamming codes?** BTL1 The minimum distance (dmin) of hamming codes is „3". Hence it can be used to detect double errors or correct single errors. Hamming codes are basically linear block codes with dmin =3.
	PART *B
1	**Find the (7,4) systematic and non-systematic cyclic code word of the message word 1101. Assume the generator polynomial as $1 + x^2 + x^3$. (7M) (April-2018) (Nov-2017)** BTL3 **Answer: Page 379 - S. Haykin** **Steps:** Find c(x) (2M) Find $x^{n-k}m(x)$ (2M) Divide $x^{n-k}m(x)$ by g(x) (2M) **Systematic cyclic codes:** $c(x) = x^{n-k}m(x) + \rho(x)$ **Non Systematic cyclic codes:** $c(x) = g(x) * m(x)$(1M)
2	**Develop the code for (n,k) linear cyclic code and explain its working. (6M) (April-2018) (Nov-2017)**BTL3 **Answer: Page 379 - S. Haykin** **Cyclic code**: Cyclic shift - any code word - code word. (2M) K=M+1; where K- Constraint Length M- No of Memory elements **Encoding** (2M) Find c(x) Find $x^{n-k}m(x)$ Divide $x^{n-k}m(x)$ by g(x) **Syndrome decoding:** s= yH^T(2M)
3	**Explain Viterbi algorithm with an appropriate coder and a received input word of length 12. Assume a coder of constraint length 6 and rate efficiency $\frac{1}{2}$. (7M) (April-2018)**BTL3 **Answer: Page 403- S. Haykin**

	Viterbi algorithm: A Maximum likelihood method - decoding convolutional encoder. (2M) **Steps for proceeding trellis tree structure**(2M) **Perform Viterbi algorithm with step by step procedure**(3M) 1. Initialization 2. Computation 3. Continue computation
4	**Draw the code tree of a Convolutional code of code rate r =$\frac{1}{2}$ and constraint Length of K = 3 starting from state table and State diagram for an encoder which is commonly used. (13M) (Nov-2017)**BTL6 **Answer: Page 393- S. Haykin** **Convolutional code:**Convolutional code - one message bits at - time - generates two or more encoded bits. -convolutional codes - string of encoded bits - input message string. (2M) **Representation**:(6M) State diagram representation Tree diagram representation. Trellis diagram representation. **Explanation** (5M)
5	**The generator polynomial of a (7,4) linear systematic cyclic block code is $1+x+x^3$. Determine the correct code word transmitted, if the received word is (i) 1011011 and (ii) 1101111. (13M) (May-2017)**BTL5 **Answer: Page 379 - S. Haykin** **Steps:** Find c(x) (2M) Find $x^{n-k}m(x)$ (3M) Divide $x^{n-k}m(x)$ by g(x) (4M) **Systematic cyclic codes:** $c(x) = x^{n-k}m(x) + \rho(x)$(4M)
6	**A rate $\frac{1}{3}$ convolutional encoder with constraint length of 3 uses the generator sequences:g_1=(1 0 0), g_2=(1 0 1) and g_3=(1 1 1)** **i) Sketch encoder diagram (2M)** **ii) Draw the state diagram for the encoder (6M)** **iii) Determine the d_{free}distance of the encoder (5M) (May-2017)**BTL6 **Answer: Page 393- S. Haykin** **Convolutional code:**Convolutional code - one message bits at - time - generates two or more encoded bits. -convolutional codes - string of encoded bits - input message string. (2M) **Representation**:(6M) State diagram representation Tree diagram representation. Trellis diagram representation. **Explanation- d_{free}**(5M)
7	**Describe the cyclic codes with the linear and cyclic property. Also represent the cyclic property of a code word in polynomial notation (12M) (Dec-2016)** BTL6 **Answer: Page 379- S. Haykin** **Cyclic code**: Cyclic shift -any code word - code word. (2M)

	Properties: Linear and cyclic property (2M) **Polynomial Representation**: $C(x) = C_{n-1}x^{n-1} + C_{n-2}x^{n-2} + \ldots + C_1x^1 + C_0x^0$ (2M) **Linear Property**: Each row- shifted version – first row $G = \begin{pmatrix} g_{n-k} & g_{n-k-1} & \ldots & g_1 & g_0 & 0 & 0 & 0 & \ldots & 0 \\ 0 & g_{n-k} & g_{n-k-1} & \ldots & g_1 & g_0 & 0 & 0 & \ldots & 0 \\ & & & . & & & & & & \\ & & & . & & & & & & \\ & & & . & & & & & & \\ 0 & 0 & \ldots & 0 & g_{n-k} & g_{n-k-1} & \ldots & g_1 & g_0 & 0 \\ 0 & 0 & 0 & \ldots & 0 & g_{n-k} & g_{n-k-1} & \ldots & g_1 & g_0 \end{pmatrix}$ (3M) **Cyclic Property:** $C(x) = C_{n-1}x^{n-1} + C_{n-2}x^{n-2} + \ldots + C_1x + C_0$ Cyclic Shifted version – also – code word (3M) $xC(x) = C_{n-1}(x^n - 1) + C_{n-2}x^{n-1} + \ldots + C_1x^2 + C_0x + C_{n-1} = C_{n-1}(x^n - 1) + C^1(x).$
8	**List the different types of errors detected by CRC code (4M) (Dec-2016)** BTL2 **Answer: Page 389 - S. Haykin** **CRC codes**: Special types -cyclic codes - check - redundancy (2M) **Error detected by CRC Codes**. (2M)
9	**Describe how the errors are corrected using hamming code with an example. (12M) (Dec-2016)** BTL2 **Answer: Page 378 - S. Haykin** **Hamming code**: special linear block code with following constraints. (2M) Consider an example and explain how the errors are corrected (6M) 1. Block length n=$2^m - 1$ 2. No of msg bits k= $2^m - m - 1$ 3. No of parity bits n-k=m Explanation (4M)
10	**The code vector [11110010] is sent, the received vector is [1100010]. Calculate the syndrome. (4M) (Dec-2016)** BTL6 **Answer: Page 373- S. Haykin** **Parity check matrix**H=$[P^T : I]$ (1M) **Syndrome** S=rH^T(1M) **Original codeword**=r ex-or e (2M)
11	**Consider a linear block code with generator matrix** **G=[1 1 0 1 0 0 0; 0 1 1 0 1 0 0; 1 1 1 0 0 1 0; 1 0 1 0 0 0 1] (Dec-2016)** **i) Determine the parity check matrix (2M)** **ii) Determine the error detecting and capability of the code (2M)** **iii) Draw the encoder and syndrome calculation circuits. (5M)** **iv) Calculate the syndrome for the received vector** **r = [1 1 0 1 0 1 0] (4M)** BTL6 **Answer: Page 370- S. Haykin** 1. H=$[P^T : I]$ (2M)

	2. t $\leq d_{min} - 1$ (2M) 3. S=rH^T (5M) 4. Original codeword=r ex-or e (4M)
12	**The generator polynomial of a (7,4) cyclic code word is $1 + x + x^3$. Develop encoder and syndrome calculator for this code. (8M) (Dec-2016)** BTL5 **Answer: Page 318 - S. Haykin** **Steps:** Find c(x) (2M) Find $x^{n-k}m(x)$ (2M) Divide $x^{n-k}m(x)$ by g(x) (2M) **Systematic cyclic codes:**$c(x) = x^{n-k}m(x) + \rho(x)$(2M)
13	**For a systematic linear block code, the three parity check digits P1, p2, P3 are given by $P_{k,n-k}$ = [1 0 1; 1 1 1; 1 1 0; 0 1 1]** **i) Construct generator matrix** **ii) Construct code generated by the matrix** **iii) Determine error correcting capacity.** **iv) Decode the received words with an example (13M) (Nov-2015)** BTL6 **Answer: Page 370- S. Haykin** G=[P:I_k] - Generator Matrix (2M) H=[P^T: I] - Parity check matrix (2M) t $\leq d_{min} - 1$ - Error detection capability (2M) S=rH^T- Syndrome (2M) **Original codeword**=r ex-or e (2M) **Explanation** (3M)
14	**A convolutional code is described by g_1=(1 0 0), g_2=(1 0 1) and g_3=(1 1 1)** **i) Draw the encoder corresponding to this code** **ii) Draw the state transition diagram for this code** **iii) Draw the trellis diagram** **iv) Find the transfer function (13M) (Nov-2015)** BTL6 **Answer: Page 393- S. Haykin** **Convolutional code:**Convolutional code - one message bits at - time - generates two or more encoded bits. -Convolutional codes - string of encoded bits - input message string. (2M) **Representation**:(6M) State diagram representation Tree diagram representation. Trellis diagram representation. **Explanation- d_{free}** (5M)
15	**Consider a (6,3) block code and explain how error syndrome helps in correcting a single error for a data 110. (13M) (Dec-2014)**BTL5

	Answer: Page 370- S. Haykin **Hamming code** – Code- Follow- Conditions (4M) Block length n=$2^m - 1$ No of msg bits k= $2^m - m - 1$ No of parity bits n-k=m **Syndrome**(3M) **Correction of single bit error** (4M) **Explanation**(2M)
16	**For a conventional encoder of constraint length 3 and rate 1/2. Obtain the encoded output for the input message 10011. (13M) (Dec-2013)**BTL5 **Answer: Page 39-3 S. Haykin** **Convolutional code:**Convolutional code - one message bits at - time - generates two or more encoded bits. -Convolutional codes - string of encoded bits - input message string. (2M) **Representation**:(6M) State diagram representation Tree diagram representation. Trellis diagram representation. **Explanation- d_{free}** (5M)
17	**Explain the transform domain approach analysis of convolution code. (8M) (May-2012)** **Answer: Page 397- S. Haykin** BTL1 **Convolutional code:**Convolutional code - one message bits at - time - generates two or more encoded bits. -Convolutional codes - string of encoded bits - input message string. (2M) **Transform domain approach** (6M)
	PART *C
1	**Draw the diagram of the ½ rate convolutional encoder with generator polynomials** **G1(D)=1+D** **G2(D)=1+D+D^2** **And complete the encoder output for input sequence 101101. (15M)** BTL2**Answer: Page 393- S. Haykin** **Convolutional code:**Convolutional code - one message bits at - time - generates two or more encoded bits. -Convolutional codes - string of encoded bits - input message string. (2M) Draw convolutional encoder (2M) **Representation**:(6M) State diagram representation Tree diagram representation. Trellis diagram representation. **Encoding** (2M) **Explanation** (3M)
2	**For a systematic linear block code, the three parity check digits P1, P2,P3 are given by P*k,n-k* =[101** **111** **110** **011]** **(i) Construct generated matrix. (4M)** **(ii) Assess the t code generated by the matrix. (4M)** **(iii) Determine error correcting capacity. (4M)**

	(iv) Decode the received words with an example. (3M) BTL5 **Answer: Page 370- S. Haykin** G=[P:I_k] - Generator Matrix (4M) H=[P^T: I] - Parity check matrix (4M) t ≤ $d_{min} - 1$ - Error detection capability (4M) S=rH^T- Syndrome **Original codeword**=r ex-or e (3M) **Explanation**
3	**For a systematic (6,3) linear block code** **G=[100 010** **001 101** **011 110],** **(i) Solve for all the code vectors (5M)** **(ii) Draw encoder circuit for the above code (5M)** **(iii) Predict minimum hamming weight (5M)** BTL6 **Answer: Page 370- S. Haykin** G=[P:I_k] - Generator Matrix Find all code words (5M) H=[P^T: I] - Parity check matrix (4M) t ≤ $d_{min} - 1$ - Error detection capability (4M) S=rH^T- Syndrome **Original codeword**=r ex-or e (2M) **Explanation**

EC8553 **DISCRETE-TIME SIGNAL PROCESSING** **L T P C**
4 0 0 4

OBJECTIVES:

- To learn discrete fourier transform, properties of DFT and its application to linear filtering
- To understand the characteristics of digital filters, design digital IIR and FIR filters and apply these filters to filter undesirable signals in various frequency bands
- To understand the effects of finite precision representation on digital filters
- To understand the fundamental concepts of multi rate signal processing and its applications
- To introduce the concepts of adaptive filters and its application to communication engineering.

UNIT I - DISCRETE FOURIER TRANSFORM **12**

Review of signals and systems, concept of frequency in discrete-time signals, summary of analysis & synthesis equations for FT & DTFT, frequency domain sampling, and Discrete Fourier transform (DFT) - deriving DFT from DTFT, properties of DFT - periodicity, symmetry, circular convolution. Linear filtering using DFT. Filtering long data sequences - overlap save and overlap add method. Fast computation of DFT - Radix-2 Decimation-in-time (DIT) Fast Fourier transform (FFT), Decimation-in-frequency (DIF) Fast Fourier transform (FFT). Linear filtering using FFT.

UNIT II - INFINITE IMPULSE RESPONSE FILTERS **12**

Characteristics of practical frequency selective filters. Characteristics of commonly used analog filters - Butterworth filters, Chebyshev filters. Design of IIR filters from analog filters (LPF, HPF, BPF, BRF) - Approximation of derivatives, Impulse invariance method, Bilinear transformation. Frequency transformation in the analog domain. Structure of IIR filter - direct form I, direct form II, Cascade, parallel realizations.

UNIT III - FINITE IMPULSE RESPONSE FILTERS **12**

Design of FIR filters - symmetric and Anti-symmetric FIR filters - design of linear phase FIR filters using Fourier series method - FIR filter design using windows (Rectangular, Hamming and Hanning window), Frequency sampling method. FIR filter structures - linear phase structure, direct form realizations.

UNIT IV FINITE WORD LENGTH EFFECTS **12**

Fixed point and floating point number representation - ADC - quantization - truncation and rounding - quantization noise - input / output quantization - coefficient quantization error - product quantization error - overflow error - limit cycle oscillations due to product quantization and summation - scaling to prevent overflow.

UNIT V INTRODUCTION TO DIGITAL SIGNAL PROCESSORS **12**

DSP functionalities - circular buffering – DSP architecture – Fixed and Floating point architecture principles – Programming – Application examples.

TOTAL: 60 PERIODS

OUTCOMES:

After studying this course, the student should be able to:

- Apply DFT for the analysis of digital signals and systems
- Design IIR and FIR filters
- Characterize the effects of finite precision representation on digital filters
- Design multirate filters
- Apply adaptive filters appropriately in communication systems.

TEXT BOOKS:

1. John G. Proakis & Dimitris G.Manolakis, ―Digital Signal Processing – Principles, Algorithms & Applications‖, Fourth Edition, Pearson Education / Prentice Hall, 2007. (UNIT I – V)

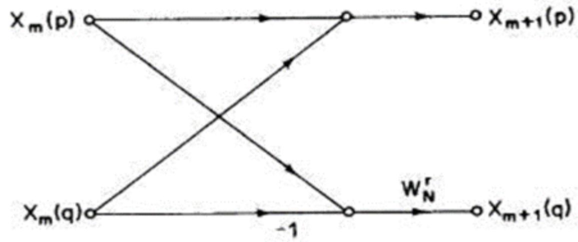
REFERENCES

1 Emmanuel C. Ifeachor & Barrie. W. Jervis, ―Digital Signal Processing‖, Second Edition, Pearson Education / Prentice Hall, 2002.
2. A. V. Oppenheim, R.W. Schafer and J.R. Buck, ―Discrete-Time Signal Processing‖, 8th Indian Reprint, Pearson, 2004.
3. Sanjit K. Mitra, ―Digital Signal Processing – A Computer Based Approach‖, Tata Mc Graw Hill, 2007.
4. Andreas Antoniou, ―Digital Signal Processing‖, Tata Mc Graw Hill, 2006.

UNIT I- DISCRETE FOURIER TRANSFORM	
Review of signals and systems, concept of frequency in discrete-time signals, summary of analysis & synthesis equations for FT & DTFT, frequency domain sampling, and Discrete Fourier transform (DFT) - deriving DFT from DTFT, properties of DFT - periodicity, symmetry, circular convolution. Linear filtering using DFT. Filtering long data sequences - overlap save and overlap add method. Fast computation of DFT - Radix-2 Decimation-in-time (DIT) Fast Fourier transform (FFT), Decimation-in-frequency (DIF) Fast Fourier transform (FFT). Linear filtering using FFT.	
PART A	
Q.No.	**Questions**
1.	**Find the DFT of the sequence x (n) = {1, 1, 0, 0} (May 2019) BTL3** Given that, x (n) = {1, 1, 0, 0} $$\begin{bmatrix}1 & 1 & 1 & 1\\ 1 & -j & -1 & j\\ 1 & -1 & 1 & -1\\ 1 & j & -1 & -j\end{bmatrix}\begin{bmatrix}1\\1\\0\\0\end{bmatrix}=\begin{bmatrix}2\\1-j\\0\\1+j\end{bmatrix}$$ The output sequence y (n), X (k) = {2, 1 - j, 0, 1 + j}
2	**Write N-point DFT for x (n), and IDFT for X (k) (May 2019) BTL1** DFT is given by, $$X(k) = \sum_{n=0}^{N-1} x(n)e^{\frac{-j2\pi kn}{N}}$$ IDFT of a discrete time signals are represented as,, $$x(n) = \frac{1}{N}\sum_{k=0}^{N-1} X(K)e^{j2\pi nk/N} \quad n = 0,1,2,\dots.N-1$$
3	**How many multiplications and additions are required to compute N point DFT using radix – 2 FFT? (Nov 2018)BTL2** The number of multiplications and additions required to compute N-point DFT using radix – 2 FFT are Nlog2 N and N/2 Log N respectively.

4

Why the computations in FFT algorithm is said to be in place? (Nov 2018)BTL2



- The nodes X_m (p) and X_m (q) represents memory locations of inputs where the input values are stored.
- After the outputs X_{m+1}(p) and X_{m+1}(q) are calculated, the same memory location is used to store the new values in place of the input values.
- An algorithm that uses the same location to store the input and output sequences is called an "in –place" algorithm.

5

Calculate the 4-point DFT of the sequence x (n) = {1, 0, -1, 0} (May 2018)BTL3

Given that,

$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ -1 \\ 0 \end{bmatrix} = \begin{bmatrix} 0 \\ 2 \\ 0 \\ 2 \end{bmatrix}$$

The output sequence X (k),

X (k) = {0, 2, 0, 2}

6

What is the relationship between Fourier Transform and DFT? (May 2018)BTL4

Fourier Transform	DFT
• Gives the frequency information for an aperiodic signal • Continuous frequency spectrum	• Obtained by performing sampling operation in both the time and frequency spectrum • Discrete frequency spectrum

7

What is twiddle factor? (Nov 2016)BTL1

It is also called phase factor of FFT.

The twiddle factor is given as,

$$W_N = e^{\frac{-j2\pi}{N}}$$

8

State and prove periodicity property of DFT. (Nov 2016)BTL1

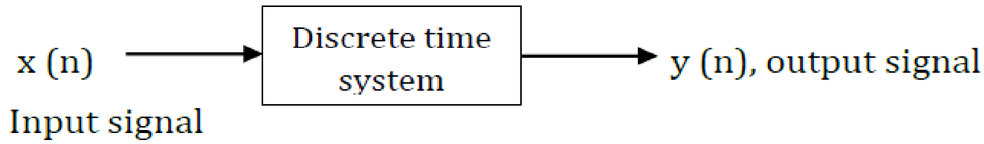
If X (K) is N – point DFT of a finite duration sequence x (n)

Then,

x (n + N) = x (n) for all n

X (k + N) = X (k) for all k

9	**What is the relation between DTFT and DFT? (May 2017)BTL4** **DTFT (Discrete Time Fourier Transform)** | **DFT (Discrete Fourier Transform)** Time domain sequence is discrete but frequency domain representation is continuous. | Both Time domain sequence and frequency domain representations are discrete. DTFT cannot be evaluated using fast algorithms. | DTFT can be evaluated using fast algorithms. DTFT is continuous version of DFT. | DFT is discrete version of DTFT.
10	**Compute DFT of the sequence x (n) = {1, -1, 1, -1}(May 2017)BTL3** $$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix} \begin{bmatrix} 1 \\ -1 \\ 1 \\ -1 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 4 \\ 0 \end{bmatrix}$$ The output sequence X (k), X (k) = {0, 0, 4, 0}
11	**Test the causality and stability of y (n) = sin x (n) (Nov 2016)BTL5** y (n) = sin x (n) A system is said to be causal system if its output depends on present and past inputs only and not on future inputs. Above system depends on present input, therefore it is called **causal.**
12	**Compare Radix 2 DIT, DIF FFT algorithm(Nov 2016)BTL4** **S.NO** | **DIT – FFT** | **DIF - FFT** 1 | The time domain sequence is decimated. | The DFT X (k) is decimated. 2 | Input sequence is to be given in bit reversal order | The DFT at the output is in bit reversal order. 3 | First calculates 2 – point DFT's and combined them. | Decimates the sequence step by step to 2-point sequence and calculates DFT.
13	**Define DT system. (Nov 2015)BTL1** • A system is defined as a physical device that performs an operation on a signal. • A discrete time system is a device or algorithm that operates on a discrete time input signal x (n), to produce another discrete time signal y (n) called the output signal.



14 **How do you obtain a digital signal for DT signal? (Nov 2015)BTL2**

A digital signal refers to an electrical signal that is converted into a pattern of bits. Unlike an analog signal, which is a continuous signal that contains time-varying quantities, a digital signal has a discrete value at each sampling point.

15 **What is bit reversal? [NOV 2015][R-2008], [MAY 2014],[MAY 2011]BTL1**

- In case of DFT FFT algorithm, the input sequence x (n) is applied in bit reversal order.
- For example each n is represented by 3 bits n2, n1, n0 then the bit reversal value of n will be n0, n1, n2.
- This means that x(0), x(1), x(2), x(3), x(4), x(5), x(6), x(7) will be reshuffled as x(0) , x(4) , x(2), x(6), x(1), x(5), x(3), x(7) after bit reversing.
- Similarly in case of DIF FFT algorithm, the output DFT X (K) is also shuffled in bit reversal order.

Input sample Index	Binary rep	Bit reversed binary	Bit reversed
0	000	000	0
1	001	100	4
2	010	010	2
3	011	110	6
4	100	001	1
5	101	101	5
6	110	011	3
7	111	111	7

16. **Compare the number of multiplications required to compute the DFT of 64 point sequence using direct computation and that using FFT.[NOV 2014]BTL4**

Number of points	**Direct computation**		**DIT FFT algorithm**	
	N^2	**N2N**	**N/2 Log_2N**	**$Nlog_2N$**
16	**256**	**240**	**32**	**64**
64	**4096**	**4032**	**192**	**384**

17.	**Obtain the circular convolution of the following sequences x (n) = {1,2,1} and h (n) = {1,-2,2}[NOV 2010] BTL3** $$\begin{bmatrix} 1 & 2 & -2 \\ -2 & 1 & 2 \\ 2 & -2 & 1 \end{bmatrix}\begin{bmatrix} 1 \\ 2 \\ 1 \end{bmatrix} = \begin{bmatrix} 3 \\ 2 \\ -1 \end{bmatrix}$$ y(n)=x(n)*h(n) y(n)={3,2,-1}
18.	**State the need for using FFT algorithms for computing Discrete Fourier Transform (DFT).BTL1** • FFT requires less number of multiplication and addition compared to direct computation of DFT. • FFT algorithm can be implemented fast on the DSP processor. • The calculation of DFT and IDFT both are possible by proper combination of DFT algorithms.
19.	**The first 5 DFT coefficient of a sequence x (n) are X (0) = 2, X (1) = 0.5 – j 1.206, X (2) = 0, X (3) = 0.5 – j 0.206, X (4) = 0. Determine DFT Coefficients.BTL3** N = 8 X (N - k) = X* (k) X (8 - k) = X* (k) k = 3, X (8 - 3) = X* (3) X(5) = X* (3) = 0.5 + j 0.206 k = 2, X (8 - 2) = X* (2) X (6) = X* (2) = 0 k = 1, X (8 - 1) = X* (1) X (7) = X* (1) = 0.5 + j 1.206
20.	**Calculate % saving in computing through radix – 2, DFT algorithm of DFT Coefficient. Assume N = 512.BTL3** Number of complex additions = N (N - 1) = 512 (512 - 1) = 2, 61,632 Number of complex computations = N^2 = 512^2== 2, 62,144

	Radix – 2 Number of complex additions $= N \log_2 N$ $= 512 \log_2 512$ $= 4{,}608$ Percentage saving Percentage saving in additions $= 100 - \frac{\text{Number of additions in radix}-2\ FFT}{\text{Number of additions in direct DFT}} * 100$ $= 100 - \frac{4608}{261632} * 100$ $= 98.2\ \%$
21	**What is zero padding? What is the purpose of it?BTL1** Zero padding means to add zeros at the end of the sequence. Because of zero padding length of the sequence increases. In FFT algorithms, Length of the sequence is $N=2^V$ For example some power of 2. If actual length of sequence is less than 'N' then zeros are appended at the end. Zero padding is used in: i. Calculation of DFT. ii. Linear filtering. iii. Better display of the frequency spectrum.
22	**State the properties of DFT? BTL1** • Periodicity • Linearity and symmetry • Multiplication of two DFTs • Circular convolution • Time reversal • Circular time shift and frequency shift • Complex conjugate • Circular correlation
23	**What is overlap-add method?BTL1**

	In this method the size of the input data block xi(n) is L. To each data block we append M-1 zeros and perform N point circular convolution of xi(n) and h(n). Since each data block is terminated with M-1 zeros the last M-1 points from each output block must be overlapped and added to first M-1 points of the succeeding blocks. This method is called overlap-add method.
24	**List the applications of FFT algorithm?BTL1** The applications of FFT algorithm includes 1) Linear filtering 2) Correlation 3) Spectrum analysis
25	**Define circular convolution?BTL1** Let $x_1(n)$ and $x_2(n)$ are finite duration sequences both of length N with DFTs $X_1(K)$ and $X_2(k)$ If $X_3(k)=X_1(k)X_2(k)$ then the sequence $x_3(n)$ can be obtained by circular convolution defined as $x_3(n)=\sum_{m=0}^{N-1} x_1(m)x_2((n-m))_N$
26	**What are the two methods used for the sectional convolution?BTL1** The two methods used for the sectional convolution are • Overlap-add method • Overlap-save method
	PART B
1	**Compute the DFT for the sequence x (n) = {1,2,3,4,4,3,2,1} Using radix – 2 DIT-FFT algorithms. .[APRIL/MAY 2017][R/2013] [16],[NOV/DEC 2014][10]BTL3** **Solution** **Twiddle factor formula: $W_8^0=1$** **$W_8^1= +0.707-j0.707$** **$W_8^2=-j$** **$W_8^3= -0.707-j0.707$ (4)**

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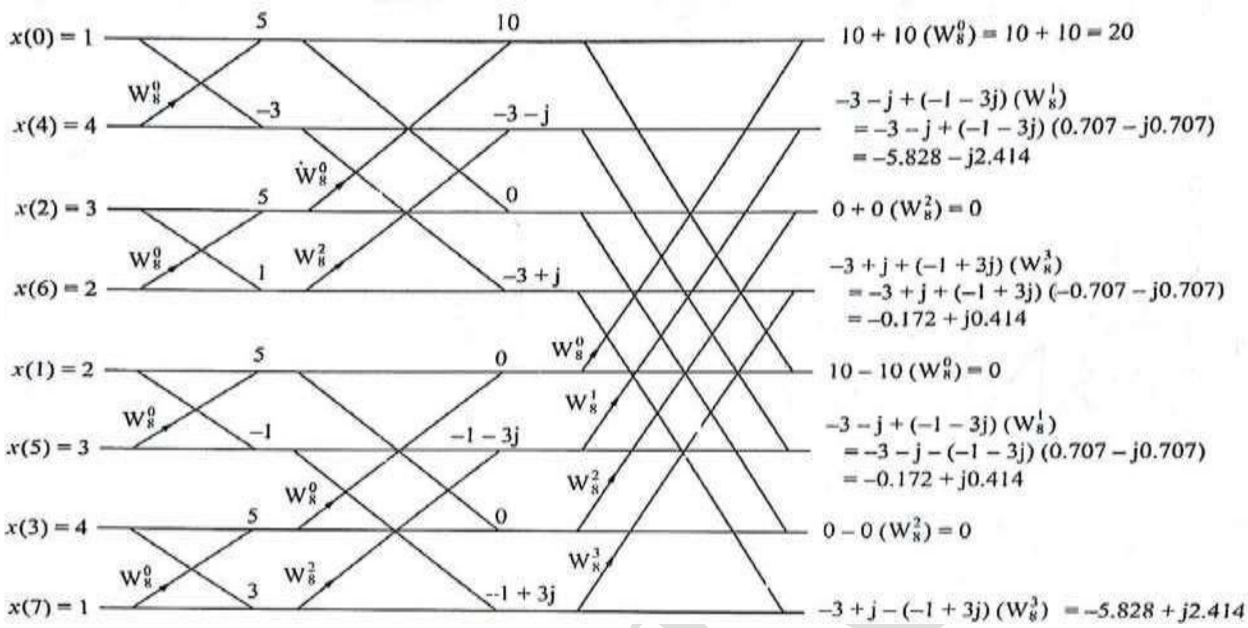

(12)

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In an LTI system the input x(n)={1,1,2,1} and the impulse response h(n)={1,2,3,4}.Perform the circular convolution using DFT and IDFT. [April/May 2017] R-2013] [16]BTL3

We know $X_3(K)=X_1(K)\ X_2(K)$

$X_1(k)=\sum_{n=0}^{N-1} x1(n)e^{-j2\pi kn/N}$ K= 0 ,1….N-1

Given: $x_1(n)=\{1,1,2,1\}$ and N=4

$X_1(0)=\sum_{n=0}^{3} x1(n)$=1+1+2+1=5

$X_1(1) = \sum_{n=0}^{3} x1(n)e^{-j\pi n/2}$=1-j-2+j=-1

$X_1(2) = \sum_{n=0}^{3} x1(n)e^{-j\pi n}$ =1-1+2-1=1

$X_1(3) = \sum_{n=0}^{3} x1(n)e^{-j3\pi n/2}$=1+j-2-j=-1

X1(k)= (5,-1,1,-1) (4)

$X_2(k)=\sum_{n=0}^{N-1} x2(n)e^{-j2\pi kn/N}$ K= 0 ,1….N-1

$X_2(0)=\sum_{n=0}^{N-1} x2(n)$ =1+2+3+4=10

$X_2(1)=\sum_{n=0}^{3} x2(n)e^{-j\pi n/2}$ =1+2(-j)+3(-1)=4(j)=-2+j2

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</table>

$X_2(2)=\sum_{n=0}^{3} x2(n)e^{-j\pi n}$ =1+2(-1)+3(1)+4(-1)=--2

$X_2(3)=\sum_{n=0}^{N-1} x2(n)e^{-j3\pi n}/2$ =1+2(j)+3(-1)+4(-j)=--2-j2

$X_2(K)$={10,-2+j2-2,-2,-j2}

$X_3(k)= X_1(K)\, X_2(K)$={50,2-j2,-2,2+j2} (6)

$X_3(n)= \frac{1}{N}\sum_{K=0}^{N-1} x3(k)e^{j2\pi kn/N}$ n= 0 ,1….N-1

$X_3(0)= \frac{1}{4}\sum_{K=0}^{3} x3(k)$ n= $\frac{1}{4}$(50+2-j2-2+2+j2)=13

$X_3(1)= \frac{1}{4}\left[\sum_{K=0}^{4} x3(k)e^{j\pi k/2}\right]= \frac{1}{4}$(50+(2-j2)j+(-2)(-1)+(2+j2)(-j)]=14

$X_3(2)= \frac{1}{4}\left[\sum_{K=0}^{4} x3(k)e^{j\pi k}\right]= \frac{1}{4}$(50+(2-j2)(-1)+(-2)(1)+(2+j2)(-1)]=11

$X_3(3)= \frac{1}{4}\left[\sum_{K=0}^{4} x3(k)e^{j3\pi k/2}\right]= \frac{1}{4}$(50+(2-j2)(-j)+(-2)(-1)+(2+j2)(j)]=12 (6)

X3(n)={13,14,11,12}

3 **State the following properties of DFT**

(a). Time reversal.b)Parseval,s theorem.**[NOV/DEC2015][R-2008][8],[MAY/JUNE 2013][R2008][8] BTL1**

(a). **<u>Time reversal</u>**

The time reversal of an N-Point sequence x(n) is attained by wrapping the sequence x(n) around the circle in clockwise direction.It is denoted As $x((-n)_N$ and If DFT[x(n)]=X(k)then

$DFT[x(-n))_N=DFT[x(N-n)]$ (4)

$X((-k))_N=X(N-K)$

$DFT[x(N-m)]=\sum_{n=0}^{N-1} x(N-n)e^{-j2\pi kn/N}$

Changing the index from n to m=N-N

$DFT[x(N-m)]= \sum_{n=0}^{N-1} x(m)e^{-j2\pi k(N-m)/N}$

$=\sum_{n=0}^{N-1} x(m)e^{j2\pi km)/N}$

$= \sum_{n=0}^{N-1} x(m)e^{-j2\pi m(N-k)/N}$

=X(N-K)

b) **Parseval, theorem.** **(4)**

If DFT[x(n)]=X(k)

and DFT[Y(n)]=Y(k)

$$\sum_{n=0}^{N-1} x(n)y*(n) = \frac{1}{N}\sum_{K=0}^{N-1} X(k)Y*(k)$$

4

Explain in detail about overlap add method and overlap save method for filtering of long data sequences using DFT.[MAY/JUNE 2014][R-2008][16],[NOV/DEC 2010][6][R2008]

With appropriate diagrams describe Overlap save method [8]
Overlap add method.[APRIL/MAY 2011][R-2008][8] (OR)

With appropriate diagrams discuss how overlap-save method and overlap odd method are used. [APRIL/MAY 2015][R-2008][16] BTL1

Overlap save method (8)

- Let the length of an input sequence be Ls and the length of an impulse response is M.
- In this method input sequence is divided into blocks of data size N=L+M-1.
- Each block consist of last (M-1) data points of previous block followed by L new data points to form a sequence of length N=L+M-1.
- For first block of data the first M-1 points are set to zero.Thus the block of data sequence are

$X_1(n)=\{0,0,0,\ldots..0,x(0),x(1),\ldots\ldots x(L-1)\}$
$X_2(n) =\{X(L-M+1),\ldots.x(L-1),x(L)\ldots\ldots..,x(2L-1)$

$$x_1(n) = \{\underbrace{0, 0, 0,}_{(M-1)\text{ zeros}} \ldots\ldots 0, x(0), x(n), \ldots\ldots x(L-1)\}$$

$$x_2(n) = \{\underbrace{x(L-M+1), \ldots\ldots, x(L-1),}_{\text{Last }(M-1)\text{ data points from }x_1(n)} \underbrace{x(L)\ \ldots\ldots, x(2L-1)}_{L\text{ new data points}}$$

$$x_3(n) = \{\underbrace{x(2L-M+1), \ldots\ldots, x(2L-1),}_{\text{Last }(M-1)\text{ data points from }x_2(n)} \underbrace{x(2L), \ldots x(3L-1)\}}_{L\text{ new data points}}$$

- Now the impulse response of the FIR filter is increased in length by appending L-1 zeros and an N-point circular convolution of $X_i(n)$ with h(n) is computed.

$$y_i(n) = x_i(n) \circledN h(n)$$

- Now we perform 5 point circular convolution of xi(n) and h(n) by appending two zeros to the sequence h(n).In the input block $y_i(n)$ first (M-1) Points are corrupted and must be discarded.

<u>Overlap add method</u> (8)

- Let the length of an input sequence be Ls and the length of an impulse response is M.
- In this method input sequence is divided into blocks of data size having the length L and M-1 zeros appended to it to make the data size of L+M-1
- Thus the data blocks may be represented as

$$x_2(n) = \{ x(L), x(L+1), \ldots\ldots, x(2L-1), \underbrace{0, 0, \ldots\ldots}_{M-1 \text{ zeros appended}} \}$$

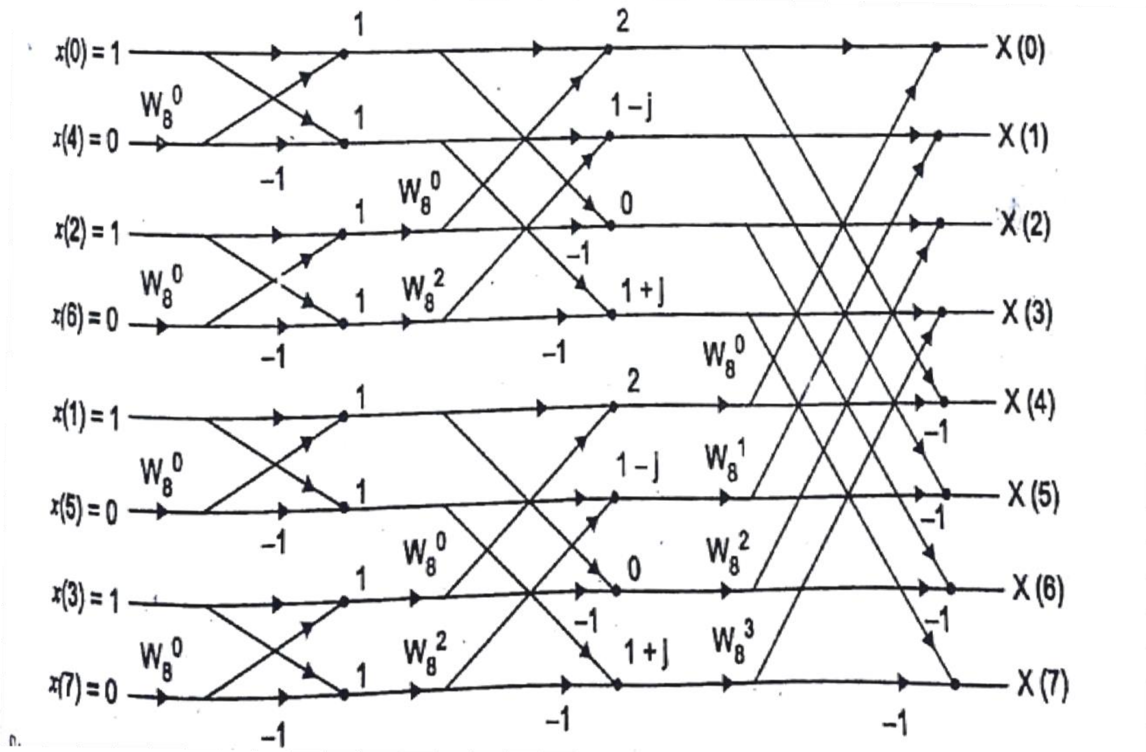
$$x_3(n) = \{ x(2L), x(2L+1), \ldots, x(3L-1), \underbrace{0, 0, \ldots\ldots}_{M-1 \text{ zeros appended}} \}$$

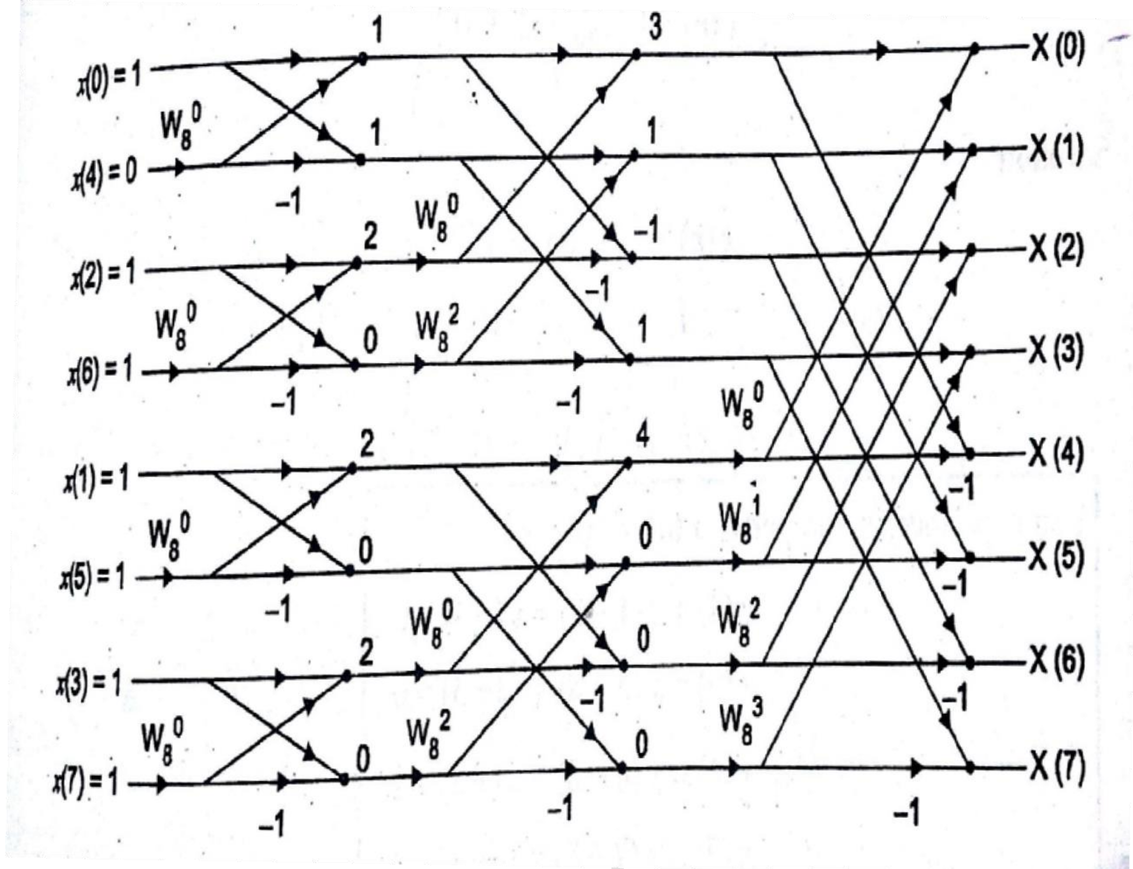
M – 1 zeros appended

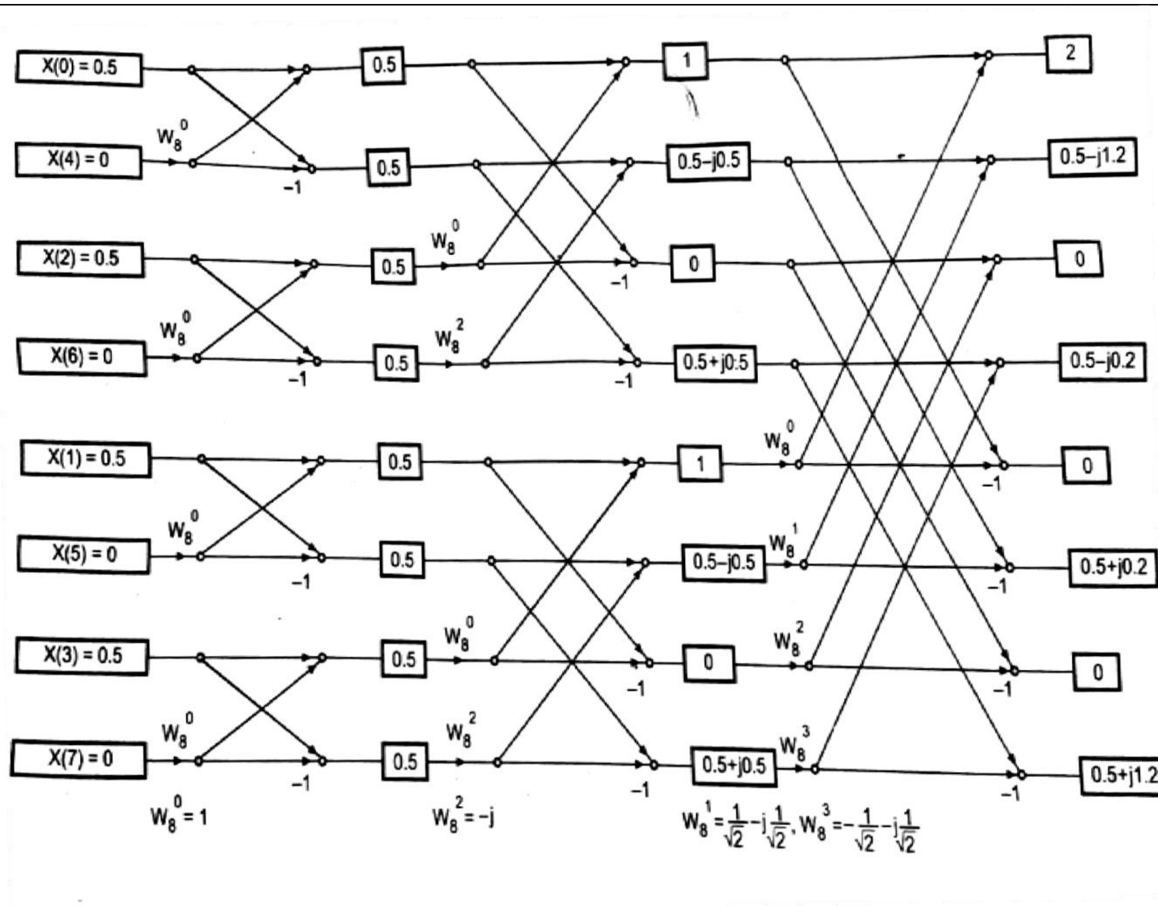
- Now L-1 Zeros are added to the impulse response h(n) and N-point circular convolution is performed. since the each data block is terminated with M-1 zeros, the last M-1 points from each output block must be overlapped and added to the first M-1 Points of the succeeding block. Hence this method is called overlap odd method. Let the output blocks are of the form.

5 **Develop a 8 point DIT FFT algorithm.Draw the signal flow graph. Determine the DFT of the following sequence x(n) = {1,1,1,1,0,0,0,0} using the signal flow graph.Show the all the intermediate results on the signal flow graph. [MAY/JUNE 2014][R-2008][16] BTL6**

Twiddle Factor (4)

	 **(10)** **X(K)={4, 1-j2.414, 0, 1-j0.414,0, 1+j0.414,0,1+j2.414}** **(2)**
6	**Evaluate the 8-point DFT for the following sequence using DIT-FFT algorithm** **x (n) =** $\begin{cases} 1, & -3 \le n \le 3 \\ 0, & \text{otherwise} \end{cases}$ **[NOV/DEC 2013][8][R-2008] BTL5** **Twiddle factor formula:** $W_8^0=1$ $W_8^1= +0.707-J0.707$ $W_8^2= -J$ $W_8^3 = -0.707-J0.707$ **(3)**

	 **X(k)={7,1,-1,1,-1,1,-1,1} (5)**
7	**Compute 8 – point DFT of the sequence x (n) = {1/2,1/2,1/2,1/2,0,0,0,0} using radix – 2 DIT.** **(10) [Nov 2010] BTL3** **Twiddle factor formula:** $W_8^0=1$ $W_8^1= +0.707-J0.707$ $W_8^2= -J$ $W_8^3 = -0.707-J0.707$ **(3)**

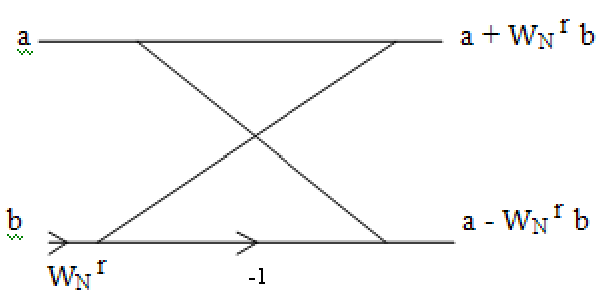
<table>
<tr><td></td><td>

X(k)={2,0.5-j1.2,0,0.5-j0.2,0,0.5+jo.2,0,0.5+j0.2} (7)</td></tr>
<tr><td>8.</td><td>Determine of LTI system the impulse response when the input sequence x(n)={-1,1,2,1} and impulse responses h(n)={-1,1,-1,1} by radix-2 DIT FFT. (8M) (May 2017) BTL3

Answer: page 1.60-Ramesh babu

$$y[n]=\sum_{k=0}^{\infty} x[k]h[n-k]$$ (4)

Draw radix -2 DIT FFT



(4)</td></tr>
<tr><td>9</td><td>Summarize the difference between overlap-save and overlap-add. [NOV/DEC 2013][R-</td></tr>
</table>

2008][8]

S.no	Overlap save method	Overlap odd method
1.	In this method the size of the input data block is N=L+M-1	In this method the size of the input data block is L
2.	Each data block consists of the last M-1 Data points of the previous data block followed by L new data points	Each data block consists of L points and we append M-1 zeros to compute N-point DFT.
3.	In each output block M-1 points are corrupted due to aliasing, as circular convolution is employed.	In this no corruption due to aliasing,as linear convolution is performed using circular convolution.
4.	To form the output sequence the first M-1 data points are discarded in each output block and the remaining data are fitted together.	To form the output sequence the last M-1 points from each output block is added to the first(m-1)points of the succeeding block.

PART * C

1

Find DFT for {1,1,2,0,1,2,0,1} using FFT DIT butterfly algorithm and plot the spectrum. (15M) (NOV 2013) BTL4

Answer: page 4.30 - Ramesh babu

- Input must be in Bit-reversal order (4)
- Calculate the twiddle factors (4)
- Draw the DIT-butterfly diagram (7)

2

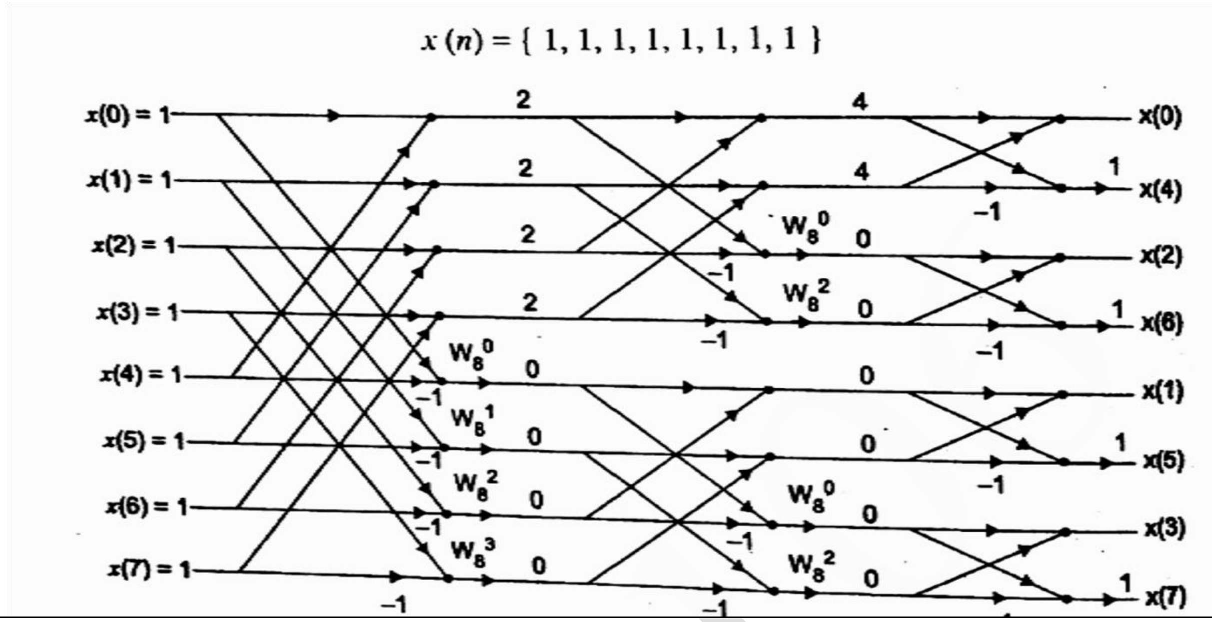
Compute te 8 − point DFT of the sequence $\mathbf{x(n) = \begin{cases} 1, & 0 \le n \le 7 \\ 0, & \text{otherwise} \end{cases}}$ **by using DIT,DIF algorithm[NOV/DEC 2013][15][R-2008] [NOV/DEC2010][12][R-2008] (12M)(MAY 2014)**

Answer: page 4.30 - Ramesh babu

- Input must be in Bit-reversal order (2)
- **Calculate the twiddle factors** (2)

  $X(k) = \sum_0^{N-1} x(n) w_N^{nk}$

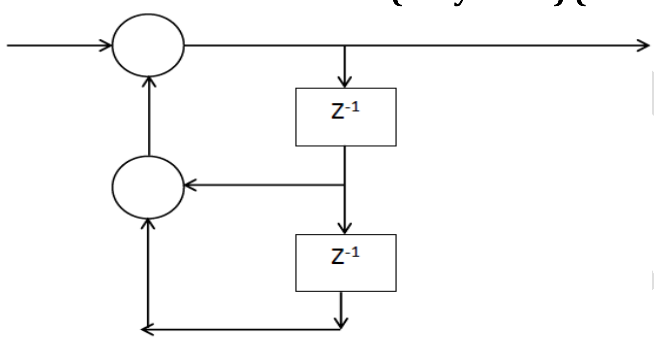
Draw the DIT-butterfly diagram (4)

	Draw DIF -butterfly diagram (7) 
3	**An 8-point sequence is given by *x*(*n*) = {2, 2, 2, 2, 1, 1, 1, 1}. Compute the 8-point DFT of *x*(*n*) by (a) Radix-2 DIT FFT algorithm (b) Radix-2 DIF FFT algorithm (15M)** BTL4 **Answer: page 4.30- Ramesh babu** **Radix-2 DIT FFT algorithm** • Input must be in Bit-reversal order (2) • Calculate the twiddle factors (2) • Draw the DIT-butterfly (2) **Radix-2 DIF FFT algorithm** • Input must be in normal order (2) • Calculate the twiddle factors (2) • Draw the DIF-butterfly diagram (3) Output will be in bit reverse order (2)

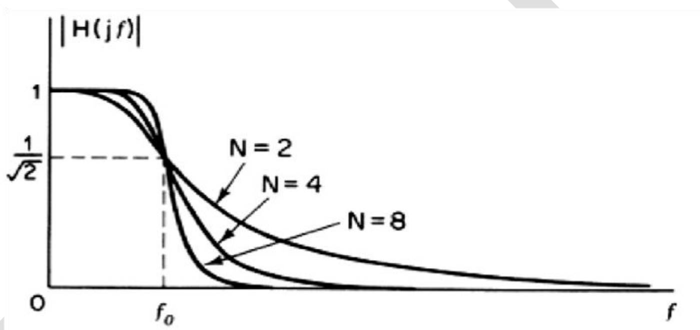
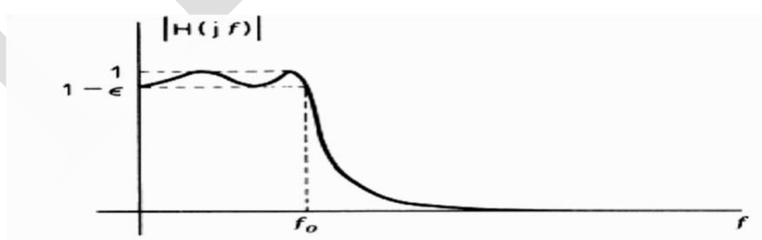
UNIT II – INFINITE IMPULSE RESPONSE FILTERS

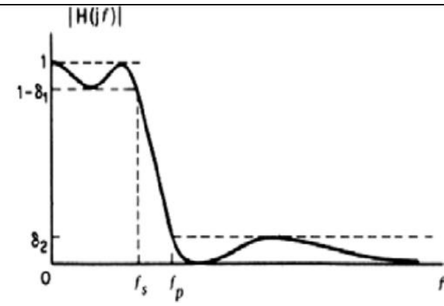
Characteristics of practical frequency selective filters. Characteristics of commonly used analog filters - Butterworth filters, Chebyshev filters. Design of IIR filters from analog filters (LPF, HPF, BPF, BRF) - Approximation of derivatives, Impulse invariance method, Bilinear transformation. Frequency transformation in the analog domain. Structure of IIR filter - direct form I, direct form II, Cascade, parallel realizations.

PART * A

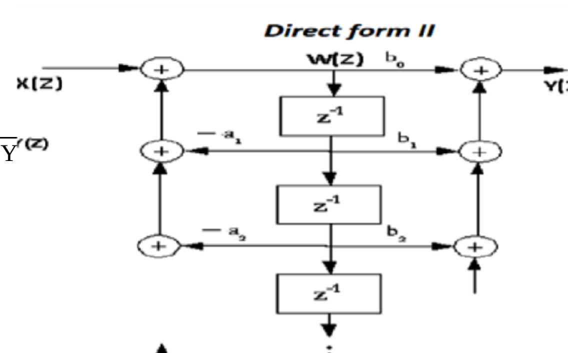
Q.No.	Questions
1.	**State the use of Z – transforms in IIR filter design. (May 2019)BTL1** ○ The z-transform is useful for the manipulation of discrete data sequences and has acquired a new significance in the formulation and analysis of discrete-time systems. ○ It is used extensively today in the areas of applied mathematics, digital signal processing, control theory, population science, and economics.
2.	**State the structure of IIR filter?(May 2019) (Nov 2018)BTL1** 
3	**What are the methods used for digitizing the analog filter into a digital filter? May 2018 –BTL1** • Impulse invariant transformation • Bilinear transformation • Approximation of derivatives • Matched Z – transformation
4	**What is meant by frequency warping? May 2018-BTL1** • The effect of the non-linear compression at high frequencies can be compensated. • When the desired magnitude response is constant over frequency. • This compression can be compensated by introducing a suitable prescaling or prewarping the critical frequencies by, $\Omega = \frac{2}{T} tan\left(\frac{\omega}{2}\right)$
5	**List the different types of filters based on frequency response. Nov 2017-BTL1** 1. Butterworth filter 2. Chebhysev filter

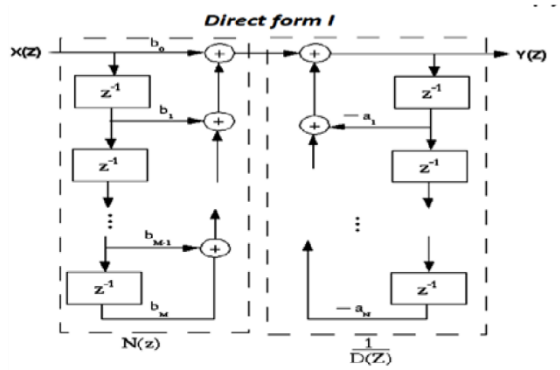
	• Low pass filter • High pass filter • Band pass filter • Band stop filter
6	**What are the properties of bilinear transformations? Nov 2018, 2017, 2016-BTL1** • The mapping for the bilinear transformation is a one-to-one mapping that is for every point Z, there is exactly one corresponding point S, and vice-versa. • The j Ω-axis maps on to the unit circle |z|=1, the left half of the s-plane maps to the interior of the unit circle |z|=1 and the half of the s-plane maps on to the exterior of the unit circle |z|=1.
7	**What are the requirements for the digital filter to be causal and stable? May 2017-BTL1** • A digital filter is causal if its impulse response h (n) = 0 for n < 0. A digital filter is stable if its impulse response is absolutely summable
8	**Discuss the need for the prewarping? May 2017-BTL2** In Bilinear Transformation, $\Omega = 2/T \tan \omega/2$ For small values of ω, $\Omega = 2/T\ \omega/2 = \omega/T$ For low frequency, the relationship between Ω and ω are linear. Therefore digital filters have the same amplitude as the analog filter. But for the high frequency, the relationship is not linear and the distortion is reduced in the digital filter. This is known as warping effect.
9	**What is known as prewarping? Nov 2016, May 2016-BTL1** When bilinear transformation is applied, the discrete time frequency is related continuous time frequency as, $\omega = 2 \tan^{-1}\left(\frac{\Omega T}{2}\right)$ This equation shows that frequency relationship is highly nonlinear. It is also called frequency warping. This effect can be nullified by applying prewarping. The specifications of equivalent analog filter are obtained by following relationship, $\Omega = \frac{2}{T} tan\left(\frac{\omega}{2}\right)$ This is called prewarping relationship.
10	**Why impulse invariant method is not preferred in the design of IIR filter other than LPF? May 2016-BTL2** In impulse invariance method, the mapping from s-plane to z-plane is many to one, i.e., all In impulse invariance method, the mapping from s-plane to z-plane is many to one, example all poles in the

	s-plane between the intervals $\frac{(2k-1)\pi}{T}$ to $\frac{(2k+1)\pi}{T}(for\ k = 0,1,2 \ldots)$ map into the entire z-plane. Thus, there is an infinite number of poles that map to the same location in the z-plane, producing aliasing effect. Due to spectrum aliasing the impulse invariance method is inappropriate for designing high pass filters. This is why the impulse invariance method is not preferred in the design of IIR filter other than low pass filters.
11	**Find H(z) for the IIR filter whose H(s)=1/(s+6) with T=0.1 sec.[April/may 2015][R-08] BTL3** In impulse invariance method H(s)=$\frac{1}{s+6}$ $$\frac{1}{s+a} = \frac{1}{1-e^{-6\,x0.1}Z^{-1}} = \frac{1}{1-0.5488Z^{-1}}$$
12	**Draw the response curve butterworth ,chebyshev and elliptic filters? [April/may 2015] [R-08]-BTL1** **Butterworth filters**  <u>Chebyshev Filters:</u>  **Elliptic Filter:**

	
13	**Distinguish between Butterworth filter and Chebyshev filter.[NOV/DEC 2015][R08], [NOV/DEC 2014][R-08]-BTL4** **Butterworth Filter** / **Chebyshev Filter** Magnitude response decreases monotonically as the frequency Ω increases from 0 to ∞ / Magnitude response exhibits ripple in the pass band and monotonically decreasing in the stop band. Transition band is more. / Transition band is less Poles are lie on a circle. / Poles are lie on an ellipse Number of poles are more. / Number of poles are less
14	**Mention the advantages of cascade realization.[May /june 2013]BTL1** ➢ Quantization errors can be minimize if we realize an LTI system in cascade form. ➢ The sensitivity of frequency response characteristics to quantization of the coefficients is minimized
15	**Give the steps in the design of a digital filter from analog filter.*[Nov 2013]BTL1*** ➢ **Bilinear transformation:** Substitute the following in H(s) to convert H(s) into H(z) $s = \frac{2}{T}\left[\frac{1 - Z^{-1}}{1 + Z^{-1}}\right]$ ➢ ***Impulse Invariance method:*** Use the partial fraction method to find the poles of the analog transfer function H(s) and substitute the following in H(s) to convert H(S) Into H(Z). $H(z) = \frac{C_k}{1 - e^{P_k T} Z^{-1}}$
16	**What are the disadvantages of direct form realization?[NOV/DEC 2013]BTL1** ➢ It is extremely sensitive to parameter quantization.

	➢ When the order of the filter N is large, a small change in a filter coefficient due to parameter quantization, results in a large change in the location of the poles and zeros of the system.
17	**Why the butterworth response is called a maximally flat response?BTL1** The Butterworth filter is a type of signal processing filter designed to have as flat a frequency response as possible in the passband. It is also referred to as a maximally flat magnitude filter.
18	**Give any two properties of chebyshev filters.[APRIL/MAY-2011] ,** **List the properties of chebyshev filters? [NOV/DEC 2011]BTL1** ➢ The magnitude response of the Chebyshev filter exhibits ripple either in passband or in stopband according to type. ➢ The poles of the chebyshev filter lie on an ellipse.
19	**Why we go for analog approximation to design a digital filter?[MAY/APRIL 2011]-BTL1** ➢ Map the desired digital filter specifications into those for an equivalent analog filter. ➢ Derive the analog transfer function for the analog prototype. ➢ Transform the transfer function for the analog prototype into an equivalent digital filter transfer function.
20	**Mention the advantages of bilinear transformation.BTL-1** ➢ The bilinear transformation is a mapping that transforms the left half of s- plane into the unit circle in the z plane only once, thus avoiding of frequency components. ➢ The mapping from s plane to the z plane in bilinear transformation is, $s = \frac{2}{T}\left[\frac{1 - Z^{-1}}{1 + Z^{-1}}\right]$ Advantages: ➢ It provides one to one mapping. ➢ Stable continuous systems can be mapped into realizable, stable digital system. ➢ There is no aliasing.
21	**Draw the direct form structure of IIR filter.[Nov/dec 2011]-BTL1**





22 **What is the advantage of direct form II realization when compared to direct form I realization?[Nov/dec 2010]BTL2**

- In direct form II realization, Number of memory locations required is less than that of direct form I realization.
- Same delay is used for input and output.

23 **Distinguish analog and digital filters?BTL5**

Analog filter	Digital filter
Analog filters are constructed from active or passive electronic component's	A digital filter consists of elements like adder, multiplier and delay unit
Analog filter processes analog inputs and generates analog outputs	A digital filter processes and generates digital data
Analog filter is described by a differential equation	Digital filter is described by a difference equation
The frequency response of an analog filter can be modified by changing the components	The frequency response can be changed the filter coefficients

24 **Compare bilinear Transformation and impulse invariant method of IIR filter design.BTL4**

Bilinear Transformation	Impulse invariant method

	Both poles and zeros of H(s) are mapped	Only poles of H(s) are mapped
	No aliasing since mapping is one to one	Aliasing of frequencies takes place
	Nonlinear frequency relationship	Linear frequency relationship

25	**What are the properties of impulse invariant transformation?BTL1** • Only poles of system function are mapped. • There is aliasing in frequency domain due to mapping • Frequency relationship $\omega = \Omega T$ is linear • Stable analog filter is converted to stable digital filter.
26	**IIR filter does not have linear phase? JustifyBTL2** Linear phase filter must have a system function that satisfies the condition $H(z) = \pm z^{-N} H(z^{-1})$ Where z^{-N} represents a delay of N units of time. But if this is the case, for every pole inside the unit circle there must be a pole outside the unit circle. Hence the filter would be unstable. A causal and stable IIR filter cannot have linear phase.
	PART B
1	**Write the procedure to design a butterwoth filter.[NOV/DEC 2015][8]BTL1** 4. Collect the parameters from the given problem. 5. Draw the low pass filter characteristics and the asked filter characteristics.. 3. For HPF, The pass band frequency Ωph and stop band frequency Ωsh are exchanged (with LPF) that is $\Omega pL = \Omega sh$ and $\Omega sL = \Omega ph$ 6. Select the transformation techniques (a) For bilinear transformation (apply prewarping) $\Omega = \frac{2}{T} tan\left(\frac{\omega}{2}\right)$ (b) For impulse invariant technique 7. Find the order of the filter (4)

(a) For LPF

$$N \geq \frac{\log(\lambda/\varepsilon)}{log(\Omega s/\quad p)}$$

(b) For HPF

$$N \geq \frac{log(\lambda/\varepsilon)}{log(\Omega p/\quad s)}$$

(c) For BPF and BST

$$N \geq \frac{\log(\lambda/\varepsilon)}{\log(\quad r)}$$

$\Omega r = \min\{|A|,|B|\}$

(1) For BPF

$$A = \frac{-\Omega 1^2 + \Omega l\, \Omega u}{1(\Omega u - \Omega l)} \qquad B = \frac{{}^2 - \Omega l\, \Omega u}{(\Omega u - \Omega l)}$$

(2) For BSF

$$A = \frac{1(\Omega u - \Omega l)}{-\Omega 1^2 + \Omega l\, \Omega u} \qquad B = \frac{(\Omega u - \quad l)}{-\Omega \quad {}^2 + \Omega l\, \Omega u}$$

8. The normalized butter worth polynomials for various value of N is given below

a. S+1

b. S^2+.707s+1

c. (s+1) (s2+s+1)

d. (s^2+.7653s+1) (s^2+1.84s+1)

e. (s+1) (s^2+.6183s+1) (s2+1.618s+1)

f. (s^2+1.93s+1) (s^2+.707s+1) (s^2+.5s+1)

g. (s+1) (s^2+1.809s+1) (s^2+1.24s+1) (s^2+.48s+1)

Transfer function of normalized LPF is

$|H(j\omega)| = \frac{1}{polynomial}$ the selection of the polynomial equation in the transfer function is based on the order of the filter.

9. Denormalize the transfer function

(a) For LPF to LPF

$S \rightarrow \frac{s}{c} \qquad \Omega c = {}^{p}/_{\varepsilon^{1/N}}$

(b) For LPF to HPF

$S \rightarrow \quad {}^{c}/_{s}$

(c) For LPF to BPF

$$S \rightarrow \frac{S^2+l\,u}{s(\Omega u-\Omega l)}$$

(d) For LPF to BSF

$$S \rightarrow \frac{S(\Omega u-\Omega l)}{s^2+\Omega l\,\Omega u}$$

10. Apply transformation technique to convert analog filter into respective digital filter

(a) For bilinear transformation technique, s→ $-\left(\frac{1-z^{-1}}{1+z^{-1}}\right)$

(b) For impulse invariant technique,

$$\frac{1}{s-p_k} \rightarrow \frac{1}{1-e^{Tp_k}Z^{-1}}$$

11. Final transfer function must be presented in the following format (4)

H(Z) = $\frac{b_0+b_1z^{-1}+b_2z^{-2}+\cdots}{1+a_1z^{-1}+a_2z^{-2}+\cdots}$ a_0 must

be always unity.

2

Write the design procedure for Chebyshev filter [NOV/DEC 2013][8]BTL1

1. Collect the parameters from the given problem.
2. Draw the low pass filter characteristics.
3. For HPF, The pass band frequency ωph and stop band frequency ωsh are exchanged (with LPF) that is

   ΩpL = Ωsh and ΩsL = Ωph
4. Select the transformation techniques

   (c) For bilinear transformation

   (d) For impulse invariant technique
5. Find the order of the filter (4)

   (d) For LPF

   $$N \geq \frac{\cosh^{-1}(\lambda/\varepsilon)}{\cosh^{-1}(\Omega s/\ \ p)}$$

   (e) For HPF

   $$N \geq \frac{\cosh^{-1}(\lambda/\varepsilon)}{\cosh^{-1}(\Omega p/\ \ s)}$$

(f) For BPF and BST

$N \geq \frac{\cosh^{-1}(\lambda/\varepsilon)}{\cosh^{-1}(\ \ r)}$

Ωr = min {|A|,|B|}

(3) For BPF

A = $\frac{-\Omega 1^2+\Omega l\,\Omega u}{1(\Omega u-\Omega l)}$ B = $\frac{^2-\Omega l\,\Omega u}{(\Omega u-\Omega l)}$

(4) For BSF

A = $\frac{1(\Omega u-\Omega l)}{-\Omega 1^2+\Omega l\,\Omega u}$ B = $\frac{(\Omega u-\ \ l)}{-\Omega\ \ ^2+\Omega l\,\Omega u}$

6. The chebyshev polynomial can be obtained by

$s_k = p(-sin\ sinh\theta + jcos\ cosh\theta)$

where $\theta = \frac{1}{N} sinh^{-1}(1/_{\varepsilon})$

$_K = \frac{(2K-1)\pi}{N}$, K= 1,2,3,…,

7. Transfer function of chebyshev filter is given by

$|H(j\Omega)| = \frac{numerator}{chebyshev\ polynomial}$

Chebyshev polynomial = (s-s_1) (s-s_2)….. (s-s_k)

8. Find the value of numerator term of the transfer function

(a) For odd value of filter order-substitute S=0 in the chebyshev polynomial

(b) For even value of filter order-substitute S=0 and ÷ by $\sqrt{1+\varepsilon}$ in the chebyshev polynomial

9. Filter conversion

(e) For LPF to HPF

S→ $\frac{P}{S}$

(f) For LPF to BPF

S→ $\frac{S^2+l\,u}{s(\Omega u-\Omega l)}$

(g) For low pass to band stop

S→ $\frac{S(\ u-l)}{s^2+\Omega l\,\Omega u}$

10. Apply transformation technique to convert analog filter into respective digital filter

(c) For bilinear transformation technique, s→ – $(\frac{1-z^{-1}}{1+z^{-1}})$

(d) For impulse invariant technique,

$$\frac{1}{s-p_k} \rightarrow \frac{1}{1-e^{Tp_k} Z^{-1}}$$

11. Final transfer function must be presented in the following format

$$H(Z) = \frac{b_0 + b_1 z^{-1} + b_2 z^{-2} + \cdots}{1 + a_1 z^{-1} + a_2 z^{-2} + \cdots} a_0$$

must be always unity.

3

Convert the analog filter into a digital filter whose system function is given by

$H(S) = \frac{s+0.2}{(s+0.2)^2+9}$ (8 marks)BTL3

$H(S) = \frac{1}{(S+1)(S+2)}$ using IITT

Solution:

$$\frac{s+a}{(s+a)^2+b^2} = \frac{1-e^{-at}(\cos bt)z^{-1}}{1- e^{-at}(\cos bt)z^{-1}+e^{-2at}z^{-2}}$$

$$\frac{s+0.2}{(s+0. \ )^2+3^2} = \frac{1-e^{-0.2t}\cos 3t\, z^{-1}}{1- e^{-0.2t}\cos 3t\, z^{-1}+e^{-2*0.2t}\, z^{-2}}$$

$$H(Z) = \frac{1+ \ .817\, Z^{-1}}{1+1.6352\, Z^{-1}+0.67Z^{-2}}$$

$$H(s) = \frac{A}{S+1} + \frac{B}{S+2}$$

1=A(S+2) + B(S+1)

When S=-2, 1=B(-2+1) ⇒ B=-1

When S=-1, 1=A(-1+2) ⇒ A=1

1 1

	$H(S) = \frac{}{(S+1)} \quad \frac{}{(S+2)} - 1$ (4) $\frac{1}{S-P_i} \rightarrow \frac{}{1-e^{TP_i} z^{-1}}$ $H(z) = \frac{1}{1-e^{-1}z^{-1}} - \frac{1}{1-e^{-2}z^{-1}} \Rightarrow \frac{(1-0.135z^{-1})-(1-0.367z^{-1})}{(1-0.367z^{-1})(1-\ .135z^{-1})}$ $H(Z) = \frac{.232\,Z^{-1}}{1-\ .502Z^{-1}+0.0495Z^{-2}}$ (4)
4	**Design a butter worth filter using BLTT** **PB** $0.8 \le \lvert H(e^{j\omega})\rvert \le 1, 0 \le \omega \le 0.2\pi$ **SB** $\lvert H(e^{j\omega})\rvert \le 0.2, 0.6 \le \omega \le \pi$ **[Nov/dec 2011][16]BTL3** Solution: Select the transformation technique Find the order of filter $N \ge \frac{\log(\lambda/\varepsilon)}{\log(\Omega s/\Omega p)}$ $\frac{1}{\sqrt{1+\varepsilon^2}} = 0.8 \Rightarrow\ = 0.75$ $\frac{1}{\sqrt{1+\lambda^2}} = 0.2 \Rightarrow\ = 4.8989$ On substituting, $N \ge 1.299 \Rightarrow N = 2$ Transfer function of normalized LPF for N=2 (5) $\lvert H(j\omega)\rvert = \frac{1}{S^2+\sqrt{\ }S+1}$ Denormalise the transfer function for LPF to LPF $S \rightarrow \frac{S}{\Omega c}$

$$\Omega c = \frac{\Omega s}{\varepsilon^{1/N}} \Rightarrow \frac{.6498}{(0.75)^{1/2}} = 0.7503$$

$$S \rightarrow \frac{S}{.7503} \qquad (5)$$

$$H(S) = \frac{.5629}{S^2+\sqrt{2}S(0.7503)+\ .5629} = \frac{.5629}{S^2+1.061S+0.5629}$$

Apply transformation technique to convert analog filter into respective digital filter

Replace $S \rightarrow \frac{\ }{T}\left(\frac{1-z^{-1}}{1+z^{-1}}\right)$

$$H(z) = \frac{.5629}{^{2}\left(\frac{1-z^{-1}}{1+z^{-1}}\right)^2 + 1.061*2\left(\frac{1-z^{-1}}{1+z^{-1}}\right)+0.5629}$$

$$= \frac{.5629\ (1+z^{-1})^2}{4(1-z^{-1})^2+2.122(1-z^{-1})(1+z^{-1})+\ .5629(1+z^{-1})^2}$$

$$H(Z) = \frac{1+\ z^{-1}+z^{-2}}{11.8757-12.212z^{-1}+2.3363z^{-2}} \qquad (6)$$

5. **Design a butter worth filter using BLTT for**

$\mathbf{0.707 \leq |H(e^{j\omega})| \leq 1 \text{ for } 0 \leq \omega \leq \pi/2}$

$\mathbf{|H(e^{j\omega})| \leq 0.2 \text{ for } 3\pi/4 \leq \omega \leq \pi}$ **(13) [April/May 2017] R -2013-BTL3**

Solution:

Select the transfer function technique BLTT

Find the order of filter

$$N \geq \frac{\log\lambda/\varepsilon}{\log\Omega s/\Omega p}$$

$$\frac{1}{\sqrt{1+\varepsilon^2}} = 0.707 \Rightarrow \quad = 1$$

	$\frac{1}{\sqrt{1+\lambda^2}} = 0.2 \Rightarrow \; = 4.8989$ $N \geq 1.802$ $N=2$ Transfer function of normalized LPF for N=2 (3) $H(j\omega) = \frac{1}{s^2+\sqrt{\ }s+1}$ Denormalised the transfer function for LPF to LPF $S \rightarrow \frac{S}{\Omega C}$, $\Omega c = \frac{\Omega p}{1/N} = 2$ $H(S) = \frac{4}{S^2+2\sqrt{2}S+4}$ (4) Applying transformation technique to convert analogue filter to digital filter $S \rightarrow \frac{(1-Z^{-1})}{1+Z^{-1}}$ $H(z)= \frac{(1+z^{-1})^2}{(1-z^{-1})^2+\sqrt{\ }(1-z^{-1})(1+z^{-1})+(1+z^{-1})^2}$ $H(Z) = \frac{(1+Z^{-1})^2}{3.414+0.5857Z^{-2}}$ (5)
6	**Analyze briefly the different structures of IIR filter. (10M) (MAY 2014) (May 2016)** (BTL2) **Answer:Page 5.55 - Ramesh babu** • Direct form –I (2M) • Direct form –II (2M) • Cascade form (2M) • Parallel form (2M) • Lattice form (2M)
7.	**Realize the given system in cascade and parallel forms** $H(z) = \frac{1+(1/3)z^{-1}}{[1-(1/2)z^{-1}+(1/3)z^{-2}][1-(1/3)z^{-1}+(1/2)z^{-2}]}$ **(6M)** (BTL4) **Answer:Page 5.68 - Ramesh babu**

	• Cascade form (3M) Parallel form (3M)
8.	**The specification of the desired low pass filter is** **$0.7 \le \|H(w)\| \le 1.0$ $0 \le w \le 0.2$** **$\|H(w)\| \le 0.2$ $0.32\pi \le \pi$** **Design Butterworth digital filter using impulse invariant transformation. (12M) (NOV 2015)** (BTL3) **Answer:Page 5.79 - Ramesh babu (similar type)** Find analog frequency (3M) Compute order (3M) Calculate transfer function (3M) Compute H(z) (3M)
9.	**Convert the given analog filter with a transfer function H (S) =$\frac{2}{(s+1)(s+2)}$ into a digital IIR filter using bilinear transformation .Assume T=1 sec.[MAY/JUNE 2013][R/2008]-BTL3(6)** Given that H (S) = $\frac{2}{(s+1)(s+2)}$ Applying bilinear transformation $H(z)=H(s)\|_{s=\frac{2}{T}\left(\frac{1-Z^{-1}}{1+Z^{-1}}\right)}$ (2) $H(z)=H(s)=\frac{2}{\left[2\left(\frac{1-Z^{-1}}{1+Z^{-1}}\right)\right]\left[2\left(\frac{1-Z^{-1}}{1+Z^{-1}}\right)+2\right]}$ $=\frac{2\left(1+Z^{-1}\right)^2}{\left(2-2Z^{-1}+1+Z^{-1}\right)\left(2-2Z^{-1}+2+Z^{-1}\right)}$ $=\frac{2(1+Z^{-1})}{4(3-Z^{-1})}$ $=\frac{0.166\left(1+Z^{-1}\right)^2}{\left(1-0.33Z^{-1}\right)}$ **(4)**
	PART-C
Q.No	**Questions**

1

Obtain the direct form I, direct form II, cascade and parallel form realization for the system y(n) = -0.1 y(n-1) + 0.2 y(n-2) + 3x(n) + 3.6 x(n-1) + 0.6 x(n-2).(Nov-2011, Nov-2014 ,May-2014,Nov-2010,May -2012[15] –BTL3

Given:

Let y(n) = -0.1 y(n-1) + 0.2 y(n-2) + 3x(n) + 3.6 x(n-1) + 0.6 x(n-2)

Direct form I **(4)**

Let $3\,x(n) + 3.6\,x(n-1) + 0.6\,x(n-2) = \omega(n)$

$y(n) = -0.1\,y(n-1) + 0.2\,y(n-2) + \omega(n)$

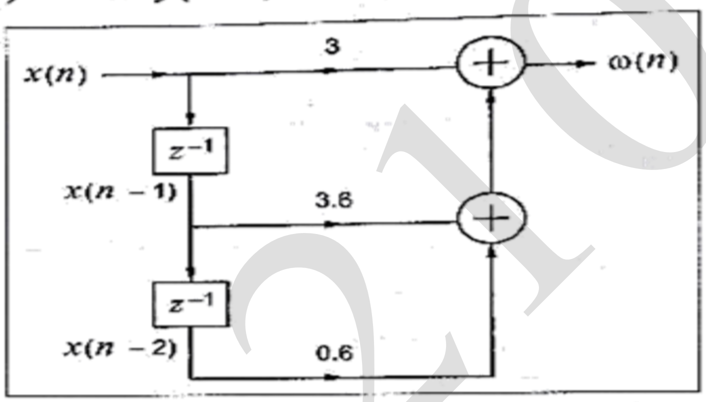
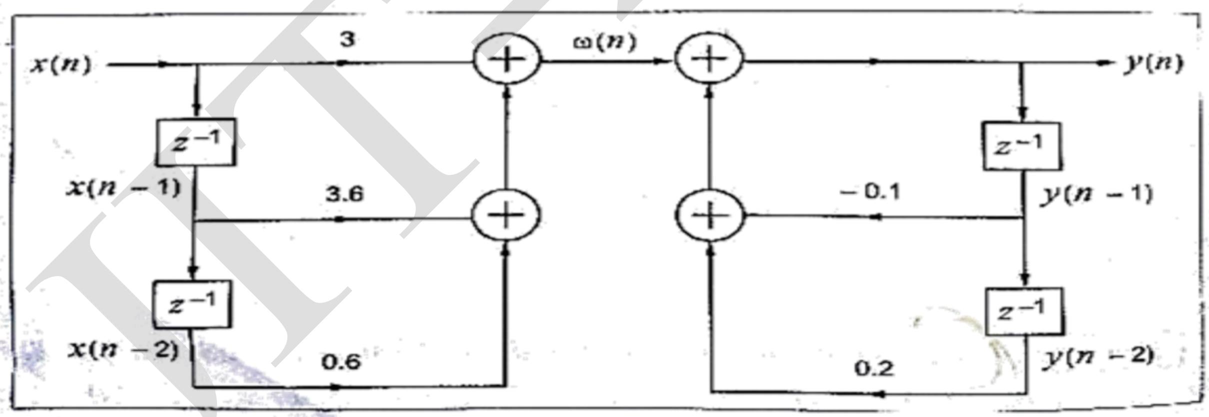


Fig. 3.42.



Direct form-II: **(4)**

y(n) = -0.1 y(n-1) + 0.2 y(n-2) + 3x(n) + 3.6 x(n-1) + 0.6 x(n-2)

Taking Z-transform on both sides we get,

Y(z) =- 0.1Y(z)zz^{-1} +0.2 Y(z)zz^{-2} +3 x(Z)+3.6X(z)zz^{-1} +0.6X(z)zz^{-2}

Y(z) + 0.1Y(z)zz^{-1} -0.2 Y(z)zz^{-2} =3 x(Z)+3.6X(z)zz^{-1} +0.6X(z)zz^{-2}

Y(z)[1+0.1zz^{-1}-0.2zz^{-2}]=X(z) [3+3.6zz^{-1}-0.6zz^{-2}]

$$H(z) = \frac{Y\ (z)}{X(z)} = \frac{3+3.6\ Z^{-1}+0.6\ \ Z^{-2}}{1+0.1\ Z^{-1}-0.2\ \ Z^{-2}}$$

$$\frac{Y(Z)}{W(Z)}\frac{W(Z)}{X(Z)} = \frac{3+3.6\ Z^{-1}+0.6\ \ Z^{-2}}{1+0.1\ Z^{-1}-0.2\ \ Z^{-2}}$$

$$\frac{Y(Z)}{W(Z)} = 3 + 3.6\ Z^{-1} + 0.6\ \ Z^{-2}$$

Y(z)= 3W(z) 3.6 $ZZ^{-1}WW(zz) + 0.6\ \ ZZ^{-2}WW(zz)$

Taking Inverse Z-Transform

Y(n)= 3W(n) 3.6 $WW(tt-1) + 0.6\ \ WW(tt-2)$ (1)

$$\frac{W(Z)}{X(Z)} = \frac{1}{1+0.1\ Z^{-1}-0.2\ \ Z^{-2}}$$

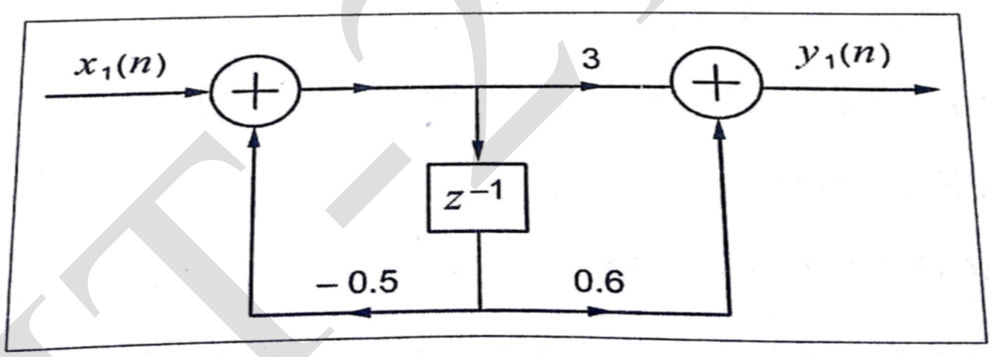
W(z)+0.1$zz^{-1}WW(zz)$-0.2zz^{-2}W(z)=X(z)

Taking Inverse Z-Transform

$$\omega(tt) + 0.1\omega\omega(tt-1) - 0.2\omega\omega(tt-2) = xx(tt)$$

X(n)= $\omega\omega(tt) + 0.1\omega\omega(tt-1) - 0.2\omega\omega(tt-2) = xx(tt)$ (2) Now

combine (1) and (2) realization ,we get direct form-II



Cascade form: (3)

$$H(z) = \frac{Y\ (z)}{X(z)} = \frac{3+3.6\ Z^{-1}+0.6\ \ Z^{-2}}{1+0.1\ Z^{-1}-0.2\ \ Z^{-2}}$$

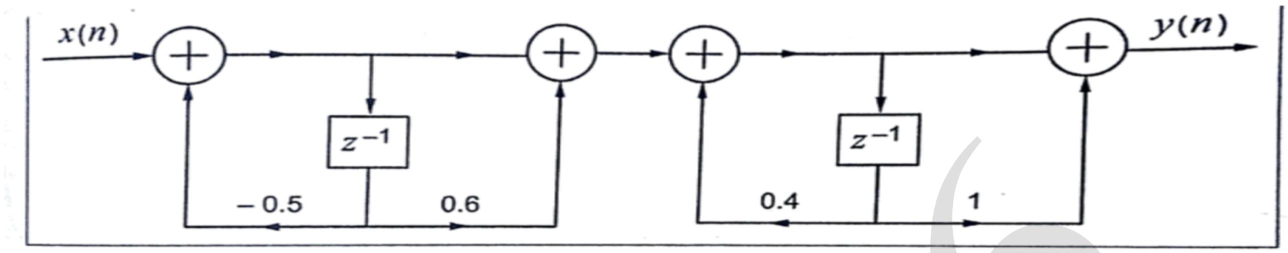
$$= \frac{(3+0.6z^{-1})(1+z^{-1})}{(1+0.5z^{-1})(1-0.4z^{-1})}$$

$$H_1(z) = \frac{3+0.6z^{-1}}{1+0.5^{\ -1}}$$

z

$$H_2(z)= \frac{1+z^{-1}}{1-0.4z^{-1}}$$

Now realize $H_1(z)$ in direct form-II as follows:



Parallel form: (4)

$$H(z) = \frac{Y(z)}{X(z)} = \frac{3+3.6\,Z^{-1}+0.6\,Z^{-2}}{1+0.1\,Z^{-1}-0.2\,Z^{-2}}$$

$$=-3+ \frac{3.9z^{-1}+6}{-0.2z^{-2}+0.1z^{-1}+1}$$

$$=-3+\frac{7}{1-0.4z^{-1}} - \frac{1}{1+0.5z^{-1}}$$

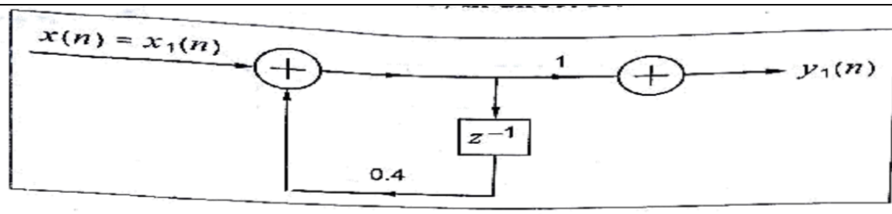
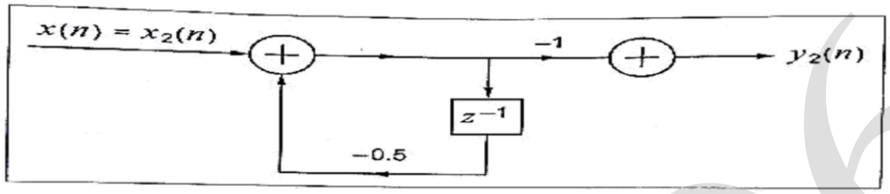
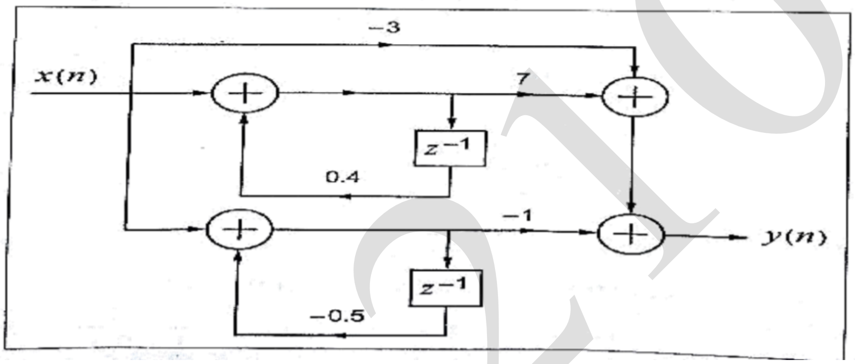
$$=-3+ \frac{6+3.9z^{-1}}{1+0.1z^{-1}-0.2z^{-2}}$$

$$= -3+\frac{A}{1-0.4Z^{-1}} +\frac{B}{1+0.5Z^{-1}}$$

Simplify the above equations we get,A=7,B=-1

$$H(Z)= -3+ \frac{7}{1-0.4z^{-1}} - \frac{1}{1+0.5z^{-1}}$$

$$H(z)=c+H_1(z).H_2(z)$$

	 *Fig. 3.48.* $H_2(z) = \frac{-1}{1+0.5z^{-1}}$ and realize $H_2(z)$ in direct form II as  *Fig. 3.49.* Now realize $H(z)$ in parallel form as follows: 
2.	**Design a third order Butterworth digital filter using impulse invariant technique. Assume the sampling period T=1Sec .(15M)**(BTL2) **Answer:Page 5.41 - Ramesh babu** Determine transfer function of normalized butterworth filter (5M) Compute H(s) (5M) Calculate H(z) (5m)
3.	**Design a digital Second order low pass Butterworth filter with cut off frequency 2200 Hz using bilinear transformation. Sampling rate is 8000 Hz.(8M)** (BTL4) **Answer:Page 5.41 - Ramesh babu** Compute transfer function of normalized butterworth filter (5M) Compute H(s) (3M)
4.	**Convert an analog filter within the system transfer function,** **H(S) =**$\frac{1}{(s+1)(s+2)}$ **using impulse invariance technique for Sampling frequency of 5 samples/second. [May/june 2016][8] –BTL3** $$H(S) = \frac{1}{(s+1)(s+2)}$$

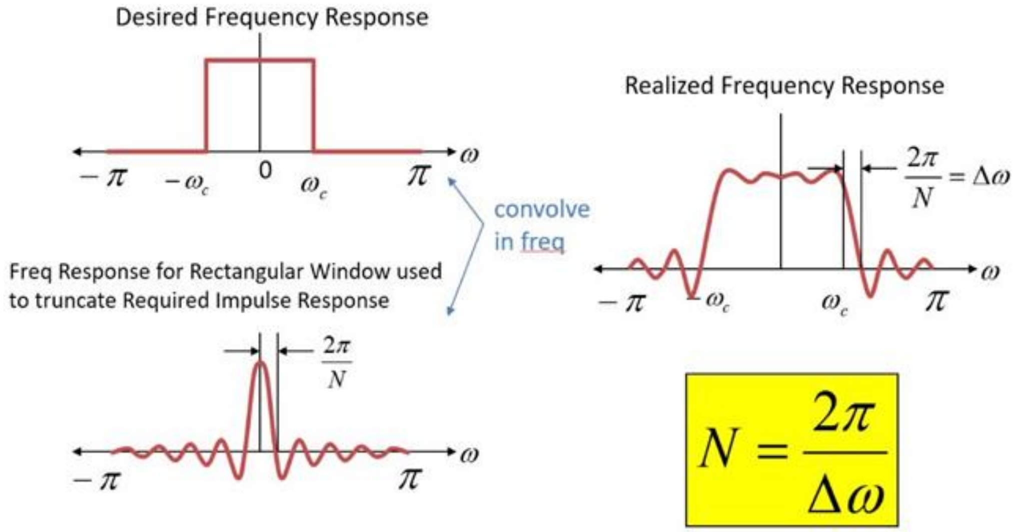
	$H(S)=\frac{A}{S+1}+\frac{B}{S+2}$ $H(s)=\frac{1}{S+1}+\frac{-1}{S+2}$ (4) It is given that sampling frequency F_S=5Hz Sampling period $T=\frac{1}{FS}=\frac{1}{5}=0.2$, T=5 sec, $\frac{1}{s-pk}\rightarrow\frac{1}{1-e^{PkT}Z^{-1}}$ $H(z)=\frac{1}{1-e^{-\times 0.2}Z^{-1}}-\frac{1}{1-e^{-2\times 0.2}Z^{-1}}=\frac{0.148\,z}{Z^2-1.48z+0.548}$ (4)

UNIT III –FINITE IMPULSE RESPONSE FILTERS

Design of FIR filters - symmetric and Anti-symmetric FIR filters - design of linear phase FIR filters using Fourier series method - FIR filter design using windows (Rectangular, Hamming and Hanning window), Frequency sampling method. FIR filter structures - linear phase structure, direct form realizations

PART * A

Q.No.	Questions
1.	**Draw the frequency response of N point rectangular window**.BTL1



2

Determine the coefficients h (n) of a linear phase FIR filter of length M = 15 which has a symmetric unit sample response and a frequency and a frequency response. BTL3

that satisfies the condition $H = \left(\frac{2\pi k}{15}\right) = \begin{cases} 1, k = 0, 1, 2, 3 \\ 0, k = 4, 5, 6, 7 \end{cases}$

$$H(k) = G(k)e^{j\pi k/M}\ ,\ k = 0, \dots \dots \dots . M - 1$$

$$\alpha = 0 \qquad G(k) = (-1)^k H_r\left(\frac{2\pi k}{M}\right),\ G(k) = -G(M-k)$$

$$h(n) = \frac{1}{M}\left\{G(0) + 2\sum_{k=1}^{U} G(k) cos\frac{2\pi k}{M}\left(n + \frac{1}{2}\right)\right\}$$

$$U = \begin{cases} \frac{M-1}{2}, & M\ odd \\ \frac{M}{2} - 1, & M\ even \end{cases}$$

3.

What is the condition satisfied by linear phase FIR filter? (Nov/Dec 16)(May/june-09)BTL1

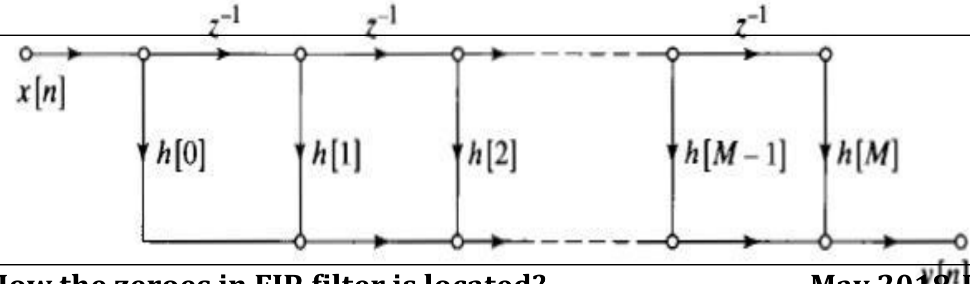
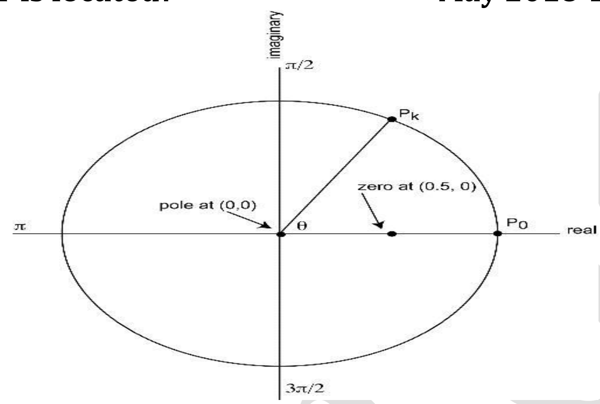
The condition for constant phase delay are

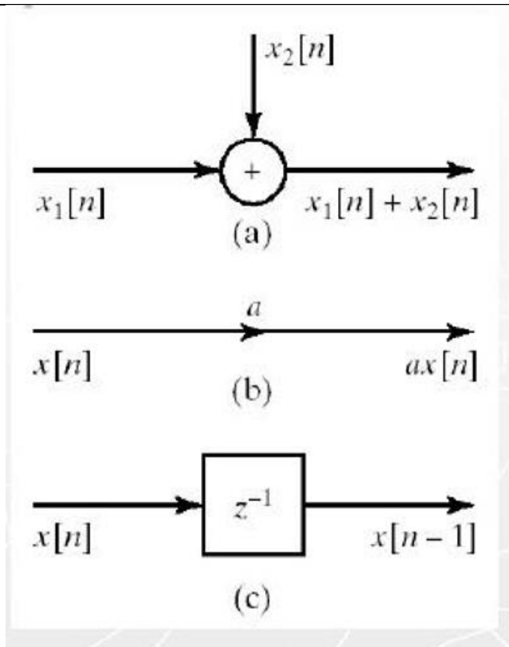
Phase delay, α = (N-1)/2 (i.e., phase delay is constant)

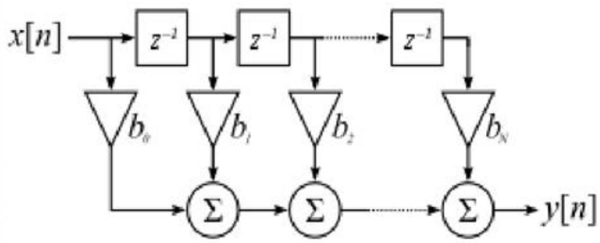
Impulse response, h(n) = h(N-1-n) (i.e., impulse response is symmetric)

4.

Draw the direct form realization of FIR system.BTL1

	
5	**How the zeroes in FIR filter is located? May 2018-BTL2**  **Assume z1, z2, z3, and z4** • Z1 is a real zero with z < 1. Then z_1^{-1} is also a real zero and there are two zeros in this group. • Z2 = -1. Then $z_2^{-1} = z_2$ and this group contains only one zero. • Z3 is a complex zero with $z_3 \neq 1$ then $z_3^{-1} = z_3^*$ and there are two zero's in this group. • Z4 is a complex zero with $z_4 \neq 1$. This group contains four zero's.
6	**Write the steps involved in FIR filter design. Nov 2017-BTL1** • From the given frequency response calculate required order of the filter. • From the order and desired frequency response calculate desired unit sample response h_d (n). • From the attenuation characteristics select suitable window function, w (n) • Calculate h (n) = h_d (n) w (n).
7	**Draw the block diagram representation of an FIR system. BTL1**





8

What is Gibb's phenomenon? May 2017-BTL1

- The desired impulse response of FIR filter is passed through the window of finite length to make the length of impulse response finite.
- This generates oscillations ringing near the band edge (cut off) frequency of the filter. This oscillatory behavior is called Gibb's Phenomenon.

 Gibb's Phenomenon indicates the index of imperfect filtering. Effects are made to reduce the oscillatory behavior near cut off frequency by using different types of windows.

9.

Compare Hamming window and Blackman window? May 2017-BTL4

Hamming window	**Blackman window**
The causal Hamming window function is given by, $\begin{cases} 0.54 - 0.46\cos\frac{2\pi n}{N-1}, 0 \le n \le M-1 \\ 0, otherwise \end{cases}$	The causal Blackman window function is given by, $\begin{cases} 0.42 - 0.5\cos\frac{2\pi n}{N-1} + 0.08cos\frac{2\pi n}{M-1}, 0 \le n \le M-1 \\ 0, otherwise \end{cases}$
The non-causal Hamming window function is given by, $\begin{cases} 0.54 + 0.46\cos\frac{2\pi n}{N-1}, n \le \frac{M-1}{2} \\ 0, otherwise \end{cases}$	The non-causal Blackman window function is given by, $\begin{cases} 0.42 + 0.5\cos\frac{2\pi n}{N-1} + 0.08cos\frac{2\pi n}{M-1},\ n \le \frac{M-1}{2} \\ 0, otherwise \end{cases}$

10.

What do you understand by linear phase response? Nov 2016-BTL1

- For a linear phase filter θ (ω) is directly proportional to ω, the linear phase filter does not alter

	the shape of the original signal. • If the phase response of the filter is nonlinear the output signal may be distorted one. • In many cases a linear phase characteristic is required throughout the pass band of the filter to preserve the shape of a given signal within the pass band. • An IIR filter cannot produce a linear phase. The FIR can give linear phase, when the impulse response of the filter is symmetric about its mid-point.
11	**What are the desirable characteristics of the window? Nov 2016, 2015-BTL1** -The desirable characteristics of the window are, • The central lobe of the frequency response of the window should contain most of the energy and should be narrow. • The highest side lobe level of the frequency response should be small. • The side lobes of the frequency response should decrease in energy rapidly as ω tends to Π.
12	**What are the two kinds of limit cycle behavior in DSP? May 2016-BTL1** • Zero limit cycle behavior • Overflow limit cycle behavior
13	**List out the advantages of FIR Filters.BTL1 May 2016** **Merits** • FIR filters have exact linear phase. • FIR filters are always stable. • FIR filters can be realized in both recursive and non-recursive structure. • Filters with any arbitrary magnitude response can be tackled using FIR sequence.
14	**What are the properties of FIR filter?BTL1 Nov 2015** • FIR filter is always stable. • A realizable filter can always be obtained. FIR filter has a linear phase response.
15	**List the disadvantages of FIR filters.BTL1 Nov 2015** **Demerits** • For the same filter specifications the order of FIR filter design can be as high as 5 to 10 times that in an IIR design.

- Large storage requirement is requirement Powerful computational facilities required for the implementation.

16 **What are the advantages of FIR filter over IIR filter?BTL4**

IIR Filter	FIR Filter
Unit impulse response has infinite duration.	Unit impulse response has finite duration.
These are all poles or poles – zero's filter	These are all zero filters
These filters can be unstable if due care is	These filters are inherently stable.
not taken.	

17 **Mention some design methods available to design FIR filter.(Nov/dec-10)-BTL1**

There are three well known method of design technique for linear phase FIR filter.

They are

1. Fourier series method and window method
2. Frequency sampling method
3. Optimal filter design methods.

Windows: i.Rectangular ii.Hamming iii.Hanning iv.Blackman v.Kaiser

18. **Write the procedure for FIR filter design by frequency sampling method.(May-05) BTL1**

- Choose the desired frequency response Hd(ω).
- Take N-samples of Hd (ω) to generate the sequence H (K) (Here H bar of k should come)
- Take inverse of DFT of H (k) to get the impulse response h (n).
- The transfer function H (z) of the filter is obtained by taking z-transform of impulse response.

19. **Compare the rectangular window and hanning window. (Dec-07)BTL4**

Rectangular window	Hamming window

1. The width of main lobe in window spectrum is $4\pi/N$.	1. The width of main lobe in window spectrum is $8\pi/N$.
2.The maximum side lobe magnitude in window spectrum is -13db	2.The maximum side lobe magnitude in window spectrum is -41db
3. In window spectrum the sidelobe magnitude slightly decreases with increasing ◌̂.	3. In window spectrum the sidelobe magnitude remains constant.
4. In FIR filter designed using rectangular window the minimum	4. In FIR filter designed using hamming window the minimum stopband

20

1. Give the equations specifying the following windows. **BTL1**

a. Rectangular window
b. Hamming window
c. Hanning window
d. Bartlett window
e. Kaiser window

a. Rectangular window:

The equation for Rectangular window is given by

$$W(n) = \begin{cases} 1 & 0 \le n \le M-1 \\ 0 & \text{otherwise} \end{cases}$$

b. Hamming window:

The equation for Hamming window is given by

$$W_H(n) = \begin{cases} 0.54 - 0.46 \cos 2\pi n/M-1 & 0 \le n \le M-1 \\ 0 & \text{otherwise} \end{cases}$$

c. Hanning window:

The equation for Hanning window is given by

$$W_{Hn}(n) = \begin{cases} 0.5[1 - \cos 2\pi n/M-1\,] & 0 \le n \le M-1 \\ 0 & \text{otherwise} \end{cases}$$

d. Bartlett window:

The equation for Bartlett window is given by

$$W_T(n) = \begin{cases} 1 - \dfrac{2|n-(M-1)/2|}{M-1} & 0 \le n \le M-1 \\ 0 & \text{otherwise} \end{cases}$$

e. Kaiser window:

The equation for Kaiser window is given by

$$W_K(n) = \begin{cases} \dfrac{I_o[\alpha\sqrt{1-(2n/N-1)^2}]}{I_o(\alpha)} & \text{for } |n| \le \dfrac{N-1}{2} \\ 0 & \text{otherwise} \end{cases}$$

where α is an independent parameter.

21	**State the equations used to convert the lattice filter coefficients to direct form FIR Filter coefficient. BTL1** $\alpha_m(0) = 1$ $\alpha_m(m) = k_m$ $\alpha_m(k) = \alpha_{m-1}(k) + \alpha_m(m) \cdot \alpha_{m-1}(m-k)$
22	**Compare Hamming window with Kaiser window.*BTL4*** <table><tr><th>Hamming window</th><th>Kaiser window</th></tr><tr><td>1.The main lobe width is equal to $8\pi/N$ and the peak side lobe level is –41dB. 2.The low pass FIR filter designed will have first side lobe peak of –53 dB</td><td>The main lobe width ,the peak side lobe level can be varied by varying the parameter α and N. The side lobe peak can be varied by varying the parameter α.</td></tr></table>
23	**Write the frequency response linear phase FIR filters when impulse Response is anti-symmetric and N is ODD.BTL1** • Anti-symmetric condition h (n) = - h (N – 1 - n) Consider N = ODD value (5) Therefore h (n) = - h (5 – 1 - n) h (0) = - h (4) h (1) = - h (3) h (2) = - h (2)
24	**What is meant by FIR filter and why it is stable?BTL1** • FIR impulse response has finite length. **Stability:** • The output of FIR filter is given as, y (n) = bo x (n) + b1 x(n-1) + …….+ bM-1 x (n-M+1). Here h (n) = {bo, b1……..bM-1}. Above equation shows that output y (n) is bounded as long as inputs are bounded. This means FIR

	filter is inherently stable.
25	**For what type of filters frequency sampling method is suitable?BTL1** Frequency sampling method is attractive for narrow band frequency selective filters where only a few of the samples of the frequency response are non-zero.
	PART-B
Q.No	**Questions**

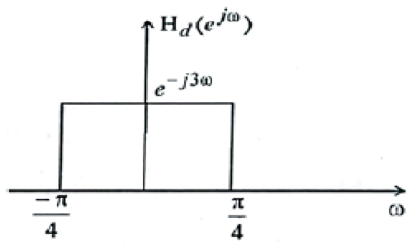
Design a filter with

$$\boldsymbol{H_d(e^{j\omega}) = e^{-j3\omega}, \frac{-\pi}{4} \le \omega \le \frac{\pi}{4}}$$

$$\boldsymbol{= 0, \frac{\pi}{4} < |\omega| < \pi}$$

Using Hanning window for $N = 7$. FInd the filter coefficients $h(n)$. NOV 2017

Solution:



BTL6

Step1: To draw the frequency response curve.

Step2: To find $h_d(n)$

Given $H_d\left(e^{j\omega}\right) = e^{-j3\omega}$

The frequency response is having a $e^{-j\omega\left(\frac{N-1}{2}\right)}$ which gives $h(n)$ symmetrical about $n = \frac{N-1}{2} = 3$ (ie) we get a causal sequence.

$$h_d(n) = \frac{1}{2\pi}\int_{-\pi}^{\pi} H_d\left(e^{j\omega}\right)e^{j\omega n}d\omega$$

	$$h_d(n) = \frac{1}{2\pi}\int_{\frac{-\pi}{4}}^{\pi} e^{-j3\omega} e^{j\omega n} d\omega$$ $$h_d(n) = \frac{1}{\pi(n-3)}\left[\sin\frac{\pi}{4}(n-3)\right] = \frac{\sin\frac{\pi}{4}(n-3)}{\pi(n-3)}$$ $$h_d(n) = \frac{\sin\frac{\pi}{4}(n-3)}{\pi(n-3)}$$ **(4)** **Step3:** To find the values of $h_d(n)$ $$h_{d(0)} = h_{d(6)} = 0.075$$ $$h_{d(1)} = h_{d(5)} = 0.159$$ $$h_{d(2)} = h_{d(4)} = 0.22$$ $$h_{d(3)} = 0.25$$ **Step4:** To find the non-causal window sequence for hanning window $$W_{Hn}(n) = 0.5 + 0.5\cos\frac{2\pi n}{N-1}, for -\left(\frac{N-1}{2}\right) \le n \le \left(\frac{N-1}{2}\right)$$

$$= 0, \text{otherwise}$$

For $N = 7$

$$W_{Hn}(n) = 0.5 + 0.5\cos\frac{2\pi}{N-1}, for -3 \leq n \leq 3$$

$$= 0, \text{Otherwise}$$

$$W_{Hn}(0) = 0.5 + 0.5\cos(0) = 1$$

(4)

$$W_{Hn}(-1) = W_{Hn}(1) = 0.5 + 0.5\cos\frac{\pi}{3} = 0.75$$

$$W_{Hn}(-2) = W_{Hn}(2) = 0.5 + 0.5\cos\frac{2\pi}{3} = 0.25$$

$$W_{Hn}(-3) = W_{Hn}(3) = 0.5 + 0.5\cos\pi = 0$$

(4)

- The causal window sequence can be obtained by shifting the sequence $W_{Hn}(n)$ to right by 3 samples. (ie)

$$W_{Hn}(0) = W_{Hn}(6) = 0$$

$$W_{Hn}(1) = W_{Hn}(5) = 0.25$$

$$W_{Hn}(2) = W_{Hn}(4) = 0.75$$

$$W_{Hn}(3) = 1$$

	Step5: To find $h(n)$ $$h(n) = h_d(n)W_{Hn}(1), for\ 0 \le n \le N-1$$ $$h(n) = h_d(n)W_{Hn}(1), for 0 \le n \le 6$$ $$h(0) = h(6) = h_d(0)W_{Hn}(0) = (0.075)(0) = 0$$ $$h(1) = h(5) = h_d(1)W_{Hn}(1) = (0.159)(0.25) = 0.0395$$ **(4)** $$h(2) = h(4) = h_d(2)W_{Hn}(2) = (0.22)(0.75) = 0.165$$ $$h(3) = h(3)W_{Hn}(3) = (0.25)(1) = 0.25$$
2	**Write the Steps or Procedure for Fir filter design using windows. Nov/Dec 2015(8)-BTL1** 1. Choose the desired frequency response of the filter $H_d(\omega)$. 2. Take invers fourier transform of $H_d(\omega)$ to obtain the desired impulse response $h_d(n)$. By definition of inverse fourier transform, $$h_d(n) = — \int_{-} H(\omega)\, e^{j\omega n} d\omega$$ 3. Choose a window sequence w(n) and determine the product of $h_d(n)$ and w(n). Let this product be h(n), $$h(n) = h_d(n)w(n)$$ 4. The transfer function H(z) of the filter is obtained by taking z-transform of h(n). Realize the filter by a suitable structure. 5. Choose a linear phase magnitude function,|H(ω)|. Using h(n) obtain an equation for |H(ω)|. Calculate |H(ω)| for varies values of ω in the range 0≤ ω≤ and sketch the graph between |H(ω)| and ω, which is the frequency response of the filter.
3.	**Design an ideal HPF with frequency response Hd (e^{jw}) = { 1 for π/4 ≤ |w|≤ π and 0 for |w|≤ π/4. Find the value of h(n) for N=11 using Hamming window. Find H(z) and compute magnitude response . (12M)(MAY 2013) (May 2016) (** BTL4**)**

	Answer: Page 6.21 - Ramesh babu The desired frequency response of HPF $h_d[n] = \begin{cases} 1-\frac{\omega_c}{\pi}; & n \neq M \\ -\frac{\sin(\omega_c(n-M))}{\pi(n-M)}; & n = M \end{cases}$ (6M) Transfer function of the filter h[n] = w[n] * hd[n] (6M)
4	**Design an Ideal differentiator with the frequency response of $H(e^{jw})$ = jw for π ≤ w ≤ π use Hamming window with N= 7 (12M) (MAY2015) (** BTL3**)** **Answer: Page 6.70- Ramesh babu (similar type)** The frequency response of ideal differentiator,(2M) Determine N is even or odd (2M) Hamming window (4M) $W_{Hn}(n) = 0.5 + 0.5\cos(2\pi n / N-1)\, for - (N-1)/2 \leq n \leq (N-1)/2$ $0, otherwise$ The filter coefficients using hamming window are, (4M) h(n)=$h_d(n)\omega_{Hn}(n) for 0 \leq n \leq 6$
5	**Design an FIR filter for the ideal frequency response using hamming window with N=7 $Hd(e^{jw})= e^{-3jw}$ for –π/8 ≤ w ≤ π/ = 0 for π/8 ≤ w ≤ π(10m)(MAY2014) (May 2016) (May 2017)(13M) (** BTL3**)** **Answer:** P**age 6.51 - Ramesh babu(similar type)** The desired frequency response (3M) $H_d(e^{j\omega}) = \sum_{n=-\infty}^{\infty} h_d(n)\, e^{-j\omega n}$ $h_d(n) = \frac{1}{2\pi}\int_{-\pi}^{\pi} H(e^{j\omega})\, e^{j\omega n}\, d\omega$ (3M) Hamming window (4M) $W_{Hn}(n) = 0.5 + 0.5\cos(2\pi n / N-1)\, for - (N-1)/2 \leq n \leq (N-1)/2$ $0, otherwise$ The filter coefficients using hamming window are, (3M) h(n)=$h_d(n)\omega_{Hn}(n) for 0 \leq n \leq 6$
6	**Explain the design procedures of FIR filter using frequency sampling method. (13M)(MAY2015) (** BTL1**)** **Answer: Page 6.80 - Ramesh babu** • Choose the desired frequency response (3M) • Compute Sample $H_d(w)$ (3M) • Compute h(n) (3M)

	• Take z-transform of h(n) (2M) Draw the realization structure (2M)
7.	**Design a HPF with a cut off frequency 1.2 rad of length N = 9 using Hamming window.(16)** **Solution** Given that, $\Omega_c = 1.2$ rad / sec T = 1 sec $\omega_c = \Omega_c T$ $\omega_c = 1.2$ radians **BTL6** The impulse response of a HPF with a cutoff frequency ω_c is, $h_d(n) = \frac{-\sin\omega_c n}{\pi} \quad n > 0$ $= 1 - \frac{\omega_c}{\pi} \quad$ for $n = 0$ $\omega_c = 1.2$ $h_d(0) = 1 - \frac{1.2}{\pi} = 0.618$ $h_d(-1) = h_d(1) = \frac{-\sin 1.2}{\pi} = -0.2966$ **(4)** $h_d(-2) = h_d(2) = \frac{-\sin 2.4}{\pi} = -0.1075$ $h_d(-3) = h_d(3) = \frac{-\sin 3.6}{\pi} = 0.0469$ $h_d(-4) = h_d(4) = \frac{-\sin 4.8}{\pi} = 0.0719$ Hamming window for $-4 \le n \le 4$ $W_H(n) = 0.54 + 0.46\cos\left(\frac{2\pi n}{8}\right)$ for $-4 \le n \le 4$

	$W_H(n) = 0.54 + 0.46\cos\left(\frac{\pi n}{8}\right)$ for $-4 \le n \le 4$ $W_H(0) = 1$ $W_H(-1) = W_H(1) = 0.865$ $W_H(-2) = W_H(2) = 0.54$ $W_H(-3) = W_H(3) = 0.215$ $W_H(-4) = W_H(4) = 0.08$ **(4)** Find filter coefficients $h(n) = h_d(n)\, W_H(n)$ $h(0) = 0.618\,(1) = 0.618$ $h(-1) = h(1) = (-0.2966)(0.865) = -0.256$ $h(-2) = h(2) = -0.058$ $h(-3) = h(3) = 0.01$ $h(-4) = h(4) = 0.0057$ **(4)** The causal filter coefficients are $h(0) = h(8) = 0.0057$ $h(1) = h(7) = 0.01$ $h(2) = h(6) = 0.058$ $h(3) = h(5) = -0.256$ $h(4) = 0.618$ **(4)**

8.

The desired frequency response of a digital fitter is

$$Hd(e^{i\omega}) = \begin{cases} e^{-j3\omega}, \frac{-\pi}{4} \le |\omega| \le \frac{\pi}{4} \\ 0, \frac{\pi}{4} \le |\omega| \le \pi \end{cases}$$

(16 marks)-BTL6

Determine the filter coefficients if the window function is defined as,

$$W(n) = \begin{cases} 1, 0 \le n \le 6 \\ 0, otherwise \end{cases}$$

Solution:

$$h_d(n) = \frac{1}{2\pi}\int_{-\pi}^{\pi} H_d(e^{j\omega})\, e^{j\omega n}\, d\omega$$

$$h_d(n) = \frac{1}{2\pi}\int_{\frac{-\pi}{4}}^{\pi/4} e^{-j3\omega} e^{j\omega n}\, d\omega = \frac{1}{2\pi}\int_{\frac{-\pi}{4}}^{\frac{\pi}{4}} e^{-j\omega(n-3)}\, d\omega$$

$$h_d(n) = \frac{1}{2\pi}\left[\frac{e^{j\omega(n-3)}}{j(n-3)}\right]_{\frac{-\pi}{4}}^{\pi/4}$$

$$h_d(n) = \frac{1}{\pi(n-3)}\left[\frac{e^{j\frac{\pi}{4}(n-3)} - e^{-j\frac{\pi}{4}(n-3)}}{2j}\right]$$

$$h_d(n) = \frac{\sin\frac{\pi}{4}(n-3)}{\pi(n-3)}$$

(4)

For $N = 7$ & symmetric condition.

For causal filter the n values are

$$n = 0\ to\ N - 1$$

$$n = 0\ to\ 6$$

So $h_d(0) = h_d(6) = 0.075$

$$h_d(1) = h_d(5) = 0.159$$

$$h_d(2) = h_d(4) = 0.22$$

$$h_d(+3) = 0.25$$

(4)

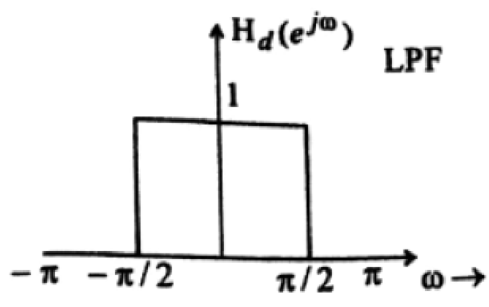
Step-2

To find the window sequence

The given window sequence is for rectangular window.

$$W_R(n) = \begin{cases} 1, 0 \le n \le 6 \\ 0, otherwise \end{cases}$$

(2)

	Step-3 The causal filter coefficients are as follows: $h_d(n) = h_d(n).W_R(n) for\ 0 \le n \le 6$ $h_d(0) = h_d(6) = h_d(0).W_R(0) = 0.075$ $h_d(1) = h_d(5) = h_d(1).W_R(1) = 0.159$ $h_d(2) = h_d(4) = h_d(2).W_R(2) = 0.22$ $h_d(3) = 0.25$ **(4)**
	PART-C
Q.No	**Questions**
1	**Design an ideal low pass filter with a frequency response** $H_d(e^{j\omega}) = 1\ for -(\pi/2) \le \lvert\omega\rvert \le (\pi/2)$ $= 0\ for -(\pi/2) \le \lvert\omega\rvert \le \pi$ **BTL-3** **Find the values of $h(n) for\ N = 11$. Find H(z). Plot the Magnitude Response** **Solution:** **Step1:** Find the frequency response curve.  **(3)**

Step2: Find $h_d(n)$

$$h_d(n) = \frac{1}{2\pi}\int_{-\pi}^{\pi} H_d(e^{j\omega})e^{j\omega n}\, d\omega$$

$$h_d(n) = \frac{1}{2\pi}\int_{-\pi/2}^{\pi/2} 1.\, e^{j\omega n}\, d\omega$$

$$h_d(n) = \frac{1}{2\pi}\left[\frac{e^{j\omega n}}{j^n}\right]_{-\pi/2}^{\frac{\pi}{2}}$$

$$h_d(n) = \frac{1}{2\pi jn}\left[e^{j\frac{\pi}{2}n} - e^{-j\frac{\pi}{2}n}\right]$$

$$h_d(n) = \frac{1}{\pi n}\left[\frac{e^{j\frac{\pi}{2}n} - e^{-j\frac{\pi}{2}n}}{2j}\right]$$

$$h_d(n) = \frac{1}{\pi n}\sin(\pi/2)n \qquad -\infty \le n \le \infty$$

$$h_d(n) = \frac{\sin(\pi/2)n}{\pi n}$$

(2)

Step3: To find $h(n)$

$$h(n) = h_d(n)$$

For $N = 11$ & symmetric filter we have,

$$h_d(0) = h(0) = \frac{\sin(\pi/2)n}{\pi n} = \lim_{n\to 0}\frac{1}{2}\left(\frac{\sin \pi n}{\pi n}\right) = \frac{1}{2}$$

$$\left[\because \lim_{\theta\to 0}\frac{\sin A\theta}{\theta} = A\right]$$

$$h_d(1) = h_d(1) = h_d(-1) = \frac{\sin \pi/2}{\pi} = 0.3183$$

$$h_d(2) = h_d(2) = h_d(-2) = \frac{\sin \pi/2(2)}{2\pi} = 0$$

$$h_d(3) = h_d(3) = h_d(-3) = \frac{sin\frac{3\pi}{2}}{3\pi} = -0.106$$

$$h_d(4) = h_d(4) = h_d(-4) = \frac{\sin 4\pi/2}{4\pi} = 0$$

$$h_d(5) = h_d(5) = h_d(-5) = \frac{\sin 5\pi/2}{5\pi} = 0.06366$$

Step4: To find the transfer function of the filter,

$$H(z) = h(0) + \sum_{n=1}^{\frac{N-1}{2}}[h(n)[z^n + z^{-n}]]$$

$$H(z) = 0.5 + \sum_{n=1}^{5} h(n)(z^n + z^{-n})$$

$$H(z) = 0.5 + 0.3183[z^1 + z^{-1}] - 0.106[z^3 + z^{-3}] + 0.06366(z^5 + z^{-5})$$

Step5: To find the transfer function of the realizable filter.

(3)

$$H'(z) = z^{-(N-1/2)}\, H(z)$$

$$H'(z) = z^{-5}[0.5 + 0.3183[z^1 + z^{-1}] - 0.106[z^3 + z^{-3}] + 0.06366[z^5 + z^{-5}]]$$

$$H'(z) = 0.06366 - 0.106z^{-2} + 0.3183z^{-4} + 0.5z^{-5} + 0.3183z^{-6} - 0.106z^{-8} + 0.06366z^{-10}$$

Step6:

The filter coefficients of causal filter are given by,

$$h(0) = h(10) = 0.06366$$

$$h(1) = h(9) = 0$$

$$h(2) = h(8) = -0.106$$

$$h(3) = h(7) = 0$$

$$h(4) = h(6) = 0.3183$$

$$h(5) = 0.5$$

Step7:

The frequency response is given by

$$\bar{H}(e^{j\omega}) = \sum_{n=0}^{\frac{N-1}{2}} a(n)\cos\omega n$$

Where,

$$a(n) = 2h\left[\left(\frac{N-1}{2}\right) - n\right]$$

$$a(0) = h\left(\frac{N-1}{2}\right) = h(5) = 0.5$$

(4)

$$a(1) = 2h[5-1] = 2\,h(4) = 0.6366$$

$$a(2) = 2h[5-2] = 2\,h(3) = 0$$

$$a(3) = 2h[5-3] = 2\,h(3) = -0.212$$

$$q(4) = 2h[5-4] = 2\,h(1) = 0$$

$$a(5) = 2h[5-5] = 2\,h(0) = 0.127$$

$$\bar{H}(e^{j\omega}) = 0.5 + 0.6366\cos\omega - 0.212\cos 3\omega + 0.127\cos 5\omega$$

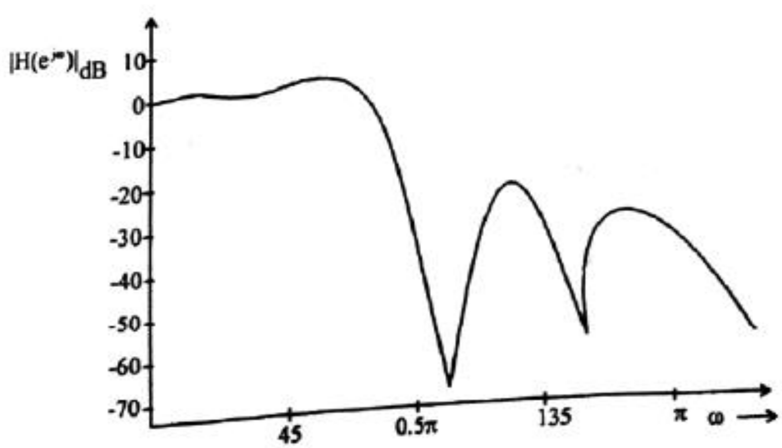
Step8: The magnitude in dB is calculated by varying ω from 0 to π and shown below.

(3

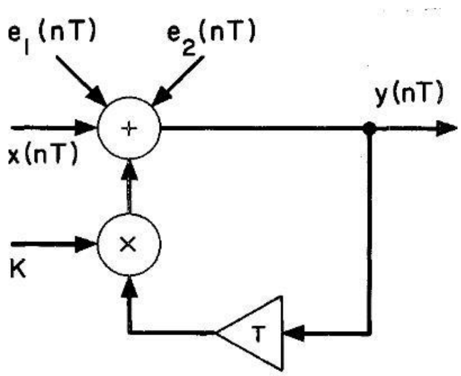
The magnitude $|H(e^{j\omega})|dB = 20\log|\bar{H}e^{j\omega}|$

ω(in degrees)	0	10	20	30	40	50	60	70
$\lvert H(e^{j\omega})\rvert dB$	0.4	0.21	−0.26	−0.517	−0.21	0.42	0.77	0.21

ω(in degrees)	80	90	100	110	120	130	150	170	180
$\lvert H(e^{j\omega})\rvert dB$	−1.79	−6	−14.56	−31.89	−20.6	−26	−24.7	−32	−26



	Prove that an FIR fliter has linear phase if the unit sample response satisfies the condition h(n) * h(N-1-n) .also discuss symmetric and anti symmetric cases of FIR filter when N is even. (12M) (NOV 2013) (BTL2**)** **Answer: Page 6.83 - Ramesh babu** Determine the frequency samples(3M) Compute filter coefficients (3M) Find N is even or odd (3M) Determine the z-transform (3M)
	The desired response of a low pass filter is $$H_d(e^{j\omega}) = \begin{cases} e^{-j3\omega} & for\ -\frac{3\pi}{4} \le \lvert\omega\rvert \le \frac{3\pi}{4} \\ 0 & for\ \frac{3\pi}{4} \le \lvert\omega\rvert \le \pi \end{cases}$$ **Determine $H(e^{j\omega})$ for M=7 using Hamming window. (15M) (Nov 2016) (** BTL3**)** **Answer:Page 452 - salivahanan book** Determine the filter coefficient (4M) Hamming window (4M) $W_{Hn}(n) = 0.5 + 0.5\cos(2\pi n / N-1)\ for -(N-1)/2 \le n \le (N-1)/2$ $0, otherwise$ Filter coefficients using hamming window, (4M) h(n)=$h_d(n)\omega_{Hn}(n) for 0 \le n \le 6$ Frequency response (3M)

<table>
<tr><th colspan="2">UNIT IV – FINITE WORD LENGTH EFFECTS</th></tr>
<tr><td colspan="2">Fixed point and floating point number representation - ADC - quantization - truncation and rounding - quantization noise - input / output quantization - coefficient quantization error - product quantization error - overflow error - limit cycle oscillations due to product quantization and summation - scaling to prevent overflow.</td></tr>
<tr><th>Q.No</th><th>Questions</th></tr>
<tr><td>1</td><td>Draw the quantization noise model for a I order system. May 2019-BTL1

</td></tr>
<tr><td>2.</td><td>What is product quantization error? Nov 2018-BTL1
• In fixed point arithmetic the product of two b bit numbers results in number 2b bits long. In digital signal processing applications, it is necessary to round this product to a b-bit number, which produce an error known as product quantization error or product round off noise.

The multiplication is modeled as an infinite precision multiplier followed by an adder where round off noise is added to the product so that overall result equals some quantization level.</td></tr>
<tr><td>3.</td><td>What is meant by floating point representation? Nov 2018-BTL1
A fixed-point number representation is a real data type for a number that has a fixed number of digits after (and sometimes also before) the radix point (after the decimal point).

Fixed-point number representation can be compared to the more complicated (and more computationally demanding) floating-point number representation.
1. Sign magnitude format
2. One's complement
3. Two's complement</td></tr>
<tr><td>4.</td><td>Distinguish between fixed point arithmetic and floating point arithmetic. May 2018, Nov 2017-BTL4</td></tr>
</table>

Fixed point	Floating point
Fast operation	Slow operation
Relatively Economical	More Expensive
Small dynamic range	Large dynamic range
Used in small computers	Used in larger, general purpose computers

5. Why is rounding preferred over truncation in realizing a digital filter?May 2019, 2018-BTL2

- The quantization error due to rounding is independent of the type arithmetic.
- The mean of rounding error is zero.
- The variance of the rounding error signal is low.

6. What are the methods used to prevent overflow?BTL1 May 2017, 2016

The overflow limit cycles can be eliminated by two methods,

1. **Saturation Arithmetic**
   In this method, if overflow occurs, then output is set to maximum allowable value. If underflow occurs, then output is set to minimum allowable value. This introduces distortion in the output but overflow oscillations are eliminated.

2. **Saling**
   The input signal to the address is properly scaled such that overflow is avoided.

7 What is meant by finite word length effect in digital systems?BTL1 Nov 2017

- The digital implementation of the filter has finite accuracy. When numbers are represented in digital form, errors are introduced due to their finite accuracy.
- These errors generate finite precision effects or finite word length effects.
- When multiplication or addition is performed in digital filter, the result is to be represented by finite word length (bits). Therefore the result is quantized so that it can be represented by finite word register.

- This quantization error can create noise or oscillations in the output. These effects are called finite word length effects.

8 What is meant by dead band of the filter?BTL1 May 2017, 2016

	• The limit cycle occurs as a result of quantization effect in multiplication. ▯ The amplitude of the output during a limit cycle is limited to a range of values called the dead band of the filter.
9	**What are the different type of fixed point representation?BTL1 Nov 2016** ▯ A fixed-point number representation is a real data type for a number that has a fixed number of digits after (and sometimes also before) the radix point (after the decimal point). ▯ Fixed-point number representation can be compared to the more complicated (and more computationally demanding) floating-point number representation. Types Sign magnitude format One's complement Two's complement
10	**Name the three quantization errors due to finite word length register inDigital filters. Nov 2016.BTL1** **Input quantization error** Any analog signals needs to be converted to digital form for processing in DSP system. 1. **Product quantization error** When the two 'b' bit numbers are multiplied, the result is '2b' bits. 2. **Coefficient quantization error** The design calculations of digital filters are done with infinite precision.
11	**What does the truncation of data result in?BTL2 Nov 2015** A truncation of data result in truncation error. Because of truncation error there can be instability of change of filtering characteristics in filters and change of DFT values in FFT algorithm.
12	**What is meant by signal scaling?BTL1** • Saturation arithmetic eliminates limit cycles due to overflow, but it causes undesirable signal distortion due to the non-linearity of the clipper. • In order to limit the amount of non-linear distortion, it is important to scale the input signal and the unit sample response between the input and any internal summing node in the system such that overflows becomes a rare event.
13	**List the representations for which truncation error is analyzed? BTL1 Nov 2015**

Range of quantization error

Types of quantization	Number representation
Truncation	Positive number and two's complement negative number
Truncation	Sign magnitude negative number and one's complement negative number
Rounding	All positive and negative numbers

Range of relative error

Types of quantization	Number representation
Truncation	Two's complement
Truncation	Sign magnitude and one's complement number
Rounding	All numbers

14

Distinguish between truncation and rounding of binary digits using Relevant examples.BTL4

Truncation

- Truncation is a process of discarding all bits less significant than least significant bit that is retained.
- Suppose we truncate the following number from 7 bits to 4 bits, we get 0.0011001 to 0.0011 and 0.0100100 to 0.0100

Rounding

- Rounding a number to b bits is accomplished by choosing the rounded result as the b bit number closest to the original number unrounded.
- For fixed point arithmetic, the error made by rounding a number to b bits satisfies the inequality, $-\frac{2^{-b}}{2} \leq x_T - x \leq \frac{2^{-b}}{2}$
- For all three types of number systems, i.e., two's complement one's complement and sign magnitude

15

Why is rounding preferred than truncation in realizing digital filters?BTL2

- The quantization error due to rounding is independent of the type arithmetic
- The mean of rounding error is zero
- The variance of the rounding error signal is low

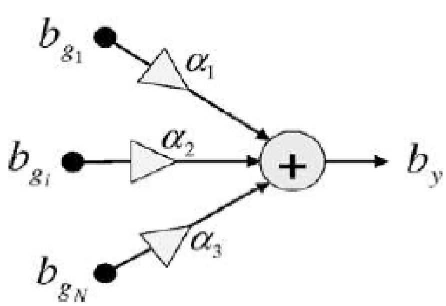
16

What is zero input limit cycle oscillation?BTL1

- For an IIR filter, implemented with infinite precision arithmetic, the output should approach zero in the steady state if the input is zero, and it should approach a constant value if the input is a constant.
- However, with an implementation using finite length register an output can occur even with zero input if there is a non-zero initial condition on one of the registers.

	• The output may be a fixed value or it may oscillate between finite positive and negative values. • This effect is referred to as (zero-input) limit cycle oscillations and is due to the non-linear nature of the arithmetic quantization.
17	**Define truncation error for sign magnitude representation and for 2's complement representation?BTL1** • For 2's complement representation, the error due to truncation for both positive and negative values of x is, $0 \geq xT - x \geq -2^{-b}$. • Where b is the number of bits and xT is the truncated value of x. the equation holds for both sign magnitude, 1's complement if $x > 0$. • If $x < 0$, then the sign magnitude and for 1's complement the truncation error satisfies, $0 \geq xT - x \geq 2^{-b}$
18	**What is meant by fixed point arithmetic? Give example.BTL1** • In the fixed point arithmetic, the digits to the left of the decimal point represent the integer part of the number and digits to rights to the decimal point represent fractional part of the number. For example, $(1458.568)_{10}$ $(1101.101)_2$ Are the fixed point numbers note that base of the number system is also written outside the bracket.
19	**What do you understand by input quantization error?BTL2** • In digital signal processing, the continuous time input signals are converted into digital using a b-bit ADC. • The representation of continuous signal amplitude by a fixed point digit produces an error, which is known as input quantization error.
20	**What is quantization error?BTL1** The quantization error arises when a continuous signal is converted into digital value. The quantization error is given by,

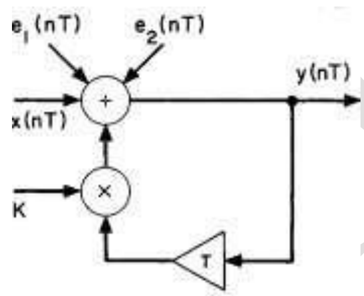
	$e(n) = x_q(n) - x(n)$ $x_q(n)$ is sampled quantized value $x(n)$ is sampled unquantized value
21	**What is overflow oscillations?BTL1** • The addition of two fixed point arithmetic numbers cause overflow when the sum exceeds the word size available to store the sum. • This overflow caused by adder make the filter output to oscillate between maximum amplitude limits. • Such limit cycles have been referred to as overflow oscillations.
22	**What are the two kinds of limit cycle behavior in DSP?BTL1** a. Zero input limit cycle oscillations b. Overflow limit cycle oscillations
23	**Explain briefly the need for scaling in the digital filter implementation.BTL2** To prevent overflow, the signal level at certain points in the digital filters must be scaled so that no overflow occurs in the adder.
24	**Why the limit cycle problem does not exist when FIR digital filter is realized in direct form or cascade form?BTL2** In the case of FIR filters, there are no limit cycle oscillations if the filter is realized in direct form or cascade form since these structures have no feedback.
25	**What is the steady state variance of the noise in the output due to quantization of the input for the first order filter?BTL2** First order filter, $y(n) = a\,y(n-1) + x(n)$ $\sigma^2 = \frac{2^{-2b}}{12}\frac{1}{1-a^2}$

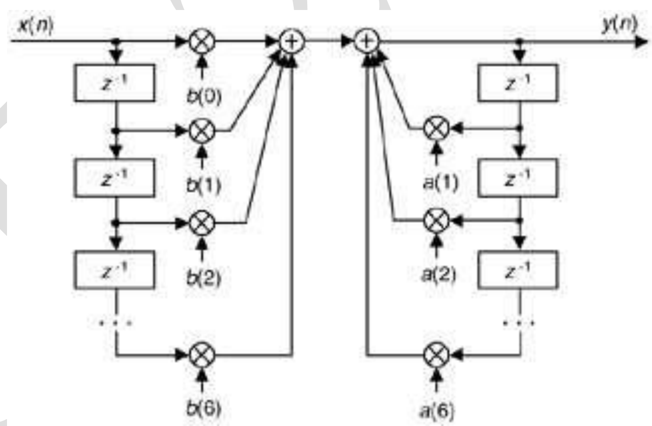
	PART-B
Q.No	**Questions**
1.	**Briefly explain the following:** **i. Coefficient quantization error (4)** **ii. Product quantization error (4)** **iii. Truncation and Rounding (5)May 2018 BTL1** **Product quantization error (4)** • In fixed point arithmetic the product of two b bit numbers results in number 2b bits long. In digital signal processing applications, it is necessary to round this product to a b-bit number, which produce an error known as product quantization error or product roundoff noise. The multiplication is modeled as an infinite precision multiplier followed by an adder where roundoff noise is added to the product so that overall result equals some quantization level. • The round off noise sample is a zero mean random variable with a variance, $\frac{2^{-2b}}{12}$ Where b is the number of bits used to represent the variables. **Fixed point product round off noise model** 

- In order to model the effects of rounding due to multiplication in digital filter, certain assumption must be made,
  1. For any n, the error sequence e (n) is uniformly distributed over the range $\frac{-q}{2}$ and $\frac{q}{2}$.

     This implies that mean value of e (n) is zero and its variance is,

     $$\sigma_e^2 = \frac{2^{-2b}}{12}.$$
  2. The error sequence e (n) is a stationary white noise sequence.
  3. The error sequence e (n) is uncorrelated with the signal sequence x (n). thus each noise source is modeled as a discrete stationary white random process with a power density spectrum of $\frac{2^{-2b}}{12}$





Truncation and Rounding (5)

- TruncationandRoundingaretwodifferentwaysofapproximatingnumericdata.
- If numbers are rounded or truncated then inaccuracies will occur. The size of the inaccuracymay increaseifthesenumbersareusedincomplexcalculations.

Truncation

- Truncation is a process of discarding all bits less significant than least significant bit thatisretained.

	Supposeifwetruncatethefollowingbinarynumberfrom8bitsto 4 bits, we obtain, • Ignore all information beyond a given number of decimal places (or significant figures). **Example: 5.26 truncated to one decimal place is 5.2 Example: 53,729truncatedto2sig.figsis53,000** **Rounding** • Roundingofanumberofbbitsisaccomplishedbychoosingtheroundedresultas the b bit number closesttotheoriginalnumberunrounded. • Takethenearestnumberwiththegivennumberofdecimalplaces(orsignificant figures). **Example: 5.26 rounded to one decimal place is 5.3 Example:53,729 roundedto2sig.figsis54,000**
2	**Explain the characteristics of limit cycle oscillation with respect to the system Described by the difference equation y (n) = 0.95 y (n-1) + x (n). Determine the Dead band of the system when x (n) = 0.875 for n = 0 and y (-1) = 0. Assume 4 – Bit Sign magnitude representation (excluding sign bit) (13) May 2017, May 2016 Nov 2017, Nov 2015 BTL3** **Solution** **Given that,** $y(n) = 0.95\, y(n-1) + x(n)$ $x(n) = 0.875$ for $n = 0$ and $y(-1) = 0$. Assume 4 – bit Sign magnitude representation (excluding sign bit) The output y (n) with rounding is given by, $y(n) = x(n) + Q[0.95]\, y(n-1)$ Where Q [] stands for quantization. For substitute the values of n……. $n = 0$ $y(0) = 0.95\, y(-1) + x(0)$ **$y(0) = 0.875$ (2)** $n = 1$ $y(1) = 0.95\, y(0) + x(1)$ $y(1) = 0.95\,(0.875) + 0$

	y (1) = 0.83125 **0.83125 convert into binary (0.83125)10 =(0.1101010……..)2** **After rounding we get,** **(0.83125)10 = (0.1101)2 = (0.8125)10** Therefore, **y (1) =(0.8125)10** **(3)** **n = 2** **y (2) = 0.95 y (1) + x (2)** **y (2) = 0.95 (0.8125) + 0** **y (2) = 0.771875** **0.771875 convert into binary (0.771875)10 =(0.110001……..)2** **After rounding we get,** **(0.771875)10 = (0.1100)2 = (0.75)10** **y (2) =(0.75)10** **(2)** **n = 3** **y (3) = 0.95 y (2) + x (3)** **y (3) = 0.95 (0.75) + 0** **y (3) = 0.7125** **0.7125 convert into binary (0.7125)10** **= (0.101101……..)2** **After rounding we get,** **(0.7125)10 = (0.1011)2 = (0.6875)10** **Therefore, y (3) =(0.6875)10** **(2)** **n = 4** **y (4) = 0.95 y (3) + x (4)** **y (4) = 0.95 (0.6875) + 0**

y (4) = 0.653125

0.653125 convert into binary

(0.653125)10 =(0.101001……..)2

After rounding we get,

(0.653125)10 = (0.1010)2 = (0.625)10

Therefore, **y (4) =(0.625)10** **(2)**

n = 5

y (5) = 0.95 y (4) + x (5)

y (5) = 0.95 (0.625) + 0

y (5) = 0.59375

0.653125 convert into binary

(0.59375)10 = (0.10011……..)2

After rounding we get,

(0.59375)10 = (0.1010)2 = (0.625)10

Therefore, **y (5) =(0.625)10** **(2)**

n = 6

y (6) = 0.95 y (5) + x (6)

y (6) = 0.95 (0.625) + 0

y (6) = 0.59375

0.653125 convert into binary

(0.59375)10 = (0.10011……..)2

After rounding we get,

(0.59375)10 = (0.1010)2 = (0.625)10

Therefore, **y (6) =(0.625)10**

	• Forabovecalculationforn≥5theoutputremainsconstantat0.625causinglimit cycle behavior. (2) **The dead band is given by,** Dead band = $\frac{\frac{1}{2}2^{-b}}{1-\lvert\alpha\rvert}$ b = 4, α = 0.95 Dead band = $\frac{\frac{1}{2}2^{-4}}{1-0.95}$ = 0.625
3.	**Two first order low pass filter whose system functions are given below are connected in Cascade, determine the overall output noise power. (13)May 2017-BTL5** $H_1(Z) = \frac{1}{1-0.5z^{-1}}$ and $H_1(Z) = \frac{1}{1-0.4z^{-1}}$ **Solution** **Given that,** $H_1(z) = \frac{1}{1-0.5z^{-1}}$ and $H_2(z) = \frac{1}{1-0.4z^{-1}}$ $H(Z) = \frac{1}{(1-0.5z^{-1})(1-0.4z^{-1})}$ The noise transfer function by $e_2(n)$ is, $H_2(z) = \frac{1}{1-0.4z^{-1}}$ The total steady state noise variance can be obtained by, $\sigma_0^2 = \sigma_{01}^2 + \sigma_{02}^2$ $\sigma_{01}^2 = \sigma_e^2 \frac{1}{2\pi j}\oint H(z)H(z^{-1})z^{-1}dz$ $H(Z^{-1}) = \frac{1}{(1-0.5z)(1-0.4z)}$ $\sigma_{01}^2 = \sigma_e^2 \frac{1}{2\pi j}\oint \frac{1}{(1-0.5z^{-1})(1-0.4z^{-1})(1-0.5z)(1-0.4z)}z^{-1}dz$ **(5)** Apply residue method, $\sigma_{01}^2=\sigma_e^2\left[(z-0.5)\frac{1}{(1-0.5z^{-1})(1-0.4z^{-1})(1-0.5z)(1-0.4z)}z^{-1}\right]_{z=0.5}+$

	$$\left[(z-0.4)\frac{1}{(1-0.4z^{-1})(1-0.5z^{-1})(1-0.5z)(1-0.4z)}z^{-1}\right] \quad z = 0.4$$ $$\sigma_{01}^2=\sigma_e^2\left[\frac{1}{(1-0.8)(1-0.25)(1-0.2)}+\frac{1}{(1-0.25)(1-0.2)(1-0.16)}\right]$$ $$\sigma_{01}^2=\sigma_e^2\,[8.333 - 5.952]$$ $$\sigma_{01}^2=\sigma_e^2\,[2.38]$$ $$\sigma_{02}^2 = \sigma_e^2\frac{1}{2\pi j}\oint H2(z)H2(z^{-1})z^{-1}dz$$ $$\sigma_{02}^2 = \sigma_e^2\frac{1}{2\pi j}\oint\frac{1}{(1-0.4z^{-1})(1-0.4z)}z^{-1}dz$$ **(5)** Apply residue method $$\sigma_{02}^2=\sigma_e^2\left[(z-0.4)\frac{1}{(1-0.4z^{-1})\,(1-0.4z)}z^{-1}\right] \quad z = 0.4$$ $$\sigma_{02}^2=\sigma_e^2[1.19]$$ $$\sigma_0^2 = \sigma_{01}^2 + \sigma_{02}^2$$ $$\sigma_0^2 = \sigma_e^2\,2.38 + \sigma_e^2\,1.19$$ $$\sigma_0^2 = \sigma_e^2\,3.57$$ $$\sigma_e^2 = \frac{2^{-2b}}{12} \qquad b = 3$$ $$\sigma_0^2 = \frac{2^{-6}}{12}3.57$$ $$\boldsymbol{\sigma_0^2 = 4.648 * 10^{-3}}$$ **(3)**
4	**Explain in detail the input quantization error and coefficient quantization Error and its effect on digital filter design, with an example. NOV 2017** **Derive the steady state input and output noise power of an analog to digital converter used in digital signal processing. (16)BTL1** Input quantization error • The quantization error arises when a continuous signal is converted into digital values. The quantization

error is given by,

$$e(n) = xq(n) - x(n)$$

xq (n) is the sampled quantized value

x (n) is the sampled unquantized value

Depending on the way in which x (n) is quantized different distributions of quantization noise may be obtained. If rounding of a number is used to get xq(n) then the error signal satisfies the relation,

$$\frac{-q}{2} \le e(n) \le \frac{q}{2}$$

Because the quantized signal may be greater or less than actual signal, For example, let x (n) = $(0.70)_{10} = (0.10110011.....)_2$

After rounding x (n) to 3 bits we have, (4)

$x_q = 0.101 + 1 = 0.110 = (0.75)_{10}$

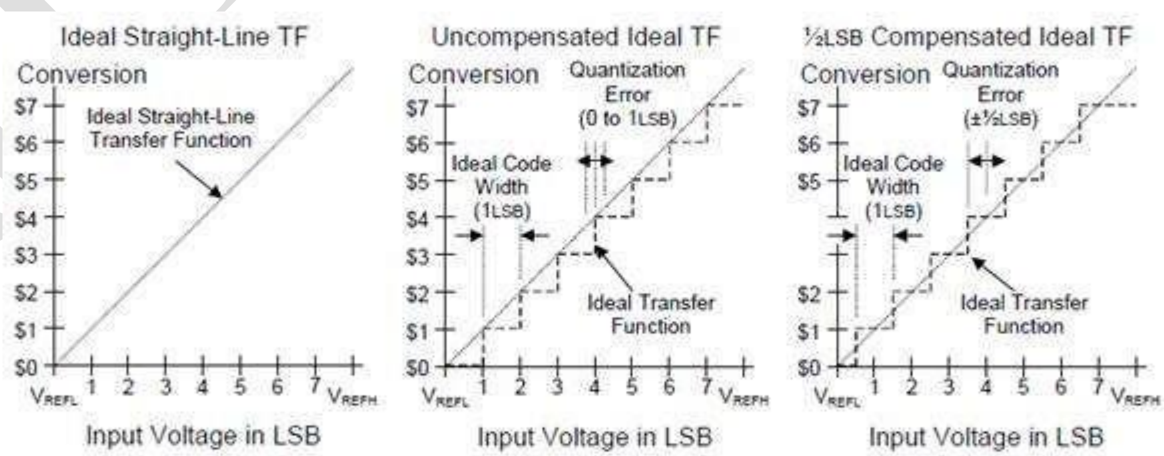
Now the error,

e (n) = xq (n) – x (n) e (n) = 0.05

This satisfies the inequality.

- The probability density function p (e) for round off error and quantization characteristics with rounding is respectively.
- The other type of quantization can be obtained by truncation. In truncation the signal is represented by the highest quantization level that is not greater than the signal. Therefore, in 2's complement truncation, the error e (n) is always negative and satisfies the inequality. (4)

$$-q \le e(n) \le 0$$

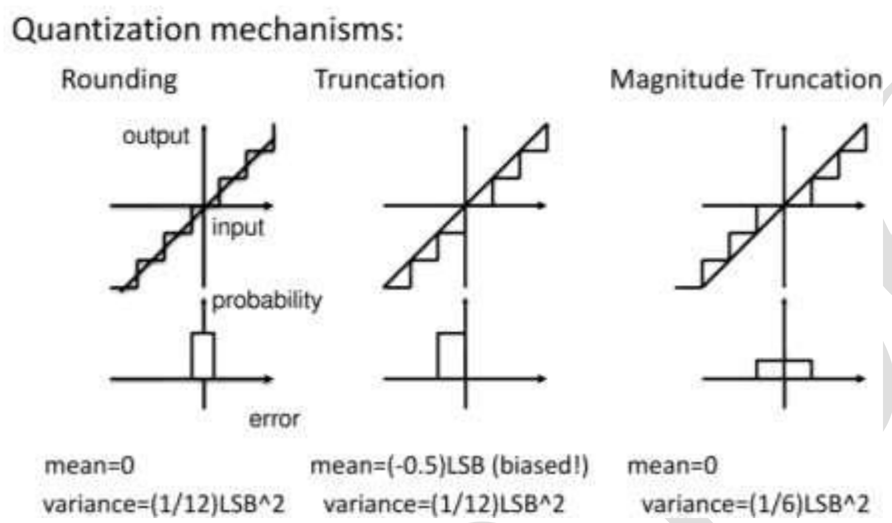


Steady state Input Noise Power

In digital signal processing of analog, the quantization error is commonly viewed as an additive noise signal,

$$xq(n) = x(n) + e(n) \quad (4)$$

Quantization Noise



Properties

- Theerrorsequencee(n)isasamplesequenceofastationaryrandomprocess.
- Theerrorsequenceisuncorrelatedwithx(n)andothersignalsinthesystem.
- The error is a white noise process with uniform amplitude probability distribution over the range of quantization error.

- In case of rounding the e (n) lies between $\frac{-q}{2}$ and $\frac{q}{2}$ with equal probability. The variance of e (n) is given by,

$$\sigma_e^2 = E[e^2(n)] - E^2[e(n)]$$

Where

E [e^2 (n)] is the average of e^2 (n)

E^2 [e (n)] is the mean value of e (n)

Therefore

$$\sigma_e^2 = \frac{2^{-2b}}{12}$$ this equation is called as steady state noise power due to input quantization.

Steady State Output Noise Power (4)

Due to A/D conversion one can represent the quantized input to a digital system with impulse response h (n), Let e (n) is the output noise due to quantization of the input. Then,

The variance of any term in the above sum is equal to $\sigma_e^2 h^2(n)$

The variance of the sum of independent random variable is the sum of their variance. If the quantization errors are assumed to be independent at different sampling instances, then the variance of the output.

$$\sigma_e^2(n) = \sigma_e^2 \sum_{n=0}^{k} h^2(n)$$

To find the steady state variance, extend the limit k up to infinity,

$$\sigma_e^2(n) = \sigma_e^2 \sum_{n=0}^{k} h^2(n)$$

Using parseval's theorem the steady state output noise variance due to the quantization error is given by,

$$\sigma_e^2(n) = \sigma_e^2 \sum_{n=0}^{k} h^2(n) = \sigma e2 \frac{1}{2\pi j} \oint H2(z)H2(z^{-1})z^{-1}dz$$

Where the closed contour of integration is around the unit circle z = 1 in which case only the poles that lie inside the unit circle are evaluated using the residue theorem.

5

The output of an A/D converter is applied to a digital filter with the system function, $\mathbf{H(z) = \frac{0.5z}{z-0.5}}$ find the output noise power from the digital filter when the input signal is quantized to have 8 bits.(13) NOV 2015. BTL5

Given data:

$$H(z) = \frac{0.5z}{z-0.5}$$

Find the output noise power from the digital filters, when the input signal is quantized to have 8-bit.

Solution:

The input quantization noise power (σe^2) is given by,

$$\sigma e^2 = \frac{2^{-2b}}{12}$$

Given b=8, therefore, $\sigma e^2 = \frac{2^{-2(8)}}{12} = 1.27X10^{-6}$

The output noise power is given by, (4)

$$\sigma e0^2 = \frac{\sigma e^2}{2\pi j} \oint H(z)\ H(z^{-1})\ z^{-1}dz$$

$$\sigma e0^2 = \frac{\sigma e^2}{2\pi j}\oint\left(\frac{0.5z}{z-0.5}\right)\left(\frac{0.5z^{-1}}{z^{-1}-0.5}\right) z^{-1}dz$$

$$\sigma e0^2 = \frac{\sigma e^2}{2\pi j}\oint\frac{0.25\,z\,z^{-1}}{(z-0.5)(1-0.5z)}\,dz$$

$$\sigma e0^2 = \frac{\sigma e^2}{2\pi j}\oint\frac{0.25}{(z-0.5)(1-0.5z)}\,dz$$

The above integral can be evaluated by the method of residues.

I=sum of residues at the poles within the unit circle within $|z| < 1$

The poles are z=0.5 (inside the unit circle, so it is stable pole.)

$z = \frac{1}{0.5} = 2\ (outside\ the\ unit\ circle, so\ it\ is\ unstable\ pole.)$

NOTE: Only consider the stable poles.i.e. Poles lie inside the unit circle.

$I = (z-0.5)\frac{0.25}{(z-0.5)(1-0.5z)}\ |\ z = 0.5$ (5)

$\boxed{I=0.333}$

The output noise power ($\sigma e0^2$)is given by,

$\sigma e0^2 = \sigma e^2\,.\,I$

$\sigma e0^2 = 0.333\sigma e^2$

$= 0.333(1.27X\ 10^{-6})$

$\boxed{\sigma e0^2 = 0.423X10^{-6}}$

Quantization of Filter Coefficients (4)

In the design of a digital filter the coefficients are evaluated with infinite precision. But they are limited by the word length of the register used to store the coefficients. Usually the filter coefficients are quantized to the word size of the register used to store them either by truncation or by rounding.

The location of poles and zeros of the digital filters directly depends on the value of filter coefficients. The quantization of the filter coefficients will modify the value of poles and zeros and so the location of the poles and zeros will be shifted from the desired location. This will create deviation in the frequency response of the System.

Hence we obtain a filter having a frequency response that is different from the frequency response of the filter with unquantized coefficients. The sensitivity of the filter frequency response

	characteristics to quantization of the filter coefficients is minimized by realizing the filter having a large number of poles and zeros as an Interconnection of second-order section. Therefore, the coefficient quantization has less effect in cascade realization when compared to other realizations.
6	**For a second order IIR filter $H(z)=\frac{1}{(1-0.9\,z^{-1})(1-0.8z^{-1})}$ find the effect of shift in pole location with 3-bit coefficient presentation in direct from and cascade form.(13) NOV 2015-BTL3** <u>Given data:</u> $H(z)=\frac{1}{(1-0.9\,z^{-1})(1-0.8z^{-1})}$ $H(z)=\frac{z^2}{(z-0.9\,)(z-0.8)}$ The roots of the denominator of H(z) are the original poles P1=0.9, P2=0.8 <u>Direct form:</u> $H(z)=\frac{1}{(1-0.9\,z^{-1})(1-0.8z^{-1})}$ $H(z)=\frac{1}{1-0.8z^{-1}-0.9\,z^{-1}+0.72\,z^{-2}}$ $H(z)=\frac{1}{1-1.7z^{-1}+0.72\,z^{-2}}$ (2) Let us quantize the coefficient by truncation of 3 bit $1.7\ \xrightarrow[binary]{convert}(1.1011)_2\xrightarrow[3\ bits]{convert}(1.101)_2\xrightarrow[decimal]{convert}(2.625)_{10}$ $1.101=1X2^1\ .\ 1X2^{-1}+0X2^{-2}+1X2^{-3}$ $=2\ .\ 0.5+\ 0\ +0.125$ $=(2.625)_{10}$ 0.70X2=1.4 0.40X2=0.8 0.80X2=1.6 0.60X2=1.2 $0.72\ \xrightarrow[binary]{convert}(0.1011)_2\xrightarrow[3\ bits]{truncate}(0.101)_2\xrightarrow[decimal]{convert}(0.62)_{10}$ 0.72X2=1.44 0.44X2=0.88 0.88X2=1.76 $(0.101)_2=1X2^{-1}+0X2^{-2}+1X2^{-3}$ $=0.5\ +\ 0\ +0.125$ $=(0.625)_{10}$

0.76X2=1.52

Let $\overline{(H(z))}$ be the transfer function. After quantizing the co-efficient.

$$\overline{H(z)} = \frac{1}{1 - 2.625\, z^{-1} + 0.625 z^{-2}}$$

The new poles are,

Pd_1=2.360

Pd_2=0.264

Compare P_1, Pd_1 and P_2, Pd_2. We can observe that there is a lot of difference in the position of quantize and unquantized poles.

<u>Cascade form:</u> (4)

We know that for cascade form,

$$H(z) = H_1(z).H_2(z)$$

Given,

$$H(z) = \frac{1}{(1 - 0.9\, z^{-1})(1 - 0.8 z^{-1})}$$

$$Therefore, H_1(z) = \frac{1}{1 - 0.9\, z^{-1}}, \qquad H_2(z) = \frac{1}{1 - 0.8\, z^{-1}}$$

P1=0.9, P2=0.8

Let us quantize the co-efficient of $H_1(z)$ and $H_2(z)$ (4)

$$0.9 \; \frac{convert}{binary} (0.1110)_2 \frac{truncate}{3\ bits} (0.111)_2 \frac{convert}{decimal} (0.875)_{10}$$

0.9X2=1.80

0.80X2=1.60

0.60X2=1.20

0.20X2=0.40

$(0.111)_2 \rightarrow 1X2^{-1}+1X2^{-2}+1X2^{-3}$

=0.5+0.25+0.125

=0.875

$$0.8 \; \frac{convert}{binary} (0.1100)_2 \frac{truncate}{3\ bits} (0.110)_2 \frac{convert}{decimal} (0.75)_{10}$$

0.80X2=1.60

0.60X2=1.20

0.20X2=0.40

0.40X2=0.80

$(0.110)_2 \rightarrow 1X2^{-1}+1X2^{-2}+0X2^{-3}$

=0.5+0.25

=0.75

$$\overline{H_1(z)} = \frac{1}{1 - 0.875\, z^{-1}} = PC_1 = 0.875 \qquad (3)$$

	$\overline{H_2(z)} = \dfrac{1}{1-0.75\,z^{-1}} = PC_2 = 0.75$ On comparing the poles of cascade system after quantization with the unquantized coefficients P_1, Pc_1 and P_2, Pc_2 are having slight difference in their poles. • From direct form, we can see that the quantized poles deviate very much from the original poles . • From cascade form, we can see that one pole is exactly the same while the other pole is very close to the original pole.
7	**For the second order IIR filter, the system function is,** $$H(Z) = \frac{1}{(1-0.5z^{-1})(1-0.45z^{-1})}$$ **Find the effect of shift in pole location with 3 bit coefficient representation in direct and cascade forms.(MAY- 2012).BTL3(16)** Solution: $$H(Z) = \frac{1}{(1-0.5z^{-1})(1-0.45z^{-1})} = \frac{z^2}{(z-0.5)(z-0.45)}$$ Original poles of H(Z) is P_1= 0.5 and P_2= 0.45. **CASE 1: DIRECT FORM** **(4)** $$H(Z) = \frac{1}{(1-0.5z^{-1})(1-0.45z^{-1})} = \frac{1}{(1-0.95z^{-1}+0.225z^{-2})}$$ **Quantization of coefficient by truncation** $\mathbf{0.95_{10}} \xrightarrow{\text{convert to binary}} 0.1111_2 \xrightarrow{\text{truncate to 3 bits}} 0.111_2 \xrightarrow{\text{convert to decimal}} 0.875_{10}$ $\mathbf{0.225_{10}} \xrightarrow{\text{convert to binary}} 0.00111_2 \xrightarrow{\text{truncate to 3 bits}} 0.001_2 \xrightarrow{\text{convert to decimal}} 0.125_{10}$ $$H(Z) = \frac{1}{(1-0.875z^{-1}+0.125z^{-2})}$$ $$\boxed{H(Z) = \frac{1}{(1-0.695z^{-1})(1-0.179z^{-1})}}$$ The poles are at P_1 = 0.695 and P_2 = 0.179. **Case *(ii)* Cascade Form** **(3)** Given,

$$H(Z)=\frac{1}{(1-0.5z^{-1})(1-0.45z^{-1})}$$

Quantization of coefficient by truncation

$$\mathbf{0.5}_{10}\xrightarrow{\text{convert to binary}}0.1000_2\xrightarrow{\text{truncate to 3 bits}}0.100_2\xrightarrow{\text{convert to decimal}}0.5_{10}$$

$$\mathbf{0.45}_{10}\xrightarrow{\text{convert to binary}}0.0111_2\xrightarrow{\text{truncate to 3 bits}}0.011_2\xrightarrow{\text{convert to decimal}}0.375_{10}$$

$$H(Z)=\frac{1}{(1-0.5z^{-1})(1-0.375z^{-1})}$$

The poles are P_1 = 0.5 and P_2 = 0.375

- From direct form, we can see that the quantized poles deviate very much from the original poles .
- From cascade form, we can see that one pole is exactly the same while the other pole is very close to the original pole.

Product Quantization Error

In fixed point arithmetic the product of two *b* bit numbers results in number of *2b* bits length. If the word length of the register used to store the result is *b* bit, then it is necessary to quantize the product to *b* bits, which produce an error known as **product quantization error or product round off noise.** In realization structures of digital system, multipliers are used to multiply the signal by constants.

The model for fixed point round off noise following a multiplication is shown in Figure . The multiplication is modeled as an infinite precision multipliers followed by an adder where round off noise is added to the product so that overall result equals some quantization level. The roundoff noise sample is a zero mean random variable with a variance $(2^{-2b}/3)$, where *b* is the number of bits used to represent the variables.

In general the following assumptions are made regarding the statistical independence of the various noise sources in the digital filter.

I. Any two different samples from the same noise source are uncorrelatcd.

2. Any two different noise source, when considered as random processes are uncorrelated.

3. Each noise source is uncorrelated with the input sequence.

Let $e_k(n)$ be the error signal from k^{th} noise source, $h_k(n)$ the impulse response for k^{th} noise source and $T_k(n)$ the noise transfer function (NTF) for k^{th} noise source.

Variance of k^{th} noise source $\sigma^2_{ek}=\frac{q^2}{12}=\frac{2^{-2b}}{3}\left(Assume\ R=2, w.k.t.\ q=\frac{R}{2^b}\right)$

8 **Explain in detail about finite word length effects in digital filter. (8) BTL-2**

Finite Word length Effects

- All the signals and systems are digital in DSP. The digital implementation has finite accuracy.
- When numbers are represented in digital form, errors are introduced due to their finite accuracy. These errors generate finite precision effects or finite word length effects.
- Let us consider an example if the first order IIR filter to illustrate how errors are encountered in discretization. Such filter can be described as, (4)

$$y(n) = \alpha\, y(n-1) + x(n)$$

The z-transform of above equation gives $z[y(n)] = \alpha\, z[y(n-1) + x(n)]$

$$X(z) = \alpha\, z^{-1} Y(z) + X(z)$$

- Here observe that 'α' is the filter coefficient when this filter is implemented on some DSP processor or software, 'α' can have only discrete values.
- Hence the actual transfer function which is implemented is given as,
- The transfer function given by above equation is slightly different from H (z). Hence the actual frequency response will be different from desired response.
- The input x (n) is obtained by sampling the analog input signal. Since the quantized takes only fixed (discrete) values of x (n), error is introduced. The actual input can be denoted by $x(n)$.

$$x(n) = x(n) + e(n)$$

- Here e (n) is the error introduced during A/D conversion process due to finite word length of the quantized. Similarly error is introduced in the multiplication of x (n) and y (n-1) in equation (1). This is because the product y (n-1) has to be quantized to one of the available discrete values. This introduces error. These errors generate finite word length effects.

Finite Word length Effects in IIR Digital Filters (4)

- When an IIR filter is implemented in a small system, such as an 8-bit microcomputer, errors arise in representing the filter coefficients and in performing the arithmetic operations indicated by the difference equation.
- These errors degrade the performance of the filter and in extreme cases lead to instability.
- Before implementing an IIR filter, it is important to ascertain the extent to which its performance will be degraded by finite word length effects and to find a remedy if the degradation is not acceptable.
- The effects of these errors can be reduced to acceptable levels by using more bits but this may be at the

	expense of increased cost. **The main errors in digital IIR filters are:** **ADC Quantization Noise:** • This noise is caused by representing the samples of the input data, by only a small number of bits. **Coefficient quantization errors:** • These errors are caused by representing the IIR filter coefficients by a finite number of bits. **Overflow errors** • These errors are caused by the additions or accumulation of partial results in a limited register length. **Finite Word length Effects in FIRFilters** • As in most DSP algorithms, the main errors arising from implementing FFT algorithms using fixed point arithmetic are, **Round off errors** • These errors are produced when the product $W^k B$ is truncated or rounded to the system word length. **Overflow errors** • These errors result when the output of a butterfly exceeds the permissible word length. **Coefficient quantization errors** • These errors result from representing the twiddle factors using a limited number of bits.
	PART-C
Q.No	**Questions**
1	**In the IIR system given below the products are rounded to 4 bits (including sign bits). The system function is** $$\boldsymbol{H(Z) = \frac{1}{(1-0.35z^{-1})(1-0.62z^{-1})}}$$ **Find the output roundoff noise power in *(a)* direct form realization and *(b)* cascade form realization.(15 marks)-BTL3** **Solution** *(a)* **<u>Direct Form Realization</u>** $$H(Z) = \frac{1}{(1-0.35z^{-1})(1-0.62z^{-1})}$$ $$H(Z) = \frac{1}{(1-0.97z^{-1}+0.217z^{-2})}$$

Direct form realization of *H (z)* is shown in Figure

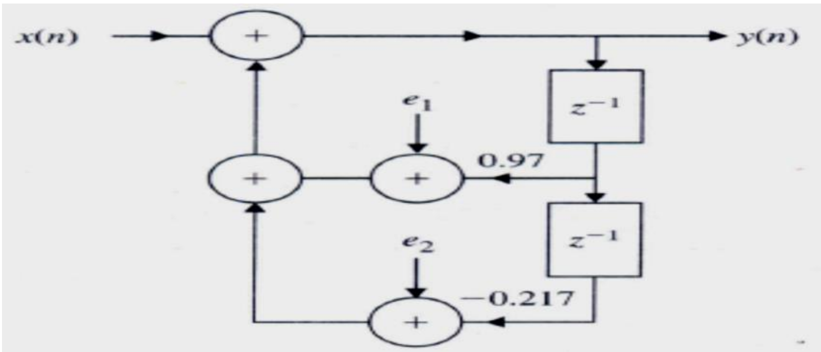
The variance of the error signal is,

Here R is not given. So take R = 2 V and b = 4 bits

$$q = \frac{R}{2^b} = \frac{2}{2^4} = \frac{1}{2^3} = \frac{1}{8}$$

$$\sigma_e^2 = \frac{(\frac{1}{8})^2}{12} = \frac{q^2}{12}$$

$$\sigma_e^2 = 1.3021X\ 10^{-3}$$



Output noise power due to the noise signal *el (n)* is,

$$\sigma_{e01}^2 = \frac{\sigma e^2}{2\pi j}\oint H(z)\ H(z^{-1})\ z^{-1}dz$$

Here,

$$H(Z) = \frac{1}{(1-0.35z^{-1})(1-0.62z^{-1})}$$

$$H(Z) = \frac{z^2}{(z-0.35)(z-0.62)}$$

Therefore, (5)

$$\sigma_{e01}^2 = \frac{\sigma e^2}{2\pi j}\oint\left(\frac{z^2}{(z-0.35)(z-0.62)}\right)\left(\frac{z^{-2}}{(z^{-1}-0.35)\ (z^{-1}-0.62)}\right) z^{-1}dz$$

$$\sigma_{e01}^2 = \frac{\sigma e^2}{2\pi j}\oint\left(\frac{z^{-1}}{(z-0.35)(z-0.62)\ (z^{-1}-0.35)\ (z^{-1}-0.62)}\right)dz$$

The stable poles of *H(z)* are P_l = 0.35 and P_2= 0.62 and unstable poles of H(z) are P3 = 2.86 and P4 = 1.62. For taking residue only consider the stable poles.

$$\mathrm{Res}[\mathrm{H(z)H(z^{-1})z^{-1}}]|(z=0.35) =$$

$$= (z-0.35)\frac{z^{-1}}{(z-0.35)(z-0.62)\ (z^{-1}-0.35)\ (z^{-1}-0.62)}\Bigg|\ z = 0.35$$

= **-1.8867.**

$$\mathrm{Res}[\mathrm{H(z)H(z^{-1})z^{-1}}]|(z=0.62) =$$

$$= (z-0.62)\frac{z^{-1}}{(z-0.35)(z-0.62)\ (z^{-1}-0.35)\ (z^{-1}-0.62)}\Bigg|\ z = 0.62$$

=4.7640.

Total = $\mathrm{Res}[H(z)H(z^{-1})z^{-1}]|(z=0.35)+\mathrm{Res}[H(z)H(z^{-1})z^{-1}]|(z=0.62)$

= **-1.8867 + 4.7640.**

= 2.8773.

Therefore,

$$\sigma_{e01}^2 = \frac{\sigma e^2}{2\pi j}\oint H(z)\ H(z^{-1})\ z^{-1}dz$$

= 1.3021 X 10^{-3} X 2.8733

= 3.7465 X 10^{-3} (5)

Here the output noise due to error source $e_2(n)$ is same as that of $e_1(n)$, *i.e.*,

e_2 (n)* noise power = noise power of *e_1(n)

$$\sigma_{e01}^2 = \sigma_{e02}^2$$

= 3.7465 x 10^{-3}

Total output noise power due to all the noise sources is,

$$\boldsymbol{\sigma_{e0}^2 = \sigma_{e01+}^2\sigma_{e02}^2}$$

$$\sigma_{e0}^2 = 7.493\ X\ 10^{-3}$$

(b) **<u>Cascade Realization</u>**

Given

$$\boldsymbol{H(Z) = \frac{1}{(1-0.35z^{-1})(1-0.62z^{-1})}}$$

Let H(z) =H_1(Z)H_2(Z), i.e.,

$$\boldsymbol{H_1(z) = \frac{1}{1-0.35z^{-1}}\ and\ H_2(z) = \frac{1}{1-0.62z^{-1}}}$$

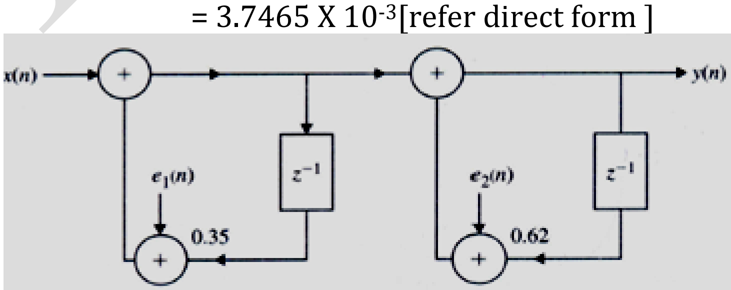
Case *(i)* ***<u>H(z) = H_1(Z)H_2(Z)</u>***

The cascade form realization of *H(z)* is shown in Figure

The order of cascading is *H_1(Z)H_2(Z).* Output noise power due to errorsignal *e_1(n)* is

$$\sigma_{e01}^2 = \frac{\sigma e^2}{2\pi j}\oint H(z)\ H(z^{-1})\ z^{-1}dz$$

= 3.7465 X 10^{-3}[refer direct form]



Output noise power due to the error, signal *e2(n)* is

$$\sigma_{e02}^2 = \frac{\sigma e^2}{2\pi j}\oint H_2(z)H_2(z^{-1})z^{-1}\,dz$$

$$H_2(z)H_2(z^{-1})z^{-1} = \frac{z^{-1}}{(z-0.62)(z^{-1}-0.62)}$$

$$\text{Res}[H_2(z)H_2(z^{-1})z^{-1}]|(z=0.62) = (z-0.62)\frac{z^{-1}}{(z-0.62)\,(z^{-1}-0.62)}\bigg|\, z=0.62$$

=1.6244

$$\sigma_{e02}^2 = \frac{\sigma e^2}{2\pi j}\oint H_2(z)H_2(z^{-1})z^{-1}\,dz$$

=1.3021 X 10^{-3} X 1.6244

= 2.1151 X 10^{-3}

Total Output noise power

$$\sigma_{e0}^2 = \sigma_{e01+}^2\sigma_{e02}^2$$

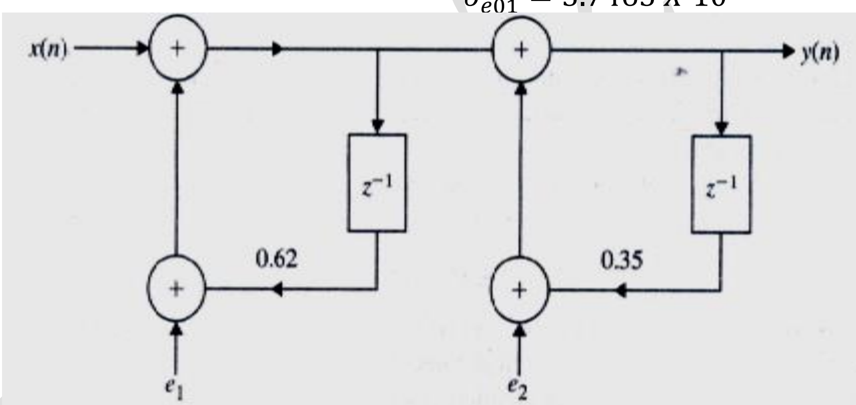
= 3.7465 x 10^{-3}+2.1151 x 10^{-3}

$$\boxed{\sigma_{e0}^2 = 5.8616\;X\;10^{-3}}$$

Case *(ii)* The order of cascading is $H(z) = H_2(Z)H_1$(z) and is shown in Figure

The output noise power due to error source $e_1$is, (5)

$$\sigma_{e01}^2 = 3.7465\;X\;10^{-3}$$



The output noise power due to error source $e_1(n)$ is,

$$\sigma_{e02}^2 = \frac{\sigma e^2}{2\pi j}\oint H_1(z)H_1(z^{-1})z^{-1}\,dz$$

$$H_1(z)H_1(z^{-1})z^{-1} = \frac{z^{-1}}{(z-0.35)(z^{-1}-0.35)}$$

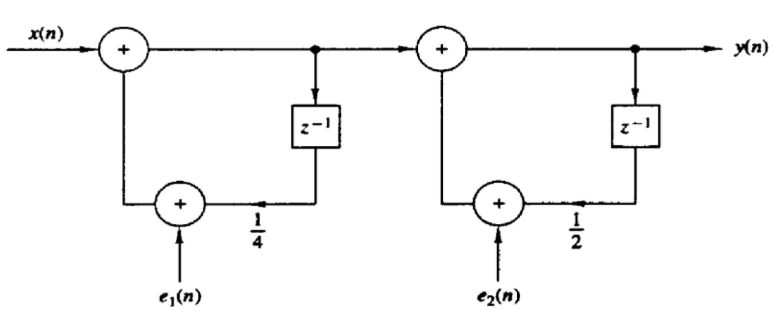
$$\text{Res}[H_1(z)H_1(z^{-1})z^{-1}]|(z=0.35) = (z-0.35)\frac{z^{-1}}{(z-0.35)\,(z^{-1}-0.35)}\bigg|\, z=0.35$$

= 1.1396

$$\sigma_{e02}^2 = 1.1396\;X\;1.3021\;X\;10^{-3}$$

= 1.4839 X 10^{-3}

Total output noise power

	$\sigma_{e0}^2 = \sigma_{e01+}^2\sigma_{e02}^2$ $=3.7465\ 10^{-3} + 1.4839 X 10^{-3}$ $\boxed{\sigma_{e0}^2 = 5.2304\, X\, 10^{-3}}$
2	**Illustrate the concept of scaling problem and limit cycles in digital signal processing. (15M)(NOV 2012)(** BTL2**)** **Answer: Page 7.30,7.33 - Ramesh babu** Limit cycle oscillation (5M) $$y(n) = \propto y(n-1) + x(n)$$ The output with rounding is given by, (5M) $$x^n = 0.875 \text{ for } n = 0$$ = 0 otherwise Signal scaling (5M) $S_0^2 = \frac{1}{I}$, Where I=$\frac{1}{2\pi j}\oint_c z^{-1} \quad dz/D(z)D(Z^{-1})$
3.	**Two first order LPF whose system function is given below connected in cascade. Determine the overall output round off noise power $H_1(z) = 1/[1-0.5z^{-1}]$and** **$H_2(z)=1/[1-0.25z^{-1}]$. (12M)(May 2017)(** BTL3**)** **Answer: Page 7.51- Ramesh babu (similar type)** Steady state output noise power (6M) $$\sigma_\epsilon^2 = ^{\sigma_e^2 \frac{1}{2}} \pi j = \oint_c H(Z)H(Z^{-1})\, dz$$ Round off noise model (6M)  (b) Cascade realization II

UNIT V – INTRODUCTION TO DIGITAL SIGNAL PROCESSORS	
DSP functionalities - circular buffering – DSP architecture – Fixed and Floating point architecture principles – Programming – Application examples.	
	PART-A
Q.No	**Questions**
1	**What are the classifications of Digital Signal Processors? BTL1** They are classified into • General purpose digital signal processor • Special Purpose digital signal processor
2.	**What are the factors that influence selection of DSPs?BTL2** • Architectural features • Execution speed • Type of arithmetic • Word Length
3.	**How is fast computation achieved in DSPs?BTL2** The fast computation in DSPs are achieved by providing single cycle multiply / accumulate (MAC) unit, pipelining of instruction execution, VLIW architecture and multiprocessor architecture.
4.	**How is fast data access achieved in Digital Signal Processors?BTL2** In Digital Signal Processors, the fast data access is achieved by high band width memory architecture like modified Harvard architecture, specialized addressing modes like circular and bit reversed addressing and DMA.
5.	**Write short notes on general purpose DSP processors.BTL2**

	• General-purpose digital signal processors are basically high speed microprocessors with hardware architecture and instruction set optimized for DSP operations. • These processors make extensive use of parallelism, Harvard architecture, pipelining and dedicated hardware whenever possible to perform time consuming operations
6.	**What is pipelining?BTL1** Pipelining a processor means breaking down its instruction into a series of discrete Pipeline stages which can be completed in sequence by specialized hardware.
7.	**Write notes on special purpose DSP processors (or)** **List the types of special purpose DSP processors. BTL1** There are two types of special; purpose hardware. • Hardware designed for efficient execution of specific DSP algorithms such as digital Filter, FFT. • Hardware designed for specific applications, for example telecommunication, digital Audio.
8.	**What are the special features of Digital Signal Processors? BTL2** a. Fast data access b. Fast computation c. Numerical fidelity d. Fast execution control
9.	**What are the applications of PDSPs? BTL1** • Cell phones, • Automated inspection, • Voicemail, • Motor control, • Video conferencing,

	• Noise cancellation, • Medical imaging, Satellite communication etc.
10	**Give some examples for fixed point DSPs. BTL1** • TM32OC50, • TMS320C54, • TMS320C55, • ADSP-219x, • ADSP-219xx.
11	**Give the functions of program bus? BTL2** • The program bus carries the instruction code and immediate operands from program Memory to the CPU.
12	**Give some example for floating point DSPs? BTL1** • TMS320C3x, • TMS320C67x, • ADSP-21xxx
13	**What are the different buses of TMS320C5x? BTL1** The C5x architecture has four buses • Program bus (PB) • Program address bus (PAB) • Data read bus (DB) • Data read address bus (DAB)

14	**What are the elements that the control processing unit of 'C5x consists of? BTL1** The central processing unit consists of the following elements: ▪ Central arithmetic logic unit (CALU) ▪ Parallel logic unit (PLU) ▪ Auxiliary register arithmetic unit (ARAU) ▪ Memory mapped registers ▪ Program controller
15	**Give the advantages of DSPs?BTL1** • Architectural features, • Execution speed, • Type of arithmetic, • Word length.
16	**What about of Harvard architecture?BTL1** • The principal feature of Harvard architecture is that the program and the data memories lie into separate spaces, permitting full overlap of instruction fetch and execution. • Typically these types of instructions would involve their distinct type. ▪ Instruction fetch ▪ Instruction decode ▪ Instruction execute

17	**What are the types of MAC is available?BTL1** There are two types MAC'S available 1. Dedicated & integrated 2. Separate multiplier and integrated unit
18	**What is meant by pipeline technique? BTL1** • The pipeline technique is used to allow overall instruction executions to overlap. • That is where all four phases operate in parallel. By adapting this technique, execution speed is increased.
19	**What are four phases available in pipeline technique? BTL1** a) Fetch b) Decode c) Read d) Execution
20	**Write down the name of the addressing modes. BTL1** ○ Direct addressing. ○ Indirect addressing. ○ Bit-reversed addressing. ○ Immediate addressing. ○ Short immediate addressing.
21	**Write the name of various part of C5X hardware. BTL1** 1. Central arithmetic logic unit (CALU) 2. Parallel logic unit (PLU)

	3. Auxiliary register arithmetic unit (ARAU) 4. Memory-mapped registers. 5. Program controller.
22	**What are the advantages and disadvantages of VLIW architecture? BTL2** The advantages of VLIW architecture are: 1. Increased performance 2. Better compiler targets 3. Potentially scalable 4. Potentially easier to program 5. Can add more execution units, allow more instruction to be packed into the VLIW instruction. The disadvantages of VLIW architecture are: 1. New kind of programmer/compiler complexity 2. Program must keep track of instruction scheduling 3. Increased memory use 4. High power consumption 5. Misleading MIPS ratings
23	**What are the different stages in pipelining? BTL1** The different stages in pipelining are: 1. the Fetch phase 2. the Decode phase 3. Memory read phase 4. the Execute phase
24	**List out the on chip peripherals in „C5x.BTL1** The on-chip peripherals interfaces connected to the „C5x CPU include 1. Clock generator 2. Hardware timer

	3. Software programmable wait state generators 4. General purpose I/O pins 5. Parallel I/O ports 6. Serial port interface 7. Buffered serial port 8. Time-divisions multiplexed (TDM) serial port 9. Host port interface 10. User unmaskable interrupts
25	**What is the function of parallel logic unit?** The function of the parallel logic unit is to execute logic operations on data without affecting the contents of accumulator
	PART-B
Q.No	**Questions**
1.	**Explain Von Neumann and Harvard architectures with simple sketches.BTL1** **Answer: Page 11.8-11.10 - Ramesh babu (13 Marks)** • Architecture Diagram-(6 Marks) • Explanation-(7 Marks)
2.	**Write the salient features of TMS320C5x family of Digital Signal Processors.BTL2** **Answer: Page 11.1-11.5 - Ramesh babu (13 Marks)**
3.	**Draw the simplified architecture of TMS320C5x processor and explain.BTL1** **Answer: Page 11.15-11.25 - Ramesh babu (13 Marks)** • Architecture Diagram-(6 Marks) • Explanation-(7 Marks)
4.	**Explain in details any two applications of DSP?BTL1** **Answer: Page 10.5-10.11 - Ramesh babu (13 Marks)** • Block Diagram-(6 Marks) • Explanation-(7 Marks)
5.	**Explain the various types of addressing modes of digital signal processor with suitable examples.** **Answer: Page 11.25-11.28 - Ramesh babu (13 Marks)**

	• Diagram-(3 Marks) • Explanation-(10 Marks)
6.	**Discuss the features and architecture of TMS 320 C50 processor.** **Answer: Page 11.15-11.25 - Ramesh babu (13 Marks)** • Architecture Diagram-(6 Marks) • Explanation-(7 Marks)
7.	**Design a DSP based system for the process of audio signals in an audio recorder system** **Answer: Page 10.9 - Ramesh babu (8 Marks)** • Block Diagram-(4 Marks) • Explanation-(4 Marks)

EC8552 COMPUTER ARCHITECTURE AND ORGANIZATION L T P C 3 0 0 3

OBJECTIVES:

- To make students understand the basic structure and operation of digital computer
- To familiarize with implementation of fixed point and floating-point arithmetic operations
- To study the design of data path unit and control unit for processor
- To understand the concept of various memories and interfacing
- To introduce the parallel processing technique

UNIT I COMPUTER ORGANIZATION & INSTRUCTIONS 9

Basics of a computer system: Evolution, Ideas, Technology, Performance, Power wall, Uniprocessors to Multiprocessors. Addressing and addressing modes. Instructions: Operations and Operands, Representing instructions, Logical operations, control operations.

UNIT II ARITHMETIC 9

Fixed point Addition, Subtraction, Multiplication and Division. Floating Point arithmetic, High performance arithmetic, Subword parallelism

UNIT III THE PROCESSOR 9

Introduction, Logic Design Conventions, Building a Datapath - A Simple Implementation scheme -An Overview of Pipelining - Pipelined Datapath and Control. Data Hazards: Forwarding versus Stalling, Control Hazards, Exceptions, Parallelism via Instructions.

UNIT IV MEMORY AND I/O ORGANIZATION 9

Memory hierarchy, Memory Chip Organization, Cache memory, Virtual memory.Parallel Bus Architectures, Internal Communication Methodologies, Serial Bus Architectures, Mass storage, Input and Output Devices.

UNIT V ADVANCED COMPUTER ARCHITECTURE 9

Parallel processing architectures and challenges, Hardware multithreading, Multicore and shared memory multiprocessors, Introduction to Graphics Processing Units, Clusters and Warehouse scale computers - Introduction to Multiprocessor network topologies.

TOTAL:45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to

- Describe data representation, instruction formats and the operation of a digital computer
- Illustrate the fixed point and floating-point arithmetic for ALU operation
- Discuss about implementation schemes of control unit and pipeline performance
- Explain the concept of various memories, interfacing and organization of multiple processors
- Discuss parallel processing technique and unconventional architectures

TEXT BOOKS:

1. David A. Patterson and John L. Hennessey, ―Computer Organization and Design‖, Fifth edition, Morgan Kauffman / Elsevier, 2014. (UNIT I-V)

2. Miles J. Murdocca and Vincent P. Heuring, ―Computer Architecture and Organization: An Integrated approach‖, Second edition, Wiley India Pvt Ltd, 2015 (UNIT IV,V)

REFERENCES

1. V. Carl Hamacher, Zvonko G. Varanesic and Safat G. Zaky, ―Computer Organization―, Fifth edition, Mc Graw-Hill Education India Pvt Ltd, 2014.

2. William Stallings ―Computer Organization and Architecture‖, Seventh Edition, Pearson Education, 2006. 65

3. Govindarajalu, ―Computer Architecture and Organization, Design Principles and Applications", Second edition, McGraw-Hill Education India Pvt Ltd, 2014

Subject Code:EC8552 **Year/Semester: III /05**
Subject Name: Computer Architecture & Organization **Subject Handler: Ms. Revathi**

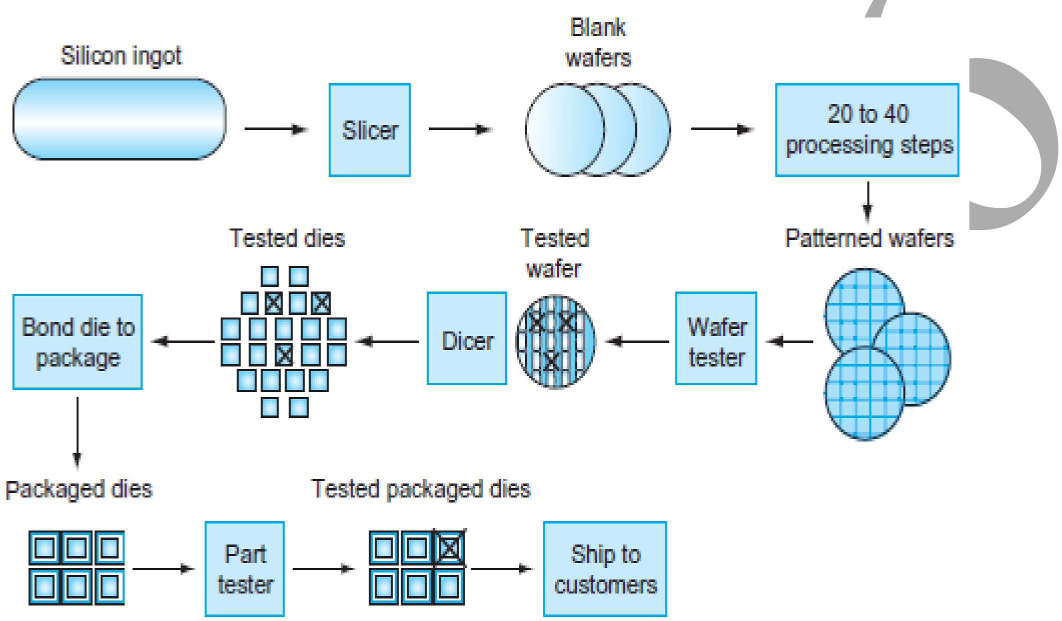
UNIT -1- COMPUTER ORGANIZATION & INSTRUCTIONS	
Basics of a computer system: Evolution, Ideas, Technology, Performance, Power wall, Uniprocessors to Multiprocessors. Addressing and addressing modes. Instructions: Operations and Operands, Representing instructions, Logical operations, control operations.	
PART A	
Q.No	**QUESTIONS**
1.	**Define computer architecture** BTL1 Computer architecture is defined as the functional operation of the individual h/w unit in a computer system and the flow of information among the control of those units.
2.	**Define computer h/w.** BTL1 Computer h/w is the electronic circuit and electro mechanical equipment that constitutes the Computer
3.	**What are the functions of control unit?** BTL2 • The memory arithmetic and logic, and input and output units store and process information and perform i/p and o/p operation • The operation of these unit must be coordinate in some way this is the task of control unit the cu is effectively the nerve center that sends the control signal to other units and sense their states.
4.	**What is an interrupt?** BTL2 An interrupt is an event that causes the execution of one program to be suspended and another program to be executed.
5.	**What are the uses of interrupts?** BTL2 • Recovery from errors • Debugging • Communication between programs • Use of interrupts in operating system
6.	**What is the need for reduced instruction chip?** BTL2 • Relatively few instruction types and addressing modes. • Fixed and easily decoded instruction formats. • Fast single-cycle instruction execution. • Hardwired rather than microprogrammed control.
7.	**Explain the following the address instruction?** BTL3 • Three-address instruction-it can be represented as add a,b,c operands a,b are called source operand and c is called destination operand. • Two-address instruction-it can be represented as add a,b • One address instruction-it can be represented as add a

	• Zero address instruction-it can be represented as Push down stack
8.	**Differentiate between RISC and CISC** BTL4 RISC & CISC reduced instruction set computer 1. complex instruction set computer simple instructions take one cycle per operation complex instruction take multiple cycles per operation. few instructions and address modes are used. many instruction and address modes. fixed format instructions are used. variable format instructions are used instructions are compiled and then executed by hardware. instructions are interpreted by the microprogram and then executed. RISC machines are multiple register set. CISC machines use single register set.
9.	**Specify three types of data transfer techniques.** BTL1 • Arithmetic data transfer • Logical data transfer • Programmed control data transfer
10.	**What is absolute addressing mode?** BTL1 The address of the location of the operand is given explicitly as a part of the instruction. Eg. move a , 2000
11.	**What is the role of MAR and MDR?** BTL1 • The MAR (memory address register) is used to hold the address of the location to or from which data are to be transferred • The MDR(memory data register) contains the data to be written into or read out of the addressed location.
12.	**Define CPI** BTL1 • The term clock cycles per instruction which is the average number of clock cycles each instruction takes to execute, is often abbreviated as CPI. CPI= CPU clock cycles/instruction count.
13.	**Define throughput and throughput rate.** BTL1 • throughput -the total amount of work done in a given time. • throughput rate-the rate at which the total amount of work done at a given time.
14.	**State and explain the performance equation? BTL2** Suppose that the average number of basic steps needed to execute one machine instruction is S,where each basic step is completed in one clock cycle. if the clock cycle rate is R cycles per second, the program execution time is given by T = (N x S) / R this is often referred to as the basic performance equation.

15.	**What are the various types of operations required for instructions?** BTL1 • Data transfers between the main memory and the CPU registers • Arithmetic and logic operation on data • Program sequencing and control • I/O transfers
16.	**What are the various units in the computer?** BTL1 • Input unit • Output unit • Control unit • Memory unit • Arithmetic and logical unit
	PART B
1	**Explain in detail, the eight ideas in computer architecture. (13m)** BTL4 **Answer**: U-1 in refer notes **Definition(2m)** **Diagram(4m)** **Explanation(7m)** • Design for Moore's Law • Use Abstraction to simplify design • Make the common case fast • Performance via parallelism • Performance via pipelining • Performance via prediction • Hierarchy of memories • Dependability via redundancy
2	**Explain in detail, the components of a computer system. (13m) (Apr/may 2018)** BTL4 **Answer**: U-1 Refer notes **Explanation(8m)** **Diagram(5m)** The five classic components of a computer are input, output, memory, datapath, and control.
3	**Explain in detail, the technologies for building processor and memory. (13m)** BTL4 **Technologies. (3m)** **Answer**: U-1 Refer notes **The manufacturing process for integrated circuits: (7m)** • The manufacture of a chip begins with silicon, a substance found in sand. Because silicon does not conduct electricity well, it is called a semiconductor. With a special chemical process, it is possible to add materials to silicon that allow tiny areas to transform into one of three devices: • Excellent conductors of electricity (using either microscopic copper or aluminum wire) • Excellent insulators from electricity (like plastic sheathing or glass) • Areas that can conduct or insulate under special conditions (as a switch) Transistors fall in the last category. • A VLSI circuit, then, is just billions of combinations of conductors, insulators, and switches manufactured in a single small package. The manufacturing process for integrated circuits is critical to the cost of the chips and hence important to computer

designers.

- The process starts with a silicon crystal ingot, which looks like a giant sausage. Today, ingots are 8–12 inches in diameter and about 12–24 inches long. An ingot is finely sliced into wafers no more than 0.1 inches thick.
- These wafers then go through a series of processing steps, during which patterns of chemicals are placed on each wafer, creating the transistors, conductors, and insulators discussed earlier.
- Today's integrated circuits contain only one layer of transistors but may have from two to eight levels of metal conductor, separated by layers of insulators.



The chip manufacturing process:

- After being sliced from the silicon ingot, blank wafers are put through 20 to 40 steps to create patterned wafers.
- These patterned wafers are then tested with a wafer tester, and a map of the good parts is made. Then, the wafers are diced into dies.
- The yield of good dies are then bonded into packages and tested one more time before shipping the packaged parts to customers. One bad packaged part was found in this final test.

Defect: A microscopic flaw in a wafer or in patterning steps that can result in the failure of the die containing that defect.

Die: The individual rectangular sections that are cut from a wafer, more informally known as chips. **Yield:** The percentage of good dies from the total number of dies on the wafer.

The cost of an integrated circuit rises quickly as the die size increases, due both to the lower yield and the smaller number of dies that fit on a wafer. To reduce the cost, using the next generation process shrinks a large die as it uses smaller sizes for both transistors and wires.

$$\text{Cost per die} = \frac{\text{Cost per wafer}}{\text{Dies per wafer} \times \text{yield}}$$

$$\text{Dies per wafer} \approx \frac{\text{Wafer area}}{\text{Die area}}$$

$$\text{Yield} = \frac{1}{(1 + (\text{Defects per area} \times \text{Die area}/2))^2}$$

	Diagram(3m)
4	**Explain in detail, the performance of a computer. (13m)** BTL4

Defining Performance:

- If you were running a program on two different desktop computers, you'd say that the faster one is the desktop computer that gets the job done first. If you were running a datacenter that had several servers running jobs submitted by many users, you'd say that the faster computer was the one that completed the most jobs during a day.
- As an individual computer user, you are interested in reducing response time—the time between the start and completion of a task—also referred to as execution time. Datacenter managers are often interested in increasing throughput or bandwidth—the total amount of work done in a given time
- Hence, in most cases, we will need different performance metrics as well as different sets of applications to benchmark personal mobile devices, which are more focused on response time, versus servers, which are more focused on throughput. To maximize performance, we want to minimize response time or execution time for some task. Thus, we can relate performance and execution time for a computer X:

$$\text{Performance}_X = \frac{1}{\text{Execution time}_X}$$

This means that for two computers X and Y, if the performance of X is greater than the performance of Y, we have

$$\text{Performance}_X > \text{Performance}_Y$$

$$\frac{1}{\text{Execution time}_X} > \frac{1}{\text{Execution time}_Y}$$

$$\text{Execution time}_Y > \text{Execution time}_X$$

- That is, the execution time on Y is longer than that on X, if X is faster than Y. To relate the performance of two different computers quantitatively. We will use the phrase "X is n times faster than Y"—or equivalently "X is n times as fast as Y"—to mean

$$\frac{\text{Performance}_X}{\text{Performance}_Y} = n$$

If X is n times as fast as Y, then the execution time on Y is n times as long as it is on X:

$$\frac{\text{Performance}_X}{\text{Performance}_Y} = \frac{\text{Execution time}_Y}{\text{Execution time}_X} = n$$

Measuring Performance: Time is the measure of computer performance:

- The computer that performs the same amount of work in the least time is the fastest. Program execution time is measured in seconds per program. However, time can be defined in different ways, depending on what we count.
- The most straightforward definition of time is called wall clock time, response time, or elapsed time. These terms mean the total time to complete a task, including disk accesses, memory accesses, input/output (I/O) activities, operating system overhead—everything.
- CPU execution time also called CPU time: The actual time the CPU spends computing for a specific task. user CPU time The CPU time spent in a program itself. system CPU time the CPU time spent in the operating system performing tasks on behalf of the program.
- A simple formula relates the most basic metrics (clock cycles and clock cycle time) to CPU time:

$$\text{CPU execution time for a program} = \frac{\text{CPU clock cycles for a program}}{\text{Clock rate}}$$

Instruction Performance : One way to think about execution time is that it equals the number of instructions executed multiplied by the average time per instruction.
Therefore, the number of clock cycles required for a program can be written as

$$\text{CPU clock cycles} = \text{Instructions for a program} \times \text{Average clock cycles per instruction}$$

clock cycles per instruction (CPI) Average number of clock cycles per instruction for a program or program
The Classic CPU Performance Equation: The basic performance equation in terms of instruction count (the number of instructions executed by the program),
CPI, and clock cycle time:

$$\text{CPU time} = \text{Instruction count} \times \text{CPI} \times \text{Clock cycle time}$$

or, since the clock rate is the inverse of clock cycle time:

$$\text{CPU time} = \frac{\text{Instruction count} \times \text{CPI}}{\text{Clock rate}}$$

The basic components of performance and how each is measured. These factors are combined to yield execution time measured in seconds per program:

$$\text{Time} = \text{Seconds/Program} = \frac{\text{Instructions}}{\text{Program}} \times \frac{\text{Clock cycles}}{\text{Instruction}} \times \frac{\text{Seconds}}{\text{Clock cycle}}$$

Instruction mix: A measure of the dynamic frequency of instructions across one or many programs. The performance of a program depends on the algorithm, the language, the compiler, the architecture, and the actual hardware.

PART-C

1

Write short notes on : i) Operations and operands ii) Representing instructions iii) Logical and control operations (15m) BTL2

Operations of the Computer Hardware:

- Every computer must be able to perform arithmetic. The MIPS assembly language Notation add a, b, c instructs a computer to add the two variables b and c and to put their sum in a.

MIPS operands

Name	Example	Comments
32 registers	\$s0–\$s7, \$t0–\$t9, \$zero, \$a0–\$a3, \$v0–\$v1, \$gp, \$fp, \$sp, \$ra, \$at	Fast locations for data. In MIPS, data must be in registers to perform arithmetic, register \$zero always equals 0, and register\$at is reserved by the assembler to handle large constants.
2^{30} memory words	Memory[0], Memory[4], . . . , Memory[4294967292]	Accessed only by data transfer instructions. MIPS uses byte addresses, so sequential word addresses differ by 4. Memory holds data structures, arrays, and spilled registers.

- The natural number of operands for an operation like addition is three: the two numbers being added together and a place to put the sum. Requiring every instruction to have exactly three operands, no more and no less, conforms to the philosophy of keeping the hardware simple: hardware for a variable number of operands is more complicated than hardware for a fixed number.
- Three underlying principles of hardware design:

Design Principle 1: Simplicity favors regularity.

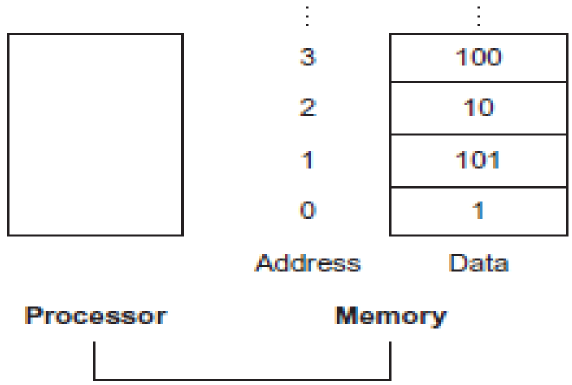
Design Principle 2: Smaller is faster.

Design Principle 3: Good design demands good compromises.

operands of the Computer Hardware:

- Unlike programs in high-level languages, the operands of arithmetic instructions are restricted; they must be from a limited number of special locations built directly in hardware called registers.
- Registers are primitives used in hardware design that are also visible to the programmer when the computer is completed, so you can think of registers as the bricks of computer construction.
- The size of a register in the MIPS architecture is 32 bits; groups of 32bits occur so frequently that they are given the name word in the MIPS architecture.
- One major difference between the variables of a programming language and registers is the limited number of registers, typically 32 on current computers, like MIPS.
- The reason for the limit of 32 registers is due to design principles of hardware technology: Smaller is faster.
- A very large number of registers may increase the clock cycle time simply because it takes electronic signals longer when they must travel farther

Memory Operands:



- Data transfer instruction is a command that moves data between memory and registers. Address A value used to delineate the location of a specific data element within a memory array.

Memory addresses and contents of memory at those locations.

- The data transfer instruction that copies data from memory to a register is traditionally called load. The actual MIPS name for this instruction is lw, standing for load word.

lw $t0,8($s3) # Temporary reg $t0 gets A[8]

- The instruction complementary to load is traditionally called store; it copies data from a register to memory. The actual MIPS name is sw, standing for store word.

sw $t0,48($s3) # Stores h + A[8] back into A[12]

- Load word and store word are the instructions that copy words between memory and registers in the MIPS architecture.

Constant or Immediate Operands:

- Many times a program will use a constant in an operation—for example, incrementing an index to point to the next element of an array.
- This quick add instruction with one constant operand is called add immediate or addi. To add 4

```
addi    $s3,$s3,4           # $s3 = $s3 + 4
```

to register $s3,

- Computer programs calculate both positive and negative numbers, so we need a representation that distinguishes the positive from the negative.
- The most obvious solution is to add a separate sign, which conveniently can be represented in a single bit; the name for this representation is sign and magnitude.

Signed and Unsigned Numbers:

- Signed versus unsigned applies to loads as well as to arithmetic. The function of a signed load is to copy the sign repeatedly to fill the rest of the register—called sign extension—but its purpose is to place a correct representation of the number within that register.
- Unsigned loads simply fill with 0s to the left of the data, since the number represented by the bit pattern is unsigned.

i) Representing instructions

- Instructions are kept in the computer as a series of high and low electronic signals and may be represented as numbers.

- In fact, each piece of an instruction can be considered as an individual number, and placing these numbers side by side forms the instruction.

Instruction format: A form of representation of an instruction composed of fields of binary numbers.

Machine language: Binary representation used for communication within a computer system. Hexa decimal Numbers in base 16.

MIPS Fields:

op	rs	rt	rd	shamt	funct
6 bits	5 bits	5 bits	5 bits	5 bits	6 bits

Here is the meaning of each name of the fields in MIPS instructions:

- op: Basic operation of the instruction, traditionally called the opcode.
- rs: The first register source operand.
- rt: The second register source operand.
- rd: The register destination operand. It gets the result of the operation.
- shamt: Shift amount. (Section 2.6 explains shift instructions and this term; it will not be used until then, and hence the field contains zero in this section.)

op	rs	rt	constant or address
6 bits	5 bits	5 bits	16 bits

ecific variant of the

Instruction	Format	op	rs	rt	rd	shamt	funct	address
add	R	0	reg	reg	reg	0	32_{ten}	n.a.
sub (subtract)	R	0	reg	reg	reg	0	34_{ten}	n.a.
add immediate	I	8_{ten}	reg	reg	n.a.	n.a.	n.a.	constant
lw (load word)	I	35_{ten}	reg	reg	n.a.	n.a.	n.a.	address
sw (store word)	I	43_{ten}	reg	reg	n.a.	n.a.	n.a.	address

same length, thereby
ons. For example, the

at and is used by the

MIPS instruction encoding.

Name	Fields						Comments
Field size	6 bits	5 bits	5 bits	5 bits	5 bits	6 bits	All MIPS instructions are 32 bits long
R-format	op	rs	rt	rd	shamt	funct	Arithmetic instruction format
I-format	op	rs	rt	address/immediate			Transfer, branch, imm. format
J-format	op	target address					Jump instruction format

MIPS instruction formats.

(iii) Logical Operations

- The instructions used for the packing and unpacking of bits into words are called logical operations.
- The first class of such operations is called shift s. They move all the bits in a word to the left or right, filling the emptied bits with 0s. For example, if register $s0 contained

Logical operations	C operators	Java operators	MIPS instructions
Shift left	<<	<<	sll
Shift right	>>	>>>	srl
Bit-by-bit AND	&	&	and, andi
Bit-by-bit OR	|	|	or, ori
Bit-by-bit NOT	~	~	nor

0000 0000 0000 0000 0000 0000 0000 1001two = 9ten and the instruction to shift left by 4 was executed, the new value would be: 0000 0000 0000 0000 0000 0000 1001 0000two = 144ten

- The dual of a shift left is a shift right. The actual name of the two MIPS shift instructions are called shift left logical (sll) and shift right logical (srl).

AND: A logical bit by- bit operation with two operands that calculates a 1 only if there is a 1 in both operands. And $t0,$t1,$t2 # reg $t0 = reg $t1 & reg $t2

OR: A logical bit-by bit operation with two operands that calculates a 1 if there is a 1 in either operand.

or $t0,$t1,$t2 # reg $t0 = reg $t1 | reg $t2

NOT: A logical bit-by bit operation with one operand that inverts the bits; that is, it replaces every 1 with a 0, and every 0 with a 1.

NOR: A logical bit-by bit operation with two operands that calculates the NOT of the OR of the two operands. That is, it calculates a 1 only if there is a 0 in both operands.

Instructions for Making Decisions:

- MIPS assembly language includes two decision-making instructions, similar to an if statement with a go to. The first instruction is

beq register1, register2, L1

- This instruction means go to the statement labeled L1 if the value in register1 equals the value in register2. The mnemonic beq stands for branch if equal.
- The second instruction is bne register1, register2, L1 It means go to the statement labeled L1 if the value in register1 does not equal the value in register2.
- The mnemonic bne stands for branch if not equal. These two instructions are traditionally called conditional branches.

the compiled MIPS code for this C if statement if (i == j) f = g + h; else f = g – h; is given as bne $s3,$s4,Else # go to Else if i ≠ j conditional branch

- An instruction that requires the comparison of two values and that allows for a subsequent transfer of control to a new address in the program based on the outcome of the comparison.

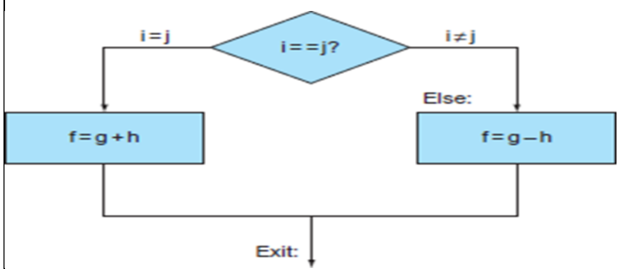
Loops:

- Decisions are important both for choosing between two alternatives—found in ifstatements—and for iterating a computation—found in loops.

Eg1: Loop: sll $t1,$s3,2 # Temp reg $t1 = i * 4

Eg 2: j Loop # go to Loop

Exit:



Case/Switch Statement:

- Most programming languages have a case or switch statement that allows the programmer to select one of many alternatives depending on a single value.
- Jump address table also called jump table. A table of addresses of alternative instruction sequences.

2 **Explain in detail, the Addressing & Addressing Modes. (15m) (Apr/may 2018)** BTL4

Answer: U-1 Refer notes **Carl hamacher book Pageno:48 (10m)**

Immediate addressing, where the operand is a constant within the instruction itself

1. Register addressing, where the operand is a register
2. Base or displacement addressing, where the operand is at the memory location whose address is the sum of a register and a constant in the instruction
3. PC-relative addressing, where the branch address is the sum of the PC and a constant in the instruction
4. Pseudodirect addressing, where the jump address is the 26 bits of the instruction concatenated with the upper bits of the PC.

Diagram(5m)

- Immediate Addressing Mode
- Absolute(Direct) Addressing Mode
- Indirect Addressing Mode
- Register Addressing Mode
- Base with index Addressing Mode
- Base with index & offset Addressing Mode
- Additional Modes(Increment & Decrement Addressing Mode)

UNIT 2- ARITHMETIC

Fixed point Addition, Subtraction, Multiplication and Division. Floating Point arithmetic, High performance arithmetic, Subword parallelism

PART A

1 **State the principle of operation of a carry look-ahead adder.** BTL2

- The input carry needed by a stage is directly computed from carry signals obtained from all the preceding stages i-1,i-2,…..0, rather than waiting for normal carries to supply slowly from stage to stage.
- An adder that uses this principle is called carry look-ahead adder.

2 **What are the main features of booth's algorithm?** BTL1

- It handles both positive and negative multipliers uniformly.
- It achieves some efficiency in the number of addition required when the multiplier has a few large blocks of 1s.

3 **How can we speed up the multiplication process?** BTL3

There are two techniques to speed up the multiplication process:

- The first technique guarantees that the maximum number of summands that must be added is n/2 for n-bit operands.
- The second technique reduces the time needed to add the summands.

4 **What is bit pair recoding? give an example.** BTL1

- Bit pair recoding halves the maximum number of summands.
- Group the booth-recoded multiplier bits in pairs and observe the following: the pair (+1 -1) is equivalent to the pair (0 +1)that is instead of adding -1 times the multiplicand m at shift position i to +1 the same result is obtained by adding +1

5 **What is the advantage of using booth algorithm?** BTL1

- It handles both positive and negative multiplier uniformly.
- It achieves efficiency in the number of additions required when the multiplier has a few large blocks of 1's.
- The speed gained by skipping 1's depends on the data.

6 **Write the algorithm for restoring division** BTL3

Do the following for n times:

- shift a and q left one binary position.
- subtract m and a and place the answer back in a.
- if the sign of a is 1, set q0 to 0 and add m back to a.

where a- accumulator, m- divisor, q- dividend.

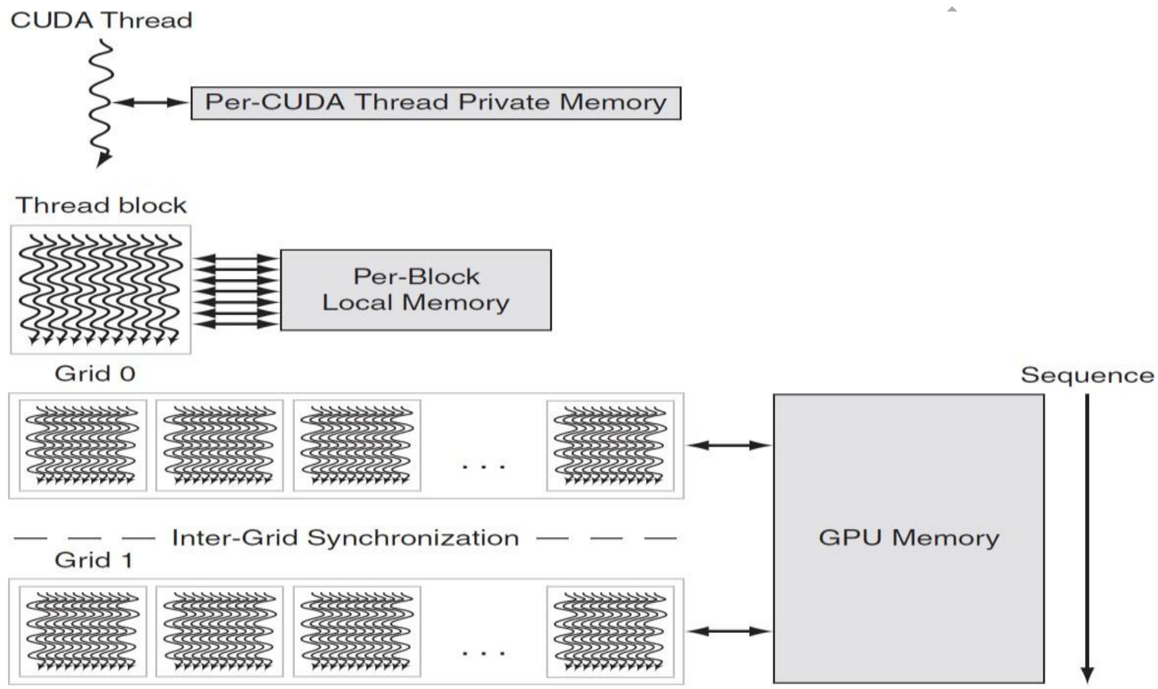
7	**Write the algorithm for non restoring division.** BTL3 Do the following for n times: step 1: do the following for n times: • If the sign of a is 0, shift a and q left one bit position and subtract m from a; otherwise, shift a and q left and add m to a. • Now, if the sign of a is 0, set q0 to 1; otherwise, set q0 to0. step 2: if the sign of a is 1, add m to a.
8	**Explain about the special values in floating point numbers.** BTL2 The end values 0 to 255 of the excess-127 exponent e are used to represent special values such as: when e= 0 and the mantissa fraction m is zero the value exacts 0 is represented. when e= 255 and m=0, the value is represented. when e= 0 and m=0, denormal values are represented. when e= 2555 and m=0, the value represented is called not a number.
9	**Write the add/subtract rule for floating point numbers.** BTL3 • Choose the number with the smaller exponent and shift its mantissa right a number of steps equal to the difference in exponents. • Set the exponent of the result equal to the larger exponent. • Perform addition/subtraction on the mantissa and determine the sign of the result • Normalize the resulting value, if necessary.
10	**Write the multiply rule for floating point numbers.** BTL3 • Add the exponent and subtract 127. • Multiply the mantissa and determine the sign of the result. • Normalize the resulting value , if necessary.
11	**What is the purpose of guard bits used in floating point arithmetic** BTL1 Although the mantissa of initial operands are limited to 24 bits, it is important to retain extra bits, called as guard bits
12	**What are generate and propagate function?** BTL1 • The generate function is given by Gi=XiYi • The propagate function is given as Pi=Xi+Yi.

13	**What is floating point numbers?** BTL1 • In some cases, the binary point is variable and is automatically adjusted as computation proceeds. • In such case, the binary point is said to float and the numbers are called floating point numbers.
14	**In floating point numbers when so you say that an underflow or overflow has occurred?** BTL5 • In single precision numbers when an exponent is less than -126 then we say that an underflow has occurred. • In single precision numbers when an exponent is less than +127 then we say that an overflow has occurred.
15	**In floating point numbers when so you say that an underflow or overflow has occurred?** BTL5 • In single precision numbers when an exponent is less than -126 then we say that an underflow has occurred. • In single precision numbers when an exponent is less than +127 then we say that an overflow has occurred.
	PART B
1	**Summarize about the sub word parallelism. (13m)** BTL2 • Since every desktop microprocessor by definition has its own graphical displays, as transistor budgets increased it was inevitable that support would be added for graphics operations. • Many graphics systems originally used 8 bits to represent each of the three primary colors plus 8 bits for a location of a pixel. The addition of speakers and microphones for teleconferencing and video games suggested support of sound as well. Audio samples need more than 8 bits of precision, but 16 bits are sufficient. • Every microprocessor has special support so that bytes and halfwords take up less space when stored in memory (see Section 2.9), but due to the infrequency of arithmetic operations on these data sizes in typical integer programs, there was little support beyond data transfers. Architects recognized that many graphics and audio applications would perform the same operation on vectors of this data. • By partitioning the carry chains within a 128-bit adder, a processor could use parallelism to perform simultaneous operations on short vectors of sixteen 8-bit operands, eight 16-bit operands, four 32-bit operands, or two 64-bit operands. The cost of such partitioned adders was small. • Given that the parallelism occurs within a wide word, the extensions are classified as subword parallelism. It is also classified under the more general name of data level parallelism. They have been also called vector or SIMD, for single instruction, multiple data (see Section 6.6). The rising popularity of multimedia applications led to arithmetic instructions that support narrower operations that can easily operate in parallel. • For example, ARM added more than 100 instructions in the NEON multimedia instruction extension to support subword parallelism, which can be used either

with ARMv7 or ARMv8. It added 256 bytes of new registers for NEON that can be viewed as 32 registers 8 bytes wide or 16 registers 16 bytes wide. NEON supports all the subword data types you can imagine except 64-bit floating point numbers:

- 8-bit, 16-bit, 32-bit, and 64-bit signed and unsigned integers
- 32-bit floating point numbers

Figure shows the memory structures of an NVIDIA GPU. We call the onchip memory that



GPU Memory structures.

is local to each multithreaded SIMD processor Local Memory.

- It is shared by the SIMD Lanes within a multithreaded SIMD processor, but this memory is not shared between multithreaded SIMD processors.
- We call the off -chip DRAM shared by the whole GPU and all thread blocks GPU Memory.
- Rather than rely on large caches to contain the whole working sets of an application, GPUs traditionally use smaller streaming caches and rely on extensive multithreading of threads of SIMD instructions to hide the long latency to DRAM, since their working sets can be hundreds of megabytes.
- Thus, they will not fit in the last level cache of a multicore microprocessor.
- Given the use of hardware multithreading to hide DRAM latency, the chip area used for caches in system processors is spent instead on computing resources and on the large number of registers to hold the state of the many threads of SIMD instructions

2 **Explain in detail, the multiplication algorithm, with a neat diagram.(13m) (Apr/may2018)** BTL4

Answer: U-2 Refer notes **carl hamacher book-page no:376**

Explanation:(5m) &Algorithm:(5m)

Step 1: bit=0, shift right C,A &Q

	Step 2: bit=1, C,A<-A+B shift right C,A, &Q **Step 3:Check Q0 bit** **Diagram:(3m)**
3	**Explain in detail, the division algorithm, with a neat diagram. (13m) (Apr/may 2018)** BTL4 **Answer: U-2** Refer notes **carl hamacher book-page no:390** **Explanation:(5m) & Algorithm:(5m)** **Step 1: Shift A&Q left 1 binary bit position** **Step 2: Subtract Divisor A<-A-B** **Step 3: Check Sign bit of A & Set Q0** **Diagram:(3m)**
4	**Explain in detail, the flow chart of floating-point multiplication. (13m)** BTL4 **Answer: U-2** Refer notes **carl hamacher book-page no:398** **Explanation:(5m) &Algorithm:(5m),** **Step 1: If either multiplicand or multiplier is 0, result will be 0** **Step 2: Add the exponents & subtract bias.** **Step 3: Multiply the mantissas & determine the sign of the result** **Step 4: Result must be normalized** **Diagram:(3m)**
	PART C
1	**Explain in detail, the block diagram of an arithmetic unit for floating-point addition & subtraction. (15m) (Apr/may 2018)** BTL4 **Answer: U-2** Refer notes **carl hamacher book-page no:393** **Explanation & Algorithm:(10m),** **Step 1: Change the sign of Q for subtraction & check zero.** **Step 2: Align mantissa** **Step 3: Addition** **Step 4: Normalization** **Diagram:(5m)**
2	**Explain in detail, the addition and subtraction operation. (15m)** BTL4 **Answer: U-2** Refer notes **Explanation:(10m),** • **Half adder** • **Full adder** • **Subtractor** • **ALU** • **Examples** **Diagram:(5m)**

UNIT-3 THE PROCESSOR

Introduction, Logic Design Conventions, Building a Datapath - A Simple Implementation scheme - An Overview of Pipelining - Pipelined Datapath and Control. Data Hazards: Forwarding versus Stalling, Control Hazards, Exceptions, Parallelism via Instructions.

PART A

1	**Define MIPS.** BTL1 MIPS: one alternative to time as the metric is MIPS (million instruction per second) MIPS=instruction count/ (execution time x1000000). This MIPS measurement is also called native MIPS to distinguish it from some alternative definitions of MIPS.
2	**Define MIPS rate.** BTL1 The rate at which the instructions are executed at a given time
3	**Define Pipelining.** BTL1 Pipelining is a technique of decomposing a sequential process into sub operations with each sub process being executed in a special dedicated segment that operates concurrently with all other segments.
4	**Define Instruction pipeline.** BTL1 • The transfer of instructions through various stages of the CPU instruction cycle, including fetch opcode, decode opcode, compute operand addresses. • Fetch operands, execute instructions and store results. this amounts to realizing most (or) all of the CPU in the form of multifunction pipeline called an instruction pipelining.
5	**What are Hazards?** BTL1 • A hazard is also called as hurdle. • The situation that prevents the next instruction in the instruction stream from executing during its designated clock cycle. stall is introduced by hazard. (ideal stage).
6	**State different types of hazards that can occur in pipeline.** BTL1&2 The types of hazards that can occur in the pipelining were, • Data hazards. • Instruction hazards. • Structural hazards.
7	**Define Data hazards.** BTL1 A data hazard is any condition in which either the source or the destination operands of an instruction are not available at the time expected in pipeline, as a result some operation has to be delayed, and the pipeline stalls.

8	**Define Instruction hazards.** BTL1 • The pipeline may be stalled because of a delay in the availability of an instruction. • For example, this may be a result of miss in cache, requiring the instruction to be fetched from the main memory. such hazards are called as instruction hazards or control hazards
9	**Define Structural hazards.** BTL1 • The structural hazards is the situation when two instructions require the use of a given hardware resource at the same time. • The most common case in which this hazard may arise is access to memory.
10	**How data hazard can be prevented in pipelining?** BTL5 Data hazards in the instruction pipelining can prevented by the following techniques. • Operand forwarding • Software approach
11	**How addressing modes affect the instruction pipelining?** BTL5 • Degradation of performance is an instruction pipeline may be due to address dependency where operand address cannot be calculated without available information needed by addressing mode. • For e.g. an instruction with register indirect mode cannot proceed to fetch the operand if the previous instructions is loading the address into the register. hence operand access is delayed degrading the performance of pipeline.
12	**How compiler is used in pipelining?** BTL5 • A compiler translates a high level language program into a sequence of machine instructions. • To reduce n, we need to have suitable machine instruction set and a compiler that makes good use of it. • An optimizing compiler takes advantages of various features of the target processor to reduce the product n*s, which is the total number of clock cycles needed to execute a program. • The number of cycles is dependent not only on the choice of instruction, but also on the order in which they appear in the program. • The compiler may rearrange program instruction to achieve better performance of course, such changes must not affect of the result of the computation.
13	**List out the methods used to improve system performance.** BTL1 The methods used to improve system performance are

	• Processor clock • Basic performance equation • Pipelining • Clock rate • Instruction set • Compiler
14	**How the interrupt is handled during exception?** BTL5 • CPU identifies source of interrupt • CPU obtains memory address of interrupt handles • PC and other CPU status information are saved • PC is loaded with address of interrupt handler and handling program to handle it.
15	**What is branch delay slot?** BTL1 The location containing an instruction that may be fetched and then discarded because of the branch is called branch delay slot.
	PART B
1	**Explain in detail, the basic implementation of MIPS. (13m)** BTL4 **Answer: U-3** refer notes pageno:3 Explanation:8m The Basic MIPS Implementation An Overview of the Implementation Diagram:5m
2	**Explain in detail, the steps involved in building a data path unit. (13m) (Apr/May 2018)** BTL4 **Answer: U-3 Refer** Notes pageno:1 Explanation:8m Diagram:5m
3	**Explain in detail, the design of the main control unit. (13m)** BTL4 **Answer: U-3** Refer Notes Explanation:8m, Diagram:5m
4	**Explain in detail, the pipelined data path and control. (13m) (Apr/May 2018)** BTL5 **Answer: U-3** Refer Notes **carl hamacher book-page no:479** **Explanation(10m)** **The Pipelined datapath(5m)** Instruction fetch:

	Instruction decode and register file read: Execute or address calculation Memory access: Write-back: **The Pipelined Control:(5m)** Instruction fetch: Instruction decode/register file read: Execution/address calculation: Memory access: Write-back**:** **Diagram:(3m)**
5	**Explain in detail, the instruction hazards. (13m)** BTL4 **Answer**: U-3 Refer Notes, **Carl hamacher book pageno:465** **Explanation(10m)** **Diagram(3m)**
6	**Explain about the Parallelism via Instructions. (13m)** BTL5 **Answer: U-3** Refer Notes Pageno:11 **Explanation(10m)** **Diagram(3m)**
	PART C
1.	**Explain the overview of pipelining. (15m)** BTL4 **Answer: u-3** Refer Notes **carl hamacher book-page no:454** Explanation(10m) Diagram(5m) An Overview of Pipelining: Designing Instruction Sets for Pipelining: Pipeline Hazards:
2.	**Explain in detail, the pipeline hazards. (15m)** BTL4 **Answe**r : U-3Refer notes Explanation(10m) Pipeline Hazards Structural Hazards Data Hazards Control Hazards Diagram(5m)
4	**Summarize about the exceptions. (15m) (Apr/May 2018)** BTL2 **Answer: U-3** Refer Notes, **carl hamacher book-page no:218** **Explanation (12m)**

Type of event	From where?	MIPS terminology
I/O device request	External	Interrupt
Invoke the operating system from user program	Internal	Exception
Arithmetic overflow	Internal	Exception
Using an undefined instruction	Internal	Exception
Hardware malfunctions	Either	Exception or interrupt

Diagram(3m)

UNIT 4- MEMORY AND I/O ORGANIZATION	
Memory hierarchy, Memory Chip Organization, Cache memory, Virtual memory. Parallel Bus Architectures, Internal Communication Methodologies, Serial Bus Architectures, Mass storage, Input and Output Devices.	
PART A	
1	**Define memory access time.** BTL1 • The time that elapses between the initiation of an operation and completion of that operation, for example, the time between the read and the MFC signals. • This is referred to as memory access time.
2	**Define memory cycle time.** BTL1 • The minimum time delay required between the initiations of two successive memory operations, for example, the time between two successive read operations.
3	**Define Static memories.** BTL1 Memories that consist of circuits capable of retaining the state as long as power is applied are known as static memories.
4	**What is locality of reference?** BTL1 • Many instructions in localized area of the program are executed repeatedly during some time period and the remainder of the program is accessed relatively infrequently. • This is referred as locality of reference.
5	**Explain virtual memory technique.** BTL2 Techniques that automatically move program and data blocks into the physical memory, when they are required for execution are called virtual memory technique
6	**What are virtual and logical addresses?** BTL1 The binary addresses that the processor issues for either instruction or data are called virtual or logical addresses.
7	**Define translation buffer.** BTL1 • Most commercial virtual memory systems incorporate a mechanism that can avoid the bulk of the main memory access called for by the virtual to physical addresses translation buffer. • This may be done with a cache memory called a translation buffer.
8	**What is optical memory?** BTL1

	• Optical or light based techniques for data storage, such memories usually employ optical disk which resemble magnetic disk in that they store binary information in concentric tracks on an electromechanically rotated disks. • The information is read as or written optically, however with a laser replacing the read write arm of a magnetic disk drive. optical memory offer high storage capacities but their access rate is are generally less than those of magnetic disk
9	**What are static and dynamic memories?** BTL1 static memory are memories which require periodic no refreshing. dynamic memories are memories, which require periodic refreshing.
10	**What are the components of memory management unit?** BTL1 • A facility for dynamic storage relocation that maps logical memory references into physical memory addresses. • A provision for sharing common programs stored in memory by different users .
11	**What are the multimedia applications which use caches?** BTL2 Some multimedia application areas where cache is extensively used are • Multimedia entertainment • Education • Office systems • Audio and video mail
12	**What do you mean associative mapping technique?** BTL1 • The tag of an address received from the CPU is compared to the tag bits of each block of the cache to see • If the desired block is present. this is called associative mapping technique.
13	**What is an i/o channel?** BTL1 An i/o channel is actually a special purpose processor, also called peripheral processor.the main processor initiates a transfer by passing the required information in the input output channel. the channel then takes over and controls the actual transfer of data.
14	**Why program controlled i/o is unsuitable for high-speed data transfer?** BTL5 • In program controlled i/o considerable overhead is incurred, because several program instruction have to be executed for each data word transferred between the external devices and main memory. • Many high speed peripheral; devices have a synchronous modes of operation, that is data transfer are controlled by a clock of fixed frequency, independent of the CPU.
15	**what is the function of i/o interface?** BTL1 The function is to coordinate the transfer of data between the CPU and external devices.

16	**Name some of the IO devices.** BTL1 • Video terminals • Video displays • Alphanumeric displays • Graphics displays • Flat panel displays • Printers • Plotters
	PART B
1	**Differentiate programmed I/O from memory mapped I/O. (13m) (Apr/May 2018)** BTL4

	Isolated-mapped I/O	Memory-mapped I/O
1.	Each port is treated as an independent unit.	Each port is treated as an independent unit.
2.	Separate address spaces for memory and input/output ports.	CPU's memory address space is divided between memory and input/output ports.
3.	Usually, processor provides less address lines for accessing I/O. Therefore, less decoding is required.	Usually, processor provides more address lines for accessing memory. Therefore more decoding is required control signals.
4.	I/O control signals are used to control read and write operations.	Memory control signals are used to control read and write I/O operations.
5.	I/O address bus width is smaller than memory address bus width.	Memory address bus width is greater than I/O address bus width.
6.	Two instructions are necessary to transfer data between memory and port.	Single instruction can transfer data between memory and port.
7.	Data transfer is by means of instruction like MOVE.	Each port can be accessed by means of IN or OUT instructions.
8.	I/O bus shares only I/O address range.	Memory address bus shares entire address range.

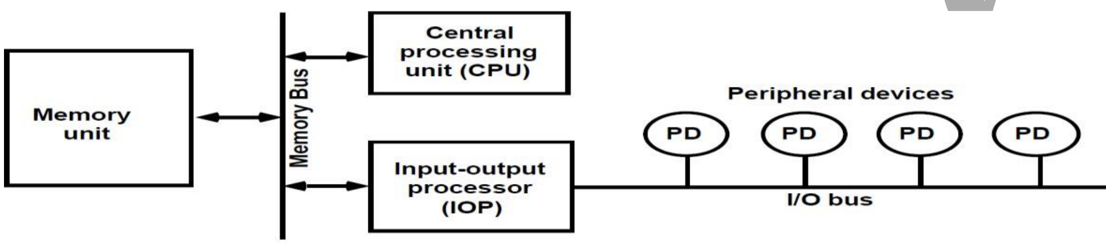
2 **Explain in detail, the architecture of I/O Processors. (13m)** BTL4

- The I/O processor (IOP) has an ability to execute I/O instructions and it can have complete control over I/O operation.
- The I/O instructions are stored in main memory. When I/O transfer is required, the CPU initiates an I/O transfer by instructing the I/O channel to execute an I/O program stored in the main memory.
- The I/O program specifies the device or devices, the area of memory storage, priority and actions to be taken for certain error conditions.

Features and Functions of IOP

1. An IOP can fetch and execute its own instructions.

2. Instructions are specially designed for I/O processing.
3. In addition to data transfer, IOP can perform arithmetic and logic operations, branches, searching and translation.
4. IOP does all work involved in I/O transfer including device setup, programmed I/O, DMA operation.
5. IOP can transfer data from an 8-bit source to 16-bit destination and vice versa.
6. Communication between IOP and CPU is through memory based control blocks. CPU defines tasks in the control blocks to locate a program sequence, called a channel program.
7. IOP supports multiprocessing environment. IOP and CPU can do processing simultaneously. This distributed processing approach improves system performance and flexibility.

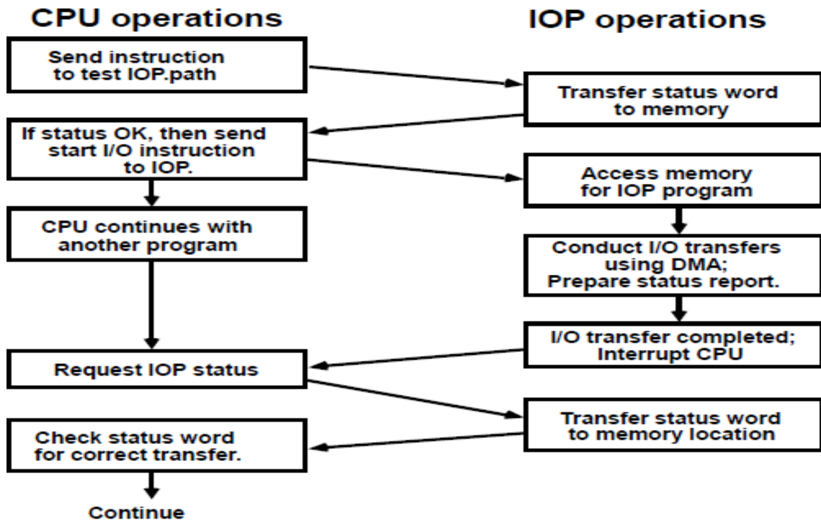


Block diagram of a computer with I/O processor

- The Figure shows the block diagram of computer system with an I/O processor.
- The CPU and I/O processor work independently and communicate with each other using centrally located memory and DMA.
- The CPU does the processing of needed in the solution of computational tasks and IOP does the data transfer between various peripheral devices and the memory unit.

CPU and IOP Communication

- The communication between CPU and IOP may be different for different processor and IOP configurations. However, in most of cases the memory based control blocks are used to store the information about the task to be performed.
- The processor uses these blocks to leave information in it for the other processor. The memory control block are linked, i.e., the address of the next memory based control blocks is available in the previous memory based control block.



CPU and IOP communication

	• The figure shows the flowchart of sequence of operations that are carried out during the CPU and IOP communication. The sequence of operations carried out during CPU and IOP communication are: 1. CPU checks the existence of I/O path by sending an instruction. 2. In response to this IOP puts the status word in the memory stating the condition f IOP and I/O device (Busy, ready, etc.) 3. CPU checks the status word and if all conditions are OK, it sends the instruction to start I/O transfer along with the memory address where the IOP program is stored. 4. After this CPU continues with another program. 5. IOP now conducts the I/O transfer using DMA and prepares status report. 6. On completion of I/O transfer, IOP sends an interrupt request to the CPU.The CPU responds to the interrupt by issuing an instruction to read the status from the IOP. The status indicates whether the transfer has been completed or is any errors occurred during the transfer.
3	**Explain in detail, the basic structure of memory hierarchy. (13m)** BTL4 **Answer: U-4** Refer Notes, **Carl hamacher book Page no:292** **Explanation(8m)** Memory management requirements **Diagram(5m)**
4	**Compare & Design the mapping techniques & functions in involved in cache memory (13m) (Apr/May2018)** BTL4&6 **Answer: U-4** Refer Notes, **Carl hamacher book Pageno:316** **Explanation(8m)** **Definition** Direct mapping Associative mapping Set Associative mapping Main memory Address **Diagram(5m)**

5	**Explain about the mass storage. (13m)** BTL4 **Answer: U-4** Refer notes, **Carl hamacher book Pageno:358** **Explanation(8m)** Definition Magnetic tape Magnetic Disk **Diagram(5m)**
	PART C
1	**Explain in detail, the concepts of virtual memory. (15m) (Apr/May 2018)** BTL4 **Answer: U-4** Refer Notes, **Carl hamacher book Pageno:337** **Explanation:10m** Definition Physical Address Virtual Address Address translation, Translation look aside buffer **Diagram:5m**
2	**Explain in detail, the methods to improve cache performance. (15m)** BTL4 **Answer: U-4** Refer Notes, **Carl hamacher book Pageno:329** **Explanation:10m** Interleaving Hit rate & Miss penalty Caches on the processor chip Other enhancements **Diagram:5m**
3	**Explain in detail, the cache memory and the accessing methods (15m)** BTL4 **Answer: U-4** Refer Notes, **Carl hamacher book Pageno:314** **Explanation:10m** Definition Page replacement Algorithms Mapping Functions **Diagram:5m**
4	**Describe about the i/p & o/p devices in detail with a neat diagram. (15m)** BTL1 **Answer: U-4** Refer notes, **Carl hamacher book Pageno:554-558** Explanation:10m Definition Diagram:5m **I/P devices:** Keyboard, Mouse,… **O/P devices:** Printer, Plotter,…

UNIT 5- ADVANCED COMPUTER ARCHITECTURE	
Parallel processing architectures and challenges, Hardware multithreading, Multicore and shared memory multiprocessors, Introduction to Graphics Processing Units, Clusters and Warehouse scale computers - Introduction to Multiprocessor network topologies.	
PART A	
1	**What is instruction level parallelism?** BTL1 Pipelining is used to overlap the execution of instructions and improve performance. this potential overlap among instructions is called instruction level parallelism (ILP).
2	**List various types of dependences in ILP.** BTL1 • Data dependences • Name dependences • Control dependences
3	**What is Multithreading?** BTL1 Multithreading allows multiple threads to share the functional units of a single processor in an overlapping fashion.to permit this sharing, the processor must duplicate the independent state of each thread.
4	**What are multiprocessors? mention the categories of multiprocessors?** BTL1 Multiprocessor are used to increase performance and improve availability. the different categories are SISD, SIMD, MISD, MIMD.
5	**What are two main approaches to multithreading?** BTL1 • fine-grained multithreading • coarse-grained multithreading
6	**What is the need to use multiprocessors?** BTL2 • Microprocessors as the fastest CPUs collecting several much easier than redesigning • Complexity of current microprocessors do we have enough ideas to sustain 1.5x/yr? can we deliver such complexity on schedule? • Slow (but steady) improvement in parallel software (scientific apps, databases, os) • Emergence of embedded and server markets driving microprocessors in addition to desktops embedded functional parallelism, producer/consumer model server figure of merit is tasks per hour vs. latency
7	**Write the software implications of a multicore processor?** BTL2 • Multi-core systems will deliver benefits to all software, but especially multi-threaded programs. • All code that supports the technology or multiple processors, for example, will benefit automatically from multicore processors, without need for modification. most server-side enterprise packages and many desktop productivity tools fall into this category
8	**Define parallel processing.** BTL1 Processing data concurrently is known as parallel processing

9 **Define multiprocessor system.** BTL1

A computer system with atleast two processor is called multiprocessor system

10 **Define parallel processing program.** BTL1

A single program that runs on multiple processors simultaneously

11 **What is cluster?** BTL1

A set of computers connected over a local area network that function as single large multiprocessor is called cluster

12 **What is multicore?** BTL1

A multicore is an architectural design that places multiple processors on a single computer chip to enhance performance and allow simultaneous process of multiple tasks more efficiently. Each processor is called core

PART B

1 **Explain the challenges in parallel processing. (13m) (Apr/May 2018)** BTL4

- The tall challenge facing industry is to create hardware and software that will make it easy to write correct parallel processing programs that will execute efficiently in performance and energy as number of cores per chip scales.
- Only challenge of parallel revolution is figuring out how to make naturally sequential software have high performance on parallel hardware, but it is also to make concurrent programs have high performance on multiprocessors as number of processors increases.
- The difficulty with parallelism is not hardware; it is that too few important application programs have been rewritten to complete tasks sooner on multiprocessors.
- It is difficult to write software that uses multiple processors to complete one task faster, and problem gets worse as number of processors increases.
- The first reason is that you must get better performance or better energy efficiency from a parallel processing program on a multiprocessor; why is it

		Software	
		Sequential	**Concurrent**
Hardware	Serial	Matrix Multiply written in MatLab running on an Intel Pentium 4	Windows Vista Operating System running on an Intel Pentium 4
	Parallel	Matrix Multiply written in MATLAB running on an Intel Core i7	Windows Vista Operating System running on an Intel Core i7

difficult to write parallel processing programs that are fast, especially as number of processors increases

- For both analogy and parallel programming, challenges include scheduling, partitioning work into parallel pieces, balancing load evenly between workers, time to synchronize, and overhead for communication between parties.
- The challenge is stiffer with more reporters for a newspaper story and with more processors for parallel programming.

	• Another obstacle, namely Amdahl's Law. It reminds us that even small parts of a program must be parallelized if program is to make good use of many cores.Speed-up Challenge: • Suppose you want to achieve a speed-up of 90 times faster with100 processors. • What percentage of original computation can be sequential? Amdahl's Law in terms of speed-up versus original execution time: $\text{Speed-up} = \dfrac{\text{Execution time before}}{(\text{Execution time before} - \text{Execution time affected}) + \dfrac{\text{Execution time affected}}{\text{Amount of improvement}}}$ 0.1% **Speed-up Challenge: Balancing Load** $\text{Speed-up} = \dfrac{1}{(1 - \text{Fraction time affected}) + \dfrac{\text{Fraction time affected}}{\text{Amount of improvement}}}$ • Example demonstrates importance of balancing load, for just a single processor with twice load of the others cuts speed-up by a third, and five times load on just one processor reduces speed-up by almost a factor of three.
2	**Explain in detail, hardware multithreading unit. (13m) (Apr/May 2018)** BTL4 **Answer: U-5** Refer Notes Pageno:5 **Explanation(10m)** **Types** **Diagram(3m)**
3	**Summarize about the Introduction to Graphics Processing Units (GPU) (13m)** BTL2 • The original justification for adding SIMD instructions to existing architectures was that many microprocessors were connected to graphics displays in PCs and workstations, so an increasing fraction of processing time was used for graphics. • As Moore's Law increased number of transistors available to microprocessors, it therefore made sense to improve graphics processing. • A major driving force for improving graphics processing was computer game industry, both on PCs and in dedicated game consoles such as Sony PlayStation. • The rapidly growing game market encouraged many companies to make increasing investments in developing faster graphics hardware, and positive feedback loop led graphics processing to improve at a faster rate than general-purpose processing in mainstream microprocessors. • Given that graphics and game community had different goals than microprocessor development community, it evolved its own style of processing and terminology. • As graphics processors increased in power, they earned name Graphics Processing Units or GPUs to distinguish themselves from CPUs. For a few hundred dollars, anyone can buy a GPU today with hundreds of parallel floating-point units, which makes high-performance computing more accessible. • The interest in GPU computing blossomed when potential was combined with a

programming language that made GPUs easier to program. Hence, many programmers of scientific and multimedia applications today are pondering whether to use GPUs or CPUs.

Here are some of key characteristics as to how GPUs vary from CPUs:

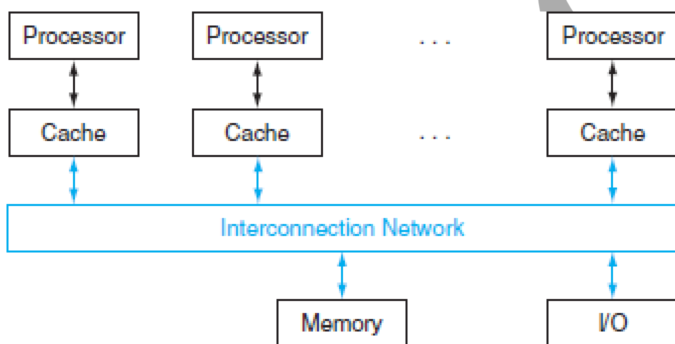
- GPUs are accelerators that supplement a CPU, so y do not need be able to perform all tasks of a CPU.
- This role allows m to dedicate all their resources to graphics. It's fine for GPUs to perform some tasks poorly or not at all, given that in a system with both a CPU and a GPU, CPU can do m if needed.
- The GPU problems sizes are typically hundreds of megabytes to gigabytes, but not hundreds of gigabytes to terabytes. These differences led to different styles of architecture:
- Perhaps biggest difference is that GPUs do not rely on multilevel caches to overcome long latency to memory, as do CPUs.
- Instead, GPUs rely on hardware multithreading (Section 6.4) to hide latency to memory. That is, between time of a memory request and time that data arrives, GPU executes hundreds or thousands of threads that are independent of that request.
- The GPU memory is thus oriented toward bandwidth rather than latency. There are even special graphics DRAM chips for GPUs that are wider and have higher bandwidth than DRAM chips for CPUs.
- In addition, GPU memories have traditionally had smaller main memories than conventional microprocessors. In 2013, GPUs typically have 4 to 6 GiB or less, while CPUs have 32 to 256 GiB.
- Finally, keep in mind that for general-purpose computation, you must include time to transfer data between CPU memory and GPU memory, since GPU is a coprocessor.
- Given reliance on many threads to deliver good memory bandwidth, GPUs can accommodate many parallel processors (MIMD) as well as many threads.
- Hence, each GPU processor is more highly multithreaded than a typical CPU, plus y have more processors.

Feature	Multicore with SIMD	GPU
SIMD processors	4 to 8	8 to 16
SIMD lanes/processor	2 to 4	8 to 16
Multithreading hardware support for SIMD threads	2 to 4	16 to 32
Largest cache size	8 MiB	0.75 MiB
Size of memory address	64-bit	64-bit
Size of main memory	8 GiB to 256 GiB	4 GiB to 6 GiB
Memory protection at level of page	Yes	Yes
Demand paging	Yes	No
Cache coherent	Yes	No

	• Similarities and differences between multicore with Multimedia SIMD extensions and recent GPUs. • At a high level, multicore computers with SIMD instruction extensions do share similarities with GPUs. • Both are MIMDs whose processors use multiple SIMD lanes, although GPUs have more processors and many more lanes. • Both use hardware multithreading to improve processor utilization, although GPUs have hardware support for many more threads. • Both use caches, although GPUs use smaller streaming caches and multicore computers use large multilevel caches that try to contain whole working sets completely. • Both use a 64-bit address space, although physical main memory is much smaller in GPUs. While GPUs support memory protection at page level, y do not yet support demand paging. • SIMD processors are also similar to vector processors. • The multiple SIMD processors in GPUs act as independent MIMD cores, just as many vector computers have multiple vector processors.
	PART C
1	**Explain in detail, the multi core processors. (15m)** BTL4 **Answer: U-5** refer notes **Carl Hamacher** Pageno book:622 Refer Q.No 3 Part-B Explanation (12m) Diagram (3m)
2	**Explain in detail about the introduction to Multiprocessor network topologies. (15m)** BTL1 **Answer: Carl Hamacher book pageno:624** Explanation(10m) Diagram(5m)
3	**Explain in detail, the shared memory multiprocessor, with a neat diagram. (15m) (Apr/May 2018)** BTL4 • Shared memory multiprocessor (SMP) is one that offers programmer a single physical address space across all processors-which is nearly always case for multicore chips • Although a more accurate term would have been shared-address multiprocessor. Processors communicate through shared variables in memory, with all processors capable of accessing any memory location via loads and stores. • Note that such systems can still run independent jobs in their own virtual address spaces, even if y all share a physical address space. • Single address space multiprocessors come in two styles. In first style, latency to a word in memory does not depend on which processor asks for it. • Such machines are called uniform memory access (UMA) multiprocessors. In second style, some memory accesses are much faster than others, depending on which processor asks for which word, typically because main memory is divided and attached to different microprocessors or to different memory controllers on

same chip.

- Such machines are called non uniform memory access (NUMA) multiprocessors. As you might expect, programming challenges are harder for a NUMA multiprocessor than for a UMA multiprocessor, but NUMA machines can scale to larger sizes and NUMAs can have lower latency to nearby memory.
- As processors operating in parallel will normally share data, you also need to coordinate when operating on shared data; otherwise, one processor could start working on data before another is finished with it.
- This coordination is called synchronization, When sharing is supported with a single address space, there must be a separate mechanism for synchronization. One approach uses a lock for a shared variable.
- Only one processor at a time can acquire lock, and or processors interested in shared data must wait until original processor unlocks variable.

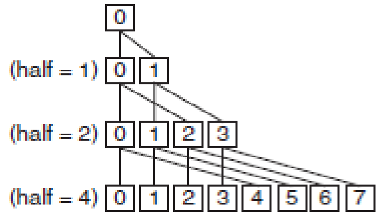


Classic organization of a shared memory multiprocessor

- OpenMP An API for shared memory multiprocessing in C, C++, or Fortran that runs on UNIX and Microsoft platforms. It includes compiler directives, a library, and runtime directives.
- A Simple Parallel Processing Program for a Shared Address Space Suppose we want to sum 64,000 numbers on a shared memory multiprocessor computer with uniform memory access time. Let's assume we have 64 processors.
- The first step is to ensure a balanced load per processor, so we split set of numbers into subsets of same size. We do not allocate subsets to a different memory space, since re is a single memory space for machine; we just give different starting addresses to each processor.
- Pn is number that identifies processor, between 0 and 63. All processors start program by running a loop that sums their subset of numbers:

```
sum[Pn] = 0;
for (i = 1000*Pn; i < 1000*(Pn+1); i += 1)
  sum[Pn] += A[i]; /*sum the assigned areas*/
```

- The next step is to add se 64 partial sums.
- This step is called a reduction, where we divide to conquer.

	•Half of processors add pairs of partial sums, and n a quarter add pairs of new partial sums, and so on until we have single, final sum.  •Each processor to have its own version of loop counter variable i, so we must indicate that it is a private variable. Here is the code,

```
half = 64; /*64 processors in multiprocessor*/
do
    synch(); /*wait for partial sum completion*/
    if (half%2 != 0 && Pn == 0)
        sum[0] += sum[half-1];
        /*Conditional sum needed when half is
        odd; Processor0 gets missing element */
        half = half/2; /*dividing line on who sums */
        if (Pn < half) sum[Pn] += sum[Pn+half];
while (half > 1); /*exit with final sum in Sum[0] */
```

•Some writers repurposed acronym SMP to mean symmetric multiprocessor, to indicate that latency from processor to memory was about same for all processors

EC8551 **COMMUNICATION NETWORKS** **L T P C**
3 00 3

OBJECTIVES: **The student should be made to:**

- Understand the division of network functionalities into layers.
- Be familiar with the components required to build different types of networks
- Be exposed to the required functionality at each layer
- Learn the flow control and congestion control algorithms

UNIT I FUNDAMENTALS & LINK LAYER 9

Overview of Data Communications- Networks – Building Network and its types– Overview of Internet - Protocol Layering - OSI Mode – Physical Layer – Overview of Data and Signals - introduction to Data Link Layer - Link layer Addressing- Error Detection and Correction.

UNIT II MEDIA ACCESS & INTERNETWORKING 9

Overview of Data link Control and Media access control - Ethernet (802.3) - Wireless LANs – Available Protocols – Bluetooth – Bluetooth Low Energy – WiFi – 6LowPAN–Zigbee - Network layer services – Packet Switching – IPV4 Address – Network layer protocols (IP, ICMP, Mobile IP)

UNIT III ROUTING 9

Routing - Unicast Routing – Algorithms – Protocols – Multicast Routing and its basics – Overview of Intradomain and interdomain protocols – Overview of IPv6 Addressing – Transition from IPv4 to IPv6.

UNIT IV TRANSPORT LAYER 9

Introduction to Transport layer –Protocols- User Datagram Protocols (UDP) and Transmission Control Protocols (TCP) –Services – Features – TCP Connection – State Transition Diagram – Flow, Error and Congestion Control - Congestion avoidance (DECbit, RED) – QoS – Application requirements.

UNIT V APPLICATION LAYER 9

Application Layer Paradigms – Client Server Programming – World Wide Web and HTTP - DNS- Electronic Mail (SMTP, POP3, IMAP, MIME) – Introduction to Peer to Peer Networks – Need for Cryptography and Network Security – Firewalls.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Identify the components required to build different types of networks
- Choose the required functionality at each layer for given application
- Identify solution for each functionality at each layer
- Trace the flow of information from one node to another node in the network

TEXT BOOK:

1. Behrouz A. Forouzan, Data Communications and Networking, Fifth Edition TMH, 2013.

Subject Code: EC8551 **Year/Semester: III /05**
Subject Name: COMMUNICATION NETWORKS **Subject Handler: S.S.VASANTHA RAJA**

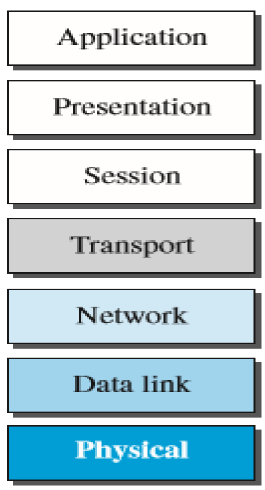
UNIT I – FUNDAMENTALS & LINK LAYER	
Overview of Data Communications- Networks – Building Network and its types– Overview of Internet - Protocol Layering - OSI Mode – Physical Layer – Overview of Data and Signals - introduction to Data Link Layer - Link layer Addressing- Error Detection and Correction	
PART * A	
Q.No.	**Questions**
1.	**Group the OSI layers by function? (NOV/DEC2013) BTL1** The seven layers of the OSI model belonging to three subgroups. Physical, data link and network layers are the network support layers; they deal with the physical aspects of moving data from one device toanother. Session, presentation and application layers are the user support layers; they allow interoperability among unrelated software systems. The transport layer ensures end-to-end reliable data transmission
2	**What is OSI? BTL1** AstandardthatspecifiesaconceptualmodelcalledOpensystemsInterconnectionnetworkinterface model, which breaks networked communications into seven layers: Application, Presentation, Session, Transport, Network, Data link, Physical
3	**Define a layer. NOV/DEC2013 BTL1** The ISO defined a common way to connect computers, called the OpenSystems Interconnection (OSI)architecture. It defines partitioning of network functionality into seven layers asshown. The bottom three layers, i.e., physical, data link and network are implemented on all nodes on the network including switches.
4	**What is meant by circuit switching? NOV/DEC2010 BTL1** Circuit switching is a methodology of implementing a telecommunications network in which two network nodes establish a dedicated communications channel (circuit) through the network before the nodes may communicate. The circuit guarantees the full bandwidth of the channel and remains connected for the duration of the communication session. The circuit functions as if the nodes were physically connected as with an electricalcircuit.
5	**Why protocols needed? BTL1** In networks, communication occurs between the entities in different systems. Two entities cannot just send bit streams to each other and expect to be understood. For communication, the entities must agree on a protocol. A protocol is a set of rules that govern data communication
6	**What are the two types of line configuration? BTL1**

	Line configuration refers to the way two or more communication devices attached to a link. Line configuration is also referred to as connection. There are two possible types of line configurations or connections. Point-to-point connection and Multipoint connection
7	**Differentiate between connection less operation and connection orientedoperation** BTL1
8	**Distinguish between Packet Switched and Circuit Switched Networks. Apr/May2017 BTL1** Circuit switching consists of a set of switches connected by physical links A connection between two stations is a dedicated path made of one more links Each connection uses only one dedicated channel on each link, Each link is divided into n channels by using TDM or FDM. In a packet-switched network, there is no resource reservation; resources are allocated on demand.
9	**Mention the different physical media? BTL1** • Twisted pair. • Coaxialcable. • Opticalfiber.
10	**What are the functions of a DTE? What are the functions of a DCE?BTL1** Data terminal equipment is a device that is an information source or an informationsink. It is connected to a network through a DCE .Data circuit-terminating equipment is a device used as an interface between a DTE and a network.
11	**What are the two interfaces provided by protocols? BTL1**

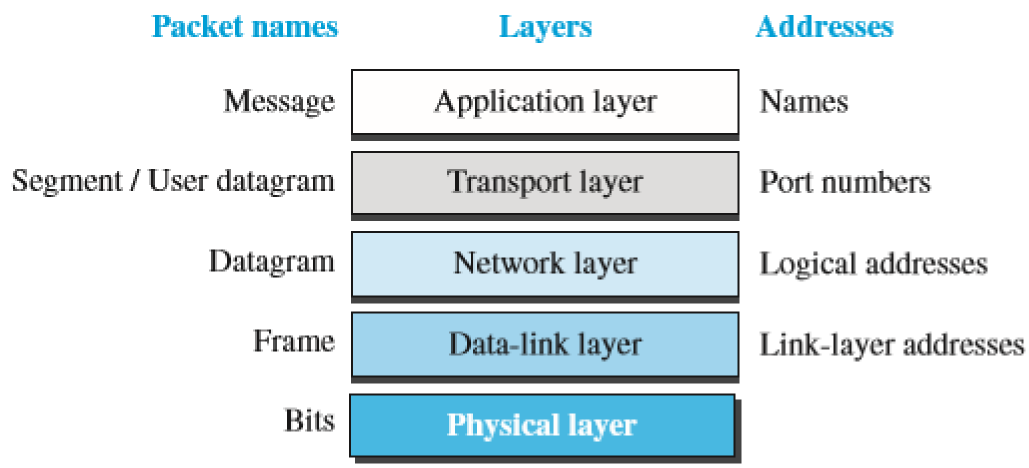
Table for item 7:

Circuit switching	*Packet switching*
Source and destination host are physically connected	No such physical connection exists
Switching takes place at the physical layer	Switching takes place at network (datagram) or data link layer (VCN)
Resources such as bandwidth, switch buffer & processing time, are allocated in advance.	Resources are allocated on demand
Resources remain allocated for the entire duration of data communication.	Resources can be reallocated when idle.
There is no delay during data transfer.	Delay exists at each switch during data transfer
Data transferred between the two stations is a continuous flow of signal	Data is transferred as discrete packets
Example: *Telephony*	Example: *Internet*

	Service interfacePeer interface Service interface- defines the operations that local objects can perform on the protocol. Peer interface- defines the form and meaning of messages exchanged between protocol peers to implement the communication service
12	**Distinguish between peer-to-peer relationship and a primary-secondary relationship.BTL1** Peer-to-peer relationship: All the devices share the link equally. Primary-secondary relationship: One device controls traffic and the others must transmit through it.
13	**DefineSignals?BTL1** Signals are actually electromagnetic waves traveling at the speed of light. The speed of light is, however, medium dependent-electromagnetic waves traveling through copper and fiber do so at about two-thirds the speed of light in vacuum
14	**Define flow control? NOV/DEC 2011,APR/MAY2015 BTL1** Flow control refers to a set of procedures used to restrict the amount of data. The sender can send before waiting for acknowledgment.
15	**What is mean by data communication?BTL1** Data communication is the exchange of data (in the form of 1s and 0s) between twodevices via some form of transmission medium (such as a wire cable).
16	**What are the three criteria necessary for an effective and efficient network?BTL1** The most important criteria are performance, reliability and security. Performance of the network depends on number of users, type of transmission medium, the capabilities of the connected h/w and the efficiency of the s/w. Reliability is measured by frequency of failure, the time it takes a link to recover from the failure and the network's robustness in a catastrophe. Security issues include protecting data from unauthorized access and viruses.
17	**What are the three fundamental characteristics determine the effectiveness of the data communication system?BTL1** The effectiveness of the data communication system depends on 3 fundamental characters: Delivery: The system must deliver data to the correct destination. Accuracy: The system must deliver data accurately. Timeliness: The system must deliver data in a timely manner.
18	**Why are standards needed?BTL1** Co-ordination across the nodes of a network is necessary for an efficient communication. If there are no standards, difficulties arise. A standard provides a model or basis for development to which everyone has agreed.
19	**For n devices in a network, what is the number of cable links required for a mesh and ring topology?BTL1** Mesh topology – n (n-1)/2 Ring topology – n
20	**Assume 6 devices are arranged in a mesh topology. How many cables are needed? How many ports are needed for each device?BTL1** Number of cables=n (n-1)/2=6(6-1)/2=15 Number of ports per device=n-1=6-1=5
21	**What are the three criteria necessary for an effective and efficient network?** BTL2 The most important criteria are performance, reliability and security. Performance of the network depends on number of users, type of transmission medium, the capabilities of the connected h/w

	and the efficiency of the software .Reliability is measured by frequency of failure, the time it takes a link to recover from the failure and the network's robustness
	PART * B
1	**Discuss in detail about the layers in OSImodel. or Draw the OSI network architecture and explain the functionalities of every layer in detail. (13M)** BTL2 **Answer Page:26-Larry L. Peterson** **Definition.(2M)** ISO defines a common way to connect computer by the architecture called Open System Interconnection (OSI) architecture. Network functionality is divided into seven layers. **Architecture (4M)**  OSI Model **OSI Layers (7M)** 1.Physical layer(1M) This layer defines the hardware equipment, cabling, wiring, frequencies, pulses used to represent binary signals etc. Physical layer provides its services to Data-link layer. 2.Data link layer(1M) The three main functions of the data link layer are to deal with transmission errors, regulate the flow of data, and provide a well-defined interface to the network layer. 3.Network layer(1M) The network layer provides the means of transferring variable-length networkpackets from a source to a destination host via one or more networks. ... Functions of the network layer include: Connectionless communication. 4.Transport layer (1M) The transport layer is responsible for delivering data to the appropriate application process on the

	host computers. ... Some transport layer protocols, for example TCP, but not UDP, support virtual circuits, i.e. provide connection-oriented communication over an underlying packet oriented datagram network. 5.Session layer(1M) The session layer establishes, controls, and ends sessions occurring between communicative applications. Primarily, the goal for the session layer is to coordinate active applications on various hosts using assigned protocols. 6.Presentation layer**(**1M) The presentation layer is layer 6 of the 7-layer Open Systems Interconnection (OSI) model. It is used to present data to the application layer (layer 7) in an accurate, well-defined and standardized format. The presentation layer is sometimes called the syntax layer. 7.Application layer (1M) The application layer is a layer in the Open Systems Interconnection (OSI) seven-layer model and in the TCP/IP protocol suite. It consists of protocols that focus on process-to-process communication across an IP network and provides a firm communication interface and end-user services.
2	**Explain about TCP/IP architecture or Internet Architecture. (May/June 2015)(15M)**BTL2 **Answer Page:28-Larry L. Peterson** **Definition of TCP** (2M) **Transmission Control Protocol (TCP)** TCP is one of the main protocols in TCP/IP networks. Whereas the IP protocol deals only with packets, TCP enables two hosts to establish a connection and exchange streams of data. **Definition of IP** (3M) An Internet Protocol address (IP address) is a numerical label assigned to each device connected to a computer network that uses the Internet Protocol for communication. An IP address serves two principal functions: host or network interface identification and location addressing. **Header Format**(5M)



Explanation &Diagram (3M)

3.

Explain Different types of Networks with neat Architecture (13M)
Answer Page : 208 Behrouz A. Forouzan
Definition of Network (2M)

A network is the interconnection of a set of devices capable of communication. In this definition, a device can be a host (or an end system as it is sometimes called) such as a large computer, desktop, laptop, workstation, cellular phone, or security system

a).Local Area Network (LAN)(4M)

A local area network (LAN) is usually privately owned and connects some hosts in a single office, building, or campus. Depending on the needs of an organization, a LAN can be as simple as two PCs and a printer in someone's home office, or it can extend throughout a company and include audio and video devices. Each host in a LAN has an identifier, an address, that uniquely defines the host in the LAN. A packet sent by a host to another host carries both the source host's and the destination host's addresses.

b).Wide Area Network (WAN) (4M)

A wide area network (WAN) is also an interconnection of devices capable of communication. However, there are some differences between a LAN and a WAN. A LAN is normally limited in size, spanning an office, a building, or a campus; a WAN has a wider geographical span, spanning a town, a state, a country, or even the world. A LAN interconnects hosts; a WAN interconnects connecting devices such as switches, routers, or modems.

c.) Switching (3M)

An internet is a switched network in which a switch connects at least two links together. A switch needs to forward data from a network to another network when required. The two most common types of switched networks are circuit-switched and packet-switched networks. We discuss both next.

4.

Briefly Explain different types of Unguided Media with architecture (13M)
Answer Page : 197 Behrouz A. Forouzan

Definition.
UNGUIDED MEDIA: (2M)

WIRELESS

Unguided medium transport electromagnetic waves without using a physical conductor. This type of communication is often referred to as wireless communication. Signals are normally broadcast through free space and thus are available to anyone who has a device capable of receiving them.

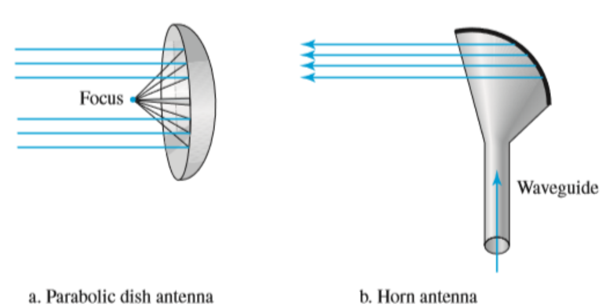
1.Radio Waves

Electromagnetic waves ranging in frequencies between 3 kHz and 1 GHz are normally called radio waves; waves ranging in frequencies between 1 and 300 GHz are called microwaves. However, the behavior of the waves, rather than the frequencies, is a better criterion for classification. Radio waves, for the most part, are omnidirectional. When an antenna transmits radio waves, they are propagated in all directions. This means that the sending and receiving antennas do not have to be aligned.

2.Microwaves

Electromagnetic waves having frequencies between 1 and 300 GHz are called microwaves. Microwaves are unidirectional. When an antenna transmits microwaves, they can be narrowly focused. This means that the sending and receiving antennas need to be aligned. The unidirectional property has an obvious advantage. A pair of antennas can be aligned without interfering with another pair of aligned antennas.

Figure 7.20 *Unidirectional antennas*



3. Infrared

Infrared waves, with frequencies from 300 GHz to 400 THz (wavelengths from 1 mm to 770 nm), can be used for short-range communication. Infrared waves, having high frequencies, cannot penetrate walls. This advantageous characteristic prevents interference between one system and another; a short-range communication system in one room cannot be affected by another system in the next room. When we use our infrared remote control, we do not interfere with the use of the remote by our neighbors.

Part- C

Explain Different types of Transmission media with architecture (16M)

Answer Page :186 Behrouz A. Forouzan

Definition (2M)

1. Transmission media are actually located below the physical layer and are directly controlled by the physical layer. We could say that transmission media belong to layer zero.

Architecture (5M)

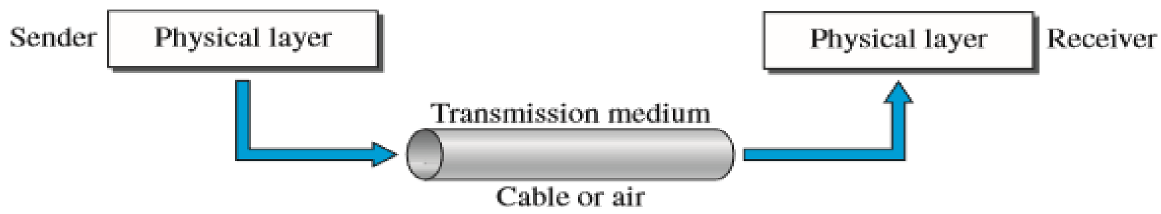
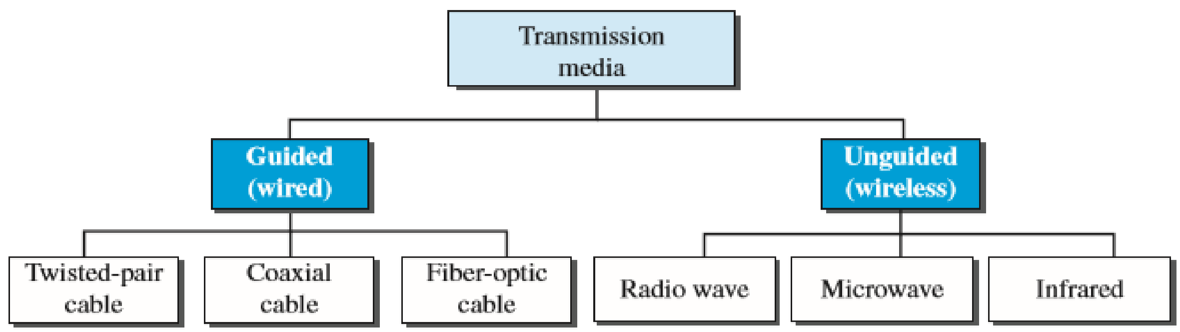


Figure 7.2 *Classes of transmission media*



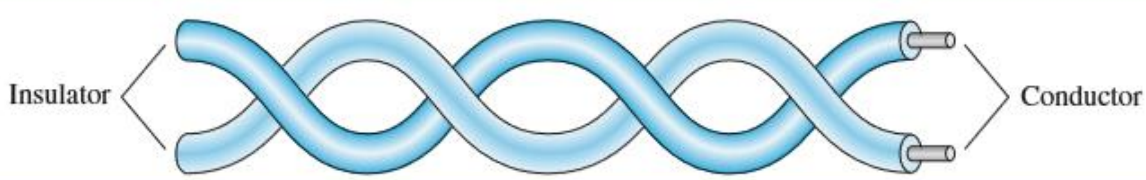
Guided Media(5M)

Guided media, which are those that provide a conduit from one device to another, include twisted-pair cable, coaxial cable, and fiber-optic cable. A signal traveling along any of these media is directed and contained by the physical limits of the medium.

Twisted-Pair Cable

A twisted pair consists of two conductors (normally copper), each with its own plastic insulation, twisted together, as shown in Figure.

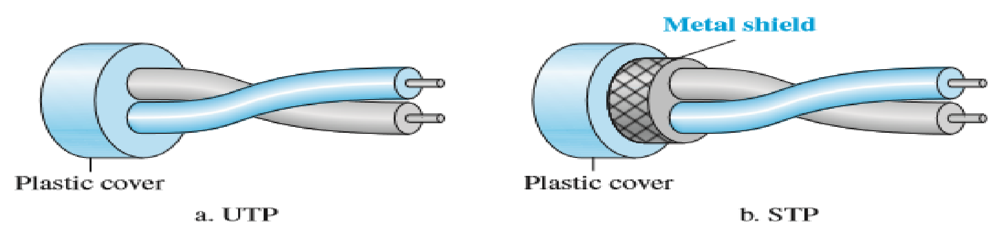
Figure 7.3 *Twisted-pair cable*



Unshielded Versus Shielded Twisted-Pair Cable.

The most common twisted-pair cable used in communications is referred to as unshielded twisted-pair (UTP). IBM has also produced a version of twisted-pair cable for its use, called shielded twisted-pair (STP). STP cable has a metal foil or braidedmesh covering that encases each pair of insulated conductors.

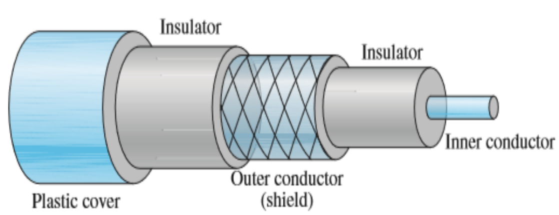
Figure 7.4 *UTP and STP cables*



Coaxial Cable (4M)

Coaxial cable (or coax) carries signals of higher frequency ranges than those in twistedpair cable, in part because the two media are constructed quite differently. Instead of having two wires, coax has a central core conductor of solid or stranded wire (usually copper) enclosed in an insulating sheath, which is, in turn, encased in an outer conductor of metal foil, braid, or a combination of the two.

Figure 7.7 *Coaxial cable*



Fiber-Optic Cable.

A fiber-optic cable is made of glass or plastic and transmits signals in the form of light. To understand optical fiber, we first need to explore several aspects of the nature of light. Light travels in a straight line as long as it is moving through a single uniform substance. If a ray of light traveling through one substance suddenly enters another substance (of a different density), the ray changes direction.

Figure 7.14 *Fiber construction*

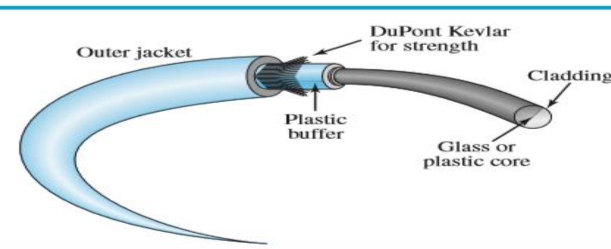
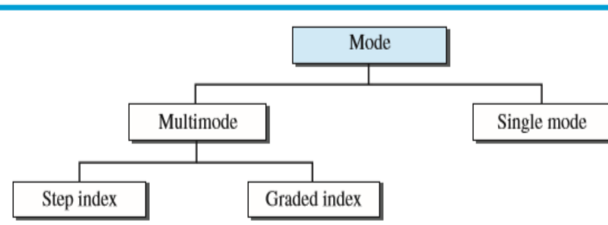


Figure 7.12 *Propagation modes*



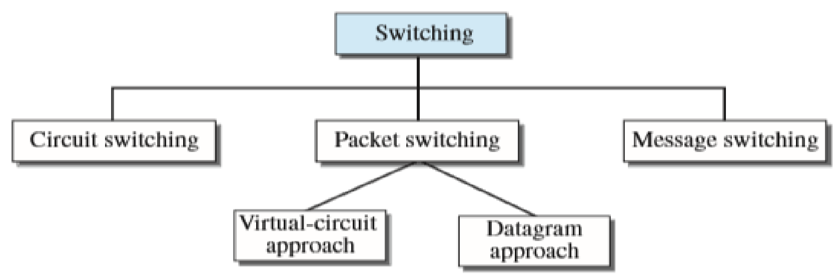
2.

Describe Switching concepts with example (16M)
Answer Page : 208 Behrouz A. Forouzan
Definition (2M)

A switched network consists of a series of interlinked nodes, called switches. Switches are devices capable of creating temporary connections between two or more devices linked to the switch. In a switched network, some of these nodes are connected to the end systems (computers or telephones, for example). Others are used only for routing.

Architecture (3M)

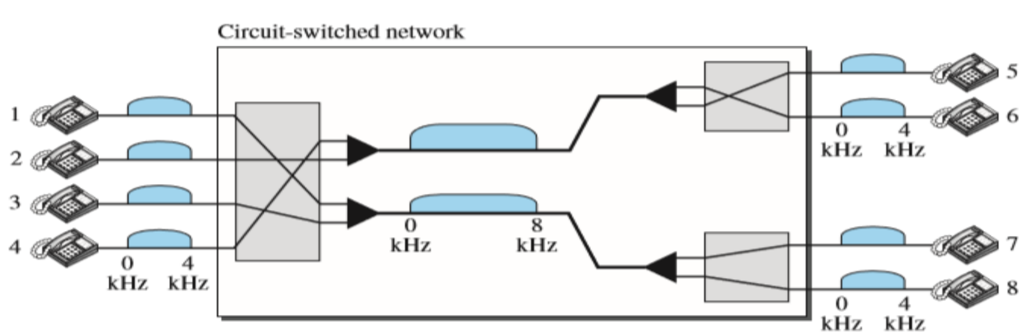
Figure 8.2 *Taxonomy of switched networks*



CIRCUIT-SWITCHED NETWORKS.(4M)

A circuit-switched network consists of a set of switches connected by physical links. A connection between two stations is a dedicated path made of one or more links. However, each connection uses only one dedicated channel on each link. Each link is normally divided into n channels by using FDM or TDM.

Figure 8.4 *Circuit-switched network used in Example 8.1*



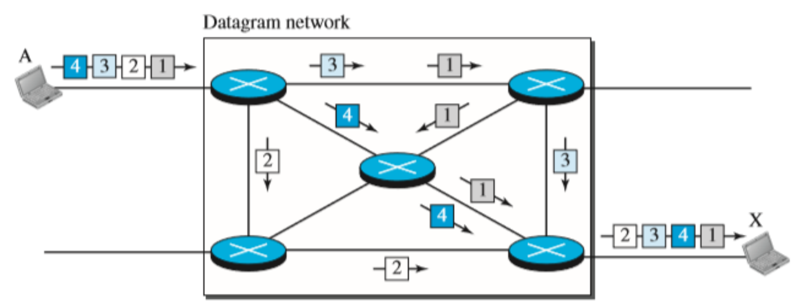
PACKET SWITCHING (7M)

In data communications, we need to send messages from one end system to another. If the message is going to pass through a packet-switched network, it needs to be divided into packets of fixed or variable size. The size of the packet is determined by the network and the governing protocol. In packet switching, there is no resource allocation for a packet. This means that there is no reserved bandwidth on the links, and there is no scheduled processing time for each packet. Resources are allocated on demand. The allocation is done on a firstcome, first-served basis. When a switch receives a packet, no matter what the source or destination is, the packet must wait if there are other packets being processed.

Datagram Networks

In a datagram network, each packet is treated independently of all others. Even if a packet is part of a multipacket transmission, the network treats it as though it existed alone. Packets in this approach are referred to as datagrams. Datagram switching is normally done at the network layer. We briefly discuss datagram networks here as a comparison with circuit-switched and virtual-circuitswitched networks.

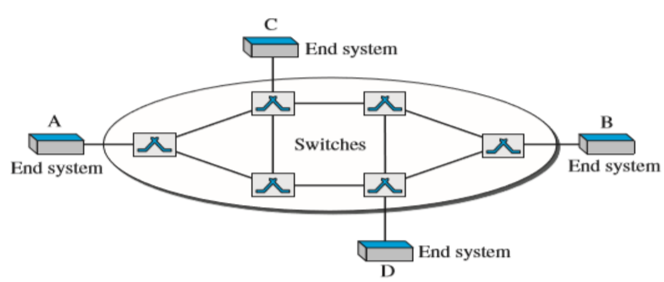
Figure 8.7 *A datagram network with four switches (routers)*



Virtual-Circuit Networks.

A virtual-circuit network is a cross between a circuit-switched network and a datagram network. It has some characteristics of both.A virtual-circuit network is normally implemented in the data-link layer, while a circuit-switched network is implemented in the physical layer and a datagram network in the network layer. But this may change in the future.

Figure 8.10 *Virtual-circuit network*



UNIT II – MEDIA ACCESS & INTERNETWORKING	
Overview of Data link Control and Media access control - Ethernet (802.3) - Wireless LANs – Available Protocols – Bluetooth – Bluetooth Low Energy – WiFi – 6LowPAN–Zigbee - Network layer services – Packet Switching – IPV4 Address – Network layer protocols (IP, ICMP, Mobile IP)	
PART * A	
Q.No.	**Questions**

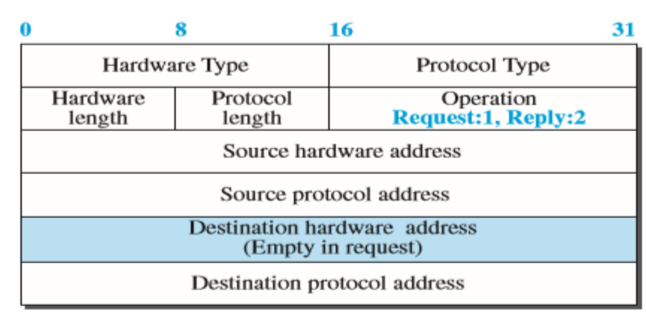
1.	**What are the functions ofMAC? BTL1** MAC sub layer resolves the contention for the shared media. It contains synchronization, flag, flow and error control specifications necessary to move information from one place to another, as well as the physical address of the next station to receive and route a packet.
2	**What isEthernet? BTL1** Ethernet is a multiple-access network, meaning that a set of nodes send and receive frames over a shared link.
3	**Advantages ofEthernet BTL1** 1. Inexpensive 2.Easy to install 3.Supports various writingtechnologies.
4	**What do you mean byARP? BTL1** ARP stands for Address resolution protocol, maps an IP address to a MAC address
5	**What do you mean byRARP? BTL1** RARP stands for Reverse Address resolution protocol, maps an MAC address to a IP address.
6	**Define Tree Traversal and Mention the different binary tree traversal techniques.** BTL1 Tree Traversal is an operation which can be performed on a binary tree is visiting all the nodes exactly once. • Inorder: traversing the LST, visiting the root and finally traversing the RST. • Preorder: visiting root, traversing LST and finally traversing RST. • Post- order: traversing LST, then RST and finally visiting root.
7	**Contrast fast Ethernet and gigabit ethernet? NOV/DEC2012 BTL1** Fast Ethernet cards connect to networks at a rate of 100 Mbps while Gigabit network cards can connect at speeds up to 1000mb/s. The main difference between the two is speed. A fast Ethernet card can run on bandwidths at 100mb/s while a gigabit Ethernet can run at ten times that speed. However, the existence of FDDIs around made this technology more like a stepping stone to something better – enter the gigabit card. Gigabit networks are made to run the best at Layer 3 switching meaning it has more route functionality than the 100mbs fast Ethernet. Gigabit Ethernet is backwards compatible meaning that it will support all current applications and requires a minimum of new learning. This goes just the same with the fast Ethernet, fast Ethernet can use 10/100 Mbps and gigabit can run on networks 10/100/1000 Mbps. Hence both cards are basically the same using the same technology except the gigabit card can run on 1000mb/s, an astonishing speed**.**
8	**What are the four prominent wirelesstechnologies? BTL1** • Bluetooth • Wi-Fi(formally known as802.11) • WiMAX(802.16) • Third generation or 3G cellularwireless
9	**What do you mean by framing? NOV/DEC2013 BTL1** A frame consists of one complete cycle of time slots, including one or more slot dedicated to each sending device
10	**What is the difference between port address, logical address and physical address? M/J2014**

	BTL1 A physical address is like your hard drive to your computer. A logical address is like a file on the server, with information or instructions that lead to it. A port address is an address assigned by the CPU (0-FFFF) that can be accessed for I/O read/write like RAM
11	**What are the functions ofLLC? BTL1** The IEEE project 802 models take the structure of an HDLC frame and divides it into 2 sets of functions. One set contains the end user portion of the HDLC frame – the logical address, control information, and data. These functions are handled by the IEEE 802.2 logical link control (LLC) protocol.
12	**Why Ethernet is said to be a I-*persistent*protocol? BTL1** An adaptor with a frame to send transmits with probability „1 „whenever a busy line goes idle.
13	**How to mediate access to a shared link? BTL1** Ethernet, token ring, and several wireless protocols. Ethernet and token ring media access protocols have no central arbitrator of access. Media access in wireless networks is made more complicated by the fact that some nodes may be hidden from each other due to range limitations of radio transmission.
14	**Show the Ethernet Frame Format. Nov/Dec17 BTL1** Ethernet is a multiple-access network, meaning that a set of nodes send and receive frames over a shared link. An Ethernet frame is preceded by a preamble and start frame delimiter (SFD), which are both part of the Ethernet packet at the physical layer. Each Ethernet frame starts with an Ethernet header, which contains destination and source MAC addresses as its first two fields. The middle section of the frame is payload data including any headers for other protocols (for example, InternetProtocol) carried in the frame. The frame ends with a frame check sequence (FCS), which is a 32-bit cyclic redundancy check used to detect any in-transit corruption ofdata
15	**What are the ways to address the framingproblem? BTL1** • Byte-Oriented Protocols(PPP) • Bit-Oriented Protocols(HDLC) • Clock-Based Framing (SONET).
16	**What are the responsibilities of data link layer? BTL1** Specific responsibilities of data link layer include the following. a) Framing b) Physical addressing c) Flow control d) Error control e) Access control
17	**Mention the types of errors. BTL1** There are 2 types of errors a) Single-bit error. b) Burst-bit error.
18	**What is redundancy? BTL1** It is the error detecting mechanism, which means a shorter group of bits or extra bits may be appended at the destination of each unit.

<table>
<tr><td>19</td><td>What is selective reject ARQ? BTL1
In selective reject ARQ only the specific damaged or lost frame is retransmitted. If a frame is corrupted in transit, a NAK is returned and the frame is resent out of sequence.</td></tr>
<tr><td>20</td><td>List the types of stations is HDLC. BTL1
HDLC differentiates between 3 types of stations.
a) Primary
b) Secondary
c) Combined</td></tr>
<tr><td>21</td><td>What is the access method used by wireless LAN? BTL2
The access method used by wireless LAN is Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)</td></tr>
<tr><td></td><td>PART – B</td></tr>
<tr><td>1</td><td>Write short notes on ARP.Or Explain in detail ARP.(13M) BTL 2
Answer Page : 245 Behrouz A. Forouzan

Definition of ARP(3M)
ARP: Associates an IP address with physical address. It is used to find the physical address of the node when its Internet address is known. Any time a host/router needs to find the physical address of another host on its network, it formats an ARP query packet that includes the IP address and broadcasts it

Packet Header Format ARP(5M)

Figure 9.8 ARP packet


Explanation (5M)</td></tr>
<tr><td>2</td><td>Explain DLC Services in detail. (13M) BTL 2

Answer Page:294- Behrouz A. Forouzan

Definition (2M)
The data link control (DLC) deals with procedures for communication between two adjacentnodes—node-to-node communication—no matter whether the link is dedicated or broadcast. Data link control functions include framing and flow and error control.
Framing(2M)
Data transmission in the physical layer means moving bits in the form of a signal from the sourceto the destination. The physical layer provides bit synchronization to ensure that the sender and receiver use the same bit durations and timing.</td></tr>
</table>

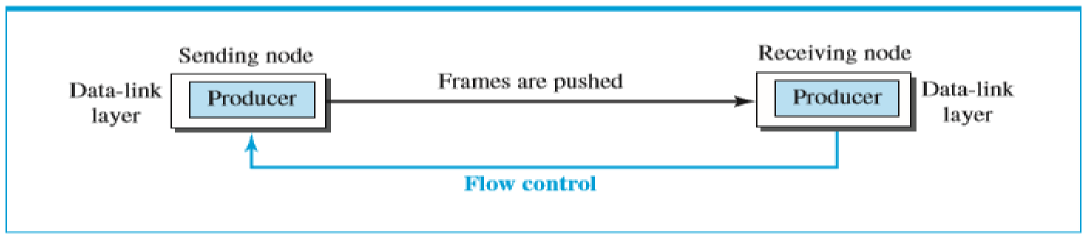
Character-Oriented Framing.(2M)

In character-oriented (or byte-oriented) framing, data to be carried are 8-bit characters from a coding system such as ASCII (see Appendix A). The header, which normally carries the source and destination addresses and other control information, and the trailer, which carries error detection redundant bits, are also multiples of 8 bits.

Flow and Error Control (4M)

One of the responsibilities of the data-link control sublayer is flow and error control at the data-linklayer. Flow Control Whenever an entity produces items and another entity consumes them, there should be a balance between production and consumption rates. If the items are produced faster than they can be consumed, the consumer can be overwhelmed and may need to discard some items. If the items are produced more slowly than they can be consumed, the consumer must wait, and the system becomes less efficient.

Figure 11.5 *Flow control at the data-link layer*



Error Control

Since the underlying technology at the physical layer is not fully reliable, we need to implement error control at the data-link layer to prevent the receiving node from delivering corrupted packets to its network layer. Error control at the data-link layer is normally very simple and implemented using one of the following two methods. In both methods, a CRC is added to the frame header by the sender and checked by the receiver.

Connectionless and Connection-Oriented(3M)

Connectionless Protocol.

In a connectionless protocol, frames are sent from one node to the next without any relationship between the frames; each frame is independent. Note that the term connectionless here does not mean that there is no physical connection (transmission medium) between the nodes; it means that there is no connection between frames.

Connection-Oriented Protocol.

In a connection-oriented protocol, a logical connection should first be established between the two nodes (setup phase). After all frames that are somehow related to each other are transmitted (transfer phase), the logical connection is terminated (teardown phase). In this type of communication, the frames are numbered and sent in order.

3 **Explain in detail about Data Link Layer Protocols (13M)** BTL2

Answer Page:299- Behrouz A. Forouzan

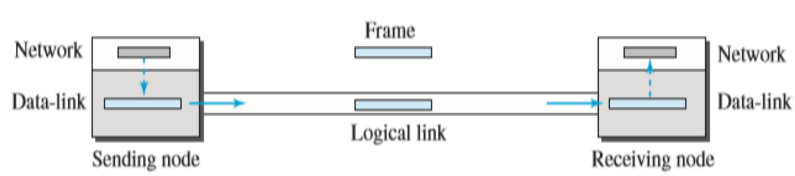
Definition(3M)

Traditionally four protocols have been defined for the data-link layer to deal with flow and error control: Simple, Stop-and-Wait, Go-Back-N, and Selective-Repeat. Although the first two protocols still are used at the data-link layer, the last two have disappeared.

Simple Protocol(5M)

Our first protocol is a simple protocol with neither flow nor error control. We assume that the receiver can immediately handle any frame it receives. In other words, the receiver can never be overwhelmed with incoming frames.

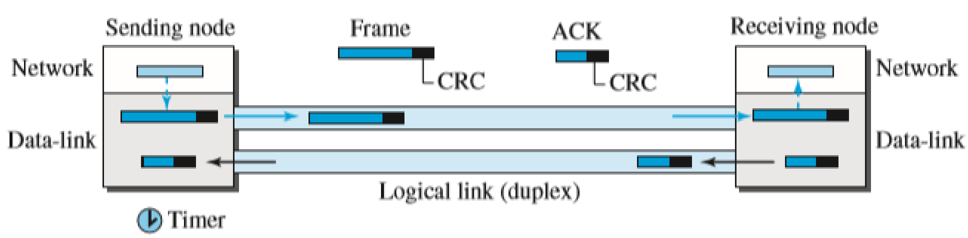
Figure 11.7 *Simple protocol*



Stop-and-Wait Protocol(5M)

Our second protocol is called the Stop-and-Wait protocol, which uses both flow and error control.In this protocol, the sender sends one frame at a time and waits for an acknowledgment before sending the next one. To detect corrupted frames, we need to add a CRC to each data frame. When a frame arrives at the receiver site, it is checked. If its CRC is incorrect, the frame is corrupted and silently discarded. The silence of the receiver is a signal for the sender that a frame was either corrupted or lost. Every time the sender sends a frame, it starts a timer.

Figure 11.10 *Stop-and-Wait protocol*



Piggybacking

Protocols have been designed in the past to allow data to flow in both directions. However, to make the communication more efficient, the data in one direction is piggybacked with the acknowledgment in the other direction. In other words, when node A is sending data to node B, Node A also acknowledges the data received from node B.

4

Explain in detail about HDLC and PPP. (13M) (Nov/Dec 2015)BTL2

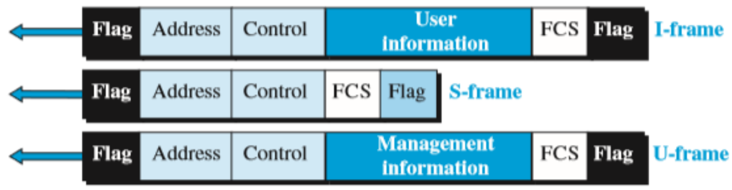
Answer Page:304- Behrouz A. Forouzan

Definition for HDLC(3M)

High-level Data Link Control (HDLC) is a bit-oriented protocol for communication over point-to-point and multipoint links. It implements the Stop-and-Wait protocol we discussed earlier. Although this protocol is more a theoretical issue than practical, most of the concept defined in this protocol is the basis for other practical protocols such as PPP.

Packet Header Format(3M)

Figure 11.16 *HDLC frames*



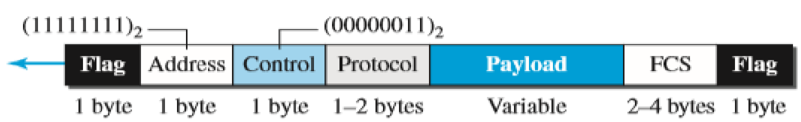
POINT-TO-POINT PROTOCOL (PPP)(4M)

One of the most common protocols for point-to-point access is the Point-to-Point Protocol (PPP). Today, millions of Internet users who need to connect their home computers to the server of an Internet service provider use PPP. The majority of these users have a traditional modem; they are connected to the Internet through a telephone line, which provides the services of the physical layer.

Services Provided by PPP(3M)

PPP defines the format of the frame to be exchanged between devices. It also defines how two devices can negotiate the establishment of the link and the exchange of data. PPP is designed to accept payloads from several network layers (not only IP). Authentication is also provided in the protocol, but it is optional. The new version of PPP, called Multilink PPP, provides connections over multiple links.

Figure 11.20 *PPP frame format*



5 **Explain how CSMA work with bandwidth allocation and Access methods.(13M)** BTL2

Answer Page:331- Behrouz A. Forouzan

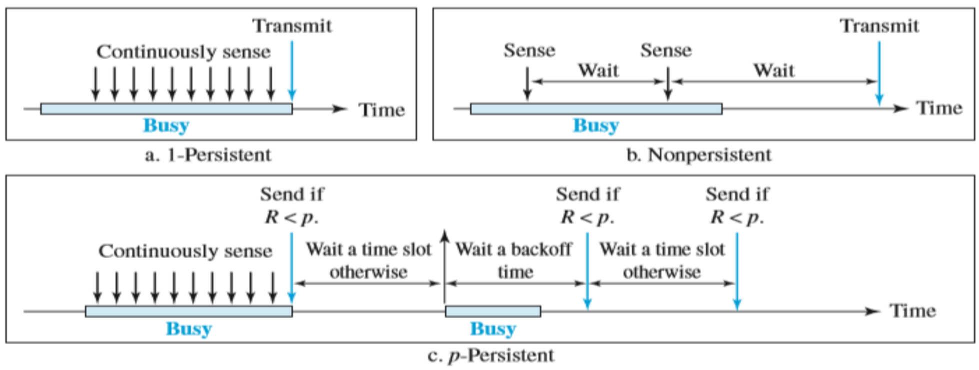
Definition CSMA(3M)

The chance of collision can be reduced if a station senses the medium before trying to use it. Carrier sense multiple access (CSMA) requires that each station first listen to the medium (or check the state of the medium) before sending.

Persistence Methods

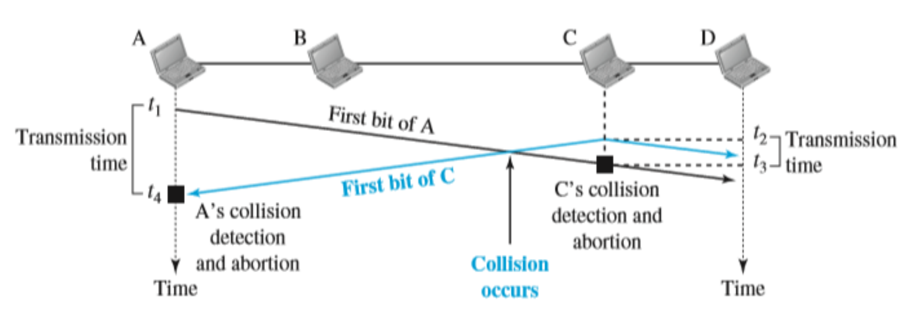
Architecture(4M)

Figure 12.9 *Behavior of three persistence methods*



	1-Persistent (2M) The 1-persistent method is simple and straightforward. In this method, after the station finds the line idle, it sends its frame immediately (with probability 1). This method has the highest chance of collision because two or more stations may find the line idle and send their frames immediately. Nonpersistent. (2M) In the nonpersistent method, a station that has a frame to send senses the line. If the line is idle, it sends immediately. If the line is not idle, it waits a random amount of time and then senses the line again. The nonpersistent approach reduces the chance of collision because it is unlikely that two or more stations will wait the same amount of time and retry to send simultaneously. p-Persistent. (2M) The p-persistent method is used if the channel has time slots with a slot duration equal to or greater than the maximum propagation time. The p-persistent approach combines the advantages of the other two strategies. It reduces the chance of collision and improves efficiency.
6	**How CSMA / CD method working for collision techniques(13M) (BTL** **Answer Page: 334- Behrouz A. Forouzan** **Definition**(2M) Carrier sense multiple access with collision detection (CSMA/CD) augments the algorithm to handle the collision. In this method, a station monitors the medium after it sends a frame to see if the transmission was successful. If so, the station is finished. If, however, there is a collision, the frame is sent again. Architecture (3M)

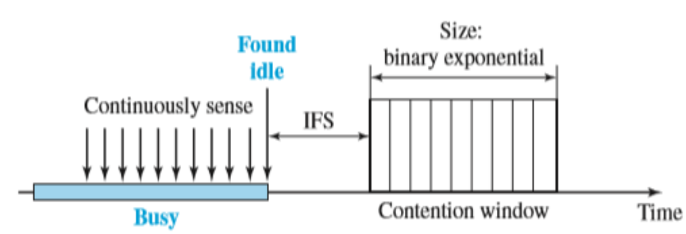
Figure 12.11 *Collision of the first bits in CSMA/CD*



CSMA/CA (4M)

Carrier sense multiple access with collision avoidance (CSMA/CA) was invented for wireless networks. Collisions are avoided through the use of CSMA/CA's three strategies: the interframe space, the contention window, and acknowledgments, as shown in Figure.

Figure 12.16 *Contention window*



Contention Window. (4M)

The contention window is an amount of time divided into slots. A station that is ready to send chooses a random number of slots as its wait time. The number of slots in the window changes according to the binary exponential backoff strategy. This means that it is set to one slot the first time and then doubles each time the station cannot detect an idle channel after the IFS time.

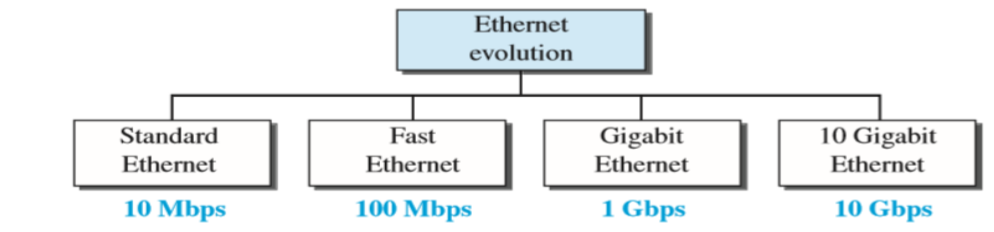
Hidden-Station Problem.

The solution to the hidden station problem is the use of the handshake frames (RTS and CTS). It also shows that the RTS message from B reaches A, but not C. However, because both B and C are within the range of A, the CTS message, which contains the duration of data transmission from B to A, reaches C. Station C knows that some hidden station is using the channel and refrains from transmitting until that duration is over.

PART *C

1

Explain different Evolution of Ethernet with neat architecture.(16M) (BTL2)
Answer Page: 364- Behrouz A. Forouzan
Definition(2M)
The Ethernet LAN was developed in the 1970s by Robert Metcalfe and David Boggs. Since then, it has gone through four generations: Standard Ethernet (10 Mbps), Fast Ethernet (100 Mbps), Gigabit Ethernet (1 Gbps), and 10 Gigabit Ethernet (10 Gbps).
Architecture (3M)



1.Standard Ethernet. (3M)
Ethernet provides a connectionless service, which means each frame sent is independent of the previous or next frame. Ethernet has no connection establishment or connection termination phases. The sender sends a frame whenever it has it; the receiver may or may not be ready for it. The sender may overwhelm the receiver with frames, which may result in dropping frames. If a frame drops, the sender will not know about it. Since IP, which is using the service of Ethernet, is also connectionless, it will not know about it either. If the transport layer is also a connectionless protocol, such as UDP, the frame is lost and salvation may only come from the application layer.

2.Fast Ethernet (100MBPS) (3M)
In the 1990s, some LAN technologies with transmission rates higher than 10 Mbps, such as FDDI and Fiber Channel, appeared on the market. If the Standard Ethernet wanted to survive, it had to compete with these technologies. Ethernet made a big jump by increasing the transmission rate to 100 Mbps, and the new generation was called the Fast Ethernet. The designers of the Fast Ethernet needed to make it compatible with the Standard Ethernet. The MAC sublayer was left unchanged, which meant the frame format and the maximum and minimum size could also remain unchanged.

3.Gigabit Ethernet (1GBPS) (3M)
The need for an even higher data rate resulted in the design of the Gigabit Ethernet Protocol (1000 Mbps). The IEEE committee calls it the Standard 802.3z. The goals of the Gigabit Ethernet were to upgrade the data rate to 1 Gbps, but keep the address length, the frame format, and the maximum and minimum frame length the same. The goals of the Gigabit Ethernet design can be summarized as follows:
1. Upgrade the data rate to 1 Gbps.
2. Make it compatible with Standard or Fast Ethernet.
3. Use the same 48-bit address.
4. Use the same frame format.
5. Keep the same minimum and maximum frame lengths.
6. Support auto negotiation as defined in Fast Ethernet.

4.10 Gigabit Ethernet (2M)

The IEEE committee created 10 Gigabit Ethernet and called it Standard 802.3ae. The goals of the 10 Gigabit Ethernet design can be summarized as upgrading the data rate to 10 Gbps, keeping the same frame size and format, and allowing the interconnection of LANs, MANs, and WAN possible. This data rate is possible only with fiber-optic technology at this time. The standard defines two types of physical layers: LAN PHY and WAN PHY.

2

Briefly explain how Ethernet IEEE802.11 work in current Technologies(16M) (BTL2)

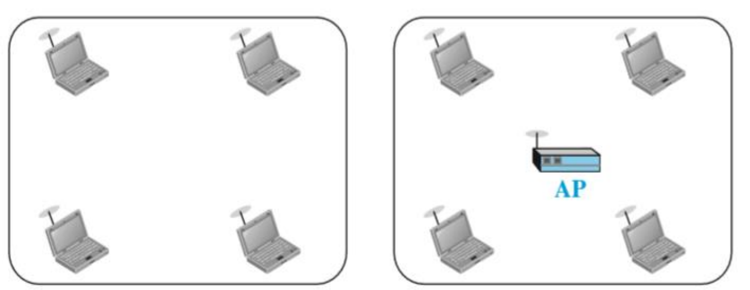
Answer Page: 439- Behrouz A. Forouzan

Definition(2M)

IEEE has defined the specifications for a wireless LAN, called IEEE 802.11, which covers the physical and data-link layers. It is sometimes called wireless Ethernet. In some countries, including the United States, the public uses the term WiFi (short for wireless fidelity) as a synonym for wireless LAN.

Basic Service Set.

IEEE 802.11 defines the basic service set (BSS) as the building blocks of a wireless LAN. A basic service set is made of stationary or mobile wireless stations and an optional central base station, known as the access point (AP).



Ad hoc BSS Infrastructure BSS

Extended Service Set

An extended service set (ESS) is made up of two or more BSSs with APs. In this case, the BSSs are connected through a distribution system, which is a wired or a wireless network. The distribution system connects the APs in the BSSs. IEEE 802.11 does not restrict the distribution system; it can be any IEEE LAN such as an Ethernet. Note that the extended service set uses two types of stations: mobile and stationary. The mobile stations are normal stations inside a BSS.

Collision During Handshaking

What happens if there is a collision during the time when RTS or CTS control frames are in transition, often called the handshaking period? Two or more stations may try to send RTS frames at the same time. These control frames may collide. However, because there is no mechanism for collision detection, the sender assumes there has been a collision if it has not received a CTS frame from the receiver. The backoff strategy is employed, and the sender tries again.

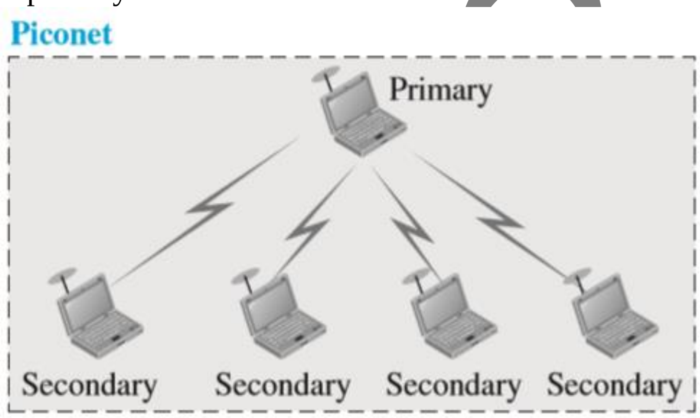
Hidden-Station Problem

The solution to the hidden station problem is the use of the handshake frames (RTS and CTS).The RTS message from B reaches A, but not C. However, because both B and C are within the range of A, the CTS message, which contains the duration of data transmission from B to A, reaches C. Station C knows that some hidden station is using the channel and refrains from transmitting until that duration is over.

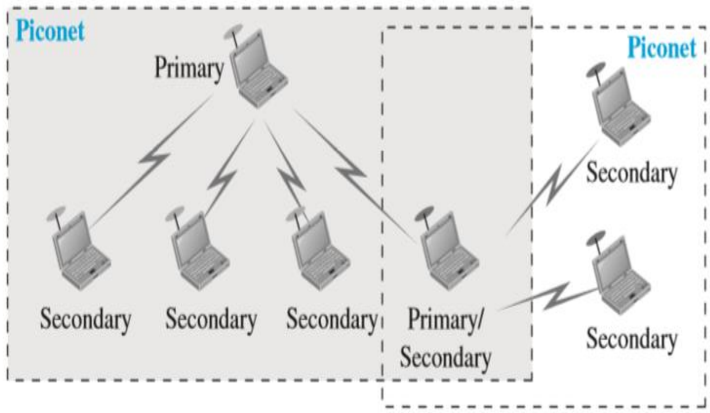
Write the Features of Bluetooth architecture with example.

Definition :
Bluetooth is a wireless LAN technology designed to connect devices of different functions such as telephones, notebooks, computers (desktop and laptop), cameras, printers, and even coffee makers when they are at a short distance from each other. A Bluetooth LAN is an ad hoc network, which means that the network is formed spontaneously; the devices, sometimes called gadgets, find each other and make a network called a piconet.

Architecture
Bluetooth defines two types of networks: piconet and scatternet.
Piconets
A Bluetooth network is called a piconet, or a small net. A piconet can have up to eight stations, one of which is called the primary; the rest are called secondaries. All the secondary stations synchronize their clocks and hopping sequence with the primary. Note that a piconet can have only one primary station.

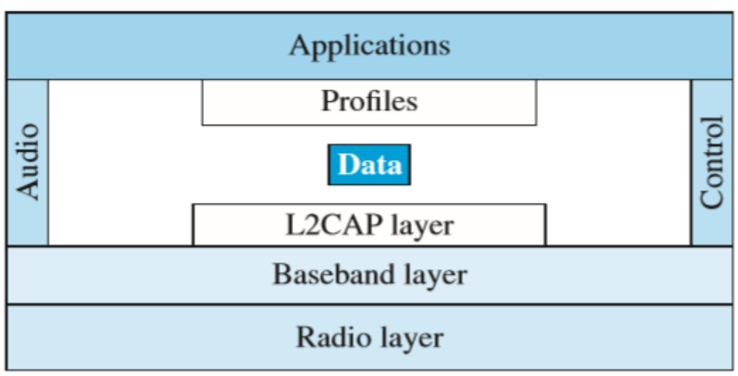


Scatternet
Piconets can be combined to form what is called a scatternet. A secondary station in one piconet can be the primary in another piconet. This station can receive messages from the primary in the first piconet (as a secondary) and, acting as a primary, deliver them to secondaries in the second piconet.



Bluetooth Layers

L2CAP The Logical Link Control and Adaptation Protocol, or L2CAP (L2 here means LL), is roughly equivalent to the LLC sublayer in LANs. It is used for data exchange on anACL link; SCO channels do not use L2CAP.



UNIT III – ROUTING

Routing - Unicast Routing – Algorithms – Protocols – Multicast Routing and its basics – Overview of Intradomain and interdomain protocols – Overview of IPv6 Addressing – Transition from IPv4 to IPv6

PART * A

Q.No.	Questions
1.	**Define Routing? BTL1** Routing is a process that takes place in the background so that, when a data packet turns up, we will have the right information in the forwarding table to be able to forward, or switch, the packet
2	**Write on the packet cost referred in distance vector and link state routing. (Apr/May2012) BTL1** In distance vector routing, cost refer to hop count while in case of link state routing, cost is a

	weighted value based on a variety of factors such as security levels, traffic or the state of the link.
3	**What is source routing? (Nov/Dec2013 BTL1** Sourcerouting, also called path addressing, allows a sender of a packet to partially or completely specify the route the packet takes through the network
4	**What is subnetting?(Nov/Dec2011) BTL1** Subnetting provides an elegantly simple way to reduce the total number of network numbers that are assigned. The idea is to take a single IP network number and allocate the IP address with that network to several physical networks, which are now referred to as subnets
5	**Explain IPV6protocol. BTL1** IPv6 (Internet Protocol version 6) is a set of basics of IPv6 are similar to those of IPv4. The most obvious improvement in IPv6 over IPv4 is that IP addresses are lengthened from 32 bits to 128 bits. This extension anticipates considerable future growth of the Internet and provides relief for what was perceived as an impending shortage of network addresses. IPv6 also supports auto-configuration to help correct most of the shortcomings in version 4, and it has integrated security and mobilityfeatures
6	**Explain Multicastrouting? BTL1** Multicast IP Routing protocols are used to distribute data (for example, audio/video streaming broadcasts) to multiple recipients. Using multicast, a source can send a single copy of data to a single multicast address, which is then distributed to an entire group of recipients
7	**What isPIM? BTL1** Protocol-Independent Multicast (PIM) is a family of multicast routing protocols for Internet Protocol (IP) networks that provide one-to-many and many-to-many distribution of data over a LAN, WAN or the Internet. It is termed *protocol- independent* because PIM does not include its own topology discovery mechanism, but instead uses routing information supplied by other routing protocols. There are four variants ofPIM: • PIM Source-SpecificMulticast • BidirectionalPIM • PIM Dense Mode • PIM SparseMode
8	**What isDVMRP? BTL1** The Distance Vector Multicast Routing Protocol (DVMRP), is a routing protocol used to share information between routers to facilitate the transportation of IP multicast packets among networks. The protocol is based on the RIP protocol. The router generates a routing table with the multicast group of which it has knowledge with corresponding distances.Whenamulticastpacketisreceived byarouter,itisforwardedbytherouter'sinterfacesspecifiedintheroutingtable
9	**Explain IPV4protocol. BTL1** IPv4 (Internet Protocol Version 4) is the fourth revision of the Internet Protocol (IP) used to identify devices on a network through an addressing system. The Internet Protocol is designed for use in interconnected systems of packet-switched computer communication networks.IPv4 is

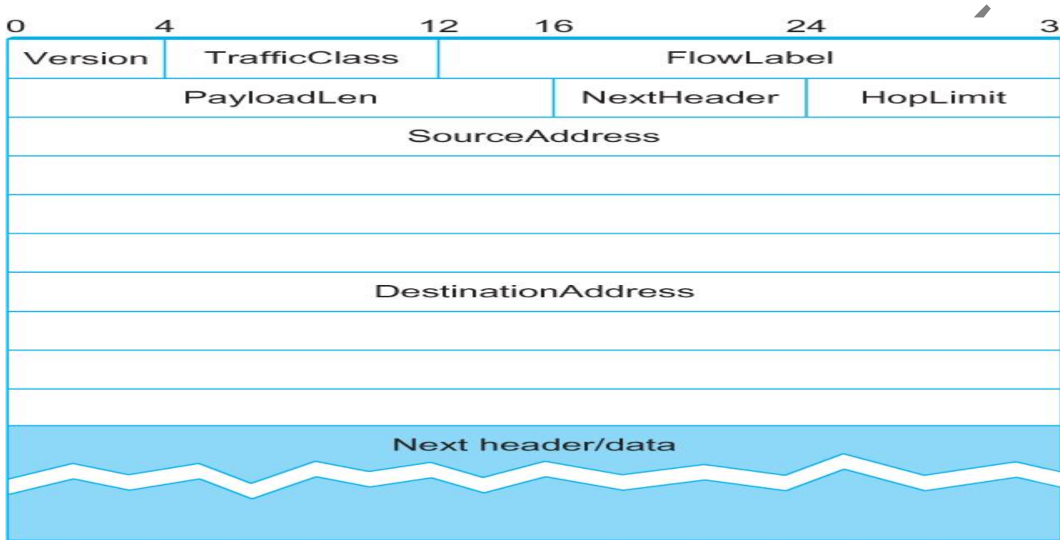
	the most widely deployed Internet protocol used to connect devices to the Internet. IPv4 uses a 32-bitaddress scheme
10	**What are the differences between IPV4 andIPV6? BTL1** <table><tr><th>IPV4</th><th>IPV6</th></tr><tr><td>A 32-bit numeric address in IPv4 is written in decimal as four numbers separated by periods. Each number can be zero to 255.</td><td>IPv6 addresses are 128-bit IP address written in hexadecimal and separated by colons.</td></tr><tr><td>For example, **1.160.10.240** could be an IP address.</td><td>An example IPv6 address could be written like this: **3ffe:1900:4545:3:200:f8ff:fe21:67cf**</td></tr></table>
11	**What is IPaddressing? BTL1** An IP address is a numerical label assigned to each divide in a computer network that uses internet protocol for communication. Two important functions at IP address • Hostidentification • Locationaddressing
12	**Why is IPV4 to IPV6 transition required? Apr/May17 BTL1** Auto Configuration - Auto Configuration is now built in and helps make IP addressing more managable. With IPv4, we relied on DHCP or manually configurating IP addresses. Direct Addressing - With Direct Addressing, the primary use of NAT (Network Area Translation) now becomes obsolete with IPv6. So, Direct Addressing is now possible. Mobility - Mobility is better integrated into IPv6 than it is with IPv4. It makes it easier for users to roam to different networks and keep their same IP address. Improved Integrated Security (IPSec) - IPSec is now integrated into IPv6, while with IPv4 it was more an add-on
13	**Differentiate between forwarding table and routing table. Nov/Dec17 BTL1** A routing table uses a packet's destination IP address to determine which IP address should next receive the packet, that is, the "next hop" IPaddress. A forwarding table uses the "next hop" IP address to determine which interface should deliver the packet to that next hop, and which layer 2 address (e.g., MAC address) should receive the packet on multipoint interfaces like Ethernet or Wi-Fi
14	**What isRIP? BTL1** RIP (Routing Information Protocol) is a widely-used protocol for managing router information within a self-contained network such as a corporate local area network or an interconnected group of such LANs. Using RIP, a gateway host (with a router) sends its entire routing table (which lists all the other hosts it knows about) to its closest neighbor host every 30 seconds. The neighbor host in turn will pass the information on to its next neighbor and so on until all hosts within the network have the same knowledge of routing paths, a state known as networkconvergence
15	**Explain aboutOSPF. BTL1** OSPF (Open Shortest Path First) is a router protocol used within larger autonomous system

	networks in preference to the Routing Information Protocol (RIP), an older routing protocol that is installed in many of today's corporate networks. Using OSPF, a host that obtains a change to a routing table or detects a change in the network immediately multicasts the information to all other hosts in the network so that all will have the same routing table information
16	**What are the responsibilities of network layer? BTL1** The network layer is responsible for the source-to-destination delivery of packetacross multiple network links. The specific responsibilities of network layer include the following: Logical addressing. Routing.
17	**What is meant by hop count? BTL1** The pathway requiring the smallest number of relays, it is called hop-count routing, in which every link is considered to be of equal length and given the value one.
18	**What is time-to-live or packet lifetime? BTL1** As the time-to-live field is generated, each packet is marked with a lifetime; usually the number of hops that are allowed before a packet is considered lost and accordingly, destroyed. The time-to-live determines the lifetime of a packet.
19	**How the routers get the information about neighbor? BTL1** A router gets its information about its neighbors by periodically sending them short greeting packets. If the neighborhood responds to the greeting as expected, it is assumed to be alive and functioning. If it does not, a change is assumed to have occurred and the sending router then alerts the rest of the network in its next LSP.
20	**What is LSP? BTL1** In link state routing, a small packet containing routing information sent by a router to all other router by a packet called link state packet.
21	**What are the metrics used by routing protocols? (Apr/May 2015) BTL1** Path length, bandwidth, load, hop count, path cost, delay, Maximum Transmission Unit (MTU), reliability and communications cost.
22	**Identify and prove the class of the following IP Address: (Nov /Dec2015)** BTL5 (a) 110.34.56.45 (b) 212.208.63.23 (a) 110.34.56.45 – Class A (b) 212.208.63.23- Class C
	PART – B
1	**Explain IPv6 packet format and how fragmentation is applied in datagram delivery. (13M)** BTL2 **Answer Page:318- Larry L. Peterson** **Definitions (3M)** Internet Protocol Version 6 (IPv6) is an Internet Protocol (IP) used for carrying data in packets from a source to a destination over various networks. IPv6 is the enhanced version of IPv4 and

can support very large numbers of nodes as compared to IPv4. It allows for 2128 possible node, or address, combinations.

Explanation(5M)

Packet Header Format(5M)



2 **Discuss about Link-state routing and routers.(13M)** BTL 2

Answer Page:277-Larry L. Peterson

Definition for OSPF(3M)

Link State (OSPF) reach its directly connected neighbors, and if we make sure that the totality of this knowledge is disseminated to every node, then every node will have enough knowledge Link-state routing is the second major class of intra domain routing protocol. The starting assumptions for link-state routing are rather similar to those for distance vector routing.

Header Format (5M)

<table>
<tr><th colspan="2">VERSION</th><th colspan="2">TYPE</th><th>MESSAGE LENGTH</th></tr>
<tr><td colspan="5">SOURCE ADDRESS</td></tr>
<tr><td colspan="5">Area Id</td></tr>
<tr><td colspan="3">Checksum</td><td colspan="2">Authentication type</td></tr>
<tr><td colspan="5">Authentication</td></tr>
</table>

Diagram (LSA): (5M)

3 **Explain about the inter domain routing (BGP) routing algorithms..(13M)** BTL2

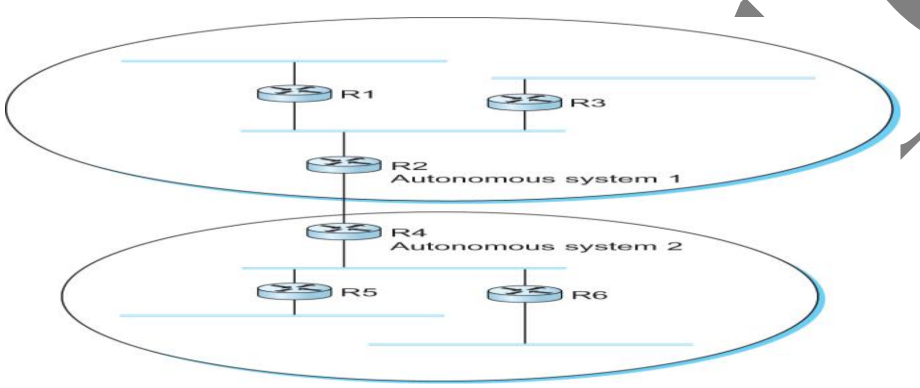
Answer Page:306-Larry L. Peterson
Definition(3M)

BGP used to exchange n/w reachability information among BGP routers and two routers are in same network or different AS may exchange information.

Types of AS (6M)

- ■ ***Stub AS*(2M)**: an AS that has only a single connection to one other AS; such an AS will only carry local traffic with in that AS. The small corporation in figure is an eg., of a stub AS.
- ■ **Multihomed AS(2M)**: an AS that has connections to more than one other AS but that refuses to carry transit traffic; for example, the large corporation at the top
- ■ ***Transit AS(2M)***: an AS that has connections to more than one other AS and that is designed to carry both transit and local traffic, such as the backbone providers.

Diagram(4M)



4

Explain in detail about RIP. (13M) (Nov/Dec 2015) BTL2

Answer Page:269-Larry L. Peterson
Definition for RIP(3M)
A very important concept in IP addressing is the network address. When an organization is given a block of addresses, the organization is free to allocate the addresses to the devices that need to be connected to the Internet. The first address in the class, however, is normally (not always) treated as a special address.
Packet Header Format(5M)

COMMAND	VERSION	MUST BE ZERO
FAMILY OF NET 1	ADDRESS OF NET 1	
ADDRESS OF NET 1		
DISTANCE TO NET 1		
FAMILY OF NET 2	ADDRESS OF NET 2	
ADDRESS OF NET 2		
DISTANCE TO NET 1		

Explanation(5M)

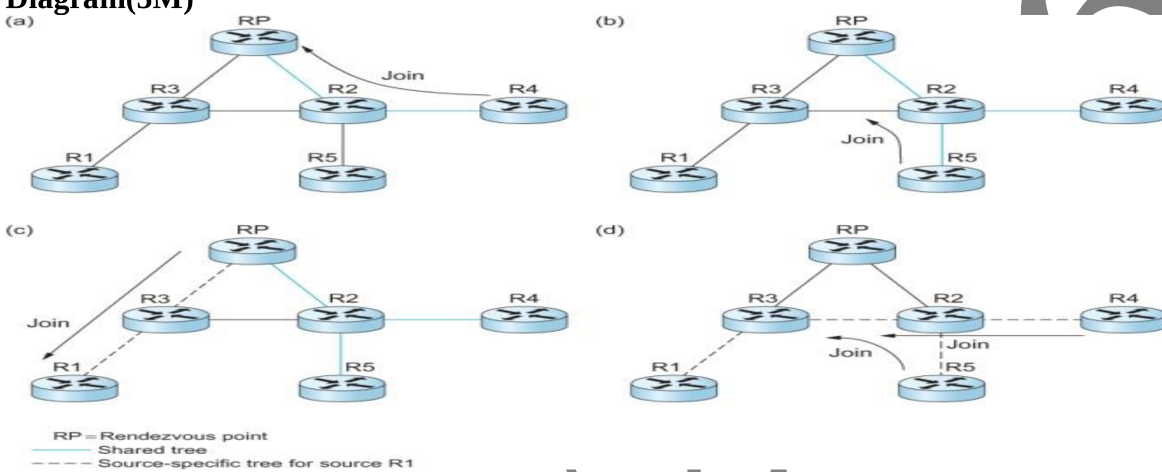
5

Explain in detail about PIM. (13M) BTL2

Answer Page:336-Larry L. Peterson
Definition (3M)

Protocol Independent Multicast, or PIM, was developed in response to the scaling problems of earlier multicast routing protocols. In particular, it was recognized that the existing protocols did not scale well in environments where a relatively small proportion of routers want to receive traffic for a certain group.

Diagram(5M)



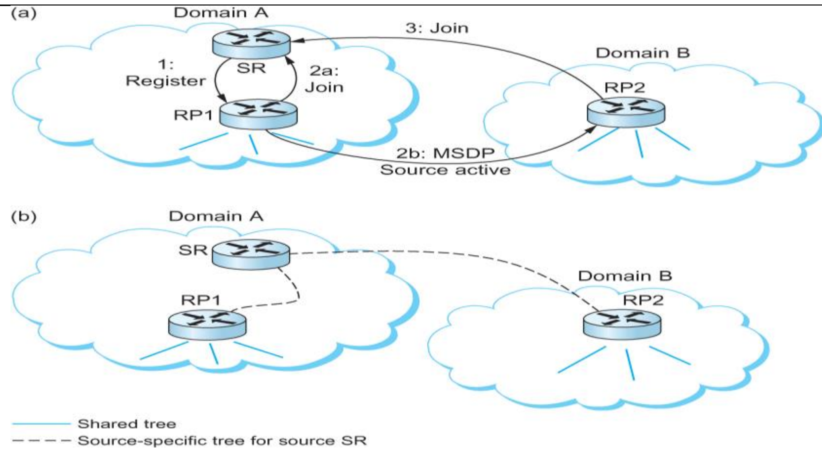
Explanation(5M)

PART –C

1

Explain multicast routing in detail.(15M)(Nov/Dec 2015) BTL2
Answer Page:332-Larry L. Peterson
Definition of Multicasting(3M)
Definition Multicast routing is the process by which the multicast distribution trees are determined or, more concretely, the process by which the multicast forwarding tables are built. As with unicast routing, it is not enough that a multicast routing protocol "work"; it must also scale reasonably well as the network grows, and it must accommodate the autonomy of different routing domains

Definition of DVMRP (3M)
Distance-vector routing, which we discussed in for unicast, can be extended to support multicast. The resulting protocol is called DVMRP Distance-vector routing, which we discussed in for unicast, can be extended to support multicast.
Diagram(4M)



Explanation(5M)

2

Explain in detail about IP v4 addressing.(13M) BTL2

Answer Page:250-Larry L. Peterson

Definition(3M)

A very important concept in IP addressing is the network address. When an organization is given a block of addresses, the organization is free to allocate the addresses to the devices that need to be connected to the Internet.

Diagram **(5M)**

Class A

0 Netid	Host ID

- **Class B**

10 Net id	Host ID

- **Class C**

110 net id	Host id

- **Class D**

1110	Multicast address

- **Class E**

1111	reserved for future use

Applications **(5M)**

3

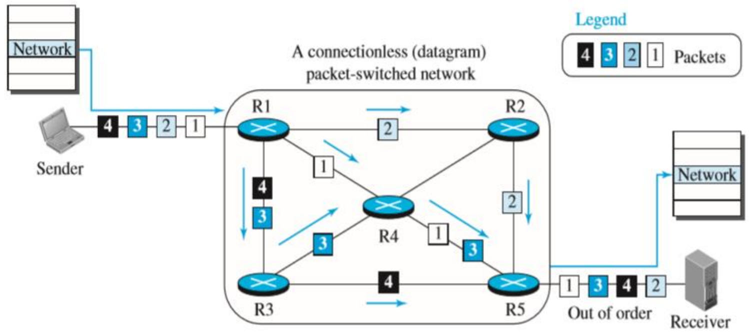
Discuss with a neat architecture of Packet Switching.

Definition Page No : 516

The source of the message sends the packets one by one; the destination of the message receives the packets one by one. The destination waits for all packets belonging to the same message to arrive before delivering the message to the upper layer. The connecting devices in a packet-switched network still need to decide how to route the packets to the final destination. Today, a packet-switched network can use two different approaches to route the packets: the datagram approach and the virtual circuit approach.

Datagram Approach:

Connectionless Service When the Internet started, to make it simple, the network layer was designed to provide a connectionless service in which the network-layer protocol treats each packet independently, with each packet having no relationship to any other packet. The idea was that the network layer is only responsible for delivery of packets from the source to the destination. In this approach, the packets in a message may or may not travel the same path to their destination.



Each packet is routed based on the information contained in its header: source and destination addresses. The destination address defines where it should go; the source address defines where it comes from. The router in this case routes the packet based only on the destination address. The source address may be used to send an error message to the source if the packet is discarded.
Virtual-Circuit Approach:
Connection-Oriented Service In a connection-oriented service (also called virtual-circuit approach), there is a relationship between all packets belonging to a message. Before all datagrams in a message can be sent, a virtual connection should be set up to define the path for the datagrams. After connection setup, the datagrams can all follow the same path.Each packet is forwarded based on the label in the packet. To follow the idea of connection-oriented design to be used in the Internet, we assume that the packet has a label when it reaches the router.

UNIT IV – TRANSPORT LAYER

Introduction to Transport layer –Protocols- User Datagram Protocols (UDP) and Transmission Control Protocols (TCP) –Services – Features – TCP Connection – State Transition Diagram – Flow, Error and Congestion Control - Congestion avoidance (DECbit, RED) – QoS – Application requirements

PART * A

Q.No.	Questions
1.	**Give any two Transport layer service.(Dec2012)** BLT1 Transport layer performs multiplexing/demultiplexing function. Multiple applications employ same transport protocol, but use different port number. According to lower layer n/w protocol, it does upward multiplexing or downward multiplexing. Reliability: Error Control and Flow Control

2

Mention the various adaptive retransmission policy ofTCP. BLT1

- Simpleaverage
- Exponential / weightedaverage
- Exponential RTT backoff
- Jacobson"s Algorithm

3

Give the datagram format ofUDP? BLT1

The basic idea of UDP is for a source process to send a message to a port and for the destination process to receive the message from a port.

Source Port Address 16 bits	Destination Port Address 16 bits
Total Length 16 bits	Checksum 16 bits

Source port address: It is the address of the application program that has created themessage.
Destination port address: It is the address of the application program that will receive themessage.
Total Length: It defines the total length of the user datagram inbytes.
Checksum: It is a 16 bit field used in errorcorrection

4

What is the main difference between TCP &UDP?(Nov/Dec2014) BLT1

TCP	**UDP**
It provides Connection oriented service	Provides connectionless service.
Connection Establishment delay will be there	No connection establishment delay
Provides reliable service	Provides unreliable, but fast service
It is used by FTP, SMTP	It is used by DNS,SNMP, audio, video and multimedia applications.

5

What are the advantages of using UDP over TCP? (Nov/Dec2010) BLT1

UDP is very useful for audio or video delivery which does not need acknowledgement. It is useful in the transmission of multimedia data. Connection Establishment delay will occur inTCP

6

What is TCP? (Nov/Dec2011) BLT1

Transmission Control Protocol provides Connection oriented and reliable services. TCP guarantees the reliable, in order delivery of a stream of bytes. It is a full-duplex protocol, meaning that each TCP connection supports a pair of byte streams, one flowing in each direction. It is used by FTP, SMTP. The different phases in TCP state machine are Connection Establishment, Data transfer and Connection Release. TCP services to provide reliable communication are Error control, Flow control, Connection control and Congestion control

7

What is the difference between service point address, logical address and physicaladdress?

	BLT1 **Service point addressing**: The transport layer header includes a type of address called a service point address or port address, which makes a data delivery from a specific process on one computer to a specific process on another computer. **Logical addressing**: If a packet passes the network boundary we need another addressing to differentiate the source and destination systems. The network layer adds a header, which indicates the logical address of the sender andreceiver. **Physical addressing**: If the frames are to be distributed to different systems on the network, the data link layer adds the header, which defines the source machine‟s address and the destination Machine‟s address.
8	**What is the use of UDP's Pseudoheader? BLT1** The pseudo header consists of three field from the IP header protocol number ,source IP address and destination IP address plus the UDP length field (which is included twice in checksum calculation).The pseudo header is used to check whether the message is delivered between 2 endpoints
9	**What are the four aspects related to the reliable delivery of data? (May/June2012) BLT1** The four aspects are Error control, Sequence control, Loss control and Duplication control.
10	**What isUDP? BLT1** It stands for User Datagram Protocol. It is part of the TCP/IP suite of protocols used for data transferring. UDP is a known as a "stateless" protocol, meaning it doesn't acknowledge that the packets being sent have been received
11	**List the flag used in TCPheader? BLT1** TCP header contains six flags. They are URG,ACK,PSH,RST,SYN,FIN
12	**What is aport? BLT1** Applications running on different hosts communicate with TCP with the help of a concept called as ports. A port is a 16 bit unique number allocated to a particular application
13	**List the services of end to endservices. BLT1** • Guarantee messagedelivery. • Delivery messages in the same order they aresent. • Deliver at most one copy of eachmessage. • Support arbitrarily largemessage. • Supportsynchronization
14	**List out the three types of addresses inTCP/IP? BLT1** Three types of addresses are used by systems using the TCP/IP protocol: the physical address, the internetwork address (IP address), and the port address
15	**List the advantages of connection oriented services over connectionless services. Apr/May17 BLT1** Connection-oriented Requires a session connection (analogous to a phone call) be established

	before any data can be sent. This method is often called a "reliable" network service. It can guarantee that data will arrive in the same order. Connectionless: Does not require a session connection between sender and receiver. The sender simply starts sending packets (called datagrams) to the destination. This service does not have the reliability of the connection-oriented method.
16	**How do fast retransmit mechanism of TCP works? Apr/May17 BLT1** In TCP/IP, fast retransmit and recovery (FRR) is a congestion control algorithm that makes it possible to quickly recover lost data packets. Without FRR, the TCP uses a timer that requires a retransmission timeout if a packet is lost. No new or duplicate packets can be sent during the timeout period. With FRR, if a receiver receives a data segment that is out of order, it immediately sends a duplicate acknowledgement to the sender. If the sender receives three duplicate acknowledgements, it assumes that the data segment indicated by the acknowledgements is lost and immediately retransmits the lost segment
17	**What are the types of port numbers used in transportlayer? BLT1** • Well-knownport • Registered port • Dynamicport
18	**What is function of transport layer?BLT1** The protocol in the transport layer takes care in the delivery of data from oneapplication program on one device to an application program on another device. They act as a link between the upper layer protocols and the services provided by the lower layer.
19	**What are the duties of the transport layer?BLT1** The services provided by the transport layer End-to- end delivery Addressing Reliable delivery Flow control Multiplexing
20	**What is meant by Concatenation?BLT1** The size of the data unit belonging to a single session are so small that several can fit together into a single datagram or frame, the transport protocol combines them into a single data unit. The combining process is called concatenation.
21	**List the flag used in TCP header. BTL1** TCP header contains six flags. They are URG,ACK,PSH,RST,SYN,FIN
	PART * B
1	**Explain TCP Reliable stream Protocol.(13M)** BTL2 **Answer: Page:388- Larry L. Peterson** **Definitions (3M)** TCP (Transmission Control Protocol) is a standard that defines how to establish and maintain a

network conversation via which application programs can exchange data. TCP works with the Internet Protocol (IP), which defines how computers send packets of data to each other.
Relationship between TCP send buffer (a) and receive buffer (b).

Explanation(5M)

Sending side :

LastByteAcked< = LastByteSent
LastByteSent< = LastByteWritten
Buffers bytes between LastByteAcked and LastByteWritten

Receiving Side

LastByteRead<NextByteExpected
NextByteExpected< = LastByteRcvd+1
Buffers bytes between NextByteRead and LastByteRcvd.
Send buffer size: MaxSendBuffer

Packet Header Format(5M)

SrcPort		**DstPort**	
SequenceNum			
Acknowledgement			
HdrLen	**0**	**Flags**	**Advertisedwindow**
Checksum			**UrgPtr**
Ooptions(Variable)			
Data			

2 **Describe with examples the three mechanisms by which congestion control is achieved in TCP .(13M)** BTL2

Answer: Page:474- Larry L. Peterson

Definition AIMD (2M)

The additive-increase/multiplicative-decrease (AIMD) algorithm is a feedback control algorithm best known for its use in TCP congestion control. AIMD combines linear growth of the congestion window with an exponential reduction when congestion takes place.

Diagram(3M)

Definition Slow start(2M)

Slow-start is part of the congestion control strategy used by TCP, the data transmission protocol used by many Internet applications. Slow-start is used in conjunction with other algorithms to avoid sending more data than the network is capable of transmitting, that is, to avoid causing network congestion.

Diagram(3M)

Definition Fast Retransmission &Fast Recovery(3M)

Fast retransmit and recovery (FRR) Posted by: Margaret Rouse. In TCP/IP, fast retransmit and recovery (FRR) is a congestion control algorithm that makes it possible to quickly recover lost data packets.

3 **Discuss TCP congestion avoidance algorithm in detail. (13M)** BTL2

Answer: Page:486- Larry L. Peterson

1.DEC Bit Method

Definition(2M)

When converting decimal numbers to binary numbers it is important to remember which the least significant bit (LSB) is, and which is the most significant bit (MSB).

Diagram(3M)

2.Random early detection (RED)

Definition(2M)

RED algorithm defines how to monitor the queue length and when to drop a pkt.

RED computes an avg. queue length using a weighted running average.

Diagram(2M)

3.Source Based Congestion Avoidance

Definition(2M)

In connectionless networks it can be done by explicit messages (choke packets) from the network to the sources or by implicit means such as timeout on a packet loss. ... Congestion control is a social (network-wide) law.

Diagram(2M)

4

Why does TCP use adaptive retransmission and describe its mechanism(13M) BTL2

Answer: Page:404- Larry L. Peterson

1. Original Algorithm **(3M)**
2. Karn/Partridge Algorithm**(3M)**
3. Jacobson/Karels Algorithm**(3M)**

Explanation(4M)

5

Explain in detail about TCP .(13M) BTL2

Answer: Page:382- Larry L. Peterson

Definition (3M)

Transmission Control Protocol provides Connection oriented and reliable services. TCP guarantees the reliable, in order delivery of a stream of bytes. It is a full-duplex protocol, meaning that each TCP connection supports a pair of byte streams, one flowing in each direction. It is used by FTP, SMTP. The different phases in TCP state machine are Connection Establishment, Data transfer and Connection Release. TCP services to provide reliable communication are Error control, Flow control, Connection control and Congestion control.

Diagram(5M)

<table>
<tr><td colspan="3">SrcPort</td><td colspan="2">DstPort</td></tr>
<tr><td colspan="5">SequenceNum</td></tr>
<tr><td colspan="5">Acknowledgement</td></tr>
<tr><td>HdrLen</td><td>0</td><td colspan="2">Flags</td><td>Advertisedwindow</td></tr>
<tr><td colspan="4">Checksum</td><td>UrgPtr</td></tr>
<tr><td colspan="5">Ooptions(Variable)</td></tr>
<tr><td colspan="5">Data</td></tr>
</table>

Explanation (5M)

PART * C

1

Explain UDP protocol operation in detail. (15M) BTL2

Answer: Page:384- Larry L. Peterson

Definition of UDP(3M)

It stands for User Datagram Protocol. It is part of the TCP/IP suite of protocols used for data transferring. UDP is a known as a "stateless" protocol, meaning it doesn't acknowledge that the packets being sent have been received.

Diagram(6M)

SrcPort	**DstPort**
Length	**Checksum**
Data	

Explanation(6M)

2

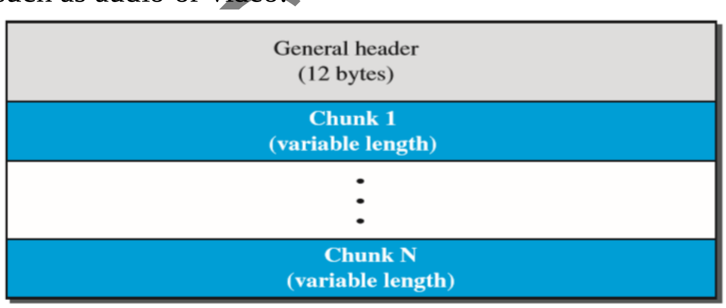
Explain the Features of SCTP with header format.

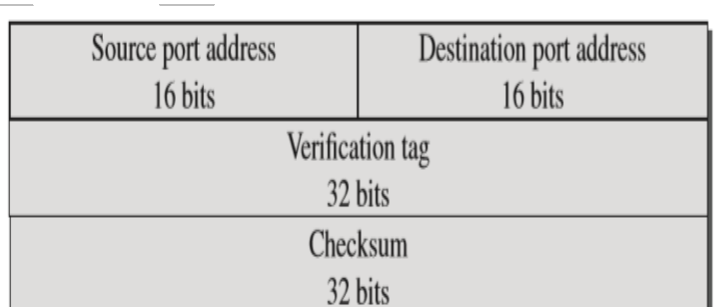
Definition

Stream Control Transmission Protocol (SCTP) is a new transport-layer protocol designed to combine some features of UDP and TCP in an effort to create a better protocol for multimedia communication.

SCTP Services

Process-to-Process Communication SCTP, like UDP or TCP, provides process-to-process communication. Multiple Streams We learned that TCP is a stream-oriented protocol. Each connection between a TCP client and a TCP server involves a single stream. The problem with this approach is that a loss at any point in the stream blocks the delivery of the rest of the data. This can be acceptable when we are transferring text; it is not when we are sending real-time data such as audio or video.





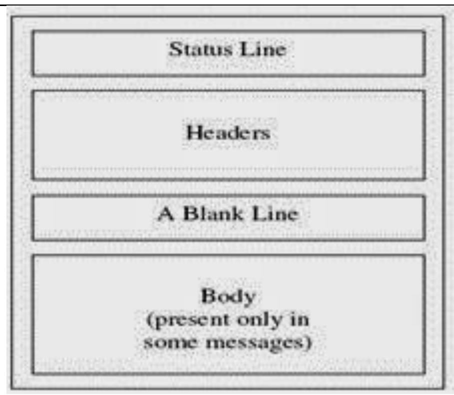
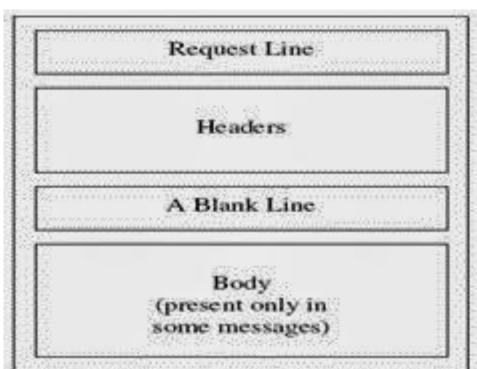
Packet Format An SCTP packet has a mandatory general header and a set of blocks called

	chunks. There are two types of chunks: control chunks and data chunks. A control chunk controls and maintains the association; a data chunk carries user data. In a packet, the control chunks come before the data chunks. General Header The general header (packet header) defines the end points of each association to which the packet belongs, guarantees that the packet belongs to a particular association, and preserves the integrity of the contents of the packet including the header itself. This prevents a packet from a previous association from being mistaken as a packet in this association. It serves as an identifier for the association; it is repeated in every packet during the association. The next field is a checksum. However, the size of the checksum is increased from 16 bits (in UDP, TCP, and IP) to 32 bits in SCTP to allow the use of the CRC-32 checksum.

UNIT V – APPLICATION LAYER	
Application Layer Paradigms – Client Server Programming – World Wide Web and HTTP - DNS-Electronic Mail (SMTP, POP3, IMAP, MIME) – Introduction to Peer to Peer Networks – Need for Cryptography and Network Security – Firewalls	
PART * A	
Q.No.	**Questions**
1.	**What are the four main properties ofHTTP? BLT1** • Global Uniform ResourceIdentifier. • Request-responseexchange. • Statelessness. • Resourcemetadata
2	**What are the four groups of HTTP Headers? What are the two methods ofHTTP? BLT1** The four groups of HTTP headers are • Generalheaders • EntityHeaders • RequestHeaders and Response Headers. Two methods • GetMethod() • PostMethod()
3	**What is WWW? (Nov/Dec 2010,May/June2014) BLT1** World Wide Web is an internet application that allows user to view pages and move from one

	web page to another. It helps to store and share data across varied distances
4	**What is the function of SMTP? NOV/DEC 2012, APR/MAY2015 BLT1** The TCP/IP protocol supports electronic mail on the Internet is called Simple Mail Transfer (SMTP). It is a system for sending messages to other computer users based on e-mail addresses. SMTP provides mail exchange between users on the same or different computers
5	**Why is an application such as POP needed for electronic messaging? (Apr/May2012) BLT1** Workstations interact with the SMTP host, which receives the mail on behalf of every host in the organization, to retrieve messages by using a client-server protocol such as Post Office Protocol. Although POP3 is used to download messages from the server, the SMTP client still needed on the desktop to forward messages from the workstation user to its SMTP mail server
6	**What is the purpose of Domain Name System? MAY/JUNE2012 BLT1** Domain Name System can map a name to an address and conversely an address to name.
7	**Discuss the three main division of the domain name space. NOV/DEC2008 BLT1** Domain name space is divided into three different sections: generic domains, country domains & inverse domain. Generic domain: Define registered hosts according to their generic behavior, uses genericsuffixes. Country domain: Uses two characters to identify a country as the lastsuffix. Inverse domain: Finds the domain name given the IPaddress
8	**What is a Webbrowser? BLT1** Web browser is a software program that interprets and displays the contents of HTML webpages.
9	**What isURL? BLT1** URL is Uniform Resource Locator. URL is a string identifier that identifies a page onthe World Wide Web(WWW)
10	**What do you mean byTELNET? BLT1** TELNET is used to connect remote computers and issue commands on those computers
11	**What are the responsibilities of ApplicationLayer? BLT1** TheApplication Layer enables the user, whether human or software, to access the network. It provides user interfaces and support for services such as e-mail, shared database management and other types of distributed information services • Network virtualTerminal • File transfer, access and Management(FTAM) • Mailservices • DirectoryServices
12	**Write down the three types of WWWdocuments. BLT1** The documents in the WWW can be grouped into three broad categories: static, dynamic and active. • *Static:* Fixed-content documents that are created and stored in aserver. • *Dynamic*: Created by web server whenever a browser requests the document. • *Active:* A program to be run at the clientside

<table>
<tr><td>13</td><td>What are the two types of connections inFTP? BLT1
The two types of connections in FTP are
Controlconnection
Openconnection</td></tr>
<tr><td>14</td><td>DefineHTTP. BLT1
HTTP is Hypertext Transfer Protocol. It is used mainly to access data on the World Wide Web. The protocol transfer data in the form of plaintext, hypertext, audio, video and so on</td></tr>
<tr><td>15</td><td>Compare the HTTP andFTP. BLT1
<table>
<tr><th>FT
P</th><th>HTT
P</th></tr>
<tr><td>FTP transfers the file from client to server and server to client.</td><td>HTTP transfer the file from server to client.(i.e. web pages)</td></tr>
<tr><td>It uses two different port connections. (i.e. port 20 and
port 21)</td><td>HTTP use only one port connection. (i.e. Port 80)</td></tr>
<tr><td>FTP uses two parallel TCP connections to transfer a file. They are Control Connection and Data
connection.</td><td>It also uses TCP protocol.</td></tr>
<tr><td>Out – of – band</td><td>In – band</td></tr>
</table></td></tr>
<tr><td>16</td><td>Define SNMP. (May/June2012) BLT1
Simple Network Management Protocol (SNMP) is an "Internet-standard protocol for managing devices on IP networks". Devices that typically support SNMP include routers, switches, servers, workstations, printers, & modem. It is used mostly in network management systems to monitor network-attached devices for conditions that warrant administrative attention</td></tr>
<tr><td>17</td><td>State the usage of conditional get in HTTP. Apr/May17 BLT1
The HTTP Protocol defines a caching mechanism, in which the proxy web-servers can cache pages, files, images etc. Since caching is in place, There is a method which the servers are asked to return the document, either the “cached” or “live” document.
This request of asking the server for a document considering a specific parameter is called aConditional GET Request</td></tr>
<tr><td>18</td><td>Give the format of HTTP response message.BLT1</td></tr>
</table>

<table>
<tr><td></td><td>
</td></tr>
<tr><td>19</td><td>Discuss the TCP connections needed in FTP.BLT1
FTP establishes two connections between the hosts. One connection is used for datatransfer, the other for control information. The control connection uses very simple rules of communication. The data connection needs more complex rules due to the variety of data types transferred.</td></tr>
<tr><td>20</td><td>Give the format of HTTP request message.BLT1

</td></tr>
<tr><td>21</td><td>Define Name Resolution. BTL1
To improve reliability, some of the name servers can be located outside the zone. The process of looking up a name and finding an address is called name resolution.</td></tr>
<tr><td>22</td><td>What is Telnet and its three main ideas.BTL1
A Telnet is a Transmission Control Protocol (TCP). Connection used to transmit data with interspersed Telnet Control Information. The Telnet Protocol is built upon three main ideas:
1. The concept of a network virtual terminal
2. The principle of negotiated options
3. A symmetric view of terminals and processes.
4. Telnet is the standard TCP/IP protocol for virtual terminal service.</td></tr>
<tr><td>23</td><td>What is TFTP? BTL1
Trivial file transfer protocol is designed for transferring bootstrap and configuration files. It is so simple and can fit into ROM of a disc less memory. TFTP does reading and writing of files.
Reading means copying files from server site to client site and writing in FTP means copying a file from client site to server site.</td></tr>
<tr><td>24</td><td>Describe why HTTP is defined as a stateless protocol? BTL1</td></tr>
</table>

Maintaining state across request – Response connections significantly increases the initial interactions in a connections since the identity of each party needs to be established and any saved state much be retrieved. HTTP is therefore stateless to ensure that internet is scalable since state is not contained in a HTTP request / response pairs by default.

PART * B

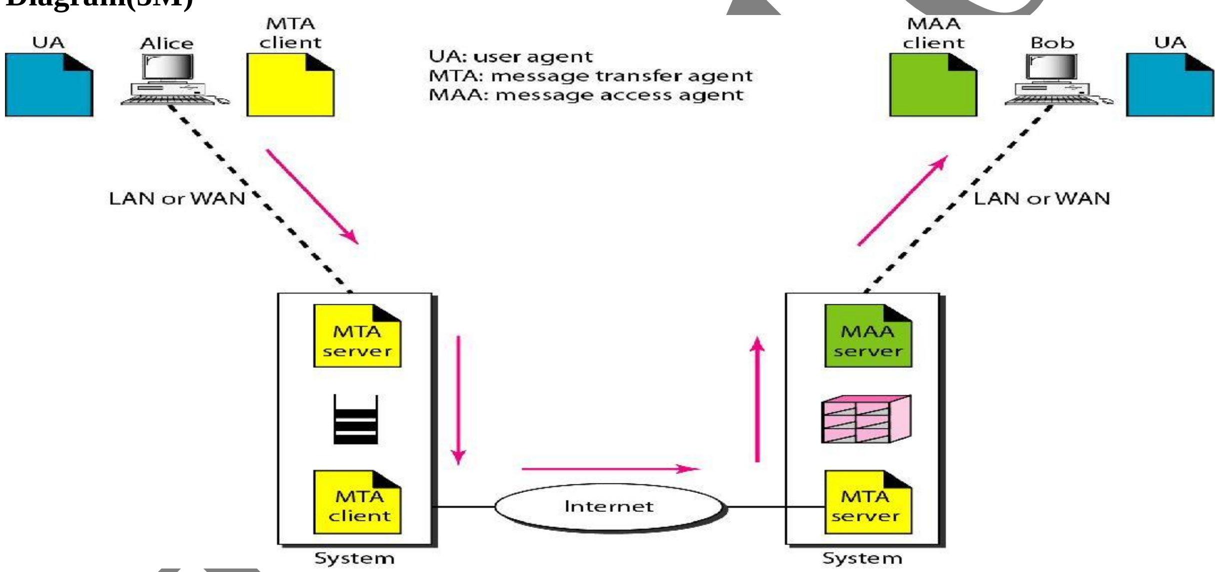
1

Discuss how the Simple Mail Transfer Protocol (SMTP) is used in electronic mail. (13M)BTL2

Answer: Page:643-Larry L. Peterson
Definition (3M)

SMTP (Simple Mail Transfer Protocol) is a TCP/IP protocol used in sending and receiving e-mail. On Unix-based systems, send mail is the most widely-used SMTP server for e-mail. ... Many mail servers now support Extended Simple Mail Transfer Protocol (ESMTP), which allows multimedia related files.

Diagram(5M)



Explanation(5M)

2

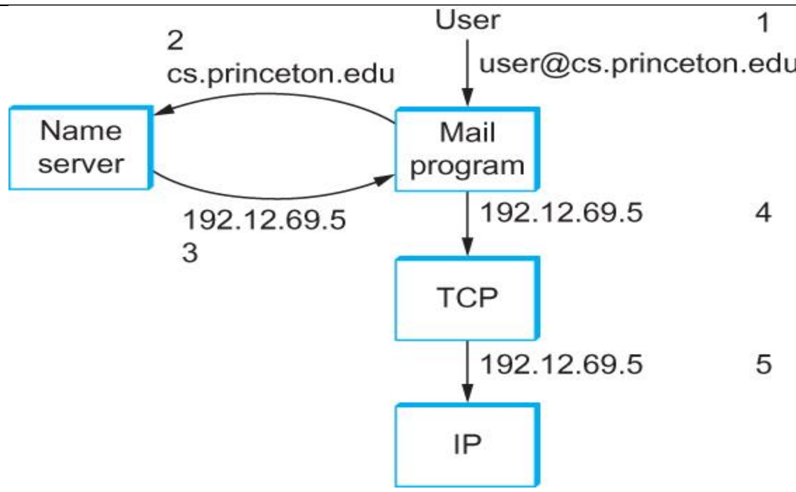
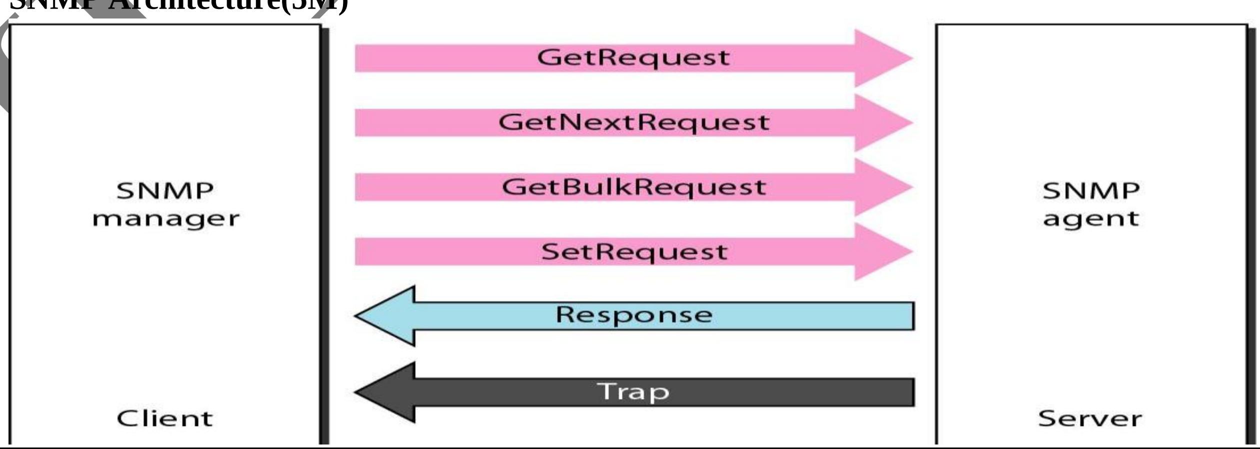
Explain the role of a DNS on a computer network, including its involvement in the process of a user accessing a web page. (13M) BTL 2

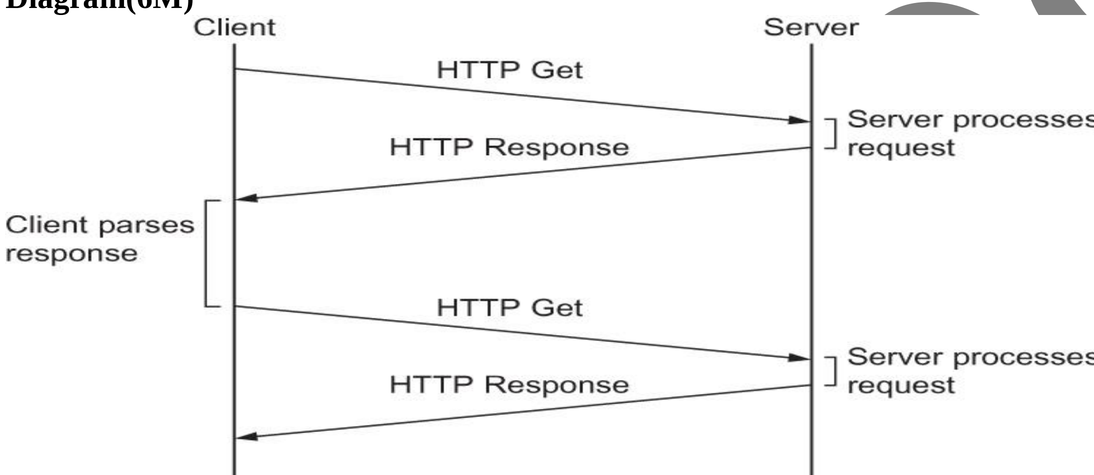
Answer: Page:657-Larry L. Peterson

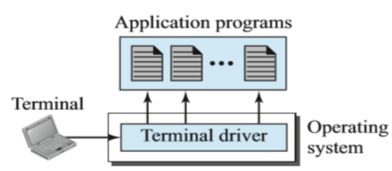
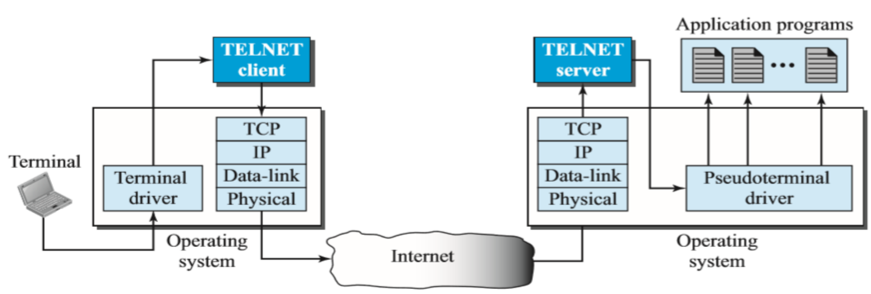
Definition (3M)

Domain Name System can map a name to an address and conversely an address to name. The Domain Name System converts domain names into IP numbers. IP numbers uniquely identify hosts on the Internet: however they are difficult to remember. We therefore need a memorable way of identifying hosts.

Diagram(5M)

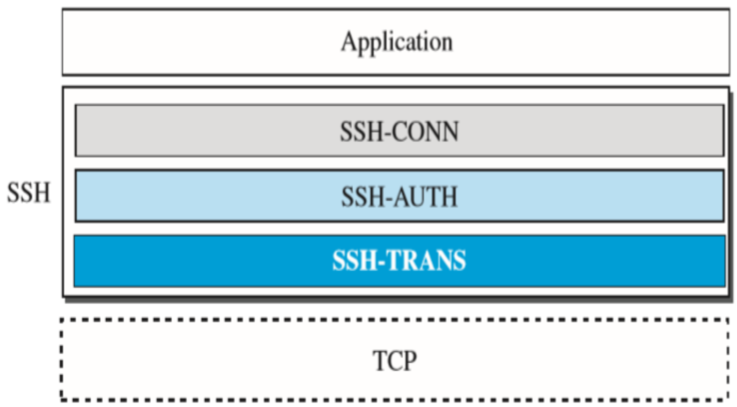
	 **Explanation(5M)**
3	**Explain in detail about FTP.(6M)**BTL2 **Answer: Page:250-Larry L. Peterson** **Definition (3M)** File Transfer *Protocol* (*FTP*) is a standard Internet *protocol* for transmitting files between computers on the Internet over TCP/IP connections. Clients initiate conversations with servers by requesting to download a file. Using *FTP*, a client can upload, download, delete, rename, move and copy files on a server **Diagram** **(3M)**
4	**Explain about SNMP and its group management. (13M)** BTL2 **Answer: Page:666-Larry L. Peterson** **Definition (3M)** • A **network is a complex system**, both in terms of the number of nodes that are involved and in terms of the suite of protocols that can be running on any one node. • All the state that is maintained and manipulated on any one of these nodes—for example, address translation tables, routing tables, TCP connection state, and so on— then it becomes tedious to manage all of this information. **SNMP Architecture(5M)** 

	Explanation(5M)
5	**Explain how HTTP involved in web services?(13M)**BTL2 **Answer: Page:650-Larry L. Peterson** **Definition (3M)** The web contains a set of cooperating clients & servers, speaking the same language HTTP. Users are exposed to web thru a graphical client pgm / web browser. All web browsers have a function, allowing the user to open a URL, which provides info about the location of objects on the web. **Diagram(6M)**  **Explanation (4M)**
	PART *C
1	**Write short notes on following protocol** **a).MIME b).IMAP c). POP3 (15M)** BTL 2 **Answer: Page:648-Larry L. Peterson** **Definition of MIME(2M)** MIME (Multi-Purpose Internet Mail Extensions) is an extension of the original Internet e-mail protocol that lets people use the protocol to exchange different kinds of data files on the Internet: audio, video, images, application programs, and other kinds, as well as the ASCII text handled in the original protocol. **Explanation(3M)** **Definition of IMAP(2M)** IMAP (Internet Message Access Protocol) is a standard email protocol that stores email messages on a mail server, but allows the end user to view and manipulate the messages as though they were stored locally on the end user's computing device(s). **Explanation(3M)** **Definition of POP3(2M)**

	POP3 (Post Office Protocol 3) is the most recent version of a standard protocol for receiving e-mail. POP3 is a client/server protocol in which e-mail is received and held for you by your Internet server. **Explanation(3M)**
2	**Explain TELNET with neat architecture.** **Definition : Page no :** One of the original remote logging protocols is TELNET, which is an abbreviation for TErminaL NETwork. Although TELNET requires a logging name and password, it is vulnerable to hacking because it sends all data including the password in plaintext (not encrypted). A hacker can eavesdrop and obtain the logging name and password. Because of this security issue, the use of TELNET has diminished in favor of another protocol, Secure Shell (SSH), which we describe in the next section. Although TELNET is almost replaced by SSH, we briefly discuss TELNET here for two reasons: 1. The simple plaintext architecture of TELNET allows us to explain the issues and challenges related to the concept of remote logging, which is also used in SSH when it serves as a remote logging protocol. 2. Network administrators often use TELNET for diagnostic and debugging purposes.  a. Local logging  b. Remote logging When a user logs into a local system, it is called local logging. As a user types at a terminal or at a workstation running a terminal emulator, the keystrokes are accepted by the terminal driver. The terminal driver passes the characters to the operating system. The operating system, in turn, interprets the combination of characters and invokes the desired application program or utility. However, when a user wants to access an application program or utility located on a remote machine, she performs remote logging. Here the TELNET client and server programs come into use. The user sends the keystrokes to the terminal driver where the local operating system accepts the characters but does not interpret them. The characters are sent to the TELNET client, which transforms the characters into a universal character set called Network Virtual Terminal (NVT) characters (discussed below) and delivers them to the local TCP/IP stack.
3	**Write the features of SSH with header format.**

Definition Page No: 907

Secure Shell (SSH) is a secure application program that can be used today for several purposes such as remote logging and file transfer, it was originally designed to replace TELNET. There are two versions of SSH: SSH-1 and SSH-2, which are totally incompatible. The first version, SSH-1, is now deprecated because of security flaws in it.



SSH Transport-Layer Protocol (SSH-TRANS) Since TCP is not a secured transport-layer protocol, SSH first uses a protocol that creates a secured channel on top of the TCP. This new layer is an independent protocol referred to as SSH-TRANS. When the procedure implementing this protocol is called, the client and server first use the TCP protocol to establish an insecure connection. Then they exchange several security parameters to establish a secure channel on top of the TCP. We discuss transport-layer security in Chapter 32, but here we briefly list the services provided by this protocol:

1. Privacy or confidentiality of the message exchanged
2. Data integrity, which means that it is guaranteed that the messages exchanged between the client and server are not changed by an intruder.
3. Server authentication, which means that the client is now sure that the server is the one that it claims to be
4. Compression of the messages, which improves the efficiency of the system and makes attack more difficult.

SSH Connection Protocol (SSH-CONN)

After the secured channel is established and both server and client are authenticated for each other, SSH can call a piece of software that implements the third protocol, SSHCONN. One of the services provided by the SSH-CONN protocol is multiplexing. SSH-CONN takes the secure channel established by the two previous protocols and lets the client create multiple logical channels over it.

GE8077 TOTAL QUALITY MANAGEMENT L T P C 3 0 0 3

UNIT I INTRODUCTION 9

Introduction - Need for quality - Evolution of quality - Definitions of quality - Dimensions of product and service quality - Basic concepts of TQM - TQM Framework - Contributions of Deming, Juran and Crosby - Barriers to TQM - Quality statements - Customer focus - Customer orientation, Customer satisfaction, Customer complaints, and Customer retention - Costs of quality.

UNIT II TQM PRINCIPLES 9

Leadership –Quality statements, Strategic quality planning, Quality Councils - Employee involvement - Motivation, Empowerment, Team and Teamwork, Quality circles Recognition and Reward, Performance appraisal - Continuous process improvement - PDCA cycle, 5S, Kaizen - Supplier partnership - Partnering, Supplier selection, Supplier Rating.

UNIT III TQM TOOLS AND TECHNIQUES I 9

The seven traditional tools of quality - New management tools - Six sigma: ConceptsMethodology, applications to manufacturing, service sector including IT - Bench marking - Reason to bench mark, Bench marking process - FMEA - Stages, Types.

UNIT IV TQM TOOLS AND TECHNIQUES II 9

Control Charts - Process Capability - Concepts of Six Sigma - Quality Function Development (QFD) - Taguchi quality loss function - TPM - Concepts, improvement needs - Performance measures.

UNIT V QUALITY MANAGEMENTSYSTEMS 9

Introduction—Benefits of ISO Registration—ISO 9000 Series of Standards—Sector-Specific Standards—AS 9100, TS16949 and TL 9000-- ISO 9001 Requirements—Implementation—Documentation—Internal Audits—Registration- ENVIRONMENTAL MANAGEMENT SYSTEM**:** Introduction—ISO 14000 Series Standards—Concepts of ISO 14001—Requirements of ISO 14001—Benefits of EMS.

TOTAL: 45 PERIODS

OUTCOMES: The student would be able to apply the tools and techniques of quality management to manufacturing and services processes.

TEXT BOOK:

1. Dale H. Besterfiled, et at., "Total quality Management", Third Edition, Pearson Education Asia,Indian Reprint, 2006.

REFERENCES:

1. James R. Evans and William M. Lindsay, "The Management and Control of Quality", 8th Edition, First Indian Edition, Cengage Learning, 2012.

2. Suganthi.L and Anand Samuel, "Total Quality Management", Prentice Hall (India) Pvt. Ltd., 2006.

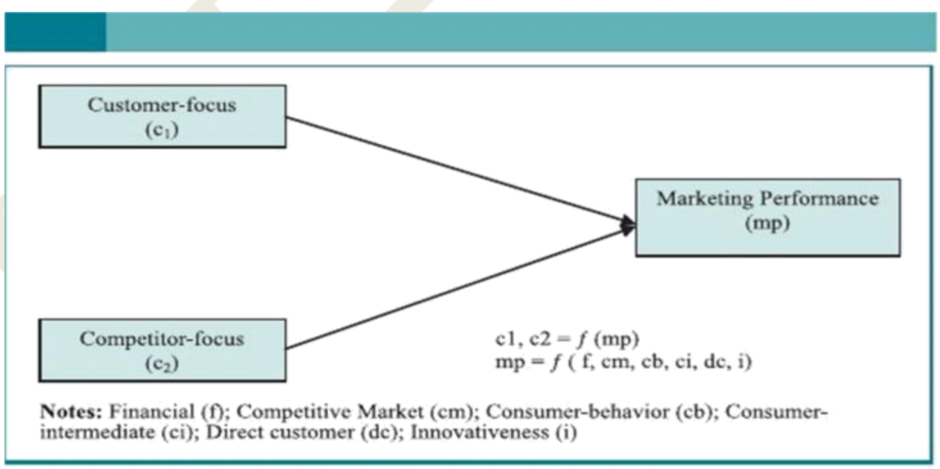
3. Janakiraman. B and Gopal .R.K., "Total Quality Management - Text and Cases", Prentice Hall (India) Pvt. Ltd., 2006.

Subject Code: GE8077 **Year/Semester: III/05**
Subject Name: Total Quality Management **Subject Handler: A.Antony Charles & Mrs. L. Patathurani**

UNIT I INTRODUCTION

Introduction - Need for quality - Evolution of quality - Definitions of quality - Dimensions of product and service quality - Basic concepts of TQM - TQM Framework - Contributions of Deming, Juran and Crosby - Barriers to TQM - Quality statements - Customer focus - Customer orientation, Customer satisfaction, Customer complaints, and Customer retention - Costs of quality.

PART * A

Q.No.	Questions
1.	**Define Quality. (June 2016, June 2015, June 2014)**BTL1 The totality of features of a product or service that bears on its ability to satisfy a stated or implied need. Thus Quality is termed as the conformance that assures the customer the right quality / specifications of the product that it intends to provide functionally with good reliability and after service.
	What is the relationship between competition and customer focus? (May 2014) BTL 1 Customer – focus is significantly related to marketing performance foodand beverages organizations in Nigeria. Competitor-focus is significantly related to marketing performance of food and beverages organizations in Nigeria 
2	**Define Total Quality Management. (Dec 2011, Dec 2013, May 2015)** BTL 1 The art of managing the total organization to achieve excellence in all spheres of activity (Bester field). The integration of all functions and processes within an organization in order to achieve the continuous improvement of the quality of goods and services.TQM aims at reducing the input costs; increases profit and return on investment by improving the quality and productivity thereby usher the company or organisation to stay in business.

<table>
<tr><td>3</td><td>Mention the basic features of TQM. (June2013,May 2018) BTL 2
Management commitment; focus on customer (both external and internal); employee involvement, empowerment; continuous improvement; treating suppliers as partners and establish performance measures for processes.</td></tr>
<tr><td>4</td><td>Writethe major benefits of TQM. (Nov 2011) BTL 1
Improved quality; higher productivity, employee participation; teamwork, working relationships, customer satisfaction, employee satisfaction, communication, profitability, market share and stock price performance.</td></tr>
<tr><td>5</td><td>Discuss some major obstacles or Barriers to TQM implementation. (Apr 2012, May 2015) BTL 2
Lack of management commitment, Inability to change organizational culture, Improper planning, Lack of continuous training and education, Paying inadequate attention to internal and external customers, Inadequate use of empowerment and teamwork, Lack of employee involvement, Emphasis on short-term results, etc.</td></tr>
<tr><td>6</td><td>Mention the four pillars of TQM. (April 2018)BTL 1
Customer Satisfaction, Continuous Improvement, Quality Leadership and Systems Approach are the four main pillars of TQM.</td></tr>
<tr><td>7</td><td>What are the different ways to create customer oriented culture in an industry? (Nov 2016)BTL 2
1. Start at the top
2. Hire people who fit
3. Get everyone involved
4. Trust your team
5. Establish good lines of communication</td></tr>
<tr><td>8</td><td>Write down the categories of quality cost.(Nov 2016)BTL 2
1. Prevention costs
2. Appraisal costs
3. Internal failure costs and
4. External failure costs.</td></tr>
<tr><td>9</td><td>Mention the quality according to Juran& Deming. (Dec 2012, Dec 2015, Dec 2017) BTL 1
Juran defines quality as fitness for use in terms of design, conformance, availability, safety and field use. And this should be religiously practiced and followed across the organisation form production to aftermarket sales (service). Deming defines that quality is a predictable degree of uniformity and dependability, at low cost and suited to the market.</td></tr>
<tr><td>10</td><td>How to measure dimensions of service quality? (Dec 2013, June 2013) BTL 1
The aftermarket sales as referred to as Service to customer are of prime importance to business sustainability. The following ideologies helps in achieving the above said and they are Service duration, Timeliness, Completeness, Consistency, Convenience, Accuracy, Courtesy, etc.</td></tr>
<tr><td>11</td><td>Compare quality requirements before and after TQM. (Nov 2015) (April 2018)BTL 4
<table><tr><th>Quality Requirements Before TQM</th><th>Quality Requirements After TQM</th></tr><tr><td>Product oriented</td><td>Customer oriented</td></tr><tr><td>Short term decisions</td><td>Long term decisions</td></tr><tr><td>Emphasis on detection</td><td>Emphasis on prevention</td></tr></table></td></tr>
</table>

12	**Listthe various quality statements. Write an example for quality statement. (June 2014, June 2016, Nov 2017)** BTL 1 The quality statements include the vision statement (universal), mission statement (task based), and quality policy (generalized) statement. Apart from the above the latest trend is the directions/guidelines given by the top management for the financial year which lays more emphasis on the immediate task to be planned and executed to meet the customer deadline and parallel working towards achieving long term vision of the organisation.
13	**What are the six basic concepts that a successful TQM programrequires?(Dec 2012, May 2012)** BTL2 The six basic concepts that a successful TQM program requires 1. Top management commitment 2. Focus on the customer 3. Effective employee involvement 4. Continuous improvement 5. Treating suppliers as partners and 6. Establishing performance measures.
14	**List the dimensions of quality. What are the elements of TQM? (May 2010, May 2013)** BTL2 The dimensions of quality are 1. Performance 2. Futures 3. Conformance 4. Reliability 5. Durability 6. Service 7. Response 8. Aesthetics and 9. Repetition.
15	**Define Quality Habit. (June 2011)** BTL 1 Quality is never an accident; it is always the result of high intention, sincere effort, intelligent direction and skilful execution; it represents the wise choice of many alternatives. It is a standard practice that must be followed effortlessly thereby achieving customer satisfaction and building trust and relationship with them.
16	**What is meant by Zero Defects?**BTL 1 Zero Defects is a management tool aimed at the reduction of defects through prevention. It is directed at motivating people to prevent mistakes by developing a constant, conscious desire to do their job right the first time. Do it right the first time cost effectively, quality consciously and safety consciously is the mantra of today's, manufacturing system.
17	**What are the seven deadly diseases.**BTL 1 The seven deadly diseases identified in an organisation that spoils the quality function are listed as Lack of constancy of purpose, Emphasis on short-term profits, Evaluation of performance, Mobility of management, Management by use only of visible figures, with little or no consideration of figures that are unknown or unknowable, Excessive Medical Costs, Excessive costs of liability.

18	**DefineQuality Control.**BTL 1 Quality control (QC) is a procedure or set of procedures intended to ensure that a manufactured product or performed service adheres to a defined set of quality criteria or meets the requirements of the client or customer. It is a measure on the existing quality to evaluate the consistency of achieving the right quality at all times.
19	**How can quality are quantified?**BTL 2 Quality is mostly subjective but it can be quantified in terms of perceived expectations of the customers and the actual performance delivered by the product. Q = P / E Where, P-Performance and E-Expectations and Q-Quality Index
20	**Define TQM triangle.**BTL 1 The essence of the total quality management concept is a triangle, each corner being a key point; the focus on the customer, continuous improvement, and teamwork.
21	**Define Deming Cycle (or) Define PDSA cycle.**BTL 1 P-D-S-A (Plan-Do-Study-Act) is a cycle of continuous improvement. It decide upon the type of quality problem to analyze and act upon with concrete solutions to the same in eliminating the quality problem from the process or product or services offered to the customer.
22	**Define SQC.**BTL 1 SQC stands for Statistical quality control. It is used to measure the degree of conformance of raw materials, processes and products to previously agreed specifications/standards.
23	**Define TQCand QA.(NOV 2018)** BTL 1 TQC stands for total quality control. TQC is the continuous process for improvement where current standards present the opportunity for the achievement of new and higher targets for improvement. This is a business philosophy that provides reliability and consistency in the delivered products/services as a check and balance system. QA stands for Quality Assurance. QA means basically the quality control is conducted in a systematic manner. It is a planned and systematic actions required to provide adequate confidence that the product or service with comply with the set standards or specification which was previously agreed upon.
24	**Define value.** BTL 2 Value = (Quality/Price). So the Customer plays an important role in determining or assessing the worthiness of the product/service and the value changes with time. Value is inversely proportional to the price criteria and economics deals it with the term so called market capitalization or Brand acquisition.
25	**Define Quality Cost and its factors.** BTL 2 Quality costs are those costs associated with the non-achievement of product/service quality defined by the requirements established the organisation / customer or society. Trend analysis and Pareto analysis are used for analyzing the quality cost. 1. Prevention costs 2. Appraisal costs 3. Internal failure costs 4. External failure costs.
26	**Define importance of customer retention.**BTL 1 It costs a company six times more to sell a product to a new customer than it does to sell to an existing one. Loyal customers generate more revenue, and are also cheaper to maintain. Customer loyalty facilitates cross-selling/up-selling of a company's other products/services, and also acts as an effective barrier to the entry of competition.
27	**Write theimportance of customer focus for an organization.** BTL 1 Customers are the most important asset of an organization. An organization's success depends on how many customers it has, how much they buy, how often they buy, and how long they are

	retained (loyalty).
28	**Define Vision statement.**BTL 2 A short declaration of what an organization aspires to be in the future. It is an ideal state that an organization continually strives to achieve. It is timeless, inspirational, and becomes deeply shared within the organization. It is of course long term strategy that the management declares with its counterparts. Vision is also referred to as long term strategy of an organisation.
29	**Write Mission statement.**BTL 2 The mission statement answers the following questions: who we are, who are our customers, what we do, and how we do it. The mission provides the guide map, milestones for achieving the vision. Mission is referred to as task based on priority and divided between departments or groups so that collective execution becomes effortless and ceaseless. Mission is also referred to as short term strategy and is of project specific.
	PART * B
1	**Describethe eight dimensions of quality. Discuss in detail. (**13M) **(June 2016, Dec 2011)** BTL 1 **Answer: Page No : 1.10 to 1.13 -Dr.V.Jayakumar** **Eight Dimensions**(5M) **Explanation:**(8M) 1. Performance 2. Features 3. Conformance 4. Reliability 5. Durability 6. Service 7. Response 8. Aesthetics 9. Reputation
2.	**Explain service quality in manufacturing industry. (13M) (June 2016)** BTL 4 **Answer: Page No : 1.13 to 1.16 -Dr.V.Jayakumar** **Dimensions of quantity in respect to service:** **Time:** This is the duration up to which a customer is made to wait. (1M) **Timeliness**: It refers to whether the promise can be kept or whether the service can be performed as promised. (1M) **Completeness**: It refers to whether all the items given by the customer is included. (2M) **Courtesy**: Whether the front office sales people greet each customer cheerfully and politely.**(**2M) **Consistency:** Whether the services are delivered in the same manner for every customer and every time for the same customer. (2M) **Accessibility and convenience**: Whether the service is easy to get for must the customer influence the service provider to get the required service. (5M) **Accuracy:**This is with regard to whether the service is done correctly even in the first instance- **Responsiveness**:Whether the service person reacts and cat quickly to resolve problems(2M)

<table>
<tr><td>3.</td><td>State and explain the barriers to TQM implementation in an organization. (Dec 2012, Dec 2015) (13M) BTL 1
Answer: Page No : 1.13 to 1.16 -Dr.V.Jayakumar

Headings: (8M)
Content :(5M)

Barrier to Tqm:
1. Lack of management commitment
2. Inadequate knowledge or understanding of TQM
3. Inability to change organizational culture
4. Improper planning
5. Lack of continuous training &education
6. Inability to build a learning organization that provides for continuous improvement
7. Incompatible organizational structure , isolated individuals and departments
8. Insufficient resources
9. Inappropriate reward system
10. Use of a pre-packaged program or inappropriately adapting TQM to organization
11. Ineffective measurement techniques and lack of access to data and results
12. Short-term focus or using a Band-Aid solution
13. Paying inadequate attention to internal and external customers</td></tr>
<tr><td>4.</td><td>Explain the contributions of Deming, Juran to TQM. (June 2016, Dec 2013) (13M) BTL 2
Answer: Page No :1.27 to 1.29;1.31 TO 1.33 -Dr.V.Jayakumar

Deming's 14 Points: (8M)
1. Create constancy of purpose for improvement of products and service.
2. Adopt a new philosophy: we are in a new economic age.
3. Cease dependence upon inspection as a way to achieve quality.
4. End the practice of awarding business based on price tag.
5. Constantly improve the process of planning, production, and service- this system includes people.
6. Institute training on the job.
7. Institute improved supervision (leadership)
8. Drive out fear.
9. Break down barriers between departments.
10. Eliminate slogans/targets asking for increased productivity without providing methods
11. Eliminate numerical quotas.
12. Remove barriers that stand between workers and their pride of workmanship.
13. Institute programs for education and retraining.</td></tr>
</table>

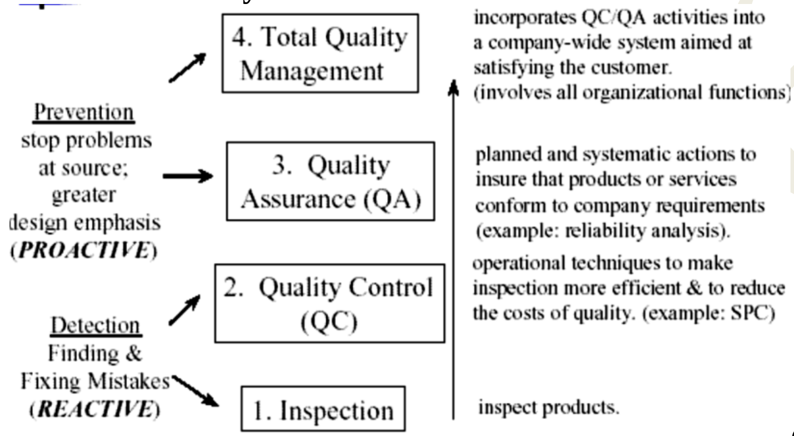
14. Put all emphasis in the company to work to accomplish the transformation.

Juran: contribution towards quality comprise the following aspects. (5M)

1. Internal customer
2. Cost of quality
3. Quality trilogy
4. Juran"s 10 steps for quality improvement;
5. The breakthrough concept

5. **Explain the concepts evolution and benefits of TQM principles. (June 2009) (13M)** BTL 2

Answer: Page No :1.24 -Dr.V.Jayakumar



(9M)

To survive- companies had to make major changes- in their quality programs.

Many hired- consultants and instituted quality training programs- for their employees.

A new concept of quality was emerging.

One result is that quality began- to have a strategic meaning.

Today, successful companies -understand that quality provides - competitive advantage. They put the customer first -and define quality -as meeting or exceeding customer expectations. (4M)

6. **Explain TQM Framework and importance of each element with case study. (13M) (May 2015, Dec 2015).**BTL 2

Answer: Page No : 1.21 TO 1.22 -Dr.V.Jayakumar

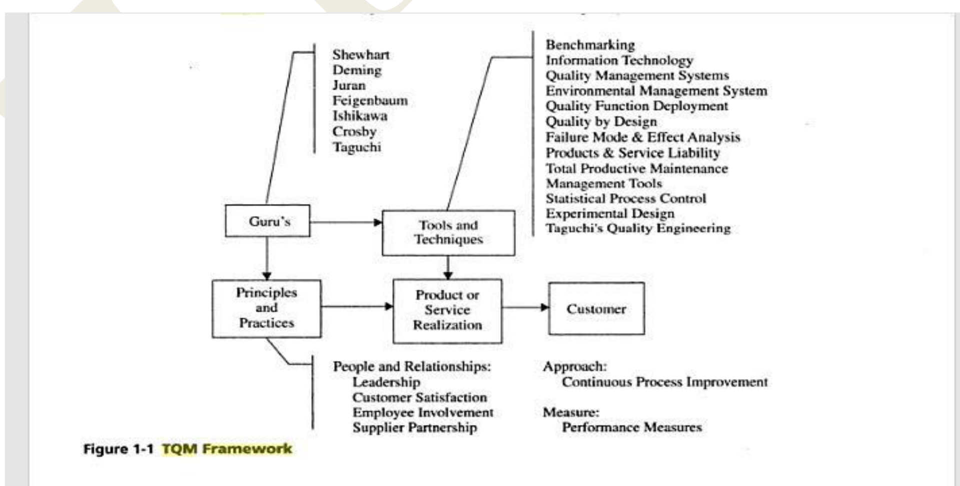


Figure 1-1 TQM Framework

(13M)

7.	**Explain the basic concepts of TQM in detail. (13M) (Dec 2013, Dec 2015)** BTL 2 **Answer: Page No : 1.18 , 1.24 -Dr.V.Jayakumar** 1. Focus on customer (both external and internal) (13M) 2. Employee involvement, empowerment 3. Continuous improvement 4. Treating suppliers as partners 5. Establish performance measures for processes 6. Designing products for quality 7. Quality at source 8. Defect prevention 9. Root cause corrective action 10. Benchmarking 11. Training 12. Positive motivation 13. Team work 14. Management by fact and 15. Quick response.
8.	**Explain the concepts evolution and benefits of TQM principles.** (**13M**) **(June 2009)** BTL 2 **Answer: Page No : 1.18 , 1.24 -Dr.V.Jayakumar** 1. Management commitment, 2. Focus on customer (both external and internal), 3. Employee involvement and empowerment, 4. Continuous improvement, 5. Treating suppliers as partners, 6. Establish performance measures for processes, 7. Designing products for quality, 8. Quality at source,Defect prevention, 10. Root cause corrective action, 11. Benchmarking, 12. Training, 13. Positive motivation, 14.Team work, 15. Management by fact, and 16. Quick response.**(**5M) **Cause-and-effect cycle of TQM:**TQM; High quality product/service ;High productivity, lower cost ;Lower price ;More competitive position ; High profit, growth ; Job security ; Satisfying place to work.(3M) **Stages in the evolution of quality:** Inspection; Quality Control (QC) ; Quality Assurance (QA) ; Quality Mgmt. (QM) ; TQM (2M) **Benefits of quality systems:**Increase in–system efficiency, worker morale, customer satisfaction.Decrease in–complaints, costs, production time.**(**3M)
9.	**Explain customer satisfaction. Write a customer satisfaction model. (13M) (May 2011)** BTL1 **Answer: Page No :2.1 -Dr.V.Jayakumar** Service quality -comparison of **expectations** with performance. A business with high service quality -will meet customer needs -whilst remaining economically competitive. Improved service quality- increase - economic competitiveness. **(**3M) **Elements towards Customer Satisfaction** "Customer satisfaction provides - leading indicator -of consumer purchase intentions and loyalty." "Customer satisfaction data -are among the most frequently collected indicators - market

	perceptions. Their principal use - twofold:" (3M) "Within organizations- the collection, analysis and dissemination -of these data send a message - about the importance of tending to customers and ensuring that- they have a positive experience with the company's goods and services." (3M) "Although sales or market share can indicate how well a firm is performing *currently*, satisfaction is perhaps the best indicator of how likely it is that the firm's customers will make further purchases *in the future*. Much research has focused on the relationship between customer satisfaction and retention. Studies indicate that the ramifications of satisfaction are most strongly realized at the extremes." (3M)
10	**Explain the 6 basic concepts of TQM (OR) Write down the underlying principles of TQM. (13M) (Nov/Dec 2011)(Nov/Dec 2015) (Nov/Dec 2016)** BTL 2 **Answer: Page No :1.20 and 1.23 -Dr.V.Jayakumar** **1. Top management commitment:** Top management should participate and completely involve in the total quality program. (2M) **2. Focus on the customer:** Achieving customer satisfaction is the heart of TQM. Customers include both internal and external customers. So focus on the customer is the key for any TQM program. (2M) 3.**Effective involvement and utilization of the entire work force :** Total quality recognizes that each person is responsible for the quality.(2M) 4. **Continuous improvement :** TQM is based on the quest for process and improvement.(2M) 5. **Treating suppliers as partners:** Since the suppliers influence the company's quality, therefore a partnering relationship should be developed between management and the suppliers.(2M) **6. Establishing performance measures for the processes:** Quantitative data are necessary to measure the continuous quality improvement activity. (3M)
	PART – C
1.	**Explain the different methods of receiving customer feedback. How they are further used to achieve customer satisfaction? (15M) (June 2016)**BTL 2 **Answer: Page No : 2.6 and 2.8 -Dr.V.Jayakumar** **Feedback enables organization to** • Discover customer satisfaction • Discover relative priorities of quality • Compare performance with the competition • Identify customer needs • Determine opportunities for improvement (5M) **Tools:**(4M) 1. Comment Card 2. Customer Questionnaire **Customer Satisfaction:** "Customer satisfaction provides a leading indicator of consumer purchase intentions and loyalty." "Customer satisfaction data are among the most frequently

collected indicators of market perceptions. Their principal use is twofold:"

- "Within organizations, the collection, analysis and dissemination of these data send a message about the importance of tending to customers and ensuring that they have a positive experience with the company's goods and services."
- "Although sales or market share can indicate how well a firm is performing currently, satisfaction is perhaps the best indicator of how likely it is that the firm's customers will make further purchases in the future. Much research has focused on the relationship between customer satisfaction and retention. Studies indicate that the ramifications of satisfaction are most strongly realized at the extremes**."** **(**6M)

2

Explain the issues related to customer complaints and retention. (15M) (Apr 2015).BTL 2
Answer: Page No : 2.9 -Dr.V.Jayakumar

Actions an organization can take to handle complaints are as follows**(**7M)

- Investigate customer's experiences by actively getting feedback, both positive and negative, and then acting on it promptly.
- Develop procedures for complaint resolution that include empowering front – line personnel.
- Analyze complaints, but understand that complaints do not always fit into neat categories.
- Work to identify process and material variations and then eliminate the root cause. "More inspection" is not corrective action.
- When a survey response is received, a senior manager should contact the customer and strive to resolve the concern.
- Establish customer satisfaction measures and constantly monitor them.
- Communicate complaint information, as well as the results of all investigations and solutions, to all people in the organization.
- Provide a monthly complaint report to the quality council for their evaluation and, if needed, the assignment of process improvement teams.
- Identify customers expectations beforehand rather than afterward through complaint analysis. For Customer Retention, we need to have both "Customer satisfaction & Customer loyalty".

The following steps are important for customer retention. (8M)
1. Top management commitment to the customer satisfaction.
2. Identify and understand the customers what they like and dislike about the organization.
3. Develop standards of quality service and performance.
4. Recruit, train and reward good staff.
5. Always stay in touch with customer.
6. Work towards continuous improvement of customer service and customer retention.
7. Reward service accomplishments by the front-line staff.
8. Customer Retention moves customer satisfaction to the next level by determining what is truly important to the customers.
9. Customer satisfaction is the connection between customer satisfaction and bottom line.

3.

Explain in detail about quality statement (15M) (May /June 2013) BTL 2

	Answer: Page : 1.37,1.38,1.40 -Dr.V.Jayakumar Three elements of quality statements are: 1. **Vision statements -** The vision statement is a short declaration of what an organization aspires to be tomorrow. (5M) **2. Mission statement -** The Mission statement is usually one paragraph, describes the function of the organization. It provides a clear statement of purpose for employees, customers and suppliers. (5M) **3. Quality policy statement:** The quality policy is a guide for everyone in the organization as to how they provide products and service to the customers. (5M)

UNIT II TQM PRINCIPLES	
Leadership – Strategic quality planning, Quality Councils – Employee involvement – Motivation, Empowerment, Team and Teamwork, Quality circles Recognition and Reward, Performance appraisal – Continuous process improvement – PDCA cycle, 5S, Kaizen – Supplier partnership – Partnering, Supplier selection, Supplier Rating.	
PART * A	
Q.No.	**Questions**
1.	**Why suppliers should be treated as partners? (Dec 2014)** BTL 3 Yes, suppliers are to be treated as partners from business point of view. The costs due to inferior materials/components from suppliers increase costs in the later stages of production. Suppliers themselves are part of the whole system and hence should be treated as long-term partners. It should be a win-win strategy for both the supplier and producer.
2	**Define 'Juran Trilogy' (Quality Trilogy) (Dec 2011)** BTL 1 The Juran Trilogy (Quality Trilogy) consists of three inter-related processes – quality planning, quality control, and quality improvement – for managing quality.
3	**Write about the roles assigned to people in Quality Circles or who constitutes QC or how is quality circle formed. (June 2014, June2016)** BTL 1 The QC organization has a four-tier structure (roles and responsibilities) consisting of Members, Leaders, Facilitators, and Steering Committee. Usually the line operator will be the head of the QC team. This is one of the important aspects to be followed in an organization marching towards Deming quality medal award.
4	**Define Empowerment. (Dec 2012)** BTL 1 Empowerment means entrusting people with authority and responsibility. The real meaning of empowering people implies making decisions as and when required independently. Decisions should adhere to the policy laid down by the company and in no way deviate from the directions or principles set by the management.
5	**Give the Maslow's basic needs.**BTL 1 Maslow's basic needs are:

	1. Physilogical 2.Safety 3.Society 4.Esteem and 5.Self-actualization needs.
6	**Define about Quality Circles (QC).**BTL 1 QC is a small team of people (around 8 to 10) coming from the same work area/department who voluntarily meet on a regular basis (about an hour every week) to identify, investigate, analyze and solve work-related problems. QC can be viewed from three angles: (i) as a form of participative management, (ii) as a HRD technique, and (iii) as a problem-solving technique.
7	**List the Japanese 5S principles. (Dec 2011)** BTL 1 5S Philosophy focuses on effective work place organization and standardized work procedures. 5S simplifies your work environment, reduces waste and non-value activity while improving quality efficiency and safety. **Sort – (Seiri)** the first S focuses on eliminating unnecessary items from the work place. **Set In Order (Seiton)** is the second of the 5Ss and focuses on efficient and effective storage methods. **Shine: (Seiso)** Once you have eliminated the clutter and junk that has been clogging Your work areas and identified and located the necessary items, the next step is to thoroughly clean the work area. **Standardize: (Seiketsu)** Once the first three 5S's have been implemented, you should concentrate on standardizing best practice in your work area. **Sustain: (Shitsuke)** This is by far the most difficult S to implement and achieve. Once fully implemented, the 5S process can increase morale, create positive impressions on customers, and increase efficiency and organization.
8	**DefineKaizen principles. (Dec 2011)** BTL 2 Kaizen, which is a Japanese word that means gradual and orderly continuous improvement, is a philosophy that covers all business activities and everyone in an organization. In the kaizen philosophy, improvement in all areas of business – cost, meeting delivery schedules, employee safety and skill development, supplier relations, new product development, and productivity – serve to improve the quality of the firm. Thus, any activity directed towards improvement falls under the kaizen umbrella.
9	**What do you understand by Supplier Rating? (May 2015).** BTL 1 Supplier rating system (often called a scorecard system) is usually based on quality, delivery, and service; however, some customers have added other categories, such as lead time, product support, technology, etc. The company constitutes a vendor quality team (VQT) that will facilitate an audit for evaluating the Supplier on delivery, quality, consistency, service and responsiveness.
10	**List the benefits of Team work. (May 2015)** BTL 5 1. Improved solutions to quality problems 2. Improved ownership of solutions 3. Improved communications 4. Improved integration.
11	**Give the traits of successful leaders. (Dec 2015)** BTL 1 1. Customers first 2. Value people 3. Build supplier partnership 4. Empower people.
12	**Define strategic quality planning. (Dec 2015)** BTL 1 It is defined as the process of deciding on objective of the organization on changes on these

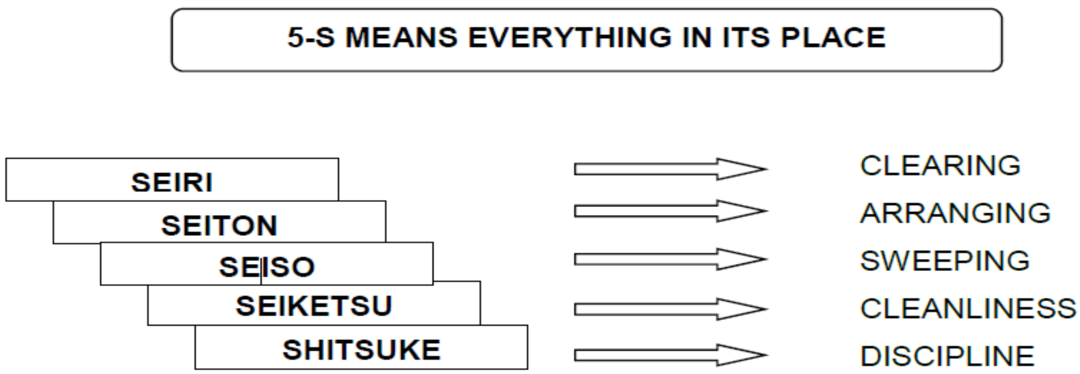
	objectives, on the resource used to obtain these objectives and on the policies that are to govern the acquisition, use and disposition of these resources.
13	**Give the conditions necessary for empowerment.**BTL 1 The conditions required are: 1. Everyone must understand the need for change. 2. The system needs to change to the new paradigm. 3. The organization must provide information, education and still to its employees.
14	**Distinguish between 'internal customer' and 'external customer'.** BTL 4 An external customer exists outside the organization and can be defined in many ways – user, buyer, and influencer. He generally falls into one of three categories: current, prospective, or lost customer. Every function within the organization – engineering, production, order processing, etc. – has an internal customer. Every person in a process is considered a customer of the preceding operation. For example, Manufacturing is a customer for Purchasing, and Dispatching is a customer for Packaging.
15	**List the different types of teams.** BTL 2 1. Process improvement team 2.Cross-functional team 3.Natural work team and 4.Self-directed work team.
16	**Mention some benefits of implementing 5S principles.** BTL 2 5S increases productivity, eliminates waste, reduces inventory, creates a pleasant workplace, improves safety, and increases the overall efficiency and effectiveness of people and machines.
17	**Distinguish between Reward and Recognition. (Dec 2010)** BTL 3 Recognition & reward: Creating incentives for suppliers is one way to ensure that they remain committed to a quality improvement strategy. Incentives may be in the form of a preferred supplier category with its rewards. Recognition may be in the form of publication of outstanding contributions in the customer's newsletter, a letter of commendation, or a plaque. The Quality Circle framework supports motivating people with both recognition and rewards (cash prizes).
18	**Give the basic steps to strategic quality planning.**BTL 3 1. Customer needs 2. Customer positioning 3. Predict the future 4. Gap analysis 5. Closing the gap 6. Alignment 7. Implementation
19	**Define Recognition and Reward.**BTL 2 Recognition is a form of employee motivation in which the organization publicly acknowledges the positive contributions an individual or team has made to the success of the organization. Reward is something tangible to promote desirable behavior. Recognition and reward go together to form a system for letting people know they are valuable Members of the organization.
20	**Classify rewards.** BTL 4 1. Intrinsic rewards: These are related to feelings of accomplishment or self-worth. 2. Extrinsic rewards: These are related to pay or compensation issues.
21	**Define on performance appraisal.**BTL 1 Performance appraisal is a systematic and objective assessment or evaluation of performance and

	contribution of an individual.
22	**Mention the steps in the PDSA cycle.**BTL 1 The basic Plan-Do-Study-Act is an effective improvement technique. The steps in the PDSA cycle are 1. Plan carefully what is to be done 2. Carry out the plan 3. Study the results 4. Act on the results by identifying what worked as planned and what didn't.
	PART - B
1	**Explain the different types of Teams formed to achieve quality and explain the various steps involved in developing a team.**(13M)**(June 2016, Dec 2012, Dec 2013)**BTL 2 **Answer : Page :4.8 to 4.12 - Dr.V.Jayakumar** **Teamwork:**Cumulative actions of the team during which each member of the team subordinates his individual interests and opinions to fulfill the objectives or goals of the group. (1M) **WHY TEAMS WORK :**(4M) 1. Many heads are more knowledgeable than one. 2. The whole is greater than the sum of its members. 3. Team members develop a rapport which each other. 4. Teams provide the vehicle for improved communication. **TYPES OF TEAMS :**(5M) 1. Process improvement team. 2. Cross – functional team. 3. Natural work teams. 4. Self – Directed / Self – Managed work teams. **CHARACTERISTICS OF SUCCESSFUL TEAMS :**(3M) 1. Sponsor 2. Team Charter 3. Team Composition 4. Training 5. Ground Rules 6. Clear Objectives 7. Accountability 8.Well-Defined decision procedure 9. Resources 10. Trust 11. Effective Problem Solving 12. Open Communication 13. Appropriate Leadership 14. Balanced Participation 15. Cohesiveness
2.	**Explain the notes on recognition and rewards. Explain the stages of team development.(13M**)BTL 2 **Answer: Page : 4.14 and 4.12- Dr.V.Jayakumar** **Recognition and Rewards:** (5M) Recognition is a process by which management shows acknowledgement of an employee's outstanding performance.

	Various ways for Recognition and Rewards are 1. Recognition can be expressed using verbal and written praise. 2. Rewards may be in the form of certificates and plaques. 3. Reward is normally in the form of cinema tickets, dinner for family etc. 4. The financial compensation (for recognition) can be paid in terms of increased salaries, commissions, gain sharing etc. 5. The efforts of employees can be recognized by promotions, special job assignments etc. 6. A letter of appreciation from the CEO or the Top Management will increase the employee's involvement. 7. Reward may be delayed but recognition should be in a timely basis. 8. Rewards should be appropriate to the improvement level. 9. People like to be recognized than any reward. 10. Special forms of recognition include pictures on the bulletin board, articles in newsletters, letter to families etc. 11. Supervisors can give on-the-spot praise for a job which is done well. **Effects of Recognition and Reward System :**(4M) 1. Recognition and reward go together for letting people know that they are valuable members for the organization. 2. Employee involvement can be achieved by recognition and reward system. 3. Recognition and reward system reveals that the organization considers quality and productivity as important. 4. It provides the organization an opportunity to thank high achievers. 5. It provides employees a specific goal to achieve. 6. It motivates employees to improve the process. 7. It increases the morale of the workers. **Stages:** (4M) **Forming stage-** Initial stage with only group of individuals and no team work. Team Purpose, roles are created. **Storming Stage -**Initial agreement roles are challenged. Hostilities, emerge which may be resolved **Norming Stage-**Formal informal relations get established. **Performing Stage -**Team operates in a successful manner with trust, openness, healthyconflict and decisiveness among the members. **Maintenance stage –** Functioning should not deteriorate with time Q **Evaluating Stage** – Evaluating team performance
3.	**Explain in detail about Performance Appraisal. What are its benefits?(13M)** **(June 2014)**BTL 2 **Answer : Page : 4.8 to 4.17- Dr.V.Jayakumar** The performance appraisal is used to let employees know how they are performing. The performance appraisal becomes a basis for promotions, increase in salaries, counseling and other purposes related to an employee's future. (3M)

	BENEFITS OF PERFORMANCE APPRAISALS : 1. It is necessary to prevail a good relationship between the employee and the appraiser. (2M) 2. Employee should be informed about how they are performing on a continuous basis, not just at appraisal time. (2M) 3. The appraisal should highlight strength and weakness and how to improve the performance. (2M) 4. Employee should be allowed to comment on the evaluation and protest if necessary. (2M) 5. Everyone should understand that the purpose of performance appraisal is to have employee involvement. 6. Errors in performance evaluations should be avoided. (2M) 7. Unfair and biased evaluation will render poor rating and hence should be eliminated. (2M)
4.	**Explain the concept of employee involvement and motivation for enhancing quality.(13M) (May 2015)**BTL 2 **Answer: Page: 4.1 to 4.2-Dr.V.Jayakumar** Employee involvement improves quality and increases productivity because • Employees make better decisions using their expert knowledge of the process • Employees are better able to spot and pin-point areas for improvement. • Employees are better able to take immediate corrective action. • Employee involvement reduces labour / management friction. • Employee involvement increases morale. • Employees have an increased commitment to goals because they are involved. • Employee involvement is one approach to improve quality and productivity. • It is a means to better meet the organization's goals for quality and productivity. (8M) **MOTIVATION - MASLOW'S HIERARCHY OF NEEDS :** Self - Actualization (1M) Esteem (1M) Social (1M) Security (1M) Survival (1M)
5.	**Explain all the elements in 5'S principle and also the implementation procedure of 5'S in a manufacturing company.(13M) (June 2016, Dec 2007, 2011, 2013)**BTL 2 **Answer: Page : 5.12 to 5.13-Dr.V.Jayakumar**

5-S : HOUSEKEEPING



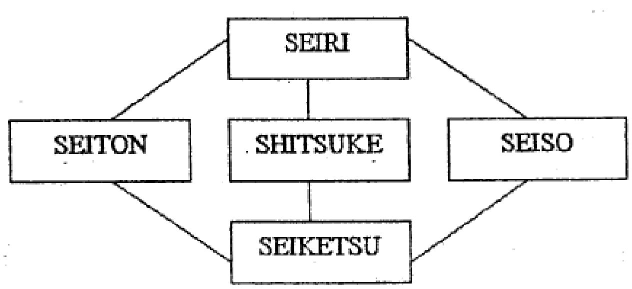
5-S MEANS EVERYTHING IN ITS PLACE

This is a house keeping technique used to establish and maintain a productive andquality environment in an organization. This method is invented in Japan which will givesafer, more efficient and more productive operation results in boosting of morale ofworkers, job involvement and satisfaction and ownership of their responsibilities (5M)

JAPANESE TERM -ENGLISH

EQUIVALENT MEANING

SEIRI Tidiness **Cleaning**– Throw away all rubbish unrelated materials in the work place
SEITON Orderliness **Arranging** – Set everything in proper place for quick retrieval and storage
SEISO Cleanliness **Sweeping** – Clean the work place, everything without fail
SEIKETSU Standardization
Maintaining Cleanliness – Standardizing the way of maintaining cleanliness **SHISUKE d**iscipline
Self Discipline– Practice '5S' daily. Make it a way of life. This also means commitment
RELATIONSHIP BETWEEN VARIOUS 5S



(4M)

IMPLEMENTING 5-S

1. Top Management resolve and training.

	2. Formation of a top level team. 3. Understanding current circumstances. 4. Establishing priorities and targets. 5. Forming sub-teams and training. 6. Major cleaning. 7. Establishing improvement plans in each priority area. 8. Implementing the plan. 9. Verifying results. 10. Standardizing. 11. Establishing full control. 12. Looking for further improvements. (4M)
6.	**Discuss about the steps involved in strategic planning.** (**13M**)**(June 2014)**BTL 2 **Answer: Page No : 3.15- Dr.V.Jayakumar** Goals – Long term planning (Eg : Win the war) Objectives – Short term planning (Eg : Capture the bridge) Goals should • Improve customer satisfaction, employee satisfaction and process • Be based on statistical evidence • Be measurable • Have a plan or method for its achievement • Have a time frame for achieving the goal • Finally, it should be challenging yet achievable (7M) **SEVEN STEPS TO STRATEGIC QUALITY PLANNING :** 1. Customer needs 5. Closing the gap 2. Customer positioning 6. Alignment 3. Predict the future 7. Implementation 4. Gap analysis (6M)
7.	**Explain about Kaizen concept.Discuss the three elements of partnering.**(**13M**) **(Nov 2011)**BTL 2 **Answer: Page: 5.21 -Dr.V.Jayakumar** **Kaizen concept:**(8M) Kaizen is a Japanese word for the philosophy that defines management's roles in continuously encouraging and implementing small improvements involving everyone. It focuses on simplification by breaking down complex progress into their sub – processes and then improving them. The Kaizen improvement focuses on the use of : • Value – added and non – value work activities.

	• Muda, which refers to the seven classes of waste – over-production, delay, transportation, processing, inventory, wasted motion, and defective parts. • Principles of motion study and the use of cell technology. • Principles of materials handling and use of one – piece flow. • Documentation of standard operating procedures. • The five S's for workplace organization. • Visual management. • Just – in – time principles. • Poka – Yoke. • Team dynamics. **Partnering**(3M) Partnering is a relationship between two or more parties based upon trust, dedication to common goals. The benefits of partnering are • Improved quality • Increased efficiency • Lower cost • Increased opportunity for innovation • Continuous improvement The three key elements to a partnership relationship are (2M) • Long term commitment • Trust • Shared Vision
9.	**What is supplier partnering? Identifyits important benefits.**(13M) **(Nov 2016, May 2013)** BTL2 **Answer : Page : 6.2 to 6.3 - Dr.V.Jayakumar** Successful supplier partnerships require commitment and continual nurturing. The following points as mandatory requirements of supplier partnerships;(2M) Supplier personnel should meet with buyer personnel beyond those in thepurchasing office. It is particularly important for them to meet with personnel whoactually use their products so that needed improvements can be identified andmade.(2M) The price-only approach to buyer –supplier negotiations should be eliminated.Product features, quality, and delivery concerns should also be part of thenegotiations. The goal of the negotiation s should be to achieve the optimum dealwhen price, feature, quality, and delivery issues are all factored in. (2M) The quality of supplier products should be guaranteed by the supplier's qualityprocesses. The buyer should have no need to inspect the supplier's products. (2M) Both partners should be capable of sharing information electronically so that the relationship is

	not inhibited by paperwork. Electronic data exchange e is particularly important for successful Just in Time (JIT). The supplier should fully understand and be able to practice just-in time (JIT). Buyers should not need to maintain inventories. **ROLE OF SUPPLIER PARTNERSHIP**(5M) 1. Timeliness 2. Information 3. Product evaluation 4. Monitor customer complaints 5. Awareness of product liability laws 6. Ensure necessary tests are done 7. Provide dependable products 8. Anticipate changing needs and acting on them 9. Commitment 10. Compliance with mandatory standards 11. Communication 12. Plan ahead for recalls
10	**Discuss different types of team and stages of team development.** (**13M**) BTL 2 **Answer: Page No : 4.8 and 4.13-Dr.V.Jayakumar** **TYPES OF TEAMS** **Process improvement team**: Involved in improvement of sub processes orprocesses. Usually has 6-10 members. Disbanded when the objective is reached. May include the local supplied and customer depending on the location (2M) **Cross functional teams:** 6-10 members temporary team. Members are Topmanagement level from various functional areas of management. Discuss complex problems and break down into smaller parts to refer it to various departmental teams for further solution. (2M) **Natural work teams**: Not voluntary and the total work unit is part of the team.Manager also a part of the team and the management selects the projects to be improved. Managers must also ensure that the entire team is comfortable with eachother. (2M) **Self-directed / self-managed work team**: Extension of natural work teams but there the group of individuals is empowered not only to do work but manage it. Nomanger will present but a coordinator (Which will be normally rotated amongmembers) will be appointed. (2M) **STAGES OF TEAM DEVELOPMENT**(5M) **Forming stage**- Initial stage with only group of individuals and no team work.Team purpose, roles are created. **Storming Stage** -Initial agreement roles are challenged. Hostilities, emergewhich may be resolved

Norming Stage-Formal informal relations get established.

Performing Stage -Team operates in a successful manner with trust, openness, healthy conflict and decisiveness among the members.

Maintenance stage –Functioning should not deteriorate with time EvaluatingStage – Evaluating team performance

PART - C

1. **Explain the principles of customer/supplier relationships.**(**15M**)BTL 3

Answer: Page: 6.1 - Dr.V.Jayakumar

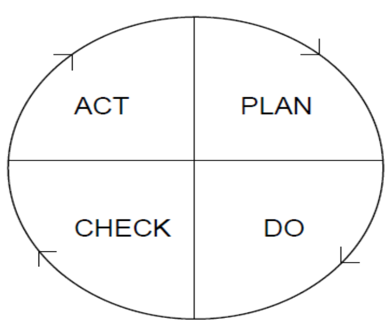
CUSTOMER – SUPPLIER RELATIONS :

Dr. Kaoru Ishikawa has given ten principles of customer-supplier relations. They are

1. Both the customer and supplier are fully responsible for the control of quality. (2M)
2. Both the customer and supplier should be independent of each other. (1M)
3. The customer is responsible for providing the supplier with clear and sufficient requirements so that the customer can know precisely what to produce. (2M)
4. Both the customer and supplier should enter into a non-adversarial contract. (1M)
5. The supplier is responsible for providing the quality that will satisfy the customer. (2M)
6. Both the customer and supplier should decide the method to evaluate the quality of the product or services. (2M)
7. Both the customer and supplier should establish in the contract the method by which they can reach an amicable settlement in case of any dispute. (1M)
8. Both the customers and supplier should continually exchange information. (2M)
9. Both the customer and supplier should perform business activities. (1M)
10. Both the customer and supplier should have the best interest of the end user in mind. (2M)

2 **Explain how PDCA cycle is practiced.Give an example.**(**15M**) **(Dec 2015)** BTL 1

Answer: Page No : 5.9 -Dr.V.Jayakumar



(3M)

PROBLEM SOLVING METHOD :

1. IDENTIFY THE OPPORTUNITY (3M)

- Identify the Problem
- Pareto analysis of external alarm signals.
- Pareto analysis of internal alarm signals.
- Proposals from key insiders.
- Proposals from suggestion schemes.

- Field study of user's needs.
- Comments of key people outside the organization.
- Customer surveys.
- Employee surveys.
- Brainstorming by work groups.
- Form the Team
- Team should be selected.
- Goals and milestones are established.
- Define the Scope.

Criteria for a good problem statement is as follows

- It clearly describes the problem.
- It states the effect.
- It focuses on what is known, unknown etc.
- It emphasizes the impact on the customer.

2. ANALYZE THE CURRENT PROCESS (3M)

The objective is to understand the process and how it is currently performed.
Step 1: The team to develop a process flow diagram.
Step 2: The target performance measures are defined.
Step 3: Collection of all available data and information.

Common items of data and information are

1. Customer information 2. Design information
3. Process information 4. Statistical information
5. Quality information 6. Supplier information

3. DEVELOP THE OPTIMAL SOLUTION(S) (3M)

This phase has the objective of establishing potential and feasible solutions and recommending the best solution to improve the process.

- Creativity plays the major role, and brainstorming is the principal technique.
- There are three types of creativity:
- Create new processes
- Combine different processes
- Modify the existing process

4. IMPLEMENT CHANGES (1M)

This phase has the objective of preparing the implementation plan, obtaining approval and implementing the process improvements.

- Approval of the quality council.
- Obtain the advice and consent of departments, functional areas, teams, individuals etc.
- Monitor the activity.

5. STUDY THE RESULTS (1M)

This phase has the objective of monitoring and evaluating the change by tracking and studying the effectiveness of the improvement efforts.

6. STANDARDIZE THE SOLUTION (1M)

- Institutionalize by positive control of the process.
- The quality peripherals – the system, environment and supervision must be certified.

	• Operators must be certified. **7. PLAN FOR THE FUTURE** The objective is to achieve improved level of process performance. • Regularly conduct reviews of progress by the quality council. • Establish the systems to identify area for future improvements. • Track performance with respective internal & external customers. • TQM tools and techniques are used to improve quality, delivery and cost.
3.	**Explain vendor development in detail.**(**15M**) **(Dec 2015)**BTL 1 **Answer: Page: 5.9 -Dr.V.Jayakumar** **RELATIONSHIP DEVELOPMENT :**(5M) For establishment of supplier relationship, the following are necessary. (a) Partnering (b) Supplier selection (c) Principles of customer / supplier relations (d) Certification (e) Periodic rating For relationship development, the following are necessary. (5M) (a) Inspection • 100% inspection • Sampling • Audit • Identity check (b) Training (2M) (c) Teams (2M) (d) Recognition and Reward (1M)

UNIT III-TQM TOOLS AND TECHNIQUES	
The seven traditional tools of quality – New management tools – Six sigma: Concepts, Methodology, applications to manufacturing, service sector including IT – Bench marking – Reason to bench mark, Bench marking process – FMEA – Stages, Types.	
PART * A	
Q.No.	**Questions**

1	**List the seven tools of quality/Elemental Statistical Tools. (Dec 2013, May 2015)** BTL 2 1. Check sheets, 2. Histograms 3, Cause and effect diagrams, 4. Pareto diagrams, 5. Stratification analysis, 6. Scatter diagrams, and 7. Control charts.
2	**Define six sigma. (June 2016)** BTL 1 Six Sigma is similar to Zero Defects (ZD), is a philosophical benchmark or standard of excellence proposed by Philip Crosby. Six Sigma strives for perfection. It allows for only 3.4 defects per million opportunities (or 99.99966 percent accuracy).
3	**When do you use the scatter diagram?(Dec 2015)** BTL 3 The purpose of the scatter diagram is to display what happens to one variable when another variable is changed. It is a preliminary investigation that checks whether strong or weak relationship exists between two variables.
4	**What are the benefits of six sigma? (Dec 2012)** BTL 1 A. In addition to a focus on defect, six sigma seeks to improve all aspects of operation. The key matrices include cycle time, process variation and yield. The ultimate result of six sigma will be increase in profit to the company.
5	**What is process capability? (June 2011)** BTL 1 Process capability analyses the relationship between two aspects of process like on design specification. If the specification limit is greater than control limits the process is capable of meeting specification and if it exceeds is not capable of meeting specifications.
6	**What are the reasons for bench marking? Or what is the purpose of bench marking? (May 2015, Dec 2015, June 2016)** BTL 1 i) Benchmarking aims at a goal setting process to facilitate comparison with the best ii) It aims at motivating and simulating company employees towards the goal of continuous quality improvement. iii) It aims at external orientation of the company iv) It aims at identifying a technological break through v) It aims at searching for industry best practices.
7	**What is Risk Prioritization Number? (June 2012)** BTL 1 RPN is a number used to prioritize the risk of failure in Potential Failure Mode and Effect Analysis. It ranges from 1 to 1000 and it's the multiplication of severity, detection and occurrence.
8	**What is check sheet?**BTL 1 A check sheet or tally sheet is a form for systematic data gathering and registering to get a clear view of the facts. A check sheet is used to indicate the frequency of a certain occurrence.
9	**Define histogram? And its types.** BTL 1 Histogram is a bar chart / diagram showing a distribution of variable quantities or characteristics. It is graphical display of the frequency distribution of numerical data. 1. Bell-shaped. 2. Double-peaked.3. Plateau. 4. Comb. 5. Skewed. 6. Truncated.7. Isolated peak and 8. Edged peak.
10	**State cause and effect diagram.** BTL 1 The cause and effect diagram or Fishbone diagram is a graphical-tabular chart to list and analyze the potential causes of a given problem. The potential or probable causes are identified and solutions or recommendations are brainstormed, execution plan prepared for implementation. A tree comparison was drawn up to explain between causes (hidden roots) and effects (foliage visible)

11	**Write about Pareto diagram.**BTL 1 A Pareto diagram is a diagnostic tool commonly used for separating the vital few causes that account for a dominant share of quality loss. Vital few (20%) and Trivial many (80%) means 20% of causes are the reason for 80% of problems and are referred to as 80:20 rules.
12	**What is scatter diagram?** BTL 1 The scatter diagram is a simple graphical device to depict the relationship between two variables. It is called as correlation diagram aims to establish relationship between two variables.
13	**What is control chart? What are the types of control charts?** BTL 1 A control chart is a graph that displays data taken over time and the variation of this data. Control charts for variables – for measurable data such as time, length, temperature, weight, pressure. Control charts for characteristics- for quantifiable data such as number of defects, typing errors in a report.
14	**When do you use control chart?** BTL 3 The purpose of control chart is to identify when the process has gone out of statistical control, thus signaling the need for some corrective action to be taken. We use to check the out of specification or rejections whether the trend is away from the nominal / mean/mid value so that the process centering can be done and can be brought within the limits of dimensions.
15	**Define statistics applications of statistical techniques.** BTL 4 Statistics is defined as the science that deals with the collection, tabulation, analysis, interpretation and presentation of quantitative data. Based on the data collected further investigations will be carried out to understand the process / product variability so that optimum controls can be introduced into the process to achieve consistency in quality and function of the product/service.
16	**Differentiate between producer's risk and consumer's risk.** BTL 4 Producer's risk: It is the probability of rejecting a good lot which otherwise would have been accepted. Consumer's risk: It is the probability of accepting a defective lot which otherwise would have been rejected.
17	**What is Benchmarking?** BTL 1 Benchmarking is comparing one's existing process outcomes with the best industrial achievement (say comparing productivity improvement with industry best for pump motor product say 97%). A target for achieving the industry best is referred as Benchmarking.
18	**Explain the stages of FMEA.** BTL 2 Specifying possibilities (Functions; possible root cause; effects; detection and prevention) and quantifying risks (Probability of cause; severity of effect).
19	**List down 7 new QC Tool.** BTL 1 The relationship diagram method; KJ method or affinity diagram; the systematic method; the matrix diagram method; Matrix data analysis; PDPC method and arrow diagram method.
20	**List down the six symbols used in a flowchart.**BTL 1

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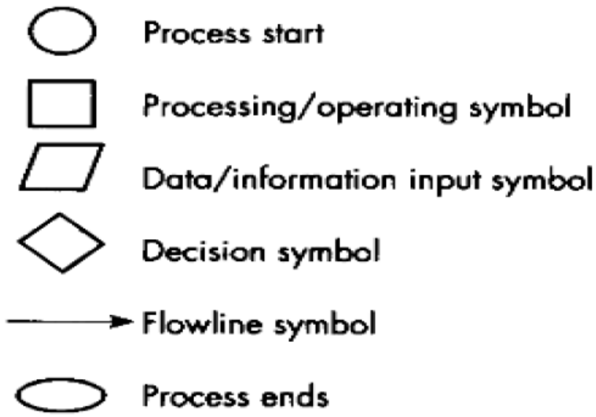
<tr><td></td><td>
</td></tr>
<tr><td></td><td>PART - B</td></tr>
<tr><td>1</td><td>Explain seven traditional tools for quality of TQM. (13M)(June 2010, Dec 2012, June 2014) BTL 2
Answer : Page :8.1 to 8.2 - Dr.V.Jayakumar

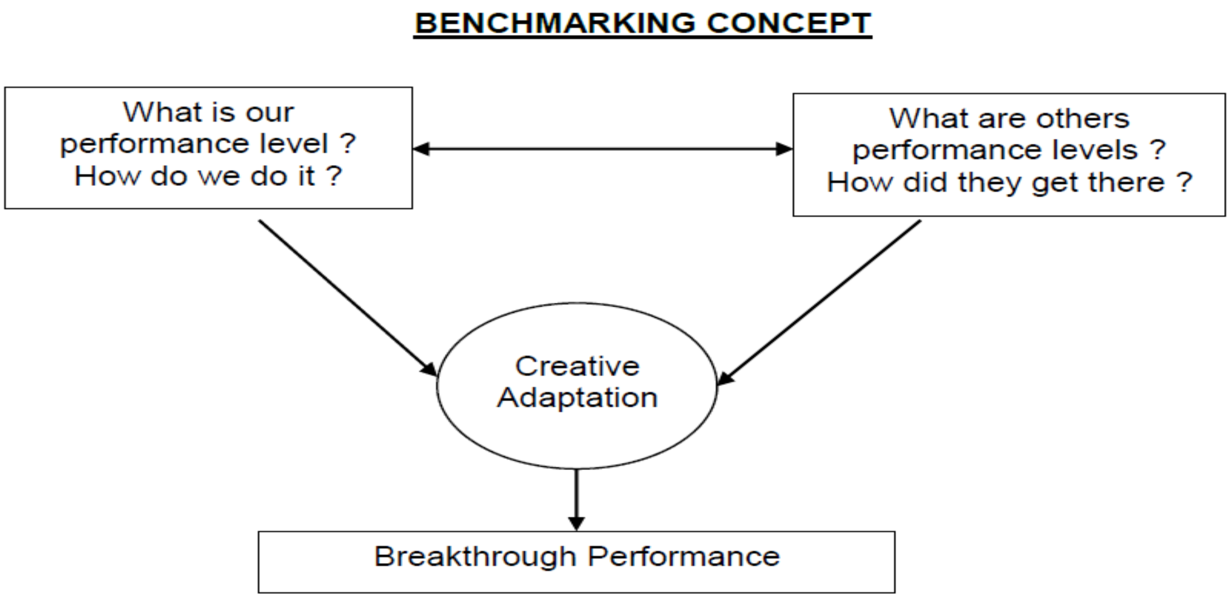
The tools of quality are

Check sheets (2M)
Histograms(2M)
Cause and effect diagrams(2M)
Pareto diagrams(2M)
Stratification analysis (2M)
Scatter diagrams (2M)
Control charts. Explain each in detail(1M)
</td></tr>
<tr><td>2.</td><td>Explain six sigma concepts with an example.(13M)(June 2013)BTL 2
Answer : Page :4.8 to 4.12 - Dr.V.Jayakumar

Six sigma stands for six standard deviation from mean (sigma is the Greek letter used to representstandard deviation in statistics).(2M)

Six sigma, similar to Zero Defect (ZD), is a philosophical benchmark or standard of excellence proposed by Philip Crosby.
Six sigma methodology provides the techniques and tools to improve the capability and reduce the defects in any process.
It was started by Motorola in 1987, in its manufacturing division.
Six sigma strives for perfection. It allows for only 3.4 defects per million opportunities (or99.999666 percent accuracy). Here a defect can be anything from a faulty party to an incorrectcustomer bill.
</td></tr>
</table>

	• Six sigma improves the process performance, decrease variation and maintains **consistent quality** of the process output. This leads to defect reduction and improvements in profits, product quality and customer satisfaction. • Six sigma incorporates the basic principles and techniques used in business, statistics and engineering. • **The objective of six sigma principle** is to achieve zero defects products/process. (5M) **NEED FOR SIX SIGMA**(3M) • A medium aircraft consists of 10,000 different parts. • At **quality**, 27 of those parts in an assembled aircraft would be defective. • So three sigma quality level cannot be accepted as good enough quality level. So we have to increase the sigma level (i.e., reducing the number of defectives). • In fact, even four sigma quality also not sufficient for the aircraft case. That's why six sigma in quality level is preferred than 3 Sigma and 4 Sigma quality levels. **THE CONCEPT OF SIX SIGMA:**(3M) • Before studying the concept of six sigma, first let us re-introduce the concept of process capability ratio (Cp) • (Assumption is that process is centered midway the specification limits, i.e., there is no shift in process mean) • Process capability ratio measures how well the product requirements match with the process capabilities. The higher the value of Cp' the better the match between product and process.
3.	**Explain bench marking and its steps with an example.** (**13M**)(**June 2016, Dec 2013, Dec 2015)**BTL 2 **Answer : Page :10.2 and 10.5 - Dr.V.Jayakumar** Benchmarking is a systematic method by which organizations can measure themselves against the best industry practices. (1M) Benchmarking is a systematic search for the best practices, innovative ideas, and highly effective operating procedures. (1M)



(1M)
The following six steps contain the core techniques of Benchmarking

1. Decide what to benchmark(1M)

- Benchmarking can be applied to any business or production process
- The strategy is usually expressed in terms of mission and vision statements
- Best to begin with the mission and critical factors
- Choosing the scope of the Benchmarking study
- Pareto analysis – what process to investigate
- Cause and Effect diagram – for tracing outputs back

2. Understand current performance (1M)

- Understand and document the current process
- Those working in the process are the most capable of identifying and correcting problems
- While documenting, it is important to quantify
- Care should be taken during accounting information

3. Plan (1M)

- A benchmarking team should be chosen
- Organizations to serve as the benchmark need to be identified
- Time frame should be agreed upon for each of the benchmarking tasks

There are three types of benchmarking
a. Internal
b. Competitive
c. Process

4. Study Others (1M)
Benchmarking studies look for two types of information

- How best the processes are practiced
- Measurable results of these practices

Three techniques for conducting the research are

- Questionnaires
- Site visits
- Focus groups

5. Learn from the data (1M)
Answering a series of questions like

- Is there a gap between the organization's performance and the performance of the best-in-class organizations?
- What is the gap? How much is it?
- Why is there a gap? What does the best-in-class do differently that is better?
- If best-in-class practices were adopted, what would be the resulting improvement?

Benchmarking studies can reveal three different outcomes

- Negative gap
- Parity
- Positive gap

6. Using the findings (1M)
The objective is to close the gap. For this

- Findings must be communicated to the people within the organization
- Action plans must be developed to implement new processes

Groups that must agree on the change

- Process owners
- Upper management

Steps for the development and execution of action plans are

- Specify tasks
- Sequence tasks
- Determine resources needs
- Establish task schedule
- Assign responsibility for each task
- Describe expected results
- 7. Specify methods for monitoring results (4M)

4. **Explain new seven TQM tools. (13M)(June 2008, Dec 2011, Dec 2015)**BTL 2
Answer : Page :9.1 - Dr.V.Jayakumar

- Why, Why (2M)
- Forced Field Analysis (1M)
- Nominal Group Technique (1M)

	• Affinity Diagram (1M) • Inter-Relationship Digraph (1M) • Tree Diagram (1M) • Matrix Diagram (1M) • Prioritization Matrices (1M) • Process Decision Program Chart (2M) • Activity Network Diagram(2M)
5.	**Explain the failure mode and effect analysis (FMEA) and its types with an example.** (**13M**)(**June 2016,June 2014, Dec 2015**)BTL 3 **Answer : Page :11.1 - Dr.V.Jayakumar** FMEA is an analytical technique that combines the technology and experience of people in identifying foreseeable failure modes of a product or process and planning for its elimination. It is a group of activities comprising the following : 1. Recognize the potential failure of a product or process. 2. Identify actions that eliminate / reduce the potential failure. 3. Document the process. (3M) Two important types of FMEA are • Design FMEA • Process FMEA (2M) **INTENT OF FMEA :** • Continually measuring the reliability of a machine, product or process. • To detect the potential product - related failure mode. • FMEA evaluation to be conducted immediately following the design phase. (2M) **BENEFITS OF FMEA:** • Having a systematic review of components failure modes to ensure that any failure produces minimal damage. • Determining the effects of any failure on other items. • Providing input data for exchange studies. • Determining how the high-failure rate components can be adapted to high-reliability components. • Eliminating / minimizing the adverse effects that failures could generate. • Helping uncover the misjudgements, errors etc. • Reduce development time and cost of manufacturing. (3M) **FMEA TEAM :** Engineers from - Assembly - Manufacturing - Materials - Quality - Service - Supplier - Customer (2M) **FMEA DOCUMENTATION :**(1M) The purpose of FMEA documentation is • To allow all involved Engineers to have access to others thoughts • To design and manufacture using these collective thoughts (promotes team approach)

6.

Explain about step and stages of FMEA.(13M) BTL 2
Answer : Page :11.3and 11.5- Dr.V.Jayakumar

Step 1 Review the process or product(2M)
- With the team, clearly define the subject of the FMEA study.
- Discuss the basic features, assembly, materials, construction, and desired functions.

Step 2 Brainstorm potential failure modes(2M)
- This can be a lot of fun.
- Use a variety of brainstorm techniques to get as broad a set of ideas as possible.
- A good technique is to individually create ideas the collate them using affinity grouping.
- Mix up the process with live brainstorming, anchoring, and focused concerns (i.e. high temperature, user abuse, etc).
- For most products, you may want to focus on one function or feature at a time.

Step 3 List potential effects of each failure mode(1M)
- Consider the possible failures and imagine what could then happen to the surrounding environment and people.

Step 4 Assign a severity ranking for each effect(1M)
- For each effect (consequence) provide a ranking score.
- Common scales include 3, 5, or 10 points.
- I often start with 10 point scale and adjust depending on the team and nature of the study.
- Common practice is to assign 9 or 10 for those effects that cause injury or death, or major damage to its surroundings.
- Document the scale actually used so others can interpret the study results properly.

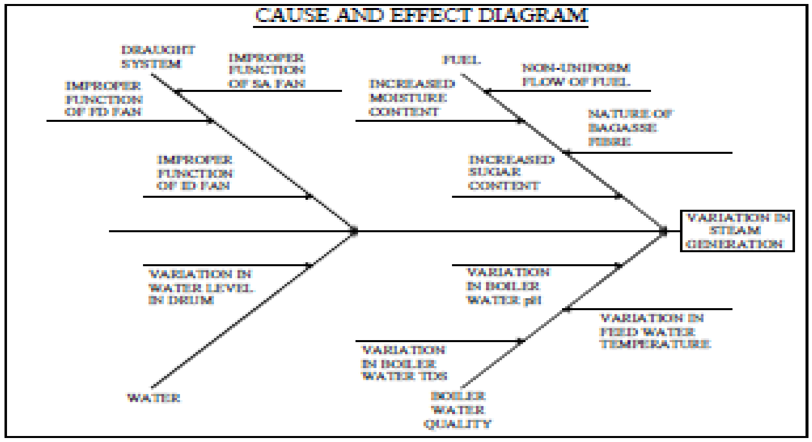
Step 5 Assign an occurrence ranking for each failure mode(1M)
- The worksheet includes a column of causes, which may help the team judge the relative frequency of occurrence of failure modes.
- Keep in mind that a failure mode may have many potential causes.

Step 6 Assign a detection ranking for each failure mode and/or effect(1M)
Detection is a bit different in ranking then severity or occurrence. A high score means the effect occurs without warning. It is not detectable.
Detection can include one or both of the following methods for alerting of potential failure.

Step 7 Calculate the risk priority number for each effect(1M)
- Just a bit of math. Multiple the severity, occurrence, and detection scores together to find the RPN value.
- Items that high dire consequences (high severity), occur often and provide no warning result in the highest RPN numbers relative to other potential failures.

	Step 8 Prioritize the failure modes for action(1M) • I recommend a three-step process here. • Address the severity 9 and 10 rankings as they are related to safety. • Review the prioritized ranks for groups of failure modes that one 'fix' (redesign, evaluation, or process improvement) may address. • The RPNs of the individual lines may not be the topped ranked value, yet collectively the action may provide significant risk reduction. • Address the highest remaining RPNs as the represent the remaining risk to the product working as expected. • No team that I know of addresses every potential failure. It is a balance of safety, functionality, customer expectation, and resources. **Step 9 Take action to eliminate or reduce the high-risk failure modes**(1M) • These may include gathering information, conducting experiments, considering design or process improvements, adding or removing functions, etc. • The idea is to do something with the study. • The prioritized list provides a guidance document that the entire team can use to focus on the highest risk areas first. **Step 10 Calculate the resulting RPN as the failure modes are reduced or eliminated**(2M) • Document the changes to the product. Ideally, the results of completed actions will reduce the risk. • Be sure to consider new information and function and recalculate. • FMEA is a process and as the program evolves and grows so should the FMEA. • It's a tool that helps the team address risks. Used as such it provides value.
7.	**Explain in detail check sheetsand Cause & Effect diagram**.**(13M) (Dec 2013)**BTL 2 **Answer : Page :4.8 to 4.12 - Dr.V.Jayakumar** The **cause and effect (CE) diagram** is a graphical-tabular chart to list and analysis the potential causes of a given problem.(2M) The cause and effect diagram is also called the fishbone diagram because of its appearance and the Ishikawa diagram after the man who developed it in 1943. (1M) Fig illustrates the basic structure of a cause and effect diagram.

Cause and effect diagram



(3M)

As shown in fig the diagram consists of a central stem leading to the effect (the problem), with multiple branches coming off the stem listing the various groups of possible causes of the problem.

The CE diagram has unlimited application in research, manufacturing, marketing, office operations, services and so forth.(2M)

The CE diagrams are used:

-To analyze cause and effect relationships;

-To facilitate the search for solutions of related problems;

-To standardize existing and proposed operations;

-To educate and train personnel in decision-making and corrective-action activities. (2M)

The cause and effect diagram may be constructed using the following steps:

- Define the effect (the problem) clearly and concisely.
- Mark the short description of the effect in a box. Then draw a line from this box towards left.
- List down all the possible minor and major causes through a brainstorming session.
- Mark the major causes on the branches and minor causes in the sub-branches of the CE diagrams.
- Look for possible solutions for these causes.
- Introduce the changes. (3M)

	PART C
1.	**Prepare a FMEA work sheet for an induction motor's shaft failure or a failure of your choice.(15M)(May 2015)**BTL 4

	Answer : Page :11.7,11.8,11.9 - Dr.V.Jayakumar **Failure mode and effect analysis** also known as **risk analysis** is a preventive measure tosystematically display the causes, effects, and possible actions regarding observed failures. (3M) **Objectives of FMEA:** The objective of FMEA is to anticipate failures and prevent them from occurring. FMEA prioritizes failures and attempts to eliminate their causes.(2M) FMEA is an engineering technique is used to define, identify and eliminate known and or potential failures, problems, errors which occur in the system, design, process and service before they reach the customer. (2M) **Benefits of FMEA:** Improve product/process reliability and quality. • Increase customer satisfaction. • Early identification and elimination of potential product/process failure modes. • Prioritize product or process deficiencies • Capture engineering/organization knowledge • Document and track the actions taken to reduce risk • Provide focus for improved testing and development. • Minimize late changes and associated cost. • Act as catalyst for teamwork and idea exchange between functions.(8M)
2.	**Develop procedure for implementation of SIX sigma in a manufacturing organization.**(**15M**)**(May 2015)**BTL 6 **Answer : Page :13.3 - Dr.V.Jayakumar** **NEED FOR SIX SIGMA** We know that, the three sigma quality, i.e., the natural variability equal to tolerance (= upper specification limit – lower specification limit). It means, in normal distribution curve, only 0.27% of the output would be expected to fall outside the specifications limits. (3M) **THE CONCEPT OF SIX SIGMA:** Before studying the concept of six sigma, first let us re-introduce the concept of process capability ratio (Cp) (2M) (Assumption is that process is centered midway the specification limits, i.e., there is no shift in process mean) (2M) Process capability ratio measures how well the product requirements match with the process capabilities. The higher the value of Cp' the better the match between product and process. (2M)

	The real meaning of 3sigma concept: • A medium aircraft consists of 10,000 different parts. • At 3sigmaquality, 27 of those parts in an assembled aircraft would be defective. • So three sigma quality level cannot be accepted as good enough quality level. So we have to increase the sigma level (i.e., reducing the number of defectives). • In fact, even four sigma quality also not sufficient for the aircraft case. • That's why six sigma quality level is preferred than 3sigma and 4sigma quality levels. (6M)
3.	**Explain about check sheet, Histogram to tally number of errors.(15M**)BTL 6 **Answer : Page :8.6- 8.9 - Dr.V.Jayakumar**

4. CHECK SHEETS

CHECK SHEET

Product : Bicycle

Nonconformity Type	Check					Total
Blister	IIII	IIII	IIII	IIII	I	21
Light spray	IIII	IIII	IIII			15
Drips	IIII	IIII	IIII	IIII	IIII	25
Others	IIII	IIII	IIII	IIII	IIII	25
TOTAL						86

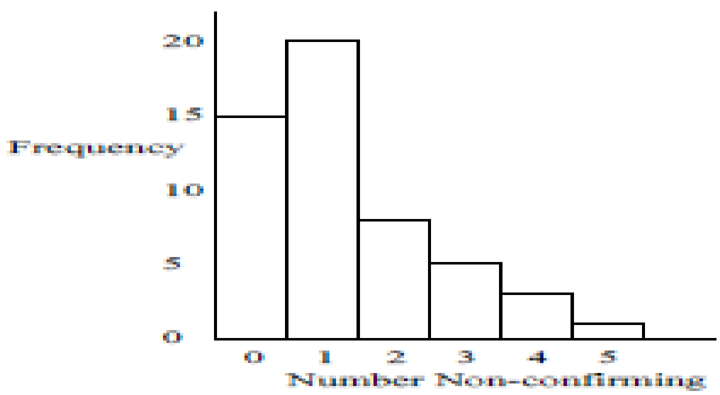
5. HISTOGRAM

Number of Errors

0	1	3	0	1	0	1	0
1	5	4	1	2	1	2	0
1	0	2	0	0	2	0	1
2	1	1	1	2	1	1	
0	4	1	3	1	1	1	
1	3	4	0	0	0	0	
1	3	0	1	2	2	3	

Tally of Number of Errors

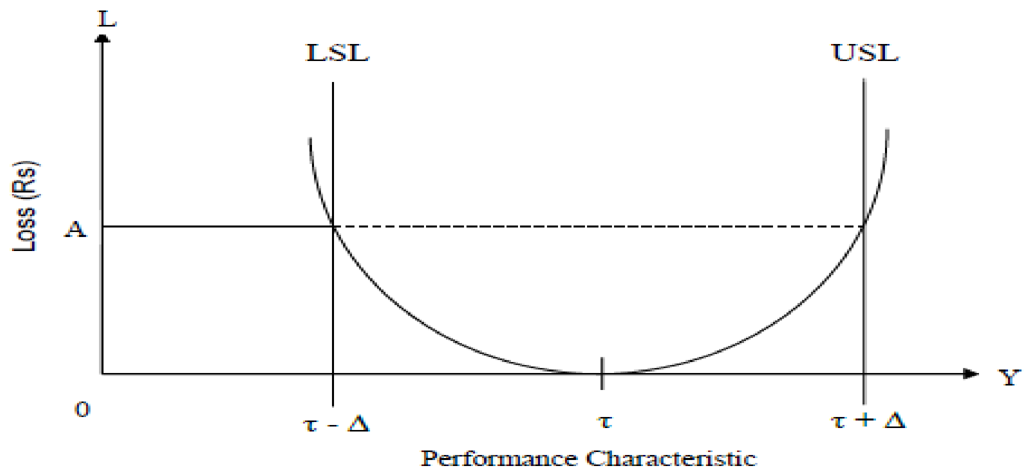
Number Non -conforming	Tabulation	Freq.
0	IIII IIII IIII	15
1	IIII IIII IIII IIII	20
2	IIII III	8
3	IIII	5
4	III	3
5	I	1



UNIT IV-TQM TOOLS AND TECHNIQUES	
Control Charts - Process Capability - Concepts of Six Sigma - Quality Function Development (QFD) - Taguchi quality loss function - TPM - Concepts, improvement needs - Performance measures.	
PART * A	
Q.No.	**Questions**
1	**What is quality circle and its structure? (June 2013, Dec 2013)** BTL1 QC is a group activity practiced at regular intervals which focuses on quality practices. It comprises of the line operator, supervisor and project engineering, headed by the lowest cadre, i.e., line operator. QC stresses upon the ownership concept to entrust the responsibilities and work as a team to achieve consistent quality in products/service offerings Executive committee, steering committee, facilitators, QC leader, Deputy Leader, members 5-8%.
2	**Give the essential feature of Total Productive Maintenance (TPM).(June 2012, Dec 2013)** BTL 1 TPM is keeping plant and equipment at their highest productive level through cooperation of all areas of the enterprise. TPM brings maintenance into focus as a necessary and vital part of the business. It is not regarded as a non-profit activity. Down time for maintenance is scheduled as an integral part of the manufacturing process.
3	**What are the three categories of losses identified in TPM? (June 2014)** BTL 1 (a) Losses that impede equipment efficiency (b) Losses that impede human work efficiency and (c) Losses that impede effective use of production resources.
4	**What is Taguchi's Loss function(TQLF)? (June 2012, June 2015)** BTL 1 The essence of the loss function concept is that whenever a product deviates from its target performance it generates a loss to society. This loss is minimum when performance is right on target, but it grows gradually as one deviates from the target.
5	**What is the importance of Taguchi's quality loss function (TQLF)? (Dec 2015)**BTL 1 The essence of TQLF is that whenever a product deviates from its target performance, it generates a loss to society. This loss is minimal when performance is right on the target, but it grows gradually as one deviates from the target.
6	**What sparked the interest of Indian Manufactures in quality circles? (Dec 2015)** BTL 1 i) Quality circles effects on individual characteristics ii) Quality circles effects on individual relations with others iii) Quality circles effects on workers and their attitudes towards the company.
7	**Indicate the different parameters used for quality performance measurement. (May 2015)**BTL 3 i) Customer ii) Production iii) Supplier iv) Research & Development v) Human resources vi) Marketing /Sales vii) Administration.
8	**What are the eight pillars of TPM?** BTL 1

	The eight pillars of TPM are: 1. 5S 2. JishuHozen (Autonomous Maintenance) 3. Kobetsu Kaizen (KK) 4. Planned Maintenance (PM) 5. Quality Maintenance (QM) 6. Training 7. Office TPM 8. Safety, Health and Environment.
9	**What is Business Process Reengineering (BPR)?** BTL 1 The fundamental rethinking and radical redesign of business processes to improve performance dramatically in terms of measures like cost, quality, service, and speed. BPR concentrates on stable and effective changes and not upside down change and changes planned are process accommodative and not adjustable.
10	**Give Taguchi's definition of quality.** BTL 2 "Loss imparted to society by a product during its life cycle", i.e. the costs incurred in the production process as well as the costs encountered during use by the customer.
11	**What is voice of customer (VOC)?** BTL 1 It is the requirements of the customers in a product and the requirements are described by them in their own words. VOC brings in the customer mind-set and does not consider with market dynamics. VOC is the basic step followed in House of quality concept.
12	**Give the seven basic steps to get an organization started toward TPM.**BTL 3 1. Management learns the new philosophy 2. Management promotes the new philosophy 3. Training is funded and developed for everyone in the organization 4. Areas of needed improvement are identified 5. Performance goals are formulated 6. An implementation plan is developed **7.** g) Autonomous work groups are established
13	**What are the steps required to construct an affinity diagram?** BTL 1 1. Phrase the objective 2. Record all responses 3. Group the responses **4.** iv. Organize groups in an affinity diagram.
14	**What are the performance measures of TQM?** BTL 1 Customer orientation, value based operations, performance compatibility, teamwork, development and monitoring. Current perspective includes VAVE (Value added value engineering) integrated with TQM, concentrates on productivity, as productivity is producing parts with right quality and quantity.
15	**What is QFD?** BTL 1 Quality function development may be defined as a system for translating consumer requirements into appropriate requirements at every stage, from research through product design and development, to manufacture, distribution, installation and marketing, sales and service.
16	**What is Poka Yoke?** BTL 1 Poka Yoke is Mistake proofing. Humans tend to make mistakes. Designing the product with the ability to alarm or inform the humans that their handling is wrong. Automation imbibes Poka-

	yoke features added to it thus separate focus on error-proofing has no longer required in a manufacturing cell.
17	**Define TPM.** BTL 2 Total Productive Maintenance was aimed at all the activities with the slogan "Maintenance for Profit". The prime objectives of TPM are improving effective operation rate of machines and equipments; improving reliability for the development of machines and equipments and enhancing manufacturing morale.
18	**What are the benefits of QFD?** BTL 1 i. Customer driven ii. Reduces implementation time iii. Promotes teamwork iv. Provides documentation.
19	**What sparked the interest of Indian Manufactures in quality circles?** BTL 1 i) Quality circles effects on individual characteristics ii) Quality circles effects on individual relations with others iii) Quality circles effects on workers and their attitudes towards the company.
	PART * B
1	**Explain about Taguchi's Quality Loss Function.** (**13M**) **(June 2013, June 2012, Dec 2014)** BTL 2 **Answer : Page :15.1 to 15.9 - Dr.V.Jayakumar** Taguchi's Quality Loss Function concept combines cost, target and variation in one metric with specifications being of secondary importance. Taguchi has defined quality as the loss imparted to society from the time a product is shipped. Societal losses include failure to meet customer requirements, failure to meet ideal performance and harmful side effects. (3M) **CUSTOMERS PERCEIVE QUALITY AS MEETING THE TARGET RATHER THAN JUST MEETING THE SPECIFICATIONS.** There are three common quality loss functions 1. Nominal - the - best. 2. Smaller - the - better. 3. Larger - the - better. (3M) **NOMINAL – THE – BEST :** Although Taguchi developed so many loss functions, many situations are approximated by the quadratic function which is called the **Nominal – the – best** type.



Quadratic Loss Function (2M)

The quadratic function is shown in figure. In this situation, the loss occurs as soon as the performance characteristic, y, departs from the target τ.

At τ, the loss is Rs. 0.

At LSL (or) USL, the loss is Rs. A.

The quadratic loss function is described by the equation L = k (y - τ) 2.

Where,

L = cost incurred as quality deviates from the target.

y = Performance characteristic

τ = target

k = Quality loss coefficient.

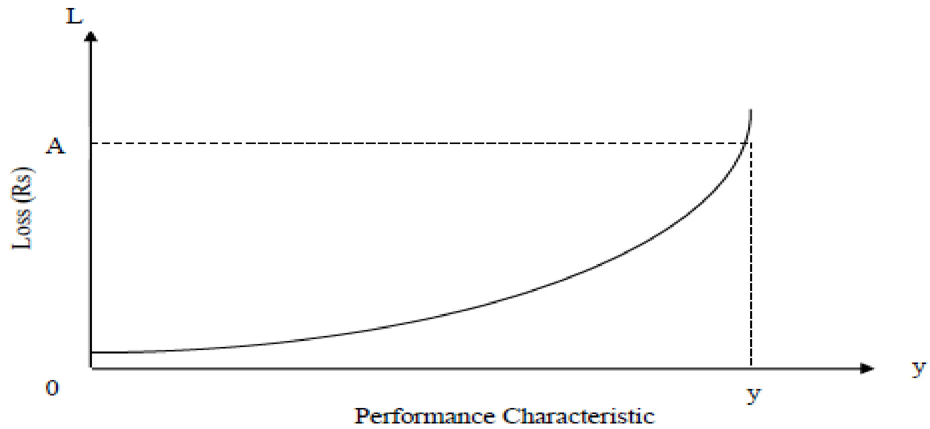
The loss coefficient is determined by setting Δ = (y – τ), the deviation from the target. When Δ is the USL (or) LSL, the loss to the customer of repairing (or) discarding the product is Rs. A.

Thus,

K = A / (y – τ)2 = A / Δ2 . (2M)

SMALLER – THE – BETTER :

The following figure shows the smaller – the – better concepts.



Smaller-the-better

The target value for **smaller – the – better** is 0. There are no negative values for the performance characteristic.

The radiation leakage from a microwave appliance, the response time for a computer, pollution from an automobile, out of round for a hole etc. are the performance characteristics for this concept. (2M)

LARGER – THE – BETTER :

The following figure shows the concept of the Larger – the – better.

In the Larger – the – better concept, the target value is ∞ (infinity), which gives a **zero loss**. There are no negative values and the worst case is at y = 0. Actually, larger – the – better is the reciprocal of smaller – the – better. The performance characteristics in Larger – the – better are bond strength of adhesives, welding strength etc. (1M)

2.

Briefly explain the steps involved in QFD. (13M) (Dec 2012, Dec 2013,Dec 2014)BTL 2

Answer : Page :14.7 - Dr.V.Jayakumar

QUALITY FUNCTION DEVELOPMENT PROCESS:

Phase 1: product planning

Step1: list customer requirements

Step2: List technical descriptors

Step3: Develop a relationship between WHATS AND HOWS

Step4: Develop a interrelationship matrix between HOWS

Step5: Do competitive assessments

	Step6: Develop prioritized customer requirements Step7: Develop prioritized technical descriptors. (4M) **Phase 2: part development** Step8: Deploy QFD process down to sub-components level both in terms of requirements and characteristics. Step9: Deploy the component deployment chart. Relate the critical sub-component control characteristics. (2M) **Phase 3: process planning** Step10: Develop the relationship between the critical characteristics and process used to create the characteristics Step11: Develop the control plan relating critical control to critical processes. (3M) **Phase 4: production planning** Step 12: Tabulate operating instructions from process requirements Step13: develop prototype and do testing Step14: Launch the final product to the market.(4M)
3.	**Explain each section of the basic structures of house of quality by selecting a suitable product.**(13M)**(June 2016, Jun 2010, June 2013, June 2014, May 2015, Dec 2015)**BTL 2 **Answer : Page :14.3 - Dr.V.Jayakumar** The primary planning tool used in QFD is the house of quality. The house of quality converts the voice of the customer into product design characteristics. QFD uses a series of matrix diagrams, also called 'quality tables', resembles connected houses.(2M) **Basic structure of house of quality:** 1. Customer requirements (1M) 2. Prioritized customer requirements (2M) 3. Technical descriptors (1M) 4. Relationship matrix (1M) 5. prioritized technical descriptors (2M) 6. Competitive assessments (2M) 7. Develop a relationship matrix between WHATS AND HOWS (2M)
4.	**Explain QFD methodology with an example.**(13M)**(Dec 2013, May 2015)** BTL 2 **Answer : Page :14.6 - Dr.V.Jayakumar** **Definition:**Quality function deployment may be defined as a system for translating consumer requirements into appropriate requirements at every stage, from research through product design

	and development, to manufacture, distribution, installation and marketing, sales and service. (2M) **OBJECTIVES OF QFD:** 1. To identify the true voice of the customer and to use this knowledge to develop products, which satisfy customers. 2. To help in the organization and analysis of all the pertinent information associated with the project. 3. Quality function development aims at translating the customers' voice into product specifications. (2M) **QC** is a group activity practiced at regular intervals which focuses on quality practices.Structure of Quality circle involves the following: 1. Executive Committee, 2. Steering committee, 3. Facilitators, 4. QC Leader 5. Deputy Leader Members (2M) This is required in Industries in order : 1. To establish baseline measures and reveal trends 2. To determine which processes need to be improved 3. To indicate process gain and losses 4. To compare goals with actual performance 5. To provide information to make informed decisions 6. To determine overall performance of the organization (3M) The commonly used techniques are 1. Time series trend graphs 2. Control charts 3. Capability index 4. Taguchi loss function 5. Cost of poor quality 6. Quality awards (4M)
5.	**Briefly explain the steps involved in QFD. (13M) (Dec 2012, Dec 2013, Dec 2014)**BTL 2 **Answer : Page :14.7 - Dr.V.Jayakumar**

	QUALITY FUNCTION DEVELOPMENT PROCESS: **Phase 1: product planning** Step1: list customer requirements Step2: List technical descriptors Step3: Develop a relationship between WHATS AND HOWS Step4: Develop a interrelationship matrix between HOWS Step5: Do competitive assessments Step6: Develop prioritized customer requirements Step7: Develop prioritized technical descriptors. (4M) **Phase 2: part development** Step8: Deploy QFD process down to sub-components level both in terms of requirements and characteristics. Step9: Deploy the component deployment chart. Relate the critical sub-component control characteristics. (2M) **Phase 3: process planning** Step10: Develop the relationship between the critical characteristics and process used to create the characteristics Step11: Develop the control plan relating critical control to critical processes. (3M) **Phase 4: production planning** Step 12: Tabulate operating instructions from process requirements Step13: develop prototype and do testing Step14: Launch the final product to the market. (4M)
6.	**Explain the types and the analysis techniques of cost of quality.** (**13M**) **(June 2013)** BTL 2 **Answer : Page :14.2 - Dr.V.Jayakumar** 1. Prevention costs-These are costs that are incurred in preventing a quality problem from arising. 2. Appraisal costs- These are costs that are incurred in assessing the products/services conform to requirements. (6M)

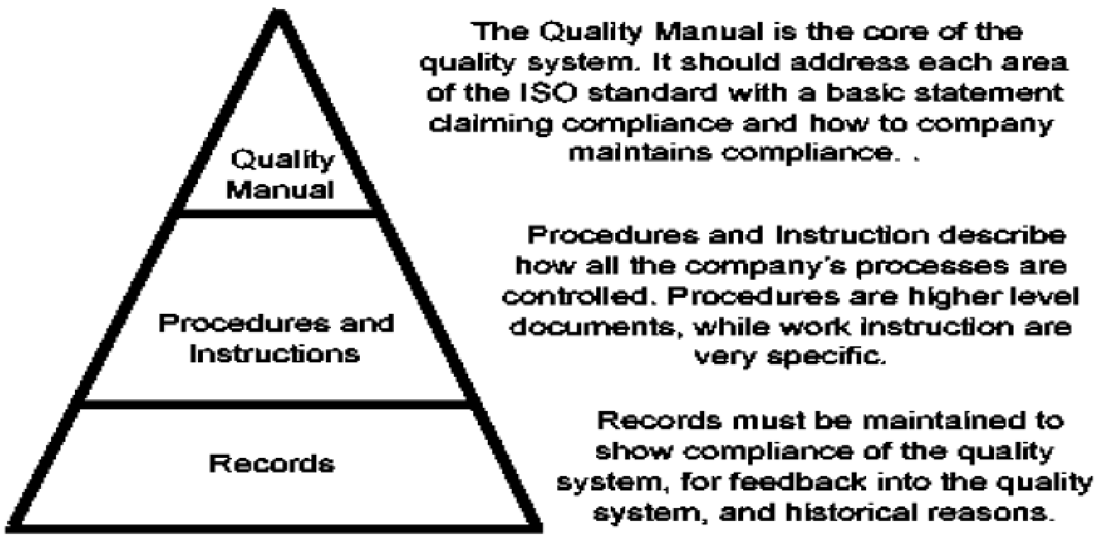
	3. Internal failure costs- These are costs required to identify, repair, replace, or dispose of defective products/services prior to delivery to the customer. (4M) 4. External failure costs- Cost of warranty, cost of loss of image, cost of service etc. (3M)
7.	**Explain six sigma concepts in detail.(OR) Develop procedure for implementation of sixsigma in a manufacturing organization.**(13M)**(May 2013, May2012, Nov 2011, May 2014, Nov 2014, Nov 2016**) BTL 4 **Answer : Page :13.3 - Dr.V.Jayakumar** **Six sigma:** A vision of quality which equates with only 3.4 defects per million opportunities (DPMO) for each product or service transaction and strives for perfection. Six sigma is a systematic method for process and product improvement and for measuring performance variation. It is also a metric for valuating performance we quality and a standard of excellence. (4M) **Six sigma process:** DMAIC **D**efine --> **M**easure --> **A**nalyze --> **I**mprove -->**C**ontrol □ **Define**: Define the Problem or Project Goal that needs to be addressed. □ **Measure**: Measure and determine customers needs and specifications. □ **Analyze**: Analyze the process to meet the customer needs. (4M) **Advantages of six sigma:** 1. Improved customer satisfaction 2. Ensures products/service meeting customer requirements 3. Reduction of waste and defects 4. Variation reduction well-defined roles and responsibilities 5. Empowering all employees for better improvement. Improved communication (5M)
	PART*C
1.	**With an example, draw QFD methodology and explain.**(15M)**(Dec 2013, May 2015)**BTL 2 **Answer : Page :14.6 - Dr.V.Jayakumar** Phase 1: product planning

	Step1: list customer requirements Step2: List technical descriptors Step3: Develop a relationship between WHATS AND HOWS Step4: Develop a interrelationship matrix between HOWS Step5: Do competitive assessments Step6: Develop prioritized customer requirements Step7: Develop prioritized technical descriptors. (5M) Phase 2: part development Step8: Deploy QFD process down to sub-components level both in terms of requirements and characteristics. Step9: Deploy the component deployment chart. Relate the critical sub-component control characteristics. (2M) Phase 3: process planning Step10: Develop the relationship between the critical characteristics and process used to create the characteristics Step11: Develop the control plan relating critical control to critical processes.(3M) Phase 4: production planning Step 12: Tabulate operating instructions from process requirements Step13: develop prototype and do testing Step14: Launch the final product to the market.(5M)
2.	**Explain the stages involved in TPM.** (**15M**)**(May 2014)** BTL 2 **Answer : Page :16.6 - Dr.V.Jayakumar** **TPM** is keeping plant and equipment at their highest productive level through cooperation of all areas of the enterprise. TPM brings maintenance into focus as a necessary and vital part of the business. It is not regarded as a non-profit activity. Down time for maintenance is scheduled as an integral part of the manufacturing process. (3M) 1. The overall goals of TPM are: a. Maintaining and improving equipment capacity. (2M) b. Maintaining equipment for life. (2M) 2. Using support from all areas of operation. (3M)

	3. Encouraging inputs from all employees. (3M) **4.** Using teams for continuous improvement. (2M)
3.	**Explain the pillars of TPM and its benefits and how they are implemented.**(15M) **(June 2016, May 2015,Nov 2015)**BTL 2 **Answer : Page : 16.6- Dr.V.Jayakumar** **TPM PHILOSOPHY – CONCEPT OF TPM** : Total Productive Maintenance (TPM) is an extension of the Total Quality Management (TQM) philosophy to the maintenance function. (2M) TPM has the following steps: 1. Management should learn the new philosophy of TPM. (2M) 2. Management should promote the new philosophy of TPM. (1M) 3. Training should be funded and developed for everyone in the organization.(1M) 4. Areas of needed improvement should be identified. Loss measurements to identify improvement needs are Down time losses, Reduced speed losses,Poor quality losses (3M) 5. Performance goals should be formulated. (2M) 6. An implementation plan should be developed. (2M) 7Autonomous worth groups should be established. (2M)

UNIT V-QUALITY SYSTEMS	
Need for ISO 9000 - ISO 9001-2008 Quality System - Elements, Documentation, Quality Auditing - QS 9000 - ISO 14000 - Concepts, Requirements and Benefits - TQM Implementation in manufacturing and service sectors.	
PART * A	
Q.No.	**Questions**
1	**What are the general requirements of quality management system? (Dec 2011)** BTL1 The organization shall establish, document, implement and maintain a quality management system and continually improve its effectiveness in accordance with the requirements of this International Standard.
2	**What are ISO 9000 standards or Objectives of ISO 9000 quality standards? (June 2007, 2014, Dec 2013, Dec 2014)** BTL1 ISO 9000 are a set of quality standards aimed at promoting the growth of international trade by facilitating harmonious interactions between suppliers and customers located in diverse locations globally. It is a quality management system [QMS] to ensure quality of products and services.
3	**Compare QS 9000 with TS 16949 quality systems. (May 2015)** BTL4 Product approach — Process approach Customer satisfaction — Employees motivation More focus on documentation — Less focus on documentation
4	**Define quality system audit. (June 2010)** BTL1 Quality system audits is a systematic, independent examination to determine whether quality activities and results comply with planned arrangements, whether these arrangements are implemented effectively, and whether these are suitable to achieve objectives.
5	**What is third party audit? (Dec 2010)** BTL1 The third party certification audit is carried out much in the same way as first party and second party quality system assessments and audits. However, the big difference is that an independent accredited auditing body carries out the assessment and audit, as opposed to carrying it out by the organization themselves.
6	**What is Environment Management Systems Standards? (Dec 2014)** BTL1 An EMS meeting the requirements of ISO 14001:2004 is a management tool enabling an organization of any size or type to: 1. Identify and control the environmental impact of its activities, products or services 2.To improve its environmental performance continually 3. To implement a systematic approach to setting environmental objectives and targets, to achieving these and to demonstrating that they have been achieved.
7	**What is QS 9000 and who have developed the system? (June 2013)** BTL1 QS 9000 is an extension of ISO 9000 and is only for automotive industries, this was developed by

	three big industries like Ford, Chrysler and General Motors of U.S.A in 1994.
8	**List the various clauses of ISO 9001-2000 standards. (May 2015)** BTL5 1. Scope 2. Normative reference 3. Terms and definitions 4. Quality management systems 5. Management responsibility 6. Resource management 7. Product realization 8. Measuring, analysis and improvement.
9	**What is quality system? (June 2016)** BTL1 Aggregate of the organizational activities, incentives, plans, policies, procedures, resources, responsibilities and the infrastructure required in formulating and implementing a total quality management approach.
10	**What are the items covered by ISO 9000 regarding quality? (Dec 2015) (BTL 1)** 1. Fundamental and vocabulary 2. Requirements 3. Guidelines for performance improvement
11	**Write short notes on ISO Certification. (Dec 2015)**BTL2 ISO defined the term quality systems as follows: The quality system is the organizational structure, responsibilities, procedures, processes and resources for implementing quality management.
12	**What are the different stages in conducting quality audit?** BTL1 1. Audit planning – schedules, personnel, notifications, checklist 2. Performance – opening meetings, audit process, noting of non-conformities 3. Reporting – Observations, suggestions for corrective action 4. Follow-up – implementation of corrective action.
13	**What are the documentation requirements of quality management systems?** BTL1 documented statements of a quality policy and quality objectives 1. quality manual 2. documented procedures and records required by this International Standard 3. documentsincluding records **4.** determined by the organization to be necessary to ensure the effective planning, operation and control of its processes
14	**What is quality manual?** BTL1 The organization shall establish and maintain a quality manual that includes; 1. the scope of the quality management system, including details of and justification for any exclusions 2. the documented procedures established for the quality management system or reference to them **3.** A description of the interaction between the processes of the quality management system.
15	**What is the need for ISO standards?** BTL1 ISO 9000 is needed to unify the quality terms and definitions used by industrialized nations and use terms to demonstrate a supplier's capability of controlling its processes. ISO 9000 and ISO 9002 are customer centric quality systems that focus on satisfying the customer by all means.

16	**Draw the documentation pyramid. (Dec 2011)**BTL2  The ISO 9001 Documentation Pyramid
17	**Give the objectives of internal audit.** BTL3 1. Determine the actual performance conforms to the documented quality systems 2. Initiate corrective action activities in response to deficiencies 3. Follow up on noncompliance items of previous audits **4.** Provide continued improvement in the system through feedback to management.
18	**What are the benefits of ISO 14001?** BTL1 1. Facilitate trade and remove trade barriers 2. Improve environmental performance of planet earth 3. To build consensus that there is a need for environment management and a common terminology for EMS.
19	**What is management's responsibility for ISO.**BTL1 Top management shall provide evidence of its commitment to the development and implementation of the quality management system and continually improving its effectiveness by a) communicating to the organization the importance of meeting customer as well as statutory and regulatory requirements, b) establishing the quality policy, c) ensuring that quality objectives are established, d) conducting management reviews, and e) ensuring the availability of resources.
20	**What are the different types of audit?**BTL1 First party audit (internal), Second party audit (by customer), and Third party audit (by independent agency). Another classification: System audit, Process audit, Product audit, Adequacy audit, and Compliance audit.
	PART * B
1	**Explain the elements and implementation of ISO 9000 (ISO 9000:2000) standards. (13M)(Dec 2012,2013, 2014, June 2014)** BTL2 **Answer : Page :18.27 - Dr.V.Jayakumar**

	1. ELEMENTS OF ISO 1. Management responsibility 2. The Quality system 3. Contract review 4. Design control 5. Document and data control 6. Purchasing 7. Control of customer-supplied product 8. Product identification and traceability 9. Process control 10. Inspection and testing 11. Control of inspection, measuring and test equipment 12. Inspection and test status 13. Control of nonconforming product 14. Corrective and preventive action 15. Handling, storage, packaging, preservation and delivery 16. Control of quality records 17. Internal quality audits 18. Training 19. Servicing 20. Statistical techniques.(10M) **2. Implementation steps** 1. Top management commitment 2. Appoint the management representative 3. Awareness 4. Appoint an implementation team 5. Training 6. Time schedule 7. Select element owners 8. Review the present system 9. Write the document 10. Install the new system. 11. Internal audit 12. Management review 13. Pre-assessment 14. Registration(3M)
2.	**Explain the features and procedures to obtain ISO 14000 environmental certification.**(13M) **(Dec 2013,May 2015)** BTL2 **Answer : Page :19.6 - Dr.V.Jayakumar**

	An EMS meeting the requirements of ISO 14001:2004 is a management tool enabling an organization of any size or type to: Identify and control the environmental impact of its activities, products or services, Implement a systematic approach to setting environmental objectives and targets, to achieving these and to demonstrating that they have been achieved.(5M) General requirements 1. Environmental policy 2. Planning 3. Implementation and operation 4. Checking and corrective action 5. Management review (8M)
3.	**Discuss briefly about four important documents to be prepared for ISO 9000 certification.** (**13M**)BTL2 **Answer : Page :18.30 - Dr.V.Jayakumar** **Steps in ISO certification:** 1. Top management commitment 2. Appoint the management representative 3. Awareness 4. Appoint the implementation team 5. Training 6. Time schedule 7. Select element owners 8. Review the present system 9. Write the documents 10. Install the new system 11. Internal audit 12. Management review 13. Pre-assessment 14. Registration 15. Award of ISO 9000 certification. Each point must be explained briefly.(10M) Documents: 1 Statethe quality policy and objectives 2: Description of the activities needed to implement the system 3: Detailed work Documents 4:Resultsof implementing the quality system (3M)
4.	**Explain the needs for documentation in Quality Management System and the documents to be prepared for QMS.**(**13M**)**(April/May 2015)(Nov/Dec 2014) (Nov/Dec 2010) (May/June 2012)**BTL2 **Answer : Page :18.30 - Dr.V.Jayakumar** **Documentation of Quality System:** **I. Necessity for Documentation**

	1. It is understood that the proper documentation is the pre-requisite for implementing quality system. 2. The document serves as a reference for the management, the staff and other agencies whose involvement is essential for implementation of the quality system. 3. Documentation serves as a reference 4. Brings about clarity of objectives and target 5. Provides standardization in work procedures 6. Brings about confidence consistency in operations 7. Develops confidence amongst employees 8. Generates customer's confidence 9. Provides a basis for continuous improvement etc. (5M) **II.Documents to be prepare** 1. Statements ofthe quality policy and objectives. 2: Description of the activities needed to implement the system. 3: Detailed work Documents. 4: Resultsof implementing the quality system (3M) **Quality Policy Manual (What? Why?)** 1. This is the first level of documentation. This is the document that defines „what will be done" and „why". 2. The „why" can be stated just once as a quality policy statement. This statement should be a short and simple definition of the organization's quality intensions 3. The policy manual communicates the quality policy and objectives of an organization. (3M) **Quality System Procedures (Who? When? Where?)** Second level of documentation 1. These procedures describes the methods that will be used to implement and perform the stated policies 2. These procedures define who should perform specific tasks, when the task should be done, and where documentation will be made. **3.** These documents collectively definethe organization's operations fromreceiving an enquiry to delivery completed product or service. (2M)
5.	**Explain the benefits of implementing ISO 14000 standards.(13M) (Dec 2014)** BTL 2 **Answer : Page :19.20 - Dr.V.Jayakumar** 1. This third level of documentation is company specific. It gives details of hoe individual work processes (machining, welding etc) are carried out within a company. 2. Work instructions should also specify how the work should be done. who should undertake the work and what records are to be maintained. 3. The work instructions may be in the form of a detailed drawing, recipe, routing sheet, specific job function, photograph, video or simply a sample for comparison of conformity.

	4. The work instructions should be written by the employees who perform the task.(5M) **Records, Formats, Forms (Evidence)** 1. Records provide evidence of activity having been performed in compliance with quality system procedure. 2. Records may be forms that are filled out, a stamp of approval on a product, or a signature and date on some type of document. 3. Records are used to provide traceability of actions taken on a specific product or batch of products. (3M) **Benefits of documentation:** **1.** Documentationregularizes the method of performing the day-to-day activities. 2. It provides formats for standardizing practices 3. It provides reference for assessing degree of enforcement in practice. 4. It facilitates trouble shooting for tracing back on the processes 5. It demonstrates the ISO quality system certification. (5M)
6.	**Explain the features of ISO 14000 and procedure to obtain ISO 14000 certification.**(13M)**(April 2015, Nov 2010, Nov 2013, Nov2014,Nov 2011, May 2014, Dec 2016)**BTL2 **Answer : Page :4.8 to 4.12 - Dr.V.Jayakumar** 1. An ISO 14000 standards are a set of norms for Environmental ManagementSystem (EMS) either at organization and process level or product level 2. The overall objective of ISO14000 Environmental management Standard isto encourage environmental protection and pollution prevention while taking into account the economic needs of society. 3. An EMS meet g the requirements of ISO 14001:2004 is a management tool enabling an organization of any size or type to: 4. Identify and control the environmental impact of its activities, products or services, and to 5. Improve its environmental performance continually, and to 6. Implement a systematic approach to setting environmental objectivesand targets, to achieving these and to demonstrating that they have been achieved.(5M) **Concepts of ISO 14001** **(Environmental Management System Model)** The EMS model consists of following five stages. 1. Environmental policy 2. Planning 3. Implementation and operation 4. Checking and corrective action 5. Management review 6. Checking andcorrective act on

7. Continuous improvement (3M)

Stage1: Environmental policy
Environmental policy should address the following issues:

1. Management commitment to continual improvement
2. Prevention of pollution
3. Creating a framework for setting objectives
4. Communication requirement with shareholders. (2M)

Stage 2: Planning
This Planning stage contains four elements such as:

1. Environment aspects of an organization's activities, products and services should
2. Be identified in order to determine the environmental impact.
3. Legal and other requirements: Organization should identify and have access to all legal and other requirements to which it subscribes.
4. Objectives and targets: The organization should establish and maintain the objectives and target at each relevant function and level.
5. Environmental management program(s): The organization should establish and maintain a program(s) for achieving the objectives and target.(1M)

Stage 3: Implementation and operation

1. This stage has seven elements such as:
2. Structure and responsibility
3. Training, awareness and competency
4. Communication
5. EMS documentation
6. Document control
7. Operational control
8. Emergency preparedness and response

Stage 4: Checking and corrective action
This stage has four elements such as:

1. Monitoring and measuring
2. Non-conformance and corrective and pr v ntive action
3. Records
4. EMS audit. (1M)

Stage 5: Management review
Management should review and revise the system in order to ensure the continuing suitability, uacy, and effectiveness of the EMS.The management must evaluate the feedback data and make ovements to the systems.(1M)

7.	**Explain the requirements of ISO 14001(Elements/Clauses of Environmental Management System) (EMS Requirements). (13M)**BTL2 **swer : Page :19.9 - Dr.V.Jayakumar** Four sections of ISO 14001 are: Section1: Scope Section2: Normative reference Section3: Definitions Section4: EMS requirements **General requirements** 1. The organization shall establish and maintain an environmental management system that includes policy, planning, implementation, operation, checking, corrective action and management review. These requirements are given in the rest of the standard. 2. Because the document is available to the public and other stakeholders, the organization may include a brief description of the company. (1M) **Environmental policy** The organization's policy statement should be based on its mission, objectives and its value. It should reflect management commitment, leadership and direction for the environmental activities. Top management shall define the organization's environmental policy and ensure that 1. It is appropriate to the nature, scale and environmental impacts of its activities, products or services 2. It includes a commitment to continual improvement and prevention ofpollution 3. It includes a commitment to comply with relevant environmental legislationand regulations, and with other requirements to which the organizationsubscribes 4. It provides the framework for setting and r vi w ng environmental objectives and targets. 5. It is documented, implemented and maintained a d communicated to all employees 6. It is available to the public. **Planning** This area has four elements: 1. Environmental aspects 2. Legal and other requirements 3. Objectives and targets 4. Environmental management program(s). 5. Environmental aspects(2M) **Legal and other requirements**

The organization shall establish and maintain a procedure to identify and have access to legal and other requirements to which the organization subscribes, that are applicable to the environmental aspects of its activities, products or services.

According to ISO 14004 , issues to be considered in the procedure should include, how the organization :

1. requirements
2. Keeps track of any changes in the legal and other requirements.
3. Communicates relevant information about l gal and other requirements toemployees in their organization. (2M)

Environmental management programs.

Following requirements can be achieved with a simple form:

1. State the objective clearly
2. State the purpose of the objective
3. Describe how the objective can be achieved
4. Identify the team leader.
5. Assign departments and individual specific tasks
6. Establish a schedule for completing the task.
7. Establish program review, this includes format, content and review schedule. (2M)

Implementation and operation

Operational controlEmergency preparedness a d response Structure and responsibility

1. Roles, responsibility and author shall be defined, documented andcommunicated to all personnel. They must be given necessary freedom andauthority to take necessary actions.
2. Training needs should be identified on a regular basis, to ensure effectiveness. Two types of Training: general awareness and job competency.

Communication

1. The key aspect of any management program is how effective it communicates with all stakeholders. The standard requires that procedures should be established and maintained for internal communication among all employees.
2. Internal communication between the various levels and functions of the organization. Receiving, documenting and responding to relevant communication from external interested parties
3. Effective communication should ensure that questions are answered and that understanding is complete and accurate.(2M)

Environmental management system documentation

The organization shall establish and maintain information describes the core elements of the management system and their interaction provides direction to related documentation.

Document control

1. The organization has established and maintained procedures for controllingall documents required by the ISO 14001 standard.
2. The purpose of Document Control is to ensure that current versions of relevantdocuments are available at all locations. (2M)

Benefits of EMS.

Global

Facilitate trade and remove trade barriers

1. improve environmental performance of planet earth
2. Build consensus that there is a need for environment management and a common terminology for EMS.

Organizational

Assuring customers of a commitment to environmental management

1. Meeting customer requirements
2. Maintaining a good public / community lations image
3. Satisfying investor criteria and improving access to capital
4. Obtaining insurance at reasonable cost
5. Increasing market share that results from a competitive advantage
6. Reducing incidents that result in liability. (2M)

8.

Discuss briefly the benefits of ISO 9000 certification.**(13M)(May 2013, May2014, May 2016)**BTL2

Answer : Page :18.2 - Dr.V.Jayakumar

Benefits of ISO 9000.

1. Itforms a solid foundation for improvement, consistency and profitability
2. It provides good platform for continuous quality improvement
3. It provides a status symbol for the organization and acts as powerful marketing tool
4. It increases the potential market share
5. It improves employees morale and ensures their total involvement
6. It establishes a firm base for management of growth , change and continuing improvement
7. It increases awareness of employees in company requirements and activities
8. It ensures customer satisfaction
9. Itgenerates customer confidence through world-class products/services
10. Itensures confidence with all stakeholders in the organization including suppliers, investors, shareholders etc.
11. It improves documentation, operating standards, and housekeeping.
12. It improves the perception of product quality.
13. Ithelps in reducing the wastage and reduction in the cost of production. (13M)

	PART*C
1.	1. **Write brief notes on Quality Auditing in QMS .(15M)(April/May2015)(Nov/Dec 2011)(May/June 2012)BTL4** **Answer : Page :18.32 - Dr.V.Jayakumar** Quality audit is the process of systematic examination of a quality systemcarried out by an internal or external quality auditor or an audit team. It is animportant part of organization's quality management system and is a key element inthe ISO quality system standard, ISO 9001. (5M) Features of Quality Audits: 1. The quality audit typically applies to quality systems or elements such as processes, products or services .Such audits are often called „quality system audits‟, „process quality audits‟. ‟Product quality audits, and „service quality service‟ respectively. 2. Quality audits are carried by staffs that are not directly responsible in the areas being audited. But preferably auditors should work in cooperation with relevant personnel. 3. Quality audit is an information gathering activity. It is not a „police‟ kind of activity. 4. Quality audit may be conducted for internal or external purposes. They need not cover whole quality system, at once, but may cover elements of it. (5M) **Types of audits:** 1. **First party audit (Internal audit)**, audit is done by an organization, where the auditee is its own client i.e., audit is done by the organization, working on itself. 2. **Second party audit**:This refers to audit by one organization onanother organization (auditee).This type of audit is normally done on a supplier by a customer. **3. Third party audit (External audit):** This refers to audit by an independentorganization on a supplier, for accreditation assessment purposes. The third party certification audit is carried out much in the same way as first party and second party quality system assessments and audits. (5M)
2.	**Explain the Objectives and stages of Quality Audits (Need for Quality Audits) (15M) BTL 2** **Answer : Page :18.32 - Dr.V.Jayakumar** 1. To determine the conformity or non-conformity of the quality systemelements with regard to specified requirements. 2. To determine the effectiveness of the implemented quality system inmeeting specified quality objectives 3. To meet regulatory requirements, if applicable. 4. To evaluate an organization's own quality system against a quality system standard, (2M)

	Stages of an Audit: Stage 1:Audit Planning: 1. Audit Schedules: It is a matrix of the timings, which details when each audit element is to be checked throughout the year 2. Audit Personnel: It refers to the appointment of the auditor. 3. Notification of auditee: This is the formal and timely request by audit to auditee for making available all quality system documents relevant to the audit. 4. Preparation of checklist: This lists all specific questions to be asked during audit. (3M) Stage 2:Execution 1. Opening/entry meetings: Opening meeting is organized to initially brief the auditee about the scope of audit. 2. Audit process: Audit is run to schedule and should cover entire scope, as planned. Regular liaison meetings should be held. 3. Audit deficiencies: During auditing, clear and precise discrepancy reports are raised. All discrepancies should be based on sound and objective evidence. (5M) Stage 3: Audit Reporting 1. Auditreporting deals with the recording of any non-conformity and summarizing the audit findings. 2. Observations of non-conformities, or suggestions for corrective actions 3. Identification of the reference documents against which audit is 4. conducted(Quality system standard), company's quality manual etc. (5M) Stage 4: Audit Follow-up 1. The auditor is responsible o ly for identifying the non-conformity. But theauditee is responsible for determining and initiating corrective action neededto correct a non-conformity. **2.** Corrective actions and subsequent follow-up should be completed within atime period.
3.	**Explain the role of senior management commitment in the implementation of quality system? (15M)(May/June 2014)**BTL2 **Answer : Page :18.27 - Dr.V.Jayakumar** **Implementation steps** **Step 1:Top management commitment** 1. The most important step in implementing a quality stem is to get the full support of upper management. 2. The top management must be willing to commit the resources necessary to achieve certification.(2M) **Step 2: Appoint the management representative**

1. This step is the Appointment of a management representative. The representative can be a member of the top management group.
2. Management representative is responsible for coordinating the implementation and maintenance of the quality system.(2M)

Step 3: Awareness

1. The next step is to create awareness about the ISO 9000 QMS.
2. Since implementation of the quality system requires involvement of all members in the organization, the members should understand the process and implications of ISO program.(1M)

Step 4: Appoint an implementation team

1. Now the implementation team should be formed
2. This team should be drawn from all levels and areas of the organization.
3. The team should identify the QMS processes and their sequence and interaction. (1M)

Step 5: Training

1. The implementation team, supervisors and internal audit team should be trained
2. Thisactivity c n be accomplished through in-house training programs, seminars ,workshop , etc.(1M)

Step 6:Time schedule

1. This activity develops a time schedule for the implementation and registrationof the system
2. This time frame will vary, depending on the size and type of the organization, (1M)

Step 7: Select element owners

1. The implementation team selects own rs for each of the system elements.Many of these owners for each of the system elements. Many of these owners will be members of the implementation team
2. Each owner has the option of selecting a team to assist in the process. (1M)

STEP 8:Review the present system

1. A review of the present quality system should be performed.
2. Copies of all the quality manuals, procedures, work instructions and forms presently in use are obtained (1M)

Step 9:Write the document

This documentation of work instructions should be done by the employee who performs the job.

	Step 10: Install the new system. 1. The policies, procedures and work instructions should be integrated into the day-t- day working of the organization. 2. Now the new system is installed (1M) **Step 11: Internal audit** 1. An internal audit of the quality system should be conducted 2. This step ensures that the system is working effectively and to provide management with information for the comprehensive management review. (1M) **Step 12: Management review** The management review should be conducted in order to determine the effectiveness of the system in achieving the stated quality goals (1M) **Step 13:Pre-assessment** It is an optional step. If a good job is done on the previous steps, then preassessment is not necessary. (1M) **Step 14: Registration** Theregistration activity includes: choosing a registrar, Submitting an application and conducting the registrar's system audit. (1M)

OMD551 BASICS OF BIOMEDICAL INSTRUMENTATION 3 0 0 0

AIM

To make students to understand the applications of electronics in diagnostic and therapeutic area.

OBJECTIVE

To study the methods of recording various biopotentials
To study how to measure biochemical and various physiological information
To understand the working of units which will help to restore normal functioning
To understand the use of radiation for diagnostic and therapy
To understand the need and technique of electrical safety in Hospitals

UNIT I BIO POTENTIAL GENERATION AND ELECTRODE TYPES 9

The origin of Bio-potentials and its propagation, types of electrodes – surface, needle and microelectrodes and their equivalent circuits, Recording problems – measurement with two electrodes.

UNIT II BIOSIGNAL CHARACTERISTICS AND ELECTRODE CONFIGURATIONS 9

Biosignal characteristics – frequency and amplitude ranges, ECG Einthoven's triangle, standard 12 lead system, EEG – 10–20 Electrode system, unipolar, bipolar and average mode, EMG – unipolar and bipolar mode.

UNIT III SIGNAL CONDITIONING CIRCUIT 9

Need for Bio-amplifier – Differential Bio-amplifier, Impedance matching circuit, Isolation amplifiers, Power line Interference, Right leg driven ECG amplifier, Band pass filtering.

UNIT IV MEASUREMENT OF NON-ELECTRICAL PARAMETERS 9

Temperature, respiration rate, pulse rate measurement, Blood pressure: indirect method – Auscultatory method, direct methods: electronic manometer, systolic and diastolic pressure, Blood flow and cardiac output measurement: indicator dilution method, dye dilution method, Ultrasonic blood flow measurement.

UNIT V BIO-CHEMICAL MEASUREMENT 9

Blood gas analyzers and non-invasive monitoring, colorimeter, sodium potassium analyzer, spectrophotometer, blood cell counter, Auto analyzer.

TOTAL: 45

TEXTBOOKS

1. Leislie Cromwell, "Biomedical instrumentation and measurement", Prentice Hall of India, New Delhi, 2007.
2. John. G. Webster, "Medical Instrumentation Application and Design", 3rd Edition, Wiley India Edition, 2007

REFERENCES

1. Khandpur, R.S., "Handbook of Biomedical Instrumentation", TATA McGraw-Hill, New Delhi, 2003.
2. Joseph J.Carr and John M.Brown, "Introduction to Biomedical equipment Technology", John Wiley and Sons, New York, 2004.

Subject Code: OMD551 **Year/Semester:III/05**
Subject Name: Basics of Biomedical Instrumentation **Subject Handler: D. Joshua Jeyasekar / R. Rubala / Parimala**

UNIT I BIO POTENTIAL GENERATION AND ELECTRODE TYPES	
The origin of Bio-potentials and its propagation, types of electrodes – surface, needle and microelectrodes and their equivalent circuits, Recording problems – measurement with two electrodes.	
PART * A	
Q.No.	**Questions**
1	**What is Resting potentials? (MAY 2015)**BTL1 The membrane of excitable cells readily permits the entry of K^+ ions and Cl^- ions, while it effectively blocks the entry of Na^+ ions. Therefore the concentration of Na^+ ions inside the cell becomes much lower than that outside the cell. Since the Na^+ ions are positive, the outside cells are more positive than the inside. Thus the charge balance is not achieved. Thus a potential difference is developed across the membrane. This membrane potential caused by the different concentration of ions is called the resting potential of the cell
2	**What is action potentials? (MAY 2015)**BTL1 When a cell membrane is excited by some form of externally applied energy, the membrane changes its electrical characteristics and begins to allow some of the Na^+ ions to enter. The movement of Na^+ ions into the cell constitutes ionic current which further reduces the barrier of the membrane to Na+ ions. The net result in Na^+ ions rush into the cell and try to balance with the ions outside. At the same time K^+ ions present inside the cell try to leave the cell. But they are unable to move as rapidly as Na^+ ions. As a result, the cell has a slightly positive potential. This potential is called as action potential
3	**What is meant by depolarization and repolarisation of a cell?** BTL1 **Depolarisation:-** When the impulse reaches the muscle, the polarized condition (-90mv) is altered. i.e., the resting membrane potential is abolished. The interior of the muscle becomes positive and outside becomes negative. This condition is called as depolarization. **Repolarisation:-** With in a short period, the muscles obtain the resting electrical potential once again. Interior of the muscle becomes negative and outside becomes positive. So, the polarized state of the muscle is re-

	established. This process is called as repolarization
4	**What is absolute refractory period?**BTL1 A short period of time during which the cell cannot respond to any stimuli is called as absolute refractory period. The time period is about 1ms.
5	**Give the Nernst equation which is used to derive action potentials (or) Write down the nernst equation.** BTL1 Nernst equation is given as $\mathbf{V_t = -\frac{kT}{q} \ln\left[\frac{[K^+]_i}{[K^+]_o}\right]} = -\,94.9$ Mv
6	**What is Half-cell potential? (MAY 2011)**BTL1 A characteristic potential difference established by the electrode and its surrounding electrolyte which depends on the metal, concentration of ions in solution and temperature. The voltage developed at an electrode-electrolyte interface is called as half cell potential or electrode potential.
7	**What are the different types of electrodes used in bipolar measurement? (MAY 2012)**BTL1 The types of biopotential electrodes are, • Surface Electrode • Micro Electrode and • Needle Electrode
8	**What is Relative refractory period?** BTL1 The period followed by absolute refractory period is the relative refractory period. During this period another action potential can be triggered, but a much stronger stimulation is required.
9	**Name few bioelectric signals.**BTL1 Some of the bio electric signals are, • ECG (Electrocardiogram) • EEG (Electroencephalogram) • EOG (Electrooculogram) • EMG (Electromyogram) • PCG (Phonocardiogram

10	**What is ECG? (NOV 2012)**BTL1 The Electrocardiograph is the instrument by which the electrical activities of the heart are recorded. The graphical registration of electrical activities of the heart is called as Electrocardiogram
11	**The contraction of skeletal muscle is termed as what? Give its specifications. (MAY 2014)** BTL5 The contraction of skeletal muscle is termed as electromyogram (EMG). The EMG signal ranges from 0.1mV to 0.5mV. The frequency components of the EMG signal vary from 20Hz to 10 KHz, which are in the audio range.
12	**Define the term Conduction velocity.** BTL1 The elapsed time 't_1' (latency) between the stimulating impulse and muscle's action potential is measured. Now the two electrodes are repositioned with the distance separation as $l_2$metres. Among the distances 1_1 and 1_2, $1_2 < 1_1$. The latency is now measured as 't_2' seconds. The conduction velocity, $v = (l_1 - l_2) / (t_1 - t_2)$
13	**Enlist the electrodes used for recording EEG. (MAY 2014)**BTL1 • Scalp electrode, • Sphenoidal electrode, • Nasopharyngeal electrode, • Electrocorticographic electrode, • Intracerebral electrode.
14	**Mention the important bands of frequencies in EEG and their importance. (MAY 2011)**BTL1 Alpha waves (8-13)Hz – to monitor the level of consciousness Beta waves (13-30)Hz – to monitor cerebral and mental activity Theta waves (4-8)Hz – to analyse the emotional stress in adults Delta waves (0.5-4)Hz – to study sleep disorders and brain tumour
15	**Define Phonocardiogram. (MAY 2011)**BTL1 The Phonocardiogram is the graphical representation of the sound recording connected with the pumping action of the heart.
16	**Differentiate between heart sounds and murmurs.**BTL4

S.No	Heart Sounds	Murmurs
1	They have transient characteristics	They have noisy characteristics
2	Short duration	Long duration
3	Heart sounds are due to the opening and closing of the valves	Murmurs are due to the turbulent flow of blood in the heart and large vessels.

17

Mention the importance of PCG signals. (JUNE 2009)BTL1

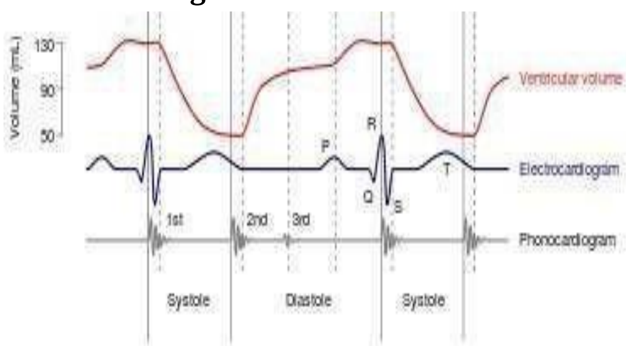
The presence of higher frequencies (murmurs) in the PCG indicates a possible heart disorder like Rheumatic valvular lesions, murmur of aortic steonosis and murmur of mitral steonosis

18

Compare the signal characteristics of ECG and PCG. (NOV 2011)(MAY 2013)BTL2

Phonocardiogram: A graphic record of heart sounds.

Electrocardiogram: A record of the electrical activity of the heart.



19

Mention the normal amplitude and frequency of EMG signal (MAY 2011)BTL1

The EMG signal ranges from 0.1mV to 0.5mV. The frequency components of the EMG signal vary from 20Hz to 10 KHz and they are restricted to the frequency range of 20Hz to 200Hz for clinical purpose using a low pass filter

20

What are the electrodes used for recording EMG?(MAY 2016) BTL1

The electrodes used for recording EMG are,

- Surface electrode

  Metal Disc electrode, Disposable electrode

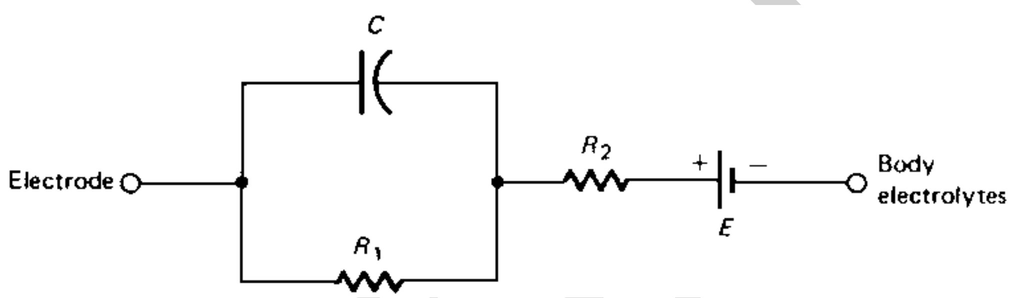
- Needle electrode

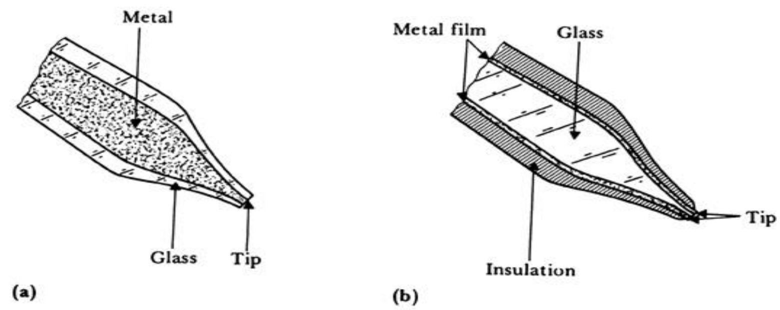
  Unipolar and Bi polar electrode

- Metal Disc electrode, Disposable electrode

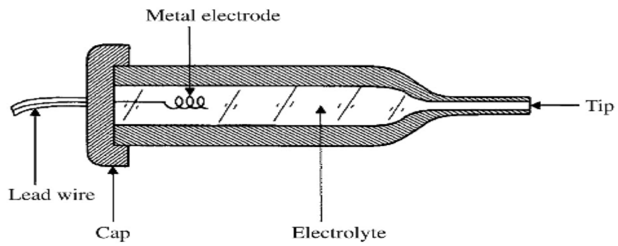
21

Define latency in EMG.(NOV 2015). BTL1

	The elapsed time between the stimulating impulse and muscle's action potential is called latency
22	**State all or none law.(NOV2016)** BTL1 In nerve and muscle cells, repolarization occurs so rapidly following depolarization that the action potential appears as a spike of 1 ms total duration. But for heart, action potential is from 150 to 300 ms and so it repolarizes much more slowly. When a cell is excited, the action potential is always the same for any given cell. This is known as all- or- nothing law.
23	**What is meant by conduction velocity? (NOV 2016)** BTL1 Conduction velocity is defined as the rate at which an action potential moves down a fiber or is propagated from cell to cell. It is also called as Nerve conduction rate.
24	**Draw the electrical equivalent circuit of a surface electrode.** BTL1  **Fig. electrical equivalent circuit**
PART * B	
1	**Explain in detail about microelectrodes with suitable diagram.(13M) (Nov/Dec-2016)** BTL1 **Answer: Page 21-Dr.M.ARUMUGAM** **Biopotential:** (3M) **Types :** 1. Micro Electrodes--- Bio electric potential near or within a single cell 2. Metal Type—Tip must be tungsten or stainless steel 3. Micro pipette---It is a glass micropipet with size of 1 micron, It is filled with electrolyte 4. Skin surface electrode —Measure ECG,EEG,EMG 5. Needle electrode ---Penetrate the skin to record EEG **Microelectrodes:** (6M) ▪ Used to measure bio-potential signals at the cellular level ▪ Due to small dimensions (mm), impedance levels - high ▪ Soamplifier needs very high input impedance



Micropipette Electrodes :(4M)



2

Explain in detail about PCG.(OR) Explain the origin of different heart sounds.(May/June-2014)(13M) BTL1

Answer: Page 133-Dr.M.ARUMUGAM

PCG:

(2M)**Phonogram**.: Graphic record of the heart sounds

Phonocardiogram: sound - from the heart

Phonocardiograph :instrument -measure the heart sounds

Aim:pick up the different heart sounds- filter out and to display them (or) record them.

Heart sounds- acoustic phenomena resulting from the vibrations of cardiac structures.

Acoustic events- heart can be divided into two categories

- Heart sounds
- Murmurs

Heart sounds(2M)

Four Groups :**1)Valve closure soundsVentricular Filling sounds 3)Valve opening Sounds 4)Extra cardiac sounds**

Physical characteristics of sound

- Frequency
- Amplitude
- Quality

Origin of the heart sounds: (5M)

four separate heart sounds - during the sequence of one complete cardiac cycle.

First heart sound: It is produced by a sudden closure of mitral and tricuspid valves associated with myocardial contraction.

- Timing: The low frequency vibrations occur approximately 0.05 sec after the onset of QRS complex of ECG.
- Duration: 0.1 to 0.12 sec.
- Frequency : 30 – 50 Hz
- Asculatory area: The first heart sound is best heard at the apex of the mid pericardium.

Second heart sound: It is due to the closure of semi lunar valves (ie) the closure of aortic and pulmonary valves

- Timing : T 0.03 – 0.05 sec after the end of T wave of ECG
- Duration : 0.08 – 0.14 sec
- Frequency : 250 Hz
- Asculatory Area: It is best heard in the aortic and pulmonary areas.

Third heart sound: It arises as the ventricles relax and the internal pressure drops well below the pressure in atrium.

- Duration : 0.04 – 0.08 sec
- Frequency : 10 – 100 Hz
- Asculatory Area: It is best heard at the apex and left lateral position after lifting the legs.

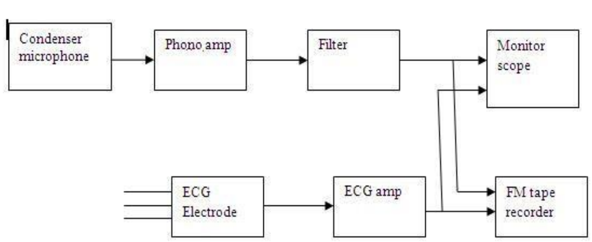
Fourth heart sound: Also called as atrial sound. It is caused by an accelerated flow of blood into the ventricles or due to atrial contraction,occurs immediately before the first heart sound.

- Timing : it starts at 0.12-0.18 sec after the onset of p-wave
- Duration :0.03-0.06 sec
- Frequency :10-50 Hz
- Ausculatory Area: Because of its low frequency, it is inaudible

Heart murmurs

Murmurs are sounds related to non – laminar flow of blood in the heart and the great

PCG RECORD SETUP :(4M)



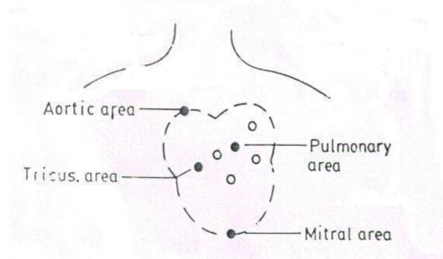


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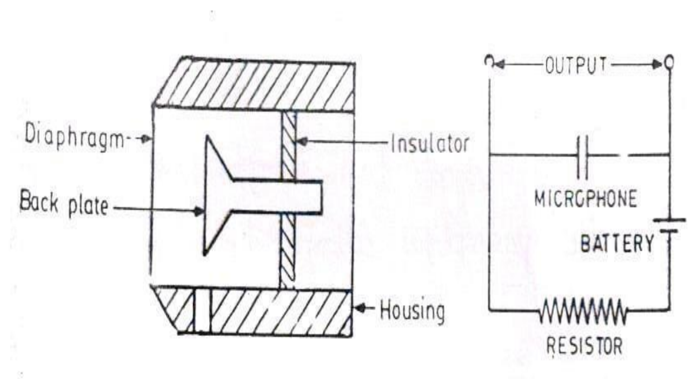
Fig. PCG Record Setup



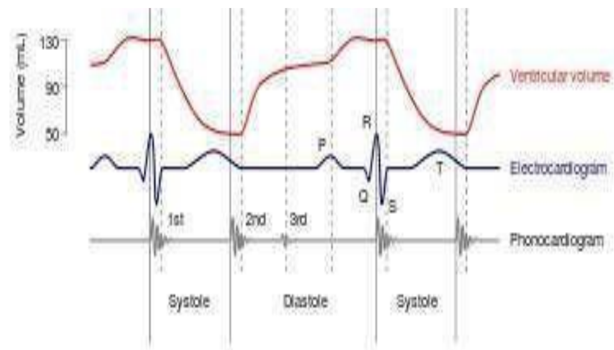


Fig. PCG waveform

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Explain in detail about unipolar and bipolar electrode with suitable diagram.(13M) (Nov/Dec-2016)

BTL1

Answer: Page 21-Dr.M.ARUMUGAM
Biopotential: (3M)

Types :

6. Micro Electrodes--- Bio electric potential near or within a single cell
7. Metal Type—Tip must be tungsten or stainless steel
8. Micro pipette---It is a glass micropipet with size of 1 micron, It is filled with electrolyte
9. Skin surface electrode —Measure ECG,EEG,EMG
10. Needle electrode ---Penetrate the skin to record EEG

Unipolar electrode---Single wire inside a needle (3M)
Bipolar electrode---Two wires inside a needle
Mostly used for contacting with internal body tissues (2M)
(a) Insulated needle electrode .
(b) Coaxial needle electrode . (2M)
(c) Bipolar coaxial electrode . (3M)
(d) Fine -wire electrode connected to hypodermic needle, before being inserted .
(e) Coiled fine -wire electrode in place

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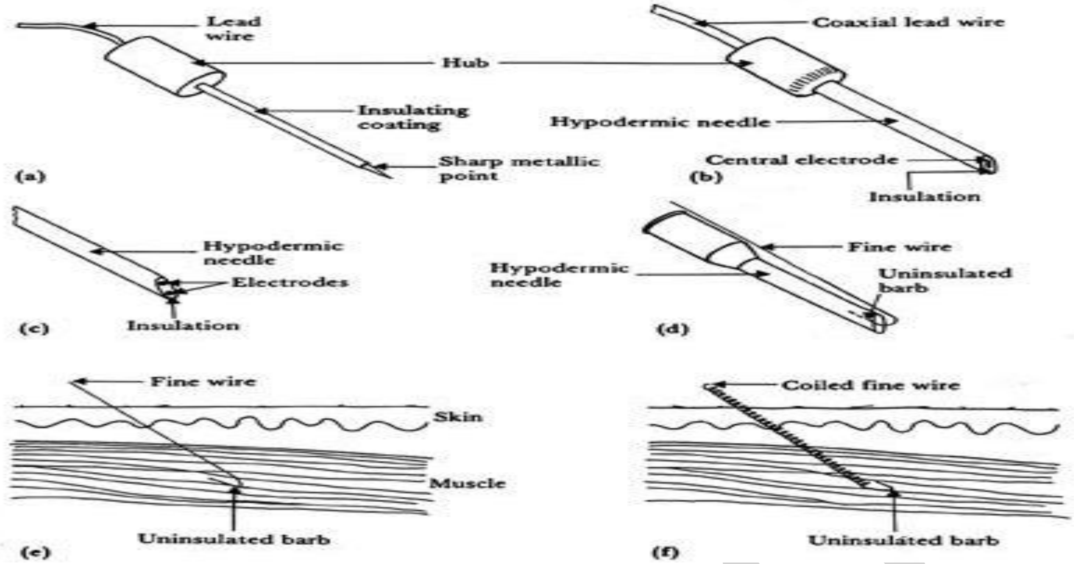


4.

Explain in detail about chemical electrode. Describe the measurement of pH of blood using pH meter.(13M) (Nov/Dec-2014) (Nov/Dec-2013)(May/June-2016)BTL1

Answer: Page: 21-Dr.M.ARUMUGAM

Chemical electrode.

pH Electrode:

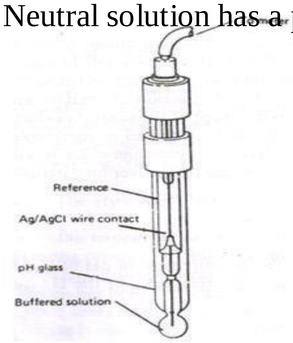
Chemical balance -human body in identified - measurement of pH contentof blood and other body fluids.

PH is defined as the logarithmic of reciprocal of H+ ion concentrations.

PH = log10 1 /[H+]

= - log10 [H+]

Neutral solution has a pH value of 7. If pH < 7, it is acidic, pH >7 it is basic. (2M+2M)



PO2 Electrode:(4M)

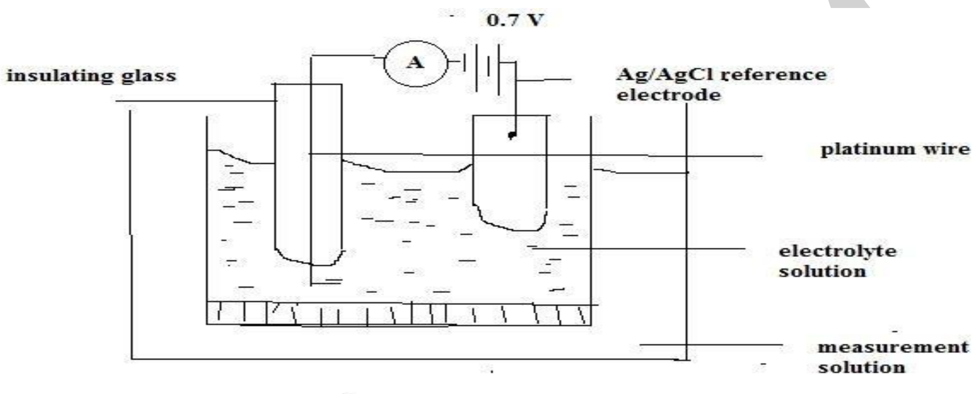
The oxygen electrode - piece of platinum wire embedded - insulating glass holder with the end of the wire exposed to the electrolyte solution into which oxygen is allowed to diffuse through the membrane The bottom of the vessel containing electrolyte- membrane permeable to oxygen and the top of vessel is sealed.

Ag - Agcl electrode is used A voltage of 0.7V is applied between the platinum wire and the reference electrode using a battery. The negative of the battery - platinum wire through an ammeter.

Reduction of oxygen takes place at platinum wire. Hence an oxidation-reduction current is developed and is proportional to the partial pressure of oxygen.

Advantages :(1M)

- The oxygen electrode - monitor the partial pressure of oxygen- biological fluids.
- It is available in integrated version consisting of platinum electrode and reference electrode in the same enclosure called Clark electrode



PCO2 Electrode:(4M)

It consists of a standard glass PH electrode covered with rubber membrane permeable to CO_2.Between the glass surface and membrane there is a thin film of water. The solution under test contains dissolved CO_2 is presented to the outer surface of rubber membrane. After equilibrium PH of aqueous film is measured by glass electrode and interpreted in terms of PCO_2.

5 **Explain in detail about surface electrode with suitable diagram.(13M) (Nov/Dec-2016)** BTL1

Answer: Page 21-Dr.M.ARUMUGAM

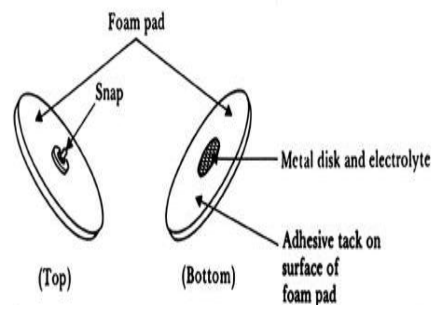
Biopotential: (3M)

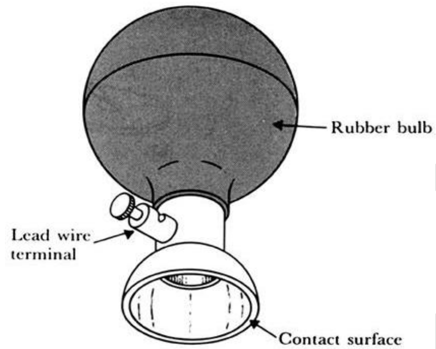
Types :

11. Micro Electrodes--- Bio electric potential near or within a single cell
12. Metal Type—Tip must be tungsten or stainless steel
13. Micro pipette---It is a glass micropipet with size of 1 micron, It is filled with electrolyte
14. Skin surface electrode —Measure ECG,EEG,EMG
15. Needle electrode ---Penetrate the skin to record EEG

Surface Electrodes :(5M)

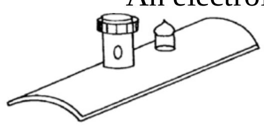
- These are placed in contact with the skin of the subject
- Early stages immersion electrodes were used.
- A bucket of saline water is used
- An improvement of immersion electrode is the plate electrode.
- Another old type electrode is suction type

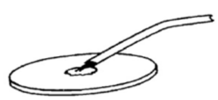


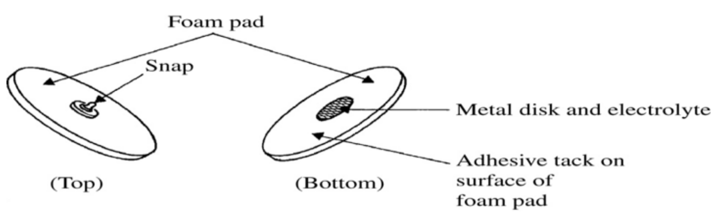


Metal-Plate Electrodes :(2M)

- consists of a metallic conductor in contact with the skin.
- An electrolyte soaked pad or gel is used to establish and maintain the contact.

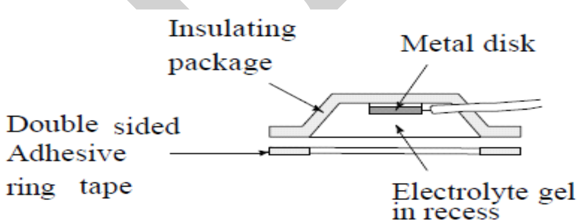






Floating electrodes:(3M)

Conductive paste reduces effect of electrode slippage and resulting motion artifact



PART* C

1

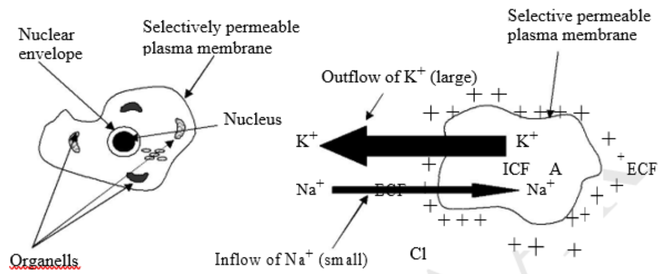
Discuss in detail about the origin of action potential and resting potential with necessary equation ad also draw the action potential wave form.(15M)(Nov/Dec- 2014)(May/June 2016)BTL6

Answer: Page4-Dr.M.ARUMUGAM

Origin of biopotential: **(**2M)

Cell is the basic building unit of human body.

Structure of cell :(2M)

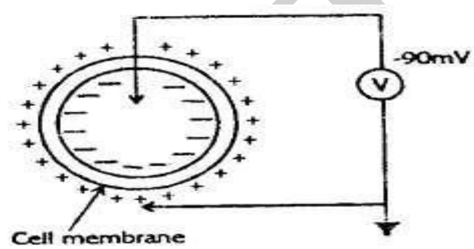


A cell consists of a plasma membrane, a nucleus and cytoplasm.

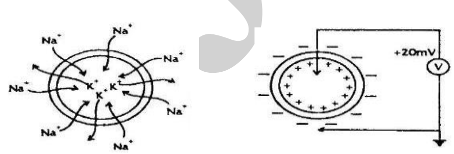
Plasma membrane: It is selectively permeable to (various ions such as) Na^+, K^+andintracellular anions. The fluid inside the plasma membrane called the **intracellular fluid** (ICF). The fluid outside the plasma membrane is called the **extracellular fluid** (ECF). The plasma membrane separates the cell's contents from its surroundings.

Resting membrane potential:(4M)

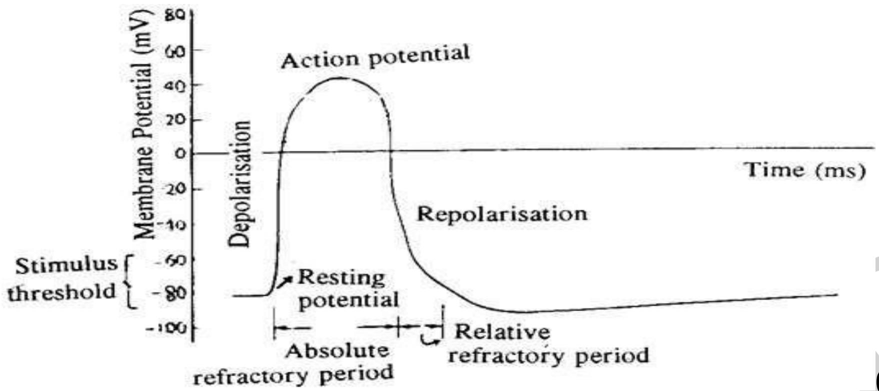
- Na^+ is large in the ECF while K^+ is large in the ICF.
- When the cell is at rest, the inflow of Na^+ is very small but the outflow of K^+ is large.
- Due to these facts, the inside of the cell membrane is more negative than its outside. This leads to a potential difference across the cell membrane called the ***restingmembrane potential*** (RMP). This has a value of 70mV to 90mV.



Action potential:(4M)



- When cell is excited, the permeability of the plasma membrane to Na^+ suddenly increases 600 times greater than that to K^+& a sudden large inflow of Na^+ takes place.
- As the inflow of Na^+ exceeds the outflow of K^+ by several times, the membrane potential suddenly

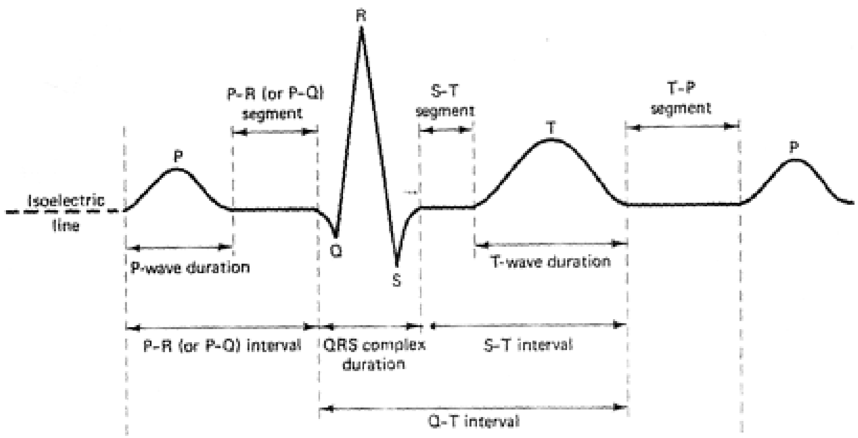
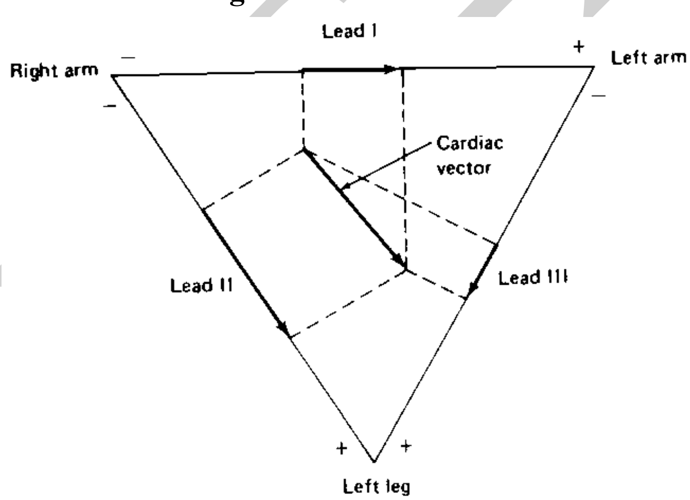
	decreases from 70mV to zero and then shoots up to 40mV. • This positive shoot over the neutral level (0mV) is called the action potential. Once generated, the action potential travels down the nerve for a long distance. • After certain (very short) period, the permeability of the plasma membrane returns to equilibrium conditions causing the membrane potential to return to the resting value i.e., RMP value.  (3M) **Absolute refractory period:** During a short period after the generation- actionpotential, the cell does not respond to any stimulus at all-**absolute refractory period**. **Relative refractory period:** It is the time period between the instant when themembrane potential becomes negative again and the instant when the membrane potential returns to RMP. During this period, the cell responds to a stimulus but less strongly than usual.

UNIT II BIOSIGNAL CHARACTERISTICS AND ELECTRODE CONFIGURATIONS

Biosignal characteristics – frequency and amplitude ranges, ECG Einthoven's triangle, standard 12 lead system, EEG – 10–20 Electrode system, unipolar, bipolar and average mode, EMG – unipolar and bipolar mode.

PART * A

Q.No.	Questions
1	**Draw ECG waveform with specification. (May 2015)** BTL 1

	
2	**State Beer's law (NOV 2016).** BTL1 A law stating that the concentration of an analyte is directly proportional to the amount of light absorbed,or inversely proportional to the logarithm of the transmitted light. Beer's law A = abc = log(100/%T) 2 - log %T where: A = absorbance a = absorptivity b = light path of the solution in cm c = concentration of the substance of interest %T = per cent transmittance—the ratio of transmitted light to incident light
3	**Draw Einthoven's triangle**. BTL1 The Einthoven Triangle
4	**What is stroke volume?(MAY 2013)** BTL1 It is defined as amount of blood pumped out by each ventricle during each beat. Normal value is 70ml.
5	**List out the various EEG signals with amplitude and frequencies. (Or) List the names and frequency**

bands of EEG signals (MAY 2011)BTL1

Alpha waves (8-13)Hz – to monitor the level of consciousness

Beta waves (13-30)Hz – to monitor cerebral and mental activity

Theta waves (4-8)Hz – to analyse the emotional stress in adults

Delta waves (0.5-4)Hz – to study sleep disorders and brain tumour

6 **What are korotk off sounds?**BTL1

In the Blood pressure (BP) measurement, when the systolic pressure exceeds the cuff pressure, then the doctor can hear some crashing, snapping sounds through the stethoscope. These sounds are called as korotkoff sounds.

7 **What is cardiac output? What are the methods of measurement of cardiac output?** BTL1 **(NOV 2016)(MAY 2015)(NOV 2014)**

Cardiac output is the amount of blood delivered by the heart to the aorta per minute. For normal adult, the cardiac output is 4- 6 liters /min. The cardiac output is measured by using three methods. They are Fick_s Method, Indicator dilation method, Measurement of cardiac output by impedance change.

8 **Give the EMG signal characteristics.** BTL 1

The EMG signal ranges from 0.1mV to 0.5mV. The frequency components of the EMG signal vary from 20Hz to 10 KHz and they are restricted to the frequency range of 20Hz to 200Hz for clinical purpose using a low pass filter

9 Give the ECG signal characteristics. BTL 1

S. No	Wave/ Segment	Cause	Amplitude (mV)	Duration (sec)
1	P Wave	Depolarisation of atria	0.25	0.12 to 0.22
2	R Wave (QRS Complex)	Repolarisation of atria and Depolarisation of ventricles	1.6	0.07 to 0.1
3	T Wave	Repolarisation of ventricles	0.1 to 0.5	0.05 to0.15
4	U Wave	Slow repolarisation of intra ventricular (Purkinje fibers) system	<0.1	0.2

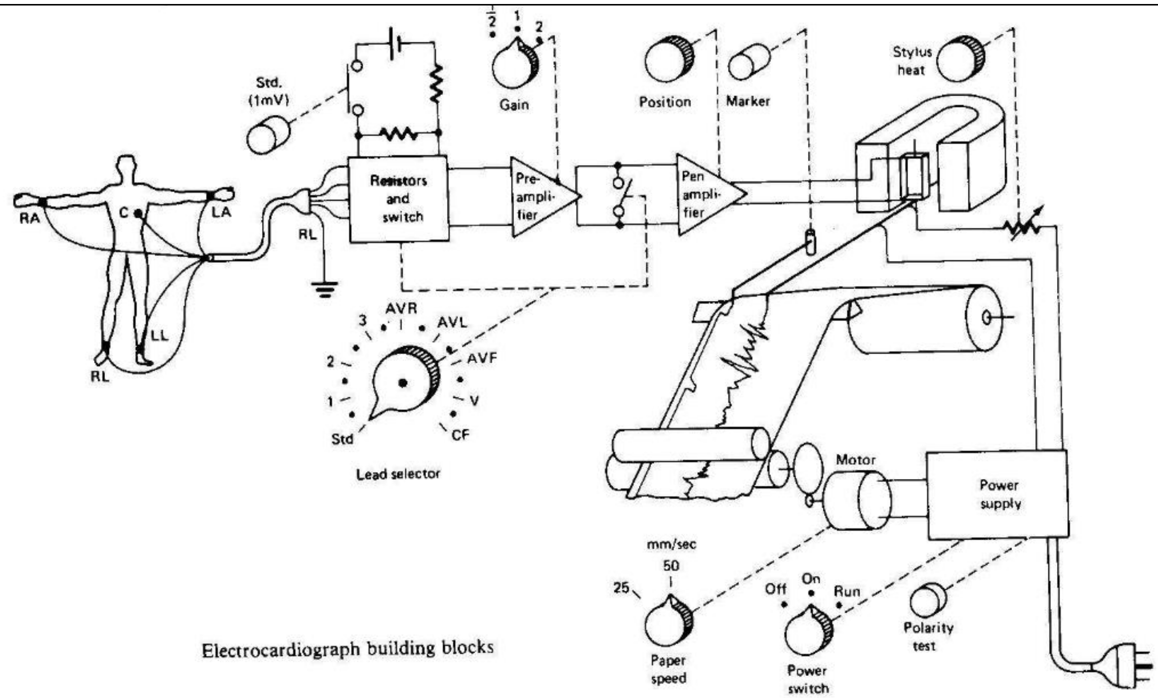
10 **Calculate the stroke volume in millilitres if the cardiac output is 5.2 litres/minute and heart rate is 76 beats/minute. (DEC 2009)**BTL3

Q = 5.2 litres/minute; HR = 76 beats/minute

	Stroke volume = $\frac{Q}{HR} = \frac{5.2 \times 1000}{76}$ = 68.42 ml
11	**What are plethysmographs and plethysmography?(NOV-2005)**BTL1 Plethysmography is the process used to measure the volume changes in any part of the body that result from the pulsations of blood occurring with each heart beat. These measurements are useful in the diagnosis of arterial obstructions and pulse wave velocity measurement which may lead to determine the heart rate.Plethysmograph produces a waveform that is similar to the arterial pressure waveform.
12	**What is systole and Diastole?**BTL Systole is the period of contraction of the ventricular muscles to pump the blood out from the ventricles in to the pulmonary artery and the aorta. Diastole is the period of dilation of heart chambers to get filled with blood. (Or) Diastole is the period of relaxation of ventricles to get filled with blood.
13	**Define tidal volume (MAY 2011)(DEC 2009)** BTL1 Tidal volume (TV) is the volume of gas inspired or expired during each normal, quiet respiration cycle.
14	**Define residual volume (MAY 2011)(JUNE 2007)** BTL1 Residual volume (RV) is the volume of gas remaining in the lungs at the end of a maximal expiration.
15	**Name any two methods of respiration rate measurement. (APR 2004)** BTL1 The methods used to measure respiration rate are, • Thermistor method • Impedance pneumography • CO_2 method of respiration rate measurement
16	**How is the respiration rate measured? (DEC 2011)** BTL1 Respiration rate is measured by one of the method • Thermistor method • Impedance pneumography • CO_2 method of respiration rate measurement
17	**Write down the demerits of indirect method of blood pressure measurement. (APR 2005)**BTL1 The demerits of indirect method of blood pressure measurement (Sphygmomanometer) are, • Does not provide continuous recording of pressure variations.

	• Less repetition rate and • The measured value depends up on the experience of the doctor and his hearing capability.
18	**Which transducer is used for measuring temperature? Why?(JUNE 2012)** BTL1 • Thermistor • High sensitivity.
19	**What is the principle used in pulse rate measurement? (JUNE 2012)**BTL1 Photo electric sensor is used to measure the pulse rate. It consists of light source and LDR. During the contraction of the heart, the blood flow to the finger tip will increase, will reduce the amount of light fall on LDR and during relaxation the amount of light will increase. This change in resistance per minute will be measured as pulse rate.
20	**How is the pulse rate measured? (MAY 2011)**BTL1 The pulse rate is measured using one of the following methods: • Electrical impedance method • Strain gauge method • Photoelectric method • Microphone method
21	**List the various indirect methods for measurement of blood pressure.(NOV 2015)**BTL1 Automatic blood pressure measuring apparatus using korotkoff's method. • The Rheographic Method. • Differntial Auscultatory Technique. • Oscillometric Measurement method. • Ultrasonic Doppler shift method.
22	**How does the pH value determine the acidity and alkalinity in blood fluid.(NOV 2015)** BTL1 pH is the measure of Hydrogen ion concentration ,expressed logarithmically. The acidity or alkalinity of a solution depends on its concentration of Hydrogen ions. Increasing the concentration of hydrogen ions makes a solution more acidic, decreasing the concentration of hydrogen ions makes it more alkaline.
23	**State the different types of test performed using auto analyzer. (MAY 2016)**BTL1 Glucose, BUN, ammonia, bilirubin, uric acid, cholesterol, triglycerides, total calcium, total protein, albumin, creatinine, phosphorus, and serum enzymes

	e.g. Kodak Ektachem
PART*B	
1	**With a neat block diagram, explain the working of ECG recorder. (**13M**)** **(May/June-2013)(May/June-2014)(Nov/Dec-2014) (Nov/Dec-2016) (May/June-2014)(May/June-2013) (Apr/May 2019)** BTL1 **Answer: Page 117-Dr.M.ARUMUGAM** **Electrocardiography:** Technique -electrical activities of the heart - studied. (4M) **Electrocardiograph**: Instrument -electrical activities of the heart - recorded. **Electrocardiogram:** Record or graphical registration - electrical activities - heart. **ECG Recorder** (4M) • Patient cable and Defibrillator Protection Circuit • Lead selector switch • Calibrator • Bio-amplifier • Auxiliary Amplifier • Isolation Power Supply • Output Unit • Power switch

	 Fig. ECG recorder (5M)
2	**With the neat diagram explain the formation of various Lead systems used for recording ECG. Describe the standard 12 lead configuration used in ECG and also describe the typical ECG waveform.(13M)** **(May/June-2013)(May/June-2014)(Nov/Dec-2014) (Nov/Dec-2016) (May/June-2014)(May/June-2013) (Apr/May 2019)** BTL1 **Answer: Page 117-Dr.M.ARUMUGAM** **Electrocardiography:** Technique -electrical activities of the heart - studied. (2M) **Electrocardiograph**: Instrument -electrical activities of the heart - recorded. **Electrocardiogram:** Record or graphical registration - electrical activities - heart. **ECG Wave:** (2M)

S. No	Wave/ Segment	Cause	Amplitude (mV)	Duration (sec)
1	P Wave	Depolarisation of atria	0.25	0.12 to 0.22
2	R Wave (QRS Complex)	Repolarisation of atria and Depolarisation of ventricles	1.6	0.07 to 0.1
3	T Wave	Repolarisation of ventricles	0.1 to 0.5	0.05 to0.15
4	U Wave	Slow repolarisation of intra ventricular (Purkinje fibers) system	<0.1	0.2

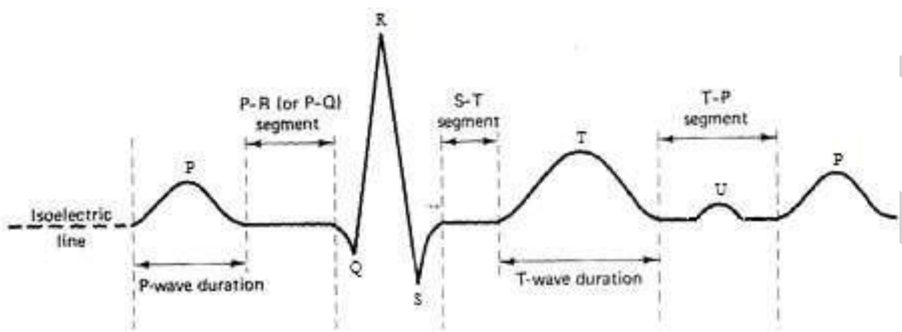


Fig.ECG waveform

Bipolar limb leads or Standard leads or Einthoven lead system (2M)

1. Lead I
2. Lead II
3. Lead III

Augmented unipolar limb leador Wilson Lead System

4. aVR
5. aVL 6. aVF

Unipolar chest leads

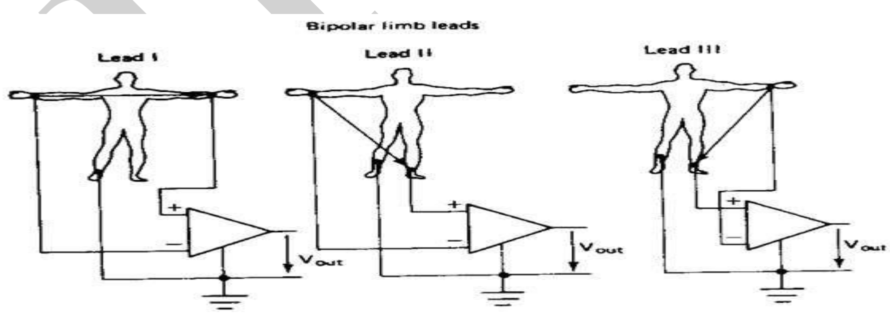
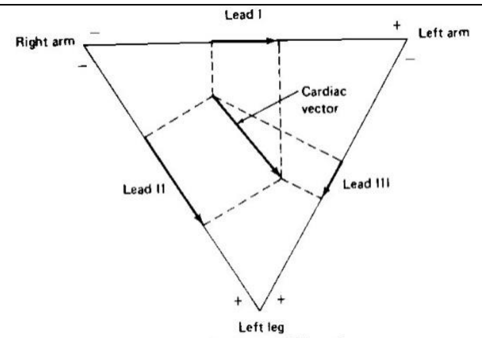


Fig. unipolar chest leads

Einthoven Triangle: (1M)

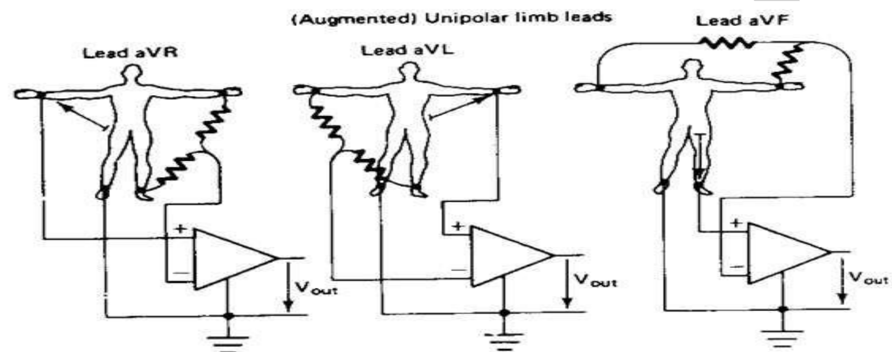


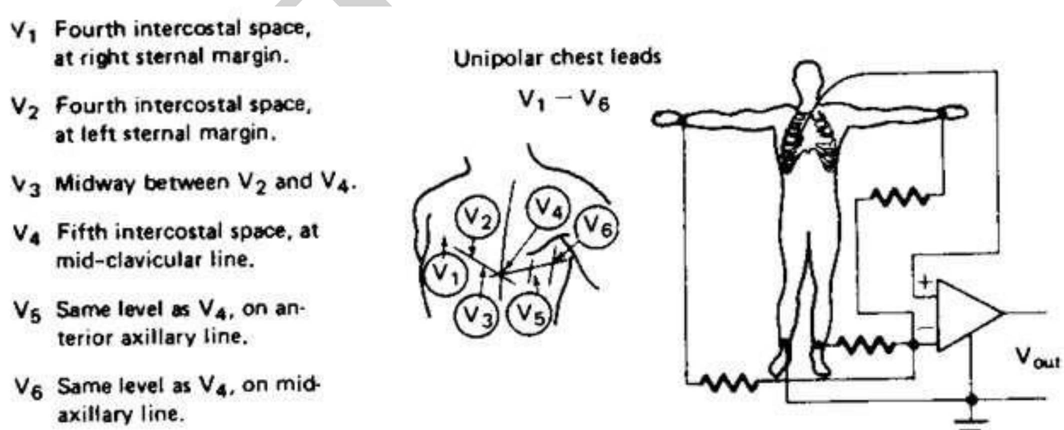
The Einthoven Triangle

The R wave nominal voltage from different lead is as given below.

Lead I	-	0.53 mv (0.07 – 1.13)mv
Lead II	-	0.71 mv (0.18 – 1.68)mv
Lead III	-	0.38 mv (0.03 – 1.31)mv

Unipolar Chest Lead: (4M)





3 **Draw the block diagram of an EEG unit and explain the different parts in it. Give the origin of brain waves and describe the 10-20 electrode (or) placement of electrode. (or) Discuss the characteristics and frequency bands of EEG signal.(13M) (May/June2016)(Nov/Dec-2013)**BTL1

Answer: Page 144-Dr.M.ARUMUGAM

EEG :(2M)

Electroencephalography: Electrical activities - brain are studied.

Electroencephalograph: Instrument - electrical activities- brain are recorded.

Electroencephalogram: Record or graphical registration -electrical activities of the brain.

Significance of EEG:

EEG - diagnosis of neurological disorders and sleep disorders.

EEG is primarily used for diagnosis including the following

- Helps to detect and localize cerebral brain lesions.
- Aid in studying epilepsy
- Assist in diagnosing mental disorders
- Assist in studying sleep patterns
- Allow observation and analysis of brain responses to sensory stimuli.

EEG electrodes transform ionic currents from cerebral tissue into electrical current used - EEG preamplifier. (2M)

5 types of electrodes are used.

1. **Scalp**: silver pads, discs or cups, stainless steel rods, chlorided silver wires.
2. **Sphenoidal**: Alternating insulated silver and bare wire and chlorided tip insertedthrough muscle tissue by a needle.
3. **Nasopharyngeal**: Silver rod with silver ball at the tip inserted through the nostril.
4. **Electrocorticographic**: Cotton wicks soaked in saline solution that rests on brain surface.

Intracerebral: sheaves of Teflon coated gold or platinum wires used to stimulate the brain.

EEG Waves: (2M)

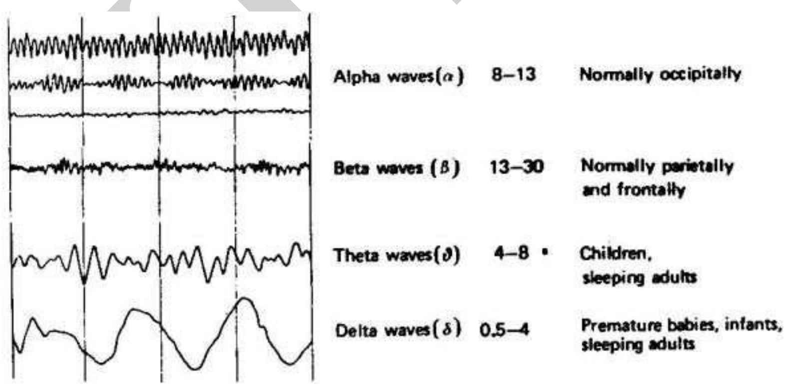


Fig. EEG Waves

Placement of Electrodes: (4M)

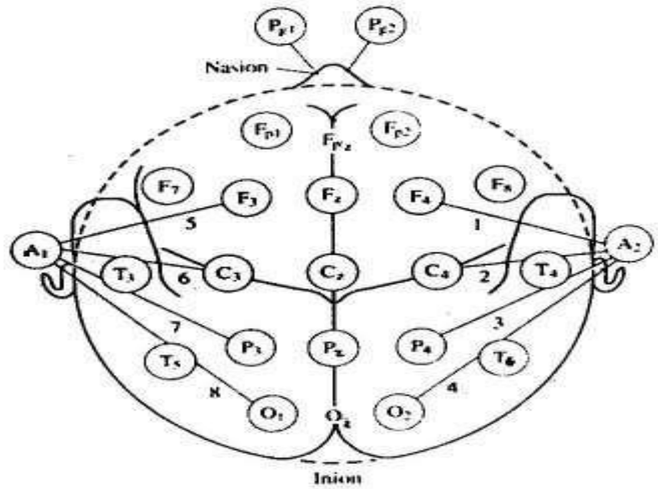


Fig. Placement of Electrodes

EEG Recorder: (5M)

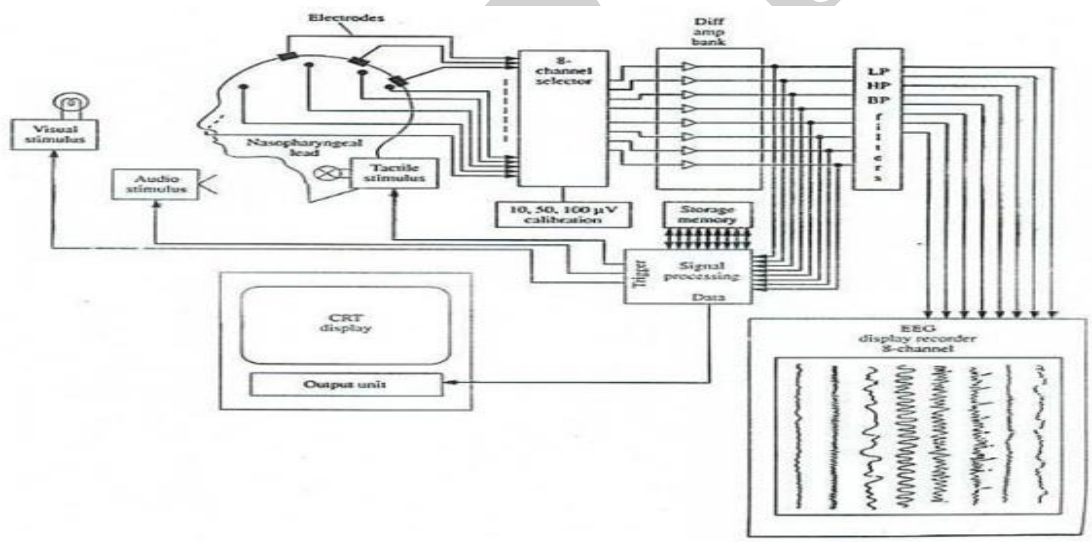


Fig: Modern EEG Unit

Analysis of EEG:

- Level of consciousness
- Brain Tumors
- Epilepsy (1)Grandmal 2)Peritmal)

Application:

- Epilepsy – EEG is very helpful to find acuteness of epilepsy.
- Anesthetic level – It is helpful to find the depth of intensity of anesthesia

- Brain injury – If there is a scar on the cerebral cortex, it creates irrigative effect on the nearby healthy cortex. It is identified by EEG waveform.
- Monitor during surgery – Doctor to find patient_s conditions.
- Effect of Yoga – Identified by EEG for a normal person initially EEG in recorded.

4

Explain in detail about EMG.(13M) (May/June-2013) (May/June-2016)BTL1

Answer: Page: 153-Dr.M.ARUMUGAM
Electromyography :(2M)

- Electromyography -recording and interpreting the electrical activity of muscle's action potential.
- The action potentials occur - positive and negative polarities - given pair electrodes
- EMG -like random noise wave form.
- The contraction of a muscle produces action potentials.

Recording setup: (8M)

- surface electrodes or needle electrodes pick-up the potentials produced by the contracting muscle fibers,surface electrodes - from Ag-AgCl and are in disc shape.
- The surface of the skin is cleaned and electrode paste is applied. The electrodes are kept - place by means of elastic bands. So, the contact impedance - reduced below 10 kilo ohms.
- **two conventional electrodes**: bipolar and unipolar type electrodes. In the case of bipolar electrode, the potential difference between two surface electrodes resting on the skin is measured. unipolarelectrode, the reference surface electrode - placed on the skin and the needle electrode which acts as active electrode, inserted - muscle.Because of the small contact area, these unipolar electrodes have high impedances from 0.5 to 100 Mega ohms.

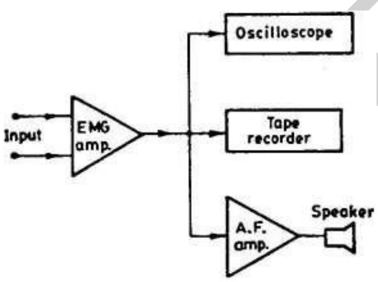
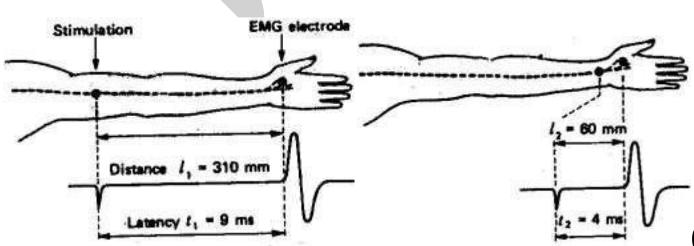


Fig. Recording setup

Determination of conduction velocities in motor nerves:



(3M)

Fig. conduction velocity

The conduction velocity, v = (l1 – l2) / (t1 – t2)

The conduction velocity in peripheral nerves is normally 50 m/s, it's below 40m/s, there is some disorder in that nerve conduction.

5

Describe the typical ECG waveform.(13M)

(May/June-2013)(May/June-2014)(Nov/Dec-2014) (Nov/Dec-2016) (May/June-2014)(May/June-2013) (Apr/May 2019)

BTL1

Answer: Page 117-Dr.M.ARUMUGAM

Electrocardiography:

Technique -electrical activities of the heart - studied. (4M)

Electrocardiograph:

Instrument -electrical activities of the heart - recorded.

Electrocardiogram:

Record or graphical registration - electrical activities - heart.

ECG Wave: (5M)

S. No	Wave/ Segment	Cause	Amplitude (mV)	Duration (sec)
1	P Wave	Depolarisation of atria	0.25	0.12 to 0.22
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3	T Wave	Repolarisation of ventricles	0.1 to 0.5	0.05 to0.15
4	U Wave	Slow repolarisation of intra ventricular (Purkinje fibers) system	<0.1	0.2

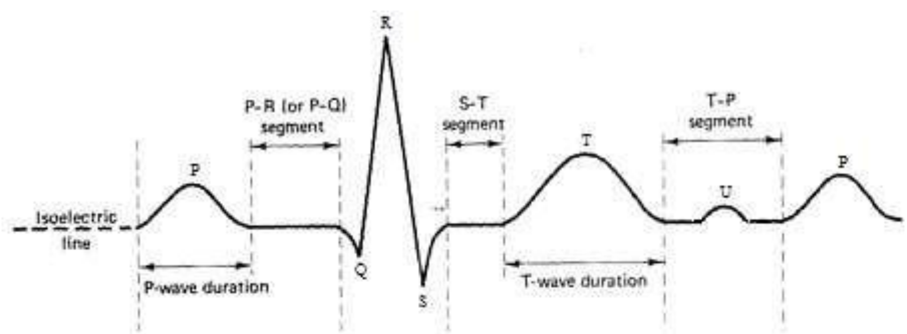

Fig.ECG waveform (4M)

Part*C

1 **With the neat diagram explain the formation of various Lead systems used for recording ECG. Describe the standard 12 lead configuration used in ECG and also describe the typical ECG**

waveform.(15M)

(May/June-2013)(May/June-2014)(Nov/Dec-2014) (Nov/Dec-2016) (May/June-2014)(May/June-2013)

(Apr/May 2019)

BTL1

Answer: Page 117-Dr.M.ARUMUGAM

Electrocardiography:

Technique -electrical activities of the heart - studied. (4M)

Electrocardiograph:

Instrument -electrical activities of the heart - recorded.

Electrocardiogram:

Record or graphical registration - electrical activities - heart.

ECG Wave: (3M)

S. No	Wave/ Segment	Cause	Amplitude (mV)	Duration (sec)
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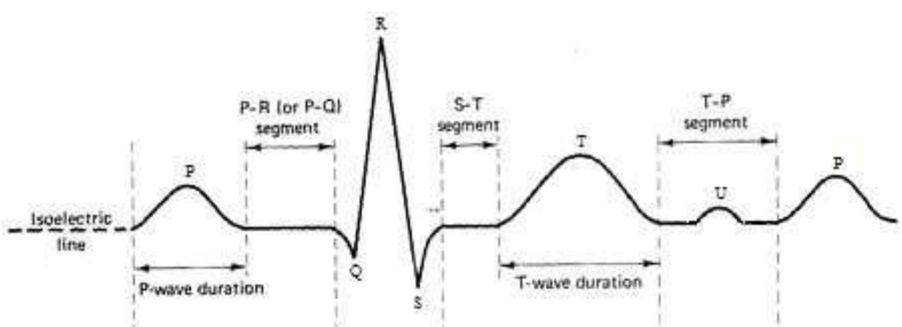


Fig.ECG waveform

Bipolar limb leads or Standard leads or Einthoven lead system (3M)

6. Lead I
7. Lead II
8. Lead III

Augmented unipolar limb leador Wilson Lead System

9. aVR
10. aVL 6. aVF

Unipolar chest leads

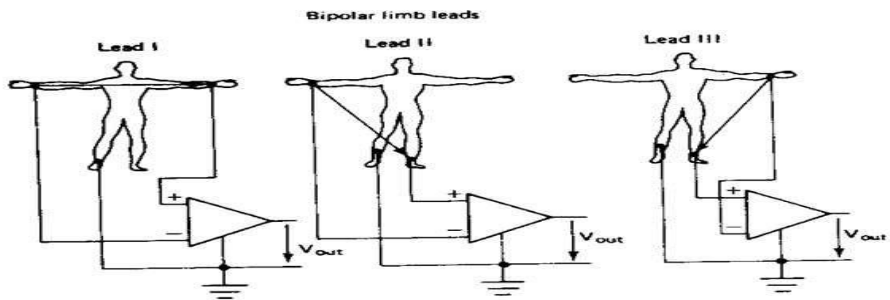
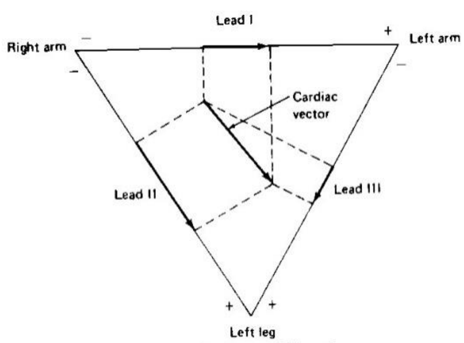


Fig. unipolar chest leads

Einthoven Triangle: (2M)

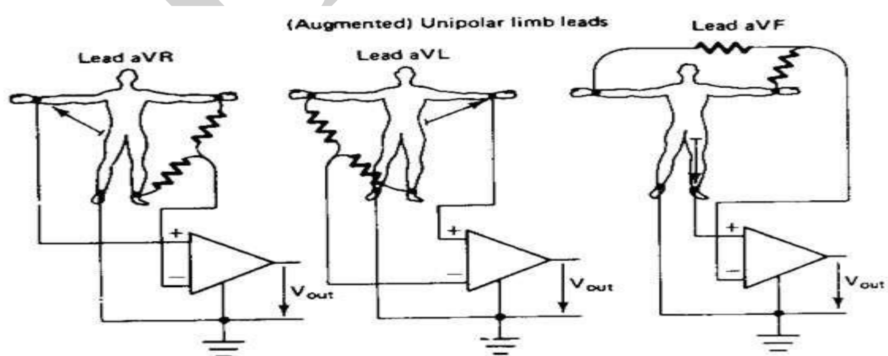


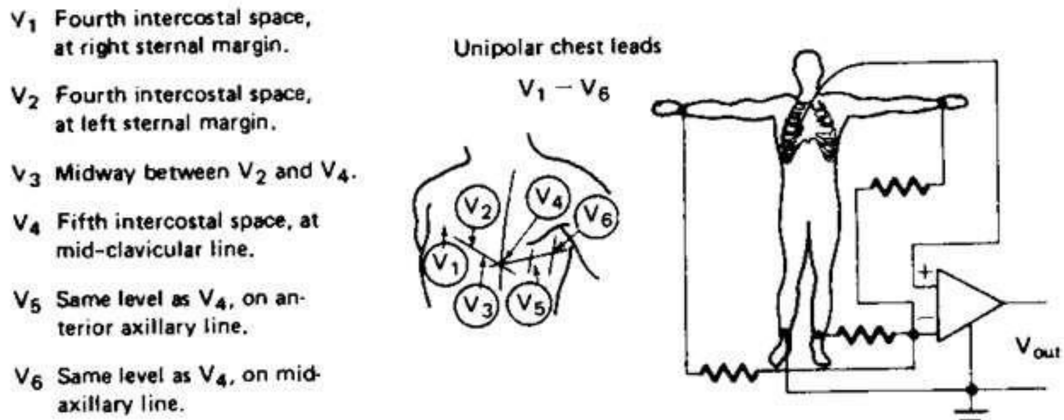
The Einthoven Triangle

The R wave nominal voltage from different lead is as given below.

Lead I	-	0.53 mv (0.07 – 1.13)mv
Lead II	-	0.71 mv (0.18 – 1.68)mv
Lead III	-	0.38 mv (0.03 – 1.31)mv

Unipolar Chest Lead: (3M)





2

Discuss the characteristics and frequency bands of EEG signal and its application.(13M) (May/June2016)(Nov/Dec-2013)BTL1

Answer: Page 144-Dr.M.ARUMUGAM

EEG :(4M)

Electroencephalography: Electrical activities - brain are studied.

Electroencephalograph: Instrument - electrical activities- brain are recorded.

Electroencephalogram: Record or graphical registration -electrical activities of the brain.

Significance of EEG:

EEG - diagnosis of neurological disorders and sleep disorders.

EEG is primarily used for diagnosis including the following

- Helps to detect and localize cerebral brain lesions.
- Aid in studying epilepsy
- Assist in diagnosing mental disorders
- Assist in studying sleep patterns
- Allow observation and analysis of brain responses to sensory stimuli.

EEG Waves: (6M)

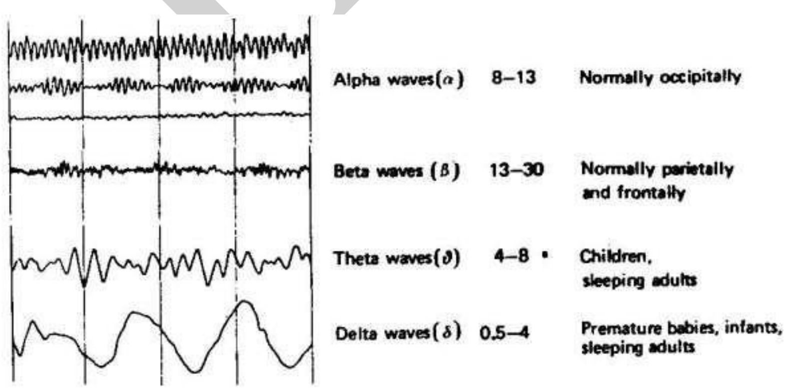


	Fig. EEG Waves **Application:** (5M) • Epilepsy – EEG is very helpful to find acuteness of epilepsy. • Anesthetic level – It is helpful to find the depth of intensity of anesthesia • Brain injury – If there is a scar on the cerebral cortex, it creates irrigative effect on the nearby healthy cortex. It is identified by EEG waveform. • Monitor during surgery – Doctor to find patient_s conditions. • Effect of Yoga – Identified by EEG for a normal person initially EEG in recorded.

UNIT III SIGNAL CONDITIONING CIRCUIT

Need for Bio-amplifier – Differential Bio-amplifier, Impedance matching circuit, Isolation amplifiers, Power line Interference, Right leg driven ECG amplifier, Band pass filtering.

Q.No.	Questions
1	**List the characteristics needed for bioamplifier (or) What are the requirements of a biological amplifier (MAY 2013), (NOV 2013)(MAY 2016)**BTL4 • Gain • Frequency response • Common-mode rejection • Noise & drift • Input impedance • Electrode polarization.
2	**Which type of electrode is applied in the case of external stimulation and what is the current range? BTL 1** The paddle shaped electrodes are applied on the surface of the chest and the current range is 20-150mA.
3	**Mention the types of pacemaker based on modes of operation of the pacemaker. BTL 1** Based on modes of operation, the pacemaker are classified into 5 types, a) Ventricular Asynchronous pacemaker (Fixed Rate Pacemaker) b) Ventricular Synchronous pacemaker c) Ventricular inhibited pacemaker (Demand pacemaker) d) Atrial synchronous pacemaker (Standby pacemaker) e) Atrial Sequential ventricular inhibited pacemaker
4	**Differentiate between internal and external pacemaker (Or) Distinguish between internal pacemakers and external pacemakers (MAY 2011)**BTL 4

S.No	External Pacemaker	Internal Pacemaker
1	The pacemaker is placed outside the body. It may be in the form of wrist watch or in the pocket, from that one wire will go into the heart through the vein.	The pacemaker is miniaturized and is surgically implanted beneath the skin near the chest or abdomen with its output leads are connected directly to the heart muscle.
2	It does not need the open chest surgery	It requires a minor surgery to place the circuit.
3	Mostly these are used for temporary heart irregularities	Mostly these are used for permanent heart damages.

5

What is fibrillation? (Or) What is meant by fibrillation?BTL 1

The heart is able to perform its important pumping function only through precisely synchronized action of the heart muscle fibres. A condition in which this necessary synchronism is lost is known as fibrillation.

6

Differentiate between internal defibrillator and external defibrillator. BTL 4

S.No	Internal Defibrillator	External Defibrillator
1	It is used when the chest is opened	It is on the chest
2	Large spoon shaped electrodes are used	Paddle shaped electrodes are used.
3	Voltage is in the range of 50 – 1000V	Voltage is in the range of 1000 – 10000V

7

Mention the types of defibrillators. BTL 1

AC defibrillator: Here a current burst of 60Hz with 6A is applied to the chest of patient through appropriate electrode

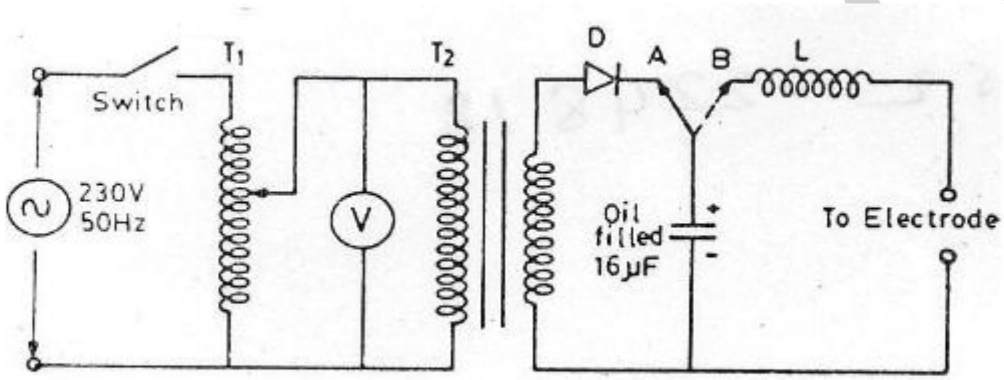
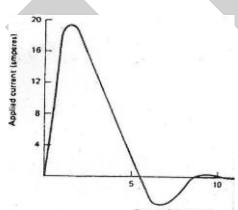
DC defibrillator: Here a capacitor is charged to a high DC voltage and then rapidly discharged through electrodes across the chest of the patient.

8

Calculate energy stored in a 16μf capacitor of a defibrillator that is charged to a potential of 5000V (dc).BTL 3

Given: C = 16μF;   V = 5000V

$$E = \frac{1}{2}CV^2 = \frac{1}{2} \text{ x } 16 \text{ x } 10^{-6} \text{ x } (5000)^2 = 200 \text{ Joules.}$$

9	**Classify the defibrillator based on applied voltage.**BTL2 Based on the nature of the voltage applied, the defibrillators can be classified into 6 types. • A.C Defibrillator • D.C Defibrillator • Synchronized D.C Defibrillator • Square pulse Defibrillator • Double square pulse Defibrillator • Biphasic D.C Defibrillator
10	**Draw the circuit of DC defibrillator and give its output specifications.(MAY 2011)** BTL 1  The wave is **monophasic** and the peak value of the current is nearly 20 A.
11	**Draw the defibrillator output waveform and indicate the output energy level. (Or) Draw the circuit of DC defibrillator and give its output specifications.(JUNE 2012)(MAY 2011)** BTL 1 Energy = 400 joules (max) 
12	**When does the need for pacemaker arise? what is its function?.(NOV 2015)** BTL 1 In abnormal situation, if the natural pacemaker i.e Sino-Atrial node ceases to function or becomes unreliable or if the triggering pulse does not reach the heart muscles, the natural and normal

	synchronization of the heart action gets disturbed which inturn changes the ECG waveform.Hence a pacemaker is needed to regulate the heart rate by giving external electrical stimulation.
13	**Why are asynchronous pacemakers no longer used? (MAY 2016)** BTL 1 By using this pacemaker ,heart rate cannot be increased to match greater physical effort. • If it is fixed in atrium, Atrium beat at a fixed rate. • If ventricle beat at a different rate then it leads to Ventricular Fibrillation.
14	**Why do we need a Heart Lung machine? (MAY 2016)** BTL 1 Cardiopulmonary bypass (CPB) is a technique that temporarily takes over the function of the heart and lungs during surgery, maintaining the circulation of blood and the oxygen content of the patient's body. The CPB pump itself is often referred to as a heart–lung machine or "the pump".
15	**What is arteriovenous (AV) graft surgery?** BTL 1 Arteriovenous (AV) graft surgery creates a synthetic access point into the body‘s circulatory system to perform dialysis. Dialysis removes wastes and extra fluid from your blood when the kidneys can no longer perform this function. This is known as kidney failure. AV graft surgery allows blood to flow from your body to the dialysis machine and back into your body after filtering.
16	**Define heart lung Machine? or What is the need for Heart lung Machine?(MAY 2016)** BTL 1 Cardiopulmonary bypass (CPB) is a technique that temporarily takes over the function of the heart and lungs during surgery, maintaining the circulation of blood and the oxygen content of the body. The CPB pump itself is often referred to as a heart–lung machine or "the pump".
17	**What is meant by AV fistula and AV graft?** BTL 1 An AV fistula is a direct connection between the patient‘s artery and one of their nearby veins. This is the absolute BEST access a patient can have because it is all their own tissue. The fistula resists clotting and infection. An AV graft (sometimes called a bridge graft) is an indirect connection between the artery and vein, most commonly a plastic tube is used, but donated cadaver arteries or veins can also be used.
18	**Why asynchronous pacemakers (Fixed rate pacemakers) no longer used? (NOV 2016)** BTL 1 Using fixed rate pacemaker the heart rate cannot be increased Simulation with a fixed impulse frequency results in the ventricles and atria beating at different rates. This

varies the stroke volume of heart and causes some loss in cardiac output.

Possibility of ventricular fibrillation will be more.

There may be competition between the natural heart beats and pacemaker beats.

What is meant by Demand Pacemaker? (NOV2013) BTL 1

It is a form of artificial pacemaker usually implanted into cardiac tissue because its output of electrical stimuli can be inhibited by endogenous cardiac electrical activity.

PART*B

1 **Draw the circuit diagram of an ECG isolation amplifier and explain its operation. (13M)**BTL1

Answer: Page: 86-Dr.M.ARUMUGAM
ECG isolation amplifier :(3M)

The signals from the different leads - LPF. This filtering reduces- interference caused by electron surgery and radio frequency emission. The filter circuit - following by high voltage and over voltage protection circuit so that amplifier can withstand large voltage. Now the signals are fed into lead selected switch and then the output is given to a d.c amplifier.

(5M)

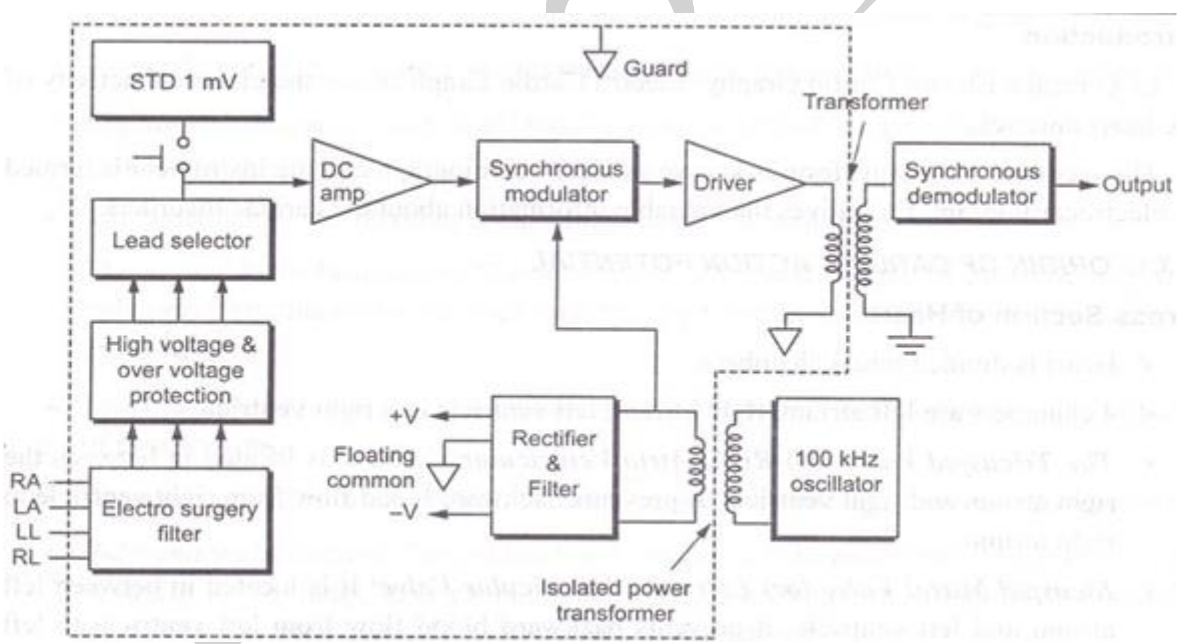


Fig. ECG isolation amplifier

(5M)

- The d.c amplifier also receives a standard d. c voltage of 1mV through a push button. The primary of an isolated power transformer is connected was 100 KHz oscillator.
- The secondary of that transformer along with rectifier and filter circuits is used to obtain isolated power supply. The synchronous modulator modulates the ECG signal from the d.c amplifier.

- Another transformer is used to deliver the output from driver of modulator to synchronous demodulator. The demodulator output is used as the input f power amplifier.
- The perfect shielding of preamplifier circuit enables to achieve higher CMRR. The line frequency interference is eliminated by introducing a notch filter after power amplifier.

2 **With neat sketch explain differential Bio-amplifier**. BTL 1

Answer: Page: 123-Dr.M.ARUMUGAM

Basic differential amplifier using BJT (6M)

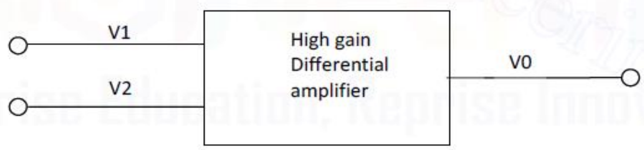


Fig. 1.12 Block diagram of Differential amplifier

Types of operation

Common mode and Differential mode operation (9M)

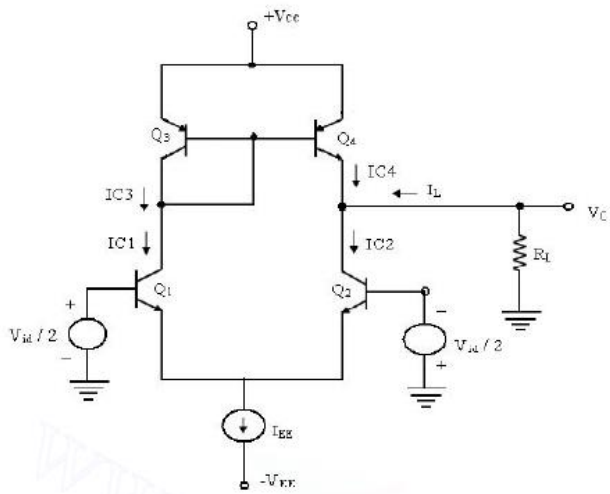


Fig. 1.13 BJT differential amplifier with current mirror active load

3 **Elaborate the need for implementing bio-amplifier in medical field**. (10M) BTL1

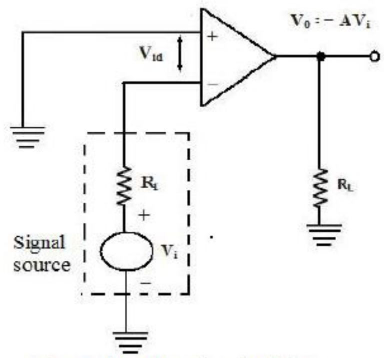
Answer: Page: 112-Dr.M.ARUMUGAM

High gain (2M)
Low Noise (2M)
Enhanced accuracy (2M)
Easy to implement (2M)
Increased efficiency (2M)

4 **Draw the inverting and non-inverting bioamplifier circuits of an op-amp in closed loop configuration. Obtain the expressions for the closed loop gain in these circuits. (10M)** (BTL2)

Answer: Page: 105-Dr.M.ARUMUGAM

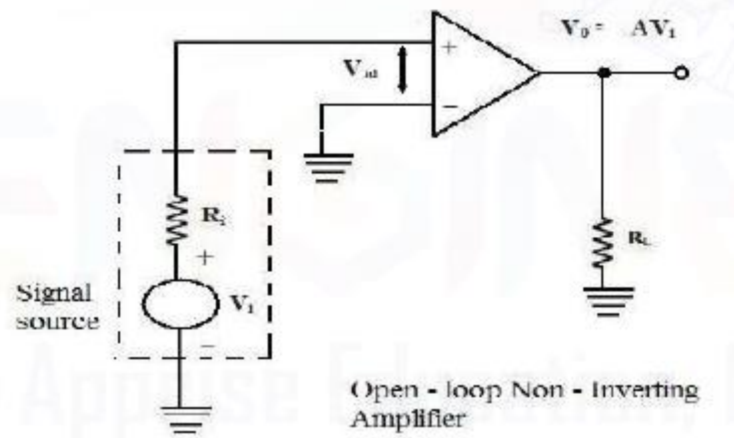
Inverting amplifier (5M)



Open - loop Inverting Amplifier

$A_{CL} = \frac{Vo}{Vi} = -\frac{R_f}{R_1}$ where, A = closed loop gain

Non – Inverting amplifier **(5M)**



Open - loop Non - Inverting Amplifier

$\boldsymbol{A_{CL} = \frac{Vo}{Vi} = 1 + \frac{R_f}{R_1}}$ **where A = closed loop gain**

PART *C

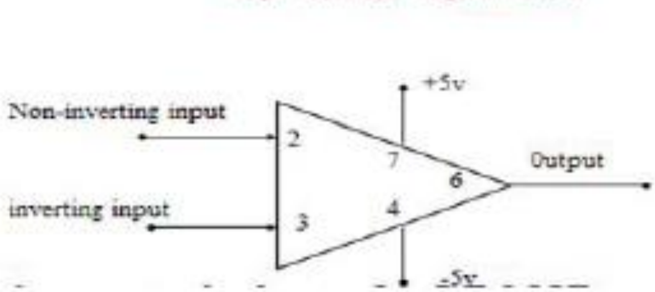
1

Explain about Ideal Op-amp in detail with suitable diagrams.(15M) BTL 2

Answer: page 41 – 48 LIC D. Roy Choudhury

Ideal op-amp (6M)

Op-amp symbol

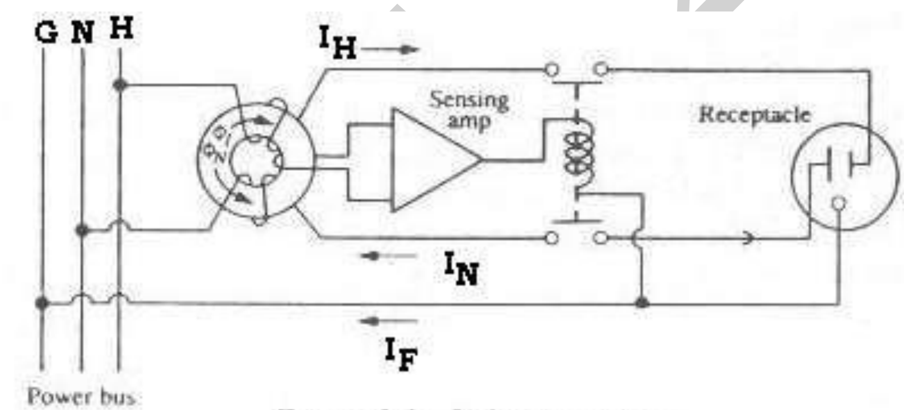


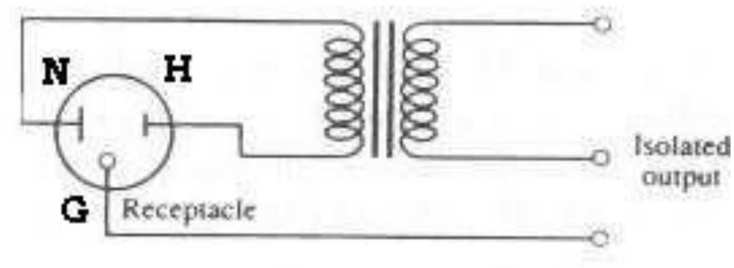
Ideal characteristics (1M)

Open loop voltage gain A=∞ (2M)

Input impedance Ri = ∞ (2M)

Output impedance Ro = 0 (2M)

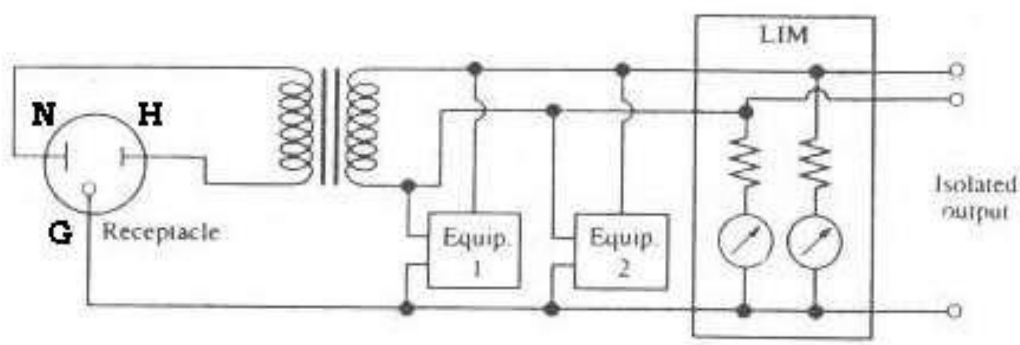
	Bandwidth BW = ∞ (1M) Zero offset V0 = 0, when V1=0, V2=0 Vd = V1 – V2 (1M)
2	**Explain how electrical hazards can be rectified in hospitals. (OR)** **Explain the working of ground fault interrupter (10M)(Nov/Dec 2016)** BTL1 **Answer: Page: 337-Dr.M.ARUMUGAM** **DEVICES TO PROTECT AGAINST ELECTRICAL HAZARDS:** (2M) Several devices are available to protect patients and health care workers from hazardous electrical currents. These range from devices to protect against high-voltage macroshock hazards to procedures that minimize the probability that a microshock will occur. **Ground Fault Interrupter (GFI):** (2M) A ground fault interrupter (GFI) protects against a shock that occurs if a person touches the hot lead with one hand and the ground with the other. The GFI opens the power lead if the hot lead current differs by more than approximately 2mA from the neutral lead current for duration of longer than 0.2 second. The GFI shown below consists of a magnetic coil on which the hot lead and the neutral lead are wound with the same number of turns, but in opposite directions  Ground fault interrupter **ISOLATION TRANSFORMER:** (2M) The isolation transformer provides a second means of protecting against an H-Iead to G-Ieadmacroshock. It also prevents sparks when the H lead touches ground, a particularly important protection in an explosive or flammable environment, such as when flammable anesthetics or excessive oxygen is present.



An isolation transformer

LINE ISOLATION MONITOR:(2M)

Line isolation monitor (LIM) puts relatively large impedance from either secondary lead through an ammeter to ground of the isolation transformer. If there is a conductive path through the equipment as shown in Figure below, the meter in the LIM will read a current. The meter on the LIM is calibrated to read what current would flow through a short-circuit fault if it should occur from either secondary to ground. An alarm in the LIM is usually set off when it is calculated that a short-circuit fault between a secondary lead and ground would draw 2 to 5 mA of current. This alarm merely indicates that the backup system has failed and the equipment is no longer isolated.



Precautions to minimize Electric shock: (2M)

The following are the precautions to be taken care to minimize the hazards due to electric shock.

- In the hospitals, use only apparatus with 3 wire power cords.
- Provide isolated input circuits on monitoring equipment.
- Periodically check the ground wire continuity of all equipment.
- Staff should be trained to recognize potentially hazardous conditions.
- The functional controls of the equipment should be clearly marked and the operating instructions must be permanently displayed so that they can be easily familiarized.
- The human assist devices such as pacemaker, ventilators, respirators, dialysers must be properly grounded.

- The mechanical construction of the equipment must be such that the patient or operator should not be injured by the equipment if properly handled.
- The connectors and the probes used in the lab must be standardized to avoid the leakage current which may be picked up by the transducer.
- High voltage and current operating equipment must not be placed where the patient monitoring equipment is connected.
- A potential difference of not more than 5mW should exist between the ground points of one outlet to other outlet.
- The patient equipment ground point must be individually connected to receptacle ground point.

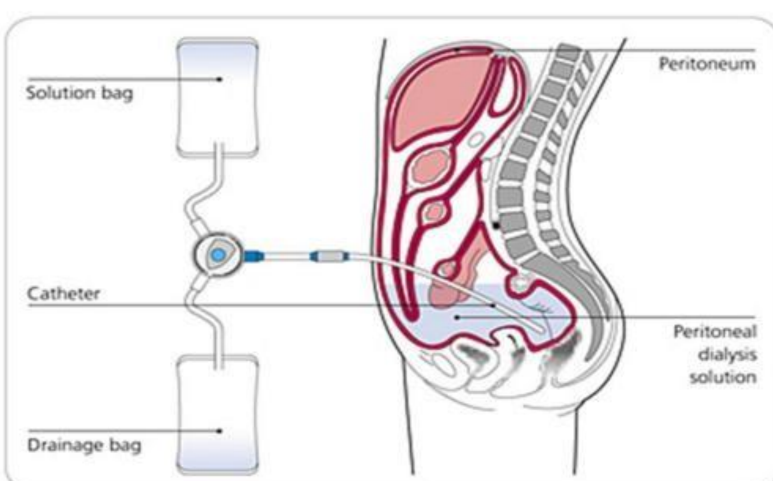
3

Discuss in detail about peritoneal dialysis (Nov/Dec 2016) (8M)BTL 6

Answer: Page: 211-Dr.M.ARUMUGAM

PERITONEAL DIALYSIS :

- Peritoneal dialysis (PD) is a treatment for patients with severe chronic kidney disease. This type of dialysis uses the patient's peritoneum in the abdomen as a membrane across which fluids and dissolved substances are exchanged from the blood. Fluid is introduced through a permanent tube in the abdomen and flushed out either every night while the patient sleeps (automatic peritoneal dialysis) or via regular exchanges throughout the day (continuous ambulatory peritoneal dialysis).
- PD is used as an alternative to hemodialysis though it is far less commonly used in many countries, such as the UnitedStates.
- It has comparable risks but is significantly less costly in most parts of the world, with the primary advantage being the ability to undertake treatment without visiting a medical facility.
- The primary complication of PD is infection due to the presence of a permanent tube in the abdomen.



- A doctor will place a soft tube, called a catheter, in your belly a few weeks before the treatment.
- When the peritoneal dialysis treatment started, dialysis solution of water with salt and other additives flows from a bag through the catheter passed into the belly.
- When the bag is empty, one can disconnect the catheter from the bag and cap it so that the patient can move around and do their normal activities.
- While the dialysis solution is inside the belly, it soaks up wastes and extra fluid from the body. After a few hours, patient drain the used dialysis solution into a drain bag.
- Then the used dialysis solution, which is now full of wastes and extra fluid, disposed

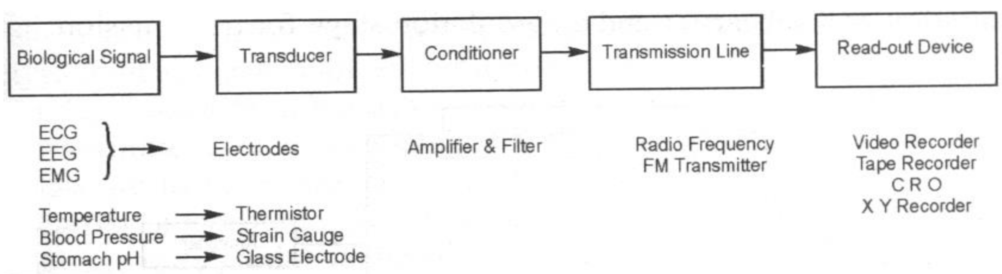
UNIT IV MEASUREMENT OF NON-ELECTRICAL PARAMETERS

Temperature, respiration rate, pulse rate measurement, Blood pressure: indirect method – Auscultatory method, direct methods: electronic manometer, systolic and diastolic pressure, Blood flow and cardiac output measurement: indicator dilution method, dye dilution method, Ultrasonic blood flow measurement.

PART *A

Q.No.	Questions
1	**What is total lung capacity and vital capacity?** BTL1 **Lung capacity** The total lung capacity is the amount of gas contained in the lungs at the end of maximal inspiration. **Vital Capacity** The vital capacity (VC) is the maximum volume of gas that can be expelled from the lungs after a maximal inspiration.
2	**What are systolic and diastolic pressures? (NOV2013)** BTL1 The heart is pumping cycle is divided into two major parts systole and diastole. Systole is defined as the period of contraction of the heart muscles specifically the ventricular muscle at which time blood is pumped into the pulmonary artery and the aorta. Systolic pressure is 120 mm Hg(average value). Diastole is the period of dilation of the heart cavities as they fill with blood. Diastolic pressure is 80 mm Hg (average value).
3	**What is cardiac output? What is the value of cardiac output if the stroke volume is 7.ml and heart rate is 70 BPM.(MAY 2016)** BTL1 Cardiac output (Q) = stroke volume (SV) x heart rate (HR)70 x 70= 4900 ml/minutes
4	**What is a radio-pill? Mention the application. (MAY-2016)** BTL1 The radio pill is capable of measuring various parameters. With the help of radio pill type devices, it is possible for use to measure or sense temperature, pH, enzyme activity, and oxygen tension values. These

	measurements can be made in associated with transducers. Pressure can be sensed by using variable inductance, temperature can be measured by using temperature-sensitive transducer. Radio is a silicon-coated capsule containing a miniature radio transmitter that can be swallowed by a patient. During its passage through the digestive tract a radio pill transmits information about internal conditions (acidity, etc.).
5	**What is principle of telestimulation? (NOV-2014)**BTL1 Telestimulation is the measurement of biological signals over long distance.
6	**Define Let-go current (NOV-2016)**BTL1 Let – go current is the minimum current to produce muscular contraction. For men—about 16mA For Women—about 10.5 Ma
7	**Define – Micro Shock (NOV-2013)** BTL1 A physiological response to a current alied to the surface of the heart that results in unnecessary stimulation like muscle contractions or tissue injury is called as micro shock.
8	**Define – Macro Shock (NOV 2014)** BTL1 A physiological response to a current applied to the surface of the body that produces unwanted stimulation like tissue injury or muscle contractions is called as macro shock.
9	**What is meant by diathermy? (NOV -2014)** BTL1 Diathermy is the treatment process by which, cutting coagulation of tissues are obtained.
10	**List the types of diathermy.** BTL4 The types of diathermy are i)Short wave diathermy ii)Microwave diathermy iii)Ultrasonic diathermy iv)Surgical diathermy
11	**What are the different types of current that are used for medical applications?** BTL1 The different types of current are Threshold current, pain current, let-go current, paralysis current, fibrillation and defibrillation current.
12	**What are the devices used to protect against electrical hazards?** BTL1 **(MAY2016) (MAY 2014)**BTL1 i).Ground fault interrupt ii).Isolation transformeriii) Line isolation monitor
13	**What are the application of Bio-Telemetry? (MAY 2013)** BTL1 The most common usage for biotelemetry is in dedicated cardiac care telemetryunits or step-down units in hospitals. Although virtually any physiological signal could be transmitted, application is typically limited

	to cardiac monitoring.
14	**What are the choices of radio carrier frequency for medical telemetry purpose? (NOV 2016)**BTL1 The biosignals are amplified to radio frequency range of few hundred KHz to about 300 KHz and then they are transmitted by transmitter antenna's.
15	**What is the use of ultrasonic diathermy? (DEC 2011)**BTL1 Ultrasonic diathermy can be used to cure few diseases like Neuritis, Arthritis, Skin ulcers
16	**Draw the block diagram of Bio-telemetry system.(DEC 2008)**BTL1  *Block Diagram of a Biotelemetry System*
17	**List the applications of Bio-Telemetry. (MAY 2011)**BTL4 Monitoring ECG even under ergonomic conditions. Monitoring the health of astronauts in space. Patient monitoring in an ambulance and other locations away from hospital. Research on unanesthetized animals.
18	**Mention the advantages of a Bio-telemetry System (MAY 2011)(JUNE 2009)(JUNE 2007)**BTL1 Major advantage of using biotelemetry is removing the cables from patient and providing a more comfortable medium to patient. Patient needs to carry only a small transmitter. Isolation of patient from high voltage completely. Transmitters in the patient side work with batteries without any danger of electrical shock.
19	**Differentiate between 'Macroshock' and 'Microshock' with respect to current applied to heart.** BTL4

S. No	Micro shock	Macros hock
1	A physiological response to a current applied to the surface of the heart that results in unwanted stimulation like muscle contraction or tissue injury is called micro shock.	A physiological response to a current applied to the surface of the body that results in unwanted stimulation like muscle contraction or tissue injury is called macros hock
2	The current rating is in micro amps	The current rating is in milli amps and Amphere
3	It is introduced due to leakage current, static electricity and interruption of power	This is introduced due to short circuit, improper grounding and using 2 pin sockets

20

What are the causes of leakage current? (Or) How do electrical hazards occur due to medical equipments? (DEC 2010)BTL1

- Ungrounded equipment
- Broken ground wire
- Unequal ground potentials

21

What is the principle of Diathermy (NOV 2015) BTL1

In diathermy, a high-frequency electric current is delivered via shortwave, microwave, or ultrasound to generate deep heat in body tissues. The heat can be used to increase blood flow or to relieve pain. Diathermy also can be used as a surgical tool to seal off blood vessels or destroy abnormal cells

PART*B

1

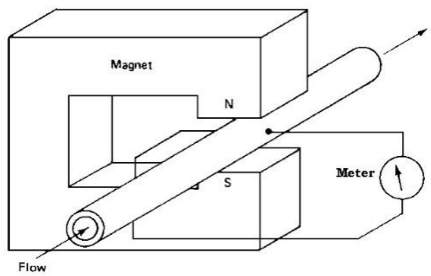
Explain the working principle of blood flow meter.Discuss about the various methods for determining cardiac output. (May/June-2016)(Nov/Dec-2016) (May/June-2013) (Nov/Dec-2013)(May/June-2013)(13M) (Apr/May 2019)BTL1

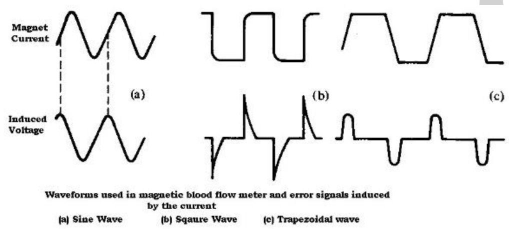
Answer: Page: 233 -Dr.M.ARUMUGAM
BLOOD FLOW METERS :(2M)

- Blood flow meters - monitor the blood flow -various blood vessels and to measure the cardiac output .Electromagnetic flow meters, Ultrasonic flow meters and laser base blood flow meters - widely used to measure the blood flow rate. Flow rates are expressed in lit/min or ml/min (cm3/min)

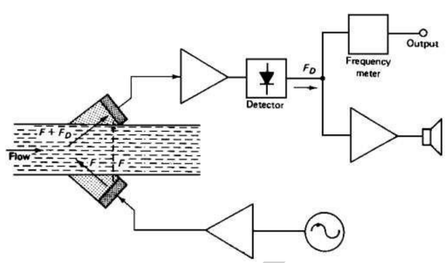
PRINCIPLE: (2M)

- Electromagnetic induction
- Ultrasound transmission or reflection
- Thermal convection
- Radiographic principles
- Indicator (dye or thermal) dilution
- Magnetic Blood Flow Meter:





Ultrasonic blood flow meter :(2M)



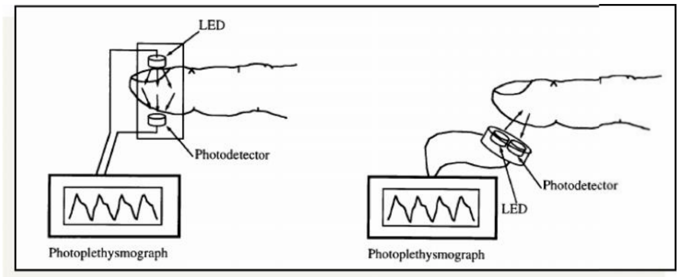
Thermal Dilution Method :(2M)

- A bolus of chilled saline solution -injected - blood circulation system (right atrium)- decrease in the pulmonary artery temperature- artery puncture is not needed - technique. Several measurements - relatively short time .A standard technique for measuring cardiac output in critically ill patients.

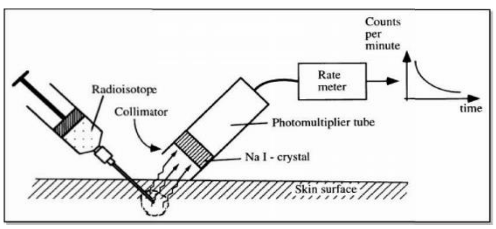
Photoelectric Method

- A beam of IR-light is directed to the part of the tissue which is to be measured for blood flow (e.g. a finger or ear lobe).

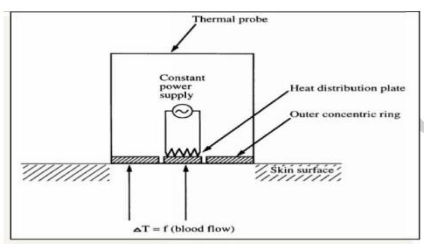
The blood flow modulates the attenuated / reflected light which is recorded. The light that is transmitted / reflected is collected with a photo detector (5M)



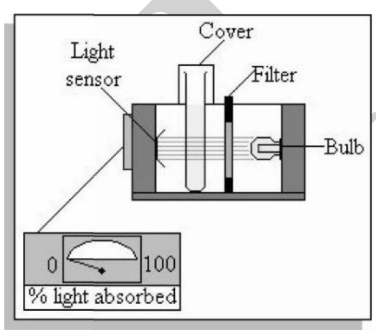
Radioisotopes

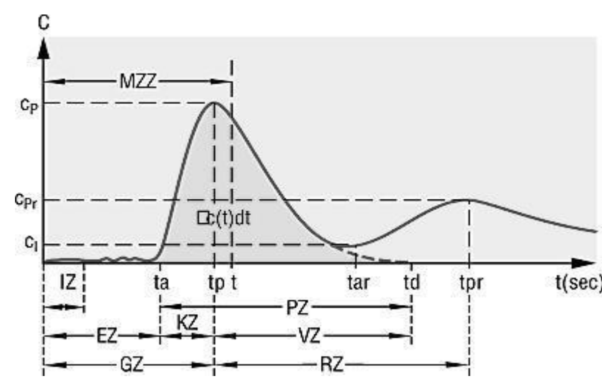


Thermal Convection Probe



Indicator Dilution Methods Dye Dilution Method





2 **How lung volume can be measured? Explain with necessary diagram.(13M)(Nov/Dec-2014) May/June-2016)**BTL1

Answer: Page: 202-Dr.M.ARUMUGAM

LUNG VOLUME :(3M)

- **Ventilation**
- **Distribution**
- **Diffusion**

Ventilation:

Ventilation deals with the determination of the ability of body to displace air volume quantitatively and the speed with which it moves the air. Spiro meters are used in the ventilation measurement.

Distribution:

It indicate the degree of lung obstructions for the flow of air and also determine the residual volume of air that cannot be removed from the lungs. Pneumotachometers are used to measure the instantaneous rate of volume flow of respired gases.

Diffusion.

It indicate the lung ability to exchange gas with the circulatory system or the rate at which gas is exchanged with the blood stream. Gas analyzers are used in the diffusion measurements.

Lung volumes and capacities : (8M)

Pulmonary function analyzers - determine the lung volumes and capacities. These parameters depend on individuals physical characteristics and condition of breathing mechanism.

TLC – Total Lung Capacity.

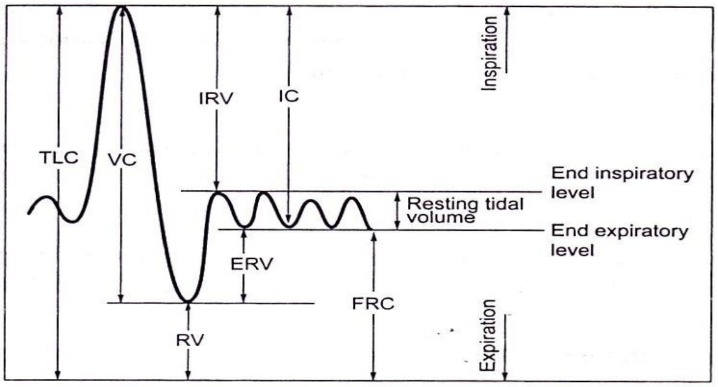
vital capacity (VC) - residual volume (RV).

TV- Tidal Volume

. IRV→ Inspiratory Reverse Volume, E

RV → Expiratory Reverse Volume.

.RV - extra volume



(2M)

IC→ Inspiratory Capacity.

FRC→ Functional Residual Capacity.

FVC → Forced VitalCapacity ,FEC→ Forced Expiratory Volume

FVC is the total amount of air. FEV is the maximum amount of gas.

3

Explain how respiration rate can be measured give its normal values.(13M) (Nov/Dec-2016) (ANY TWO METHOD)BTL1

Answer: Page:43 -REFER NOTES

Measurement of Respiration rate: (2M)

- Thermistor placed in front of the nostril
- Displacement transducer put across the chest
- Impedance electrodes

The respiratory signal from any one of these transducers is amplified and the time interval is measured between two successive pulses.

The measuring range is 0-50 respiration / minute.

The methods used to measure respiration rate are,

- Thermistor method
- Impedance Pneumography
- CO2 measurement of respiration rate
- Displacement method

Thermistor Method: (2M)

- thermistor - placed in front of the nostrils by means of a suitable holding device to detect the difference in temperature between the inspired and expired air.

- Since the inspired air passes through the lungs and respiratory tract, its temperature is increased while coming out. This change in temperature is detected by using thermistor.
- Incase the difference in temperature of the outside air and expired air is small, the thermistor can be initially heated to an appropriate temperature and the variation of its resistance in synchronous with the respiration rate can be detected
- thermistor - placed as part of a voltage dividing circuit or in a bridge circuit whose unbalance signal can be amplified to obtain the respiration rate.

Displacement Method: (2M)

- During each respiratory cycle, the thoracic volume changes. These changes can be sensed by means of displacement transducer.
- The transducer is held by an elastic band which goes around the chest.
- The respiratory movement results in resistance changes of the strain gauge element connected as one arm of a wheatstone bridge circuit. Bridge output varies with chest expansion and yields signals corresponding to respiratory activity.
- Changes in the chest circumference can also be detected by a rubber tube filled with mercury. The tube is fastened firmly around the chest
- During inspiration, the chest expands and the rubber tube increases in length and the resistance of the mercury from one end of the tube to the other end changes. The change in resistance can be measured by sending a constant current through it and measured in terms of change in voltage during each respiratory cycle.

Impedance Pneumography: (3M)

Impedance Pneumograph is based on the fact that the impedance across the chest changes during each respiratory cycle.

low voltage 50 to 500KHz AC signal is applied to the chest of the patient through surface electrodes and the modulated signal is detected.

High value fixed resistors are connected in series with each electrode to create a constant AC current source. The signal voltage applied to the differential AC amplifier is the voltage drop across the resistance representing patient's thoracic impedance. $Eo = I.(R \pm \Delta R)$

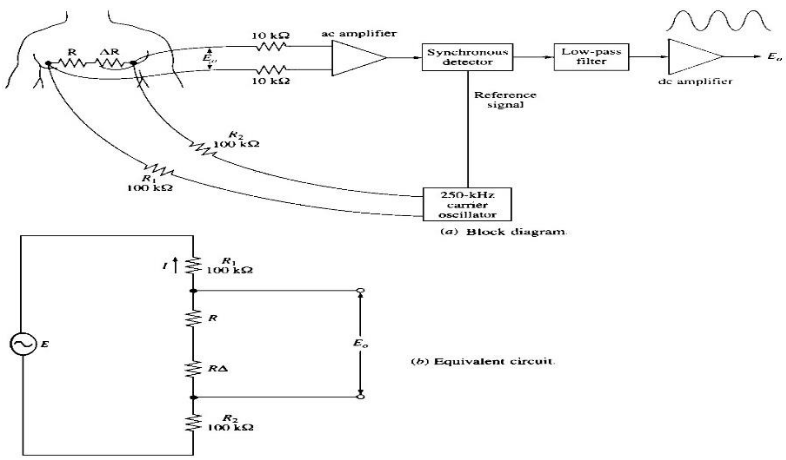
Where,

Eo – Output potential in volts.

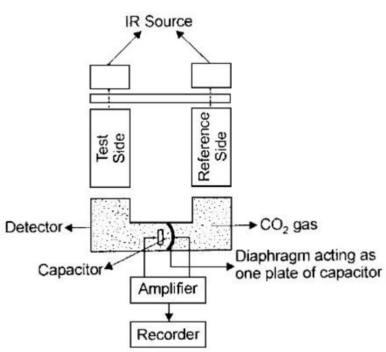
I – Current through the chest in amps.

R – Chest impedance without respiration in ohms. (6M)

ΔR – Change of chest impedance caused by respiration in ohms.



CO2 method of respiration rate measurement: Respiration rate can also be measured by continuously monitoring the CO2 contained in the subject's alveolar air.



When infrared rays are passed through the expired air containing a certain amount of CO2 some of the radiations are absorbed by it. There is a proportional loss of heat energy associated with the rays.

The detector converts this heat loss of the rays into an electrical signal. This signal is used to obtain the average respiration rate.

Two beams of equal intensity of infrared radiations from the infrared source fall on one half of each of the condenser microphone assembly.

The infrared rays from the infrared source are chopped at 25 KHz by the chopper motor. A disc is connect ed to the spindle of the chopper motor.

The detector has two identical portions separated by a thin flexible metal diaphragm. One is called test side and the other is called as reference side.

The detector is filled with a sample of pure CO2. Because of absorption of CO2 in the analysis cell, the beam falling on the test side of the detector is weaker than that falling on the reference side.

The gas in the reference side would be heated more than that on the analysis side. As a result, the diaphragm is pushed slightly to the analysis side of the detector.

The diaphragm forms one plate of the capacitor.

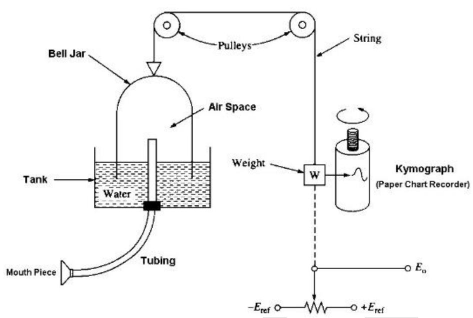
The voltage developed across the diaphragm is amplified, shaped and suitably integrated to the give the respiration rate.

Spirometer:

Conventional spirometer is shown in figure below. This instrument uses a bell jar, suspended from above, in a tank of water. An air hose leads from a mouthpiece to the space inside of the bell above the water level. A weight is suspended from the string that holds the bell in such a way that it places a tension force on the string that exactly balances the weight of the bell at atmospheric pressure.

When no one is breathing into the mouthpiece, the bell will be at rest with a fixed volume above the water level. But when the subject exhales, the pressure inside the bell increases above atmospheric pressure causing the bell to rise. Similarly, when the patient inhales, the pressure inside the bell decreases. The bell will rise when the pressure increases and drop when the pressure decreases.

The change in bell pressure changes the volume bell, which also causes the position of the counterweight to change. We may record the volume changes on a piece of graph paper by attaching a pen to the counterweight or tension string.



Bell-Jar mechanical Spirometer

The chart recorder is a rotary drum model called a kymograph. It rotates slowly at speeds between 30 and 2000 mm/min.

Some spirometers also offer an electrical output that is the electrical analog of the respiration waveform. Most frequently the electrical output is generated by connecting the pen and weight assembly to a linear potentiometer.

If precise positive and negative potentials are connected to the ends of the potentiometer, then the electrical signal will represent the same data as the pen.

3 **Explain about blood pressure measurement.(OR)Explain the principle of Sphygmomanometer. (13M)(Nov/Dec-2016) (Nov/Dec-2013)(May/June-2013)**BTL1

Answer: Page: 43 -REFER NOTES

BLOOD PRESSURE MEASUREMENT :

Pressure is defined as force per unit area p = F / A (2M)

P = pressure in Pascal, F= force,

A=Area

Pressure - increased by increasing the applied force or by decreasing the area.

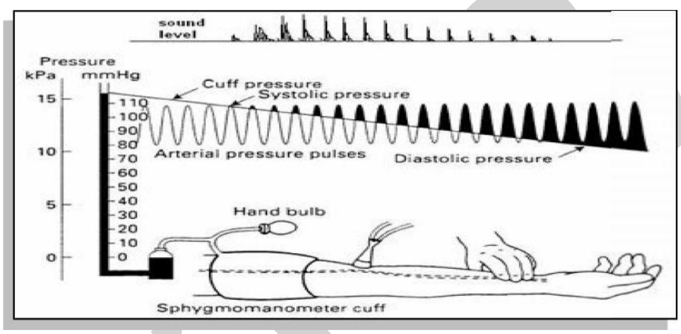
Hydrostatic pressure: If the force in a system under pressure is not varied then pressure is known as Hydrostatic pressure

Hydrodynamic pressure: If the force in a system under pressure is varied then pressure is known as Hydrodynamic pressure

Methods :

- Indirect method using sphygmomanometer(2M)
- Direct method

Indirect method using sphygmomanometer:(4M)



Then doctor slowly reduces the pressure in the cuff & he watch the mercury column when the systolic pressure exceeds the cuff pressure. Then doctor can hear some crashing, snapping sound through stethoscope -korotkoff sound.

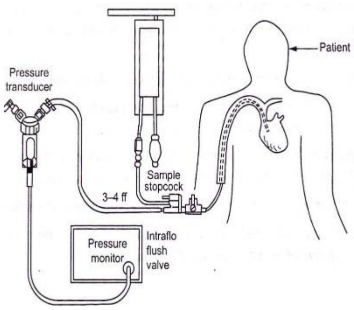
Korotkoff sound - vanished when the pressure drops below the diastolic pressure. Pressure reading in the mercury column during onset of korotkoff sound is noted as systolic pressure usually 120 mmHg. Pressure reading - mercury column at which korotkoff sound - disappeared is noted as diastolic pressure usually 80 mmHg for normal persons. Korotkoff sound is disappeared at some point. That is known as muffling.

Advantages :

- Method is very simple
- Painless techniques
- There is no hazardous surgical procedure involved. Disadvantages

- Effective result depend on the fact how accurately doctor read pressure values when koratkoff sound is heard.

Direct method:



Probe used in Direct blood pressure measurement:(3M)

Catheter tip probe sensor mounted at the tip of the probe. Pressure exerted on the tip is converted to the corresponding electrical signal. In fluid filled catheter type. Pressure exerted on the fluid filled column is transmitted to external transducer. This transducer converts pressure in to electrical signal.

Direct method of blood pressure measurement:

Here fluid filled catheter is used. Before inserting catheter into blood vessel, fluid filled system should be completely flushed out. Usually sterile saline is used for this purpose. Because blood clotting is avoided.

M2 reading = peak systolic value - peak to peak pressure value.

5

Explain the working of temperature measurement?(8M)BTL1

Answer: Page: 47-REFER NOTES

The variation in the temperature is a direct result of the variation in blood pressure. The metabolic rate and temperature have a close relation.

Body temperature is one of the indicators of a person being normal.

Basically two types of temperature measurement cam be obtained from the human body

- Systemic
- Skin surface

Systemic Temperature: (4M)

Systemic temperature is the temperature of the internal regions of the body. This temperature is maintained by balancing the heat generated by the active tissues of the body (muscles & Liver) and the heat lost by the body to the environment.

Systemic temperature is measured by using temperature sensing devices placed in mouth, under the armpits or in the rectum.

The normal oral (mouth) temperature of a healthy person is 37˚C. The normal under arm temperature of a healthy person is 36˚C and The normal rectum temperature of a healthy person is 38˚C.

The systemic body temperature can be measured more accurately at the tympanic membrane in the ear.

Even for the healthy person, the temperature will not be constant. It will vary about 1 to 1 ½ ˚C in the early morning compared to the late afternoon.

The temperature control center for the body is located deep within the brain. Here the temperature of the blood is monitored and its control functions are coordinated.

If the surrounding temperature is warm, then the body is cooled by perspiration due to secretion of the sweat glands and by increased circulation of blood near the surface. The body acts as a radiator.

If the surrounding temperature becomes too low, then the body conserves heat by reducing the blood flow near the surface to the minimum required for maintenance of the cells. At the same time metabolism is increased.

Surface of Skin temperature: (4M)

Surface or skin temperature is a result of a balance but here the balance is between the heat supplied by blood circulation in the local area and the cooling of that area by conduction, radiation, convection and evaporation. Thus skin temperature is a function of the surface circulation, environmental temperature, air circulation around the area from which the measurement is to be taken and perspiration.

To obtain a meaningful skin temperature measurement, it is usually necessary to have the subject remain with no cloth covering the region of measurement in a fairly cool ambient temperature.

Measurement of systemic Body temperature:

Mercury Thermometer:

Mercury thermometer is the standard method of temperature measurement.

Mercury thermometer is used where continuous recording of temperature is not required.

Mercury thermometers are inexpensive, easy to use and sufficiently accurate.

Electronic Thermometer:

Now-a-days electronic thermometers are available as a replacement of mercury thermometer. IT has disposable tip and requires only less time for reading and also much easier to read the value.

Electronic thermometers are used where continuous recording and accuracy of the temperature is necessary.

Two types of electronic temperature sensing devices are found in biomedical applications. They are,

- Thermocouple

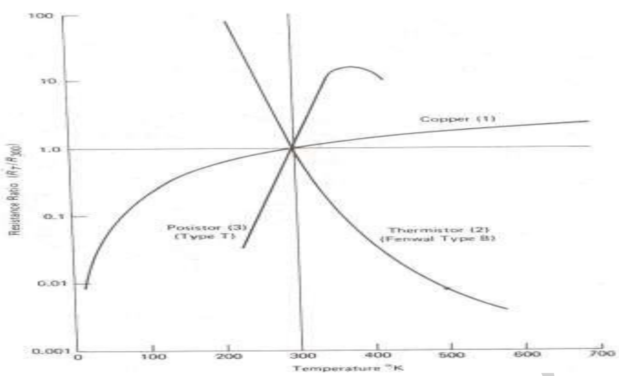
- Thermistor

Thermistors are variable resistance devices formed into disks, Beads, Rods or other desired shapes. They are manufactured from mixtures of oxides of various elements such as nickel, copper, magnesium, manganese, cobalt, titanium and aluminium.

After the mixture is compressed into shape, it is shaped at a high temperature into a solid mass. The result is a resistor with a large temperature coefficient.

Most metals show an increase in resistance of about 0.3 to 0.5 percent per ˚C temperature rise and the thermistors show decrease in resistance by 4 to 6 percent per ˚C temperature rise.

A Comparison of resistance Vs Temperature curves for copper, thermistor, posistor is as shown below.



Skin temperature Measurement:

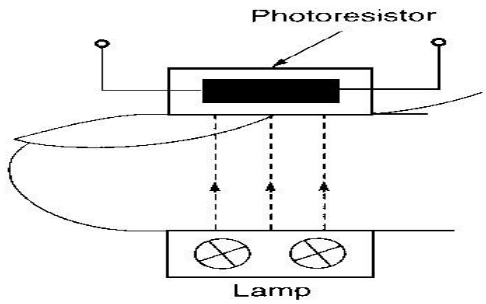
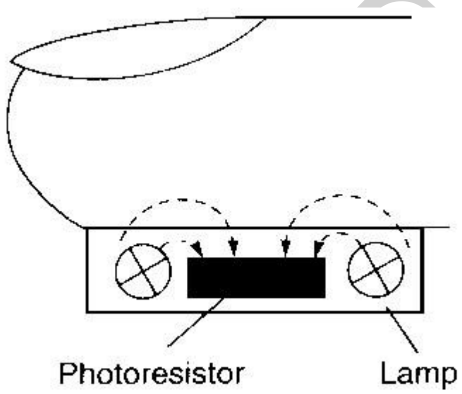
Although the systemic skin temperature remains very constant throughout the body, skin temperature can vary several degrees from one point to another. The range is usually from about 30 to 35°C (85 to 95◦F). Exposure to ambient temperatures, the covering of fat over capillary areas, and local blood circulation patterns are just a few of the many factors that influence the distribution of temperatures over the surface of the body. Often, skin temperature measurements can be used to detect or locate defects in the circulatory system by showing differences in the pattern from one side of the body to the other.

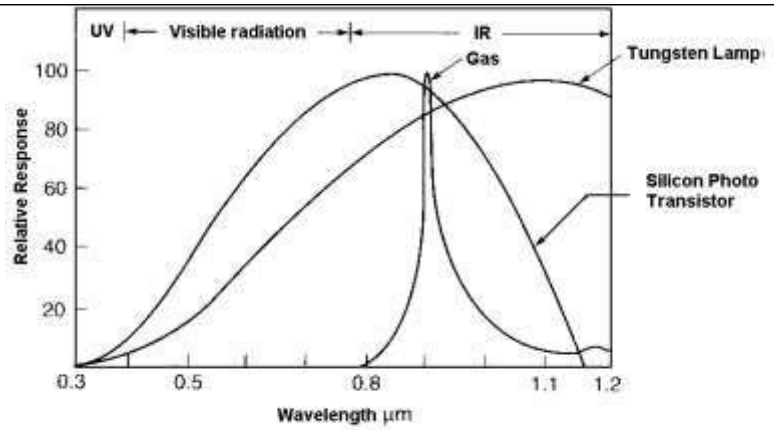
Skin temperature measurements from specific locations on the body are frequently made by using small, flat thermistor probes taped to the skin. The simultaneous readings from a number of these probes provide a means of measuring changes in the spatial characteristics of the circulatory pattern over a time interval or with a given stimulus.

The human skin has been found to be an almost perfect emitter of infrared radiation. That is, it is able to emit infrared energy in proportion to the surface temperature at any location of the body. If a person is allowed to remain in a room at about 21°C (70°F) without clothing over the area to be measured, a device sensitive to infrared radiation can accurately read the surface temperature. Such a device, called an infrared thermometer.

PART *C

1	**Explain the working of pulse measurement?(15M)**BTL1 **Answer: Page: 47-REFER NOTES** The pulse can be felt by placing the finger tip over the radial artery in the wrist or some other locations where an artery seems just below the skin. The pulse pressure and waveform are indicators for blood pressure and blood flow. The instrument used to detect the arterial pulse and pulse pressure waveform is called as plethysmograph. The pulse waveform travels at 5 to 15 m/sec depending up on the size and rigidity of arterial walls. The methods used to detect volume (pulse) change due to blood flow are, • Electrical Impedance changes • Strain Gauge or microphone (mechanical) • Optical change (Changes in density) (5M) **Electrical Impedance changes:** Electrical Impedance method measures the impedance change between 2 electrodes caused by the change in blood volume between them. The change in the impedance (0.1 ohm) may be as small as compared to the total impedance (Several hundred ohms). The impedance is measured by applying an alternating current between electrodes attached to the body. An alternating current (10 – 100 KHz) is used. **Strain Gauge or microphone (mechanical):** The mechanical method involves the use of strain gauge connected to a rubber band placed around the limb or finger. Expansion in the band due to change in blood volume causes a change in resistance of the strain gauge. A sensitive crystal microphone is placed on the skin surface to pick up the pulsation. (5M) **Optical change (Changes in density):** The most commonly used method to measure blood volume change is photo electric method. In this method we have 2 types of method • Transmittance method • Reflectance method **Transmittance method:** (5M)

	In transmittance method, a light emitting diode (LED) and photoresistor are mounted in an enclosure that fits over the tip of the patient's finger. The light is transmitted through the finger tip of the subject's finger and the resistance of the photoresistor is determined by the amount of light reaching it. With each contraction of the heart, blood is forced to the extremities and the amount of blood in the finger increases. It alters the optical density with the result that the light transmission through the finger reduces and the resistance of the photoresistor increases accordingly.  *transmission method* The photoresistor is connected as part of a voltage divider circuit and produces a voltage that varies with the amount of blood in the finger. This voltage that closely follows the pressure pulse and its waveshape can be displayed on an oscilloscope or recorded on a strip-chart recorder. **Reflectance method:** The arrangement used in the reflectance method of photoelectric plethysmography is shown in the figure below.  *reflectance method* The photoresistor is placed adjacent to the exciter lamp. Part of the light rays emitted by the LED is reflected and scattered from the skin and the tissues and falls on the photoresistor. The quantity of light reflected depends upon the amount of blood filling the capillaries and, therefore, the voltage drop across the photoresistor, connected as a voltage divider, will vary in proportion to the volume changes of the blood vessels.



Relative spectral response for silicon phototransistor and the radiant spectral distribution of a tungsten lamp and a gallium-aresenide lamp

The LED phototransistor-photoplethysmograph transducer (Lee et al, 1975) consists of a Ca-As infrared emitting diode and a phototransistor in a compact package measuring 6.25 x 45 x 4.75 mm. The peak spectral emission of the LED is at 0.94mm with a 0.707 peak bandwidth of 0.04mm. The phototransistor is sensitive to radiation between 0.4 and 1.1mm as shown above.

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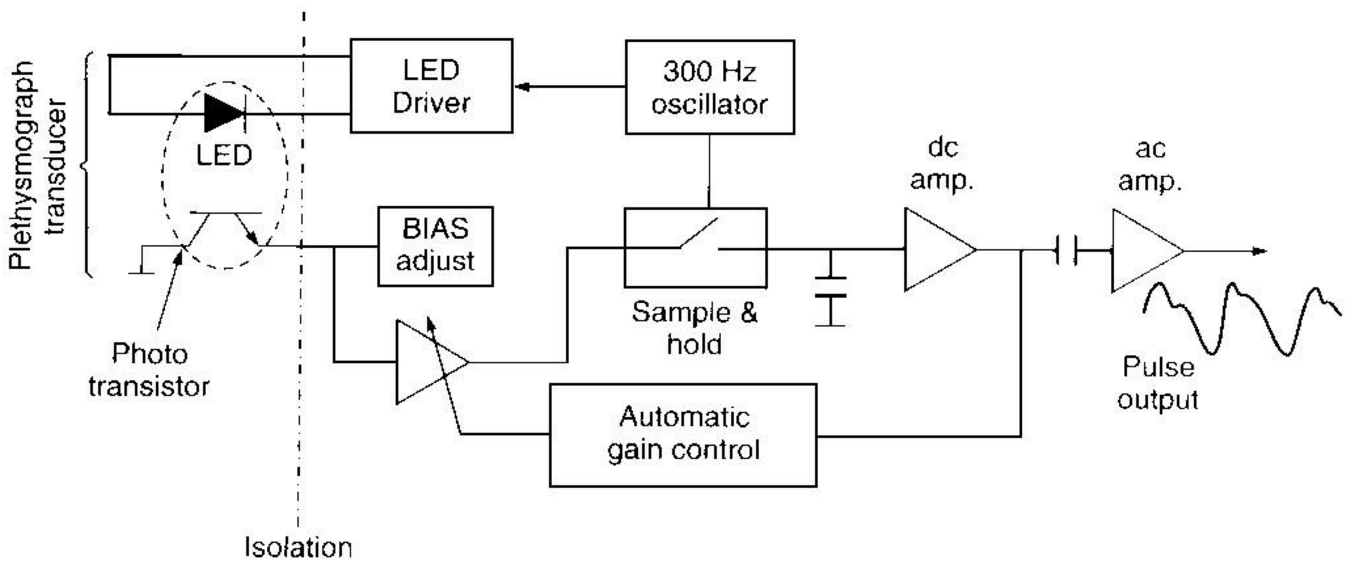
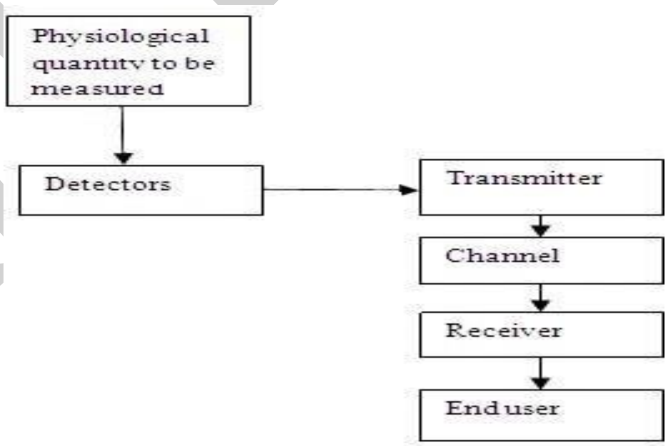


Block diagram for processing plythysmographic signal

The circuit consists of two parts, a LED oscillator - driver, which produce 300 Hz, 50S- infrared light pulses to the finger probe attached to the patient, and a phototransistor that picks up the attenuated light. The electrical signal obtained from the phototransistor is amplified and its peak value is sampled and filtered. An automatic gain control circuit adjusts the amplifier gain to yield a constant average pulse height at the output.

The ac component with a frequency in the heart rate range (0.8-5 Hz) is further amplified to output the

	plethysmographic pulse rate form. This signal is transmitted across the isolation barrier, demodulated, low-pass filtered and transmitted to the analog multiplexer resident on the CPU board.
2	**Discuss in detail about Telemetry Principles. (10M) (Nov/Dec-2013)(May/June-2014)**BTL6 **Answer: Page: 312-Dr.M.ARUMUGAM** **Design considerations for a telemetry system**(2M) • Simplicity of the telemetry system • Transmission should be with maximum fidelity • Telemetry components should be less weight and size • High reliability and stability is must • Power consumption should be small • Shielding of the cable is a must in wire based transmission **Telemetry system:** • information regarding - quantity being measured transmitted to a remote location for application like data processing • recording or displaying. • In other words telemetry means measuring at a distance. Therefore it becomes essential to transmit data through some form of communication channels. **Methods of classification of telemetry system:**(2M) • On the basis of the characteristics of electric signal such as voltage current position,frequency and pulse • Based on form of data transmitted –analog and digital • Based on transmission of distance –short distance type or long distance type • Based on whether user has control over transmission channel or not. • The physiological quantity to be measured by a suitable detector and given to the transmitter. The electrical telemetry system is broadly classified as DC systems and AC systems.  (6M)

DC telemetry system:

The signal is transmitted through a telemetry or communication channel which uses direct transmission via cables in order to convey the desired information . This is known as land line telemetry.

AC telemetry system:

It is used both for land line and radio frequency air borne telemetry techniques. Electronics means are used for sensors that provide an AC output or voltage to frequency converter. The data is available in the form of current or voltage which is generally weak . Hence It is modulated with carrier signals for transmission. These modulated signals are demodulated at the receiving end which means recovering the original signal from carrier wave. Basically there are three types of modulation

Amplitude modulation:

In this type of modulation the amplitude of the carrier is varied in accordance with the signal to be transmitted.

Frequency modulation:

In this type of modulation the instantaneous frequency of the carrier is varied in accordance with the amplitude of the modulating signal.

Phase modulation:

Here phase angle is varied in accordance to be transmitted signal.

Communication channels(or) Transmission media:

The most widely used communication channels are cables and electromagnetic radiation radio links. Optical ,ultrasonic and magnetic induction data links are also used for many applications. Land line telemetry utilizes cables or wires to transmit data. When data is to be transmitted for more than 1km radio links are preferred. For frequency above 30MHz microwave links are used. For short range transmission up to 50m frequency modulation used.

3

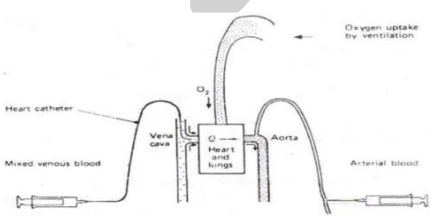
Discuss about the various methods for determining cardiac output.(15M)(May/June-2013)BTL1

Answer: Page: 246 -Dr.M.ARUMUGAM

Flick's Method: (4M)

Determination of cardiac output - analysis of gas-keeping - organism. The cardiac output is calculated by continuously infusing oxygen into blood or removing it from the blood and measuring the amount of oxygen in blood before and after its passage. Let I be the amount of infused or removed oxygen per unit time. I is equal to the difference between amount in blood arriving at and departing from it.

I=CAQ - CVQ



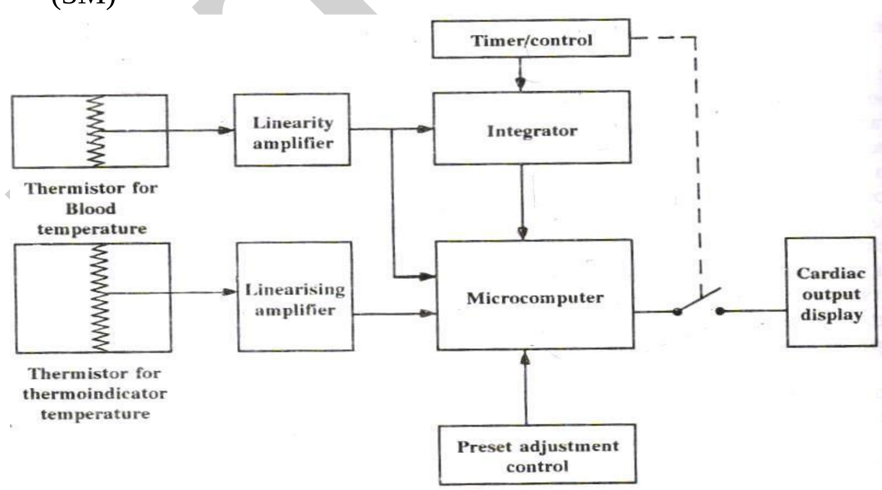
Indicator Dilution Method: (3M)

- This is based on the principle that if we introduce an indicator in the blood circulation
- and then measuring the concentration of indicator with respect to time. We can estimate the volume flow of blood. Let M mg of an indicator is injected into the right heart. After passing through the right heart, lungs and left heart, the indicator appears - arterial circulation. The presence of the indicator- peripheral artery - detected by a detector. The output of the detector - directly proportional - concentration of indicator.
- The detector is displayed on a chart recorder with respect to time. Let an increment in volume dv passes the sampling site in time dt. Let the mass of indicator in dv = dm

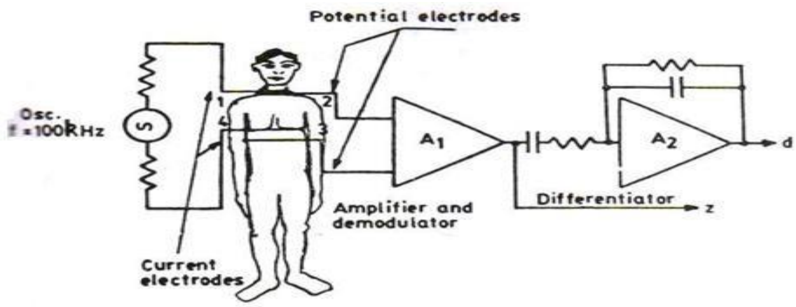
Thermo Dilution Method. : (3M)

Thermo dilution method - adapted to measure cardiac output. A bolus of about 10ml of 5% dextrose in water at room temperature is injected as a thermal indicator into right artrium. After mixing- detected in the pulmonary artery by means of a thermistor mounted at the tip of a miniature catheter probe. The temperature difference between the injectate temperature and the circulating blood temperature in the pulmonary artery is measured. The reduction in temperature is integrated w.r.t time and the meter reads the cardiac output.

(3M)



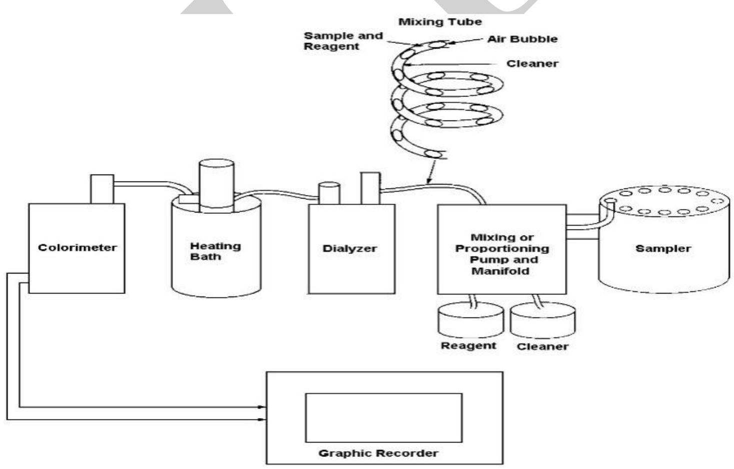
Measurement of cardiac output by impedance change. (2M)

	
UNIT V BIO-CHEMICAL MEASUREMENT	**9**
Blood gas analyzers and non-invasive monitoring, colorimeter, sodium potassium analyzer, spectrophotometer, blood cell counter, Auto analyzer	
PART*A	
Q.No.	**Questions**
1	**State different types of tests performed by auto analyzer.(MAY2016)** BTL1 • Mixing • Reaction • Colorimetric determination
2	**What is thermograph? (NOV 2015)**BTL1 The instrument used to record the temperature distribution over the surface of the body or skin is called as thermograph.
3	**List out the applications of thermography (MAY 2011)**BTL1 Thermography is used in diagnising many diseases like breast cancer, Rheumatic diseases, burns, perniones, joint diseases and location of placenta.
4	**Mention the types of lasers used in medical field (Or) What types of lasers are used for patient treatment (Or) What are the applications of lasers in medicine?**BTL1 CO2 Laser – Surgery, Dental treatment Nd – YAG – Surgery, dental treatment, Photocoagulation Argon ion – Ophthalmology (Photocoagulation of small blood vessels in eye) Ruby laser – Retinal treatment, dental treatment
5	**What are the types of lasers used for therapeutic purposes? (APR 2005)**BTL1

	The types of lasers used for therapeutic purpose are, CO2, Ruby, Nd-YAG, Argon ion.
6	**Mention the advantages of LASER in surgery.**BTL1 Highly sterile Highly localized and precise Non contact surgery Dry-field, almost bloodless surgery Short periods of surgical time.
7	**List out the properties of LASER. (Or) List out the characteristics of LASER .**BTL1 Monochromaticity Spatial and temporal coherence Directionality Brightness.
8	**What is the principle of cryogenic technique? Give any two medical application of the same. (Or) What is meant by Cryogeny? (APR 2004)**BTL1 Tissues can be killed when their temperature is below –20C. When the tissues are at –20C, there is a formation of ice crystals and increase of salt concentration within the cells. Thus necrosis of the tissue takes place. This method of killing diseased cells is called as cryogenic surgery or cryogenic technique. The process of freezing the cells by applying agents at very low temperature is called as cytogeneses. Application: Cancer Therapy Dermatology Rhythm disorders of heart Treatment of arrhythmia
9	**Explain the principle of telemedicine. (MAY 2008)**BTL1 Telemedicine is a rapidly developing application of clinical medicine where medical information is transferred via telephone, the internet or other networks for the purpose of consulting and sometimes remote

	medical procedures or examinations.
10	**State the applications of telemedicine. (MAY 2016)**BTL1 • Tele radiology. • Tele cardiology. • Tele education. • Tele consultation
11	**What is meant by single channel telemetry? (NOV 2015)**BTL1 In a majority of the situations requiring monitoring of the patients by wireless telemetry, the parameter which is most commonly studied is the electrocardiogram. It is known that the display of the ECG and cardiac rate gives sufficient information on the loading of the cardiovascular system of the active subjects
12	**Bring out the clinical applications of endoscopy (NOV 2015)**BTL1 A health care provider may use endoscopy for any of the following: investigation of symptoms, such as symptoms in the digestive system including nausea, vomiting, abdominal pain, difficulty swallowing and gastrointestinal bleeding. confirmation of a diagnosis, most commonly by performing a biopsy to check for conditions such as anemia, bleeding, inflammation, and cancers of the digestive system. giving treatment, such as cauterization of a bleeding vessel, widening a narrow esophagus, clipping off a polyp or removing a foreign object.
13	**List the types of pumping sources used in LASER? (MAY 2016)**BTL1 The pump source is the part that provides energy to the laser system.A helium–neon (HeNe) laser uses an electrical discharge in the helium-neon gas mixture, a Nd:YAG laser uses either light focused from a xenon flash lamp or diode lasers, and excimer lasers use a chemical reaction
14	**What is medical thermography? Mention its applications.(NOV 2014)**BTL1 Thermography is the process of recording true thermal image of the surfaces of objects under study. It displays images representing the thermal radiation of skin areas. Thermogram contain both qualitative and quantitative information relevant to the image itself and to temperature. Medical applications of thermography

	Tumors Inflammation Diseases of peripheral vessels Orthopedic diseases
15	**Define - Endoscopes and mention some of its types.(MAY 2014)**BTL1 Endoscope is a tubular optical instrument to inspect or view the body cavities which are not visible to the naked eye normally. Types of endoscopes are cardio scope, bronchoscope, laparoscope, horoscope, gastro scope etc.
16	**List the applications of Endoscope.**BTL1 Endoscopes are used in hospitals for examination, treatment of disease and surgery
17	**Define the physical factors which affect the amount of infrared radiation from the human body.(NOV 2016)**BTL1 Emissivity Reflection Transmittance and absorption
18	**List the types of pumping sources used in LASER .(MAY 2016)**BTL1 ➢ Optical pumping ➢ Electrical pumping ➢ Gas dynamic pumping
19	**What is meant by telemedicine?** BTL1 Telemedicine is the remote diagnosis and treatment of patients by means of telecommunications technology.
20	**What is the use of laparoscope?** BTL1 The laparoscope is used for analyzing abdominal related diseases and to perform operations in the abdominal region.
PART*B	

1	**Explain the working principle of auto analyzer(May/June-2014)(8M)**BTL1 **Answer: Page: 39-REFER NOTES** **AUTO ANALYZER :**(2M) The autoanalyzer - measures blood chemistry and displays - graphic readout. **ELEMENTS:** (4M) **Sampler** - aspirates samples, standards, and wash solutions - autoanalyzer system. **Proportioning pump and manifold** - introduces (mixes) samples with reagents to effect the proper chemical color reaction to be read by the colorimeter. It also pumps fluids at precise flow rates to other modules, as proper color development depends on reaction time and temperature. **Dialyzer** - separates interfacing substances from the sample material by permitting selective passage of sample components through a semipermeable membrane. **Heating bath** - heats fluids continuously to exact temperature (typically 37°C incubation, equivalent to body temperature). Temperature - critical to color development. **Colorimeter** - monitors the changes in optical density of the fluid stream flowing through a tubular flow cell. Color intensities (optical densities) proportional substance concentrations are converted to equivalent electrical voltages **Recorde**r – Converts optical density electrical signal from the colorimeter into a graphic display on a moving chart. (2M) 
2	**Describe the operation of the automatic blood cell counter..(13M) (May/June 16)(Nov/Dec-14) (Nov/Dec-2012)**BTL1

Answer: Page: 274-Dr.M.ARUMUGAM
BLOOD CELL COUNTER COUNT -TWO METHOD:(5M)

- Electrical method called aperture impedance change
- Optical method called flow cytometry

The platelets are involved in the clotting of blood. The red blood cells in the blood consist of hemoglobin.

When the hemoglobin in the blood decreases, anemia is produced. The amount of hemoglobin is normally 130-170 g/l for men and 120-160 g/l for women. To determine retain proportion of blood cells in a given volume of blood, hematocrit or packed cell volume is used. The packed cell volume is the ratio between the height of the packed cells and height of blood in the tube. Normal range of packed cell volume for men is 42-54% and for women is 37-47%.

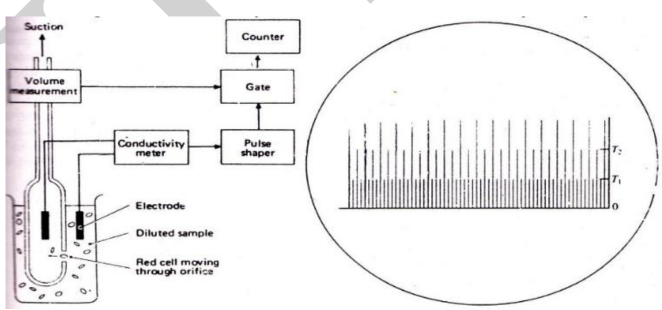
The number of red blood cells can be counted using a microscope, but the microscopic counting is time consuming. Now-a-days automatic red blood cell counters are used.

Automatic Red Blood Cell Counter:(8M)

This method is based on the fact that red cells have a higher electrical resistivity than the saline solution in which they are suspended. Fig .shows the automatic blood cell A diluted blood sample is drawn through a small orifice by means of a section pump. The electrodes are placed such that one in the surrounding sample chamber and other in the suctioned blood. The electrodes are attached with the conductivity bridge such that their resistance forms one arm of bridge. Before suctioning, the resistance of the electrode arm is equal to R.

The threshold is first set to zero and the counter output is given by the total number of particles (WBCs + RBCS + platelets) per litre. Then the threshold is set to T1 and the counter gives the total number RBCS

and WBCS per litre. After that the threshold is set to T2 and the counter reads the total number of WBCS per litre.



3 **Explain in detail about blood gas analysers. Describe the measurement of pH of blood using pH meter.(13M) (Nov/Dec-2014) (Nov/Dec-2013)(May/June-2016)**BTL1
Answer: Page: 21-Dr.M.ARUMUGAM
pH Electrode:

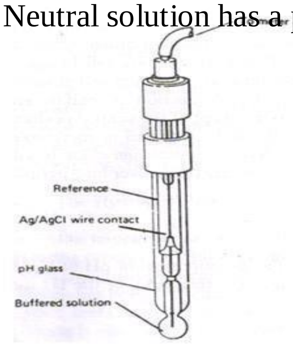
Chemical balance -human body in identified - measurement of pH contentof blood and other body fluids.

PH is defined as the logarithmic of reciprocal of H+ ion concentrations.

$PH = \log_{10} 1/[H^+]$

$= -\log_{10} [H^+]$

Neutral solution has a pH value of 7. If pH < 7, it is acidic, pH >7 it is basic. (2M+2M)



PO2 Electrode:(4M)

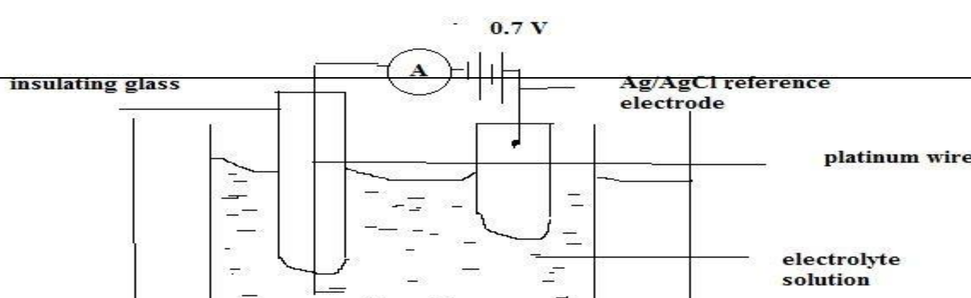
The oxygen electrode - piece of platinum wire embedded - insulating glass holder with the end of the wire exposed to the electrolyte solution into which oxygen is allowed to diffuse through the membrane The bottom of the vessel containing electrolyte- membrane permeable to oxygen and the top of vessel is sealed.

Ag - Agcl electrode is used A voltage of 0.7V is applied between the platinum wire and the reference electrode using a battery. The negative of the battery - platinum wire through an ammeter.

Reduction of oxygen takes place at platinum wire. Hence an oxidation-reduction current is developed and is proportional to the partial pressure of oxygen.

Advantages :(1M)

- The oxygen electrode - monitor the partial pressure of oxygen- biological fluids.
- It is available in integrated version consisting of platinum electrode and reference electrode in the same enclosure called Clark electrode

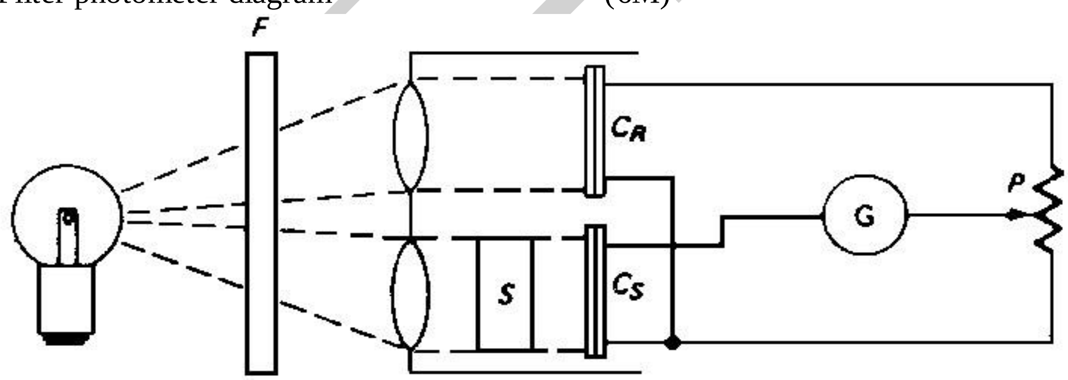


PCO2 Electrode:(4M)

It consists of a standard glass PH electrode covered with rubber membrane permeable to CO2.Between the glass surface and membrane there is a thin film of water. The solution under test contains dissolved CO2 is presented to the outer surface of rubber membrane. After equilibrium PH of aqueous film is measured by glass electrode and interpreted in terms of PCO2.

4

Describe the working principle and operation of colorimeter.(13M) BTL1
Answer: Page: 284-Dr.M.ARUMUGAM
Transmittance T = I1/I0 (2M)
Absorbance or optical density A = log(1/T) (2M)
When an interference filter is used to select a given wavelength, it is called filter photometer (3M)
Filter photometer diagram (6M)



Filter photometer

PART*C

1

Describe the operation of the blood cell counter. Explain the principle of operation of Coulter counter. what is its applications.(15M) (May/June 16)(Nov/Dec-14) (Nov/Dec-2012)BTL1

Answer: Page: 274-Dr.M.ARUMUGAM
BLOOD CELL COUNTER COUNT -TWO METHOD:(4M)

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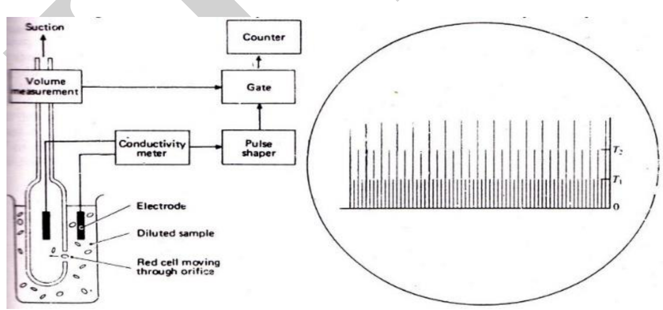
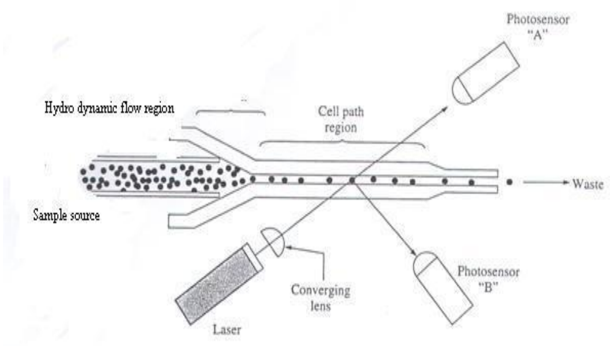
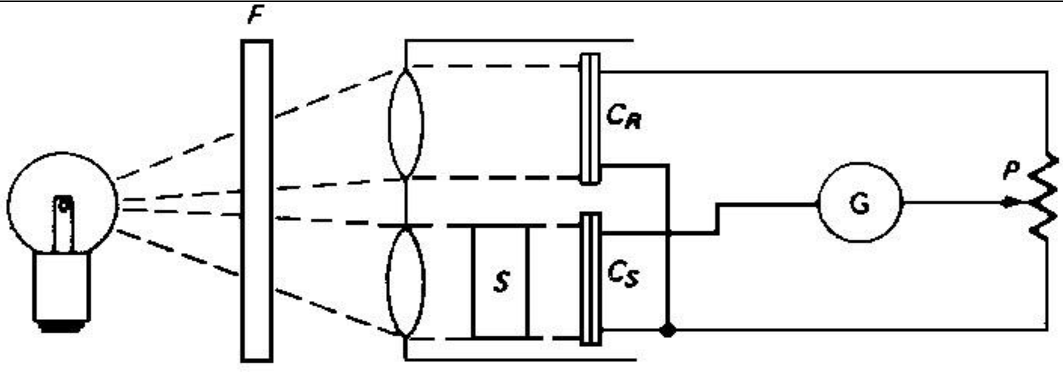


Laser Blood Cell Counter:(5M)

This is a modern technique which gives the number of RBCs, WBCs and Platelets , hematocrit and concentration of hemoglobin. The basic Principle is that the angle of scattered light intensity is different

	for different sized particles. The sample blood is heavily diluted to reduce the number of particles counted to one at a time. A sheath fluid is directed around the blood stream to confine it to the center of aperture through which a laser beam is passed. Thus the blood cells are illuminated by the laser light and they scatter light. The scattered light from platelets and red blood cells are directed into two photo detectors. The output of the photo detector is given to a digital voltmeter which gives the density of red blood cells or platelets. To separates WBCs from RBCs, we can destroy the RBCs by a lying agent. This frees the hemoglobin from the blood and its concentration can be measured. Once again the measurements are made by which the concentration of WBCs can be measured. 
2	Elaborate spectrophotometer and its application in Bio-chemical measurement. (15M) BTL1 **Answer: Page: 286-Dr.M.ARUMUGAM** Diffraction grating or prism is used as a monochromator to get different spectral components or wavelengths. (4M) Light from a halogen lamp passes through an entrance slit s1 (2M) Incident on a conclave reflector which focuses the light on a diffraction grating to disperse light. (3M) From reflector light beam directs to the sample through a narrow slit s2 (2M) Sensitive photodetector D detects transmitted light. (2M) Generation of electrical output Diagram: (2M)



Filter photometer