JEPPIAAR
INSTITUTE OF TECHNOLOGY
“Self-Belief | Self Discipline | Self Respect”

QUESTION BANK

REGULATION :2013
YEAR : IV
SEMESTER : 07
BATCH : 2016-2020

DEPARTMENT OF ELECTRONICS & 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**.**

DEPARTMENT VISION

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 of analog and digital electronics.

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

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REGULATION: 2013 **ACADEMIC YEAR: 2019-2020**

EC6701 **RF AND MICROWAVE ENGINEERING** **L T P C**
3 0 0 3

OBJECTIVES:

- To deal with the microwave generation and microwave measurement techniques
- To instill knowledge on the properties of various microwave components.
- To deal with the issues in the design of microwave amplifier.
- To inculcate understanding of the basics required for circuit representation of RF networks.

UNIT I - TWO PORT NETWORK THEORY 9

Review of Low frequency parameters: Impedance, Admittance, Hybrid and ABCD parameters, Different types of interconnection of Two port networks, High Frequency parameters, Formulation of S parameters, Properties of S parameters, Reciprocal and lossless Network, Transmission matrix, RF behavior of Resistors, Capacitors and Inductors.

UNIT II - RF AMPLIFIERS AND MATCHING NETWORKS 9

Characteristics of Amplifiers, Amplifier power relations, Stability considerations, Stabilization Methods, Noise Figure, Constant VSWR, Broadband, High power and Multistage Amplifiers, Impedance matching using discrete components, Two component matching Networks, Frequency response and quality factor, T and Pi Matching Networks, Microstrip Line Matching Networks.

UNIT III - PASSIVE AND ACTIVE MICROWAVE DEVICES 9

Terminations, Attenuators, Phase shifters, Directional couplers, Hybrid Junctions, Power dividers, Circulator, Isolator, Impedance matching devices: Tuning screw, Stub and quarter wave transformers. Crystal and Schottkey diode detector and mixers, PIN diode switch, Gunn diode oscillator, IMPATT diode oscillator and amplifier, Varactor diode, Introduction to MIC.

UNIT IV- MICROWAVE GENERATION 9

Review of conventional vacuum Triodes, Tetrodes and Pentodes, High frequency effects in vacuum Tubes, Theory and application of Two cavity Klystron Amplifier, Reflex Klystron oscillator, Traveling wave tube amplifier, Magnetron oscillator using Cylindrical, Linear, Coaxial Voltage tunable Magnetrons, Backward wave Crossed field amplifier and oscillator.

UNIT V - MICROWAVE MEASUREMENTS 9

Measuring Instruments : Principle of operation and application of VSWR meter, Power meter, Spectrum analyzer, Network analyzer, Measurement of Impedance, Frequency, Power, VSWR, Qfactor, Dielectric constant, Scattering coefficients, Attenuation, S-parameters.

TOTAL: 45 PERIODS

OUTCOMES:

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

- Explain the active & passive microwave devices & components used in Microwave communication systems.
- Measure and analyze Microwave signal and parameters.
- Generate Microwave signals and design microwave amplifiers.
- Analyze the multi- port RF networks and RF transistor amplifiers.

TEXT BOOKS:

1.Reinhold Ludwig and Gene Bogdanov, “RF Circuit Design: Theory and Applications”, Pearson Education Inc., 2011. (UNIT I, II, III,IV,V)

2. Robert E Colin, “Foundations for Microwave Engineering”, John Wiley & Sons Inc, 2005 (UNIT I, II, III,IV,V)

REFERENCES

1. David M. Pozar, “Microwave Engineering”, Wiley India (P) Ltd, New Delhi, 2008.
2. Thomas H Lee, “Planar Microwave Engineering: A Practical Guide to Theory, Measurements and Circuits”, Cambridge University Press, 2004.
3. Mathew M Radmanesh, “RF and Microwave Electronics”, Prentice Hall, 2000.
4. Annapurna Das and Sisir K Das, “Microwave Engineering”, Tata Mc Graw Hill Publishing Company Ltd, New Delhi, 2005.

Subject Code: EC6701 **Year/Semester: IV /07**
Subject Name: RF AND MICROWAVE ENGINEERING **Subject Handler: Ms.A.Parimala**

UNIT I - TWO PORT NETWORK THEORY	
Review of Low frequency parameters: Impedance, Admittance, Hybrid and ABCD parameters, Different types of interconnection of Two port networks, High Frequency parameters, Formulation of S parameters, Properties of S parameters, Reciprocal and lossless Network, Transmission matrix, RF behavior of Resistors, Capacitors and Inductors.	
PART * A	
Q.No.	**Questions**
1	**Define s-matrix. [Nov/Dec2016]** BTL1 In a microwave junction there is intersection of three or more components.There will be an output port ,in addition there may be reflection from the junction of other ports.Totally there may be many combinations,these are represented easily using a matrix called S matrix.
2	**Enumerate the Properties of s-matrix. [Nov/Dec2012, April /May 15]** BTL1 1. It possess symmetric property sij =sji 2. It possess unitary property 3. [s][s]*=[i]
3	**Why s-matrix is used in MW analysis? [Nov/Dec2011]** BTL1 S matrix is used in MW analysis to overcome the problems which occurs when H,Y,&Z parameters are used in high frequencies. • Equipment is not readily available to measure total voltage &total current at the ports of the network. • Short and open circuits are difficult to achieve over a broad band of frequencies. • Active devices,such as power transistor &tunnel diodes,frequently won‟t have stability for a short or open circuit.
4	**Give ABCD matrix for a two port network.** BTL1 V1= A B V2 I1= C D -I2
5	**What is ABCD matrix? [April/May2017]** BTL1 ABCD matrix is a transmission matrix.these parameters express voltage and current at output in terms of those at input port. V1=AV2-BI2 I1=CV2-DI2
6	**List the advantages of ABCD matrix.** BTL1 • They are used in power transmission lines. • They are very helpful in the case of cascade networks.
7	**Evaluate the Scattering matrix for N port device.** BTL1 [S]= S11 S12 S13…… S1n S21 S22 …………S2n

	S31 S32 ………….S3n . . . . . . Sm1 Sm2 ………...Smm
8	**Give the S matrix of uniform transmission line.** BTL1 S= 0 e^{-jbl} e^{-jbl} 0
9	**Mention the properties of impedence [z] & admittance[y] matrix.** BTL1 • For a lossless junction y and z are symmetric. • $[y]=[z]^{-1}$ • Elements of matix [Z] &matrix [Y] are Frequency dependent.
10	**State the properties of scattering matrix for a lossless junction.** BTL1 • The product of any column of the S-matrix with conjugate of this column equals unity. • The product of any column of the scattering matrix with the complex conjugate of any other column is zero.
11	**Define transmission matrix.** BTL1 When a number of microwave devices are connected in cascade. Each junction is represented by a transmission matrix which gives the output quantities in terms of input quantities
12	**Express power input and power output under matched conditions for a two port network in terms of wave components. [May/June 2013]** BTL2 Microwave circuits are analyzed using scattering(S) parameters, which linearly relate the reflected waves amplitude with those of incident waves. The incident and reflected amplitudes of microwave at any port are used to characterize a microwave circuits. Input power at n^{th} port P_{in} = $\frac{1}{2} \|a_n\|$^2 Reflected power at the n^{th} port P_{in} = $\frac{1}{2} \|b_n\|$^2
13	**Write the voltage matrix for an N-port microwave circuits.** BTL1 V1 Z11 Z12 ….. Z1N I1 V2 Z12 Z22 ….. Z2N I2 .=. . …… …. . . VN ZN1 ZN2….. ZNN IN Where Zij=Elements of impedence

	matrix. [Z]=Impedence martrix
14	**Give two examples for two port junctions.** BTL2 - The junction of two rectangular guides of unequal height - A symmetrical junction consisting of two similar rectangular guides joined by an intermediate guide of greater width.
15	**State the unique property of Scattering matrix.** BTL1 Unitary Property: the row of a scattering matrix multiplied by the complex conjugate of the same row of the scattering matrix is one.
16	**Write the scattering matrix for a ideal waveguide section.** BTL1 [S]=[0 11 0]
17	**Define reciprocal and symmetrical networks. [May/June2013]** BTL1 A reciprocal network is defined to be a network that satisfies the reciprocity theorem. It states that when some amount of emf(or voltage) is applied at one point in a passive linear network, that will produce the current at any other point. The same amount of current is produced when the same emf is applied in the new location. In terms of S parameter, $S_{ij} = S_{ji}$ (i not equal to j),where, i=1,2….N &j=1,2,…..N Due to symmetry of the network topology, the input impedance at the input port is equal to the impedance in the output network. The equality of the input and output impedance leads to the equality of input and output reflection coefficients. In general, for any symmetrical passive n port network, $S_{ij} = S_{ji}$ For any symmetrical and reciprocity networks, we can always write as S_{11}=S_{22}& S_{12}=S_{21}
18	**What is ESR? [Nov/Dec2013]** BTL1 Practical capacitors and inductors are used in electric circuit not ideal components with only capacitance or inductance. The ideal capacitances and inductors are in series with resistance. This type of resistance is called equivalent series resistance(ESR).
19	**List any four reasons for the wide use of RF. [May/June 2014]** BTL1 (i) RF is reusable (ii) Wireless data transmission (iii) Low cost, and (iv) Bandwidth efficiency
20	**Give the relationship between S and Z. [May/June 2014]** BTL2 $S = (Z-Z_0I) / (Z+Z_0I)$ Where, Z0 - Characteristic impedance I- Circuit Current.
21	**Explain the high frequency limitations of conventional tubes. [April/May 2015]** BTL1 Conventional vacuum triodes, tetrodes, and pentodes are less useful signal sources at the frequencies above 1FHz due to (i) Lead – Inductance (ii) Interelectrode – Capacitance effects

(iii) Transit – Angle effects
(iv) Gain – BW product limitation.

22 **Enlist the applications of inductors.** BTL3

Inductors have a variety of applications in RF circuits such as,

(i) Resonance circuits
(ii) Filters
(iii) Phase shifters
(iv) Delay networks
(v) RF Chokes.

23 **Why the S-parameters are used in microwaves? [Nov/Dec 2011]** BTL2

The H, Y, Z and ABCD parameters are difficult at microwave frequencies due to following reasons.

- Equipment is not readily available to measure total voltage and total current at the ports of the networks.
- Short circuit and open circuit are difficult to achieve over a wide range of frequencies.
- Presence of active devices makes the circuit unstable for short (or) open circuit. Therefore, microwave circuits are analyses using scattering (or) S parameters which linearly relate the reflected wave‟s amplitude with those of incident waves.

24 **Mention the purpose of resistors.** BTL3

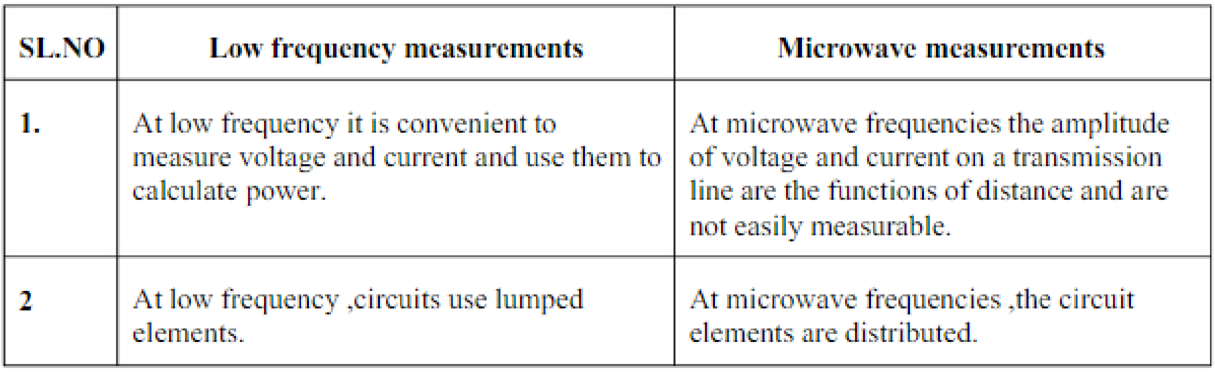
Purpose of Resistors:

i. In transistor bias networks, to establish an operating point.
ii. In attenuators, to control the flow of power.
iii. In signal combiners, to produce a higher output power.
iv. In transmission lines, to create matched conditions.

25 **Define Quality-factor (Q) of Capacitor.** BTL1

It is defined as “the measure of the ability of an element to store energy, equal to 2π times the average energy stored divided by the energy dissipated per cycle".

26 **State the difference between low frequency and high frequency measurements in microwave circuits. [April/May 2015], [May/June 2016]** BTL4



SL.NO	Low frequency measurements	Microwave measurements
1.	At low frequency it is convenient to measure voltage and current and use them to calculate power.	At microwave frequencies the amplitude of voltage and current on a transmission line are the functions of distance and are not easily measurable.
2	At low frequency ,circuits use lumped elements.	At microwave frequencies ,the circuit elements are distributed.

27 **Specify X band frequency range. [Nov/Dec 2018]** BTL1

The X- band frequency range : 8 – 12.5 GHz
The X-band wavelength : 3.7 – 2.4 cm

28 **Define lossless network. [Nov/Dec 2018]** BTL1

In any lossless passive network, its containing no resistive elements, always the power entering the circuit will be equal to the power leaving the network which leads to in the conserved power.

29 **List RF bands available in microwave system. [Nov/Dec 2016], [April/May 2017]** BTL1

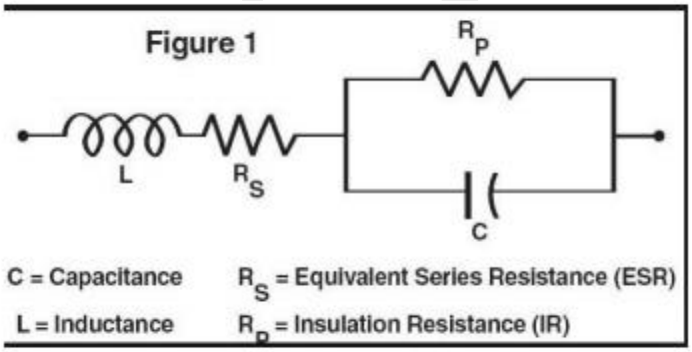
3-30MHz HF	HF
30-300MHz VHF	VHF
0.3-1GHz UHF	UHF
1-2GHz	L
2-4GHz	S
2-4GHz	C
8-12GHz	X
12-18GHz	Ku
18-27GHz	K
27-40GHz	Ka
40-300GHz	Millimeter
>300GHz	SubMillimeter

30 **State the limitations in measuring Z, Y and ABCD parameters at microwave frequencies. [Nov/Dec – 11], [Nov/Dec 2017]** BTL1

The limitations in measuring Z, Y and ABCD parameters at microwave frequencies are,

- Equipment is not readily available to measure total voltage and current at the ports of the network.
- Short circuit and open circuit are difficult to achieve over a wide range of frequencies.
- Presence of active devices such as power transistors and tunnel diodes makes the circuit unstable.

31 **Draw the equivalent circuit with resistor and inductor. [April/May 2015, May/June2016]** BTL1



PART B

1 **(i)Describe the properties and applications of RF waves. (8M) [Nov/Dec 2016]** BTL2

Ans: Text book: RF circuit Design, Theory and applications by Reinhold Ludwig Gene Bogdanov. Pg:no: 163-166

1) Symmetry of [s] for a reciprocal network (2M)
2) Unitary property of lossless network (2M)
3) Zero property and Phase shift property (2M)
4) Applications (2M)

(ii)Examine in detail about low frequency parameters. (8M) [April/May 2015, April/May

2017, May/June 2016] BTL2

Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:1.1

Low Frequency Parameters: (8M)

1) Impedance
2) Admittance
3) Hybrid

2 **(i)Show Z and Y matrix formulation of multiport network.(8M) [May/June 2016]**

BTL2

Ans: Refer notes

Z Parameter (4M)

The impedance parameters are obtained by expressing the port voltages V1 and V2 in terms of port currents I1 and I2.

$$V_1=Z_{11}I_1+Z_{12}I_2$$
$$V_2=Z_{21}I_1+Z_{22}I_2$$

Where Z_{11},Z_{12},Z_{21},Z_{22} are called as impedance parameters. The matrix is

$$\begin{pmatrix} V_1 \\ V_2 \end{pmatrix} = \begin{pmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \end{pmatrix} = \{Z\} \begin{pmatrix} I_1 \\ I_2 \end{pmatrix}$$

Where the matrix Z is called impedance matrix of two port network.

$Z_{11}= V_1/I_1$at $I_2=0$ = Input impedance with output ports open.

$Z_{21}= V_2/I_1$at $I_2=0$ = Forward transfer impedance with output ports open.

$Z_{12}= V_1/I_2$at $I_1=0$ = Reverse transfer impedance with input ports open.

$Z_{22}= V_2/I_2$at $I_1=0$ = Output impedance with output ports open.

Y Parameter (4M)

The resulting two port i-v relationship is given by,

$$I_1=Y_{11}V_1+Y_{12}V_2$$
$$I_2=Y_{21}V_1+Y_{22}V_2$$

Where Y_{11},Y_{12},Y_{21},Y_{22} are called as admittance parameters. The matrix is,

$$\begin{pmatrix} I_1 \\ I_2 \end{pmatrix} = \begin{pmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{pmatrix} \begin{pmatrix} V_1 \\ V_2 \end{pmatrix} = [Y] \begin{pmatrix} V_1 \\ V_2 \end{pmatrix}$$

When we drive at port1 with port2 shorted (V2=0), the

$Y_{11}= I_1/V_1$at $V_2=0$ = Input admittance with output ports shorted.

$Y_{21}= I_2/V_1$at $V_2=0$ = Forward transfer admittance with output ports shorted.

$Y_{12}= I_1/V_2$ at $V_1=0$ = Reverse transfer admittance with input ports shorted.

$Y_{22}= I_2/V_2$ at $V_1=0$ = Output admittance with output ports shorted.
All of these parameters are impedance with dimensions in ohms.

(ii)What are the limitations of ABCD,Z,Y and h parameters. (5M) BTL3
Ans: Refer notes

- Equipment is not readily available to measure total voltage and total current at the ports of the network.
- Short circuit and open circuit are difficult to achieve over a wide range of frequencies.
- Presence of active devices makes the circuit unstable for short or open circuit.

3 **Verify the lossless and reciprocity properties of any two port network using scattering matrix. (16M) [Nov/Dec 2014, May/June 2016, Nov/Dec 2016]** BTL3
Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:1.8-1.11

Reciprocity property (4M)
Loosless network (4M)
Proof (8M)

Symmetry of [s] for a reciprocal network

The reciprocal device has a same transmission characteristics in either direction of a pair of ports and is characterized by a symmetric scattering matrix

$S_{ij} = S_{ji}$; $i \neq j$
Which results

$[S]_t = [S]$

$$[s] = ([z]+[u])^{-1} \, ([z]-[u])$$

$$[R] = [Z] - [U]$$

$$[Q] = [Z] + [U]$$

For a reciprocal network Z matrix Symmetric

$$[R]\,[Q] = [Q]\,[R]$$

$$[Q]^{-1}[R][Q][Q]^{-1} = [Q]^{-1}[Q][R][Q]^{-1}$$

$$[Q]^{-1}[R] = [R][Q]^{-1}$$

$$[Q]^{-1}[R]\,[S] = [R][Q]^{-1}$$

4 **Give a detailed note on resistor, inductor and capacitor.(13M)** BTL1
Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:2.3-2.12
Description of resistor, inductor and capacitor with circuit diagram (10M)

	Applications and its uses (3M)
5	**Construct the transmission matrix of 2 port network (13M). [Nov/Dec 2016, Nov/Dec 2018]** BTL5 **Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:1.13-1.14** Definition of transmission matrix (2M) T-Matrix theory along with diagram (6M) Derivation (5M) $\begin{bmatrix} b1 \\ a1 \end{bmatrix} = \begin{bmatrix} T11 & T12 \\ T21 & T22 \end{bmatrix} \begin{bmatrix} a2 \\ b2 \end{bmatrix}$ From S to T: $\frac{T_{11}}{S_{21}} = -\det(S)$ Where det(T) is the determinant of matrix $T_{12} = \frac{S_{11}}{S_{21}}$ $T_{21} = -\frac{S_{22}}{S_{21}}$ $T_{22} = \frac{1}{S_{21}}$ From T to S: $S_{11} = \frac{T_{12}}{T_{22}}$ $\frac{S_{12}}{T_{22}} = \det(T)$ Where det(T) is the determinant of matrix $S_{21} = \frac{1}{T_{22}}$ $S_{22} = -\frac{T_{21}}{T_{22}}$
	PART * C
1	**Discuss the importance of low frequency and high frequency parameters of two port networks.(15M) [Nov/Dec 2014,April /May 15, April/May 2017]** BTL 2 **Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:1.1-1.4** Low Frequency Parameters: (7M) • Impedance • Admittance

<table>
<tr><td></td><td>• Hybrid
High Frequency parameter (8M)
1) S-parameter</td></tr>
<tr><td>**2**</td><td>**State and explain the properties of S-Parameters. (15M)**
[May/June 2013, May/June 2014,April/May 2015, April/May 2017, Nov/Dec 2017, Nov/Dec 2018] BTL2
Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:1.8-1.10
• Define Zero diagonal elements for perfect matched network
• Symmetry of [s] for a reciprocal network (4M)
• Unitary property of lossless network (4M)
• Zero property (2M)
• Phase shift property (5M)</td></tr>
<tr><td>**3**</td><td>**The S parameters of a two port network are given by**
S11=0.2<90° S22=0.2<90°
S12=0.5<90° S21=0.5<0°
(a)Determine whether the network is lossy or not and
(b)Is the network symmetrical and reciprocal? Find the insertion loss of network.(15M)
[Nov/Dec 2013, Nov/Dec 2012] BTL3
Ans: Refer notes
• symmetry property of lossless network (10M)
• Reciprocal property (5M)
Solution:
$S_{11}S_{11}^{*}+S_{21}S_{21}^{*}=1$
$|S_{11}|^{2}+|S_{21}|^{2}=1$
$(0.2)^{2}+(0.5)=1$
0.04+0.25 = 1
Therefore the network is not lossless.
For symmetrical and reciprocal networks, we can always write as
S11=S22
S12=S21
Since this is symmetrical and reciprocal network
Insertion loss = 20log 1/|S12|
= -20log |S12|
= -20log|0.5|
= 6.02dB.</td></tr>
</table>

UNIT II – RF AMPLIFIERS AND MATCHING NETWORKS 9

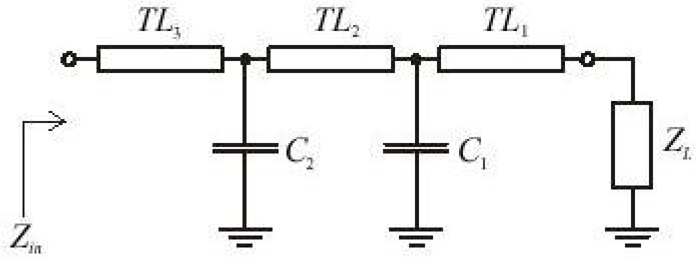
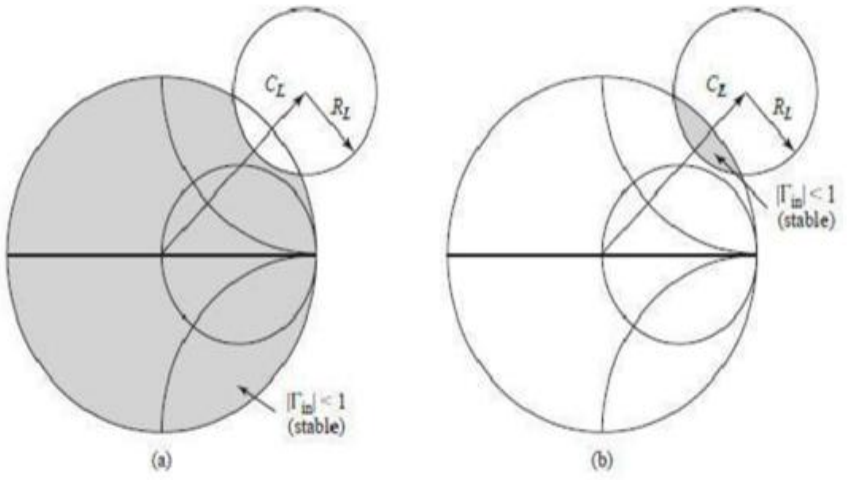
Characteristics of Amplifiers, Amplifier power relations, Stability considerations, Stabilization Methods, Noise Figure, Constant VSWR, Broadband, High power and Multistage Amplifiers, Impedance matching using discrete components, Two component matching Networks, Frequency response and quality factor, T and Pi Matching Networks, Microstrip Line Matching Networks

PART * A

Q.No.	Questions
1	**Write the function of matching networks. [Nov/Dec 2015, Nov/Dec 2011]** BTL1 Matching networks can help stabilize the amplifier by keeping the source and load impedances in the appropriate range. Impedance matching (or tuning) is an important issue for - Maximum power is delivered when load is matched to line (assuming the generator is matched) - Power loss is minimized. S/N- ratio of receiver components is increased. - Amplitude and phase errors are reduced.
2	**What is function of input and output matching networks?** BTL1 Input and output matching networks are needed to reduce undesired reflections and improve the power flow capabilities.
3	**Paraprase the parameters used to evaluate the performance of an amplifier? [Nov/Dec2015]** BTL1 Key parameters of amplifier, to evaluate the performance are • Gain and gain flatness(in dB) • Operating frequency and bandwidth (in Hz) • Output power (in dB) • Power supply requirements (in V and A) • Input and output reflection coefficients (VSWR) • Noise figure (in dB)
4	**State transducer power gain.[Nov/Dec2013, April/May 2017]** BTL1 Transducer power gain is nothing but the gain of the amplifier when placed between source and load. G_T= Power delivered to the load/Available power from the source. GT=PL/Pavg
5	**Define Unilateral Power gain. [Nov/Dec 2014]** BTL1 It is the amplifier power gain, when feedback effect of amplifier is neglected i.e.S12=0. $\mathbf{G_{TU} = \vert S_{21}{}^2\ (1- \Gamma_S\ {}^2)\ (1- \vert\Gamma_L\ {}^2)/(1- \Gamma_S\ \Gamma_{in})^2\ (1- S_{22}\Gamma_L)^2}$
6	**Describe available Power Gain (GA) at Load.** BTL1 The available power gain for load side matching (TL = T*Out) is given as, G_A= Power available from the network/power available from the source $G_A = {}_N/P_A$
7	**Interpret the principle of Operating Power Gain.** BTL1 The operating power gain is defined as “the ratio of power delivered to the load to the power supplied to the amplifier”.

	G= Power delivered to the load/Power supplied to the amplifier G= P_L/P_{in}
8	**Write a short note on feedback of RF circuit.** BTL1 (1)If |T|>1, then the magnitude of the return voltage wave increases called positive feedback, which causes instability (oscillator). (2)If |T|<1, then the return voltage wave is totally avoided (amplifier). It is called as negative feedback.
9	**Give the expression that relates nodal quality factor (Qn) with loaded quality factor (Q_L). [Nov/Dec 2013,April/May 2015]** BTL6 Nodal quality factor (Qn) is defined as ratio of the absolute value of the reactance Xs to the corresponding Resistance R_s $Q_n = [X_s] / R_s$ The nodel quality factor is $Q_L = Q_n / 2$
10	**What are the need of Impedance Matching Network?[May/June 2013, May/June 2016]** BTL1 - Minimal power loss in feed line - Maximum power delivery - Improving the S/N ratio of the system for sensitive receiver components - Reducing amplitude & phase errors in a power distribution networks - Minimum reflection in transmission line - Optimal efficiency
11	**Define power gain of amplifier in terms of S- parameter and reflection coefficient. [Nov/Dec 2012, Nov/Dec 2013]** BTL1 **Transducer Power Gain** Transducer Power Gain is nothing but the gain of the amplifier when placed between source and load $G_T = \frac{(1-\|i\|^2)\|S21\|^2(1-\|S\|^2)}{\|1-sin\|^2\|1-S22_L\|^2}$ The Operating power gain is defined as the ratio of power delivered to the load to the power supplied to the amplifier. $G_T = \frac{(1-\|i\|^2)\|S21\|^2}{\|1-sin\|^2\|1-S22_L\|^2}$
12	**Enumerate the considerations in selecting a matching network.[Nov/Dec 2012]** BTL1 - Complexity of the system - Bandwidth requirement - Adjustability - Implementation - Maximum power delivery - Optimal efficiency.
13	**Define Stability. [May/June 2014]** BTL1 Stability refers to the situation where the amplifier remains stable for any passive source and load at the selected frequency and bias condition.
14	**State the significance of microstrip matching networks. [Nov/Dec 2014]** BTL1 - Distributed microstrip lines and lumped capacitors - Less susceptible to parasitic

	• Easy to tune • Efficient PCB implementation • Small size for high frequency.
15	**Explicate noise figure. [Nov/Dec 2011, Nov/Dec2016]** BTL1 Noise figure F is defined as "the ratio of the input SNR to the output SNR". F = Input SNR/Output SNR
16	**Define unconditional stability. [May/June 2016,Nov/Dec2017]** BTL1 It refers to the situation where the amplifier remains stable for any passive source and load at the selected frequency and bias conditions.
17	**Mention the advantages of smith chart in the design of matching networks.** BTL1 The smith chart allows immediately observing whether or not a particular impedance transformation is capable of achieving the desired matching. Moreover, the total number of possible network configurations can be readily be seen.
18	**What is the advantage of T and Pi matching networks?** BTL1 The addition of third element into the two element (L) matching network introduces an additional degree of freedom in the circuit and allows us to control the value of Q_L by choosing an appropriate intermediate impedance for wider (matching) bandwidth.
19	**Why we go for double stub matching networks?** BTL4 (i)They require a variable length transmission line between the stub and the input port, or between the stub and load impedance. ii)Usually this does not a problem for fixed networks, but may create difficulties for variable tuners.
20	**Designate the considerations in selecting a matching network. [Nov / Dec 2014]** BTL1 Factors in the selection of matching networks are Complexity of the system • Bandwidth requirement • Adjustability • Implementation • Maximum power delivery or transfer • Optimal efficiency
21	**Why it is necessary to go for microstrip matching network? [Nov/Dec2018]** BTL1 Matching networks can help stabilize the amplifier by keeping the source and load impedances in the appropriate range. Matching network is important for the following reasons. Maximum power loss is in the feed line • Maximum power delivery or transfer • Improving the S/N ratio of the system
22	**Mention the type of losses in microstrip line. [Nov/Dec 2013]** BTL1 • Dielectric looses • Ohmic losses • Radiation loss
23	**State the disadvantages of strip lines.** BTL1 • Greater losses • Lower Q

	• Lower power handling capacity
24	**Name some limitations of microstrips.** BTL1 • Higher attenuation compared to waveguide structures .Hence it cannot be used in systems where extremely low loss is requirement. • At high frequency the required dimensions are very small causing fabrication problems. • Open strip suffers radiation losses.
25	**What is the function of input and output matching networks?** BTL1 Input and output matching networks are needed to reduce undesired reflections and improve the power flow capabilities.
	PART B
1	**Explain the micro strip matching network.(8M) [Nov/Dec 2011,May/June 2014, April/May 2017, Nov/Dec 2016]** BTL2 **Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:3A9-3A11** Circuit diagram (4M)  Description of the microstrip network (4M)
2	**Write mathematical analysis of amplifier stability. (13M)[Nov/Dec2011,April/May 2015, May/June 2016,Nov/Dec 2018]** BTL4 **Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:3.6-3.11** 1) Conditional stability (4M) 2) Unconditional stability (5M) 3) Stability circles (4M) 
3	**Explain in brief about VSWR and noise figure circle. (8M) [Nov/Dec 2018]** BTL1

Ans: Refer notes
VSWR definition, equations and procedure (4M)
Noise figure definition, equation,procedure (4M)

PART* C

1 **Microwave amplifier is characterized by its s parameters. Derive equations for power gain, available gain and transducer gain. (15M) [Nov/Dec 2011, Nov/Dec 2012, May/June 2013,May/June 2016,April/May 2015]** BTL4

Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:3.1-3.6

Transducer power gain:

It is nothing but the gain of the amplifier when placed between source and load.

G_T= Power delivered to the load/Available power from the source.

$G_T=P_L/P_{avg}$

Unilateral Power gain (7M)

It is the amplifier power gain, when feedback effect of amplifier is neglected i.e.S12=0.

$$G_{TU} = \frac{|S_{21}^2\ (1-\Gamma_S\ ^2)\ (1-|\Gamma_L\ ^2)}{(1-\Gamma_S\ \Gamma_{in})^2\ (1-S_{22}\ \Gamma_L)^2}$$

Available power gain(8M)

The available power gain for load side matching (TL = T*Out) is given as,

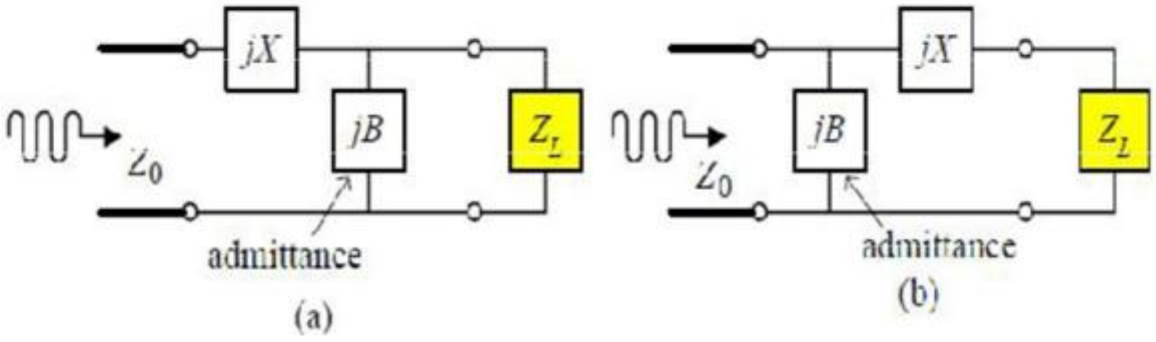
G_A= Power available from the network/power available from the source

$G_A= P_N/P_A$

2 **Discuss the smith chart approach to design the L-section and T- section matching networks (15M) [May/June 13, May/June 2014, Nov/Dec2018]** BTL5

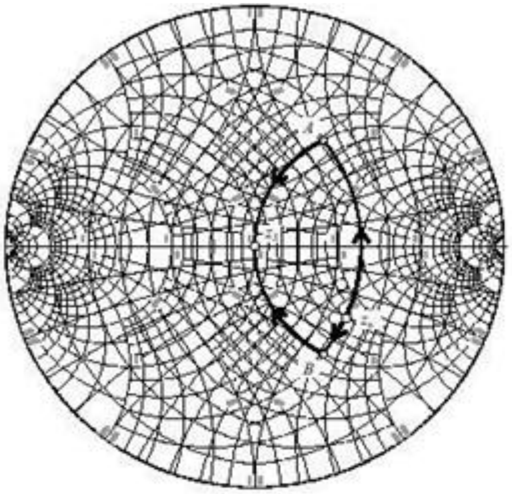
Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:3A.2-3A.5

L-Section network (8M)

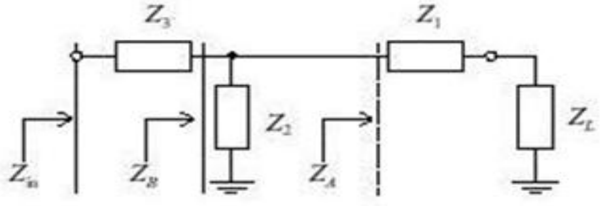


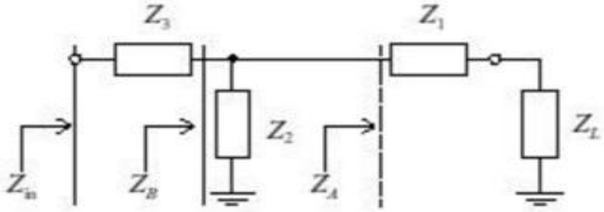
(a) (b)

Smith chart:

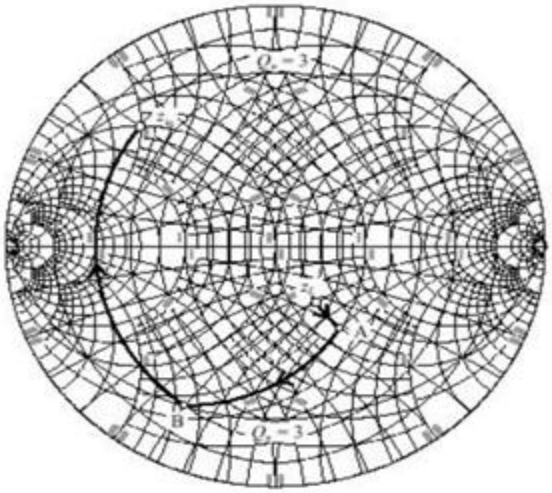


T-Section network (7M)





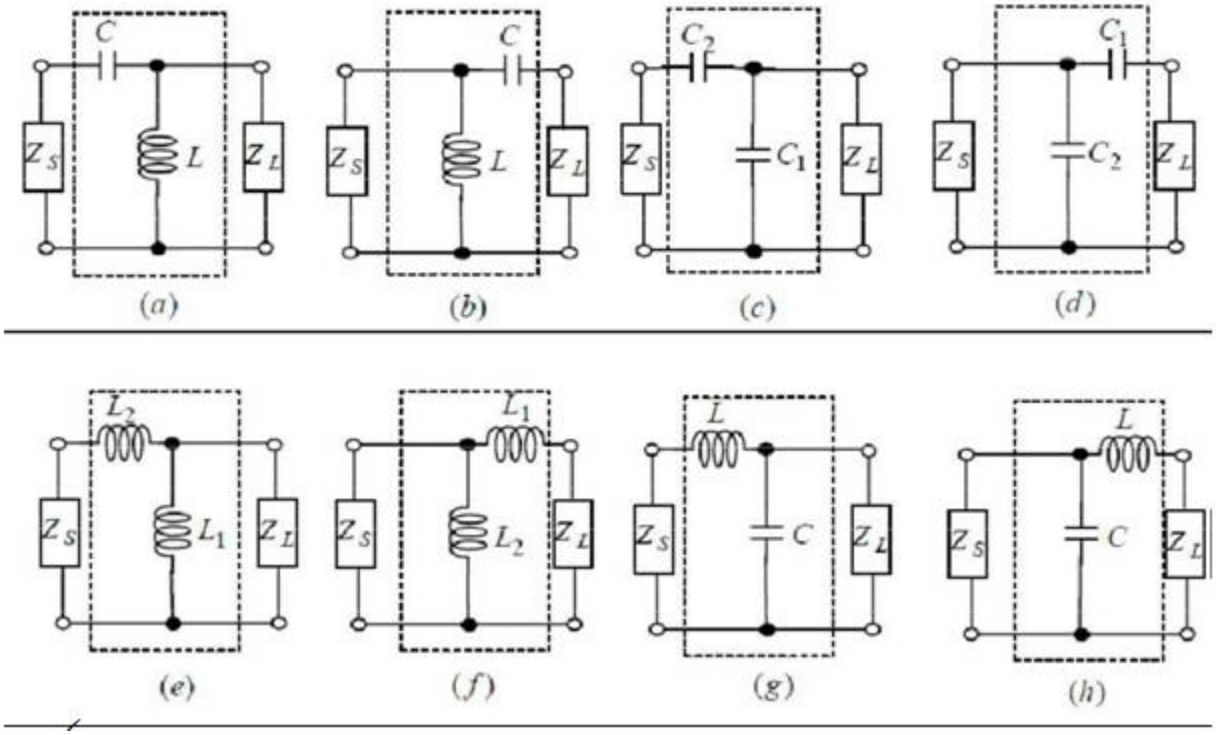
Smith chart:



3 **Discuss about the Impedance matching netork using lumped elements and draw the frequency response curve. (15M) [Nov/Dec 2016]** BTL3

Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:3A.8-3A.9

Circuit diagram of lumped element (5M)
Description of the impedance matching network (5M)
Frequency response curve (5M)



Frequency Response curve:

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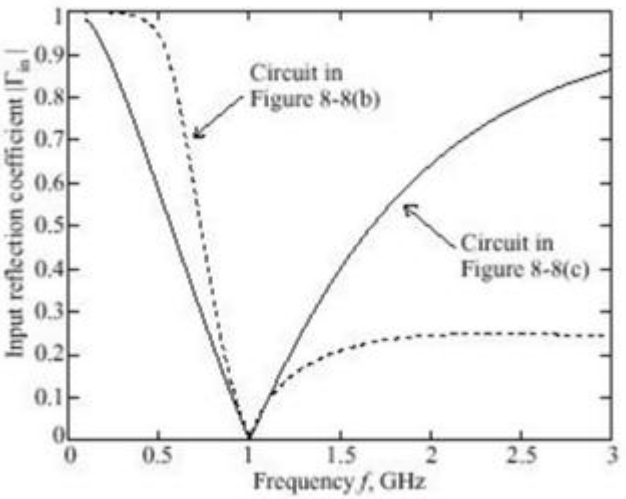

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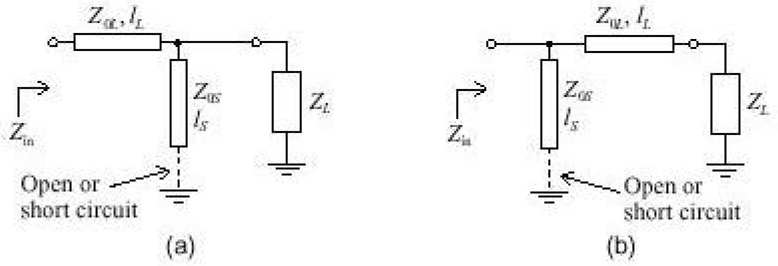
Discuss about single and double stub matching. (15M)[Nov/Dec 2017] BTL3

Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:3A.10-3A.11

Single stub matching:
Definition with Circuit diagram (5M)
Description along with smith chart (10M)



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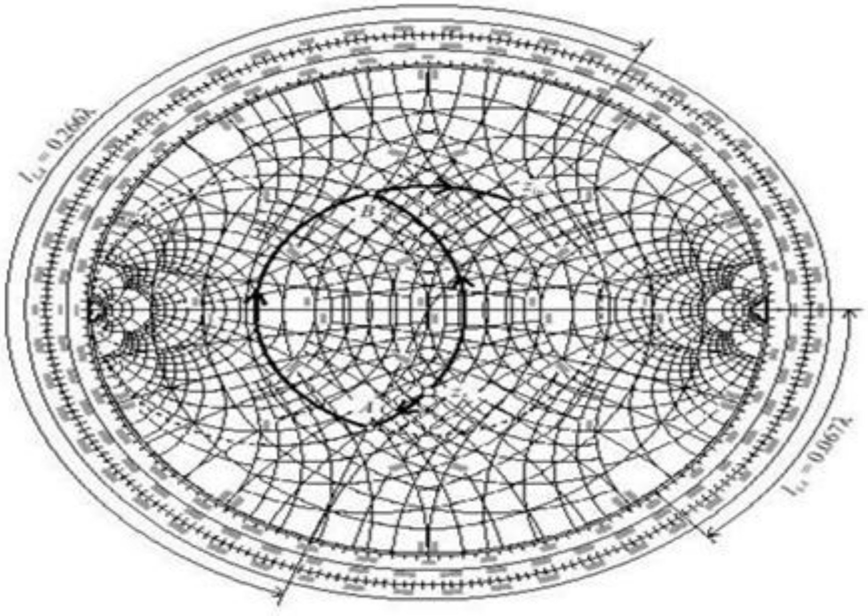
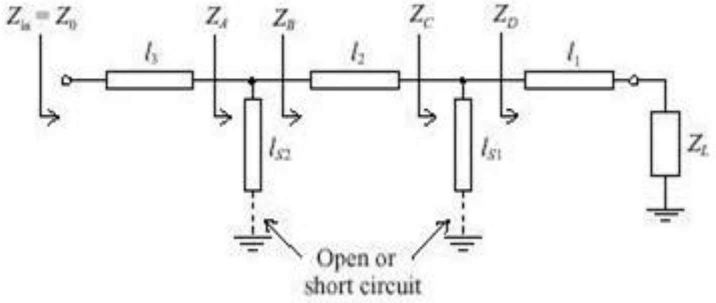
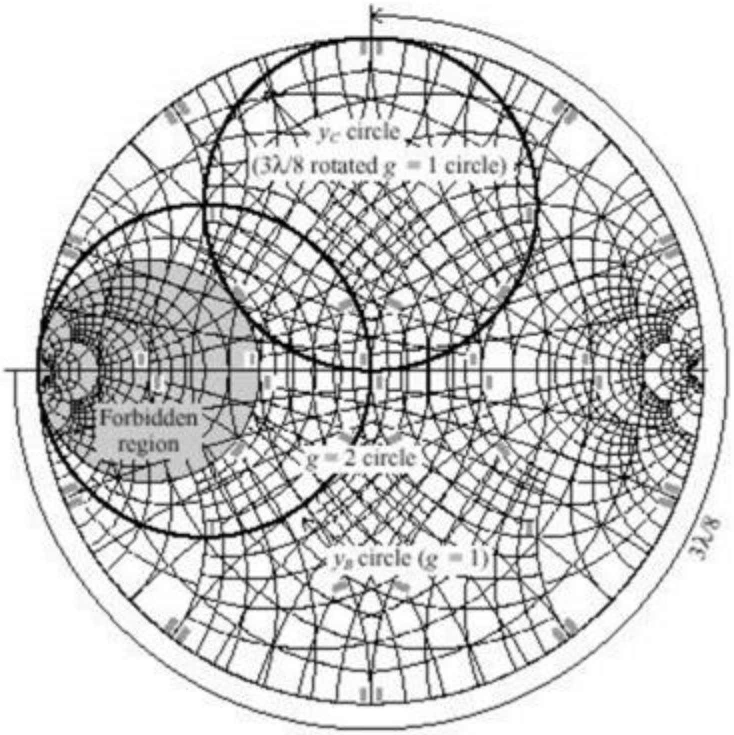


Double stub matching

Definition with Circuit diagram (4M)
Description along with smith chart (4M)

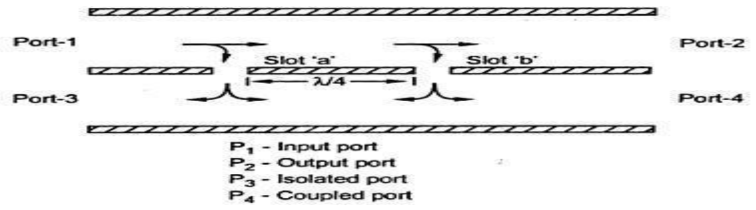


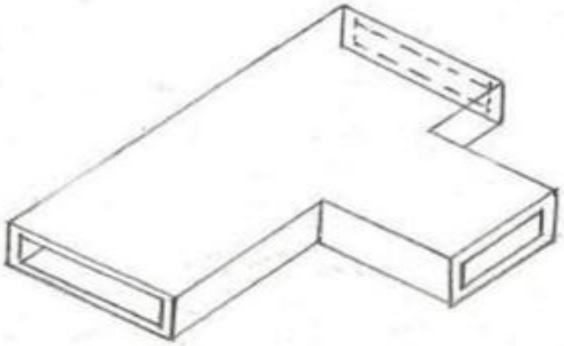
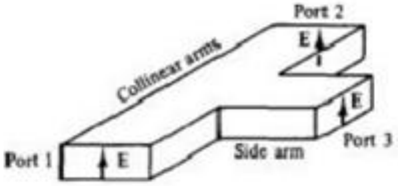
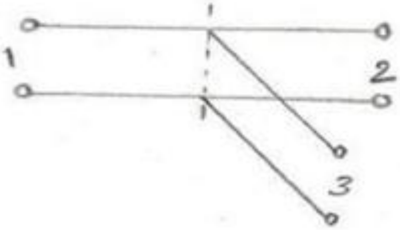

y_C circle
(3λ/8 rotated g = 1 circle)
Forbidden region
g = 2 circle
y_B circle (g = 1)
3λ/8

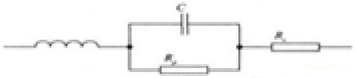
UNIT III - PASSIVE AND ACTIVE MICROWAVE DEVICES 9

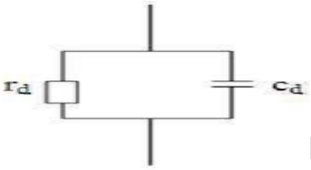
Terminations, Attenuators, Phase shifters, Directional couplers, Hybrid Junctions, Power dividers, Circulator, Isolator, Impedance matching devices: Tuning screw, Stub and quarter wave transformers. Crystal and Schottkey diode detector and mixers, PIN diode switch, Gunn diode oscillator, IMPATT diode oscillator and amplifier, Varactor diode, Introduction to MIC.

PART * A

Q.No.	Questions
1	**What are matched terminators? [May/June 2014]** BTL1 Low power co axial termination Resistance strip Standard mis matches
2	**Name the microwave passive devices which make use of faraday rotation.[Apr/May 2015]** BTL1 Isolator Gyrator Circulator
3	**Define ferrites. Why it is needed in circulator? [Nov/Dec 2013], [May/June 2014]** BTL2 Ferrites are non metallic meterials with resistives nearly 10 ^{14} times greater than metals and also the dielectric constant is in between 10 $^{-15}$ and relative permeability of the order of 1000
4	**Mention the application of gyrator and isolator. [Nov/Dec 2014]** BTL3 Gyrator : - In can be in radar antenna as a duplexer - It will handle a low power . hence they are used as low power devices Isolator: - Isolator are generally used to improve the frequency stability of microwave generators, such as klystrons and magnetrons in which the reflection from the load affects the generating frequency
5	**Interpret isolator. Why it is called uniline? [Nov/Dec 2016]** BTL1 An isolator or uniline is two port non reciprocal devices, which produce a minimum attenuation to wave in one direction and very high attenuation in the opposite direction.
6	**Draw the Structure of Two hole Directional coupler. [May/June 2016]** BTL3 
7	**Sketch the diagram for H – plan tee. [Nov/Dec 2012]** BTL3

	 H Plane Tee  
8	**What is H-Plane Tee?** BTL1 It is a wave guide tee in which the axis of the slide arm is shunting the E- field or parallel to the H-field of the main guide.
9	**Give the applications of directional coupler.** BTL3 • Unidirectional power measurement • SWR measurement • Unidirectional wave launching • Reflectometer • Balanced duplexer.
10	**Define directivity of directional coupler.** BTL1 • It is defined as a ratio of forward power P_f to the back power P_b expressed in dB. D(dB)= $10\log_{10} P_f/P_b$ • It is a measure of how well the directional coupler distinguishes between the forward and reverse travelling powers.
11	**Explain Gunn Effect and classify the elements that exhibit Gunn Effect.[May/June 2016]** BTL2 Gun effect was first observed by GUNN in n_type GaAs bulk diode. According to GUNN, above some critical voltage corresponding to an electric field of 2000-4000v/cm, the current in every specimen became a fluctuating fuction of time. The frequency of oscillation was determined mainly by the specimen and not by the external circuit. The elements area) Gallium arsenide b)Indium phosphate c) Cadmium telluride d)Indium arsenide
12	**State the factors reducing efficiency of IMPATT diode. [April/May 2017]** BTL1 • Space charge effect • Reverse saturation current effect

	• High frequency skin effect • Ionization saturation effect.
13	**What is Transferred electron effect?[Nov/Dec 2012]** BTL3 Some materials like GaAs exhibit negative differential mobility, when biased above a threshold value of the electric field. This behavior is called transferred electron effect. The electrons in the lower energy band will move to the higher energy ban d its called TED.
14	**Enumerate the factors that reduces the efficiency in Impatt Diode.** BTL1 • Space charge effect • Reverse saturation current effect • High frequency skin effect • Ionization saturation effect.
15	**Mention the ideal characterize of dielectric material in MMIC.[Nov/Dec 2017]** BTL2 • Small size and Weight • High reliability • Improved reproducibility • Improved performance • Eventual cost reduction when produced in large quantities.
16	**What are the necessary condition for Gunn diode?** BTL1 This mode is defined in the region when the fL value is about 10^7 cm/s and the n0/L > 10^{12} cm^2. In this region the device is unstable because of the cyclic formation of either the accumulation layer or the high field domain.
17	**List the gunn modes of operations**. BTL1 • Transit time mode • LSA mode • Quenched time mode • Delayed mode
18	**Draw the equivalent circuit for varactor diode.[April/May 2015]** BTL3 
19	**Explain the use of power dividers.** BTL1 Power dividers are used to divide the input power into a number of smaller amounts of power for exciting the radiating elements in an array antenna.
20	**Interpret the principle of Microwave phase shifter. [Nov/Dec-2018]** BTL1 When a wave propagates on a line,a phase difference prevails between any two arbitary points along its paths.The phase difference between two points
21	**What are junctions?Give some examples.** BTL2 A microwave circuit consists of several microwave devices connected in some way to achieve the desired transmission of MW signal.The interconnection of two or more microwave may be regarded as MW junction. Eg:Magic Tee,Hybrid Ring

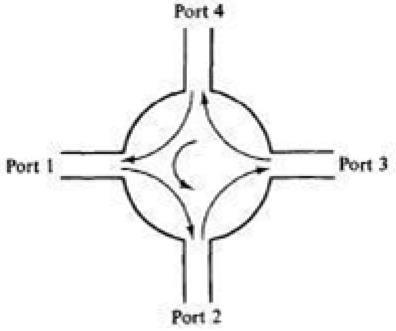
22	**What is Tee junction?Give two examples.** BTL1 In MW circuits a wave guide or coaxial junction with three independent ports is referred to as tee junction. Eg: E- Plane Tee,H-plane Tee.
23	**Demonstrate the principle of negative resistance in gunn diode.** BTL1 The carrier drift velocity increases linearly from 0 to maximum when the electric field is increased from 0 to threshold value in gunndiodes.When the electric field is beyond the threshold value of 3000v/cm the drift velocity is decreased and the diode exhibit negative resistance.
24	**State the applications of Magic Tee. [April/May 2017]** BTL3 • Measurements of impedance • As duplexer • As mixer • As an isolator
25	**Define coupling factor(C).** BTL1 • It is defined as the ratio of incident power Pi to the forward power Pf measured in dB. Coupling factor (dB) = 10log10 Pi/pf • The coupling factor is a measure of how much of the incident power is being sampled.
26	**Elucidate the working principle of varactor diode. [May/June 2016]** BTL1 Varactor diode is a p-n junction diode whose capacitance is varied by varying the reverse voltage. The varactor diode should always be operated in reverse bias. when a reverse bias voltage is applied, the electrons from n-region and holes from p-region moves away from the junction. As a result, the width of depletion region increases and the capacitance decreases.
27	**Draw equivalent circuit of gunn diode. [Nov/Dec 2018]** BTL1  Parallel circuit
28	**What is the s-Matrix of 4 port circulator? [April/May 2017]** BTL3 Clockwise [S]= 0 0 0 1 1 0 0 0 0 1 0 0 0 0 1 0 Anticlockwise [S] = 0 1 0 0 0 0 1 0 0 0 0 1 0 0 1 0
	PART B
1	**Discuss Structure and principle of operation of Isolator.(8M) [Nov/dec-2011,12,13, Nov/Dec 2016, May/June 2016]** BTL3 **Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:6.7-6.9** Construction, Diagram (4M) Principle of operation (4M)

2

Illustrate the Structure and principle of operation of circulator(13M) [Noc/Dec-2011,12,13,14, Nov/Dec 2016, May/June 2016] BTL3

Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:6.3-6.7

Construction, Diagram (4M)
Principle of operation (6M)
Scattering matrix (3M)



S-Matrix

$$S=\begin{bmatrix} 0 & S_{12} & S_{13} & S_{14} \\ S_{21} & 0 & S_{23} & S_{24} \\ S_{31} & S_{32} & 0 & S_{34} \\ S_{41} & S_{42} & S_{43} & 0 \end{bmatrix}$$

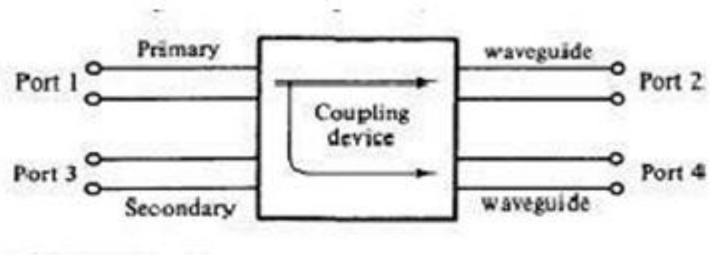
$$S=\begin{bmatrix} 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

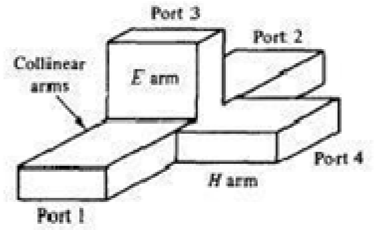
3

Explain how directional coupler can be used to measure the reflected power.(13M) [Nov/Dec 2012, Nov/ Dec 2013,Apr/May 2015, Nov/Dec2018] BTL2

Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:5.12-5.16

Construction, Diagram (4M)
Principle of operation (6M)
Scattering matrix (3M)



	$S=\begin{bmatrix} 0 & S_{12} & 0 & S_{14} \\ S_{21} & 0 & S_{23} & 0 \\ 0 & S_{32} & 0 & S_{34} \\ S_{41} & 0 & S_{43} & 0 \end{bmatrix}$ $S=\begin{bmatrix} 0 & p & 0 & jq \\ p & 0 & jq & 0 \\ 0 & jq & 0 & p \\ jq & 0 & p & 0 \end{bmatrix}$
4	**With neat schematic sketch explain the working principle and construction of phase shifter. (13M) BTL3 [Apr/May 2015, May/June 2016]** BTL2 **Ans: Refer notes** Schematic diagram and Construction (4M) Working Principle (4M) Derivation of field component (E1,E2….E6) (5M)
5	**Illustrate the working principle of varactor diode with neat diagram. (13M) [Nov/Dec2016]** BTL2 **Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:8.4-8.7** Schematic diagram and Construction (6M) Working Principle,Theory of operation (5M) Applications (2M)
	PART * C
1	**Derive the equation for S matrix of magic TEE. (15M) [Nov /Dec 2012, May /June 2013, 2014, Nov/ Dec 2013, Nov/Dec2017]** BTL4 **Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:5.27-5.32** Construction and working principle (10M) S Matrix (5M) 

	$S=\begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44} \end{bmatrix}$ But $S_{21} = 0, S_{12} = 0, S_{43} = 0, S_{34} = 0$ $S_{11} = 0, S_{22} = 0, S_{33} = 0, S_{44} = 0$ $S_{14} = S_{24}, S_{13} = -S_{23}$ For port-3 and port-4 matched, the S matrix becomes $S=\begin{bmatrix} 0 & 0 & S_{13} & S_{14} \\ 0 & 0 & -S_{13} & S_{14} \\ S_{31} & S_{32} & 0 & 0 \\ S_{41} & S_{42} & 0 & 0 \end{bmatrix}$ $S=\begin{bmatrix} 0 & 0 & S_{13} & S_{13} \\ 0 & 0 & -S_{13} & S_{13} \\ S_{13} & -S_{13} & 0 & 0 \\ S_{13} & S_{13} & 0 & 0 \end{bmatrix}$ $S=\frac{1}{\sqrt{2}}\begin{bmatrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 1 & -1 & 0 & 0 \\ 1 & 1 & 0 & 0 \end{bmatrix}$
2	**With neat diagram , explain the working principle of Gunn diode mention its application.(15M) [Nov/Dec2011,12,13,14,May/June 2014, May/June 2016 ,April/May 2015, Nov/Dec2017 Nov/Dec2018]** BTL2 **Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:9.5-9.7** Ridley-Watkins-Hilsum (Rwh} Theory (8M) Two Valley Model Theory (7M)
3	**Draw the construction diagram and explain the working of IMPATT diode.(15M)** BTL5 **[Nov/Dec 2012,May/June 2013,April/May 2015,May/June 2016, April/May 2017]** **Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:10.7-10.11** Construction, Diagram (7M) Principle of operation (4M) Power output and efficiency (4M)
4	**Explain in detail with suitable diagrams the fabrication techniques of a monolithic microwave IC (15M) [Nov/Dec2018]** BTL3 **Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:11.7-11.11** Description of the following with necessary diagram • Diffusion (2M)

	• Oxidation and film deposition (2M) • Epitaxial growth (2M) • Lithography (3M) • Etching and photoresist(3M) • Deposition (3M)

UNIT IV - MICROWAVE GENERATION 9

Review of conventional vacuum Triodes, Tetrodes and Pentodes, High frequency effects in vacuum Tubes, Theory and application of Two cavity Klystron Amplifier, Reflex Klystron oscillator, Traveling wave tube amplifier, Magnetron oscillator using Cylindrical, Linear, Coaxial Voltage tunable Magnetrons, Backward wave Crossed field amplifier and oscillator.

PART * A

Q.No. Questions

1. **What is the role of slow wave structure in TWT?[May/June 2013,May/June 2014, April/May 2017, Nov/Dec2017]** BTL1

Slow wave structure are a special circuits that are used in microwave tubes to reduce the wave velocity in a certain direction so that the electron beam and the signal were interact

2 **Compare M and O type tubes. [Nov/Dec 2012,Nov/Dec2018, Nov/Dec2017]** BTL4

M type Tubes	**O type Tubes**
Static magnetic field is perpendicular to the electric field	Static magnetic field is same direction to the electric field
Magnetron is the M type Tube	Klystron and TWT are the O type tubes
Electron travel in curved path	Electron travel in linear path

3 **Compare TWT & Klystron. [Nov/Dec 2013, April/May 2015, April/May 2017]** BTL4

Klystron Amplifier	**TWTA**
Linear beam or O type tubes	Linear beam or O type tubes
Uses a cavities for input and output Circuits	Uses non resonant wave circuit

4 **State the limitation in conventional vacuum tubes. [April/May 2015]** BTL1

The concentional tubes such as triode, tetrodes, pentodes can be used as amplifiers and oscillators more efficiently. But these conventional tubes can not used as amplifier or oscillator at high frequency (>1000MHZ) because at higher frequencies output drops off

The factors of contributing of output at UHF are

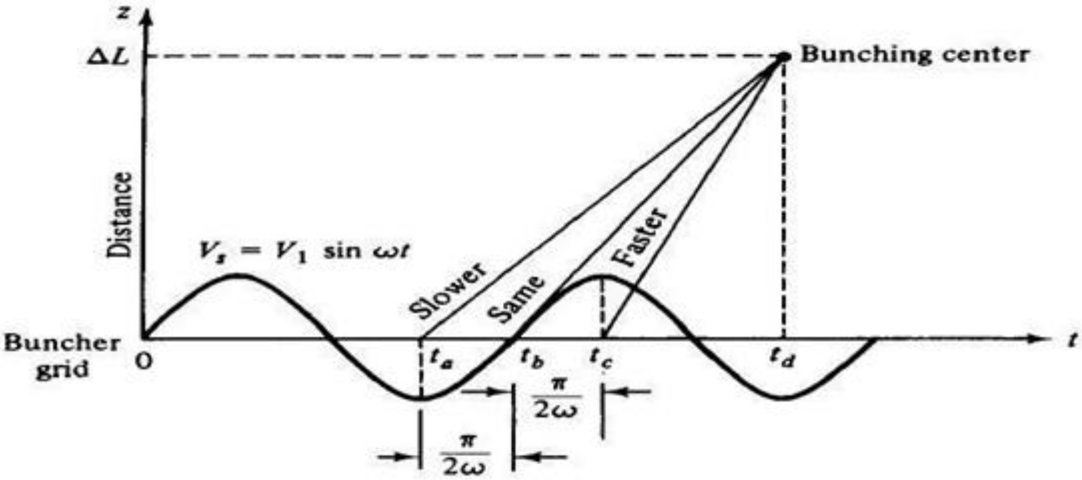
- Circuit resistance
    a) Inter electrode capacitance
    b) Lead inductance

	• Transit time effects • Cathode emission plate heat dissipation area • Power loss due to skin effect, radiation and dielectric loss • Gain band width product
5	**Describe about convection current in TWT. [May/June 2014]** BTL1 The convection current induced in the electron beam is by the axial electric field. When the space charge effect is considered, the electron velocity, charge density, current density and the axial electric field will perturbate about their averages or DC values. $I= j\beta_e I_0E_1/2vo(j\beta_e-\gamma^2)$
6	**Define resonant frequency.** BTL1 Resonant frequency fr at which the energy in the cavity attains maximum value=2We or 2Wm
7	**Mention the drawbacks available in klystron.** BTL1 • Klystrons are essentially narrowband devices • In klystrons and magnetrons, the microwave circuit consists of a resonant structures which limits the BW of the tube.
8	**What is TWT? [May/June 2016]** BTL1 A travelling wave tube amplifier (TWTA) circuit uses a helix slow wave non resonant microwave guiding structures. It is a bradband devices.
9	**State the characteristics of TWTA.** BTL1 • Frequency range: 3GHz and higher • Bandwidth: about 0.8GHz • Efficiency: 20 to 40% • Power output: upto 10Kw average • Power gain: upto 60dB
10	**Specify the applications of TWT.** BTL3 • Microwave power satellite • Higher power satellite transponder output and • Radar transmitters.
11	**Expound the advantages of TWT** BTL1 • BW is large • High Reliability • High gain • Higher duty cycle.
12	**Name four types of slow wave structures.** BTL1 • Helical line • Folded back line • Zigzag line and • Inter digital line.
13	**Define Velocity modulation. [April/May 2016]** BTL1 The variation in electron velocity in the drift space is known as velocity modulation.
14	**What is meant by bunching.?** BTL1 The electrons passing the first cavity gap at zeros of the gap voltage pass through with

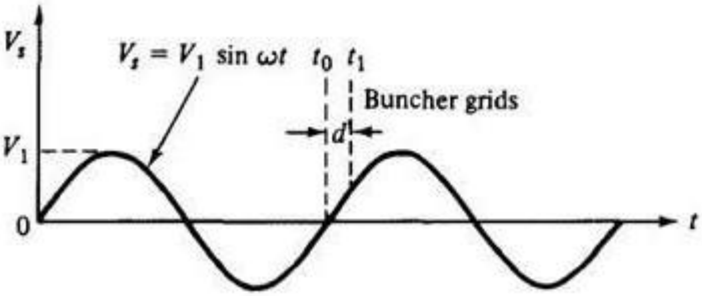
	unchanged velocity, those passing through the positive half cycles of gap voltage undergo an increase in velocity; those passing through the negative half cycle of gap voltage undergo an increase in velocity. As a result of these, electrons bunch together in drift space. This is called bunching.
15	**State the power gain,power output and efficiency of two cavity klystron amplifier.** BTL1 • Efficiency: about 40% • Power output: Average power is upto 500KW and pulsed power is upto 30MW at 10GHz. • Power gain: about 30dB.
16	**Classify the assumptions for calculation of RF power in Reflex Klystron?** BTL1 • Cavity grids and repeller are plane parallel and very large in extent. • No RF field is excited in repeller space • Electrons are not intercepted by the cavity anode grid. • No debunching takes place in repeller space. • The cavity RF gap voltage amplitude V, is small compared to the dc beam voltage VO
17	**Establish the condition for oscillation in Reflex klystron.** BTL1 The necessary condition for oscillation is that the magnitude of the negative real part of the electronic admittance should not be less than the total conductance of the cavity circuit i.e. –Ge ≥G. Where G=Gc + Gb +G1 = 1/ Rsh Rsh - effective shunt resistance Gc - copper losses of cavity Gb- beam loading conductance G1 - load conductance
18	**What is the effect of transit time?** BTL1 There are two effects. • At low frequencies, the grid and anode signals are no longer 180 O out of phase, thus causing design problems with feedback in oscillators. • The grid begins to take power from the driving source and the power is absorbed even when the grid is negatively biased.
19	**Enlist the applications of reflex klystron.** BTL3 • Signal source in MW generator • Local oscillators in receivers • It is used in FM oscillator in low power MW links. • In parametric amplifier as pump source
20	**How the klystron amplifier can act as klystron oscillator?** BTL1 When the klystron amplifier is given a positive feedback such that the overall phase shift becomes zero 360° and Av = I then klystron amplifier acts as an oscillator.
21	**Define Transit time in Reflex klystron.** BTL1 The time taken by the electron to travel into the repeller space and back to the gap. T =n + ¾
22	**Write the parameters on which bunching depend on.** BTL2 • Drift space should be properly adjusted. • D.C anode voltage • Signal amplitude should be such that proper bunching takes place.
23	**State the characteristics of magnetron and of 2-cavity klystron amplifier.**

	Magnetron: [Nov/Dec 2016] BTL1 Operating frequencies 70 GH z Output power 40 MW Efficiency 40 to 70% **2-cavity klystron:** Efficiency 40% Power output average power 500 KW Pulsed power 30 MW Power gain about 30 db
24	**Describe strapping.** BTL1 The magnetron has eight or more coupled cavity resonators and hence several modes of oscillation are possible. The oscillating frequency of different modes are not same and are quite close to each other which results in mode jumping. i.e., a 3 cm π mode oscillation which is normal for a particular magnetron Could become a 3.05 cm 3/4 mode oscillation. This result in oscillations of reduced power at wrong frequency. To prevent this. Strapping is used. It consists of two rings of heavy gauge wire connecting alternate anode poles. It provides a phase difference 0f 2 π radians for the modes other π-mode and thus preventing the occurrence of other modes, except the π-mode .
25	**State the applications of magnetrons.** BTL3 • Pulse work in radar • Linear particle accelerators. • Radar transmitters • Microwave ovens
26	**Explain the concept of frequency pulling and frequency pushing in magnetrons.** BTL1 Frequency pulling is caused by changes in the load impedance reflected into the cavity resonators. Frequency pushing is due to the change in anode voltage which alters the orbital velocity of electron clouds.
27	**Define electronic efficiency.** BTL1 The electronic efficiency of the klyston amplifier is defined as the ration of the output power to the input power. Efficiency: Pout/Pin = $\beta_0 I_2 V_2/2I_0 V_0$
28	**What is hull cutoff condition?** BTL1 In a magnetron, the electron will just graze the anode and return towards the cathode depends on Vo and Bo . The hull cut of magnetic equation is Boc = (8Vo m / e) ½ / b(1- a 2 / b2)
29	**Classify the types of magnetron.** BTL4 • Split anode magnetron • Cyclotron-frequency magnetron • Travelling wave magnetrons.
30	**Why magnetron is called as cross filed device?** BTL1 In cavity magnetron, there exists a radial electric field and an axial magnetic field perpendicular to each other and hence magnetron is called as a cross filed device.
	PART B
1	**Explain the working principle of reflex klystron and derive the expression of bunching parameters. (13M) [Nov/ Dec 2013, April/May 2017, Nov/Dec 2018]** BTL5

	Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no:12.19-12.22 Construction with schematic diagram (3M) Velocity Modulation process with diagram(10M)
2	**A pulsed cylindrical magnetron is operated with following parameters:** **Anode Voltage = 25KV (13M) [May/June 2013, Nov/Dec 2014, April/May 2015, May/June2016]** BTL5 **Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no: SQ.36** Beam current = 25A Magnetic density = 0.35Wb/m2 Radius of cathode cylinder =4cm Radius of anode cylinder = 8cm Calculate a) The anguar frequency (4M) (b)The cutoff voltage (4M) (c)The cutoff magnetic flux density. (5M) **Solution:** a) Angular frequency $\omega_c = \frac{e}{m} B_0$ = 1.759 $\times 10^{11} \times 0.34$ = 0.62 $\times 10^{11}$ radian b) The cutoff voltage V_{OC} = $\frac{e}{8m} B0^2 b^2 (1-\frac{a^2}{b^2})2$ = 1/8 × 1.759 $\times 10^{11} \times (0.35)^2$ × $(8\times10-2)^2$ $(1-16/64)^2$ = 0.22 × 7.84× 10^7 ×0.5625 = 9.7MW c) The cutoff magnetic flux density BOC = $\frac{(113.7\times10^{-8})^{\wedge}0.5}{6\times10^{-2}}$ = 17.7mWb/m^2
3	**With neat diagrams and relevant equations, explain about helix traveling wave tube. (13M) [April/May 2017,Nov/Dec 2018]** BTL2 **Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no: 13.3-13.5** Construction with schematic diagram, Principle of operation (6M) Slow wave structure diagram with explanation (7M)
	PART* C
1	**Explain the operation of two cavity klystron amplifier and compare it with traveling wave tubes. (15M) [Nov/Dec 2011,Nov/Dec 2012,May/June2013,May/June 2014, Nov/Dec2014,April/May2017,Nov/Dec2016,May/June2016]** BTL4 **Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no: 12.3-12.9** 1) Velocity Modulation process (8M) 2) Bunching Process with power output (7M) Pout = $\frac{1.16I0}{\sqrt{2}} \times \frac{V0}{\sqrt{2}} = 0.58 I_0 V_0 = 0.58 P_{in}$ Bunching Distance



Velocity Modulation process



2

A two cavity klystron amplifier has the following parameters: Beam voltage,V_0=1000v, Beam current I_0=25mA:

Frequency f=3GHz,R_0=40KΩ
Gap spacing in either cavity,d=1mm Spacing between the two cavities,L=4cm Effective shunt impedance, R_{sh}=30kΩ

Calculate input gap voltage, voltage gain and efficiency. (15M) [Nov/Dec 2012, Nov/Dec2017, April/May 2015] BTL5
Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no: SQ.26

Maximum output voltage (5M)
Gap transit time (5M)
Voltage gain and efficiency(5M)

(a) For maximum output voltage V2, $J_1(X)$ must be maximum. This means

$J_1(X)$=0.582 at X=1.841. The electron velocity just leaving the cathode is

$$V_0 = (0.593\times10^6)\sqrt{V_0}$$

$$= (0.593\times10^6)\sqrt{10^3}$$

$$= (0.593\times10^6)\sqrt{31.62}$$

$= 0.59$

$= \theta_{g=1\,rad}$

$= 3x10^6 \times 31.62\ V_0 = 1.88 \times 10^7 m/s$

(a) The d.c electron transit time across the gap, $\tau = \frac{d}{v_0} = \frac{1x1o^{-3}}{1.7x10^7} = .05ns$

(b) Input voltage for maximum output voltage: The gap transit angle is

$$\theta_g = \omega \frac{d}{v0}$$

$$= \frac{2\pi(3\times10^9)\times10^{-3}}{1.88\times10^7}$$

$$= \frac{18.284\times10^6}{1.88\times10^7}$$

The beam coupling coefficient is= βi= sin(θg/2)/(θg/2)= sin (1/2)/(1/2)

$$= \frac{0.479}{0.5} = 0.958$$

The dc transit angle between the cavities is

$$\theta_0 = \omega T_0 = \omega \frac{L}{v_0}$$

$$= 2\pi\ (3\times10^9)\ \frac{4\times10^{-2}}{1.88\times10^7}$$

$= 6.28 \times 3\times2.128$

$= 40$rad.

The maximum input voltage V1 is then given by

$$V_{1max} = \frac{2V_0\,X}{\beta_i\theta_0}$$

$$= \frac{2(1000)(1.841)}{(0.952)(40)}$$

$$= \frac{3682}{38.08}$$

$V_{1\ max} = 96.5V$

	$\frac{\beta_0 \; I_2 \; V_2}{2 \; I_0 \, V_0}$ (b) The voltage gain $A_v = \frac{\beta_0 \, \theta_0}{R_0} \; \frac{J_1(X)}{X} \; R_{sh}$ $= \frac{(0.959)^2 \; (40)(0.582)30 \times 0^3}{4\times10^4 \; \times 1.841}$ $= \frac{0.92 \times 23.28 \times 30}{7.364}$ $= \frac{64.253}{7.364}$ $A_V = 8.595$ (a)Efficiency $\eta = \frac{\beta_0 \; I_2 \; V_2}{2 \; I_0 \, V_0}$ Where $I_2 = 2 \; \beta_0 I_0 \; J_1(X)$ $I_2 = 2 \times 25\times10^{-3} \times 0.582$ $I_2 = 29.1 \times 10^{-3}$ A $V_2 = \beta_0 \; I_2 \; R_{sh}$ $= (0.959) \; (29.1\times10^{-3})(30\times10^{3})$ $V_2 = 831$V Sub all values in η w get η = 46.38%
3	**Draw cross section of Magnetron oscillator and explain the process of bunching. (15M) [April/May 2015, Nov/Dec 2018]** BTL3 **Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no: 14.2-14.4** Cylindrical magnetron construction and working principle (8M) Bunching Process (7M)

UNIT V- MICROWAVE MEASUREMENTS 9

Measuring Instruments : Principle of operation and application of VSWR meter, Power meter, Spectrum analyzer, Network analyzer, Measurement of Impedance, Frequency, Power, VSWR, Qfactor, Dielectric constant, Scattering coefficients, Attenuation, S-parameters.

PART * A

Q.No.	Questions
1.	**Name the possible errors VSWR measurements.[May/June 2013, May/June 2016]** BTL1 The signal source give a signal frequency. any spurious signals present leads to the shift in maxima and minima and hence error is resulted in the readings There should not be any undesired reflection. for this matched load can be used as shown. These undesiresd reflection cause peaks and nodes to shift position in the standing wave pattern and VSWR thus measured will not be accurate. For higher VSWR near 10, the minimum voltage will be small and there will be deformation in the pattern because of high coupling at maximum voltage in errors.
2	**Classify the errors in impedance measurements [May/June 2014]** BTL1 • Scalar errors • Vector errors/Phase errors
3	**Explicit the significance of VSWR measurement. [Nov/Dec 2014]** BTL1 **VSWR** and the magnitude of voltage reflection coefficient (Γ) are very important parameters which determine the degree of impendence matching VSWR and Γ are also used for measurement of load impendence by the slotted line Method
4	**What is Bolometer?** BTL1 It is a power sensor whose resistance change with changed temperature as it absorb the microwave power. It is a short thin metallic wire sensor with positive temperature coefficient of reistance
5	**Define insertion loss. [Nov/Dec2017]** BTL1 It is defined as difference in power arriving at the terminating load .with or without The network in circuit Insertion loss(db)=10 log(po/pi)
6	**Explain radiation pattern.** BTL1 Radiation pattern is a representation of radiation characteristics of an antenna which is a function of elevation angle azimuth angle for a constant radial distance and frequency
7	**Interpret the concept of spectrum analyzer. [Nov/Dec2016]** BTL1 Spectrum analyzer is a broad band super heterodyne receiver which is used to display a wave in frequency domain additionally, power measurements, side bands can also be observed.
8	**State the principle by which high power measurements could be done by calorimetric Method. (April/May 2017)** BTL2 The measurement involves conversion of microwave energy into heat, absorbing this heat in a fluid

	(usually water) and then measuring the temperature rice of the fluid.
9	**Differentiate baretter and thermistor. [Nov/Dec2018]** BTL4 **Baretter** • baretter has positive temperature coefficient. • it has thin wire. • less sensitive. • required less bias current **Thermistor** • negative temp coefficient. • small bead of semi conductor material. • more sensitive. • require more sensitive.
10	**What are tunable detector?** BTL1 The tunable detectors are used to demodulate the signal and couple the required output to high frequency scope analyzer.The low frequency demodulated output is detected using non reciprocal detector diode monunted in the microwave transmission line.
11	**Describe about slotted section with line carriage.** BTL1 It is a microwave sectioned coaxial line connecting a coaxial E-field probe which penetrates inside a rectangular waveguide slotted section.The longitudinal slot is cut along the center of the waveguide broad walls.The probe is made to move along the slotted wall which samples the electric field propotional to probe voltage.
12	**Enlist the main purpose of slotted section with line carriage. [April/May 2017]** BTL2 • For determination of location of voltage standing wave maxima and minima • along the line. • Measure the VSWR and standing wave pattern. • Wavelength. • Impedence. • Reflection coeffient. • Return loss measurement.
13	**Describe about VSWR meter.[April/May 2015]**BTL1 VSWR meter is a highly sensitive,high gain,high theta,low noise voltage amplifier tuned normally at fixed frequency of 1KHZ of which microwave signals modulated.This meter indicates calibrated VSWR reading fir any loads.
14	**What is calorimeter?** BTL1 It is convenient device setup for measuring the high power at microwave which involves conversion of microwave energy in to heat,absorbing the heat in a f luid and determine the temp.
15	**Mention the disadvantages of single bridge circuit.** BTL1 • Change in resistance due to mismatch at the microwave input port results in incorrect reading • The thermistor is sensitive to change in the ambient temp resulting in false Readings
16	**How will you determine the VSWR and return loss in reflecto meter method? [Nov/Dec2017]** BTL2

	The voltage ratio between port3 or port4 is known reflecting coefficient (T) determined we determine VSWR and return loss as VSWR=(1+T)/(1-T) Return loss=-20 log(T)
17	**List the different types of Impedence measurement methods.** BTL4 • Slotted line method • Reflectometer method • Reactor discontructer method
18	**List out the methods to measure microwave frequency.** BTL1 1.Wavemeter method 2.Slotted line method 3.Downconversion method
19	**What is a wavemeter?** BTL1 It is a device used for frequency measurement in microwave.It has cylindrical cavity with a variable short circuit termination .It changes the resonant frequency of cavity by changing cavitylength.
20	**Define dielectric constant.** BTL1 It is defined by the ratio of permittivity of medium to permittivity of freespace. xr=x/xo=((10^-9)/36p)
21	**How the S-parameter of a microwave circuit measured? [Nov/Dec 2016]** BTL2 S-parameters are conveniently measured using the deschamps method which utilizes the measured value of complex input reflection coefficient under a number of a reactive terminations.
22	**Classify the methods for measuring dielectric constants.** BTL1 • Waveguide method • cavity pertubaration method
23	**List the types of spectrum analyzer.** BTL1 • Real time spectrum analyzer • Swept tuned frequency spectrum analyzer
24	**Mention some application of spectrum analyzer.[May/June 2016]** BTL3 Identifying frequency terms and their power levels measuring harmonic distortion in a wave Determine type of wave modulation Signal to noise ratio for identifying wave distortion
25	**What is network analyzer? [Nov/Dec 2016]** BTL1 A Network analyzer measures both amplitude and phase of a signal over a wide frequency range. It requires accurate reference signal and a test signal.
26	**Interpret the significance of VSWR measurement? [Nov/Dec 2014]** BTL1 VSWR and the magnitude of voltage reflection coefficient are the very important parameters which determine the degree of impedance matching.
27	**Define SWR. [April/May 2017]** BTL1 Standing wave ratio is defined as the ratio of maximum voltage to the minimum voltage. $S = E_{max}/E_{min}$ Or $S = \frac{1+\Gamma}{1-\Gamma}$ Where Γ= Reflection coefficient.
28	**Name the errors possible in VSWR measurements. [May/June 2013, May/June 2014, May/June 2016]** BTL1 • Vmax and Vmin may not be measured in the square law region of the crystal detector. • The probe thickness and depth of penetration may produce reflections in the line and also distortion in the field to be measured.

When VSWR is < 1.05, the associated VSWR of connector produces significant error in VSWR measurement. Very good low VSWR (<1.01) connectors should be used for very low VSWR measurements.

29 **Distinguish between low frequency measurements and microwave measurements. [April/May2015]** BTL4

S.No	Low frequency measurements	Microwave measurements
1	At low frequency it is convenient to measure voltage and current and use them to calculate power	At Microwave frequencies the amplitude of voltage and currents on a distribution line are the functions of a distance and are not easily measurable.
2	At low frequency, circuits use lumped elements.	At Microwave frequencies the circuit elements are distributed.

PART B

1 **Write short notes on network analyzer. (13M) [April/May 2015]** BTL2

Ans: Refer notes

- Block diagram (6M)
- Theory of operation (7M)

2 **Explain the procedure to measure the impedance of load. (13M) [May/June 2014, Nov/Dec2016, May/June 2016, April/May 2017, Nov/Dec2018]** BTL2

Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no: 15.7-15.9

Impedance measurement with slotted line:

- Block diagram (6M)
- Procedure with theory of operation (7M)

3 **Write a brief note on dielectric constant and attenuation measurements. (13M) [Nov/Dec2018]** BTL1

Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no: 15.11

- Dielectric constant/Attenuation block diagram (6M)
- Theory with procedure (7M)

4 **Explain spectrum analyzer and its applications. (13M)[Nov/Dec 2018]** BTL3

Ans: Refer notes

- Block diagram (4M)
- Theory of operation (6M)
- Applications (3M)

5 **Discuss in detail about the measurement of frequency. [april/May 2017, Nov/Dec2018] (13M)**

BTL2

Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no: 15.14-15.15

	• Block diagram of frequency measurement (6M) • Theory of operation (7M)
	PART * C
1	**Explain how low VSWR can be measured using microwave bench. (15M) [Nov/Dec 2011, Nov/Dec 2012,Nov/Dec 2014, Nov/Dec2016, May/June 2016, April/May 2017, Nov/Dec2018]** BTL3 **Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no: 15.2-15.6** • Double Minima method (8M) • Reflectometer method (7M)
2	**Demonstrate the principle of microwave power measurements. (15M) [Nov/Dec 2011, May/June 2014,April/May15, Nov/Dec 2018]** BTL3 **Ans: Ref book: RF and microwave engineering by K.Muralibabu. Pg:no: 15.16-15.24** • Diode detector (4M) • Bolometer sensor (6M) • Thermocouple sensor (5M)
3	**Discuss the working principle of operation and application of VSWR meter and Powermeter. (15M)** BTL3 **Ans: Refer notes** • Block diagram of VSWR meter and Power meter (8M) • Theory with principle of operation (7M)

EC6702 OPTICAL COMMUNICATION AND NETWORKS L T P C

3 0 0 3

OBJECTIVES:

- To Facilitate the knowledge about optical fiber sources and transmission techniques
- To Enrich the idea of optical fiber networks algorithm such as SONET/SDH and optical CDMA
- To Explore the trends of optical fiber measurement systems

UNITI INTRODUCTION TO OPTICAL FIBERS 9

Evolution of fiber optic system- Element of an Optical Fiber Transmission link-- Total internal reflection-Acceptance angle –Numerical aperture – Skew rays Ray Optics-Optical Fiber Modes and Configurations -Mode theory of Circular Waveguides- Overview of Modes-Key Modal concepts Linearly Polarized Modes -Single Mode Fibers-Graded Index fiber structure.

UNITII SIGNAL DEGRADATION OPTICAL FIBERS 9

Attenuation - Absorption losses, Scattering losses, Bending Losses, Core and Cladding losses, Signal Distortion in Optical Wave guides-Information Capacity determination -Group Delay-Material Dispersion, Wave guide Dispersion, Signal distortion in SM fibers-Polarization Mode dispersion, Intermodal dispersion, Pulse Broadening in GI fibers-Mode Coupling -Design Optimization of SM fibers-RI profile and cut-off wavelength.

UNITIII FIBER OPTICAL SOURCES AND COUPLING 9

Direct and indirect Band gap materials-LED structures -Light source materials -Quantum efficiency and LED power, Modulation of a LED, lasers Diodes-Modes and Threshold condition -Rate equations -External Quantum efficiency - Resonant frequencies -Laser Diodes, Temperature effects, Introduction to Quantum laser, Fiber amplifiers- Power Launching and coupling, Lencing schemes, Fiber -to- Fiber joints, Fiber splicing-Signal to Noise ratio , Detector response time.

UNITIV FIBER OPTIC RECEIVER AND MEASUREMENTS 9

Fundamental receiver operation, Pre amplifiers, Error sources – Receiver Configuration– Probability of Error – Quantum limit. Fiber Attenuation measurements- Dispersion measurements – Fiber Refractive index profile measurements – Fiber cut- off Wave length Measurements – Fiber Numerical Aperture Measurements – Fiber diameter measurements.

UNITV OPTICAL NETWORKS AND SYSTEM TRANSMISSION 9

Basic Networks – SONET / SDH – Broadcast – and –select WDM Networks –Wavelength Routed Networks – Non linear effects on Network performance –-Link Power budget -Rise time budget Noise Effects on System Performance-Operational Principles of WDM Performance of WDM + EDFA system – Solutions – Optical CDMA – Ultra High Capacity Networks.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of the course, students will be able to

- Discuss the various optical fiber modes, configurations and various signal degradation factors associated with optical fiber
- Explain the various optical sources and optical detectors and their use in the optical communication system.
- Analyze the digital transmission and its associated parameters on system performance

TEXT BOOK:

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2. J.Senior, "Optical Communication, Principles & Practice", Prentice Hall of India, 3rd Edition, 2008.
3. J.Gower, "Optical Communication System", Prentice Hall of India, 2001.

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UNIT I - INTRODUCTION TO OPTICAL FIBERS

Evolution of fiber optic system- Element of an Optical Fiber Transmission link-- Total internal reflection-Acceptance angle –Numerical aperture – Skew rays Ray Optics-Optical Fiber Modes and Configurations -Mode theory of Circular Wave guides- Overview of Modes-Key Modal concepts Linearly Polarized Modes -Single Mode Fibers-Graded Index fiber structure.

PART * A

Q.No.	Questions
1.	**Why partial reflection does not suffice the propagation of light? (Nov/Dec 2017)** BTL4 • The reason is that, at each reflection a part of the optical energy launched into the optical fiber would be lost and after a certain distance along the length of the fiber the optical power would be negligibly low to be of any use. Thus total internal reflection is an absolute necessity at each reflection for a sustained propagation of optical energy over long distance along the optical fiber.
2	**A graded Index optical fiber has a core with a parabolic index profile which has a diameter of 50 micrometer. The fiber has a NA of 0.2. Calculate the total number of guided modes in the fiber when it is operating at a wavelength of 1micrometer.(Nov/Dec 2017)** BTL3 **Given:** NA=0.2 Core diameter=50micrometer So, core radius=25micrometer Wavelength=1micrometer $V = \frac{2\pi}{\lambda} a(NA)$ V=31.4 The number of guided modes for a parabolic profile $M_g = \frac{V^2}{4}$ $M_g = 246.49 = 247.$
3	**What are the advantages of Optical fiber? (Apr/May 2017)** BTL1 • Enormous potential Bandwidth. • Small size & Weight • Electrical isolation • Immunity to interference &crosstalk • Signal security & low transmission loss.
4	**A multimode silica fiber has a core refractive index n1=1.48 and cladding refractive index n2=1.46. Find Numerical Aperture of fiber. (Apr/May 2017)** BTL3

	Given: Core refractive index n1=1.48 Cladding refractive index n2=1.46 NA=$\sqrt{n_1{}^2 - n_2{}^2}$ NA=0.24248
5	**Define acceptance angle and Numerical Aperture. (Nov/Dec 2016), (Nov/Dec 2014)** BTL1 **Acceptance Angle** Maximum angle to the axis at which light may enter the fiber in order to be propagated. **Numerical Aperture (NA)** It is to obtain a relationship between the acceptance angle & refractive indices of 3 media involved, Namely core, cladding & air. $NA = n_0 \sin\theta_a = \sqrt{(n_1{}^2 - n_2{}^2)}$
6	**What are the conditions for light to be propagation inside a fiber? (Nov/Dec 2016)** BTL2 • The phenomenon of total internal reflection is used to guide the light in the optical fiber. To get total reflection, the ray should travel from denser region rarer region i.e. from core to clad region. • Of the fiber and the angle of incidence in the denser medium should be greater than the critical angle of that medium.
7	**What are the conditions for the single mode propagation? (May/Jun 2016)** BTL2 The basic requirement for single mode fiber is that the core be small enough to restrict transmission to a single mode. This lowest-order mode can propagate in all fibers with smaller cores (as long as light can physically enter the fiber).
8	**Define phase and group velocity (May/Jun 2016), (Nov/Dec 2015)** BTL1 **Phase velocity**: As a monochromatic light wave propagates along a waveguide in the direction of wave front with constant phase is called phase velocity **Group velocity**: Speed at which energy in a particular mode travels along a fiber.
9	**What is total internal reflection in a fiber? (Nov/Dec 2015)** BTL1 Total Internal reflection occurs at the interface between two dielectrics of different refractive indices when light is incident on the dielectric of lower index from the dielectric of high index and the angle of incidence of the ray exceeds the critical value
10	**List any 2 advantages of single mode fibers. (Nov/Dec 2014)** BTL1 • No intermodal dispersion • Information capacity of single mode Fiber is Large.
11	**The refractive indexes of the core and cladding of a silica fiber are 1.48 and 1.46 respectively. Find the acceptance angle for the fiber. (Nov/Dec 2013)** BTL3 Core refractive index n1=1.48 Cladding refractive index n2=1.46 Maximum acceptance angle θ_{max}=Acceptance angle $\theta_A = \sin^{-1} NA$ NA= $\sqrt{n_1{}^2 - n_2{}^2}$

	$= \sqrt{((1.48)^2 - (1.46)^2)}$ NA = 0.24248 $\theta_A = \sin^{-1} 0.24248$ $\theta_A = 14.032 \circ$
12	**Determine the normalized frequency at 820nm for a step index fiber having a 25micrometer radius. The refractive indexes of the cladding and the core are 1.45 and 1.47 respectively. How many modes propagate in this fiber at 820nm? (Nov/Dec 2013)** BTL3 Given: Wavelength λ = 820nm Core radius a = 25micrometer Core refractive index n1=1.47 cladding refractive index n2=1.45 normalized frequency v $= \frac{2*3.14*a}{\lambda}\ (NA)$ $= \frac{2*3.14*(25X10^{-6})}{(820X10^{-9})} \left(\sqrt{(1.47)^2 - (1.45)^2}\right)$ =46.33 Mode propagation $M_g = \frac{V^2}{2}$ M_g=1073
13	**Calculate the cutoff wavelength of a single mode fiber with core radius of 4micrometer and Δ=0.003. (Nov/Dec 2012)** BTL3 normalized frequency v$= \frac{2*3.14*a}{\lambda}\ (NA)$ $\lambda = \frac{2*3.14*a}{V}\ (NA)$ Let V=2.405; n1=1 and a=4micrometer, **Δ=0.003** $\lambda = 0.809$
14	**For a fiber with core refractive index of 1.54 and fractional refractive index difference of 0.01. Calculate its Numerical Aperture. (Nov/Dec 2012)** BTL3 Given Core refractive index n1=1.54 Δ=0.01 $NA = n1\sqrt{2\Delta}$ NA=0.217
15	**Assume that there is a glass rod of refractive index 1.5, surrounded by air. Find Critical incident angle.** BTL3 Given Glass rod(core) refractive index n1 = 1.5 Cladding refractive index n2=1 $\varphi_c = \sin^{-1}(\frac{n_2}{n_1})$ $= \sin^{-1}(\frac{1}{1.5})$ = 41.81degrees

16 **What are the limitations of optical fiber Communication systems?** BTL2

- It is costly and it has limited bend radius
- Because of the impurities present in optical fiber, absorption leads to loss of light/information

17 **What is the necessity of cladding for an optical fiber?** BTL2

- To avoid leakage of light from the fiber
- To avoid mechanical strength for the fiber
- To protect core from scratches and other mechanical damages.

18 **List the uses of optical fiber.** BTL2

- To act as light source at the inaccessible places
- To transmit the optical images. (example: endoscopy)
- To act as sensors to do mechanical, electrical and magnetic measurements
- To transmit the information which are in the form of coded signals of the telephone communications, computer data etc.

19 **What is Snell's law?** BTL1

The relationship at the interface is called Snell's Law.
It is given by the equation
$n1sin\varphi 1 = n2sin\varphi 2$

20 **Why step index single mode fiber preferred for long distance Communication?** BTL4

- The step index single mode fiber is preferred for long distance communication because
- They exhibit higher transmission bandwidth because of low fiber losses.
- They have superior transmission quality because of the absence of the model noise.
- The installation of single mode fiber is easy and will not require any fiber replacement over twenty plus years.

21 **Differentiate between mono-mode fiber and multi-mode fiber.** BTL4

Mono-mode fiber	**Multi-mode fiber**
Only one ray passes through the fiber	More than one ray passes through fiber at a time.
Coupling efficiency is less.	Coupling efficiency is large.
LED is not suitable for single mode fiber.	LED is suitable for multi mode fiber
Intermodal dispersion is not present.	Intermodal dispersion is present
Fabricating single mode fiber is difficult.	Fabricating multi-mode fiber is easy

22 **Define- Birefringence.** BTL1

- Manufactured optical fibers have imperfections such as asymmetrical lateral stresses, non - circular cores and variations in refractive index profiles.
- These imperfections break the circular symmetry of the ideal fiber and lift the degeneracy

of the two modes. These modes propagate with different phase velocity and it is called as fiber birefringence.

23 **Compare Ray optics and wave optics.** BTL4

Ray optics	**Wave optics**
It is used to represent the light propagation	It is used to analyze mode theory
It is used to study reflection and refraction of light	It is used to analyze diffraction and interference of light waves

24 **What is V number of a fiber?** BTL1

Normalized frequency or V number is a dimensionless parameter and represent the relationship among three design parameters variables of the fiber viz core radius a, relative refractive index Δ and the operating wavelength λ.

It is expressed as V = (2*π* Numerical aperture(a)) / λ

25 **What is meant by linearly polarized mode?** BTL1

The field components HE, EH, TE, TM forms linearly polarized modes. Linearly polarized Modes are labeled LPjm where j and m are integers designation mode solutions.

26 **Define Refractive Index.** BTL1

Ratio of velocity of Light in vacuum to Velocity of Light in Medium.

PART * B

1 **Explain phase shift with total internal reflection and evanescent field.(13M) (Nov/Dec 2017)** BTL1

Answer:Page:10-12- Notes

Snells law n1sinφ1 = n2sinφ2 (2M)

Refraction-diagram (3M)

Critical angle-diagram and explanation (4M)

- Ray should travel from denser region rarer region i.e. from core to clad region.
- Fiber and the angle of incidence in the denser medium should be greater than the critical angle of that medium.

Total internal reflection- diagram (4M)

- Total Internal reflection occurs at the interface between two dielectrics of different refractive indices when light is incident on the dielectric of lower index from the dielectric of high index and the angle of incidence of the ray exceeds the critical value

2 **Discuss whether TEM waves exist in an optical Fiber. If not what type of mode will propagate in a practical optical fiber(13M) (Nov/Dec 2017)** BTL4

Answer:Page:26-28- John M senior

No (2M)

Planer wave propagation diagram (6M)

TE & TM mode --- in practical fiber & Figure (5M)

3	**Compare the structure and characteristics of step index and graded index fiber./ Classify fibers and Explain them./ Explain the Features of Multimode and single mode Step index fiber and compose them. (Nov/Dec 2016) (13M), (Nov/Dec 2011)** BTL4 **Answer:Page:19-21 &33-35- notes** **Types of fiber** (3M) Step index(refractive index is uniform)- Single mode, Multimode Graded index(refractive index varies throughout the fiber)- Multimode **Structure Figure** (5M) **Refractive index Formula** (5M) For step index--- $n_2 = n_1(1-\mathit{\Delta})$ For graded Index--- $n(r) = \left(\begin{matrix} \left(n_1[1-2\Delta(\frac{r}{a})^{\alpha}]^{\frac{1}{2}}\right) & for\ 0 \leq r \leq a \\ \left(n_1(1-2\Delta)^{\frac{1}{2}}\right) = n_2 & for\ r \geq a \end{matrix} \right)$
4	**A graded Index optical fiber has a core with a parabolic index profile (α=2) which has a diameter of 50 micrometer. The fiber has a NA of 0.2. Calculate the total number of guided modes in the fiber when it is operating at a wavelength of 1micrometer.(7M)(Nov/Dec 2017)** BTL4 **Answer:Page:84 - notes** $\mathrm{M_g} = \frac{\mathrm{V}^2}{4}$ (1M) $\mathrm{V} = \frac{2\pi \mathrm{a}}{\lambda}\mathrm{NA}$ (1M) V=31.4 (3M) $\mathrm{M_g} = 246.49$ (2M)
5	**Find the core radius necessary for single mode operation at 1320nm of a step index fiber with n1=1.48 and n2=1.478. Determine the numerical Aperture and acceptance angle of this optical fiber.(13M) (Apr/May 2017) (13M)** BTL4 **Answer:Page:84-85- notes** $V = \frac{2\pi a}{\lambda} n_1 \sqrt{2\Delta} ==> a = 6.5\mu m$ (5M) $NA = \sqrt{{n_1}^2 - {n_2}^2} ==> NA = 0.076$ (4M) $\theta_a = \sin^{-1} NA = 4.35°$ (4M)
6	**Explain the Evolution of optical Fiber (8M)** BTL1 **Answer: page:4-5 -Notes** **First Generation** (3M) • Operated at 850nm • GaAS based source optical source, silicon photodiode **Second generation** (2M)

	• Operated at 1300nm • Bit rate range from 10 to 100 Mb/s over distance ranging from 500m to tens of KMs **Third generation** (3M) • 1550nm. • Lowest attenuation but high dispersion. • Remedy: Dispersion Shifted Fiber.
7	**Discuss the mode theory of circular waveguides. (8M)** BTL3 **Answer: page:4-5 -Notes** • Introduction (1M) • Overview of Modes (2M) • Key Modal Concept & Linearly Polarized Wave (5M)
8	**A step index multimode fiber with a numerical aperture of 0.2 support approx. 1000 modes at an 850nm wavelength. What is the diameter of its core? (7M) (Apr/May 2017)** BTL4 **Answer:Page:85- notes** $N = 4.9\left[\frac{d\ NA}{\lambda}\right]^2$ (4M) N=60.7µm (3M)
9	**Derive Numerical Aperture of an optical fiber. (8M)(May/Jun 2016), (Nov/Dec 2013)** BTL1 **Answer:Page:14-16- notes** **Figure representation** (3M) **Snell's law**== > n1sinφ1 = n2sinφ2 (1M) **Derivation** (4M) $NA = n_0 \sin\theta_a = \sqrt{(n_1{}^2 - n_2{}^2)}$
10	**Discuss on the transmission of light through graded index fiber. (13M) (Nov/Dec 2014)** BTL2 **Answer:Page:33-34- notes** **Introduction** ---- Refractive index varies throughout the fiber. (1M) **Structure diagram** (2M) **Refractive index** --- $n(r) = \left(\begin{array}{ll} \left(n_1[1-2\Delta(\frac{r}{a})^{\alpha}]^{\frac{1}{2}}\right) & for\ 0 \le r \le a \\ \left(n_1(1-2\Delta)^{\frac{1}{2}}\right) = n_2 & for\ r \ge a \end{array}\right)$ (2M) **Local Numerical Aperture** $NA(r) = \left([n^2(r) - n_2{}^2]^{\frac{1}{2}} = NA(0)\sqrt{1-(\frac{r}{a})^{\alpha}}\right)$ (2M) **Axial Numerical Aperture** $NA(0) = \left([n^2(0) - n_2{}^2]^{\frac{1}{2}} = [n_1{}^2 - n_2{}^2]^{\frac{1}{2}}\right) = n_1\sqrt{2\Delta}$ (2M) **Modes**

	$M = \frac{\alpha}{\alpha+2}\alpha^2 k^2 {n_1}^2 \Delta$ (2M) **Comparison of NA and Fibers for various α- Graph** (2M)
14	**A SI fiber with silica-core refractive index of 1.458, V=75 and NA=0.3 is to operated at 820nm. What should be its core size and cladding refractive index? Calculate the total number of modes entering this fiber. (6M) (Nov/Dec 2012)** BTL4 **Answer:Page:87- notes** $NA = \sqrt{{n_1}^2 - {n_2}^2} \;==> n_2 = 1.426$ (2M) $V = \frac{2\pi a}{\lambda} n_1 \sqrt{2\Delta} \;==> a = 32\mu m$ (2M) $M = \frac{V^2}{2} \;==> 2812.5$ (2M)
15	**Calculate NA of silica fiber with its core refractive index (n1) of 1.48 and cladding refractive index of 1.46 What should be the new value of n1 in order to change the NA to 0.23. (6M) (Nov/Dec 2011)** BTL4 **Answer:Page:44-45- notes** $NA = \sqrt{{n_1}^2 - {n_2}^2} \;==> NA = 0.242$ (3M) For NA= 0.23 $n_1 = 1.47$ (3M)
17	**Calculate NA of silica fiber with its core refractive index (n1) of 1.48 and cladding refractive index of 1.46 What should be the new value of n1 in order to change the NA to 0.23. (7M) (Nov/Dec 2011)** BTL4 **Answer:Page:45- notes** $NA = \sqrt{{n_1}^2 - {n_2}^2} \;==> NA = 0.242$ (4M) For NA= 0.23 $n_1 = 1.47$ (3M)
	PART*C
1	**Draw the block diagram of optical fiber transmission link and explain/With the help of a block diagram explain the different components of an optical fiber link. (15M)** BTL1 **Answer:Page:5-9- notes** **Introduction** (2M) **Block diagram & explanation** (8M) Block Diagram Explanation Optical fiber- core, cladding, splicer, connector Transmitter – LED,LASER, WDM Receiver- PIN, Photo diode **Advantages** (2M) • Enormous potential Bandwidth. • Small size & Weight, Electrical isolation • Immunity to interference &crosstalk • Signal security & low transmission loss.

	Applications (3M) • To act as light source at the inaccessible places • To transmit the optical images. (example: endoscopy) • To transmit the information which are in the form of coded signals of the telephone communications, computer data etc.
2	**Consider a fiber with 25micrometer core radius, core index n1=1.48 and Δ=0.01. if λ=1320nm, what value of V and how many modes propagate in the fiber. What percent of optical power flows in the cladding? If the core cladding difference is reduced to Δ=0.003, how many modes does the fiber support and what fraction of the optical power flows in the cladding? (15M) (Nov/Dec 2016)** BTL4 **Answer:Page:46- notes** For Δ=0.01 $V = \frac{2\pi a}{\lambda} n_1 \sqrt{2\Delta}\ ==> v = 25$ (3M) $M = \frac{V^2}{2}\ ==> 312.5$ (3M) Percentage of power flows=$\frac{4}{3\sqrt{M}}\ ==> 7.5\%$ (2M) For Δ=0.003 $V = \frac{2\pi a}{\lambda} n_1 \sqrt{2\Delta}\ ==> v = 9.20$ (3M) $M = \frac{V^2}{2}\ ==> 40.5$ (2M) Percentage of power flows=$\frac{4}{3\sqrt{M}}\ ==> 20.95\%$ (2M)
3	**With diagram, Explain acceptance angle and Numerical Aperture of Fibers and total internal reflection.(15M) (Nov/Dec 2015), (May/Jun 2014)** BTL1 **Answer:Page:12-16- notes** **Total Internal Reflection** (5M) Total Internal reflection occurs at the interface between two dielectrics of different refractive indices when light is incident on the dielectric of lower index from the dielectric of high index and the angle of incidence of the ray exceeds the critical value **Acceptance Angle** (4M) Maximum angle to the axis at which light may enter the fiber in order to be propagated. **Numerical Aperture** (6M) It is to obtain a relationship between the acceptance angle & refractive indices of 3 media Involved, Namely core, cladding & air. Figure representation Snell's law== > n1sinφ1 = n2sinφ2 Derivation $NA = n_0 \sin\theta_a = \sqrt{({n_1}^2 - {n_2}^2)}$

UNIT II – SIGNAL DEGRADATION OPTICAL FIBERS

Attenuation – Absorption losses, Scattering losses, Bending Losses, Core and Cladding losses, Signal Distortion in Optical Wave guides-Information Capacity determination –Group Delay-Material Dispersion, Wave guide Dispersion, Signal distortion in SM fibers-Polarization Mode dispersion, Intermodal dispersion, Pulse Broadening in GI fibers-Mode Coupling –Design Optimization of SM fibers-RI profile and cut-off wavelength.

PART * A

Q.No.	Questions
1.	**Define Attenuation. (Nov/Dec 2017)** BTL1 • Attenuation is Fiber loss or signal loss determines the maximum unamplified or repeater less separation between transmitter and receiver. • Attenuation mechanisms are: Absorption, Scattering & Radiative losses of optical energy.
2	**A manufacturer's data sheet lists the material dispersion Dmat= 110ps/nm.km at a wavelength of 860nm. Find the RMS pulse broadening per km due to material dispersion if the optical source has a spectral width 40nm at b an output wavelength of 860nm. (Nov/Dec 2017)** BTL4 Given: $\sigma_\lambda = 40nm$ M=110ps/nm.km RMS pulse broadening per km due to material dispersion $\sigma_m(1\ KM) = \sigma_\lambda LM = (40) * 1 * (110ps\ km)$ =4.4ns km-1
3	**What is intra modal dispersion? (Apr/May 2017)** BTL1 • It is the pulse spreading that occurs within a single mode fiber. • The spreading arises from the finite spectral emission width of an optical source. This phenomenon is also known as Group velocity Dispersion (GVD). • Causes of Intramodal Dispersion: Waveguide dispersion, Material Dispersion.

4	**Define group delay. (Apr/May 2017)** BTL2 • Each Spectral component of any particular mode takes different amount of time to travel a certain distance. As a result of this difference in time delays, optical signal pulse spreads out with time as it is transmitted over the fiber. • Group delay depends on wavelength.
5	**What are the causes of absorption? (Nov/Dec 2016)** BTL2 • Atomic defects • Extrinsic Absorption by impurity atoms in the glass material • Intrinsic Absorption by basic constituent atoms of the fiber material
6	**What is Polarization Mode Dispersion (PMD)? / What do you meant by polarization dispersion in a fiber? (Nov/Dec 2016),(Nov/Dec 2015)** BTL2 • Signal energy at a given wavelength occupies 2 orthogonal polarization modes. • A varying Birefrengence along its length will cause each mode to travel at a slightly different velocity. The resulting difference in propagation times will result in pulse spreading which is called as PMD.
7	**What is chromatic dispersion? (May/Jun 2016)** BTL2 • It is also called as Intramodal dispersion. • It is the pulse spreading that occurs within a single mode fiber. • The spreading arises from the finite spectral emission width of an optical source. This phenomenon is also known as Group velocity Dispersion (GVD). • Causes of Chromatic Dispersion: Waveguide dispersion, Material Dispersion.
8	**What are the types of fiber losses which are given per unit distance? (Nov/Dec 2014)** BTL2 • Absorption loss. • Scattering Loss. • Radiative loss of optical energy..
9	**Distinguish meridional rays from Skew rays. (May/Jun 2014), (Nov/Dec 2013)** BTL4 • A meridional ray is a ray that passes through the axis of an optical fiber. (Total Internal Reflection). • A skew ray is a ray that travels in a non-planar zigzag path and never crosses the axis of an optical fiber (Helical Path).
10	**Identify the causes of scattering loss. (May/Jun 2014)** BTL4 • Microscopic variations of material density • Compositional Fluctuations • Structural inhomogeneities • Defects during manufacturing
11	**What are the 2 reasons for Chromatic dispersion? (Nov/Dec 2012)** BTL4 Causes of Chromatic Dispersion: • Waveguide dispersion, Material Dispersion.
12	**What are the most important non linear effects of optical fiber communication? (Nov/Dec 2012)** BTL2

	• Wavelength Division Multiplexing(WDM) • Four wave mixing • Cross phase modulation.
13	**Define Attenuation Coefficient of a fiber. (Nov/Dec 2011)** BTL1 • If P (0) is the optical power in a fiber at the origin (at Z = 0), then the power P(Z) at a distance z further down the fiber then P (z) = P (0) e^-αpz . • The above equation can be rewritten as αp = (1 / z) {P(0) / P(z)}. Where αp is the fiber attenuation coefficient given in units of km-1.
14	**What are the types of material absorption losses in silica glass fibers?** BTL2 The types of material absorption losses in the glass composition are • Absorption by impurity atoms in the glass material. • Intrinsic absorption by the basic constituent atoms in the glass material.
15	**Differentiate linear scattering from non-linear scattering.** BTL4 • Linear scattering mechanisms cause the transfer of some or all of the optical power contained within one propagating mode to be transferred linearly into a different mode. • Non-linear scattering causes the optical power from one mode to be transferred in either the forward or backward direction to the same or other modes at different frequencies.
16	**What are the ways to reduce macro bending losses?** BTL4 • Designing fibers with large relative refractive index differences. • Operating at the shortest wavelength possible.
17	**Define – Group Velocity Dispersion. (GVD).** BTL1 Intra-modal dispersion is pulse spreading that occurs within a single mode. The spreading arises from the finite spectral emission width of an optical source. This phenomenon is known as Group Velocity Dispersion.
18	**Define- Beat Length.** BTL1 Beat Length is defined as the period of interference effects in a bi-refringent medium. When two waves with different linear polarization states propagate in a bi-refringent medium, their phases will evolve differently.
19	**What is wave guide dispersion?** BTL2 • Wave guide dispersion occurs because of a single mode fiber confines only about 80% of optical power to the core. Dispersion arises since 20% of light propagates in cladding travels faster than the light confined to the core. • Amount of wave-guide dispersion depends on fiber design. Other factor for pulse spreading is inter modal delay.
20	**What is material dispersion?** BTL2 • Material dispersion arises from the variation of the refractive index of the core material as a function of wavelength. Material dispersion is also referred to as chromatic dispersion. This causes a wavelength dependence of group velocity of given mode. • So it occurs because the index of refraction varies as a function of optical wavelength. Material dispersion is an intra modal dispersion effect and is for particular importance for

	single mode wave guide.
21	**What is pulse broadening?** BTL2 • The broadening arises from the finite spectral emission width of an optical source. • Dispersion induced signal distortion is that, a light pulse will broaden as it travels along the fiber. This pulse broadening causes a pulse to overlap with neighboring pulses. • After a time ‘t’, the adjacent pulses can no longer be individually distinguished at the receiver and error will occur
22	**What is polarization?** BTL2 Polarization is a fundamental property of an optical signal. It refers to the electric field orientation of a light signal which can vary significantly along the length of a fiber.
23	**What is fiber birefringence?** BTL2 Imperfections in the fiber are common such as symmetrical lateral stress, non circular imperfect variations of refractive index profile. These imperfections break the circular symmetry of ideal fiber and mode propagate with different phase velocity and the difference between their refractive index is called fiber birefringence.
24	**Write a note on scattering losses.** BTL2 Arises from microscopic variation in the material density from compositional fluctuation and from structural in-homogeneities or defects occurring during fiber manufacture.
25	**What is the measure of information capacity in optical waveguide?** BTL2 • It is usually specified by bandwidth distance product in Hz. • For a step index fiber the various distortion effects tend to limit the bandwidth distance product to 20 MHz.
PART *B	
1	**A multimode step index fiber has a numerical Aperture of 0.3 and a core refractive index of 1.45. the material dispersion for the fiber is 250ps.nm-1km-1 which makes material dispersion the totally dominating chromatic dispersion mechanism. Estimate (a) the total rms pulse broadening per km when the fiber is used with an LED source of rms spectral width 50nm and (b)the corresponding bandwidth – length product of the fiber. (13M) (Nov/Dec 2017)** BTL4 **Answer:Page:84- notes** $\sigma_{\lambda} = \sigma_{\lambda} LM \;== 12.5 ns\ km^{\wedge} - 1$ (4M) $\sigma_{s} = \frac{L\,(NA)^2}{4\sqrt{3}\,n_1 c} \;== 29.9 ns\ km^{-1}$ (6M) B*L= 6.2MHz.KM (3M)
2	**Discuss about the design optimization of single mode fiber. (13M) (Nov/Dec 2016)** BTL2 **Answer:Page:78-82- notes** **Introduction_** (3M) Application of SM fiber - Telecomm companies, microwave speed localized applications Features - Very low attenuation, large Bandwidth, High quality signal transfer **Refractive index Profiles_** (5M) 1300nm optimized fibers Dispersion shifted fibers

	Dispersion flattened fibers Large Effective core area fibers **Cut off wavelength** (5M) Effective cutoff wavelength: largest wavelength - mode power 0.1db
3	**What is waveguide dispersion? Derive an expression for time delay produced due to waveguide dispersion. (6M) (Nov/Dec 2016)** BTL2 **Answer:Page:68-69- notes** **Definition** (2M) 80% power confined in core, 20% power in cladding- cladding power propagates faster than Core - waveguide dispersion. **Derivation** (4M) $\tau_{wg} = \frac{L}{C}\left[n_2 + n_2\Delta\frac{(d(Vb))}{dv}\right]$
4	**When the mean optical power Launched into an 8km length of fiber is 120λw, the mean optical power at the fiber output is 3λw. Determine (a) the overall signal attenuation or less in decibels through the fiber assuming there are no connector or splices. (b) The signal attenuation per kilometer for the fiber. (c) The overall signal attenuation for a 10km optical link using the same fiber with splices at 1 km intervals, each giving an attenuation of 1 dB. (d) The numerical input/output power ratio.(13M) (May/Jun 2016)** BTL4 **Answer:Page:84-85- notes** Overall signal attenuation =10 log$\frac{P_i}{P_o}$ = => 16db (3M) signal attenuation per km $\alpha_{dB}L = 10log\frac{P_i}{P_o} ==> 2dBkm^\wedge - 1$ (3M) over all signal attenuation = 29Db (3M) Numerical power ratio = $10^{\frac{dB}{10}}$= = > 794.3 (4M)
5	**Derive an expression for pulse broadening in graded index fiber./ What do you meant by pulse broadening? Explain its effect on information carrying capacity of a fiber. (7M)(Apr/May 2017), (Nov/Dec 2011)** BTL2 **Answer:Page:73-77- notes** **Derivation** (5M) $\sigma = ({\sigma^2}_{intermodal} + {\sigma^2}_{intramodal})^{\frac{1}{2}}$ **Information carrying capacity** (2M) Bandwidth* Distance product (MHz.Km) Step index B*L= about 20MHz.Km Graded Index B*L= > 2.5GHz.Km
6	**What are the causes of signal attenuation in optical fiber? Explain about it in detail.(13M) (Apr/May 2017) (Nov/Dec 2015)** BTL2 **Answer:Page:51-61- notes** **Introduction** (2M)

	Fiber loss- determines max, unamplified separation of transmitter - receiver **Absorption loss** (4M) Absorption- atomic defects in the glass imperfections Intrinsic – imperfection in atoms of the fiber material Extrinsic - impurity atoms in the glass material **Scattering Loss** (4M) Rayleigh scattering **Bending loss** (3M) Micro bending- Small bends Macro bending- Bend radii > fiber diameter
PART*C	
1	**With necessary diagrams, Explain the causes and types of fiber attenuation loss. (15M) (Nov/Dec 2015) (May/June 2014) (Nov/Dec 2013)** BTL2 **Answer:Page:51-61- notes** **Introduction** (2M) Fiber loss- determines max, unamplified separation between transmitter - receiver **Absorption loss** (5M) Absorption- atomic defects in the glass imperfections Intrinsic – imperfection in atoms of the fiber material Extrinsic - impurity atoms in the glass material **Scattering Loss** (4M) Rayleigh scattering **Bending loss** (4M) Micro bending- Small bends Macro bending- Bend radii > fiber diameter Figures
2	**With diagram, Explain Intra and inter modal dispersion.(15M) (Nov/Dec 2015), (May/Jun 2014), (Nov/Dec 2013)** BTL1 **Answer:Page:103-106- notes** **Pulse broadening-explanation** (5M) **Derivation** $\sigma = (\sigma^2{}_{intermodal} + \sigma^2{}_{intramodal})^{\frac{1}{2}}$ **Information carrying capacity** Bandwidth* Distance product (MHz.Km) Step index B*L= about 20MHz.Km Graded Index B*L= > 2.5GHz.Km **Intra model dispersion** (5M) **Waveguide Dispersion**

	Definition- 80% power confined in core, 20% power in cladding- cladding power propagates faster than Core - waveguide dispersion. $$\tau_{wg} = \frac{L}{C}\left[n_2 + n_2\Delta\frac{(d(Vb))}{dv}\right]$$ **Intermodal dispersion** (5M) different values of group delay
3	**When the mean optical power Launched into an 8km length of fiber is 120λw, the mean optical power at the fiber output is 3λw. Determine (a) the overall signal attenuation or less in decibels through the fiber assuming there are no connector or splices. (b) The signal attenuation per kilometer for the fiber. (c) The overall signal attenuation for a 10km optical link using the same fiber with splices at 1 km intervals, each giving an attenuation of 1 dB. (d) The numerical input/output power ratio.(15M) (May/Jun 2016)** BTL4 **Answer:Page:84-85- notes** Overall signal attenuation =10 log $\frac{P_i}{P_o}$ = => 16db (3M) signal attenuation per km $\alpha_{dB}L = 10log\frac{P_i}{P_o}$ $==> 2dBkm\text{^} - 1$ (4M) over all signal attenuation = 29 db (4M) Numerical power ratio = $10^{\frac{dB}{10}}$= = > 794.3 (4M)

UNIT III – FIBER OPTICAL SOURCES AND COUPLING	
Direct and indirect Band gap materials-LED structures -Light source materials -Quantum efficiency and LED power, Modulation of a LED, lasers Diodes-Modes and Threshold condition -Rate equations -External Quantum efficiency -Resonant frequencies -Laser Diodes, Temperature effects, Introduction to Quantum laser, Fiber amplifiers- Power Launching and coupling, Lencing schemes, Fiber -to- Fiber joints, Fiber splicing-Signal to Noise ratio , Detector response time.	
PART * A	
Q.No.	**Questions**
1	**Write the laser diode rate equation. (Nov/Dec 2017)** BTL1 Steady state Photon density= Stimulated photon + Spontaneously Generated Photon $$P_s = \frac{\tau_{ph}}{qd}(J - J_{th}) + \tau_{ph}R_{sp}$$
2	**Give some possible Lensing schemes to improve optical source to fiber coupling Efficiency. (Nov/Dec 2017)** BTL1

- Round ended fiber
- Non imaging microscope in contact with both fiber and source
- Spherical ended Fiber
- Taper ended Fiber

3 **What are the mechanisms behind lasing action? (Nov/Dec 2016)** BTL2

If emitting area of source is smaller than the core area, a miniature lens may be placed in between the source and the fiber to improve power-coupling efficiency. This is the mechanism behind lasing action.

4 **Define external quantum efficiency. (Nov/Dec 2016)** BTL1

The external quantum efficiency is defined as the number of photons emitted per Radiative electron-hole pair recombination above threshold

5 **What is minimum detectable optical power? (Apr/May 2017)** BTL1

It is defined as the optical power necessary to produce a photocurrent of the same magnitude as the root mean square of the total current

6 **Compare the optical sources: LASER and LED (Apr/May 2017), (Nov/Dec 2013)** BTL4

LED	Laser
The output obtained is incoherent.	The output obtained is coherent.
Less expensive and less complex.	More expensive and more complex.
Long life time.	Less life time.
Their response is fast	Their response is faster than LED
Bandwidth of LED is moderate	Bandwidth of Laser diode is higher
wide range of wavelengths are available	A small range of wavelength is available

7 **What are the pumping mechanisms used in Erbium Doped Fiber Amplifier.(May/Jun 2016)** BTL1

- Co directional pumping
- Counter directional pumping
- Bidirectional pumping

8 **Why is the double hetero-structure preferred for optical fiber communication? Justify your answer. (May/Jun 2016)** BTL4

- Very large injection efficiencies, essentially only injecting the majority carriers from the wide-gap material into the small-gap material.
- If the refractive indices of the material of core are proper then light confinement will also be proper.

9 **What is meant by hetero junction structure? (Nov/Dec 2015)** BTL1

- A hetero-junction is an interface between two adjoining single crystal semiconductors with different band-gap energies. Devices are fabricated with hetero junctions are said to have hetero-structure.

- Advantages of Hetero-junction are
  - Carrier and optical confinement
  - High output power
  - High coherence and stability

10 **Define internal quantum Efficiency of LED and LASER. (Nov/Dec 2015), (Nov/Dec 2014), (May/Jun 2014)** BTL1

- The internal quantum efficiency is the fraction of the electron-hole pairs that Recombine radiatively.
- If the Radiative recombination rate is R and the nonradiative recombination ratio is Rnr, then the internal quantum efficiency is the ratio of the Radiative recombination rate to the total recombination rate.

11 **Compare and contrast of surface LED and Edge LED. (Nov/Dec 2012)** BTL4

Surface Emitting LED	Edge emitting LED
Wider spectral width (typically 125 nm)	Narrow spectral width (typically 75 nm)
Emission pattern is less directional	Emission pattern is more directional

12 **Why silicon is not used to fabricate LED or LASER diode? (Nov/Dec 2011)** BTL4

- LEDs and LASER are constructed of gallium arsenide (GaAs), gallium arsenide phosphide (GaAsP), or gallium phosphide (GaP).
- Silicon and germanium are not suitable because those junctions produce heat and no appreciable IR or visible light.

13 **What are the advantages of LED?** BTL2

The advantages of LEDs are

- They have long life
- LEDs are less complex circuits than Laser diodes
- Fabrication is easier, Less expensive
- Used for short distance communication

14 **What do you mean by direct band gap Materials?** BTL2

- In some materials a direct transition is possible from valance band to conduction band.
- In other words, Electron and Hole has the same momentum value. such type of materials is called as direct band gap materials.
- Example: GaAs, InP, InGaAs.

15 **What do you mean by in direct band gap Materials?** BTL2

- Conduction band minimum and valence band Maximum energy levels occur at different values of momentum. Hence band to band recombination must involve a third particle to conserve momentum. Such type of materials is called as indirect band gap materials.
- Example: Silicon, Germanium.

16 **What is meant by hetero-junction? List the advantages of hetero junction.** BTL1

A hetero-junction is an interface between two adjoining single crystal semiconductors with different band-gap energies. Devices are fabricated with hetero junctions are said to have hetero-structure.

Advantages of Hetero-junction are

- Carrier and optical confinement
- High output power
- High coherence and stability.

17 **What is population inversion?** BTL1

- Under thermal equilibrium, the lower energy level E1 of the two level atomic systems contains more atoms than upper energy level E2.
- To achieve optical amplification, it is must to create non-equilibrium distributions of atoms such that population of the upper energy level is greater than lower energy level i.e. N2 is > N1.This condition is known as population inversion.

18 **Distinguish between direct and external modulation of LASER diodes.** BTL4

Direct Modulation	External Modulation
Easy to demonstrate and has low cost.	Complex and expensive
Low gain	High gain

19 **What is a DFB LASER? Differentiate DFB LASER from other types of LASERs?** BTL1

- In Distributed Feedback LASER, the lasing action is obtained by periodic variations of refractive index, which are incorporated into multilayer structure along the length of the diode.
- DFB LASER does not require optical feedback unlike the other LASERs.

20 **List out the disadvantages of direct band gap materials.** BTL1

- Direct band gap materials are not used for making conventional diodes and recombination process is efficient, it produce narrow spectral width.
- As a result, recombination of electrons and holes, then carriers gets reduced.

21 **What are the advantages of double hetero structure optical sources?** BTL1

- High quantum efficiency
- High brightness(Radiance)

22 **Give an example for each direct and indirect band gap materials.** BTL2

For direct bandgap material: GaAlAs, InGaAsP; For Indirect Band gap material: Si, Ge

23 **Define – Responsivity of a photo detector.** BTL1

Responsivity is defined as the ratio of output photo current to the incident optical power.

24 **Define – Avalanche Effect.** BTL1

The newly created carriers are accelerated by the high electric field, thus gaining enough energy to cause further impact ionization. This phenomenon is called avalanche effect.

25 **Define – Impact Ionization.** BTL1

In order for carrier multiplication to take place, the photo-generated carriers must traverse a region where a very high electric field is present. In this high field region, a photo generated electron or hole can gain energy so that it ionizes bound electrons in the valence band upon colliding with them. This current multiplication mechanism is known as impact ionization.

PART * B

1 **Give an account on the direct and indirect band gap materials. (7M)** BTL2

Answer:Page:147- Keiser

	Introduction (2M) - Band Gap : represents the minimum energy difference between the top of the valence band and the bottom of the conduction band. **Figure** (3M) **Explanation** (2M) - Electron and hole - same momentum value – direct band gap - Indirect band gap – occurs at different values of momentum.
2	**With diagram, Explain surface and edge emitters LED Structures. (7M) (May/Jun 2014), (Nov/Dec 2011)** BTL1 **Answer:Page:96-99- notes** **Introduction** Features- no stabilization circuit required, requires less complex, Economic **LED Structures** (1M) 2 configuration Homo junction & Hetero junction 2 configuration for fiber optics Surface emitters – active Light emitting region – perpendicular to axis of the fiber Edge emitters – Active region- Parallel to fiber axis & 2 Guiding Region **Surface emitters** (3M) Active Light emitting region – perpendicular to axis of the fiber Figure **Edge emitters** (3M) Active region- Parallel to fiber axis & 2 Guiding Region Figure
3	**With steps, derive the internal quantum efficiency of LED. (13M) (Nov/Dec 2017), (Nov/Dec 2013)** BTL4 **Answer:Page:96-104- notes** **Introduction** (1M) Features- no stabilization circuit required, requires less complex, Economic **LED Structures** (6M) 2 configuration Homo junction & Hetero junction 2 configuration for fiber optics Surface emitters – active Light emitting region – perpendicular to axis of the fiber Edge emitters – Active region- Parallel to fiber axis - 2 Guiding Region **Internal Quantum Efficiency** (6M) Fraction of electron hole pairs that recombine radiatively $\eta_{int}=\frac{R_r}{R_r+R_{nr}}$
4	**A double Heterojunction LED emitting at a peak wavelength of 1310nm has Radiative and non-radiative recombination time of 45ns and 95ns respectively. The drive current is 35 mA. Determine internal quantum efficiency and internal power level. If the refractive index of the light source material is n=3.5, find the power emitted from the devices.(7M) (Nov/Dec 2016)** BTL4

Answer:Page:136- notes

$\eta_{int} = \frac{\tau}{\tau_r} = 0.678ns$ (3M)

$\tau = \frac{\tau_r \tau_{nr}}{\tau_r + \tau_{nr}} = 30.53ns$ (4M)

5 **Draw and explain the structure of Fabry-Perot resonator cavity for a laser diode. Derive laser diode rate equations. (13M)** BTL1,2

Answer:Page:163-167- Keiser

Introduction (1M)

- Laser diode - improved LED - uses stimulated emission in semiconductor - Fabry-Perot resonator with both optical, carrier confinements.

Characteristics (2M)

- Nanosecond - even picosecond response time (GHz BW).
- Spectral width of the order of nm or less.
- High output power (tens of mW).
- Narrow beam (good coupling to single mode fibers).

Structure & Explanation (6M)

- Three distinct radiation modes - Longitudinal, lateral, transverse modes.
- End mirrors- Provides strong optical feedback in longitudinal direction- roughening the edges, cleaving the facets, radiation- longitudinal direction rather than lateral direction.

Rate Equations (4M)

$$\frac{d\Phi}{dt} = Cn\Phi + R_{sp} - \frac{\Phi}{\tau_{ph}}$$

$$\frac{dn}{dt} = \frac{J}{qd} - \frac{n}{\tau_{sp}} - Cn\Phi$$

8 **Describe about Fibre –to- Fibre joints (7M)** BTL2

Answer:Page:215-220- notes

Introduction (1M)

Interconnects- low-loss.

Interconnects occur at,

- Optical source
- Photo detector
- Within the cable
- Intermediate point in a link

Types (4M)

- Permanent bond: SPLICE
- Easily demountable connection: CONNECTOR
- FIGURE

Three different types of misalignment can occur, (2M)

- Longitudinal Separation.
- Angular misalignment.
- Axial displacement or lateral displacement.

9 **Explain with necessary expressions, about Power Launching and coupling.** (13M) BTL2

Introduction (2M)

Coupling Efficiency

Measure of the optical power emitted from a source that can be coupled into an optical fiber

$$\eta = \frac{P_f}{P_s}$$

Flylead : short length o fiber attached to optical source

Lensing Schemes (2M)

Used to improve coupling Efficiency

Types

- Round ended fiber
- Non imaging microscope in contact with both fiber and source
- Spherical ended Fiber
- Taper ended Fiber

Figure (3M)

Non imaging Microscope (4M)

Figure

$$\eta_{max} = \begin{cases} (\frac{a}{r_s})^2 NA^2 & \frac{r_s}{a} > NA \\ 1 & \frac{r_s}{a} > NA \end{cases}$$

Laser diode to Fiber Coupling (2M)

- Edge emitting laser diodes - emission pattern – FWHM- 30– 50 in the plane perpendicular to the active area junction & 5 – 10o in the plane parallel to the junction.
- Coupling efficiencies- between 50 and 80%.

PART-C

1 **Draw and compare LED and LASER diode Structures.(15M) (Nov/Dec 2015), (Nov/Dec 2014), (Nov/Dec 2011)** BTL1,2

Answer:Page:96-101 &107-111- notes

LED (7M)

Introduction (1M)

Features- no stabilization circuit required, requires less complex, Economic

LED Structures (3M)

2 configuration

Homo junction & Hetero junction

2 configuration for fiber optics

Surface emitters – active Light emitting region – perpendicular to axis of the fiber

Edge emitters – Active region- Parallel to fiber axis & 2 Guiding Region

Figures (3M)

LASER(8M)

Introduction (1M)

Basic principle- Absorption, Spontaneous Emission, Stimulated Emission

Febry Perot resonator cavity (3M)

Latitude, Longitudinal, Transverse

Figure

Distributed Feedback LASER (4M)

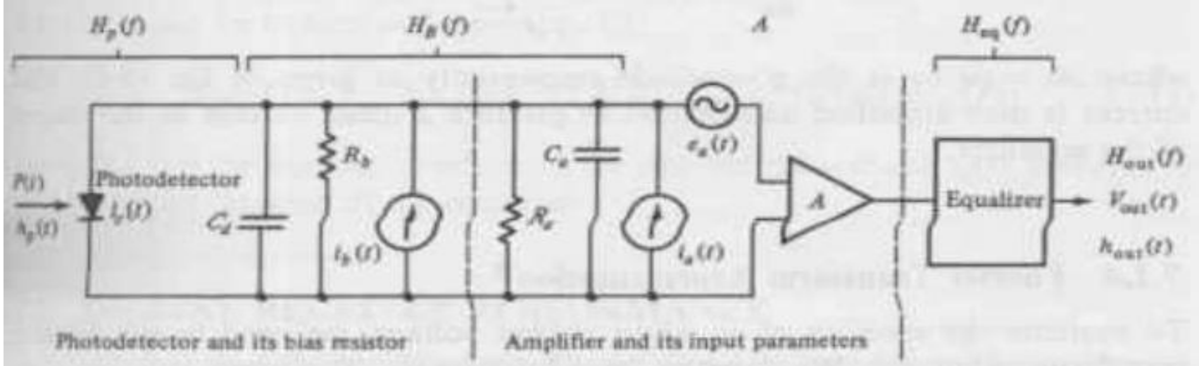
	Optical Feedback not required ,Feedback grating Figure
2	**With neat sketch explain about Lencing schemes. (15M)** BTL2 **Answer:Page:212-215- notes** **Types** (3M) • Rounded end fiber. • Nonimaging Microsphere (small glass sphere in contact with both the fiber and source). • Imaging sphere (a larger spherical lens used to image the source on the core area of the fiber end). • Cylindrical lens (generally formed from a short section of fiber). • Spherical surfaced LED, spherical ended fiber. • Taper ended fiber. **Figure** (4M) **Problem in using lens:** (2M) • Lens size – small, fabrication, handling difficulties. • Taper end fiber - Greater precision **Non imaging Microscope** (3M) • Assumptions: refractive indices shown in the fig., emitting area - circular. • Figure **Laser diode to fiber Coupling** (3M) • Edge emitting laser diodes - emission pattern – FWHM- 30 – 50o in the plane perpendicular to the active area junction & 5 – 10o in the plane parallel to the junction. • Coupling efficiencies- between 50 and 80%.
3	**What is Fiber Splicing? Discuss About Fusion Splicing and Mechanic Splicing. (15M) (Nov/Dec 2016)** BTL1,2 **Answer:Page:127-129- notes** **Need of splicing** (3M) Permanent joint- used to create long optical link. Points to be consider: mechanical strength, geometrical difference in fiber, Fiber misalignment at joint. **Types of Splicing** (3M) Fusion splice – permanent splice, thermal bond to fiber ends, less loss. V-groove mechanical splice- v-shaped channel, loss depends on fiber size & eccentricity. Elastic tube splice – lateral, longitudinal & Angular alignment done automatically. **Figures** (6M) **Splicing Single Mode Fiber** (3M)

UNIT IV – FIBER OPTIC RECEIVER AND MEASUREMENTS

Fundamental receiver operation, Pre amplifiers, Error sources – Receiver Configuration– Probability of Error – Quantum limit .Fiber Attenuation measurements- Dispersion measurements – Fiber Refractive index profile measurements – Fiber cut- off Wave length Measurements – Fiber Numerical Aperture

Measurements – Fiber diameter measurements.

PART * A

Q.No.	Questions
1	**Draw the generic structure of trans impedance amplifier.(Nov/Dec 2017)** BTL1 
2	**Define Receiver Sensitivity. (Nov/Dec 2017)** BTL2 Receiver sensitivity is the minimum magnitude of input signal required to produce a specified output signal having a specified signal-to-noise ratio, or other specified criteria.
3	**What are the methods employed for measuring attenuation in optical fiber? (Apr/May 2017)** BTL1 • Cut back method. • Insertion loss Method. • OTDR based Attenuation Measurement.
4	**Define BER. (Nov/Dec 2016)** BTL1 To divide the number of errors (N_e) occurring over a certain interval t by the number of pulses (N_t) transmitted during this interval. This is called either bit rate or bit error rate. BER=$\frac{N_e}{N_t}$= $\frac{N_e}{B_t}$
5	**What is cut back method? (Nov/Dec 2016)** BTL1 • Taking a set of optical output power measurements over the required Spectrum using a long length of fiber usually at least a kilometer is known as cut back technique. • The fiber is then cut back to a point 2 m from the input end and maintaining the same launch conditions, another set of power output measurements are taken.
6	**Mention a Fiber diameter Measurement Technique. (Nov/Dec 2015)** BTL1 • Shadow method
7	**State the significance of maintaining the fiber outer diameter constant.(Nov/Dec 2014)** BTL1 • Speed is large • More accuracy • Faster Diameter measurement
8	**What are the receiver error sources?** **or** **Mention error sources in fiber optic receiver. (May/Jun 2014), (Nov/Dec 2012), (Nov/Dec 2011)** BTL1

	The error sources of receiver are, - Thermal noise. - Dark current noise. - Quantum noise.
9	**List out different methods for measuring refractive index profile.** BTL1 The different methods for measuring refractive index profile are, - Interferometric method. - Near field scanning method. - End field scanning method.
10	**Define Quantum Limit.** BTL1 Quantum Limit is defined as the minimum received optical power required for a specific bit error rate performance in a digital system.
11	**A digital fiber optic link operating at 1310 nm, requires a maximum BER of 10-8. Calculate the required average photons per pulse. (N / D 2013)** BTL4 The probability error Pr(o) = e^-N = 10-8 Solving for N = 8 log 10 = 18.42 An average of 18 photons per pulse is required for this BER.
12	**How does dark current arise?** BTL4 - When there is no optical power incident on the photo detector a small reverse leakage current flows from the device terminals known as dark current. - Dark current contributes to the total system noise and gives random fluctuations about the average particle flow of the photocurrent.
13	**Define Modal Noise and Mode Partition Noise.** BTL1 - Disturbances along the fiber such as vibrations, discontinuities, connectors, splices and source / detector coupling may cause fluctuations in the speckle patterns. It is known as modal noise. - Phenomenon which occurs in multimode semiconductor LASERs when the modes are not well stabilized is known as mode partition noise.
14	**What is meant by (1/f) noise corner frequency?** BTL1 - The (1 / f) noise corner frequency is defined as the frequency at which (1/f) noise, which dominates the FET noise at low frequencies and has (1/f) power spectrum.
15	**List out different methods for measuring refractive index profile.** BTL1 The different methods for measuring refractive index profile are, - Interferometric method. - Near field scanning method. - End field scanning method.
16	**What are the standard fiber measurement techniques?** BTL2 The standard fiber measurement techniques are, - Fiber attenuation measurement & Fiber dispersion measurement. - Fiber refractive index profile measurement. - Fiber cutoff wavelength measurement & Fiber numerical aperture measurement. - Fiber diameter measurement.
17	**What are the methods used to measure fiber dispersion?** BTL1

	The methods used to measure fiber dispersion are, • Time domain measurement. • Frequency domain measurement.
18	**What are the methods used to measure fiber refractive index profile?** BTL1 The methods used to measure fiber refractive index profile are, • Interferometric method. • Near infra scanning method. • Refracted near field method.
19	**What are the noise effects on system performance?** BTL1 The main penalties are • Modal noise. • Wavelength chirp. • Spectral broadening. • Mode-partition noise.
20	**What are the system requirements?** BTL1 The key system requirements are as follows • The desired or possible transmission distance. • The data rate or channel bandwidth. • Bit error rate (BER).
21	**Define – Extinction Ratio.** BTL1 The extinction ratio ε is defined as the ratio of the optical energy emitted in the 0 bit period to that emitted during 1 bit period.
22	**Define – Modal Noise.** BTL1 • It arises when the light from a coherent LASER is coupled into a multimode Fiber operating at 400Mbps and higher. • It mainly occurs due to mechanical vibrations and fluctuations in the frequency of the optical source.
23	**What are the measures to avoid modal noise?** BTL4 The measures to avoid modal noise are, • Use LEDs • Use LASER having more longitudinal modes • Use a fiber with large numerical aperture • Use a single mode fiber
24	**What is reflection noise?** BTL1 • It is the optical power that gets reflected at the refractive index discontinuities such as splices, couplers and filters or connectors. • The reflected signals can degrade both the transmitter and receiver performance.
25	**What do you mean by thermal noise?** BTL2 • Thermal noise is due to the random motion of electrons in a conductor. • Thermal noise arises from the detector load resistor and from the amplifier electronics.

PART * B	
1	**Discuss the fundamental receiver operation with neat block diagram.(13M)** BTL1 **Answer:Page:144-146- notes** **Block Diagram** (3M) **Explanation** (3M) Digital Signal Transmission $i(t) = \begin{pmatrix} T_b & \text{for binary 1} \\ 0 & \text{for binary 0} \end{pmatrix}$ Transmitter—conversion of Electrical signal i(t) into optical output power P(t) Receiver –PIN or Avalanche Photodiode Amplifier, Filter, Decision circuit **Diagrammatic Representation of Each step** (7M)
2	**What are the performance measures of a digital receiver? Derive an expression for bit error rate of a digital receiver. (13M) (Nov/Dec 2016)** BTL1 **Answer:Page:152-155- notes** **Introduction** (4M) $V_{out}(t) > threshold = binary\ 1$ $V_{out}(t) < threshold = binary\ 0$ **Probability of Error** (6M) $BER = \frac{N_e}{N_t} = \frac{N_e}{Bt}$ $BER = \frac{1}{2} erfc\left(\frac{Q}{\sqrt{2}}\right)$ $BER = P_e(Q) = \frac{1}{2}[1 - erfc(\frac{v}{2\sqrt{2\sigma}})]$ **Quantum Limit** (3M) Minimum received power level $P_r(0) = e^{-\bar{N}}$
3	**Discuss about optical detection noise. /Explain the error sources of fundamental receiver operations. (7M) (Nov/Dec 2015)** BTL2 **Answer:Page:146-148- notes** **Introduction** (2M) Noise- unwanted Components of electrical signal Noise source Model- figure **Types of Noise** (5M) Internal Noise- Shot Noise, Thermal noise External Noise Inter symbol Interference
4	**Explain any 2 types of preamplifiers used in a receiver. (13M) (Nov/Dec 2013)** BTL4 **Answer:Page:305-311- Keiser** **Preamplifier need** (2M) To provide low noise level, high BW, high gain, high dynamic range.

	Circuit, Explanation and waveform of any 2 of the following (11M) • High-impedance FET • High Impedance Bipolar • Trans impedance • High speed circuits
5	**Explain the dispersion measurements methods in optical fiber. (13M) (Nov/Dec 2017), (Nov/Dec 2014), (May/Jun 2014)** BTL1,2 **Answer:Page:164-168- notes** **Classification** (1M) Intermodal dispersion Chromatic dispersion Polarization –Mode dispersion **Time domain intermodal dispersion measurement** (6M) Narrow pulse optical energy insertion in one end- measuring broadening at another end Figure Optical 3 db Bandwidth & Electrical 3 db bandwidth Relation between Optical & Electrical Bandwidth - $\frac{1}{\sqrt{2}}$ **Frequency domain intermodal dispersion measurement** (6M) Figure H(f)=$\frac{p_{out}(f)}{p_{in}(f)}$
6	**Explain how attenuation measurements could be done. (7M) (Nov/Dec 2015)** BTL1,2 **Answer:Page:161-168- notes** **Attenuation** Result of absorption, scattering and waveguide effect (1M) Types **Cut back method** (3M) Experimental setup figure α=$\frac{10}{L} log \frac{P_N}{P_F}$ **Insertion loss method** (3M) $A = 10log\frac{P_1(\lambda)}{P_2(\lambda)}$
7	**Write Short Notes on Fiber cut off wavelength Measurement. (7M)(Nov/Dec 2012), (Nov/Dec 2011)** BTL1 **Answer:Page:169-171- Notes** **Definition** (2M) Effective cut off wavelength is a wavelength greater than the ratio between total power to the launched higher order modes and fundamental modes. **Experimental setup diagram** (3M) **Waveforms** (2M)
8	**Explain the measurement techniques used in the case of Fiber diameter. (13M) (Nov/Dec 2011)** BTL1

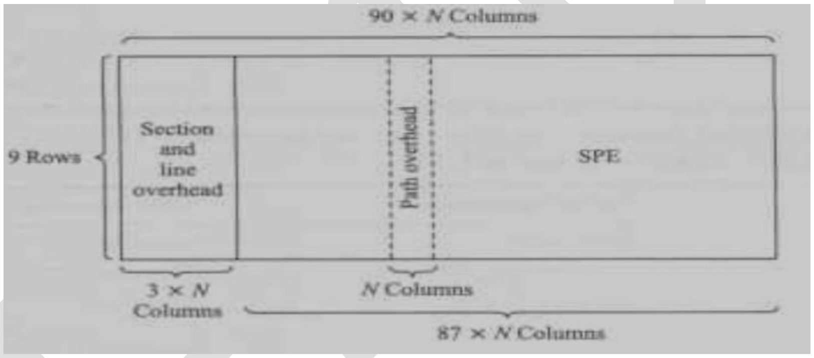
	Answer:Page:173-174- Notes **Outer diameter** (8M) Shadow Method- uses fiber image projection & Experimental setup- figure **Advantages** (2M) High speed, High accuracy **Core diameter** (3M) Step change in refractive index profile at the core-cladding interface.
PART*C	
1	**Discuss on the Numerical Aperture measurements of optical fiber. (15M) (Nov/Dec 2017), (Nov/Dec 2014), (May/Jun 2014), (Nov/Dec 2011)** BTL2 **Answer:Page:171-173- Notes** **Introduction** (1M) NA- Light gathering capacity- $NA = \sin\theta_a = \sqrt{{n_1}^2 - {n_2}^2}$ **Measurement Technique** (14M) Far field angle from fiber using a scanning photo detector and a rotating stage Far field pattern by trigonometric fiber $NA = \frac{A}{(A^2+4D^2)^{\frac{1}{2}}}$
2	**Explain any 2 methods used for measurement of refractive index profile of the fiber. (15M) (May/Jun 2016), (Nov/Dec 2012), (Nov/Dec 2011)** BTL2 **Answer:Page:175-179- Notes** **Introduction** (2M) To determine NA and Number of modes propagating within the fiber **Types** **Interferometric method** (7M) Transmitted light Interferometric, reflected light Interferometric $\delta_n = \frac{q\lambda}{x}$ Figure **Refracted Near- field method /Near- Field scanning method** (6M) Figure & Advantages – No leaky mode correction factor, no external calibration.
3	**Define the terms- 'Quantum limit' and 'Probability of Error' with respect to a receiver with typical values. (15M)(Nov/Dec 2013)** BTL1,4 **Answer:Page:152-155- Notes** **Introduction** (3M) $V_{out}(t) > threshold = binary\ 1$ $V_{out}(t) < threshold = binary\ 0$ **Probability of Error** (8M) $BER = \frac{N_e}{N_t} = \frac{N_e}{Bt}$ $BER = \frac{1}{2} erfc\left(\frac{Q}{\sqrt{2}}\right)$ $BER = P_e(Q) = \frac{1}{2}[1 - erfc(\frac{v}{2\sqrt{2\sigma}})]$

	Quantum Limit (4M) Minimum received power level $P_r(0) = e^{-\bar{N}}$

UNIT V – OPTICAL NETWORKS AND SYSTEM TRANSMISSION

Basic Networks – SONET / SDH – Broadcast – and –select WDM Networks –Wavelength Routed Networks – Non linear effects on Network performance –-Link Power budget -Rise time budget Noise Effects on System Performance-Operational Principles of WDM Performance of WDM + EDFA System – Solutions – Optical CDMA – Ultra High Capacity Networks.

PART * A

Q.No.	Questions
1	**Draw the basic structure of STS-1 SONET frame. (Nov/Dec 2017)** BTL1 
2	**Mention any 2 nonlinear effects present in optical fiber. (Nov/Dec 2017)** BTL1 • Four wave mixing • Wavelength division multiplexing • Cross phase modulation
3	**Name two popular architectures of SONET/SDH Network. (Nov/Dec 2016)** BTL1 • Two fiber, unidirectional, Path switched ring (two fiber UPSR). • Two fiber or four fiber, Bidirectional, Line switched ring (two or four fiber BLSR).
4	**Distinguish SONET and SDH. (Nov/Dec 2015)** BTL2 **SONET** • Synchronous Optical Network used in North America • ANSI TI.105.06 Standard • Bit rate signal: STS-N, Optical carrier: OC-N **SDH** • Synchronous Digital Hierarchy • ITU-T G.957 standard • Bit Rate Signal: STM-M

5	**Obtain the transmission bit rate of the basic SONET frame in Mbps. (Nov/Dec 2013)** BTL4 The transmission bit rate of the basic SONET frame is, STS-1= (90bytes/row)(9rows/frame)(8bits/byte)(125microseconds/frame) =51.84Mb/s.
6	**How inter channel cross talk occurs in a WDM system? (Nov/Dec 2013)** BTL2 • It arises when an interfering signal comes from a neighboring channel that operates at different wavelength. • Power penalty of inter channel crosstalk is, $penalty_{inter} = -5 \log (1-\in)$
7	**Enumerate Various SONET/SDH Layers. (Nov/Dec 2011)** BTL1 SONET defines 4 layers namely, • photonic layer • Section layer • Line layer • Path layer
8	**What are the common topologies used for fiber optical network? (Nov/Dec 2011)** BTL1 The three topologies used for fiber optical network are, • Bus topology • Ring topology and Star topology
9	**Calculate the number of independent signals that can be sent on a single fiber in the 1525-1565 nm bands. Take the spectral spacing as per ITU-T recommendation G.692. (Nov/Dec 2011)** BTL3 Given: Mean frequency spacing as per ITU- T is 0.8nm. Wavelength = 1565nm – 1525nm = 40 nm. Number of independent channel = (40nm / 0.8nm) = 50 channels
10	**Define – WDM.** BTL1 • In fiber-optic communications, wavelength –division multiplexing(WDM) is a technology which multiplexes a number of optical carrier signals into a single optical fiber by using different wavelengths (i.e. colors) of LASER light. • This technique enables bidirectional communications over one strand of fiber, as well as multiplications of capacity.
11	**What are the drawbacks of broadcast and select networks for wide area network applications?** BTL2 • Without the use of optical booster amplifiers, splitting losses occurs. • More wavelengths are needed as the number of nodes in the network Grows
12	**The specifications of the light sources are converted to equivalent rise time in rise time budget. Why?** BTL3 • A rise time budget is a convenient method to determine the dispersion, Limitation of an optical link. • For this purpose, the specifications of the light sources (both the fiber and the photo detector) are converted to equivalent rise time. • The overall system rise time is given in terms of the light source rise time, fiber dispersion time and the photo detector rise time.
13	**What are the types of broadcast and select network?** BTL1

	The types of broadcast and select network are - Single – hop networks Multi – hop networks
14	**What is meant by power penalty?** BTL1 When nonlinear effects contribute to signal impairment, an additional amount of power will be needed at the receiver to maintain the same BER. This additional power (dB) is known as the power penalty.
15	**What is meant by cross- phase modulation (XPM)?** BTL1 Cross- phase modulation, which converts power fluctuations in particular wavelength channel to phase fluctuations in the co propagating channels
16	**What is reflection noise?** BTL1 - It is the optical power that gets reflected at the refractive index discontinuities such as splices, couplers and filters or connectors. - The reflected signals can degrade both the transmitter and receiver performance.
17	**What are the effects of reflection noise in high speed systems?** BTL1 They cause optical feedback which leads to optical instabilities that may lead to inter-symbol interference and intensity noise.
18	**What is chirping?** BTL1 - The D.C. modulation of a single longitudinal mode semiconductor LASER can cause a dynamic shift of the peak wavelength emitter from the device. - This phenomenon, which results in dynamic line width broadening under the direct modulation of the injection current, is referred to us frequency chirping.
19	**What are the basic performances of the WDM?** BTL1 The basic performances of WDM are, - Insertion loss - Channel width - Cross talk
20	**What are the two different types of WDM?** BTL1 The two different types of WDM are - Unidirectional WDM - Bidirectional WDM
21	**What is the best way to minimize chirping?** BTL4 It is to choose the LASER emission wavelength close to the zero-dispersion of the wavelength of the fiber.
22	**What are the components of system rise time?** BTL2 The four basic components that contribute to the system rise time are - Modal dispersion time of the link - Material dispersion time of the fiber - Transmitter (source) rise time - Receiver rise time.
23	**Give the range of system margin in link power budget.** BTL1 The system margin is usually (6 -8)db. A positive system margin ensures proper operation of the circuit. A negative value indicates that insufficient power will reach the detector to achieve the bit error

	rate, BER.
	PART * B
1	**Draw the generic configuration of SONET and Explain the functions of add drop multiplexer in SONET. (13M) (Nov/Dec 2016)** BTL1 (i) **Answer:Page:197-199- Notes** **Introduction to SONET/SDH** (6M) • Synchronous optical Network/synchronous digital Hierarchy • ANSI TI 105.06 standard/ ITU-T G.957 standard • STS-N&OC-N/STM-M • Structure of SONET (ii) **Answer:Page:204- Notes** **Introduction to add or drop MUX** (2M) • Different Links- point to point link, Linear chain, UPSR, BLSR, Interconnected rings **Add/Drop Multiplexer** (5M) • OC-12 Path and OC-3path Figure.
2	**Explain the layered architecture and transmission formats of SONET. (7M) (May/Jun 2016)** BTL2 **Answer:Page:197-199- Notes** • Synchronous optical Network/synchronous digital Hierarchy (1M) • ANSI TI 105.06 standard/ ITU-T G.957 standard (1M) • Structure of SONET (2M) • STS-N&OC-N/STM-M (3M)
3	**Explain with neat sketch of 2 popular architecture of SONET. (13M) (May/Jun 2016)** BTL2 **Answer:Page:197-199- Notes** **Ring Architecture** (1M) **Classification** (2M) Path switching (4M) 2 fiber, Unidirectional path switched ring Figure (Primary path, Secondary Path) Line switching (6M) 2 fiber/ 4 fiber bidirectional line switched ring Figure (Primary path, Secondary Path) Figure- Protection Switching
4	**Explain SONET Layers and frame structure with diagram. (7M) (Nov/Dec 2015), (May/Jun 2014)** BTL2 **Answer:Page:197-199- Notes** • Synchronous optical Network/synchronous digital Hierarchy (1M) • ANSI TI 105.06 standard/ ITU-T G.957 standard (1M) • Structure of SONET (2M) • STS-N&OC-N/STM-M (3M)
5	**Discuss the following:**

	(i) WDM Networks (7M) **(ii) Ultra High Capacity Networks (6M) (Nov/Dec 2014)** BTL2 (i) **Answer:Page:215-218- Notes** Link Bandwidth- $B = \sum_{i=1}^{N} B_i$ (2M) Optical power requirements for specific BER- (BER=14dB& SNR=18-20db)- (2M) Cross talk – Inter channel, Intra channel (3M) (ii)**Answer:Page:221-224- Notes** **Ultrahigh capacity WDM** (2M) 1530-1560nm to 1530-1610nm **Bit interleaved TDM** (2M) Figure Small channels operating at peak rate (media rate) **Time slotted TDM** (2M) 100Gb/s Speed High speed Networks Large data blocks, Shorter user access time, low delay
8	**What is "four- fiber BLSR" ring I in a SONET? Explain the reconfiguration of the same during node or fiber failure. (13M) (Nov/Dec 2013)** BTL2 **Answer:Page:201-203- Notes** **Ring Architecture** (1M) **Classification** (5M) Path switching 2 fiber, Unidirectional path switched ring Line switching 2 fiber/ 4 fiber bidirectional line switched ring Figure (Primary path, Secondary Path) Figure- Protection Switching 4 fiber bidirectional line switched ring (4M) Figure (Primary path, Secondary Path) **Figure- Protection Switching** (3M)
9	**Explain nonlinear effects on network performance. (13M) (Nov/Dec 2011)** BTL2 **Answer:Page:422 -501- Keiser** **Classification** Effective Length & Area (3M) Stimulated Ramann Scattering (3M) Stimulated Brillouin Scattering (3M) Four wave mixing (4M)
PART*C	
1	**Explain SONET/SDH. Draw the generic configuration of SONET and explain the functions of add drop multiplexer in SONET. (15M)** BTL1 **Answer:Page:197 -199- Notes** **Introduction to SONET/SDH** (7M)

	• Synchronous optical Network/synchronous digital Hierarchy • ANSI TI 105.06 standard/ ITU-T G.957 standard • STS-N&OC-N/STM-M **Structure of SONET** (2M) (ii)**Answer:Page:204- Notes** **Introduction to add or drop MUX** (2M) Different Links- point to point link, Linear chain, UPSR, BLSR, Interconnected rings **Add/Drop Multiplexer** (4M) OC-12 Path and OC-3path Figure.
2	**Explain in detail different types of Broadcast and select WDM networks (or) Discuss the concepts of Media Access Control Protocol in Broadcast and Select Networks. (or) What is 'Broadcast and select multi hop network'? Explain. (15M) (May/Jun 2016), (Nov/Dec 2012)** BTL2 **Answer:Page:206 -210- Notes** **Introduction** (2M) Single hop: No electrical conversion Multi hop: electro-Opto conversion **Classification** Broadcast & select single hop Networks (5M) Broadcast & select single hop Networks (5M) Shuffle Net Multihop Networks (3M)

Multiple Choice Questions (MCQ)

UNIT-1 INTRODUCTION TO OPTICAL FIBER

1	**Multimode step index fiber has** a) Large core diameter & large numerical aperture b) Large core diameter and small numerical aperture c) Small core diameter and large numerical aperture d) Small core diameter & small numerical aperture **Answer: a**
2	**Optical fibers for communication use are mostly fabricated from** a) Plastic b) Silica or multicomponent glass c) Ceramics d) Copper **Answer: b**
3	**A multimode step index fiber has a large core diameter of range** a) 100 to 300 μm b) 100 to 300 nm c) 200 to 500 μm d) 200 to 500 nm **Answer: a**
4	**Multimode graded index fibers with wavelength of 0.85μm have numerical aperture of 0.29 have core/cladding diameter of** a) 62.5 μm/125 μm b) 100μm/140 μm c) 85 μm/ 125 μm d) 50 μm/ 125μm **Answer: b**

5	**Fiber mostly suited in single-wavelength transmission in O-band is** a) Low-water-peak non dispersion-shifted fibers b) Standard single mode fibers c) Low minimized fibers d) Non-zero-dispersion-shifted fibers **Answer: b**
6	**Light incident on fibers of angles________the acceptance angle do not propagate into the fiber** a) Less than b) Greater than c) Equal to d) Less than and equal to **Answer: b**
7	**What is the numerical aperture of the fiber if the angle of acceptance is 16 degree** a) 0.50 b) 0.36 c) 0.20 d) 0.27 **Answer: d**
8	**When a ray of light enters one medium from another medium, which quality will not change** a) Direction b) Frequency c) Speed d) Wavelength **Answer: b**
9	**In an optical fiber, the concept of Numerical aperture is applicable in describing the ability of ___________** **a.** Light Collection **b.** Light Scattering **c.** Light Dispersion **d.** Light Polarization **Answer: a**
10	**Which among the following is/are determined by the fiber characterization?** **a.** Fiber integrity & performance for desired transmission rate **b.** Installation practices **c.** Service Implementation **d.** All of the above **Answer: d**
11	**In the structure of fiber, the light is guided through the core due to total internal ______** **a.** reflection **b.** refraction **c.** diffraction **d.** dispersion **Answer: a**
12	**In the structure of a fiber, which component provides additional strength and prevents the fiber from any damage?** **a.** Core

	b. Cladding **c.** Buffer Coating **d.** None of the above **Answer: c**
13	**Which rays exhibit the variation in the light acceptability ability of the fiber?** **a.** Meridional **b.** Skew **c.** Leaky **d.** All of the above **Answer: b**
14	**The difference between the mode's refractive indices is called as** a) Polarization b) Cutoff c) Fiber birefringence d) Fiber splicing **Answer: c**
15	**Plastic fibers are less widely used than glass fibers. State whether the statement is true or false.** a) True b) False **Answer: a**
	UNIT-2 SIGNAL DEGRADATION OPTICAL FIBERS
1	**Which kind of dispersion phenomenon gives rise to pulse spreading in single mode fibers?** **a.** Intramodal **b.** Intermodal **c.** Material **d.** Group Velocity **Answer: a**
2	**A typically structured glass multimode step index fiber shows as variation of attenuation in range of** a) 1.2 to 90 dB km^{-1}at wavelength 0.69μm b) 3.2 to 30 dB km^{-1}at wavelength 0.59μm c) 2.6 to 50 dB km^{-1}at wavelength 0.85μm d) 1.6 to 60 dB km^{-1}at wavelength 0.90μm **Answer: c**
3	**A fiber which is referred as non-dispersive shifted fiber is** a) Coaxial cables b) Standard single mode fibers c) Standard multimode fibers d) Non zero dispersion shifted fibers **Answer: b**
4	**During the design of FOC system, which among the following reasons is/are responsible for an extrinsic absorption?** **a.** Atomic defects in the composition of glass **b.** Impurity atoms in glass material **c.** Basic constituent atoms of fiber material **d.** All of the above

	Answer: b
5	**Rayleigh scattering is the type of** a) Linear scattering losses b) Non-linear scattering losses c) Fiber bends losses d) Splicing losses **Answer: a**
6	**Absorption losses due to atomic defects mainly include-** a) Radiation b) Missing molecules, oxygen defects in glass c) Impurities in fiber material d) Interaction with other components of core **Answer: b**
7	**Optical fibers suffer radiation losses at bends or curves on their paths. State true or false** a) True b) False **Answer: a**
8	**How the potential macro bending losses can be reduced in case of multimode fiber?** a) By designing fibers with large relative refractive index differences b) By maintaining direction of propagation c) By reducing the bend a) By operating at larger wavelengths **Answer: a**
9	**What is dispersion in optical fiber communication?** a) Compression of light pulses b) Broadening of transmitted light pulses along the channel c) Overlapping of light pulses on compression d) Absorption of light pulses **Answer: a**
10	**Chromatic dispersion is also called as intermodal dispersion. State whether the given statement true or false.** a) True b) False **Answer: b**
11	**In waveguide dispersion, refractive index is independent of** a) Bit rate b) Index difference c) Velocity of medium d) Wavelength **Answer: d**
12	**Polarization modal noise can _________ the performance of communication system.** a) Degrade b) Improve c) Reduce d) Attenuate **Answer: a**
13	**Dispersion-shifted single mode fibers are created by**

	a) Increasing fiber core diameter and decreasing fractional index difference b) Decreasing fiber core diameter and decreasing fractional index difference c) Decreasing fiber core diameter and increasing fractional index difference d) Increasing fiber core diameter and increasing fractional index difference **Answer: a**
14	**The variant of non-zero-dispersion-shifted fiber is called as** a) Dispersion flattened fiber b) Zero-dispersion fiber c) Positive-dispersion fiber d) Negative-dispersion fiber **Answer: d**
	UNIT 3 FIBER OPTICAL SOURCES AND COUPLING
1	**In spontaneous emission, the light source in an excited state undergoes the transition to a state with _______** **a.** Higher energy **b.** Moderate energy **c.** Lower energy **d.** All of the above **Answer: C**
2	**Rayleigh scattering is the types of** a) Linear scattering losses b) Non-linear scattering losses c) Fiber bends losses d) Splicing losses **Answer: a**
3	**A device which converts electrical energy in the form of a current into optical energy is called as** a) Optical source b) Optical coupler c) Optical isolator d) Circulator **Answer: a**
4	**Which process gives the laser its special properties as an optical source?** a) Dispersion b) Stimulated absorption c) Spontaneous emission d) Stimulated emission **Answer: d**
5	**__________________ in the laser occurs when photon colliding with an excited atom causes the stimulated emission of a second photon.** a) Light amplification b) Attenuation c) Dispersion d) Population inversion **Answer: a**
6	**In surface emitter LEDs, more advantage can be obtained by using**

	a) BH structures b) QC structures c) DH structures d) Gain-guided structure **Answer: c**
7	**In a multimode fiber, much of light coupled in the fiber from an LED is** a) Increased b) Reduced c) Lost d) Unaffected **Answer: c**
8	**The internal quantum efficiency of LEDs decreasing _______________ with ________________ temperature.** a) Exponentially, decreasing b) Exponentially, increasing c) Linearly, increasing d) Linearly, decreasing **Answer: b**
9	**The optical bandwidth is _____________ the electrical bandwidth.** a) Smaller b) Greater c) Same as d) Zero with respect to **Answer: b**
10	**Quantum efficiency is a function of photon wavelength. Determine the given statement is true or false.** a) True b) False **Answer: b**
11	**The more advantages optical amplifier is** a) Fiber amplifier b) Semiconductor amplifier c) Repeaters d) Mode hooping amplifier **Answer: b**
	UNIT 4 FIBER OPTIC RECEIVER AND MEASUREMENT
1	**_____________ refers to any spurious or undesired disturbances that mask the received signal in a communication system.** a) Attenuation b) Noise c) Dispersion d) Bandwidth **Answer: b**
2	**Which are the two main sources of noise in photodiodes without internal gain?** a) Gaussian noise and dark current noise b) Internal noise and external noise c) Dark current noise & Quantum noise d) Gaussian noise and Quantum noise **Answer: c**
3	**A technique used for determining the total fiber attenuation per unit length is ________ method.** a) Frank

	b) Cut-off c) cut-back d) Erlangen **Answer: c**
4	**What type of a light source is usually present in the cut-back method?** a) Tungsten or xenon b) LED c) Laser d) Photo-sensor **Answer: a**
5	**The device used to remove any scattered optical power from the core is __________** a) Mode setup terminator b) Nodal spectrum c) Mode stripper d) Attenuator **Answer: c**
6	**________________ Measurement checks the impurity level in the manufacturing process.** a) Material reflectometry b) Material absorption loss c) Material attenuation loss d) Calorimetric loss **Answer: c**
7	**___________ Measurement give an indication of the distortion to the optical signals as they propagate down optical fibers.** a) Attenuation b) Dispersion c) Encapsulation d) Frequency **Answer: b**
8	**The detailed knowledge of the refractive index profile predicts the __________ of the fiber.** a) Nodal response b) Variation in frequency c) Impulse response d) Amplitude **Answer: c**
9	**_______________ have been widely used to determine the refractive index profiles of optical fibers.** a) Interference microscopes b) Gyro meters c) Mode-diameter device d) Tunable microscopes **Answer: a**
10	**The ________ method gives an accurate measurement of the refractive index profile.** a) Slab b) Biometric c) GSLB

	d) Tuning **Answer: a**
11	**A multimode fiber has many cutoff wavelengths. State whether the given statement is true or false**. a) False b) True **Answer: b**
12	**The _______ method is the most commonly used method for the determination of the fiber refractive index profile.** a) Refracted near-field method b) Bending-reference c) Power step method d) Alternative test method **Answer: a**
13	**The ____________ affects the light gathering capacity and the normalized frequency of the fiber.** a) Numerical aperture b) Amplitude modulation c) Responsivity d) Quantum efficiency **Answer: a**
14	**The shadow velocity is given by 0.4 μm μs^{-1} and shadow pulse of width 300 μs is registered at an instant by the photodetector. Determine the outer diameter of the optical fiber in μm.** a) 100 μm b) 120 μm c) 140 μm d) 90 μm **Answer: b**
15	**The numerical aperture for a step index fiber is sine angle of the ____________** a) Efficient angle b) Aperture c) Acceptance angle d) Attenuation **Answer: c**
UNIT-5 OPTICAL NETWORKS AND SYSTEM TRANSMISSION	
1	**Which type of scattering occurs due to interaction of light in a medium with time dependent optical density variations thereby resulting into the change of energy (frequency) & path?** **a.** Stimulated Brilliouin Scattering (SBS) **b.** Stimulated Raman Scattering (SRS) **c.** Mie Scattering **d.** Rayleigh Scattering

	Answer: b
2	**Each stage of information transfer is required to follow the fundamentals of ____________** a) Optical interconnection b) Optical hibernation c) Optical networking d) Optical regeneration **Answer: c**
3	**The ring and star topologies are combined in a ________ configuration.** a) Mesh b) Fringe c) Data d) Singular **Answer: a**
4	**Electrical devices in optical network are basically used for _____________** a) Signal degradation b) Node transfer c) Signal control d) Amplification **Answer: c**
5	**The standardization towards a synchronous optical network termed SONET commenced in US in_______** a) 1985 b) 1887 c) 2001 d) 1986 **Answer: a**
6	**The ___________ sits at the top of hierarchy of the OSI layer model.** a) Session layer b) Transport layer c) Application layer d) Data link layer **Answer: c**
7	**Which of the following is used to provide wavelength signal service among the nodes?** a) Regularization b) Hopping c) Optical enhancing d) Pulse breakdown **Answer: b**
8	**The routing and wavelength assignment problem addresses the core issue of _____________** a) Traffic patterns in a network b) Wavelength adjustment c) Wavelength continuity constraint

	d) Design problem **Answer: c**
9	**SONET stands for** a) synchronous optical network b) synchronous operational network c) stream optical network d) shell operational network **Answer: a**
10	**In SONET, STS-1 level of electrical signalling has the data rate of** a) 51.84 Mbps b) 155.52 Mbps c) 466.56 Mbps d) none of the mentioned **Answer: a**
11	**The photonic layer of the SONET is similar to the __________ of OSI model.** a) network layer b) data link layer c) physical layer d) none of the mentioned **Answer: c**
12	**In SONET, each synchronous transfer signal STS-n is composed of** a) 2000 frames b) 4000 frames c) 8000 frames d) 16000 frames **Answer: c**
13	**Which one of the following is not true about SONET?** a) frames of lower rate can be synchronously time-division multiplexed into a higher-rate frame b) multiplexing is synchronous TDM c) all clocks in the network are locked to a master clock d) none of the mentioned **Answer: d**
14	**What is SDH?** a) sdh is similar standard to SONET developed by ITU-T b) synchronous digital hierarchy c) both (a) and (b) d) none of the mentioned **Answer: c**

EC6703 EMBEDDED & REAL TIME SYSTEMS L TPC

3 003

OBJECTIVES:

- Learn the architecture and programming of ARM processor.
- Be familiar with the embedded computing platform design and analysis.
- Be exposed to the basic concepts of real time Operating system.
- Learn the system design techniques and networks for embedded systems

UNIT I INTRODUCTION TO EMBEDDED COMPUTING & ARM PROCESSORS 9

Complex systems and micro processors– Embedded system design process –Design example: Model train controller- Instruction sets preliminaries - ARM Processor – CPU: programming input and output-supervisor mode, exceptions and traps – Co-processors- Memory system mechanisms – CPU performance- CPU power consumption.

UNIT II EMBEDDED COMPUTING PLATFORM DESIGN 9

The CPU Bus-Memory devices and systems–Designing with computing platforms – consumer electronics architecture – platform-level performance analysis - Components for embedded programs-Models of programs-Assembly, linking and loading – compilation techniques- Program level performance analysis – Software performance optimization – Program level energy and power analysis and optimization – Analysis and optimization of program size- Program validation and testing.

UNIT III PROCESSES AND OPERATING SYSTEMS 9

Introduction – Multiple tasks and multiple processes – Multirate systems- Preemptive real-time operating systems-Priority based scheduling- Interprocess communication mechanisms – Evaluating operating system performance-power optimization strategies for processes – Example Real time operating systems-POSIX-Windows CE.

UNIT IV SYSTEM DESIGN TECHNIQUES AND NETWORKS 9

Design methodologies- Design flows - Requirement Analysis – Specifications-System analysis and architecture design – Quality Assurance techniques- Distributed embedded systems – MPSoCs and shared memory multiprocessors.

UNIT V CASE STUDY 9

Data compressor - Alarm Clock - Audio player - Software modem-Digital still camera - Telephone answering machine-Engine control unit – Video accelerator.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of the course, students will be able to

- Describe the architecture and programming of ARM processor.
- Outline the concepts of embedded systems
- Explain the basic concepts of real time Operating system design.
- Use the system design techniques to develop software for embedded systems

- Differentiate between the general purpose operating system and the real time operating system

- Model real-time applications using embedded-system concepts.

TEXT BOOK:

1. Marilyn Wolf, “Computers as Components - Principles of Embedded Computing System Design”, Third Edition “Morgan Kaufmann Publisher (An imprint from Elsevier), 2012.

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2. David. E. Simon, “An Embedded Software Primer”, 1st Edition, Fifth Impression, Addison-Wesley Professional, 2007.
3. Raymond J.A. Buhr, Donald L.Bailey, “An Introduction to Real-Time Systems- From Design to Networking with C/C++”, Prentice Hall, 1999.
4. C.M. Krishna, Kang G. Shin, “Real-Time Systems”, International Editions, Mc Graw Hill 1997
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UNIT I - INTRODUCTION TO EMBEDDED COMPUTING & ARM PROCESSORS

Complex systems and micro processors– Embedded system design process –Design example: Model train controller- Instruction sets preliminaries - ARM Processor – CPU: programming input and output-supervisor mode, exceptions and traps – Co-processors- Memory system mechanisms – CPU performance- CPU power consumption.

PART * A

Q.No.	Questions
1.	**What is an embedded system?** (BTL 1) An embedded system employs a combination of hardware & software (a "computational engine") to perform a specific function; is part of a larger system that may not be a "computer"; works in a reactive and time-constrained environment.
2	**What are the typical characteristics of an embedded system**? **(**BTL 1) **Typical characteristics:** a. Perform a single or tightly knit set of functions; b. Increasingly high-performance & real-time constrained; c. Power, cost and reliability are often important attributes d. That influence design;
3	**What are the advantages of embedded system?** (BTL 1) **Advantages**: a. Customization yields lower area **b.** power and cost.
4	**What are the disadvantages of embedded system ?** (BTL 1) **Disadvantages:** Higher HW/software development overhead design, compilers, debuggers etc., may result in delayed time to market.
5	**What are the applications of an embedded system? (NOV/DEC 2017)** (BTL 1) **Embedded Systems Applications**: a) Consumer electronics, e.g., cameras, camcorders, b) Consumer products, e.g., washers, microwave ovens, c) Automobiles (anti-lock braking, engine control,) d) Industrial process controllers & avionics/defence applications e) Computer/Communication products, e.g., printers, FAX machines.
6	**What are the real-time requirements of an embedded system?** (BTL 1)

	Hard-real time systems: where there is a high penalty for missing a deadline e.g., control systems for aircraft/space probes/nuclear reactors; refresh rates for video, or DRAM. **Soft real-time systems:** where there is a steadily increasing penalty if a deadline is missed. e.g., laser printer: rated by pages-per-minute, but can take differing times to print a page (depending on the \"complexity\" of the page) without harming the machine or the customer.
7	**What are the various embedded system requirements?** (BTL 1) Types of requirements imposed by embedded applications: a) Functional requirements b) Temporal requirements c) Dependability requirements
8	**What are the main components of an embedded system?** (BTL 1) Three main components of embedded systems: a) The Hardware b) Application Software c) RTOS
9	**Define embedded microcontroller.** (BTL 1) An embedded microcontroller is particularly suited for embedded applications to perform dedicated task or operation. Example: 68HC11xx, 8051, PIC, 16F877, etc.
10	**What are the two essential units of a processor on an embedded system?** (BTL 1) a) Program flow control unit (CU) b) Execution unit (EU)
11	**What does the execution unit of a processor in an embedded system do?** (BTL 1) The execution unit implements data transfer and data conversion. It includes ALU and circuits that execute instruction for jump, interrupt, etc.
12	**Give examples for general purpose processor.** (BTL 1) a) Microprocessor b) Microcontroller c) Embedded processor d) Digital Signal Processor e) Media Processor
13	**Define microprocessor.** (BTL 1) A microprocessor fetches and processes the set of general-purpose instructions such as data transfer, ALU operations, stack operations, I/O operations and other program control operations.
14	**What is the need for LCD and LED displays?** (BTL 1) **Uses of LCD and LED display:** a) It is used for displaying and messaging. b) Example: Traffic light status indicator, remote controls, signals, etc., c) The system must provide necessary circuit and software for the output to LCD controller.
15	**Give some examples for small scale embedded systems.** (BTL 1) 68HC05, PIC 16F8x, 8051, etc. 8051, 80251, 80x86, 80196, 68HC11xx ARM7, Power PC, Intel 80960, etc.
16	**Define system on chip (SOC) with an example.** (BTL 1) Embedded systems are being designed on a single silicon chip called system on chip. SOC is a new design innovation for embedded system. Eg. Mobile phone.

17	**List the important considerations when selecting a processor.** (BTL 1) a. Instruction set b. Maximum bits in an operand c. Clock frequency **d.** Processor ability
18	**What are the various types of memory in embedded systems?** (BTL 1) a. RAM internal External b. ROM/PROM/EEPROM/Flash c. Cache memory
19	**What is watch dog timer?** (BTL 1) Watch dog timer is a timing device that resets after a predefined timeout.
20	**When is Application Specific System processors ASSPs) used in an embedded system?** (BTL 1) An ASSP is used as an additional processing unit for running the application specific tasks in place of processing using embedded software.
21	**Define ROM image.** (BTL 1) Final stage software is also called as ROM image .The final implement able software for a product embeds in the ROM as an image at a frame. Bytes at each address must be defined for creating the image.
22	**Name some of the software's used for the detailed designing of an embedded system.** (BTL 1) Final machine implementable software for a product a. Assembly language b. High level language c. Machine codes d. Software for device drivers and device management.
23	**What are the requirements of embedded system?** (BTL 1) a. Reliability b. Low power consumption c. Cost effectiveness d. Efficient use of processing power
24	**What are the challenges of embedded systems?** (BTL 1) a. Hardware needed b. Meeting the deadlines c. Minimizing the power consumption d. Design for upgradeability
25	**Give the steps in embedded system design?** (BTL 1) a. Requirements b. Specifications c. Architecture d. Component e. System integration
	PART * B
1	
	Explain in details about Model train controller. (13M) (NOV/DEC 2017) (BTL2) **Answer: Page: 28-34 -Marilyn wolf**

	Model train control system. (3M) System setup. Signaling the train. Power supply and the console. **Requirements.**(2M) The console shall be able to control upto 8 trains on a single track. Inertia control, throttle control. Requirements in chart form. **Digital Command Control**.(4M) The DCC standard given in 2 documents. Standard 9.1 & standard 9.2 The electrical standard deals with voltage and current on the track. Bit encoding in DCC. **Conceptual specification**.(4M) A train control system turns commands into packets. Command comes from the command unit. Console class, formatter class, transmitter class, receiver class, controller class, motor interface class.
2	**Explain in details about Embedded System Design Process. (13M) (APR 2016)** (BTL 2) **Answer: page 10 - 12 Marilyn wolf** **Major levels of abstraction**. (6M) Requirements, specification, architecture, components, system integration. **Top down approach**. (4M) To begin with most abstract description of the system and conclude with concrete details. **Bottom up approach**. (3M) To start with components to build a system Do not have perfect insight into how latter stages of the design process changes out.
3	**What is Formalisms for system Design? (13M)** (BTL 2) **Answer: page 20 - 21 Marilyn wolf** **Unified Modeling Language**. (7M) Useful because it encourages design by successive refinement & progressively adding detail to the design. Designed to be useful at many levels of abstraction in the design process. **Object oriented design Vs Programming** (6M) It allows a system to be described in a way that closely models real world objects. It provides a basic set of primitives.
4	**What is Instruction Sets and explain in details about ARM instruction sets?(13M) (NOV/DEC 2017)** (BTL2) **Answer: page 28-34 Marilyn wolf** **Memory organization**.(4M) Computer architecture taxonomy. Von – Neumann & Harvard architecture Complex instruction set computer & Reduced instruction set computer. **Data operations**.(3M) ARM a load – store architecture. **Register direct addressing**(2M) Add r0, r1, r3. The instruction sets register r0 to sum of the values stored in r1 & r2. **Indirect addressing**.(1M) LDR r0, [r1] **More addressing modes**.(3M)

	Base + offset addressing Auto indexing, post indexing.
5	**Explain in details Supervisor mode, Exceptions and traps. (13M)** (BTL 2) **Answer: page 114 - 115 Marilyn wolf** **Supervisor mode**.(4M) Complex systems often implemented as several programs that communicate with other. ARM instruction in supervisor mode called SWI. **Exceptions**.(5M) Internally detected error. It requires both prioritization and vectoring. The vector number for an exception is pre-defined by the architecture. **Traps**. (4M) Also known as software interrupt. This causes the CPU to enter supervisor mode.
6	**Explain in detail about Memory System Mechanisms and CPU performance in a coprocessor system. (13M) (Apr/May 2016)** (BTL 2) **Answer: page 116 - 122 Marilyn wolf** **Caches**.(4M) Widely used to speed up reads and writes in memory systems. **First and Second level cache**. (4M) A small fast memory that holds copies of some of the contents of main memory. **Cache organization**.(4M) A cache controller mediates between the CPU and the memory system comprised of the cache and main memory. Cache hit, cache miss, Average memory access time. ARM caches. (1M)
7	**Write the flow of control in ARM. (8M)(Apr/May 2017)** (BTL 2) **Answer: page 66-71 Marilyn wolf** **Branch instruction**. (4M) The basic mechanism in ARM for changing the flow of control. Branches PC relative the branch specifies the offset from the current PC value to the branch target. B #100. **C functions**. (4M) The other important class of C statement to consider the function. Sub routines and procedures the common name. Nested function calls.
8	**Explain in detail the operation of ARM processor and coprocessor. (13M) (Apr/May 2016)** (BTL 2) **Answer: page 57 – 60, 115 – 116 Marilyn wolf** **Operation of ARM.** (7M) A family of RISC architecture. Arm 7 uses a von – Neumann architecture, while Arm 9 uses a Harvard architecture. It supports 2 basic types of data: Standard Arm word is 32 bit long. The word may be divided into four 8 – bit bytes. A load – store architecture. Other important basic register **current program status register(CPSR).** **Co-processors in ARM**.(6M) It provides flexibility at the instruction set level.

	Co – processor instructions can load and store co – processor registers or can perform internal operations.
9	**What are ways of programming the input and output devices in an embedded system design? (13M)(Apr/May 2017)** (BTL 2) **Answer: page 96-102 Marilyn wolf** **Input and output devices** (4M) They have some analog or non electronic component. The interface between the CPU and the device's internals a set of registers. Devices typically have several registers : **Data registers, Status registers.** Input and Output primitives (4M) Microprocessors can provide programming support for input and output in two ways: **I/O instructions** **Memory – mapped I/O** **Busy wait I/O** (5M) The simplest way to communicate with devices in a program. Asking an I/O device whether it finished by reading its status register often called polling.
10	**Discuss on the operation of coprocessor used with ARM processor. (13M) (NOV/DEC 2017)** (BTL2) **Answer: page 115-116 Marilyn wolf** **Operation**. (7M) It provides flexibility at the instruction set level. Co – processor instructions can load and store co – processor registers or can perform internal operations. **Functions** (6M) Most architectures use illegal instruction traps to handle these situations. The ARM architecture provides support for up to 16 co – processors attached to a CPU. An example ARM co – processor the floating – point unit.
	PART *C
1	**Elaborate Requirements in detail and all other Embedded system design process. (15M) (Apr/May 2017)** (BTL 2) **Answer: page 10-19 Marilyn wolf** **Requirements**. (7M) It may be functional or non – functional. Typical non – functional requirements include: Performance, cost, physical size and weight, power consumption. Validating requirements : one way to build a mock – up. As part of system design we will use simple requirements methodology. Internal consistency of requirements. **Specification.** (2M) It is the contract between the customer and the architects. **Design** (2M) It is a plan for the overall structure of the system. A sample system architecture given in the form of a block diagram. **Components** (2M) It includes in general both hardware – FPGA boards - and software modules. **Integration.** (2M) Bugs typically found during system integration and good planning can help us find the bugs quickly.

2	**Briefly elaborate CPU performance. (15M)** (BTL 2) **Answer: page 128-132 Marilyn wolf** **Pipelining**. (7M) Modern CPU's designed as pipelined machines in which several instructions executed in parallel. **ARM 7 has a 3 – stage pipeline**: Fetch, Decode, Execute. Risc machines designed to keep the pipeline busy. **Pipeline stalls** – multiple load instruction an example of an instruction that requires several cycles. Branches also introduce **control stall** delays into the pipeline, also known as branch penalty. **Cache Performance**. (8M) The extra time required to access a memory location not in the cache often called the **cache miss penalty.** **Compulsory miss, conflict miss, capacity miss.**
3	**Explain in detail CPU power consumption. (15M) (Apr/May 2017)** (BTL 2) **Answer: page 133-134 Marilyn wolf** **CMOS power characteristics**. (8M) Virtually all digital systems built with CMOS circuitry. **Power supply voltage** – Power consumption of a CMOS circuit proportional to square of the power supply voltage (v^2). **Capacitive toggling** – By reducing the speed at which the circuit operates, we can reduce it's power consumption. **Leakage** – The only way to eliminate leakage current to remove the power supply. **Static and Dynamic Power management**. (7M) **Static power management –** This mechanism invoked by the user but does not otherwise depend on CPU activities. e.g., Power – down mode **Dynamic power management –** This mechanism takes actions to control power based upon the dynamic activity in the CPU. e.g., CPU may turn off certain sections of the CPU.

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UNIT II - EMBEDDED COMPUTING PLATFORM DESIGN

The CPU Bus-Memory devices and systems–Designing with computing platforms – consumer electronics architecture – platform-level performance analysis - Components for embedded programs- Models of programs- Assembly, linking and loading – compilation techniques- Program level performance analysis – Software performance optimization – Program level energy and power analysis and optimization – Analysis and optimization of program size- Program validation and testing.

PART * A

Q.No.	Questions
1.	**Differentiate synchronous communication and iso-synchronous communication**. (BTL 1) **<u>Synchronous communication</u>** When a byte or a frame of the data is received or transmitted at constant time intervals with uniform phase difference, the communication is called synchronous communication. **Iso-synchronous communication** Iso-synchronous communication is a special case when the maximum time interval can be varied.
2	**What are the three ways of communication for a device?** (BTL 1) 1. Iso-synchronous communication 2. synchronous communication 3. Asynchronous communication
3	**Expand a) SPI b) SCI** (BTL 1) a) SPI—serial Peripheral Interface **b)** SCI—Serial Communication Interface
4	**Define software timer**. (BTL 1) This is software that executes and increases or decreases a count variable on an interrupt from a timer output or form a real time clock interrupt. A software timer can also generate interrupt on overflow of count value or on finishing value of the count variable.
5	**What is I2C?** (BTL 1) I2C is a serial bus for interconnecting ICs .It has a start bit and a stop bit like an UART. It has seven fields for start,7 bit address, defining a read or a write, defining byte as acknowledging byte, data byte, NACK and end.
6	**What is a CAN bus? Where is it used?** (BTL 1) CAN is a serial bus for interconnecting a central Control network. It is mostly used inautomobiles. It has fields for bus arbitration bits, control bits for address and data length data bits, CRC check bits, acknowledgement bits and ending bits.
7	**What is USB? Where is it used?** (BTL 1) USB is a serial bus for interconnecting a system. It attaches and detaches a device from the network. It uses a root hub. Nodes containing the devices can be organized like a tree structure. It is mostly used in networking the IO devices like scanner in a computer system.
8	**What are the features of the USB protocol?** (BTL 1) A device can be attached, configured and used, reset, reconfigured and used, share the bandwidth with other devices, detached and reattached.

9 **Why are SPCI parallel buses important?** (BTL 1)

SPCI serial buses are important for distributed devices. The latest high speed sophisticated systems use new sophisticated buses.

10 **What is meant by UART?** (BTL 1)

1. UART stands for universal Asynchronous Receiver/Transmitter.
2. UART is a hardware component for translating the data between parallel and serial interfaces.
3. UART does convert bytes of data to and from asynchronous start stop bit.
4. UART is normally used in MODEM.

11 **What does UART contain?** (BTL 1)

1. A clock generator.
2. Input and Output start Registers
3. Buffers.
4. Transmitter/Receiver control.

12 **What is meant by HDLC?** (BTL 1)

1. HDLC stands for “High Level Data Link Control”.
2. HDLC is a bit oriented protocol.
3. HDLC is a synchronous data Link layer

13 **Write the HDLC’s frame structure.** (BTL 1)

Flag	Address	Control	Data	FCS	Flag

14 **Name some control bit of timer.** (BTL 1)

1.Timer Enable
2.Timer start
3.Up count Enable
4.Timer Interrupt Enable

15 **What is status flag?** (BTL 1)

Status flag is the hardware signal to be set when the timer reaches zeros.

16 **List out some applications of timer devices.** (BTL 1)

1.Real Time clock
2.Watchdog timer
3.Input pulse counting
4.TDM
5.Scheduling of various tasks

17 **State the special features on I^2C.** (BTL 1)

1.Low cost
2.Easy implementation
3.Moderate speed upto 100 kbps).

18 **Write the disadvantages of I^2C. (**BTL 1)

1.Slave hardware does not provide much support
2.Open collector drivers at the master leads to be confused

19 **Draw the data frame format of CAN.** (BTL 1)

Start	Arbitration Field	Control Field	Data field	CRC field	Acknowledgement Field	End Of frame

	1 12 6 0-64 16 2 7
20	**What is ISA?** (BTL 1) 1.ISA stands for Industry standard Architecture. 2.Used for connecting devices following IO addresses and interrupts vectors as per IBM pc architecture.
21	**Define CPCI.** (BTL 1) 1.CPCI stands for Compact Peripheral Component Interfaces. 2.CPCI is to be Connected via a PCI. 3.CPCI is used in the areas of Telecommunication Instrumentation abd data communication applications.
22	**What is meant by PCI-X?** (BTL 1) 1.PCI X offers more speed over PCI. 2.30 times more speed than PCI.
23	**Define Real Time Clock RTC.** (BTL 1) Real time clock is a clock which once the system stats does not stop and cant be reset and its count value cant be reloaded.
24	**Define Time-out or Time Overflow.** (BTL 1) A state in which the number of count inputs exceeded the last acquirable value and on reaching that state, an interrupt can be generated.
25	**What are the two standards of USB?** (BTL 1) 1.USB 1.1 2.USB 2.0
	PART * B
1	**Explain in details about Memory Devices. (13M)** (BTL 2) **Answer: page 172 – 175 Marilyn wolf** Memory system organization. (7M) **DRAM Organization** – Most bulk memory in modern systems are dynamic RAM & very dense. Value must be refreshed periodically, because the values inside the memory cells decay over time. * A simple memory is organized as a two – dimensional array. Special modes – Burst and page mode. **Types of DRAM** – Synchronous DRAM, Extended data out DRAM (EDO DRAM), Fast page mode DRAM (FPM DRAM), double data rate DRAM (DDR DRAM). (2M) Memory packaging – Single in – line memory module (**SIMMs**), Double in – line memory module (**DIMMs**). Memory controllers – It is the interface between the CPU and memory components. (2M) Channels and Banks – These are 2 ways to add parallelism to the memory system. ROM – These are preprogrammed with fixed data. (1M) Flash memory – It can be erased and rewritten using standard system voltages. (1M) Boot – block flash – It keeps the boot – up code in a protected block but allow updates to other blocks.
2	**Explain in details about different Bus Structures.13m, BTL – 1** **Answer: page 159 – 161, 170 - 172 Marilyn wolf**

	CPU bus. (1M) The bus is the mechanism by which the CPU communicates with memory and devices.(3M) Bus organization and protocol. (2M) Bus master – CPU serves as the bus master.(2M) Four cycle handshake – it is the basic building block.(2M) System bus configuration. (1M) A small block of a logic known as a bridge allows the buses to connect to each other.(2M)
3	**Design a system with computing platforms in detail.(13M)** (BTL 4) **Answer: page 176 – 183 Marilyn wolf** Choosing a platform. (1M) Hardware – CPU, bus, memory, input and output devices.(2M) Software – digital filtering and FFT.(1M) Intellectual property. (2M) Run time software libraries. Software development environments. Schematics, netlists, and other hardware design information. **Development environments**. (3M) Software development done on a pc is host. The hardware on which the code will finally run is known as target. **Debugging techniques**. (4M) Important debugging tool is break point. 1.Microprocessor in – circuit emulator,2.logic analyzer.
4	**Explain in details about Development and Debugging techniques. (13M) (APR/MAY 2016)** (BTL2) **Answer: page 180 – 183 Marilyn wolf** Cross compiler. (1M) It is a compiler that runs on one type of machine but generates code for another.(2M) Test bench program. (2M) We often create a test bench program. **Debugging techniques**. (3M) A good deal of software debugging can be done by compiling and executing code on a pc. 1.ICE. (2M) 2.Micro processor in – circuit emulator (ICE) is a specialized software tool. 3.Logic Analyzer. (3M) It is the other major instrumentation in the embedded system designers arsenal.
5	**What is analysis and optimization of execution time, power, energy and program size? (13M) (NOV/DEC 2017)** (BTL2) **Answer: page 266 – 270 Marilyn wolf** The execution time of a program often varies with the input data.(2M) The cache has a major effect on program performance.(1M) Execution times may vary even at the instruction level.(1M) Measuring execution speed – average case execution time, worst case execution time, best case execution time.(2M) **Elements of program performance :** Execution time = program path + instruction timing.(2M) Measurement driven performance analysis. Program level energy and power analysis and optimization: (2M) Measuring energy consumption for a piece of code.(1M)

	Try to use registers efficiently. Analyze cache behavior to find major cache conflicts. Instruction conflicts, array data conflicts.(1M) Make use of page mode accesses. (1M)
6	**Explain Assembly, Linking and Loading.(13M)** (BTL 2) **Answer: page 228 – 234 Marilyn wolf** Program generation work flow.(1M) The assemblers job is to translate symbolic assembly language statements into bit level of instructions known as object codes.(2M) Absolute and Relative addresses. (2M) Absolute addresses – assembler assumes that the starting address of the assembly language program has been specified by the programmer. Relative addresses – origin of the assembly language module is to be computed later. **Assemblers**. (2M) Translates opcodes and formats the bit in each instruction. Symbol table.(2M) The name of each symbol and its address is stored in a symbol table. **Linking**. (2M) A linker allows a program to be stitched together out of several smaller pieces. **Loader**: (2M) The program that brings the program in to memory for execution is called a loader.
7	**Describe the basic compilation techniques. (13M) (APR/MAY 2017, BTL2),(NOV/DEC 2017)** (BTL2) **Answer: page 236 – 245 Marilyn wolf** Compilation process. (2M) Speed, size, power consumption. (3M) Compilation process : compilation = translation + optimization. (2M) Basic compilation methods. (2M) We consider the basic job of translating the high – level language program with little or no optimization. (2M) Procedures. (1M) The linkage mechanism provides a way for the program to pass parameters in to the program.(1M)
8	**Explain in detail optimization of program size of an embedded system. (13M) (APR/MAY 2017)** (BTL2) **Answer: page 266 – 270 Marilyn wolf** Program level energy and power analysis and optimization: (2M) Measuring energy consumption for a piece of code.(3M) Try to use registers efficiently. (3M) Analyze cache behavior to find major cache conflicts. Instruction conflicts, array data conflicts. (3M) Make use of page mode accesses. (2M)
9	**Discuss various programming models in detail. (APR/MAY 2017) (13M) (NOV/DEC 2017)** (BTL2) **Answer: page 223 – 226 Marilyn wolf** **Programming models** (1M) 1.One fundamental model for programs is the control / data flow graph (CDFG). (3M) It has constructs that model both data(arithmetic and other computations) and control

	operations(conditionals). (3M) 2.Data flow graphs – it is a model of a program with no conditionals. (2M) More precisely with only one entry and exit point – is known as a basic block. (2M) Control / data flow graphs – 2 types of nodes. (1M) Decision nodes and data flow nodes. (1M)
10	**Describe the basic types of memory components commonly used in embedded systems. (13M) (APR/MAY 2016)** (BTL2) **Answer: page 172 – 175 Marilyn wolf** **DRAM Organization** (4M) – Most bulk memory in modern systems are dynamic RAM. It is very dense. Its value must be refreshed periodically, because the values inside the memory cells decay over time. **Types of DRAM** (3M) – Synchronous DRAM, Extended data out DRAM (EDO DRAM), fast page mode DRAM (FPM DRAM), double data rate DRAM (DDR DRAM). ROM (2M) – These are preprogrammed with fixed data. Flash memory (2M) – It can be erased and rewritten using standard system voltages. Boot – block flash (2M) – It keeps the boot – up code in a protected block but allow updates to other blocks.
	PART *C
1	**Elaborate program validation and testing.(15M)** (BTL 2) **Answer: page 271 – 279 Marilyn wolf** **Clear box testing**. (6M) The control / data flow graph extracted from a programs source code is an important tool. We must accomplish the following 3 things in a test: Provide the program with inputs. Execute the program to perform the test. Examine the outputs to determine whether the test was successful. Execution paths – we want to test the program by forcing it to execute along chosen paths. **Black box testing**.(5M) These are generated without knowledge of the code being tested. When used in conjunction with clear box tests they help provide a well – rounded test set. Random tests – are generated with a given distribution. Regression tests – form an extremely important category of tests. **Evaluating functional tests**. (4M) Methodological techniques are important for understanding the quality of your test. One interesting method for analyzing the coverage of your tests is error injection.
2	**Explain in detail about Program level performance analysis and explain the optimization of program level energy, power and program size. (15M) (APR/MAY 2017, 2016)** (BTL2) **Answer: page 254 – 259, 266 – 270 Marilyn wolf** **Program level performance analysis** (8M) Because embedded systems must perform functions in real time, we often need to know how fast a system runs. The execution time of a program often varies with the input data. The cache has a major effect on program performance. Execution times may vary even at the instruction level. Measuring execution speed – average case execution time, worst case execution time, best case execution time. Elements of program performance : Execution time = program path + instruction timing.

	Measurement driven performance analysis. **Program level energy and power analysis and optimization**: (7M) Measuring energy consumption for a piece of code. Try to use registers efficiently. Analyze cache behavior to find major cache conflicts. Instruction conflicts, array data conflicts. Make use of page mode accesses.
3	**Discuss the design pattern, loop transformations and scheduling.(12M)** **Explain clear – box testing. (3M) (NOV / DEC 2015)** (BTL 2) **Answer: page 245,251,271 Marilyn wolf** **Loop transformation** (6M) Loops are important program structures. Many techniques have been designed to optimize loops. A simple but useful transformation is known as loop unrolling. Loop fusion – it combines 2 or more loops in to a single loop. Loop distribution – is the opposite of loop fusion. Loop tiling – breaks up a loop into a set of nested loops. Array padding – adds dummy data elements to a loop. Dead code – it can never be executed. Register allocation – is a very important compilation phase. **Scheduling** (6M) – we may be able to improve the register allocation by changing the order. Software pipelining technique for reordering instructions. One useful code for generating code is template matching. Clear box testing. (3M) The control / data flow graph extracted from a programs source code is an important tool.

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UNIT III – PROCESSES & MULTIPLE OPERATING SYSTEM

Introduction – Multiple tasks and multiple processes – Multirate systems- Preemptive real-time operating systems- Priority based scheduling- Interprocess communication mechanisms – Evaluating operating system performance- power optimization strategies for processes – Example Real time operating systems-POSIX-Windows CE.

PART * A

Q.No.	Questions
1.	**What are the states of a process?** (BTL1) 1. Running 2. Ready 3. Waiting
2	**What is the function in steady state?** (BTL1) Processes which are ready to run but are not currently using the processor are in the 'ready' state.
3	**Define scheduling.** (BTL1) This is defined as a process of selection which says that a process use the processor at given time.
4	**What is scheduling policy?** (BTL1) It says the way in which processes are chosen to get promotion from ready state to running state.
5	**What is schedulability?** (BTL1) It indicates any execution schedule is there for a collection of process in the system's functionality.
6	**What are the types of scheduling?** (BTL1) 1. Time division multiple access scheduling. 2. Round robin scheduling.
7	**Define round robin scheduling.** (BTL1) This type of scheduling employs the hyper period as an interval. The processes run in the given order.
8	**What is scheduling overhead?** (BTL1) It is defined as time of execution needed to select the next execution process.
9	**What is meant by context switching?** (BTL1) The actual process of changing from one task to another is called a context switch.
10	**Define priority scheduling.** (BTL1) A simple scheduler maintains a priority queue of processes that are in the runnable state.
11	**What is critical instant analysis?** (BTL1) It is used to know about the schedule of a system. Its says that based on the periods given, the priorities to the processes has to be assigned.

12	**Define earliest deadline first scheduling.** (BTL1) This type of scheduling is another task priority policy that uses the nearest deadline as the criterion for assigning the task priority.
13	**What is IDC mechanism?** (BTL1) It is necessary for a 'process to get communicate with other process' in order to attain a specific application in an operating system.
14	**What are the two types of communication?** (BTL1) 1. Blocking communication 2. Non blocking communication
15	**Give the different styles of inter process communication.** (BTL1) 1. Shared memory. 2. Message passing.
16	**What is critical instant?** (BTL1) It is the situation in which the process or task possess highest response time.
17	**What is rate monotonic scheduling?** (BTL1) Rate monotonic scheduling is an approach that is used to assign task priority for a preemptive system.
18	**Define initiation time.** (BTL1) It is the time at which the process goes from the waiting to the ready state. It is generally measured from the event.
19	**Define aperiodic process.** (BTL1) It is initiated by an event, such as external data arriving or data computed by another process.
20	**Define Deadline.** (BTL1) It specifies when a computation must be finished. The deadline for an aperiodic process is measured from initiation time. The deadline for a periodic process may occur at sometime other than the end of the period.
21	**Define Utilization.** (BTL1) It is defined as the CPU time for useful work to the total available CPU time.
22	**Name the scheduling states.** (BTL1) 1. Waiting 2 .Ready 3. Execution
23	**Define scheduling policy.** (BTL1) It defines how processes are selected for promotion from the ready state to the running state.
24	**What is kernel?** (BTL1) It is a part of the operating system that determines what process is running.
25	**What are the major styles of interprocess communication?** (BTL1) 1. Shared memory 2. Message passing
	PART * B
1	**1. Explain in details about Real time Operating systems. (13M)** (BTL 2)

	Answer: Page: 319 – 325 Marilyn wolf ➢ Preemptive operating system and to use priorities to control what runs at any given time. (2M) ➢ Two basic concepts. (3M) ➢ Introduce preemption alternative to C function. ➢ Introduce priority based scheduling. ➢ Processes, context. (3M) ➢ Steady state – everything initialized, OS,timer interrupt. ➢ Processes, object oriented design. (5M) ➢ UML processes active objects. An active class in UML. A collaboration diagram with active and normal objects.
2	**Explain in detail process state and scheduling. (13M) APR/MAY 2016** (BTL2) **Answer: Page 316 – 317 Marilyn wolf** ➢ 3 basic scheduling states. (4M) ➢ The operating system considers a process to be in one of 3 basic scheduling states : ➢ Waiting, ready, or executing. ➢ Scheduling states of a process. (3M) ➢ A process can go in to the executing state only when it has all its data, is ready to run. ➢ Scheduling policy. (3M) ➢ It defines how processes are selected for promotion from the ready to the running state. ➢ Scheduling overhead. (3M) ➢ The execution time required to choose the next execution process.
3	**Explain in details about Inter Process communication mechanisms. (13M) (APR/MAY 2017,APR/MAY 2016, NOV/DEC 2017)** (BTL2) **Answer: Page 340 - 344 Marilyn wolf** ➢ Shared memory communication.(4M) ➢ Two components such as a CPU and an I/O/ device, communicate through a shared memory location. ➢ Message passing.(4M) ➢ It complements the shared memory model. ➢ A queue is a common form of message passing. ➢ Signals.(3M) ➢ Another form of inter process communication commonly used in Unix is signals. ➢ Mailboxes.(2M) ➢ It is a simple mechanism for asynchronous communication.
4	**Explain evaluating operating system performance in detail. (13M)** (BTL2) **Answer: Page 344 – 347 Marilyn wolf** ➢ Context switching time. (4M) ➢ It depends on several factors: ➢ The amount of CPU context that must be saved. ➢ Scheduler execution time. ➢ Interrupt latency. (3M) ➢ It is critical because data may be lost when an interrupt is not serviced in a timely fashion. ➢ Critical sections. (3M) ➢ The longer the critical section, the greater the potential delay. ➢ ISH performs the minimal operations required to respond to the device.

	➢ Caches and RTOS performance. (3M) ➢ A properly sized cache can allow a microprocessor to run a set of processes much more quickly.
5	**Explain in detail about Power optimization strategies for processes.(13M) (APR/MAY 2017,NOV/DEC 2017)** (BTL2) **Answer: Page 349 – 352 Marilyn wolf** ➢ Power down trade - offs. (4M) ➢ It is strategy for determining when to perform certain power management options. ➢ Power up the system when a request is received. ➢ Predictive power management.(3M) ➢ A more sophisticated method is predictive shut down. ➢ A simple technique is to use fixed times. ➢ Architecture.(3M) ➢ A more advanced technique is based on a more thorough analysis of the system state. ➢ ACPI.(3M) ➢ Advanced configuration and power interface is an open industry standard for power management services.
6	**Explain in detail rate monotonic scheduling with example. (13M)** (BTL 2). **Answer: Page 326 – 330 Marilyn wolf** ➢ Theory (5M) ➢ It was introduced by Liu and Layland. ➢ First scheduling policies developed for real time systems. ➢ RMS is a static scheduling policy. ➢ The theory underlying RMS is rate monotonic analysis (RMA). ➢ CPU Utilization. (4M) ➢ Total CPU utilization for a set of n tasks is ➢ U = $\sum_{i=1}^{n} \frac{T_i}{t_i}$ ➢ Implementation. (4M) ➢ C code for an RMS scheduler run at the operating systems timer interrupt.
7	**With neat diagram explain Shared Memory communication. (13M)** (BTL2) **Answer: Page 340 - 341 Marilyn wolf** ➢ Shared memory communication.(7M) ➢ Two components such as a CPU and an I/O/ device, communicate through a shared memory location. ➢ Shared memory communication implemented on a bus. (6M) ➢ CPU, shared location, I/O device and bus.
8	**Brief about multiple tasks and multiple processes. (13M) (APR/MAY 2016)** (BTL2) **Answer: Page 308 – 310 Marilyn wolf** ➢ Tasks and processes. (4M) ➢ Tasks are part of the systems functionality. ➢ A process is a single execution of a program. ➢ Processes that share the same address space is thread. ➢ Scheduling overhead. (5M) ➢ Scheduling overhead is paid for at a non linear rate. ➢ Character, compressor, compression table, bit queue. ➢ Asynchronous input. (4M) ➢ A control panel on a machine provides an example of a different type of rate control

	problem, the asynchronous input.
9	**Explain in detail earliest deadline first scheduling. (13M) (APR/MAY 2017)** (BTL2)**.** **Answer: Page 308 – 310 Marilyn wolf** ➢ Earliest deadline first scheduling. (8M) ➢ It is a well known scheduling policy. ➢ It is a dynamic priority scheme – it changes process priorities during execution based on initiation times. ➢ It can achieve higher CPU utilizations than RMS. ➢ Implementation (5M) ➢ EDF can achieve 100% utilization. ➢ The implementation of EDF is more complex than the RMS code.
	PART *C
1	**Explain multirate systems with neat diagrams. (15M)** (BTL 2) **Answer: Page 310 – 319 Marilyn wolf** ➢ Timing requirements. (4M) ➢ Two important requirements on processes: initiation time and deadline. ➢ The period of a process is the time between successive executions. ➢ A set of processes with data dependencies is known as a task graph. ➢ CPU usage metrics. (5M) ➢ The simplest and most direct measure is utilization. ➢ U = $\frac{CPU\ time\ for\ useful\ work}{total\ available\ CPU\ time}$ ➢ Process state and scheduling. (4M) ➢ The operating system considers a process to be in one of 3 basic scheduling states: **waiting, ready, or executing.** ➢ Running periodic processes. (2M) ➢ First step: while loop, a timed loop, multiple timers, timer plus counters.
2	**Explain in detail Priority based scheduling. (15M)** (BTL 2) **Answer: Page 325 – 333 Marilyn wolf** ➢ Round robin scheduling (2M) ➢ A common scheduling algorithm in general purpose OS. ➢ Rate monotonic scheduling. (4M) ➢ It was introduced by Liu and Layland. ➢ First scheduling policies developed for real time systems. ➢ RMS is a static scheduling policy. ➢ The theory underlying RMS is rate monotonic analysis (RMA). ➢ Shared resources. (5M) ➢ We may create a critical timing race or race condition that causes erroneous operation. ➢ Semaphores – a primitive provided by the OS. ➢ Priority inversion. (2M) ➢ A low priority process blocks execution of a higher priority process by keeping hold of its resource. ➢ EDF Scheduling. (2M) ➢ It is a well known scheduling policy. ➢ It is a dynamic priority scheme – it changes process priorities during execution based on initiation times.

	➢ It can achieve higher CPU utilizations than RMS.
3	**Brief the functions of** **i)POSIX and (8M) (APR/MAY 2017)** (BTL2) **ii)Windows CE. (7M) (NOV/DEC 2017)** (BTL2) **Answer: Page 352-360 Marilyn wolf** Posix. (8M) ➢ It is a version of the Unix OS created by a standards organization. ➢ A new process is created by making a copy of the existing one. ➢ A dual – kernel approach uses a specialized kernel. ➢ Processes in POSIX, process model, Real time scheduling in POSIX, Posix semaphores, posix pipes, posix message queues. Windows CE. (7M) ➢ It supports devices such as smart phones, electronic instruments etc. ➢ Windows CE is designed to run on multiple hardware platforms and instruction set architectures. ➢ Win CE architecture, Win CE memory space, OAL architecture in windows CE, Win CE threads and drivers, kernel and user address spaces. ➢ Win CE scheduling, win CE interrupts – ISH, ISR, IST.

Subject Code:EC6703 Year/Semester: IV /07
Subject Name: EMBEDDED & REAL TIME SYSTEMS Subject Handler: W.NANCY

UNIT IV – SYSTEM DESIGN TECHNIQUES AND NETWORKS

Design methodologies- Design flows - Requirement Analysis – Specifications-System analysis and architecture design – Quality Assurance techniques- Distributed embedded systems – MPSoCs and shared memory multiprocessors.

PART * A

Q.No.	Questions
1.	**Define process.** (BTL1) Process is a computational unit that processes on a CPU under the control of a scheduling kernel of an OS. It has a process structure, called Process control block. A process defines a sequentially executing program and its state.
2	**What is meant by PCB?** (BTL1) Process Control Block' is abbreviated as PCB.PCB is a data structure which contains all the information and components regarding with the process.
3	**Define task and Task state.** (BTL1) A task is a set of computations or actions that processes on a CPU under the control of a scheduling kernel. It also has a process control structure called a task control block that saves at the memory. It has a unique ID. It has states in the system as follows: idle, ready, running, blocked and finished
4	**Define Task Control Block TCB.** (BTL1) A memory block that holds information of program counter, memory map, the signal dispatch table, signal mask, task ID, CPU state and a kernel stack.
5	**What is a thread?** (BTL1) Thread is a concept in Java and UNIX and it is a light weight sub process or process in an application program. It is controlled by the OS kernel. It has a process structure, called thread stack, at the memory. It has a unique ID. It has states in the system as follows, running, blocked and finished.
6	**Define Inter process communication.** (BTL1) An output from one task passed to another task through the scheduler and use of signals, exception, semaphore, queues, mailbox, pipes, sockets, and RPC.
7	**What is shared data problem?** (BTL1)

	If a variable is used in two different processes and another task interrupts before the operation is completed then the value of the variable may differ from the one expected. This is known as shared data problem.
8	**Define Semaphore. (APR/MAY 2017)** (BTL1) Semaphore provides a mechanism to let a task wait till another finishes. It is a way of synchronizing concurrent processing operations. When a semaphore is taken by a task then that task has access to the necessary resources. When given resources unlock, Semaphore can be used as an event flag or as a resource key.
9	**Define Mutex.** (BTL1) A phenomenon for solving the shared data problem is known as semaphore. Mutex is a semaphore that gives instance to two tasks mutually exclusive access to resources.
10	**Differentiate counting semaphore and binary semaphore.**(BTL1) **Binary semaphore** When the value of binary semaphore is one, it is assumed that no task has taken it and that it has been released. When the value is 0, it is assumed that it has been taken. **Counting semaphore** Counting semaphore is a semaphore which can be taken and given number of times. Counting semaphores are unsigned integers.
11	**What is Priority inversion? (APR/MAY 2017)** (BTL1) A problem in which a low priority task inadvertently does not release the process for a higher priority task.
12	**What is Deadlock situation?** (BTL1) A set of processes or threads is deadlocked when each process or thread is waiting for a resource to be freed which is controlled by another process.
13	**Define Message Queue.** (BTL1) A task sending the multiple FIFO or priority messages into a queue for use by another task using queue messages as an input.
14	**Define Mailbox and Pipe.** (BTL1) A message or message pointer from a task that is addressed to another task
15	**Define Socket.** (BTL1) It provides the logical link using a protocol between the tasks in a client server or peer to peer environment.
16	**Define Remote Procedure Call.** (BTL1) A method used for connecting two remotely placed methods by using a protocol. Both systems work in the peer to peer communication mode and not in the client server mode.
17	**What is RTOS?** (BTL1) An RTOS is an OS for response time controlled and event controlled processes. RTOS is an OS for embedded systems, as these have real time programming issues to solve.
18	**List the set of OS command functions for a device.** (BTL1) 1.Create and open 2.Write 3.Read **4.**Close and delete
19	**What are the three methods by which an RTOS responds to a hardware source "call on interrupt"?** (BTL1)

	1. Direct call to ISR by an interrupt source 2. Direct call to RTOS by an interrupt source and temporary suspension of a scheduled task. 3. Direct call to RTOS by an interrupt source and scheduling of tasks as well as ISRs by the RTOS.
20	**Name any two important RTOS**. (BTL1) 1. MUCOS 2. VxWorks
21	**What is meant by well tested and debugged RTOS?** (BTL1) An RTOS which is thoroughly tested and debugged in a number of situations
22	**What is sophisticated multitasking embedded system?** (BTL1) A system that has multitasking needs with multiple features and in which the tasks have deadlines that must be adhered to.
23	**What are the features of UC/OS II?** (BTL1) 1. Preemptive 2. Portable 3. Scalable 4. Multitasking
24	**What are the real time system level functions in UC/OS II? State some?** (BTL1) 1. Initiating the OS before starting the use of the RTOS fuctions. 2. Starting the use of RTOS multi-tasking functions and running the states. 3. Starting the use of RTOS system clock.
25	**What are the different types of scheduling supported by VxWorks?** (BTL1) 1. Preemptive priority 2. Time slicing
	PART * B
1	**Explain in details about Accelerated system design. (13M) (APR/MAY 2016)** (BTL2) **Answer: Page: 432- 434 Marilyn wolf** • Accelerators (5M) • Processing elements for embedded multiprocessors. • Provide large performance increases - applications with computational kernels. • Hardware / software co-design (4M) • The design of accelerated systems - example. • The simultaneous design of hardware and software - meeting system objectives. • CPU accelerators in system (4M) • Memory, CPU, CPU bus, Accelerator (data registers, control registers, accelerator logic)
2	**Discuss in detail about several interconnected networks used especially for distributed embedded computing. (13M) (APR/MAY 2016)** (BTL2) **Answer: Page: 414 – 419 Marilyn wolf** • Network abstraction (5M) • The OSI model layers. • Physical, data link, network, transport, session, presentation, application. • CAN bus (4M) • Designed for automotive electronics. • Uses bit serial transmission. Recessive, dominant.

	• Sends data on network in packets as data frames. • Architecture of CAN controller. (4M) • Bus interface, protocol controller, host interface.
3	**Explain in detail the advanced techniques for specification. (13M)** (BTL 2) **Answer: Page:391 – 394 Marilyn wolf** • Control oriented specification languages. (7M) • SDL language, state charts, AND / OR tables. • A well known technique for state based specification - State chart. • SDL language for specifying communication protocols, telephone systems. • Advanced specification. (6M) Specification of real world Uses safety critical system in aircraft. Used in many applications - much of the complexity in control structure.
4	**Explain the features and applications of Internet enabled embedded systems. (13M) (APR/MAY 2016)** (BTL2) **Answer: Page:429 – 431 Marilyn wolf** • Internetworking (4M) • IP - fundamental protocol. • A node transmits data among different types of networks - known as router. • Protocol utilization (3M) • Node A, Router, Node B. • IP packet structure (3M) • Header, data payload with data. • Internet service stack. (3M) • FTP, HTTP, SMTP, Telnet, SNMP,TCP, UDP, IP.
5	**Explain networks for embedded systems and Internet-enabled embedded system. (13M)** (BTL 2) **Answer: Page: 414 – 416, 429 – 431 Marilyn wolf** • Network abstraction. (3M) • The OSI model layers. • Physical, data link, network, transport, session, presentation, application. • CAN bus (4M) • Designed for automotive electronics. • Uses bit serial transmission. Recessive, dominant. • Sends data on the network in packets - data frames. • Internetworking. (6M) • The IP -fundamental protocol. • A node transmits data among different types of networks -router. • Protocol utilization - Node A, Router, Node B. • IP packet structure
6	**Elaborate I2C bus with neat diagram. (13M)** (BTL 2) **Answer: Page:422-425 Marilyn wolf** • Physical layer (4M) • Used to link microcontrollers in to systems. • 2 lines – SDL and SCL. • Electrical interface to the I2C bus (3M)

	• Structure of an I2C bus system (3M) • Data link layer (3M) • Every I2C device has an address. • Format of an I2C address transmission.
7	**Explain in detail catagories of multiprocessors. (13M)** (BTL 2) **Answer: Page:412 - 414 Marilyn wolf** • Major types. (4M) • Shared memory Vs message passing • System – on chip Vs distributed • Architectures. (4M) • Shared memory architecture, message passing architecture. • MPSOCs. (5M) Very common in single chip embedded multiprocessors.
8	**Explain how the concepts of MPSOC and shared memory multiprocessors are used in embedded application. (13M) (NOV/DEC 2017)** (BTL2) **Answer: Page:412 - 414 Marilyn wolf** • MPSOC (7M) • Very common in single chip embedded multiprocessors. • e.g., ARM MPcore. • Shared memory multiprocessors (6M) • Shared memory Vs message passing • Shared memory architecture and message passing architecture.
	PART *C
1	**Explain design flows with a neat sketch. (15M)** (BTL 2) **Answer: Page: 383 – 386 Marilyn wolf** • Waterfall model. (5M) • The first model proposed for the software development process. • Consists of 5 major phases: requirements, architecture, coding, testing, maintenance. • Spiral model. (5M) • Alternative model of software development. • System feasibility, specification, prototype, initial system, enhanced system. • Successive refinement. (5M) • Rough prototype, successive models of the system further refined.
2	**Write down the quality assurance for system design techniques. (15M) (APR/MAY 2017,NOV/DEC 2017)** (BTL2). **Answer: Page: 400 – 406 Marilyn wolf** • Techniques. (5M) • Vital for delivery of satisfactory system. • ISO 9000: process crucial, Documentation important, Communication important. • Verifying the specification. (5M) • Long live bugs more expensive to fix. Requirements validation, prototyping languages, validation of specifications. • Design reviews. (5M) • Design review format – designers , review leader, review audience.

3	**Elaborate Can bus, I2c bus and distributed computing in cars and airplanes. (15M) (APR/MAY 2017)** (BTL2). **Answer: Page: 416 – 425 Marilyn wolf** • Can bus. (6M) • Designed for automotive electronics. • Uses bit serial transmission. Recessive , dominant. • Sends data on the network in packets - data frames. • I2c bus. (5M) • Used to link microcontrollers in to systems. • 2 lines – SDL and SCL. • Electrical interface to the I2C bus • Structure of an I2C bus system • Data link layer (4M) • Every I2C device has an address. • Format of an I2C address transmission. • Distributed computing.

Subject Code:EC6703 **Year/Semester: IV /07**
Subject Name: EMBEDDED & REAL TIME SYSTEMS **Subject Handler: W.NANCY**

UNIT V – CASE STUDY	
Data compressor - Alarm Clock - Audio player - Software modem-Digital still camera - Telephone answering machine-Engine control unit – Video accelerator.	
	PART * A
Q.No.	**Questions**
1.	**What is PIC?** BTL1 PIC refers to Programmable Intelligent Computer. PIC is microprocessor lies inside a personal computer but significantly simpler, smaller and cheaper. It can be used for operating relays, measuring sensors etc.
2	**What are the main elements inside a PIC?** BTL1 Processing engine, Program memory, data memory and Input/Output.
3	**What are the types of program memory in a PIC?** BTL1 Read-only, EPROM and EEPROM, Flash
4	**Define pseudo-code.** BTL1 Pseudo-code is a useful tool when developing an idea before writing a line of true code or when explaining how a particular procedure or function or even an entire program
5	**What is a PDA?** BTL1 PDA (Personal Digital Assistant) is a device that can be used to receive, display and transcribe information. PDA can run a wide variety of applications
6	**What is a set-top box or STB or STU?** BTL1 A set top box (STB) or set top unit (STU) is an information appliance device that generally contains a tuner and connects to a television set and an external source of signal, turning the source signal into content in a form that can then be displayed on the television screen or other display device. **USES :** Cable television and satellite television system
7	**What are FOSS tools in embedded systems?** BTL1 GNU Compiler Collection (gcc) and GNU debugger (gdb) are the most popular FOSS (Free

	and open source) tools used in embedded systems.
8	**List the major components in the Personal Digital Assistant System.** BTL1 Process or memory Connectivity Power management unit User interface.
9	**Why most designers use FOSS tools in embedded system development?** BTL1 Because, It makes software portable. It speeds up the development process It provides good foundation for system development activities.
10	**What is signal servicing function?** BTL1 The signal service is a bureau of the government organized to collect from the whole country simultaneously report to local metrological condition upon comparison of which at certain office, predictions concerning the weather are telegraphed to various sections also known as signal publicity display.
11	**Write short notes on H/W and S/W co-design.** BTL1 Embedded systems architecture design is the task of selecting and programming a suitable configuration of components for a required system application. Building an embedded system is not an easy task. Every embedded system consist of an embedded hardware and embedded software. So software and hardware plays a main role in design of embedded system architecture.
12	**Why we go for Co-Design?** BTL1 **Need For Co-Design :** Co-design refers to parallel or concurrent development of hardware and software for an embedded system. Co-design reduces the overall design and development cycle of the embedded system. It helps the designer to find the bugs at early stage. It also reduces the number of errors, particularly at the hardware-software interface level.
13	**What is MBasic Compiler Software?** BTL1 From version 5.3.0.0 onward, Basic Micro offers one version of its MBasic compiler, the “Professional” version. MBasic runs under Microsoft’s Windows operating system in any version from Windows 95 to Windows XP. The computer requires an RS-232 port for connection to the ISP-PRO programmer board.
14	**What is a Jog Memory?** BTL1 It is used to buffer data to maintain playing during a jog to the drive. The player reads ahead and puts data into the jog memory.
15	**What is EFM?** BTL1 Eight to fourteen encoding. It is used to ensure a minimum transition rate.
16	**State block motion estimation?** BTL1 Rather than sending each frame separately, as in motion JPEG, some frames are sent as modified forms of other frames using a technique known as block motion estimation.
17	**What is Engine control Unit?** BTL1 This unit controls the operation of a fuel injected engine based on several measurements taken from the running engine.

18	**Define Emios.** BTL1 Enhanced modular IO subsystem. It provides 28 input and output channels controlled by timers. Each channel can perform a variety of functions.
19	**Define OPWFMB.** BTL1 Output pulse width and frequency modulation buffered mode. It will automatically generate a waveform whose period and duty cycle can be varied by writing registers in the Emios.
20	**What is SAE?** BTL1 **Society of Automotive Engineers.** It has several standards for automotive software. e.g., J2632 – Coding practices for C code.
21	**What is EXIF?** BTL1 **Exchangeable Image File Format.** It is a standard widely used to further extend the information stored in an image file.
22	**What is DCF standard?** BTL1 **Design rule for Camera File standard.** It specifies 3 major steps. 1.JPEG Compression 2.EXIF file generation 3.DOS FAT image store
23	**What is TIFF?** BTL1 **Tagged Image File Format** It is often used to store uncompressed images. It also supports several compression methods as well.
24	**Write about thumbnail?** BTL1 It is the smaller version of a file used for quick display. It is widely used both by cameras and computers. It saves computation time and energy.
25	**What is Perpetual Coding?** BTL1 Audio compression is a lossy process that relies on perpetual coding. The coder eliminates certain features of the audio stream so that the result can be encoded in fewer bits.
	PART * B
1	**Explain the working of telephone answering machine. (13M)** BTL 2 **Answer: Page: 361 – 363 Marilyn wolf** **Operation** (5M) Adaptive differential pulse code modulation coding scheme. Simple technique but yields 2X compression ratios on voice data. ADPCM compression system. (1M) Encoder, Decoder. (7M) The answering machine ultimately connect to a telephone subscriber line. At the other end of the subscriber line is the central office.
2	**Explain the working of Engine control unit. (13M) (APR/MAY 2017)** BTL2 **Answer: Page: 369 – 370 Marilyn wolf** **Operation.** (7M) The engine measures throttle, rpm, intake air volume, and other variables.

	The engine controller computes injector pulse width, spark. **Working**(6M) The engine controller must deal with processes that happen at different rates. The controller adjusts duration up or down based upon readings from the exhaust oxygen sensor.
3	**Explain Video compression techniques in video accelerator. (13M)** BTL 2 **Answer: Page: 441 – 443 Marilyn wolf** **Compression techniques** (8M) It uses several component algorithms together in a feedback loop. The DCT used in JPEG plays a key role in MPEG 2. Black motion estimation, macro blocks, block diagram, block motion estimation.(5M)
4	**Explain briefly Data Compressor. (13M)** BTL 2 **Answer: Page: 137-141 Marilyn wolf** **Requirements, algorithm** (6M) Use Huffman coding technique. It takes in a sequence of input symbols and then produces a stream of output symbols. **UML collaboration** (5M) Input, data compressor, output for the data compressor. Name, data compression module. **Specifications** (2M) Definition of data compressor
5	**Elaborate the system architecture of Alarm clock. (13M)** BTL 2 **Answer: Page: 197-199 Marilyn wolf** **Major software components** (7M) State diagram for scan key board. Interrupt driven routine can update the current time. A foreground program can poll the buttons and execute their commands. **Functions** (6M) Preprocessing button inputs.
6	**Brief about Audio player with appropriate diagrams. (13M) (NOV/DEC 2017)** BTL2 **Answer: Page: 200-202 Marilyn wolf** **Theory of operation** (5M) Auto decompression, perceptual coding, masking. Layer 1, layer 2, layer 3. **Theory of Requirements** (5M) Purpose, inputs, outputs, functions, performance etc. MPEG Layer 1 encoder and decoder (3M) Filter bank, FFT, quantizer / encoder, masking model.
7	**With neat diagram explain the operation and requirements of Software Modem.(13M) (NOV/DEC 2017)** BTL2 **Answer: Page: 280-283 Marilyn wolf** **Operation** (7M) FSK detection scheme. Receiving bits in the modem with start bit and message bit along with sampling interval mentioned. **Requirements** (6M) Purpose, inputs, outputs, functions, performance, manufacturing cost and power, physical size and weight.
8	**Explain the operation of Digital Still Camera. (13M) (APR/MAY 2017)** BTL2 **Answer: Page: 285-290 Marilyn wolf**

	Theory of operation (5M) Determine the exposure and focus. Capture the image, develop the image, compress the image. Generate and store the image as a file. **Imaging algorithms** (3M) Pixels, luminance, chrominance, histogram. **Image Compression** (2M) Lossless and lossy compression, JPEG. **Requirements** (3M) Purpose, inputs, outputs, functions, performance, manufacturing cost and power, physical size and weight.
	PART *C
1	**Elaborate operation, requirements, specification, testing of a telephone answering machine. (15M)** BTL 2 **Answer: Page: 361-369 Marilyn wolf** **Operations** (5M) Adaptive differential pulse code modulation (ADPCM), coding scheme, ADPCM compression technique. **Requirements** (4M) Purpose, inputs, outputs, functions, performance, manufacturing cost and power, physical size and weight. **Specification** (4M) Class diagram for the answering machine, physical class interfaces, message classes, operational classes and state diagram. **Testing** (2M) The modules should be tested.
2	**Brief about Engine control unit with architecture and component design and testing. (15M) (NOV/DEC 2017)** BTL2 **Answer: Page: 371 – 374 Marilyn wolf** **Operation**. (7M) The engine measures throttle, rpm, intake air volume, and other variables. The engine controller computes injector pulse width, spark. **Working**(6M) The engine controller deals with processes that happen at different rates. The controller adjusts duration up or down based upon readings from the exhaust oxygen sensor. **Design and testing**. (2M) Any testing performed on an actual engine must be conducted using an engine controller.
3	**Explain design process in software modem. (15M) (APR/MAY 2016)** BTL2 **Answer: Page: 280 - 285 Marilyn wolf** **Operation** (4M) FSK detection scheme. Receiving bits in the modem with start bit and message bit along with sampling interval mentioned. **Requirements** (2M) Purpose, inputs, outputs, functions, performance, manufacturing cost and power, physical size and weight. **Specification**. (3M) Class diagram for modem. The class include physical classes for line – in, line – out.

	System architecture. (4M) One small subsystem – Interrupt handlers 2 major subsystems – Transmitter, Receiver Component design, testing. (2M) Test bench construction. Test the bit detectors.

EC6004 **SATELLITE COMMUNICATION** **L T P C**
3 0 0 3

OBJECTIVES:

The student should be able to:

- Understand the basics of satellite orbits.
- Understand the satellite segment and earth segment.
- Analyze the various methods of satellite access.
- Understand the applications of satellites

UNIT I SATELLITE ORBITS 9

Kepler‟s Laws, Newton‟s law, orbital parameters, orbital perturbations, station keeping, geo stationary and non Geo - stationary orbits – Look Angle Determination Limits of visibility – eclipse - Sub satellite point – Sun transit outage - Launching Procedures - launch vehicles and propulsion

UNIT II SPACE SEGMENT AND SATELLITE LINK DESIGN 9

Spacecraft Technology - Structure, Primary power, Attitude and Orbit control, Thermal control and Propulsion, communication Payload and supporting subsystems, Telemetry, Tracking and command. Satellite uplink and downlink Analysis and Design, link budget, E/N calculation - performance impairments - system noise, inter modulation and interference, Propagation Characteristics and Frequency considerations System reliability and design lifetime.

UNIT III EARTH SEGMENT 9

Introduction – Receive – Only home TV systems – Outdoor unit – Indoor unit for analog (FM) TV – Master antenna TV system – Community antenna TV system – Transmit – Receive earth stations – Problems – Equivalent isotropic radiated power – Transmission losses – Free - space transmission – Feeder losses – Antenna misalignment losses – Fixed atmospheric and ionospheric losses – Link power budget equation – System noise – Antenna noise – Amplifier noise temperature – Amplifiers in cascade – Noise factor – Noise temperature of absorptive networks – Overall system noise temperature – Carrier to - Noise ratio – Uplink – Saturation flux density – Input back off – The earth station - HPA – Downlink – Output back off – Satellite TWTA output – Effects of rain – Uplink rain – Fade margin – Downlink rain – Fade margin – Combined uplink and downlink C/N ratio – Inter modulation noise.

UNIT IV SATELLITE ACCESS 9

Modulation and Multiplexing: Voice, Data, Video, Analog – digital transmission system, Digital video Brocast, multiple access: FDMA, TDMA, CDMA, Assignment Methods, Spread Spectrum communication, compression – encryption.

UNIT V SATELLITE APPLICATIONS 9

INTELSAT Series, INSAT, VSAT, Mobile satellite services: GSM, GPS, INMARSAT, LEO, MEO, Satellite Navigational System. Direct Broadcast satellites (DBS) - Direct to home Broadcast (DTH), Digital audio broadcast (DAB) – World space services, Business TV(BTV), GRAMSAT, Specialized services – E –mail, Video conferencing, Internet.

TOTAL: 45 PERIODS

OUTCOMES:

Upon Completion of the course, the students will be able to:

- Analyze the satellite orbits.
- Analyze the earth segment and space segment.
- Design various satellite applications

TEXT BOOK:

1. Dennis Roddy, “Satellite Communication”, 4th Edition, Mc Graw Hill International, 2006.

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REGULATION : 2013 **ACADEMIC YEAR : 2018-2019**

Subject Code: EC6004 **Year/Semester: IV /07**
Subject Name: SATELLITE COMMUNICATION **Subject Handler: R.Thandaiah Prabu**

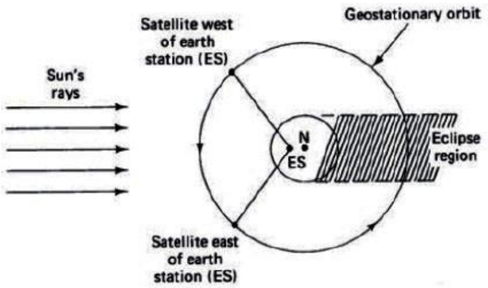
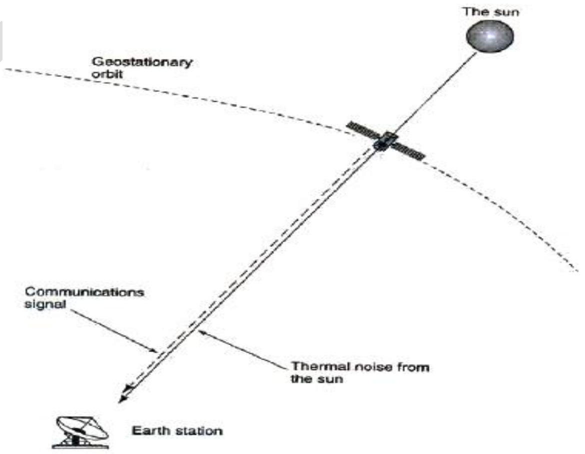
UNIT I - SATELLITE ORBITS

Keplers Laws, Newtons law, orbital parameters, orbital perturbations, station keeping, geo stationary and non Geo - stationary orbits – Look Angle Determination Limits of visibility – eclipse - Sub satellite point – Sun transit outage - Launching Procedures - launch vehicles and propulsion.

PART * A

Q.No.	Questions
1.	**What is Satellite?** BTL1 An artificial body that is projected from earth to orbit either earth (or) another body of solar systems. Types: Information satellites and Communication Satellites
2	**Define Satellite Communication.** BTL1 It is defined as the use of orbiting satellites to receive, amplify and retransmit data to earth stations.
3	**State Kepler's first law.** BTL1 It states that the path followed by the satellite around the primary will be an ellipse. An ellipse has two focal points F1 and F2. The center of mass of the two body system, termed the barycenter is always centered on one of the foci. e = [square root of (a2– b2)] / a
4	**State Kepler's second law.** BTL1 It states that for equal time intervals, the satellite will sweep out equal areas in its orbital plane, focused at the barycenter
5	**State Kepler's third law.** BTL1 It states that the square of the periodic time of orbit is perpendicular to the cube of the mean distance between the two bodies. Where, n = Mean motion of the satellite in rad/sec. μ= Earth's geocentric gravitational constant. With the n in radians per sec. the orbital period in second is given by, $a^3 = \frac{\mu}{n^2}$ $p = \frac{2\pi}{n}$
6	**Define apogee.** BTL1 The point farthest from the earth.
7	**Define Perigee.** BTL1 The point closest from the earth.
8	**What is line of apsides?** BTL1 The line joining the perigee and apogee through the center of the earth.
9	**Define ascending node.** BTL1 The point where the orbit crosses the equatorial plane going from south to north
10	**Define descending node.** BTL1 The point where the orbit crosses the equatorial plane going from north to south

11	**Define Inclination.** BTL1 The angle between the orbital plane and the earth's equatorial plane. It is measured at the ascending node from the equator to the orbit going from east to north.
12	**Define mean anomaly.** BTL1 It gives an average value of the angular position of the satellite with reference to the perigee.
13	**Define true anomaly.** BTL1 It is the angle from perigee to the satellite position, measured at the earth's center.
14	**What is meant by azimuth angle?** BTL1 It is defined as the angle produced by intersection of local horizontal plane and the plane passing through the earth station, the satellite and center of earth.
15	**Give the 3 different types of applications with respect to satellite systems.** BTL1 • The largest international system (Intelsat) • The domestic satellite system (Dom sat) in U.S. • U.S. National oceanographic and atmospheric administrations (NOAA)
16	**Mention the 3 regions to allocate the frequency for satellite services.** BTL1 • Region1: It covers Europe, Africa and Mangolia • Region2: It covers North & South Ameriaca and Greenland. • Region3: It covers Asia, Australia and South West Pacific.
17	**Give the types of satellite services.** BTL1 • Fixed satellite service, • Broadcasting satellite service • Navigational satellite services, • Mobile satellite service • Meteorological satellite services
18	**What is mean by Dom sat?** BTL1 Domestic Satellites. These are used for voice, data and video transmissions within the country.
19	**What is mean by INTELSAT & SARSAT ?** BTL1 International Telecommunication Satellite, Search and rescue satellite.
20	**Define polar-orbiting satellites.** BTL1 Polar orbiting satellites orbit the earth in such a way as to cover the north and south polar regions.
21	**Give the advantage of geostationary orbit.** BTL1 There is no necessity for tracking antennas to find the satellite positions.
22	**Define look angles. BTL1** The azimuth and elevation angles of the ground station antenna are termed as look angles.
23	**Write short notes on station keeping.** BTL1 It is the process of maintenance of satellite's attitude against different factors that can cause drift with time. Satellites need to have their orbits adjusted from time to time, because the satellite is initially placed in the correct orbit, natural forces induce a progressive drift.
24	**What are the geostationary satellites?** BTL1 The satellites present in the geostationary orbit are called geostationary satellite. The geostationary orbit is one in which the satellite appears stationary relative to the earth. It lies in equatorial plane and inclination is '0'. The satellite must orbit the earth in the same direction as the earth spin. The orbit is circular.

25	**What is sun transit outage.** BTL1 The sun transit is nothing but the sun comes within the beam width of the earth station antenna. During this period the sun behaves like an extremely noisy source and it blanks out all the signal from the satellite. This effect is termed as sun transit outage.
	PART * B
1	**Describe in details about earth eclipse of satellite and sun transit outage (13 M)** BTL2 **Answer: Page: 92-94 - Dennis Roddy** **Eclipse:** GEO eclipsed each day & tilted 23.4°. **(4 M)** Spring equinox & autumnal equinox. Eclipse - solar cells do not function, Operating power - batteries. **(3 M)**  **<u>Sun transit outage</u>** Added noise temperature **(3 M)** 6000 to 10000 K Depend on - antenna size, elevation angle, location and environment.  **(3 M)**
2	**What are orbital elements? Derive the six orbital elements of satellite from Kepler's three laws of planetary motion. (13 M)** BTL2 **Answer: Page: 29- 31, 35 - Dennis Roddy** **The orbital elements: (7 M)** 1. The semi major axis (a) – half of major axis 2. The eccentricity (e) - oblateness 3. The mean anomaly (M) – average angle 4. The argument of perigee – line of nodes to perigee

5. The inclination – angle from equator
6. The right ascension of the ascending node – first time arises to ascending node

1. **Kepler's first law** - Orbit elliptical, sun one of the foci. **(6 M)**
2. **Kepler's second law** - Equal time intervals, satellite will sweep equal areas
3. **Kepler's third law** square of the periodic time of orbit = cube of the mean distance $(D_1/D_2)^3 = (P_1/P_2)^2$

3 **Explain about Geo-stationary & near Geo-stationary orbits. (13 M)** BTL2

Answer: Page: 77, 89 - Dennis Roddy

Satellite follows as it revolves around earth **(3 M)**

Depending on: Altitude, Inclination & Orbital Period

Table - **(3 M)**

Features	GEO	MEO	LEO
Height (Km's)	36000	6000 - 12000	200 – 3000
Time per orbit (Hrs)	24	5 – 12	1.5
Speed (Km's / hr)	11000	19000	27000
Time Delay (ms)	250	80	10
Time in Site of Gateway	Always	2 – 4 hrs	< 15 min
Satellite for Global Coverage	3	10 – 12	50 – 70

4 **Explain about frequency allocations for satellite services. (13 M)** BTL2

Answer: Page: 2 Dennis Roddy

share limited frequency band **(6 M)**

Table - **(7 M)**

Band	Uplink (GHz)	Downlink (GHz)
C	6	4
Ku	14	12
Ka	30	20
X	8.2	7.5
S	40	20
Q	44	21
L	1.525 to 1.559	1.626 to 1.660

5 **Explain about the Orbital perturbations in detail (13 M)** BTL2

Answer: Page: 38 - Dennis Roddy

Gravitational pull of sun and moon **(2 M)**

Effect of a Non Spherical Earth **(3 M)**

Oblate Spheroid

$$n = n_o\left[1 + \frac{k_1(1 - 1.5\sin^2 i)}{a^2(1 - e^2)^{1.5}}\right]$$

Anamalistic period - earth's oblateness **(2 M)**

$$p_A = \frac{2\pi}{n}$$

Regression of the nodes - opposite to the direction of satellite motion **(2 M)**

Equatorial ellipticity - not perfectly circular, eccentricity order 10^{-5}**. (2 M)**

Atmospheric drag - below about 1000 km **(2 M)**

6 **Determine the limits of visibility for an earth station situated at mean sea level, at latitude**

48.42° north, and longitude 89.26 degrees west. Assume a minimum angle of elevation of 5°. (13 M) BTL3

Answer: Page: 87 - Dennis Roddy

$$\lambda_E = 48.42°, \Phi E = -89.26°, El\min = 5° \quad \textbf{(1 M)}$$

$$\sigma_{\min} = 90° - El_{\min} = 95° \quad \textbf{(2 M)}$$

$$S = \arcsin\left(\frac{R}{a_{GSO}}\sin\sigma_{\min}\right) = 8.66° \quad \textbf{(2 M)}$$

$$b = 180 - \sigma_{\min} - S = 76.34° \quad \textbf{(2 M)}$$

$$B = \arccos\left(\frac{\cos b}{\cos\lambda_E}\right) = 69.15° \quad \textbf{(2 M)}$$

$$\Phi E + B \approx -20° \quad \textbf{(2 M)}$$

$$\Phi E - B \approx -158° \quad \textbf{(2 M)}$$

7 **A geostationary satellite is located at 90°W. Calculate the azimuth angle for an earth station antenna at latitude 35°N and longitude 100°W. And also find the range and antenna elevation angle. (13 M)** BTL3

Answer: Page: 78 - Dennis Roddy

Φ_{SS} = - 90° (West) **,** λ_E = 35° (North), Φ_E = - 100° (West) **(1 M)**

$B = \Phi_E - \Phi_{SS} = -100 + 90 = -10°$ **(2 M)**

$$b = \arccos(\cos \boldsymbol{B} \cos\lambda_E) = 36.23° \quad \textbf{(2 M)}$$

$$A = \arcsin\left(\frac{\sin|B|}{\sin b}\right) = 17.1° \quad \textbf{(2 M)}$$

azimuth is, by inspection, λ_E *> 0 and B < 0, therefore Az =180°- A = 162.9 °* **(2 M)**

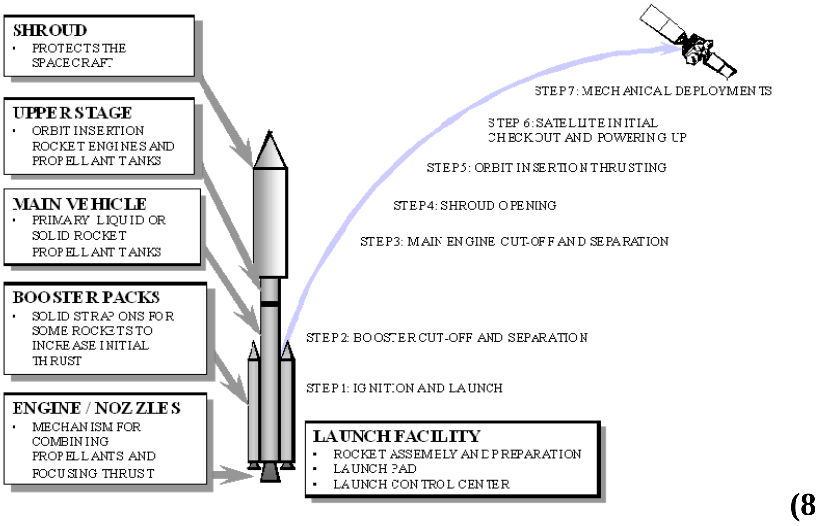
$$d = \sqrt{R^2 + a^2{}_{GSO} - 2Ra_{GSO}\cos b} = 37215 \text{ km} \quad \textbf{(2 M)}$$

$$El = \arccos\left(\frac{a_{GSO}}{d}\sin b\right) = 48° \textbf{(2 M)}$$

PART * C

1 **Illustrate the procedures employed for launching spacecraft in GEO orbits. (15 M)** BTL3

Answer: **Page: 94 - Dennis Roddy**

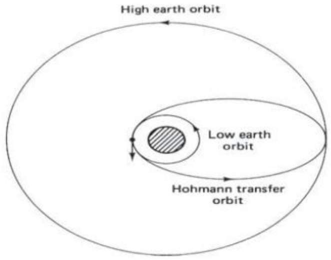


(8 M)

Launch vehicles: expendable or reusable. **(1 M)**

Methods of launching a satellite: Using apogee kick motor, Using spacecraft thrusters, Direct insertion to GEO **(1 M)**

Diagram - (1 M)



Hohmann transfer orbit – parking orbit **(2 M)**

$$U = \frac{1}{2}\, mv^2 - \frac{GmM}{r} \ \textbf{(2 M)}$$

Final velocity - sum of the velocity increments of all the stages.

2

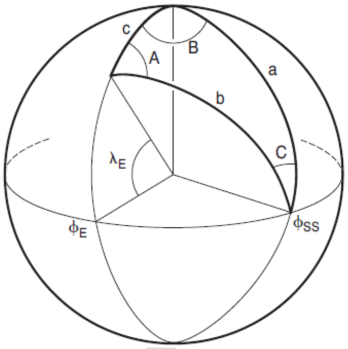
What are look angles and derive the expressions for azimuth and elevation BTL2

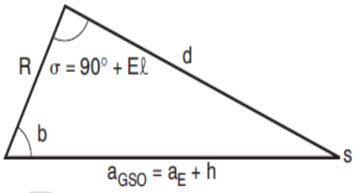
Answer: Page: 78 - Dennis Roddy

Look angles for the geostationary: latitude $\lambda_{E,,}$ longitude Φ_{E} , subsatellite point Φ_{SS} **(5 M)**

Latitudes: North - positive angles, south negative angles.

Longitudes : East - positive angles, west - negative angles.





(5 M)

a = 90°, c = 90°- λ_E *and B*= Φ_E - Φ_{SS} **(5 M)**

Napier's rules $b = \arccos(\cos \boldsymbol{B} \cos \lambda_E)$

$$A = \arcsin\left(\frac{\sin|B|}{\sin b}\right)$$

Angle	λ_E	**B**	**A_z, Degrees**
a	< 0	< 0	A
b	< 0	> 0	360° - A
c	> 0	< 0	180° - A
d	> 0	> 0	180° + A

range *d* $d = \sqrt{R^2 + a^2{}_{GSO} - 2Ra_{GSO} \cos b}$

Angle of elevation $El = \arccos\left(\frac{a_{GSO}}{d}\sin b\right)$

3

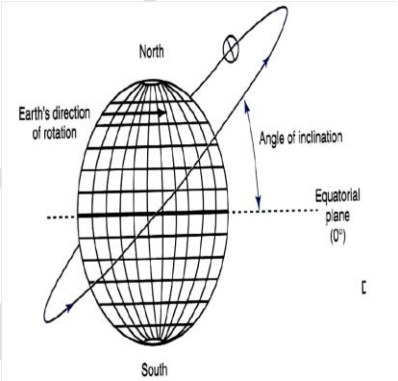
Illustrate the orbital parameters with suitable diagrams (15 M) BTL3

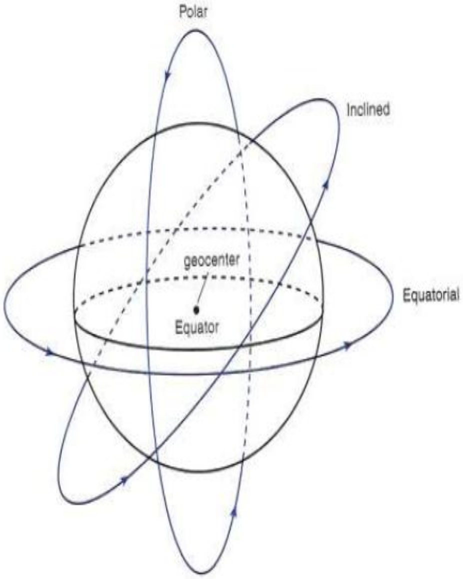
Answer: Page: 32 - Dennis Roddy

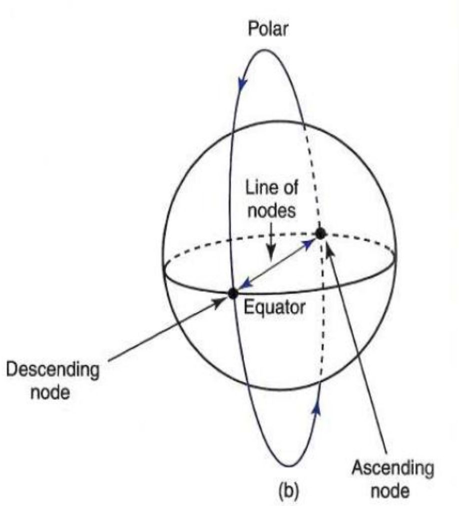
Diagram (7 M)

16 points - (8 M)

1. Sub Satellite Path – Point to trace
2. Apogee – Farthest Distance
3. Perigee – Closest
4. Line of apsides – Joining of Apogee and Perigee
5. Ascending node – South to north
6. Descending node – North to South
7. Line of nodes – Joining of Ascending and Descending
8. Inclination – Angle from Equator
9. Declination – Angle of Tilt
10. Prograde orbit – West to East
11. Retrograde orbit – East to West
12. Argument of perigee (w) – Line of Nodes to Perigee
13. Right ascension of the ascending node (Ω) – First time of arises to ascending node
14. Mean Anomaly – Average Angle
15. True Anomaly – True Angle







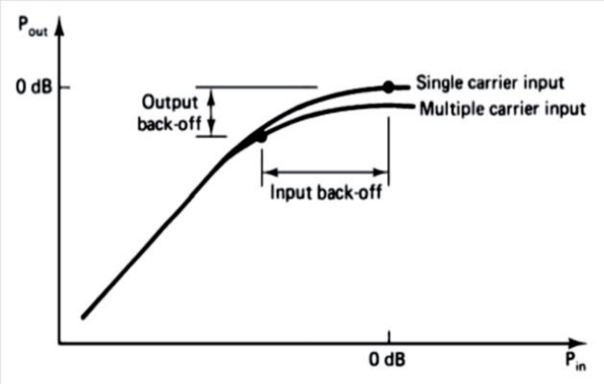
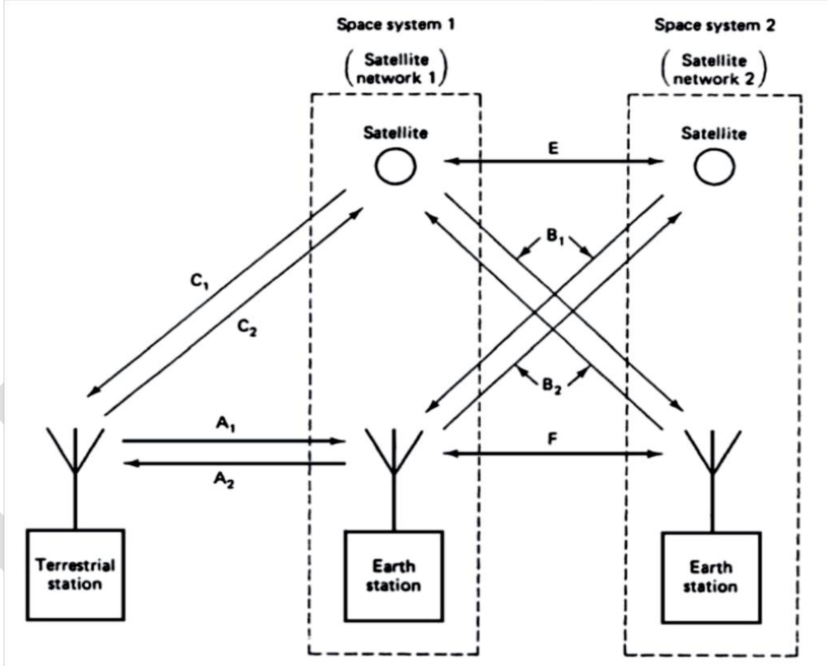
UNIT II - SPACE SEGMENT AND SATELLITE LINK DESIGN

Spacecraft Technology - Structure, Primary power, Attitude and Orbit control, Thermal control and Propulsion, communication Payload and supporting subsystems, Telemetry, Tracking and command. Satellite uplink and downlink Analysis and Design, link budget, E/N calculation - performance impairments - system noise, inter modulation and interference, Propagation Characteristics and Frequency considerations - System reliability and design lifetime.

PART * A

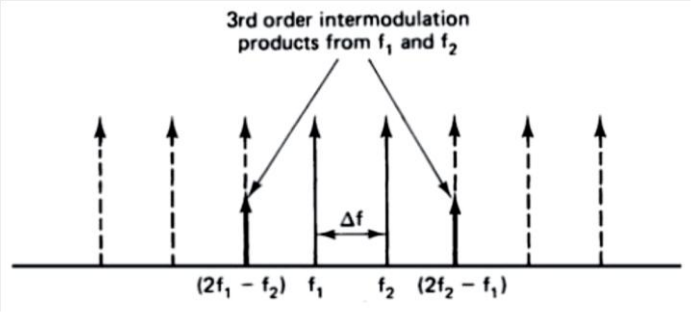
Q.No.	Questions
1.	**Give the two segments of basic satellite communication.** BTL1 a. Earth segment (or) ground segment b. Space segment
2	**Write short notes on attitude control system?** BTL1 It is the system that achieves and maintains the required attitudes. The main functions of attitude control system include maintaining accurate satellite position throughout the life span of the system.
3	**What is declination?** BTL1 The angle of tilt is often referred to as the declination which must not be confused with the magnetic declination used in correcting compass readings.
4	**What is meant by payload?** BTL1 It refers to the equipment used to provide the service for which the satellite has been launched.
5	**What is meant by transponder?** BTL1 In a communication satellite, the equipment which provides the connecting link between the satellites transmit and receive antennas is referred to as the transponder.
6	**Write short notes on station keeping.** BTL1 It is the process of maintenance of satellite's attitude against different factors that can cause drift with time. Satellites need to have their orbits adjusted from time to time, because the satellite is initially placed in the correct orbit, natural forces induce a progressive drift.
7	**What is meant by Pitch angle?** BTL1 Movement of a spacecraft about an axis which is perpendicular to its longitudinal axis. It is the degree of elevation or depression.
8	**What is an propellant?** BTL1 A solid or liquid substance burnt in a rocket for the purpose of producing thrust
9	**What is an Yaw?** BTL1 Yaw is the rotation of a vehicle about its vertical axis.
10	**What is an zero 'g'?** BTL1 Zero 'g' is a state when the gravitational attraction is opposed by equal and opposite inertial forces and the body experiences no mechanical stress.
11	**Describe the spin stabilized satellites.** BTL1 In a spin stabilized satellites, the body of the satellite spins at about 30 to 100 rpm about the axis perpendicular to the orbital plane. The satellites arm normally dual spin satellites with a spinning section and a despun section on which antennas are mounted. These are kept stationary with respect to earth by counter rotating the despun section.
12	**What is meant by frequency reuse?** BTL1 The carrier with opposite senses of polarization may overlap in frequency. This technique is

	known as frequency reuse.
13	**What is meant by spot beam antenna?** BTL1 A beam generated by a communication satellite antenna of sufficient size that the angular spread of sufficient size that the angular spread of the energy in the beam is very small with the result that a region that is only a few hundred km in diameter is illuminated on earth.
14	**What is meant by momentum wheel stabilization?** BTL1 During the spin stabilization, flywheels may be used rather than spinning the satellite. These flywheels are termed as momentum wheels.
15	**What is polarization interleaving?** BTL1 Overlap occurs between channels, but these are alternatively polarized left hand circular and right hand circular to reduce interference to acceptable levels. This is referred to as polarization interleaving.
16	**Define S/N ratio.** BTL1 The S/N introduced in the preceding section is used to refer to the ratio of signal power to noise power at the receiver output. This is known as S/N ratio.
17	**What is an intermodulation noise?** BTL1 Intermodulation distortion in high power amplifier can result in signal products which appear as noise and it is referred to as intermodulation noise.
18	**What is an antenna loss?** BTL1 It is added to noise received as radiation and the total antenna noise temperature is the sum of the equivalent noise temperature of all these sources.
19	**What is TWTA?** BTL1 TWTA means Traveling Wave Tube Amplifier. The TWTA is widely used in transponder to provide the final output power required to the trans tube and its power supplies.
20	**What is meant by thermal control and why this is necessary in a satellite?** BTL1 Equipment in the satellite generates heat which has to be removed. The element used in the satellite to control thermal heat is called thermal control. The most important consideration is that the satellite's equipment should operate as nearly as possible in a stable temperature environment
21	**What are the functions carried out in TT&C?** BTL1 Telemetry- Gathering or measure information about satellite. Tracking- track the satellite's movement and send correction signals as Required Comment- sends information about the satellite to earth station.
22	**List out the advantages of TWT.** BTL1 The advantage of the TWT over other types of tube amplifiers is that it can provide amplification over a very wide bandwidth. Input levels to the TWT must be carefully controlled, however, to minimize the effects of certain forms of distortion
23	**Define input back off.** BTL1 In a TWTA, the operating point must be backed off to a linear portion of the transfer characteristic to reduce the effects of intermodulation distortion. The point from the saturation point to linear region at the input is called input backoff.
24	**What is meant by Pitch, yaw and roll axis?** BTL1 **Roll, pitch, and yaw axes.** The yaw axis is directed toward the earth's center, the pitch axis is normal to the orbital plane, and the roll axis is perpendicular to the other two. For an equatorial orbit, movement of the satellite about the roll axis moves the antenna footprint north and south; movement about the pitch axis moves the footprint east and west; and movement

	about the yaw axis rotates the antenna footprint.
25	**Why the operation near the saturation point of a TWTA is to be avoided when multiple carriers are being amplified simultaneously?** BTL1 In order to reduce the inter modulation distortion; the operating point of the TWT must be shifted closer to the linear portion of the curve to control the sideband generation. After the modulation due to nonlinear transfer characteristics in the curve. 
	PART * B
1	**Describe various interference noise in detail. (13 M)** BTL2 **Answer: Page: 399 - Dennis Roddy**  **(5 M)** ***A*1:** Interference - earth station **(8 M)** ***A*2:** Interference - terrestrial station ***B*1:** Interference - earth station of another space system ***B*2:** Interference - space station of another space system ***C*1:** Interference - terrestrial station ***C*2:** Interference - space station ***E:*** Interference - space station of another space system ***F:*** Interference - earth station of another space system
2	**Describe the various Intermodulation Noise in detail (13 M)** BTL 2

Answer: Page: 383 - Dennis Roddy

Multiple carriers pass through any device with nonlinear characteristics. **(2 M)**



(3 M)

Intermodulation noise: (8 M)

Intermodulation products are not distinguishable separately

$$\frac{N_o}{C} = \left(\frac{N_o}{C}\right)_U + \left(\frac{N_o}{C}\right)_D + \left(\frac{N_o}{C}\right)_{IM}$$

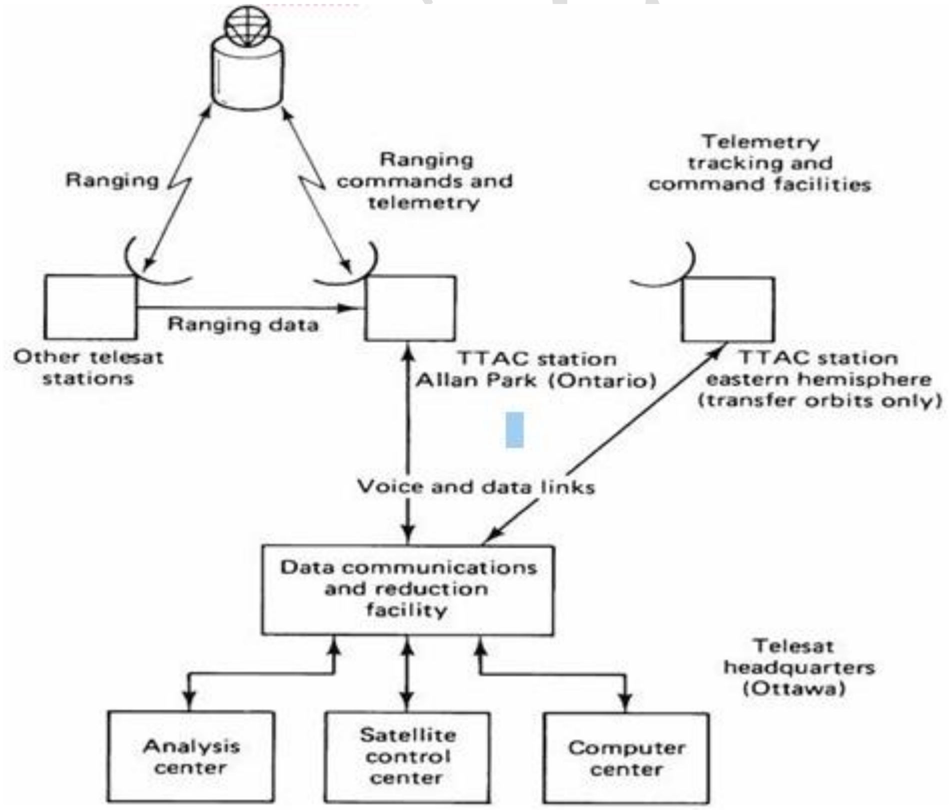
$$\left[\frac{\mathrm{C}}{\mathrm{N}_0}\right]_D = [\mathrm{EIRP}]_D - [\mathrm{B}_o]_o + \left[\frac{\mathrm{G}}{\mathrm{T}}\right]_D - [\mathrm{LOSSES}]_D - [\mathrm{K}]$$

3

Illustrate the concept of Telemetry, Tracking & Command and explain its blocks (13 M)

BTL3

Answer: Page: 212 - Dennis Roddy



(4M)

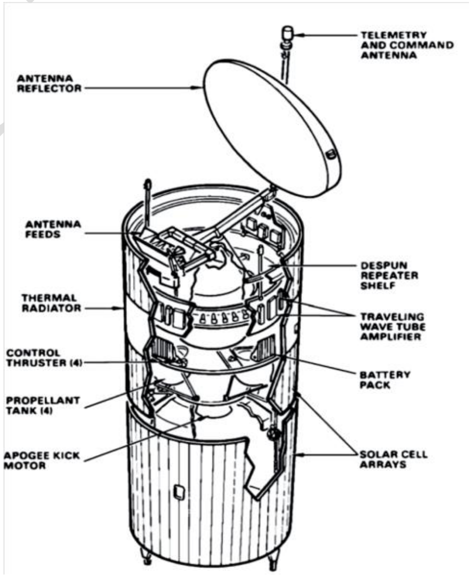
Telemetry (3 M)
Attitude Information
Magnetic Field Intensity
Direction and Spacecraft Information
Temperatures
Power Supply Voltages and Stored Fuel Pressure.

Tracking (3 M)
Transfer and drift orbital phases
various disturbing forces
Track the satellite's movement
Send correction signals

Command (3 M)
Manual operation
Transponder switching
Station keeping
Attitude changes
Gain control
Redundancy control.
Separation commands,
Antenna and solar panel deployment
Apogee motor firing

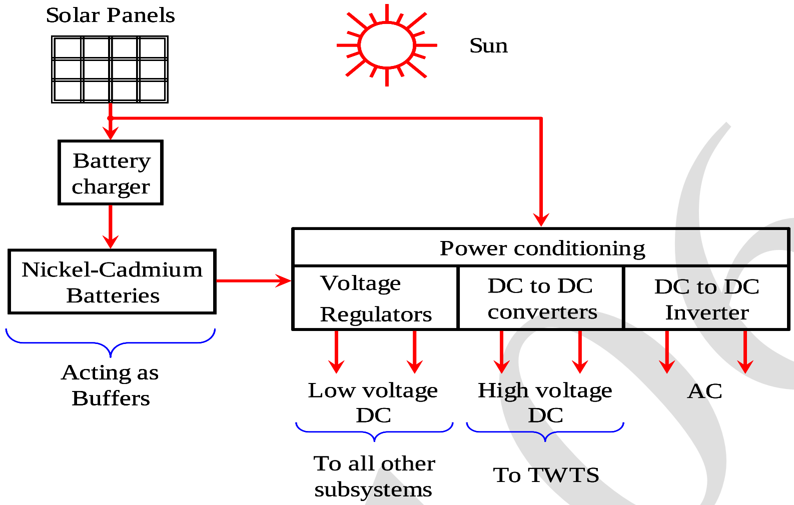
4

Explain Thermal Control & Power Supply in satellite communication system (13 M) BTL2
Answer: Page: 199 - Dennis Roddy
Thermal Control (6 M)
Stable temperature environment.
Thermal blankets and shields - provide insulation.



The Power Supply (7 M)

The primary electrical power - solar cells.
Higher power solar cells - ***solar sails.***



5 **Briefly explain about design life time and system reliability in satellite communication system (13 M)** BTL2

Answer: Page: 219 - Dennis Roddy

Design Lifetime (5 M)

1. Type of service to be provided (DTH/DBS)
2. communication capacity (Transponder Bandwidth, EIRP)
3. coverage area
4. technological limitations
5. Environmental conditions

Environmental conditions (3 M)

1. Zero Gravity
2. Atmospheric pressure and temperature
3. Space particles
4. Magnetic fields
5. Other considerations

System Reliability (5 M)

Reliability - space craft components.
Probability - component or system performs within a specified time t.

$$R = e^{-\int_0^t \lambda dt}$$

High failure, low failure and random failures

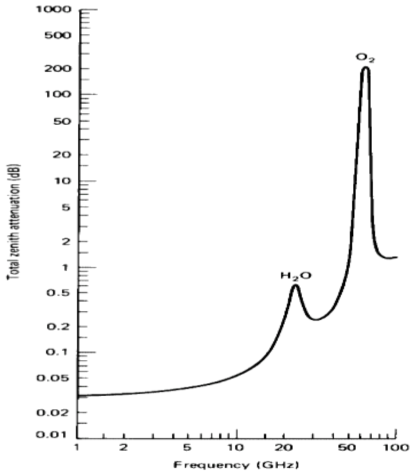
6 **Describe the various Propagation factors/ Atmospheric Losses in detail (13 M)** – BTL2

Answer: Page: 103 - 130 - Dennis Roddy

Atmospheric Attenuation – weather related losses **(2 M)**

Atmospheric Absorption - absorption losses**.**

Total attenuation A = αL [dB]



Disturbances: **(2 M)**

- Scintillation;
- Polarization rotation.
- Absorption
- Dispersion
- Frequency change
- Variation in direction of arrival

Diagram - (3 M)

Scintillations – variation in amplitude, phase, polarization, or angle **(2 M)**

Polarization (2 M)
Property - Electromagnetic waves
Electric and Magnetic - polarization of the signal.

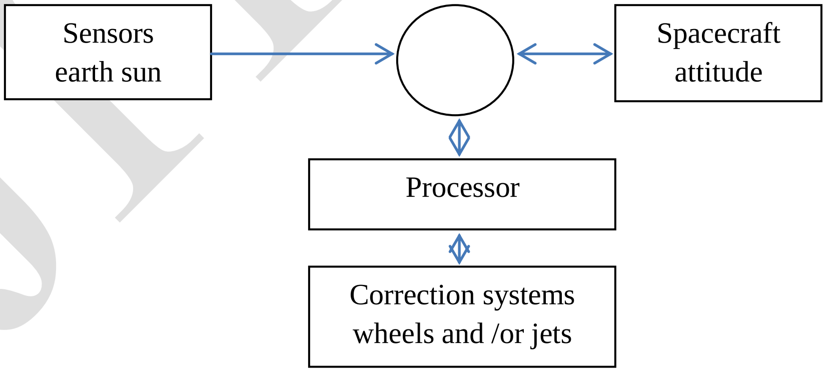
Types: (2 M)
Linear polarization
Circular polarization
Elliptical polarization

PART * C

1

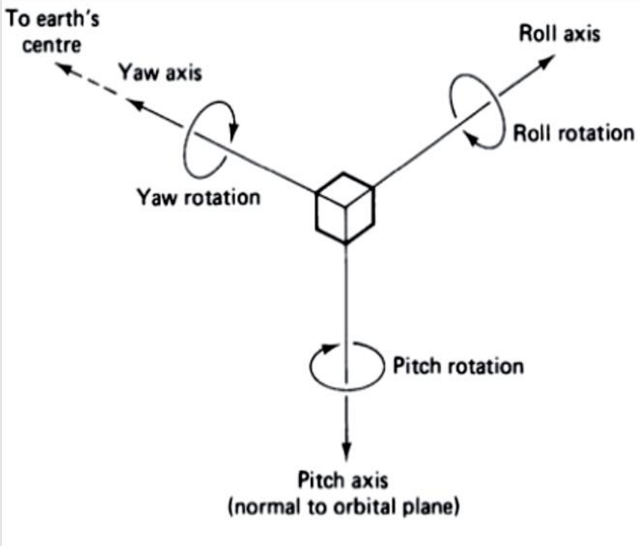
With a neat block diagram, explain the attitude and orbit control system present in the space segment. (15 M) – BTL2
Answer: Page: 202 - Dennis Roddy
The attitude control subsystem: **(2 M)**

- Antennas – toward the earth
- Solar array - toward the sun.

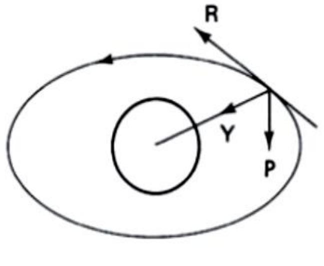


(2 M)

Corrections - spinning momentum wheels or by thrusters, or by some combination.



(a)



(b)

(2 M)

yaw axis - toward the earth's center **(2 M)**
pitch axis - orbital plane
roll axis - perpendicular to the other two.
Roll axis - antenna footprint north and south
pitch axis - footprint east and west
yaw axis - rotates the antenna footprint.

Methods of stabilization:

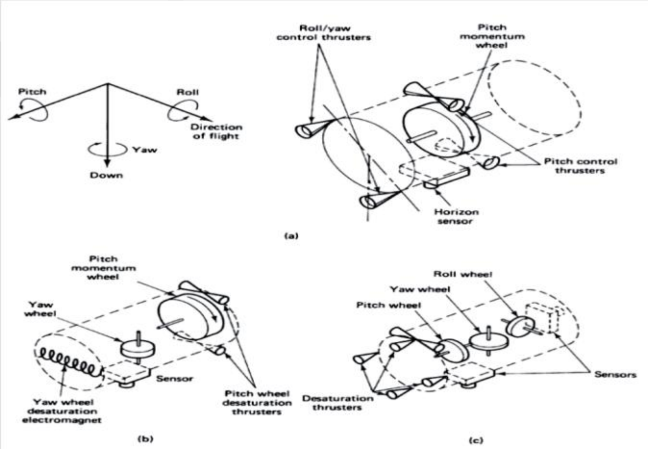
Passive methods: Include gravity-gradient stabilization and magnetic damping **(2 M)**

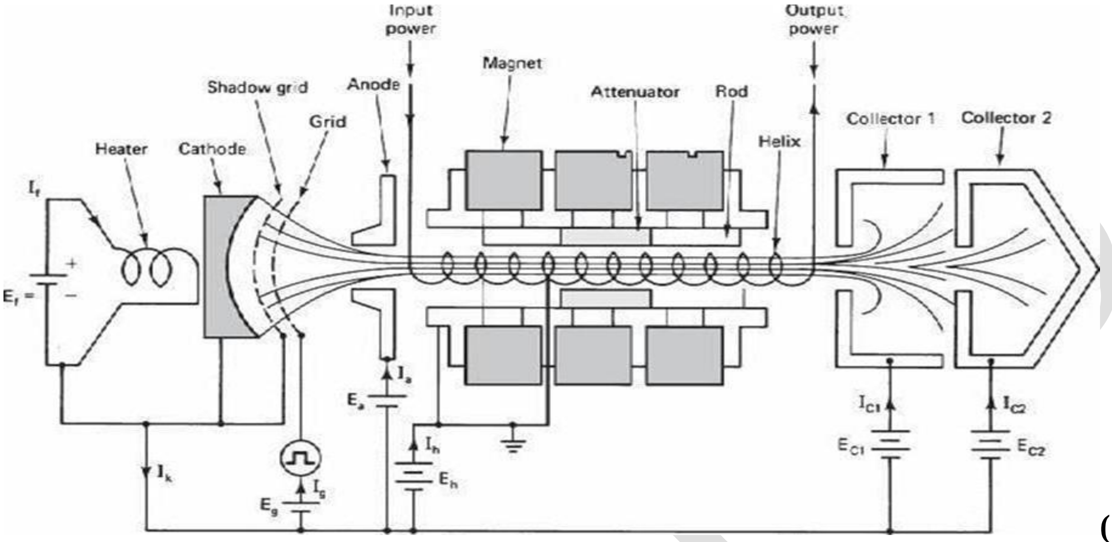
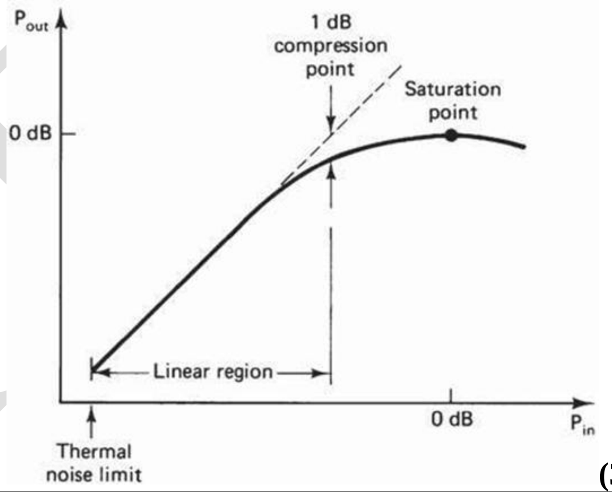
Active methods: Include spin stabilization and three axis stabilization.

Spinning satellite stabilization: (2 M)

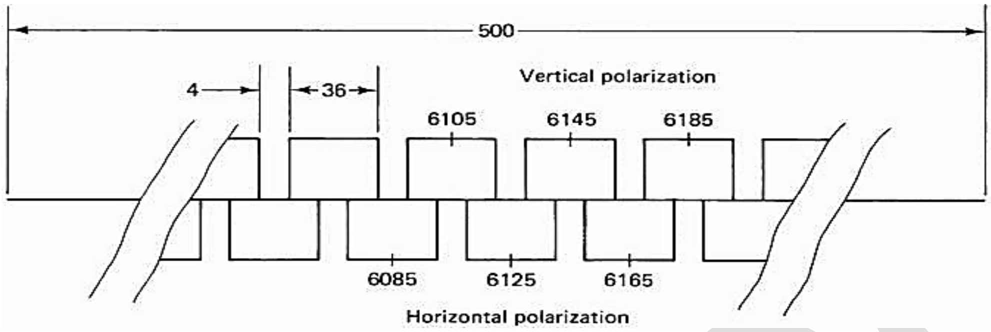
- Cylindrical satellites.
- Mechanically balanced about one particular axis nutation dampers.
- momentum wheels
- Reaction wheel.

(3 M)



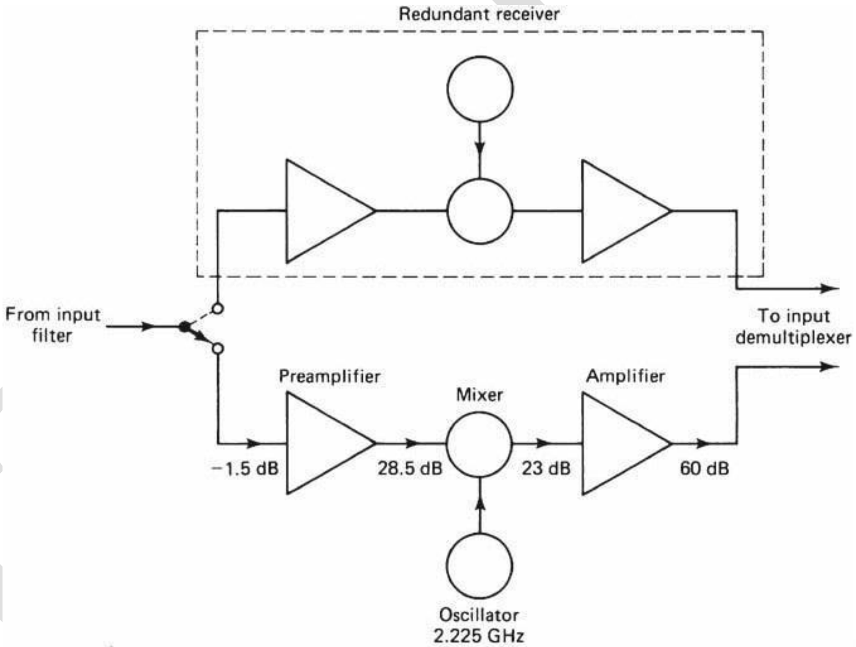
2	**Describe briefly the most common type of high-power amplifying device used aboard a communication satellite. (15 M)** BTL2 **Answer: Page: 218 - Dennis Roddy**  **(7 M)** Traveling-wave tube amplifiers (TWTAs) - final output power. **(5 M)** Helix - slow wave structure. Amplification - wide bandwidth. Maximum power output - saturation point. thermal noise limit at the low end - ***1dB compression point***  **(3 M)**
3	**Describe the Communication Payload for the space segment in detail (15 M)** BTL2 **Answer: Page: 213 - Dennis Roddy** Series of interconnected units **(2 M)** Single communications channel - communications satellite. Transponder bandwidth - 36 MHz **(3 M)** 4 MHz guard band between transponders

12 transponders
500-MHz bandwidth

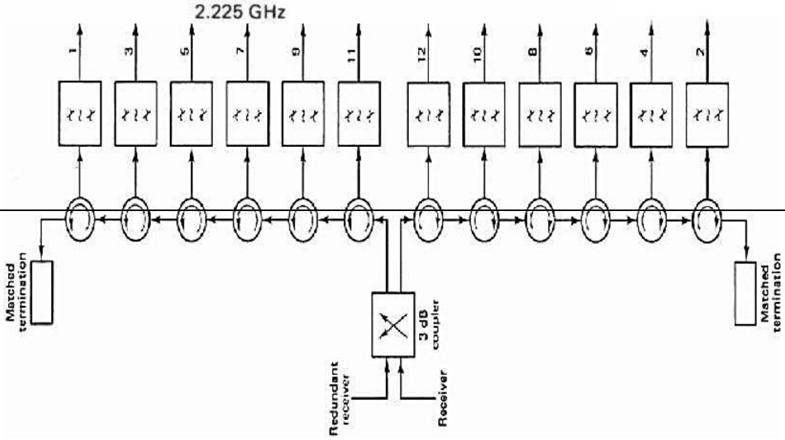


(2 M)

The wideband receiver (4 M)
duplicate receiver
redundant receiver



The input Demultiplexer (4 M)
Separates the broadband input
Frequency range 3.7 to 4.2 GHz
Greater frequency separation
Adjacent channel interference.

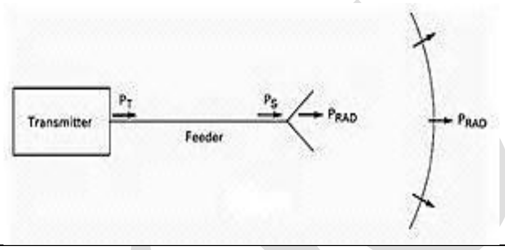


UNIT III - EARTH SEGMENT

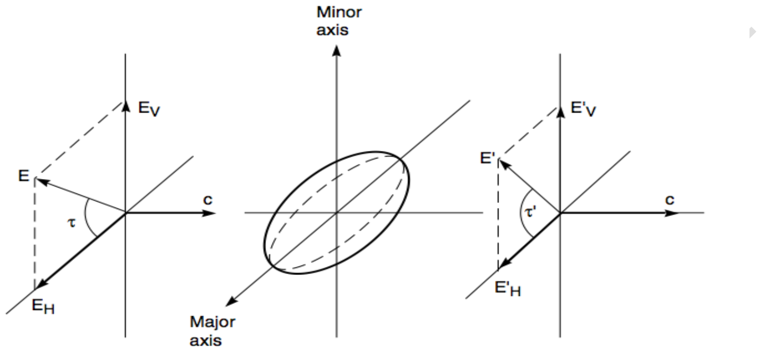
Introduction – Receive – Only home TV systems – Outdoor unit – Indoor unit for analog (FM) TV – Master antenna TV system – Community antenna TV system – Transmit – Receive earth stations – Problems – Equivalent isotropic radiated power – Transmission losses – Free - space transmission – Feeder losses – Antenna misalignment losses – Fixed atmospheric and Ionospheric losses – Link power budget equation – System noise – Antenna noise – Amplifier noise temperature – Amplifiers in cascade – Noise factor – Noise temperature of absorptive networks – Overall system noise temperature – Carrier to - Noise ratio – Uplink – Saturation flux density – Input back off – The earth station - HPA – Downlink – Output back off – Satellite TWTA output – Effects of rain – Uplink rain – Fade margin – Downlink rain – Fade margin – Combined uplink and downlink C/N ratio – Inter modulation noise.

PART * A

Q.No.	Questions
1.	**Define Saturation flux density.** BTL1 The flux density required at the receiving antenna to produce saturation of TWTA is termed the saturation flux density.
2	**The range between a ground station and a satellite is 42000 km. Calculate the free space loss a frequency of 6 GHz.** – BTL3 [Free space loss] = 32.4 + 20 log 42000 + 20 log 6000 = 200.4 dB
3	**What is noise power spectral density?** BTL1 Noise power per unit Bandwidth is termed as the noise power spectral density.
4	**Explain about MATV system.** BTL1 MATV – Master Antenna TV system. It is used to provide reception of DBS TV channels to the user group. Example : Apartment users It consists of one outdoor unit and various indoor units. Each user can independently access all the channels.
5	**What is mean by ODU and IDU.** BTL1 ODU – The Home Receiver Outdoor Unit IDU – The Home Receiver Indoor Unit
6	**Give the difference between KU-band and the C-band receive only systems.** -BTL1 Operating frequency of outdoor unit.
7	**Define earth segment.** BTL1 Earth segment of a satellite communication system consists of transmit earth station and receive earth station. Example : TV Receive Only systems (TVRO systems)
8	**Define diplexer & *orthocoupler.*** BTL1 The same feed horn may be used to transmit and receive carriers with the same polarization. The transmit and receive signals are separated in a device known as a *diplexer*, The polarization separation takes place in a device known as an *orthocoupler*, or *orthogonal mode transducer* (OMT). Separate horns also may be used for transmit and receive functions, with both horns using the same reflector.
9	**What is an EIRP?** BTL1 EIRP means Equivalent Isotropic Radiated Power

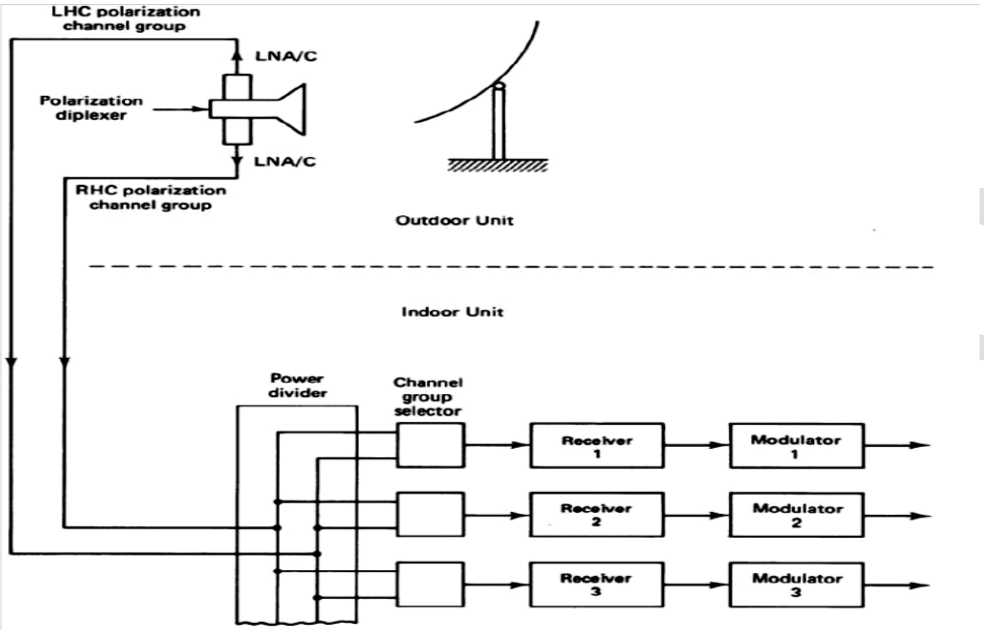
	An isotropic radiator is one that radiates equally in all directions. It is a measure of radiated or transmitted power of an antenna. $P_t = P_{out}/L_t$ $EIRP = P_t G_t = Gp_s$ $Maximum\ flux\ density\ \varphi_m = \frac{Gp_s}{4\pi r^2}$ [EIRP] = [P_S] + [G] dBW 
10	**Write about CATV system.** BTL1 CATV – Community Antenna TV system. As in MATV system, it consists of one outdoor unit and separate feeds for each sense of polarization.
11	**When the available bandwidth is 500 MHz, how many transponder each of bandwidth 36 MHz can be accommodated.** – BTL3 500 MHz Bandwidth – 12 transponders 12 * 36 MHz + 12*4 MHz (guard time) = 500 MHz
12	**What is known as polarization interleaving with reference to the downlink frequency?** BTL1 Overlap occurs between channels, but these are alternatively polarized left hand circular and right hand circular to reduce interference to acceptable levels. This is referred to as polarization interleaving. The downlink frequency band spans a range of 500 MHz are arbitrary polarized, left hand circular polarization and right hand circular polarization to reduce the interference to acceptable levels.
13	**A satellite downlink of 10GHz operates with a transmit power of 5W and an antenna gain of 48.2 dB. Calculate the EIRP in dBw** – BTL3 [EIRP] = [P_S] + [G] dBW [EIRP] = 10 log (6W/1W) + 48.2 = 56 dBw
14	**List the attitude of a satellite controlled through active control.** BTL1 • To stabilize the attitude control on spacecraft by spin stabilization • 3 axis stabilization • Momentum wheel stabilization • Reaction wheel • Magnetic torques • Gas jets or thrusters
15	**Write the objectives with which the downlink of any satellite communication system must be designed** BTL1 • Expected performance of the earth station receiver • Frequency band determination • Determine transponder output power from its gain or output backoff • Establish a downlink power and noise budget for the receiving earth station

16	**Why is noise temperature a useful concept in communication receiver?** BTL1 • Noise temperature is a useful concept in communication receivers, since it provides the way of determining how much thermal noise is generated by active and passive devices in the receiving system. • At microwave frequencies, temperature increase can generate electrical noise over a wide bandwidth • C/N ratio requirements met by making the noise level low.
17	**For a given satellite and signal transmission and signal transmission, what are the earth station parameters affecting the C/N ratio?** BTL1 • EIRP – Equivalent Isotropic radiated power • G/T – Gain of the receiving antenna & temperature increase due to losses
18	**Why thermal control is needed?** BTL1 • Equipment in the satellite generates heat which has to be removed. The element used in the satellite to control thermal heat is called thermal control. • In spacecraft, the function of thermal control system is to keep the spacecraft component systems within acceptable temperature ranges during all mission phases. • To maintain the optimum performance and success of the mission. • Protects the equipment from overheating either by thermal insulation from external heat & by proper heat removal from internal sources
19	**Define sky noise.** BTL1 It is a term used to describe the microwave radiation which is present throughout universe and which appears to originate from matter in any form, at finite temperature.
20	**Define noise factor.** BTL1 An alternative way of representing amplifier noise is by means of its noise factor. In defining the noise factor of an amplifiers, usually taken as 290k
21	**What is meant by redundant receiver?** BTL1 A duplicate receiver is provided so that if one fails, the other is automatically switched in. The combination is referred to as a *redundant receiver*, meaning that although two are provided, only one is in use at a given time.
22	**An antenna has a noise temperature of 35 K and is matched into a receiver which has a noise temperature of 100 K. Calculate (*a*) the noise power density and (*b*) the noise power for a bandwidth of 36 MHz.** – BTL3 $\boldsymbol{N_o = \frac{P_N}{B_N} = K\,T_N}$ $N_o = (35 + 100) * 1.38 * 10^{-23} = 1.86 * 10^{-21}\,J$ $\boldsymbol{P_N = K\,T_N\,B_N}$ $P_N = 1.86 * 10^{-21} * 36 * 10^{6} = 0.067\,pW$
23	**Define Cross-Polarization Discrimination.** BTL1 Depolarization can cause interference where orthogonal polarization is used to provide isolation between signals, as in the case of frequency reuse. The most widely used measure to quantify the effects of polarization interference is called Cross-Polarization Discrimination **XPD = 20 log (E_{11}/E_{12})**
24	**For a satellite circuit the carrier-to-noise ratios are uplink 23 dB, downlink 20 dB, intermodulation 24 dB. Calculate the overall carrier- to-noise ratio in decibels.** – BTL3

	$\frac{N_o}{C} = \left(\frac{N_o}{C}\right)_U + \left(\frac{N_o}{C}\right)_D + \left(\frac{N_o}{C}\right)_{IM}$ $\frac{N_o}{C} = 10^{-2.4} + 10^{-2.3} + 10^{-2} = 0.0019$ $\left[\frac{\mathrm{C}}{\mathrm{N_0}}\right] = 10\log(0.0019) = 17.2\ dBHz$
25	**A satellite link operating at 14 GHz has receiver feeder losses of 1.5 dB and a free-space loss of 207 dB. The atmospheric absorption loss is 0.5 dB, and the antenna pointing loss is 0.5 dB. Depolarization losses may be neglected. Calculate the total link loss for clear-sky conditions.** – BTL3 **[LOSSES]** = [FSL] + [RFL] + [AML] + [AA] **[LOSSES]** = 207 + 1.5 + 0.5 + 0.5 = 209.5 Db
	PART * B
1	**Describe the Effects of Rain in satellite communication system. (13 M)** BTL2 **Answer: Page: 375 - Dennis Roddy** Rainfall results - Attenuation **(2 M)** Rain attenuation - Increases frequency Worse – Ku, C band. 

	(3 M) **Uplink rain-fade margin (4 M)** Rainfall Results: Increase Noise Temperature - Degrading [$C/N0$] Earth Station HPA - Fade Margin Requirement. **Downlink rain-fade margin (4 M)** $\left[\frac{\mathrm{C}}{N}\right]_D = [\mathrm{EIRP}]_D + \left[\frac{\mathrm{G}}{\mathrm{T}}\right]_D - [\mathrm{LOSSES}]_D - [\mathrm{K}] - [B]$ $T_{sky} = T_{cs} + T_{rain}$ To Avoid: Gain increased Larger Dish - receiver front end - lower noise temperature.
2	**Describe the MATV systems with suitable diagram. (13 M)** BTL2 **Answer: Page: 243 - Dennis Roddy** A master antenna TV (MATV) - Reception of DBS TV/FM channels **(7 M)** small group of users

Example: Apartment building.



(6 M)

3

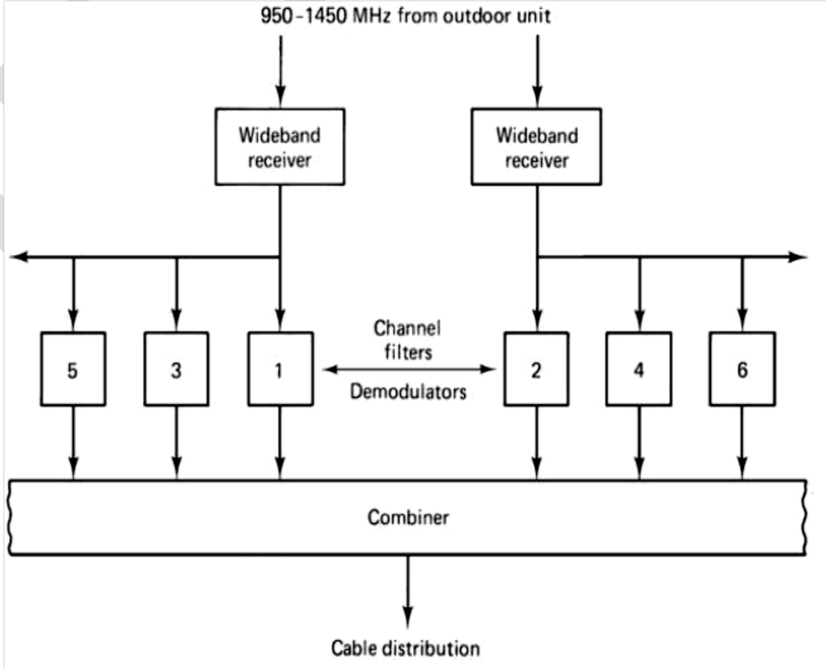
Describe the CATV systems with suitable diagram. (13 M) BTL2

Answer: Page: 243 - Dennis Roddy

The CATV - single outdoor unit **(7 M)**

Separate feeds – polarization

All channels - available simultaneously at the indoor receiver.



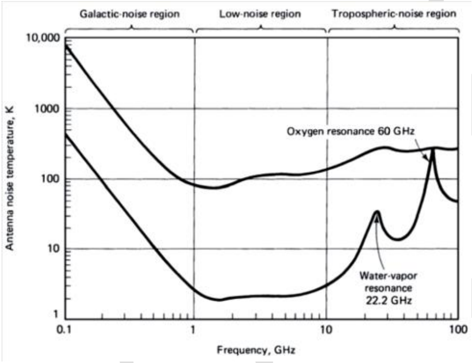
(6 M)

4

Explain the performance impairment with various noise parameters. (13 M) BTL3
Answer: Page: 357 - Dennis Roddy
SYSTEM NOISE (6 M)
Receiver power - Pico watts.
Available Noise Power $\boldsymbol{P_N = K\,T_N\,B_N}$
Noise power spectral density $\boldsymbol{N_o = \frac{P_N}{B_N} = K\,T_N}$

Intermodulation Noise: high-power amplifiers - signal products - noise **(2 M)**

Antennas Loss – Alignment **(2 M)**
Sky Noise - microwave radiation -finite temperatures.



(3 M)

5

Explain the procedures and emphasize the significance for measuring critical satellite parameters C/N$_0$ and G/T. (13 M) BTL3
Answer: Page: 366 - Dennis Roddy
Carrier to Noise Ratio: performance of a satellite link **(2 M)**
Link budget calculations - Carrier to Noise Ratio

$$\left[\frac{\mathbf{C}}{\mathbf{N_0}}\right] = [\boldsymbol{P_R}] - [\boldsymbol{P_N}] \textbf{ (11 M)}$$

$$\left[\frac{\mathrm{C}}{\mathrm{N_0}}\right] = [\mathrm{EIRP}] + [\mathrm{GR}] - [\mathrm{LOSSES}] - [\mathrm{K}] - [\mathrm{T}_S] - [\mathrm{B}_N]$$

$$\left[\frac{\mathbf{G}}{\mathbf{T}}\right] = [\boldsymbol{G_R}] - [\boldsymbol{T_S}]$$

$$\left[\frac{\mathrm{C}}{\mathrm{N_0}}\right] = [\mathrm{EIRP}] + \left[\frac{\mathrm{G}}{\mathrm{T}}\right] - [\mathrm{LOSSES}] - [\mathrm{K}] - [\mathrm{B}_N]$$

$$P_N = K\,T_N\,B_N = N_0 B_N$$

$$\left[\frac{\mathrm{C}}{N}\right] = \left[\frac{\mathrm{C}}{\mathrm{N_0} B_N}\right]$$

$$\left[\frac{\mathbf{C}}{\boldsymbol{N}}\right] = \left[\frac{\mathbf{C}}{\mathbf{N_0}}\right] - [\boldsymbol{B_N}]$$

$$\left[\frac{\mathrm{C}}{\mathrm{N_0}}\right] = \left[\frac{\mathrm{C}}{N}\right] + [B_N]$$

$$\left[\frac{\mathrm{C}}{\mathrm{N_0}}\right] = [\mathrm{EIRP}] + \left[\frac{\mathrm{G}}{\mathrm{T}}\right] - [\mathrm{LOSSES}] - [\mathrm{K}]$$

6

Discuss the various design issues related with uplink design and Input Backoff. (13 M) BTL2

Answer: Page: 367 - Dennis Roddy

Uplink: Earth station to satellite **(2 M)**

$$\left[\frac{\mathrm{C}}{\mathrm{N_0}}\right]_U = [\mathrm{EIRP}]_U + \left[\frac{\mathrm{G}}{\mathrm{T}}\right]_U - [\mathrm{LOSSES}]_U - [\mathrm{K}] \ \textbf{(8 M)}$$

$$[\varphi_m] = [EIRP] + 10\log\frac{1}{4\pi r^2}$$

$$-[FSL] - 10\log\frac{\lambda^2}{4\pi} = 10\log\frac{1}{4\pi r^2}$$

$$[\varphi_m] = [EIRP] - [FSL] - 10\log\frac{\lambda^2}{4\pi}$$

$$[A_O] = 10\log\frac{\lambda^2}{4\pi}$$

$$[EIRP] = [\varphi_m] + [FSL] + [A_O]$$

$$[EIRP] = [\varphi_m] + [FSL] + [A_O] + [AA] + [PL] + [AML]$$

$$[EIRP]_U = [\varphi_S] + [A_O] + [LOSSES]_U - [RFL]$$

Input back off: Earth station EIRP - reduced Back Off **(3 M)**

$$[EIRP]_U = [EIRP_S]_U - [B_O]_i$$

$$\left[\frac{\mathrm{C}}{\mathrm{N_0}}\right]_U = [\varphi_S] + [A_O] - [B_O]_i + \left[\frac{\mathrm{G}}{\mathrm{T}}\right]_U - [\mathrm{K}] - [RFL]$$

7

(i) For a satellite circuit the carrier-to-noise ratios are uplink 23 dB, downlink 20 dB, intermodulation 24 dB. Calculate the overall carrier- to-noise ratio in decibels. (7 M) BTL3

Similar Problem: Page: 366 - Dennis Roddy

$$\frac{N_o}{C} = \left(\frac{N_o}{C}\right)_U + \left(\frac{N_o}{C}\right)_D + \left(\frac{N_o}{C}\right)_{IM} \textbf{(3 M)}$$

$$\frac{N_o}{C} = 10^{-2.4} + 10^{-2.3} + 10^{-2} = 0.0019$$

$$\left[\frac{\mathrm{C}}{\mathrm{N_0}}\right] = 10\log(0.0019) = 17.2\ dBHz$$ **(4 M)**

(ii) Under clear-sky conditions, the downlink [*C*/*N*] is 20 dB, the effective noise temperature of the receiving system being 400 K. If rain attenuation exceeds 1.9 dB for 0.1 percent of the time, calculate the value below which [*C*/*N*] falls for 0.1 percent of the time. Assume *Ta* _ 280 K. (6 M) – BTL3

Similar Problem: Page: 363 - Dennis Roddy

$$T_{rain} = T_a\left(1 - \frac{1}{A}\right)$$ **(3 M)**

$$T_{rain} = 280\left(1 - \frac{1}{1.55}\right) = 99.2\ K$$ **(3 M)**

PART * C

1

With the aid of a block schematic, describe the functioning of the indoor and outdoor receiving unit of a satellite TV/FM receiving system intended for home reception. (15 M) BTL3

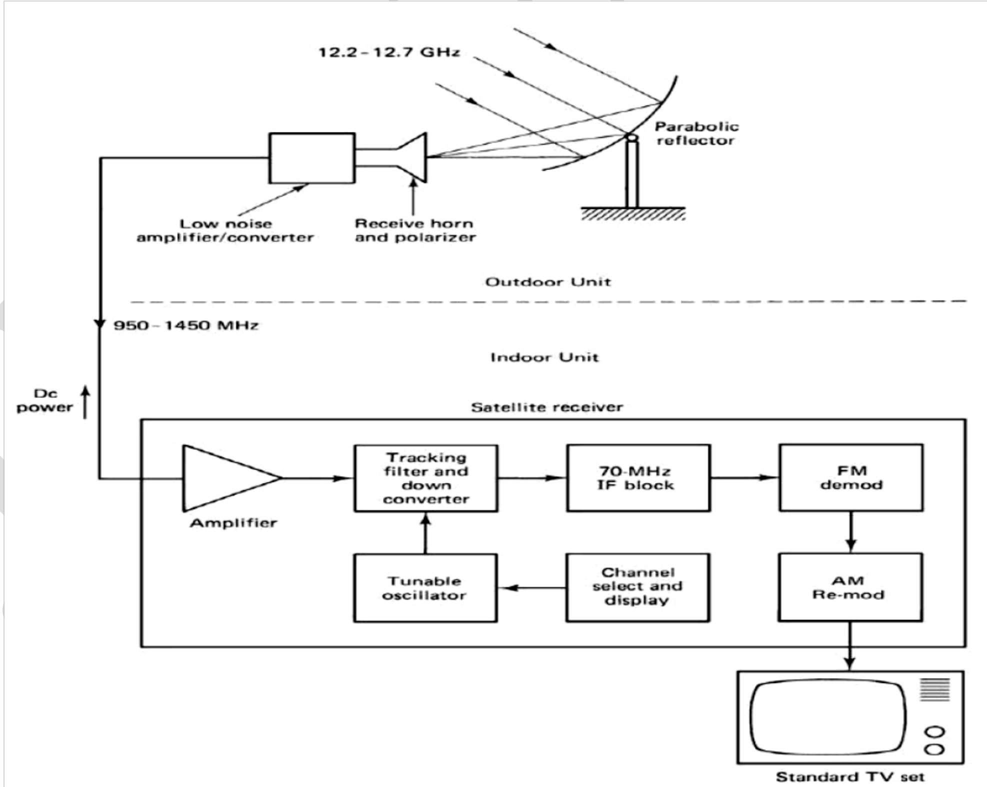
Answer: Page: 209 - Dennis Roddy

Direct broadcast satellite (DBS) service **(2 M)**

Directly to home TV receivers

Ku (12-GHz) band

Dish diameter - 1.83 m (6 feet) to about 3 m (10 feet) **(2 M)**



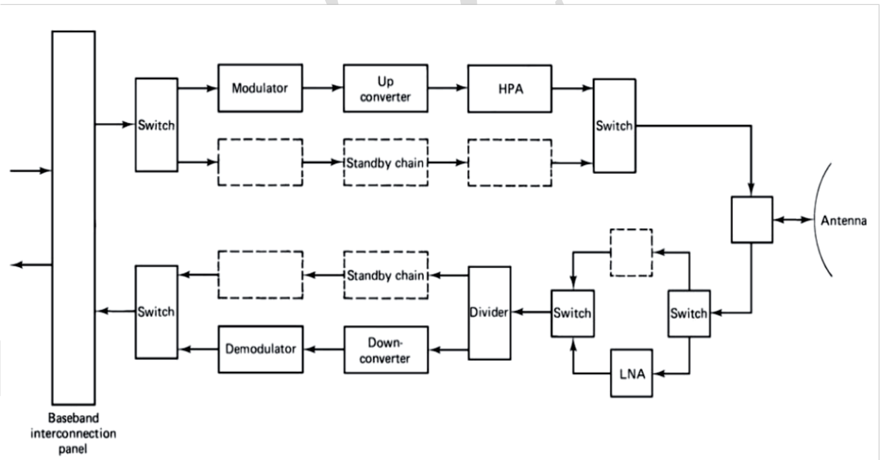
(6 M)

The outdoor unit: (2 M)

Gain: 3 m dish - 4 GHz
1 m dish - 12 GHz
Polarization interleaving.
Low-noise amplifier (LNA)

The Indoor unit: (3 M)
Range 950 to 1450 MHz.
Tracking filter - desired channel
Polarization interleaving - separate the frequency.
Vestigial single side- band (VSSB)
70 MHz - FM intermediate frequency (IF)

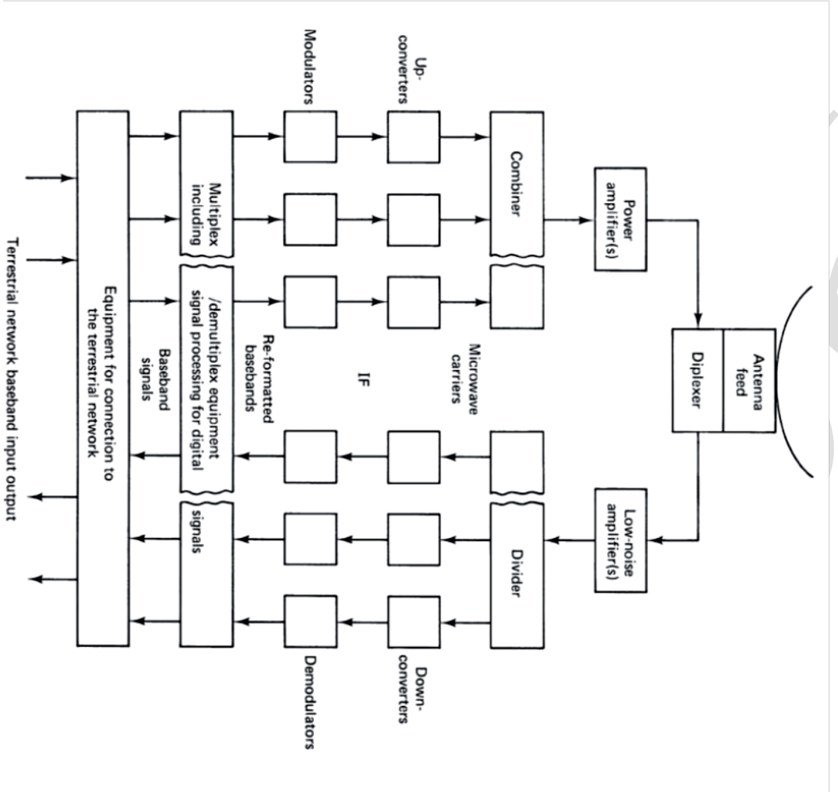
Draw a block diagram for transmitter and receiver of earth segment. (15 M) BTL3
Answer: Page: 246 - Dennis Roddy
Transmit-receive stations - both functions **(4 M)**
Telecommunication traffic - network TV.
Redundancy - duplicated.
Redundant - automatically switched.



(4 M)

Interconnection Equipment **(3 M)**
Multiplexing
Intermediate Frequency
Nominal frequency

Up/Down converters
Combiner.



(4 M)

3

Derive the Signal Transmission Link-Power Budget to calculate the carrier power. (15 M) BTL3

Answer: Page: 356 - Dennis Roddy

Carrier Power - calculation of received signal **(2 M)**

Link Power Budget - transmitted power, losses and gain

$$[P_R] = [EIRP] + [G_R] - [LOSSES] \quad \textbf{(2 M)}$$

Link Budget parameters (3 M)

EIRP	Free space path loss
System noise temperature	Figure of merit for receiving system
Carrier to thermal noise ratio	Carrier to noise density ratio
Carrier to noise ratio	Transmitter power at the antenna
Antenna gain compared to isotropic radiator	

$$EIRP = P_t G_t = Gp_s \quad \textbf{(2 M)}$$

$$Maximum\ flux\ density\ \varphi_m = \frac{Gp_s}{4\pi r^2}$$

[EIRP] : $[EIRP] = [P_S] + [G]$ dBW

$$G = \eta_I \left(\frac{\pi D}{\lambda}\right)^2$$
$$G = \eta_I (10.472\, fD)^2$$

Antenna Gain (3 M)

$$G(\theta) = \frac{P(\theta)}{P_0 / 4\pi}$$

$[P_R]$ = [EIRP] + $[G_R]$ - [LOSSES]

[EIRP] = $[P_S]$ + [G] dBW, where:

[LOSSES] = [FSL] + [RFL] + [AML] + [AA] + [PL],

[FSL] - free-space spreading loss
[RFL] - receiver feeder loss
[AML] - antenna misalignment loss
[AA] - atmospheric absorption loss
[PL] -polarization mismatch loss

$$\boxed{P_r = \frac{P_t G_t G_r}{L_p L_a L_{ta} L_{ra} L_{pol} L_{other} L_r}}$$

The transmission formula: **(3 M)**

$$P_r = EIRP - L_{ta} - L_p - L_a - L_{pol} - L_{ra} - L_{other} + G_r - L_r$$

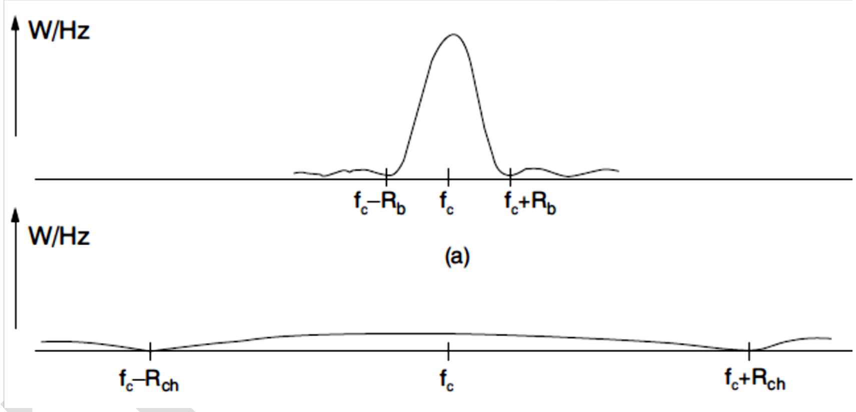
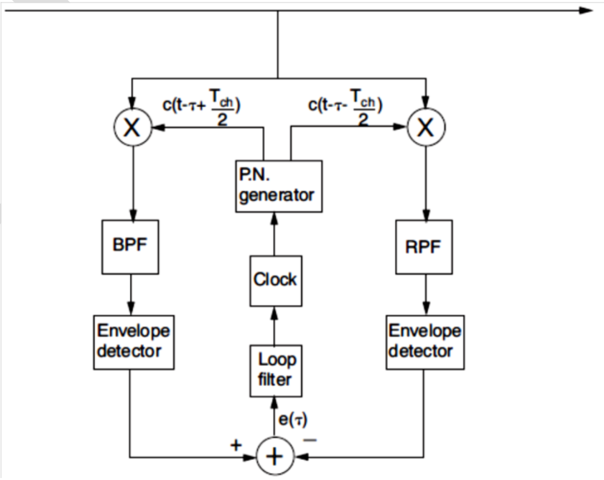
UNIT IV SATELLITE ACCESS

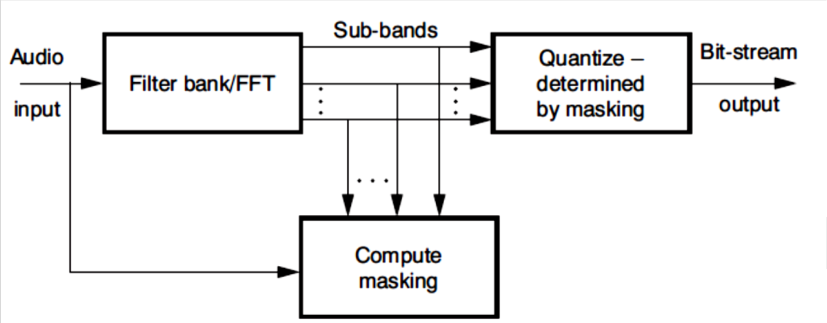
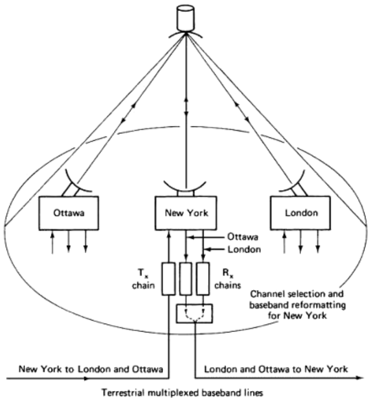
Modulation and Multiplexing: Voice, Data, Video, Analog – digital transmission system, Digital video Broadcast, multiple access: FDMA, TDMA, CDMA, Assignment Methods, Spread Spectrum communication, compression – encryption.

PART * A

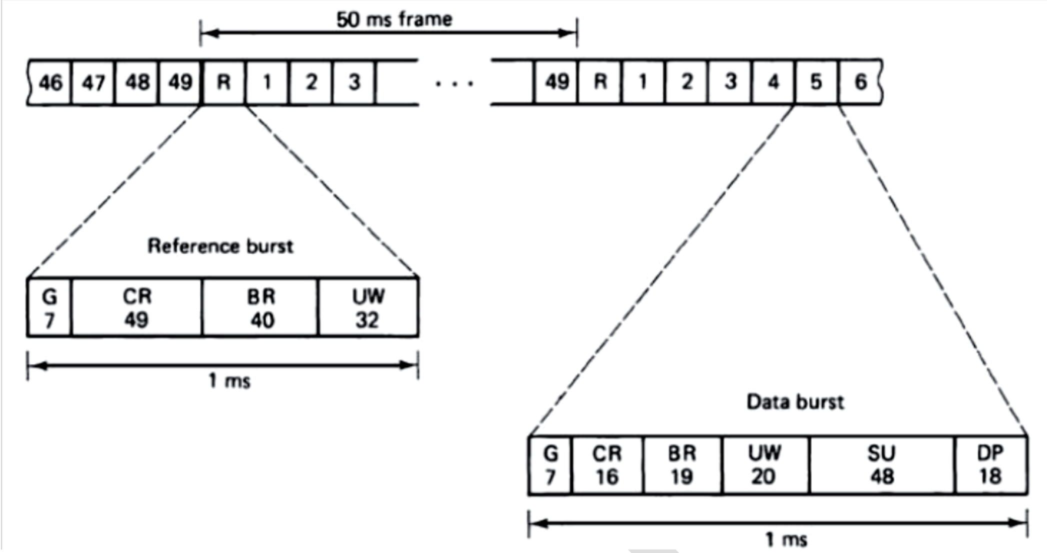
Q.No.	Questions
1.	**What is a single mode of operation?** - BTL1 A transponder channel abroad a satellite may be fully loaded by a single transmission from an earth station. This is referred to as a single access mode of operation.
2	**What are the methods of multiple access techniques?** - BTL1 FDMA – Frequency Division Multiple Access Techniques TDMA – Time Division Multiple Access Techniques
3	**What is an CDMA?** - BTL1 CDMA – Code Division Multiple Access Techniques In this method, each signal is associated with a particular code that is used to spread the signal in frequency and time.
4	**Give the types of CDMA.** - BTL1 • Spread spectrum multiple access • Pulse address multiple access
5	**What is SCPC?** - BTL1 SCPC means Single Channel Per Carrier. In a thin route circuit, a transponder channel (36 MHz) may be occupied by a number of single carriers, each associated with its own voice circuit.
6	**What is a thin route service?** - BTL1 SCPC systems are widely used on lightly loaded routes, this type of service being referred to as a thin route service.
7	**What is an TDMA? What are the advantages?** - BTL1 • TDMA – Time Division Multiple Access Techniques Only one carrier uses the transponder at any one time, and therefore Inter modulation products, which results from the non -linear amplification of multiple carriers are absent. • **Advantages:** The transponder traveling wave tube can be operated at maximum power output.
8	**What is preamble?** - BTL1 Certain time slots at the beginning of each burst are used to carry timing and synchronizing information. These time slots collectively are referred to as preamble.
9	**Define guard time.** - BTL1 It is necessary to prevent the bursts from overlapping. The guard time will vary from burst to burst depending on the accuracy with which the various bursts can be positioned within each frame.
10	**What is meant by decoding quenching?** - BTL1 In certain phase detection systems, the phase detector must be allowed for some time to recover from one burst before the next burst is received by it. This is known as decoding quenching.
11	**What is meant by direct closed loop feedback?** - BTL1 The timing positions are reckoned from the last bit of the unique word in the preamble. The loop

	method is also known as direct closed loop feedback.
12	**What is meant by feedback closed loop control?** - BTL1 The synchronization information is transmitted back to an earth station from a distant that is termed feedback closed loop control.
13	**Define frame efficiency.** - BTL1 It is measure of the fraction of frame time used for the transmission of traffic
14	**What is meant by digital speech interpolation?** - BTL1 The point is that for a significant fraction of the time, the channel is available for other transmission and advantages are taken of this in a form of demand assignment known as digital speech interpolation.
15	**What is meant by telephone load activity factor?** - BTL1 The fraction of time a transmission channel is active is known as the telephone load activity factor.
16	**What are the types of digital speech interpolation?** - BTL1 Digital time assignment speech interpolation, Speech predictive encoded communications
17	**What is meant by freeze out?** - BTL1 It has assumed that a free satellite channel will be found for any incoming speed spurt, but there is a finite probability that all channels will be occupied and the speech spurt lost. Losing a speech spurt in this manner is referred to as freeze out.
18	**What are the advantages of SPEC method over DSI method?** - BTL1 Freeze out does not occur during overload conditions.
19	**Define satellite switched TDMA?** - BTL1 Space Division Multiplexing can be realized by switching the antenna interconnections in synchronism with the TDMA frame rate, this being known as satellite switched TDMA.
20	**What are SS / TDMA?** - BTL1 repetitive sequence of satellite switch modes, also referred to as SS/TDMA
21	**What is processing gain?** - BTL1 The jamming or interference signal energy is reduced by a factor known as the processing gain.
22	**What is burst code word?** - BTL1 It is a binary word, a copy of which is stored at each earth station.
23	**What is meant by burst position acquisition?** - BTL1 A station just entering, or reentering after a long delay to acquire its correct slot position is known as burst position acquisition.
24	**What is an single access?** - BTL1 A transponder channel aboard a satellite may be fully loaded by a single transmission from earth station.
25	**What is an multiple access technique?** - BTL1 A transponder to be loaded by a number of carriers. These may originate from a number of earth station may transmit one or more of the carriers.
26	**What is meant by space division multiple access?** - BTL1 The satellite as a whole to be accessed by earth stations widely separated geographically but transmitting on the same frequency that is known as frequency reuse. This method of access known as space division multiple access.
27	**What are the limitations of FDMA-satellite access?** - BTL1 • If the traffic in the downlink is much heavier than that in the uplink, then FDMA is relatively

	inefficient. • Compared with TDMA, FDMA has less flexibility in reassigning channels. • Carrier frequency assignments are hardware controlled.
28	**Write about pre-assigned TDMA satellite access.** - BTL1 Example for pre-assigned TDMA is CSC for the SPADE network. CSC can accommodate upto 49 earth stations in the network and 1 reference station. All bursts are of equal length. Each burst contains 128 bits. The bit rate is 128 Kb / s.
29	**Write about demand assigned TDMA satellite access.** - BTL1 The burst length may be kept constant and the number of bursts per frame used by the given station is varied when the demand is varied.
30	**What is an important feature of Intelsat SCPC system?** – BTL1 The system is that each channel is voice activated. This means that on a two way telephone conversation only one carriers is operative at any one time.
	PART *B
1	**Explain the principle behind spectrum spreading and dispreading and how this is used to minimize interference in a CDMA system. Also determine the throughput efficiency of the system. (13 M)** – BTL 2 **Answer: Page: 473 - Dennis Roddy**  **(3 M)**  **(4 M)** Direct sequence spread spectrum **(6 M)** chip rate > Information bit rate BPF – PN Generator – Envelop Detector

	CDMA Throughput $$N_0 = \frac{(k-1)P_R}{B_N}$$
2	**With the neat block diagram explain the system of video compression method using MPEG-1. (13 M)** – BTL 2 **Answer: Page: 536 - Dennis Roddy**  **(6 M)** Masking tone - Test tone **(7 M)** 18 dB - Masking threshold S/N= 6 db Frequency masking Mpeg-1 - DBS systems - 192 kb/s Filter Bank – Quantizer – Masking
3	**Illustrate pre assigned FDMA and Demand assigned FDMA (13 M)** – BTL 3 **Answer: Page: 425 - Dennis Roddy** **pre assigned FDMA (7 M)** Three earth stations – Ottawa - New York - London. single satellite transponder Communicates each other's.  **Demand assigned FDMA (6 M)** Transponder frequency bandwidth – subdivided - number of channels. Polling method - master earth station continuously polls - earth stations in sequence Call request – encountered - frequency slots assigned - pool available frequencies.
4	**Illustrate the pre Assigned and Demand Assigned TDMA (13 M)** – BTL 3 **Answer: Page: 452 - Dennis Roddy** CSC - 49 earth stations - network - reference station **(6 M)**

50 bursts in a frame.
Burst length - constant
Number of bursts per frame - varied as demand requires.



(7 M)

5 **Derive the expression for FDMA Downlink Analysis (13 M)** – BTL 3
Answer: Page: 433 - Dennis Roddy

$$\left(\frac{N}{C}\right) = \left(\frac{N}{C}\right)_U + \left(\frac{N}{C}\right)_D + \left(\frac{N}{C}\right)_{IM} \textbf{(2 M)}$$

$$\left(\frac{N}{C}\right)_{REQ} \geq \left(\frac{N}{C}\right)_U + \left(\frac{N}{C}\right)_D + \left(\frac{N}{C}\right)_{IM} \textbf{(2 M)}$$

$$\left(\frac{N}{C}\right)_{REQ} \geq \left(\frac{N}{C}\right) \textbf{(2 M)}$$

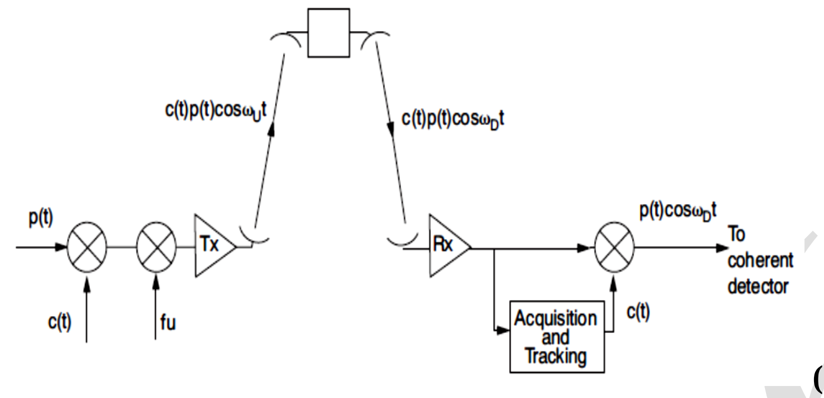
$$\left(\frac{N}{C}\right)_{REQ} \geq \left(\frac{N}{C}\right)_D \textbf{(2 M)}$$

$$\left[\frac{\mathrm{C}}{\mathrm{N}}\right]_D = [\mathrm{EIRP}]_D + \left[\frac{\mathrm{G}}{\mathrm{T}}\right]_D - [\mathrm{LOSSES}]_D - [\mathrm{K}] - [\mathrm{B}] \textbf{ (2 M)}$$

$$\left[\frac{\mathrm{C}}{\mathrm{N}}\right]_{REQ} \leq [\mathrm{EIRP}]_{PS} + \left[\frac{\mathrm{G}}{\mathrm{T}}\right]_D - [\mathrm{LOSSES}]_D - [\mathrm{K}] - [\mathrm{B}_{TR}] \textbf{ (2 M)}$$

$$[B] = [\alpha] + [B_{TR}] - [K] \textbf{ (1 M)}$$

6 **Illustrate the Basic CDMA system in detail (13 M)** – BTL 3
Answer: Page: 472 - Dennis Roddy



(6 M)

Chip Rate: **(7 M)**

$$T_{CH} = \frac{1}{R_{CH}}$$

Periodic Time:

$$T_N = NT_{ch}$$

Maximal sequence: $N = 2^n - 1$

PART * C

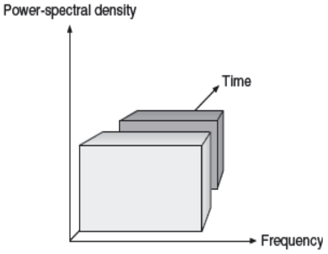
1

Describe the principles of TDMA, FDMA and CDMA (15 M) – BTL 2

Answer: Page: 423 - Dennis Roddy

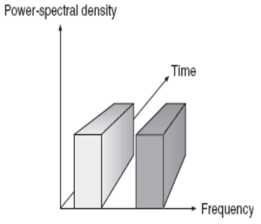
TDMA (5 M)

- single carrier frequency - several users
- System not continuous - bursts.
- handoff - simpler
- Duplexers - not required.
- High transmission rates - FDMA channels.
- High synchronization - required



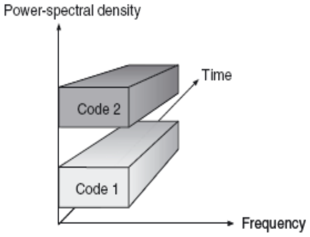
FDMA (5 M)

- Channel carries - one phone circuit at a time.
- channel not in use - cannot be used by other users
- Continuous transmission scheme
- Narrowband systems.
- Inter-symbol interference - low.
- Mobile unit - duplexers.
- Requires - RF filter - adjacent channel interference



CDMA (5 M)

- CDMA system - same frequency.
- Soft capacity limit.
- Frequency dependent transmission impairments
- Multipath fading - substantially reduced



Channel data rates - very high

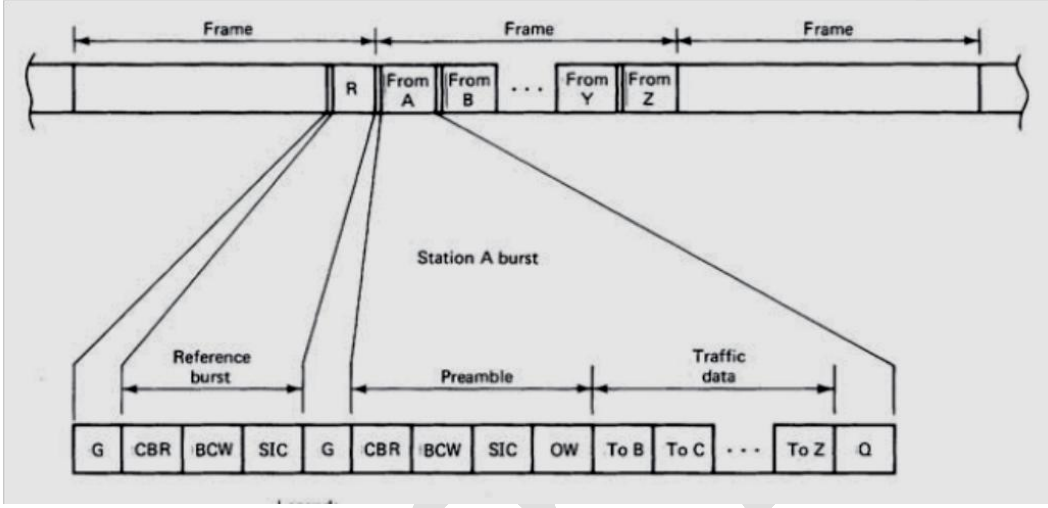
Macroscopic spatial diversity - soft handoff.

Near far problem occurs - CDMA receiver

2

Explain the TDMA burst and frame structure of satellite system. Draw the necessary diagrams. (15 M) – BTL 2

Answer: Page: 440 - Dennis Roddy



(7 M)

Explanation of Guard time – G **(8 M)**

Carrier and bit-timing recovery - CBR

Burst code word - BCW

Station identification code - SIC

control and delay channel - CDC

service channel – SC

voice-order-wire channel – VOW

Preamble

Postamble

3

In detail give an account of various compression standards used in the satellite context. (15 M) – BTL 3

Answer: Page: 536 - Dennis Roddy

MPEG: (5 M)

International Standards Organization - International Electrochemical Commission - (ISO/IEC)

MPEG-2 - video compression

Analog outputs: red (R) - green (G) - blue (B) color cameras

Convert - luminance component (Y) - chrominance components (Cr) - (Cb)

$$\begin{bmatrix} \mathrm{Y} \\ \mathrm{Cr} \\ \mathrm{Cb} \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.168736 & -0.331264 & 0.5 \\ 0.5 & -0.418688 & -0.081312 \end{bmatrix} \begin{bmatrix} \mathrm{R} \\ \mathrm{G} \\ \mathrm{B} \end{bmatrix}$$

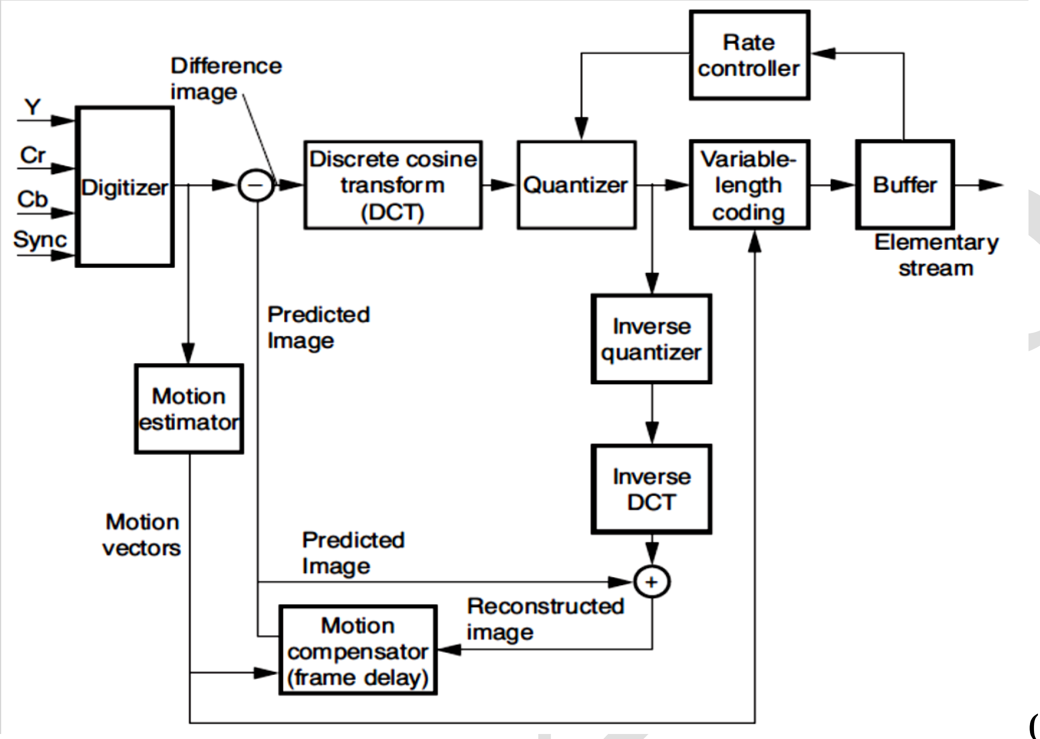
chroma subsampling - Y:U:V

Y - luminance sampling rate

U - Cb sampling rate

V - Cr sampling rate

Discrete cosine transform (DCT) - spatial frequency Domain **(5 M)**
Motion estimation: I – P - B frames.
MPEG-2 - multichannel audio – mono, stereo



(5 M)

UNIT V SATELLITE APPLICATIONS

INTELSAT Series, INSAT, VSAT, Mobile satellite services: GSM, GPS, INMARSAT, LEO, MEO, Satellite Navigational System. Direct Broadcast satellites (DBS) - Direct to home Broadcast (DTH), Digital audio broadcast (DAB) – World space services, Business TV(BTV), GRAMSAT, Specialized services – E –mail, Video conferencing, Internet.

PART * A

Q.No.	Questions
1.	**Give the 3 different types of applications with respect to satellite systems.** BTL1 • The largest international system (Intelsat) • The domestic satellite system (Dom sat) in U.S. • U.S. National oceanographic and atmospheric administrations (NOAA)
2	**Mention the 3 regions to allocate the frequency for satellite services.** BTL1 • Region1: It covers Europe, Africa and Mongolia • Region2: It covers North & South America and Greenland. • Region3: It covers Asia, Australia and South West Pacific.
3	**Give the types of satellite services.** BTL1 • Fixed satellite service • Broadcasting satellite service • Mobile satellite service • Navigational satellite services • Meteorological satellite services
4	**What is mean by Dom sat?** BTL1 Domestic Satellites. These are used for voice, data and video transmissions within the country.
5	**What is mean by INTELSAT?** BTL1 International Telecommunication Satellite.
6	**What is mean by SARSAT?** BTL1 Search and rescue satellite.
7	**What are the applications of Radarsat?** BTL1 • Shipping and fisheries. • Ocean feature mapping • Iceberg detection • Crop monitoring
8	**What is ECEF?** BTL1 The geocentric equatorial coordinate system is used with the GPS system. It is called as earth centered, earth fixed coordinate system.
9	**What is dilution of precision?** BTL1 Position calculations involve range differences and where the ranges are nearly equal; any error is greatly magnified in the difference. This effect, brought a result of the satellite geometry is known as dilution of precision.

10	**What is PDOP?** BTL1 With the GPS system, dilution of position is taken into account through a factor known as the position dilution of precision.
11	**What is DBS?** BTL1 Satellites are used to provide the broadcast transmissions. It is used to provide direct transmissions into the home. The service provided is known as Direct Broadcast Satellite services. Example: Audio, TV and internet services.
12	**Give the frequency range of US DBS systems with high power satellites.** BTL3 • Uplink frequency range is 17.3 GHz to 17.8 GHz • Downlink frequency range is 12.2 GHz to 12.7 GHz
13	**Give the frequency range of US DBS systems with medium power satellites.** BTL3 • Uplink frequency range is 14 GHz to 14.5 GHz • Downlink frequency range is 11.7 GHz to 12.2 GHz
14	**What is DTH?** BTL1 DBS television is also known as Direct To Home (DTH). • DTH stands for Direct-To-Home television. DTH is defined as the reception of satellite programmes with a personal dish in an individual home. • DTH Broadcasting to home TV receivers take place in the ku band(12 GHz).□This service is known as Direct To Home service.
15	**Write about bit rates for digital television.** BTL1 It depends format of the picture. Uncompressed Bit rate = (Number of pixels in a frame) * (Number of pixels per second) * (Number of bits used to encode each pixel)
16	**Give the satellite mobile services.** BTL1 • DBS – Direct Broadcast satellite • VSATS – Very Small Aperture Terminals • MSATS – Mobile Satellite Service • GPS – Global Positioning Systems • Micro Sats • Orb Comm – Orbital Communications Corporation • Iridium
17	**What are GCC and GEC?** BTL1 • GCC - Gateway Control Centers • GEC – Gateway Earth Stations
18	**What is INMARSAT?** BTL1 It is the first global mobile satellite communication system operated at L band and internationally used by 67 countries for communication between ships and coast so that emergency lifesaving may be provided. Also it provides modern communication services to maritime, land mobile, aeronautical and other users.
19	**List out the regions covered by INMARSAT.** BTL1 • Atlantic ocean region, east (AOR-E) • Atlantic ocean region, west (AOR-W) • Indian ocean region (IOR) • Pacific ocean region (POR)

20	**What is INSAT?** BTL1 INSAT – Indian National Satellite System. INSAT is a Indian National Satellite System for telecommunications, broadcasting, meteorology and search and rescue services. It was commissioned in 1983. INSAT was the largest domestic communication system in the Asia-Pacific region.
21	**What do you meant by VSAT?** BTL1 VSAT stands for very small aperture terminal system. The trend is toward even smaller dishes, not more than 1.5 m in diameter
22	**List out the INSAT series.** BTL1 • INSAT -1 • INSAT-2 • INSAT-2A • INSAT-2E • INSAT-3
23	**What is GSM?** BTL1 GSM (Global System for Mobile communications: originally from Groupe Spécial Mobile) is the most popular standard for mobile phones in the world. GSM differs from its predecessors in that both signaling and speech channels are digital, and thus is considered a second generation (2G) mobile phone system. This has also meant that data communication was easy to build into the system.
24	**What is GPRS?** BTL1 General packet radio service (GPRS) is a packet oriented mobile data service available to users of the 2G cellular communication systems global system for mobile communications (GSM), as well as in the 3G systems. In the 2G systems, GPRS provides data rates of 56 -114 kbit/s.
25	**What is GPS?** BTL1 In the GPS system, a constellation of 24 satellites circles the earth in near-circular inclined orbits. By receiving signals from at least four of these satellites, the receiver position (latitude, longitude, and altitude) can be determined accurately. In effect, the satellites substitute for the geodetic position markers used in terrestrial surveying. In terrestrial the GPS system uses one-way transmissions, from satellites to users, so that the user does not require a transmitter, only a GPS receiver.

PART *B

1

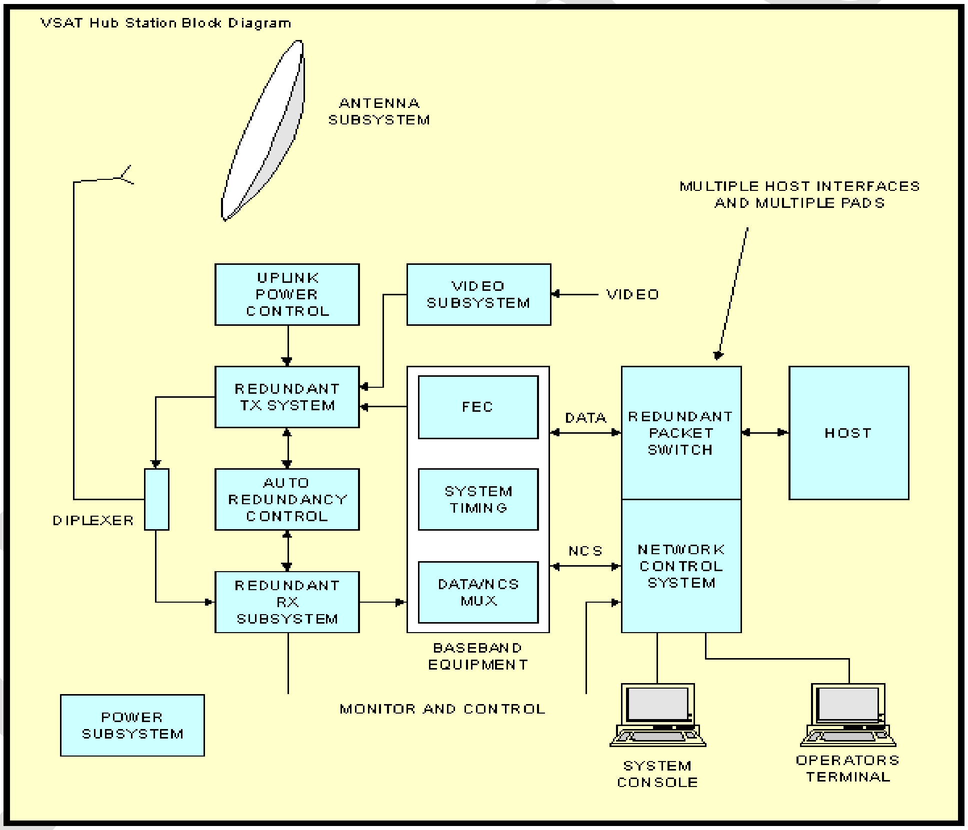
Describe the operation of typical VSAT system. State briefly where VSAT systems and find widest applications. (13 M) BTL2

Answer: Page: 564 - Dennis Roddy

Very Small Aperture Terminal System. **(4 M)**
smaller dishes - 1.5 m diameter
hub station - service provider
VSAT systems - Ku band - C-band

Applications: (3 M)

- Supermarket shops
- Chemist shops
- Small Business
- Office
- Commercial shipping communications.



(6 M)

2

Explain why a minimum of four satellites are visible at an earth location utilizing the GPS system for position determination. What does the term dilution of precision refer to? (13 M) BTL2

Answer: Page: 569 - Dennis Roddy

The Global Positioning System - satellite based navigation system **(3 M)**
Operated: U.S. Department - Defense

<table>
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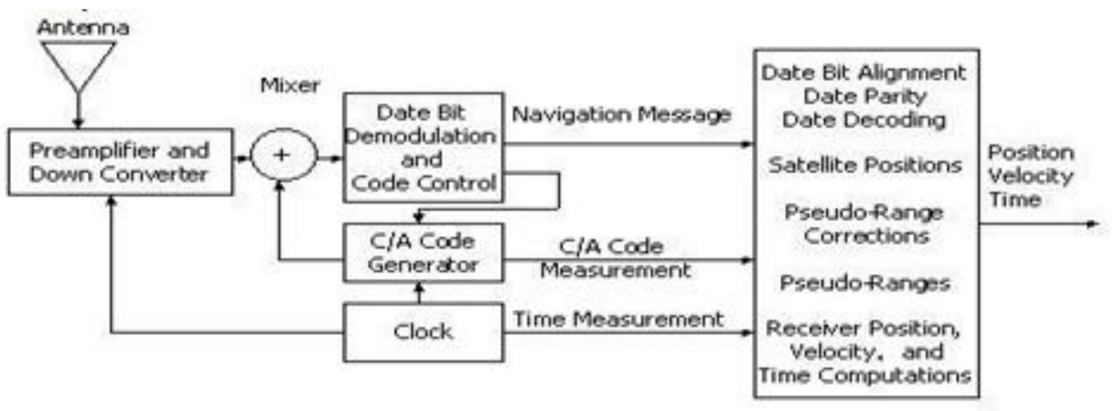
Major Components: satellites – control - monitor stations - receivers.
Operation - triangulation -exact location.



(4 M)

Three Segments of GPS: **(3 M)**
Space Segment: Satellites orbit
Control Segment: control - monitoring stations
User Segment: civilians - military

To determines a Position: **(3 M)**
Precise location s
Distance - each satellite
Triangulation - determine position
</td>
</tr>
<tr>
<td>3</td>
<td>
Illustrate the concept of Direct to home Broadcast (DTH) service. (13 M) BTL3

Answer: Page: 531 - Dennis Roddy
DTH - Direct to Home television. **(4 M)**
Reception of satellite programmes - personal dish - individual home.
ku band - 12 GHz
proposed - 1996.
Working principle:
KU Band - dish - set top box.
</td>
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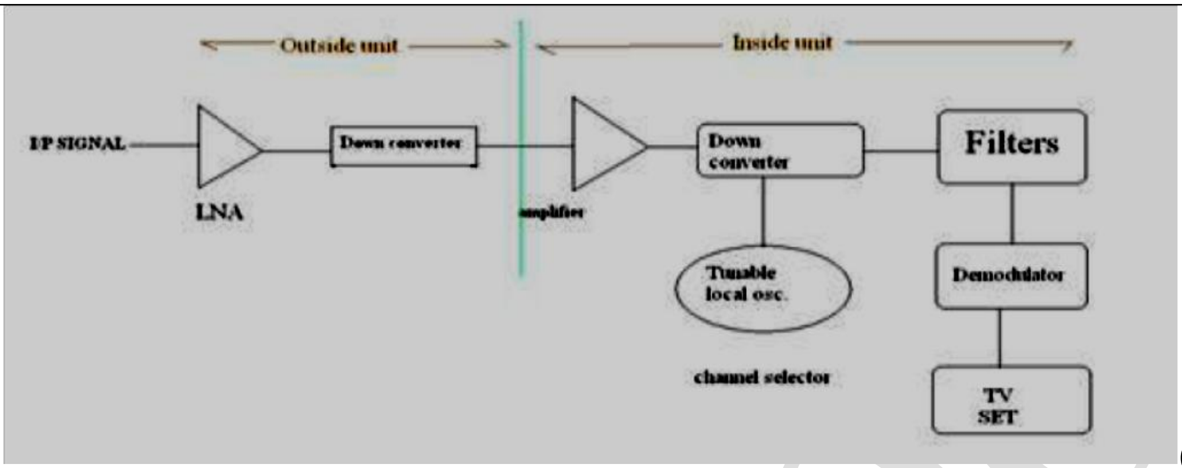


(5 M)

Advantage: (4 M)

- Digital quality: picture - sound quality.
- Interactive channels
- provide local channels
- Satellite broadcast: rural - semi-urban areas

4

Briefly explain about the GRAMSAT and list the silent features. (13 M) BTL2

Answer: Page: 492 - Dennis Roddy

ISRO - GRAMSAT satellites **(4 M)**
Eradicate illiteracy - rural belt
Rural development of the nation.

Features of GRAMSAT: **(4 M)**

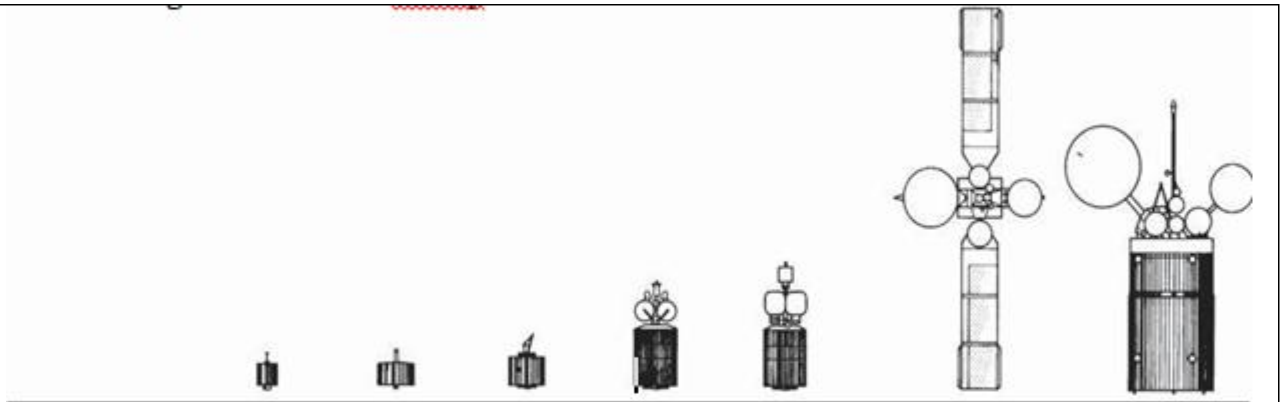
- Connecting state capital to districts - blocks - villages.
- computer connectivity data broadcasting
- TV-broadcasting facilities: e governance - development information – teleconferencing - helping disaster management.
- Providing rural - education broadcasting.

Gramsat projects **(5 M)**

- Interactive training
- Broadcasting services - rural development
- Computer interconnectivity and data exchange services
- Tele health and telemedicine services

5

Illustrate the various configurations of INSAT Series. (13 M) BTL3
Answer: Page: 487 - Dennis Roddy



Designation: Intelsat	I	II	III	IV	IV A	V	V A/V B	VI
Year of first launch	1965	1966	1968	1971	1975	1980	1984/85	1986/87
Prime contractor	Hughes	Hughes	TRW	Hughes	Hughes	Ford Aerospace	Ford Aerospace	Hughes
Width (m)	0.7	1.4	1.4	2.4	2.4	2.0	2.0	3.6
Height (m)	0.6	0.7	1.0	5.3	6.8	6.4	6.4	6.4
Launch vehicles		Thor Delta		Atlas-Centaur		Atlas-Centaur and Ariane	Atlas-Centaur and Ariane	STS and Ariane
Spacecraft mass in transfer orbit (kg)	68	182	293	1385	1489	1946	2140	12,100/3720
Communications payload mass (kg)	13	36	56	185	190	235	280	800
End-of-life (EOL) power of equinox (W)	40	75	134	480	800	1270	1270	2200
Design lifetime (years)	1.5	3	5	7	7	7	7	10
Capacity (number of voice channels)	480	480	2400	8000	12,000	25,000	30,000	80,000
Bandwidth (MHz)	50	130	300	500	800	2137	2480	3520

Any 6 Parameters **(13 M)**

PART * C

1

Briefly explain the following concepts

- **i) Satellite email services (5 M)**
- **ii) Internet (5 M)**
- **iii) Video conferencing (5 M)** BTL2

Answer: Page: 488 - Dennis Roddy

Satellite-email services: **(5 M)**

Internet services - terrestrial networks,

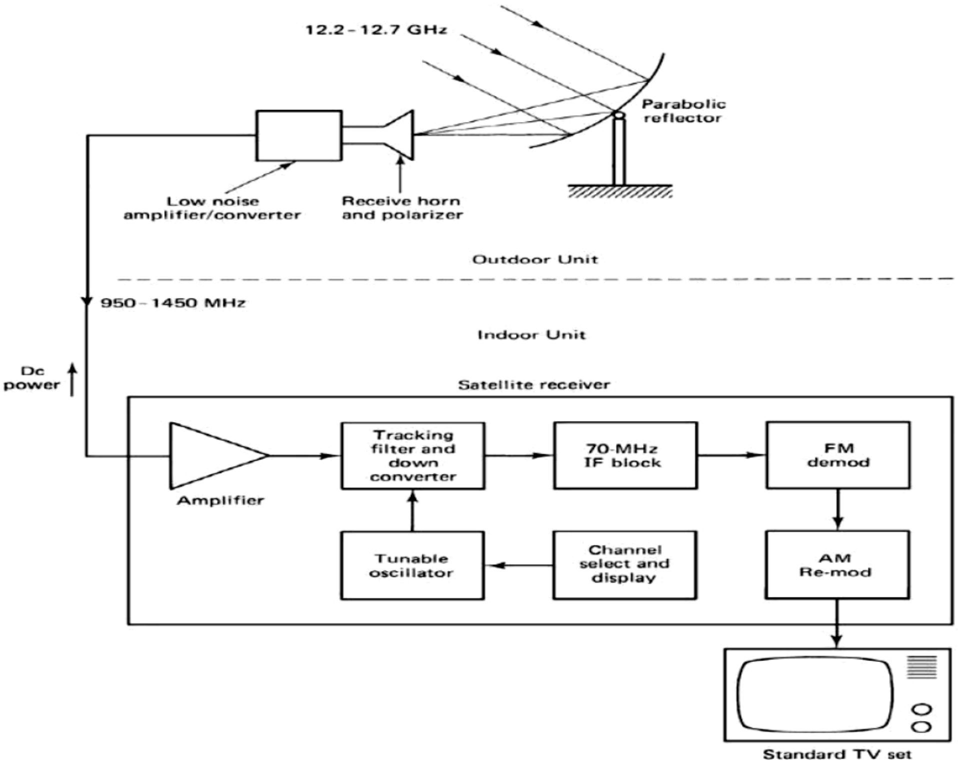
Features and Benefits

- No need - configure an e-mail client
- Service - low bandwidth Inmarsat terminals
- previewing Inbox and deleting any unwanted e-mails
- No surcharge – No monthly subscription fees
- Service billed - standard airtime prices.

Video Conferencing: **(5 M)**

Two way interactivity - lower cost.

	video conferencing - connect each site **Satellite Internet access: (5 M)** Internet access - communications satellites. geostationary satellites - high data speeds , Ka band - downstream data speeds - 50 Mbps.
2	**Illustrate the concept of GSM architecture and its services. (15 M)** BTL3 **Answer: Page: 492 - Dennis Roddy** GSM - standard DCS1800 - cellular communications systems **GSM architecture: (5 M)** Mobile Station (MS) Base Station Sub-System (BSS) Network and Switching Sub-System (NSS) Operation Sub -System (OSS) **channels air interface: (5 M)** FCCH, SCH, PAGCH, RACH, CBCH, BCCH, FACCH, TCH/F, TCH/H **Mobility Management:** ability to support roaming users. **Difficulties (5 M)** a. Remote/Rural Areas. b. Time to deploy. c. Areas of ‘minor’ interest. d. Temporary Coverage. **GSM service security:** Cryptographic algorithms - security. A5/1, A5/2, A5/3 - stream ciphers - air voice privacy.
3	**Illustrate the Direct Broadcast Satellite service in detail. (15 M)** – BTL3 **Answer: Page: 209 - Dennis Roddy** Direct broadcast satellite (DBS) service **(2 M)** Directly to home TV receivers Ku (12-GHz) band Dish diameter - 1.83 m (6 feet) to about 3 m (10 feet) **(2 M)**



(6 M)

The outdoor unit: (2 M)

Gain: 3 m dish - 4 GHz
1 m dish - 12 GHz

Polarization interleaving.

Low-noise amplifier (LNA)

The Indoor unit: (3 M)

Range 950 to 1450 MHz.

Tracking filter - desired channel

Polarization interleaving - separate the frequency.

Vestigial single side- band (VSSB)

70 MHz - FM intermediate frequency (IF)

EC6009 ADVANCED COMPUTER ARCHITECTURE L T P C 3 0 0 3

OBJECTIVES: The student should be made to:

- Understand the micro-architectural design of processors
- Learn about the various techniques used to obtain performance improvement and power savings in current processors

UNIT I FUNDAMENTALS OF COMPUTER DESIGN 9

Review of Fundamentals of CPU, Memory and IO – Trends in technology, power, energy and cost, Dependability - Performance Evaluation

UNIT II INSTRUCTION LEVEL PARALLELISM 9

ILP concepts – Pipelining overview - Compiler Techniques for Exposing ILP – Dynamic Branch Prediction – Dynamic Scheduling – Multiple instruction Issue – Hardware Based Speculation – Static scheduling - Multi-threading - Limitations of ILP – Case Studies.

UNIT III DATA-LEVEL PARALLELISM 9

Vector architecture – SIMD extensions – Graphics Processing units – Loop level parallelism.

UNIT IV THREAD LEVEL PARALLELISM 9

Symmetric and Distributed Shared Memory Architectures – Performance Issues –Synchronization – Models of Memory Consistency – Case studies: Intel i7 Processor, SMT & CMP Processors

UNIT V MEMORY AND I/O 9

Cache Performance – Reducing Cache Miss Penalty and Miss Rate – Reducing Hit Time – Main Memory and Performance – Memory Technology. Types of Storage Devices – Buses – RAID – Reliability, Availability and Dependability – I/O Performance Measures.

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

- Evaluate performance of different architectures with respect to various parameters
- Analyze performance of different ILP techniques
- Identify cache and memory related issues in multi-processors

TEXT BOOK:

1. John L Hennessey and David A Patterson, ―Computer Architecture A Quantitative Approach‖, Morgan Kaufmann/ Elsevier, Fifth Edition, 2012.

REFERENCES:

1 Kai Hwang and Faye Briggs, ―Computer Architecture and Parallel Processing‖, Mc Graw-Hill International Edition, 2000.

2 Sima D, Fountain T and Kacsuk P, ‖Advanced Computer Architectures: A Design Space Approach‖, Addison Wesley, 2000.

Subject Code: EC6009 **Year / Sem : IV / 7**
Subject Name: Advanced Computer Architecture **Subject Handler: Mrs.R.Dayana**

UNIT I FUNDAMENTALS OF COMPUTER DESIGN

Review of Fundamentals of CPU, Memory and IO – Trends in technology, power, energy and cost, Dependability - Performance Evaluation

PART A

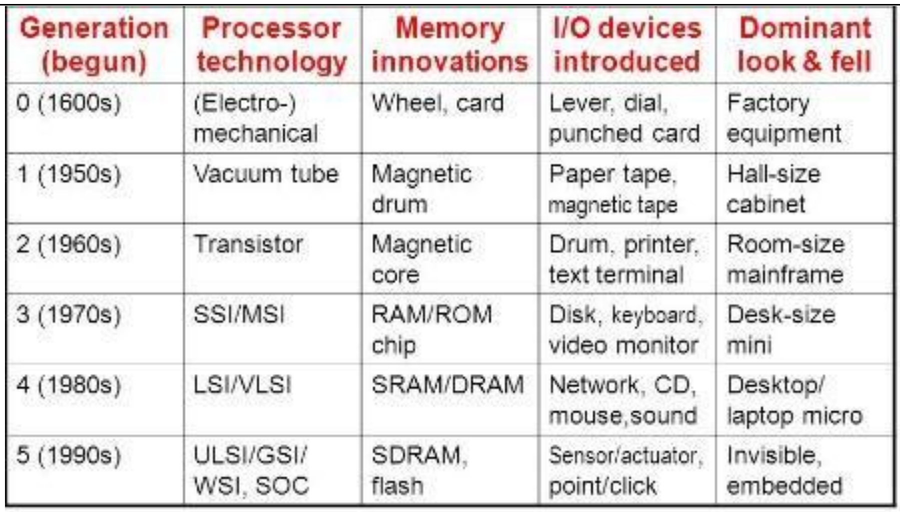
Q. No	Question & Answers
1	**Define Personal Mobile Device (PMD) (Nov/Dec 2016)**BTL1 Personal Mobile Device (PMD) is the term we apply to a collection of wireless devices with multimedia user interfaces such as cell phones, tablet computers and so on. Applications on PMD are often Web-based and media-oriented like the Google Goggles.
2	**Explain soft real time**BTL2 In some applications, a more nuanced requirement exists: the average time for a particular task is constrained as well as the number of instances when some maximum time is exceeded. Such approaches, sometimes called soft real time, space arise when it is possible to occasionally miss the time constrain on an event, as long as not too many are missed.
3	**What does the desktop market tense to optimise?(Apr/May 2016)**BTL3 The desktop market tensed to be driven to optimise price: performance. This combination of performance (measured primarily in terms of compute performance and graphic performance) and price of the system is what matters most to customers in this market and hence to computer designer.
4	**What are clusters?**BTL1 The growth of Software has a Service (SaaS) for applications like search, social networking, and video sharing, multiplayer games, online shopping and so on has led to the growth of a class of computers called clusters. Clusters are collection of desktop computers or servers connected by local area networks to act as a single large computer.
5	**Explain the two kinds of parallelism in applications**BTL2 There are basically two kinds of parallelism in applications: Data – Level Parallelism (DLP) arises because there are many data items that can be operated on at the same time. Task – Level Parallelism (TLP) arises because tasks of work are created that can operate independently and largely in parallel.
6	**What are the ways in which a computer hardware can exploit DLP and TLP? (Nov/Dec 2016)**BTL4 Instructions Level Parallelism Vector Architecture and Graphic Processor Units (GPUs) Thread Level Parallelism Requested Level Parallelism
7	**List out the general categories of operations**BTL3 The general categories of operations are data transfer, arithmetic logical, control and floating points.
8	**Enumerate operand sizes that most ISAs support?**BTL5 Most ISAs like 80 x 86, ARM ad MIPS support operand sizes of 8-bit (ASCII character),

	16-bit (Unicode character or half word), 32-bit (integer or word), 64-bit (double word or long integer), and IEEE 754 floating points in 32-bit (single precision) and 64-bit (double precision).
9	**What are the five implementation techniques which are critical to modern implementation?**BTL1 Integrated circuit logic technology Semiconductor DRAM (dynamic random-access memory) Semiconductor Flash (electronically erasable programmable read-only memory) Magnetic disk technology Network technology
10	**What is bandwidth?**BTL1 Bandwidth is the total amount of work done in a given time, such as mega-bytes per second for a disk transfer. It is also known as throughput.
11	**What is latency?**BTL1 Latency is the time between the start and the completion of an event, such as milliseconds for a disk access. It is also known as response time.
12	**List out the two basic choices of an encoding.** BTL3 The two basic choices of encoding are fixed length and variable length. All ARM and MIPS instructions are 32 bits long, which simplifies instruction decoding.
13	**What are the conditional branches that ISAs support?**BTL3 Virtually all ISAs, support conditional branches, unconditional jumps, procedure calls and returns. All three uses PC-relative addressing where the branch address is specified by an address field that is added to the PC.
14	**What does an ARM stand for?**BTL1 ARM stands for Advanced RISC Mission, which is one of the most popular example of RISC architectures. ARM processors wherein 6.1 billion chips shipped in 2010 or roughly 20 times as many chips that shipped with 80 x 86 processors.
15	**Point out the biggest challenge that a computer designer faces in every class of computer.** BTL4 Power is the biggest challenge facing the computer designer for nearly every class of computer. First, power must be brought in and distributed around the chip, and modern microprocessors use hundreds of pins and multiple inter connect layers just for power and ground. Second, power is dissipated as heat and must be removed.
16	**Define sustained power consumption.** BTL1 This metric is widely called the thermal design power (TDP), since it determines the cooling requirement. TDP is neither peak power, which is often 1.5 times higher, nor it is the actual average power that will be consumed during a given computation, which is likely to be lower still. A typical power supply for a system is usually sized to exceed the TDP, and a cooling system is usually designed to match or exceed TDP.
17	**What is called dynamic energy?** BTL2 For CMOS chips, the traditional primary energy consumption has been in switching transistors, also called dynamic energy. The energy required per transistor is proportional to the product of the capacitive load driven by the transistor and the square of the voltage.
18	**Definethe power required per transistor.** BTL1 **(Apr/May 2016)** The power required per transistor is just the product of the energy of a transitions multiplied by the frequency of transitions. For a fixed task slowing clock rate reduces power but not

	energy.
19	**Label the formula used to calculate the cost of packaged integrated circuit**BTL4 Cost of integrated circuit = (Cost of die + Cost of testing die + Cost of packaging and final test)/ Final test yield Where, Cost of die = Cost of wafer / (dies per wafer x die yield)
20	**Illustrate the Wall-clock time**BTL3 The most straight forward definition of time is called Wall-clock time, response time or elapsed time, which is the latency to complete a task, including disk accesses, memory accesses, input/ output activities, operating system overhead, etc.
21	**What is die?**BTL2 Die is the square area of the wafer containing the integrated circuit.
22	**How is the cost of die calculated?**BTL3 The cost of a die is determined from cost of a wafer; the number of dies fit on a wafer and the percentage of dies that work, i.e., the yield of the die.
23	**What is the sustained power consumption?**BTL1 The metric is widely called the thermal design power (TDP), since it determines the cooling requirement.
24	**Define latency**BTL1 Latency or response time is the time between the start and the completion of an event, such as milliseconds for a disk access
25	**What is embedded computer?**BTL2 An embedded system is a special-purpose system in which the computer is completely encapsulated by the device it controls. Unlike a general-purpose computer, such as personal computer, an embedded system performs pre-defined tasks, usually with very specific requirements.

PART B

Q.No	**Questions**
1	**Illustrate the fundamentals of CPU along with the classification of various generation of computer (13M)** **Answer:Page 2- John L. Hennessy** BTL3 • **Explanation on the progression and development (7M)** Computer technology - incredible progress - first general-purpose electronic computer • Personal computer - more performance- more main memory - more disk • rapid improvement -advances in the technology - innovation in computer design. **Classification of various generations of computer (5M)**



Generation (begun)	Processor technology	Memory innovations	I/O devices introduced	Dominant look & fell
0 (1600s)	(Electro-) mechanical	Wheel, card	Lever, dial, punched card	Factory equipment
1 (1950s)	Vacuum tube	Magnetic drum	Paper tape, magnetic tape	Hall-size cabinet
2 (1960s)	Transistor	Magnetic core	Drum, printer, text terminal	Room-size mainframe
3 (1970s)	SSI/MSI	RAM/ROM chip	Disk, keyboard, video monitor	Desk-size mini
4 (1980s)	LSI/VLSI	SRAM/DRAM	Network, CD, mouse,sound	Desktop/ laptop micro
5 (1990s)	ULSI/GSI/ WSI, SOC	SDRAM, flash	Sensor/actuator, point/click	Invisible, embedded

2 **Point out the various classes of computers and explain the Myopic view the instruction set architecture-(13M)**

Answer:Page 11 - John L. Hennessy BTL3

- **Personal Mobile Device (PMD) (2M)** collection of wireless devices
- **Desktop Computing (2M)** The first, and still the largest market in dollar terms
- **Servers (2M)** provide larger-scale and more reliable file and computing services.
- **Embedded Computers (2M)**Everyday machines—most microwaves, most washing machines
- **Clusters/Warehouse-Scale Computers(2M)** Applications like search - social networking
- **Instruction Set Architecture: (3M) The Myopic View of Computer Architecture** refer to the actual programmer

3 **Describe the trends in technology along with the implementation technologies (Nov/Dec 2018) (13M)**

Answer:Page 17 - John L. Hennessy BTL3

Explanation (1M)designed to survive rapid changes - computer technology.
Four implementation technologies, - change at a dramatic pace - critical to modern implementations:

- **Integrated circuit logic technology (4M)**—Transistor density increases by about 35% per year
- **Semiconductor DRAM (4M)** (dynamic random-access memory
- **Magnetic disk technology (4M)**—Prior to 1990 - density increased by about 30% per year - doubling in three years.
- **Network technology (4M)**—both on the performance of switches - on the performance of the transmission system.

4 **Illustrate the system perspective of power and energy in Integrated circuits (Apr/May 2017) (13M)**

Answer:Page 21 - John L. Hennessy BTL3

Trends in Power in Integrated Circuits: (7M)

	Explanation • switching transistors - dynamic power • Power required per transistor **Energy and Power within a Microprocessor** For CMOS chips, the traditional primary energy consumption - switching transistors - dynamic energy.(along with all the formulae) **Trends in Cost: (6M)** **Explanation** computer designs - costs tend to be less important **The Impact of Time, Volume, and Commoditization** The cost of a manufactured computer component decreases over time **Cost of an Integrated Circuit** Increasingly competitive computer marketplace where standard parts—disks, Flash memory, DRAMs
5	**Explain the dependability in integrated circuits (13M) (Apr/May 2016,Nov/Dec 2018) Answer:Page 33 - John L. Hennessy** BTL2 • **Explanation about dependability: (6M)** designed and constructed at different layers of abstraction. • descend recursively down • Some faults are widespread • Utter failure of a module at one level • Find ways to build dependable computers. • **Module reliability (4M)**measure of the continuous service • **Module availability (3M)**- measure of the service accomplishment
6	**Assume a disk subsystem with the following components and MTTF:** • **10 disks, each rated at 1,000,000-hour MTTF** • **1 ATA controller, 500,000-hour MTTF** • **1 power supply, 200,000-hour MTTF** • **1 fan, 200,000-hour MTTF** • **1 ATA cable, 1,000,000-hour MTTF** **Using the simplifying assumptions that the lifetimes are exponentially distributed and that failures are independent, compute the MTTF of the system as a whole.(Apr/May 2017)(13M)** **Answer:Page 43 - John L. Hennessy** BTL5 • **Formula (3M)+ Solving (10M)** • Formula to show what to expect when we can tolerate a failure and still provide service. • To simplify the calculations - assume that the lifetimes of the components - exponentially distributed - no dependency between the component failures. • MTTF for our redundant power supplies - mean time until one power supply fails divided by the chance - other will fail before the first one. • Chance of a second failure - before repair - small - MTTF of the pair is large.

7	**List out the types of benchmarking technique and how it is use to sort out performance evaluation(13M)** **Answer:Page 36 - John L. Hennessy** BTL3 **Benchmarking explanation (2M):** measure performance - real applications, such as a compiler. Examples include • **kernels,(1M)** small, key pieces of real applications; • **toy programs (1M),** 100-line programs • **synthetic benchmarks (1M)**, fake programs **Desktop Benchmarks (2M)** two broad classes: processor-intensive benchmarks and graphics-intensive benchmarks - **Server Benchmarks (2M)** Just as servers have multiple functions - there multiple types of benchmarks**Reporting Performance Results (2M)** Guiding principle of reporting performance measurements –*reproducibility* **Summarizing Performance Results (2M)** Practical computer design - evaluate myriad design choices - quantitative.
PART C	
1	**Discuss the various trends in technology, power, energy and cost (Apr/May 2017,Nov/Dec2019)(15M)** **Answer:Page 17 - John L. Hennessy** BTL3 **Trends in Technology (5M):** • Designed to survive rapid changes in computer technology • successful new instruction set architecture may last decades • for example, the core of the IBM mainframe has been in use for more than 40 years.. **Trends in Power in Integrated Circuits (5M):** • switching transistors - dynamic power • Power required per transistor • Energy and Power within a Microprocessor **Trends in Cost (5M):** • computer designs • Increasingly competitive computer marketplace
2	**Discuss about the guidelines and principles that are useful in design and evaluate the performance of computer systems with example (15M)(Apr/May 2017)** **Answer:Page 36 - John L. Hennessy** BTL4 **Definition of response time, execution time and throughput (4M):** • User of a desktop computer – faster computer- program runs in less time • *Response time* • T*hroughput* **Comparison alternative between two computers and detailed explanation (11M):** • The computer user - interested in reducing response timeThe administrator of a large

	data processing center - increasing throughput—the tota • l amount of work done in a given time • The phrase –X is faster than Y‖
3	**Show that the ratio of the geometric means is equal to the geometric mean of the performance ratios, and that the reference computer of SPECRatio matters not.(15M)(Apr/May 2017)** **Answer:Page 43 - John L. Hennessy** BTL4 **Formula (4M):**Execution time$_y$/Execution time$_x$=n n= Performance$_x$/Performance$_y$ **Solving (9M)** **Answer(2M)**
4	**Write short notes on energy and power consumption in a microprocessor.(15M)(Nov/Dec 2016)** **Answer:Page 11 - John L. Hennessy** BTL3 • Dynamic power • increasing the number of transistors increases power • Leakage current increases in processors with smaller transistor sizes. • Power$_{static}$ =Current$_{static}$ x Voltage **Trends in Power in Integrated Circuits: (8M)** • switching transistors - dynamic power • Calculate Power required per transistor • Energy and Power within a Microprocessor **Trends in Cost: (7M)** • computer designs - costs tend to be less important— specifically supercomputers—cost-sensitive designs - growing significance. • Disks, Flash memory, DRAMs • High Volume

UNIT II INSTRUCTION LEVEL PARALLELISM

ILP concepts – Pipelining overview - Compiler Techniques for Exposing ILP – Dynamic Branch Prediction – Dynamic Scheduling – Multiple instruction Issue – Hardware Based Speculation – Static scheduling - Multi-threading - Limitations of ILP – Case Studies.

PART A

1	**Define the concept of pipelining. (Nov/Dec 2016)**BTL2 Pipelining is an implementation technique whereby multiple instructions are overlapped in execution. It takes advantage of parallelism that exists among actions needed to execute an instruction.
2	**What is a Hazard? Mention the different hazards in pipeline.** BTL3 Hazards are situations that prevent the next instruction in the instruction stream from executing during its designated clock cycle. Hazards reduce the overall performance from the ideal speedup gained by pipelining. The three classes of hazards are, • Structural hazard • Data hazard • Control hazard
3	**List the various dependences. (Apr/May 2016)**BTL3 Data dependence Name dependence Control dependence
4	**What is Instruction Level Parallelism? (or) What is ILP?** BTL2 Pipelining is used to overlap the execution of instructions and improve performance. This potential overlap among instructions is called instruction level parallelism (ILP) since instruction can be evaluated parallel.
5	**Give an example of control dependence.** BTL3 If p1 { s1;} If p2 {s2;} S1 is control dependence on p1, and s2 is control dependence on p2.
6	**Write the concept behind using reservation station.** BTL4 Reservation station fetches and buffers an operand as soon as available, eliminating the need to get the operand from a register.
7	**Define the idea behind dynamic scheduling. Also write advantages of dynamic scheduling.** BTL3 In dynamic scheduling the hardware rearranges the instruction to reduce the stalls while maintaining dataflow and exception behaviour. **Advantages:** it enables handling some cases when dependence are unknown at compile time It allows code that was compiled with one pipeline in mind and run efficiently on a different pipeline.
8	**What are branch target buffers?** BTL1 To reduce the branch penalty we need to know from what address to fetch by end of Instruction fetch. A branch prediction cache that stores the predicted address for the next instruction after a branch is called a branch-target buffer or branch target cache.
9	**Mention the idea behind hardware-based speculation.**BTL2 • It combines three key ideas:

	• Dynamic branch prediction to choose which instruction to execute, • Speculation to allow the execution of instructions before control dependence are resolved. Dynamic scheduling is used to deal with the scheduling of different combinations of basic blocks.
10	**What is loop unrolling?** BTL1 A simple scheme for increasing the number of instructions relative to the branch and overhead instructions is loop unrolling. Unrolling simply replicates the loop body multiple times, adjusting the loop termination code.
11	**Give an example for data dependence. (Apr/May 2017)**BTL4

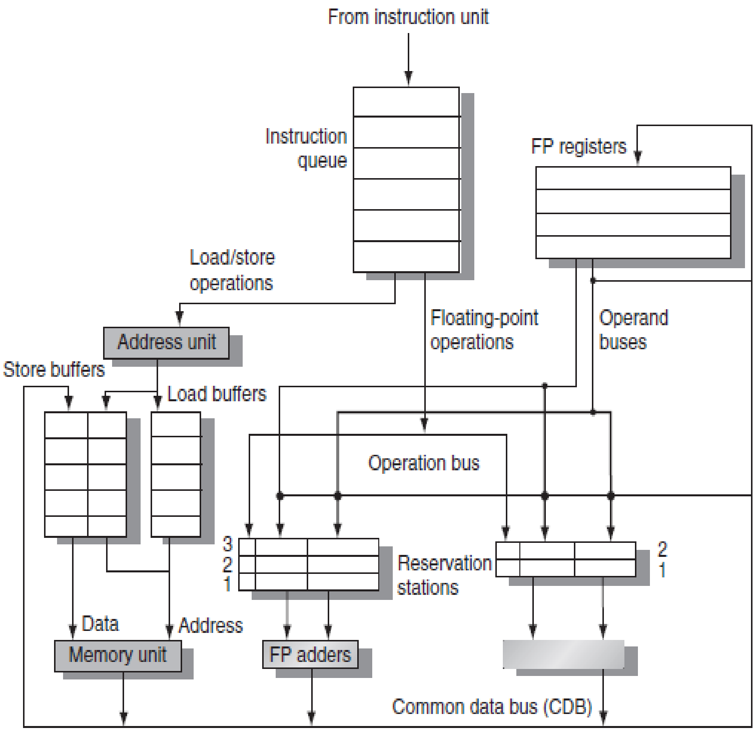
```
Loop: L.D       F0, 0(R1)
ADD.D           F4, F0, F2
S.D             F4, 0(R1)
DADDUI R1, R1, #-8
BNE             R1, R2, LOOP
```

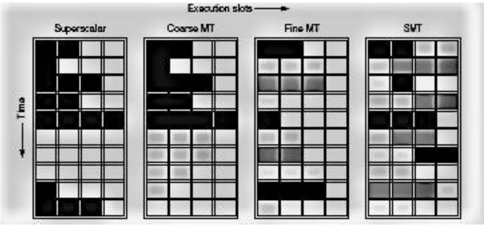
12	**What is software pipelining?** BTL2 Software pipelining is a technique for reorganizing loops that each iteration in the software pipelined code is made from instruction chosen from different iterations of the original loop.
13	**What is global code scheduling?** BTL1 Global code scheduling aims to compact code fragment with internal control structure into the shortest possible sequence that preserves the data and control dependence. Finding a shortest possible sequence is finding the shortest sequence for the critical path.
14	**What is poison bit?** BTL1 Poison bits are a set of status bits that are attached to the result registers written by the specified instruction when the instruction causes exceptions. The poison bits causes a fault then a normal instruction attempts to use the register.
15	**What are the disadvantages of supporting speculation in hardware?** BTL1 Its complexity and additional hardware required.
16	**What are the limitations of ILP?** BTL1 The hardware model, limitation on the window size and maximum issue count, the effects of realistic branch and jump prediction, the effects of finite registers, the effect of imperfect alias analysis.
17	**Write down the formula to calculate the pipeline CPI.**BTL3 Pipeline CPI= Ideal pipeline CPI + Structural stalls + Data hazards stalls + Control stalls
18	**List out the two conditions imposed by control dependencies.** BTL3 The two conditions imposed by control dependencies are: • An instruction that is control dependent on a branch cannot be moved before the branch so that its execution is no longer controlled by the branch. • An instruction that is not control dependent on a branch cannot be moved after the branch so that its execution is controlled by the branch.
19	**When anti-dependence occurs in name dependence? (Apr/May 2017)** BTL3 An anti-dependence between instruction –I‖ and instruction –j‖ occurs when instruction ―j‖ writes a register or memory location that instruction ―i‖ reads.
20	**What is scoreboarding technique?** BTL2 Scoreboarding is a technique for allowing instructions to execute out of order when there are

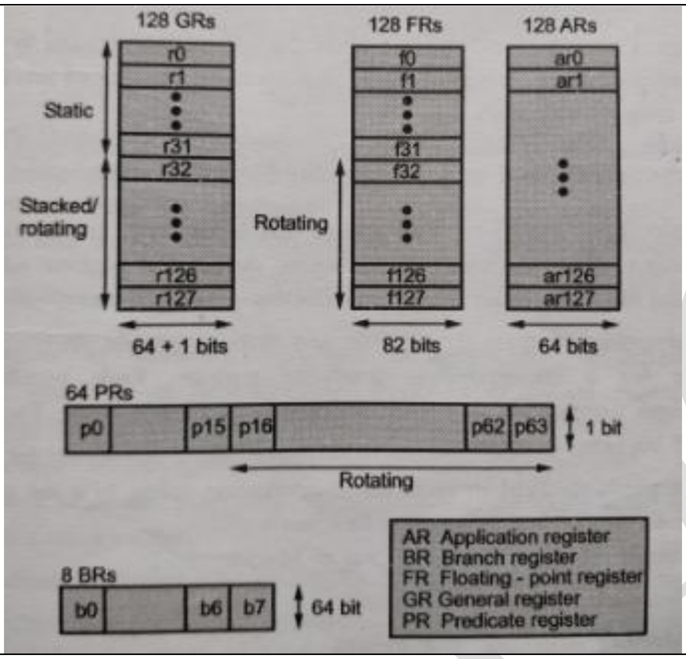
	sufficient resources and no data dependence.
21	**Define speculation.**BTL2 If the branch is taken, the DSUBU instruction will execute and will be useless, but it will not affect the program results. This type of code scheduling is called speculation.
22	**List the classification of data hazards.**BTL3 Data hazards are classified into three types depending on the order of read and write accesses in the instructions • Read After Write (RAW) • Write After Write (WAW) • Write After Read (WAR)
23	**Write down the formula to calculate the pipeline CPI.**BTL4 Pipeline CPI= Ideal pipeline CPI + Structural stalls + Data hazards stalls + Control stalls
24	**List out the approaches to exploit ILP.**BTL3 The two approaches to exploit ILP are dynamic or hardware intensive approach and static or compiler intensive approach.
25	**List out the two conditions imposed by control dependencies.** BTL3 The two conditions imposed by control dependencies are: • An instruction that is control dependent on a branch cannot be moved before the branch so that its execution is no longer controlled by the branch. • An instruction that is not control dependent on a branch cannot be moved after the branch so that its execution is controlled by the branch.
PART B	
1	**Describe the given dependencies (13M)(Nov/Dec 2016)**BTL1 **i. Data dependency (5M)** **ii. Control dependency (4M)** **iii. Name dependency(4M)** **Answer: Page 150 - John L. Hennessy** **Data Dependences: (5M)** **Definition: (2M)** • An instruction j - data dependent - instruction i • Instruction i produceresult - used - instruction j • Instruction j - data dependent - instruction k • Instruction k - data dependent - instruction i. **Explanation with example: (3M)** • MIPS code sequence increments -vector values – memory - starting 0(R1) • The last element - 8(R2)) - a scalar - register F2. **Name Dependences: (4M)** **Definition: (2M)** • Name dependence occur - two instructions • Same register - memory location • No data flow - the instructions associated – name

	Explanation: (2M) • Anti-dependence • An output dependence **Control Dependences: (4M)** **Definition: (2M)** • Determineinstruction ordering. • Branch instruction. • Instruction i executed - correct program order **Explanation: (2M)** • First basic block program • Control dependent – branch set • Preserve program order
2	**What is data hazard and explain the different types of data hazards? (13M) (Apr/May 2016,Nov/Dec 2018)** BTL3 **Answer: Page 153 - John L. Hennessy** **Data Hazards** **Definition: (3M)** • Dependence - instructions • Overlap - pipelining - instructions reorder • Change -operand order - access **Explanation: (5M)** • Preserve instruction order • Executed sequentially –determineoriginal source program • Software -hardware techniques • Exploit parallelism - preserve program order • Affect program outcome • Detect - avoid hazards **Classification: (5M)** • Data hazards classification - three types - order - read - write accesses.
3	**Summarize the concept of loop unrolling and scheduling. (13M)** BTL2 **Answer: Page 161 - John L. Hennessy** **Definition: (3M)** • Simple scheme - increase instructions number • Branch relative • Overhead instructions - loop unrolling • Replicate the loop body multiple times - loop termination code. **Loop unrolling - scheduling (10M):** • Improve scheduling • Eliminates the branch • Eliminate the data use stalls

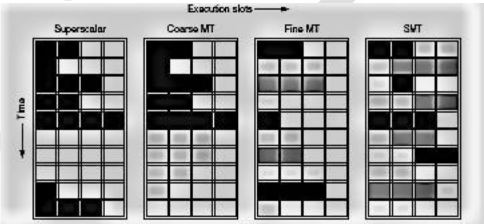
	• Use different registers - each iteration
4	**Evaluate the ways to overcome data hazards with dynamic scheduling. (13M)** BTL5 **Answer: Page 167 - John L. Hennessy** **Need for dynamic scheduling (4M):** • Imprecise exceptions - two possibilities: • The pipeline - *completed* instructions –*later*program order • The pipeline - *not yet completed* instructions - *earlier* program order Allow out-of-order execution - split the ID pipe stage - five-stage pipeline - two stages: **1.Issue** **2.Read operands** **Dynamic Scheduling: The Idea with example (9M)** • Eliminate major limitation - simple pipelining techniques • Use in-order instruction issue -execution • Instructions - program order issue • Multiple functional units- lie idle
5	**Discuss dynamic scheduling using Tomasulo's approach.(13M)(Apr/May 2017)** BTL3 **Answer: Page 170 - John L. Hennessy** **Limitation of previous method: (2M)** • Use in-order instruction issue • Instructions issued - program order • Instruction - stalled pipeline • No later instructionsproceed **Dynamic Scheduling definition with example (4M):** • Dependence - two closely spaced instructions - pipeline • Hazard result- a stall - result • For example: DIV.D F0,F2,F4 ADD.D F10,F0,F8 SUB.D F12,F8,F14 **Tomasulo's approach explanation with diagram (4M+3M):**

	
6	**Explain hardware-based speculation and identify the steps involved in instruction execution.(13M)**BTL5 **Answer: Page 183 - John L. Hennessy** **Definition (4M):** - Choose instructions execution - Speculation - execute instructions - control dependencies. - Dynamic scheduling - scheduling - different combinations - basic blocks. **Explanation with example(9M):** - Hardware-based speculation - Predicted flow - data values - execute instructions - Executing programs - data-flow execution. - PowerPC 603/604/G3/G4 - MIPS R10000/R12000 - Intel Pentium II/III/ 4 - Alpha 21264
7	**Explain the concept of multithreading and list out and explain the four different approaches to it.(13M)(Nov/Dec 2018)**BTL2 **Answer: Page 223 - John L. Hennessy** **Definition (4M):** - Allow multiple threads - share functional units - single processor - Overlapping fashion - Exploit thread-level parallelism (TLP) - Multiprocessor - multiple independent threads operated- parallel. - Multithreading - the processor core - a set of threads

	- Duplicating private state – registers - program counter. **Approaches to multithreading Explanation with diagram: (6M+3M)** - A superscalar with no multithreading support - A superscalar with coarse-grained multithreading - A superscalar with fine-grained multithreading - A superscalar with simultaneous multithreading  - Instruction stream state (registers and memory) - Register state - thread context - Threads - same process (program) - different programs - Threads - same program - share same address space (shared memory model) - Processor keeps track -single thread context - Multitasking
8	**Analyze the case study for exploring the impact of Micro-architectural techniques.(13M)**BTL4 **Answer: Page 247 - John L. Hennessy** **Purpose of the case study (4M):** - Demonstrate the interaction - hardware - software factors - Production - instruction-level parallel execution. - Concise code - Gain intuition - hardware - software factors - Determine the execution time - particular code type - given system. - Explain Itanium -64 - diagram (5M+4M)

	
Part C	
1	**Demonstrate on how the ILP is exploited using Multiple Issue and Static Scheduling.(15M)(Apr/May 2017)**BTL3 **Answer: Page 192 - John L. Hennessy** **Need for multiple issue and static scheduling (4M):** • Eliminate data - control stalls. • Achieve an ideal CPI - one. **Explanation: (7M)** • Improve performance. • Decrease the CPI - less than one. • CPI – not reduced below one. • Issue one instruction every clock cycle. • Allow multiple instructions - issue - clock cycle. • Multiple-issue processors - three major flavors: 1. Statically scheduled superscalar processors. 2. VLIW (very long instruction word) processors 3. Dynamically scheduled superscalar processors. **Table (4M)**
2	**Give the basic compiler techniques for exploiting ILP using VLIW processor.(15M) (Apr/May 2017)**BTL2 **Answer: Page 156 - John L. Hennessy** **Instruction-Level Parallelism: Concepts and Challenges: (7M)**

	• Potential overlap - instruction execution • Pipeline concept - improve system performance • Various techniques - increase parallelism amount • Reduces the data impact - control hazards • Increase processor ability - exploit parallelism There are two approaches to exploiting ILP. • **Static Technique – Software Dependent** • **Dynamic Technique – Hardware Dependent** **Basic Pipeline Scheduling and Loop Unrolling with example: (8M)** • Keep a pipeline full parallelism • Instructionsexploited - find sequences - unrelated instructions • Overlapped pipeline. • Avoid a pipeline stall • Execute dependent instruction • Separatesource instruction • Distance - clock cycles.
3	**Compare hardware and software speculation.(15M)(Apr/May 2017)**BTL4 **Answer: Page 221 - John L. Hennessy** **Explanation(5M):**Hardware-based speculation - three key ideas: • Dynamic branch prediction • Speculation - allow instruction execution • Dynamic scheduling **Table (10M):** • Dynamic runtime disambiguation • Control flow • Exception model • Code Speculation • Dynamic scheduling • Hardware –software
4	**Discuss the important limitations to ILP.(15M) (Apr/May 2017)** BTL1 **Answer: Page 149 - John L. Hennessy** **Instruction-Level Parallelism (3M)** • Exploit parallelism - instructions. • Amount of parallelism -*basic block* • Average dynamic branch frequency - 15% - 25% • Three - six instructions execute - a pair of branches. **Limitations of ILP** **The Hardware Model (4M)**

	• An ideal processor - all artificial constraints - ILP removed. • Imposed - actual data flow - registers or memory. The assumptions - perfect processor: • **Register renaming (2M)**— WAW - WAR hazards • **Branch prediction (2M)**— All conditional branches - predicted exactly. • **Jump prediction (2M)**—All jumps - perfectly predicted. • **Memory-address alias analysis (2M)**—All memory predictions
5	**Define multithreading. Explain how ILP is achieved using multithreading with an example. (15M)(Nov/Dec 2016)**BTL3 **Answer: Page 223 - John L. Hennessy** **Definition (4M):** • Allows multiple threads - share - functional units - single processor • Overlapping fashion • Exploit thread-level parallelism (TLP) • Multiprocessor - multiple independent threads operating - once - parallel. • Multithreading share processor core - a set of threads • Duplicating only private state - registers - program counter. **Approaches to multithreading Explanation with diagram: (4M+3M)** • A superscalar with no multithreading support • A superscalar with coarse-grained multithreading • A superscalar with fine-grained multithreading • A superscalar with simultaneous multithreading  **Achieving ILP using multithreading (4M)** • Instruction stream - state (registers and memory) • Register state - thread context • Threads - part - same process (program) - different programs • Threads - same program - share same address space (shared memory model) • Processor tracks- context - single thread • Multitasking

Unit-III DATA-LEVEL PARALLELISM

Vector architecture – SIMD extensions – Graphics Processing units – Loop level parallelism.

PART-A

1	**What is data level parallelism?** BTL1 Data level parallelism uses vectorization techniques to specify with a single instruction a large number of operations to be performed on independent data. A few of these vector instructions running concurrently can provide a large operation parallelism for many consecutive cycles. Data parallelism is the simultaneous execution on multiple cores of the same function across the elements of a dataset.
2	**What is vector processor? (Apr/May 2016)** BTL1 A vector processor is an ensemble of hardware resources, including vector registers, functional pipelines, processing elements and register counters, for performing vector operations. Vector processing occurs when arithmetic or logical operations are applied to vectors. The conversion from scalar processing to vector code is called vectorization
3	**List advantages of vector processors.** BTL3 • Require lower instruction bandwidth. Reduced by fewer fetches and decodes. • Easier addressing of main memory. Load/Store units access memory with known patterns. • Elimination of memory wastage. • Simplification of control hazards. Loop-related control hazards from the loop are eliminated.
4	**List the disadvantages of vector processors.** BTL3 **Disadvantages:** • Still requires a traditional scalar unit for the non-vector operations • Difficult to maintain precise interrupts • Compiler or programmer has to vectorizer programs • Not very efficient for small vector sizes.
5	**Point out or name the vector processor models.** BTL4 There two primary types of architecture for vector processors: • Register-to-register model • Memory – memory vector processor.
6	**What are the types of data dependencies in loops?** BTL1 Data dependence is of two types: Loop carried dependencies and Not loop carried dependence.
7	**When anti-dependence occurs in name dependence?** BTL2 An anti-dependence between instruction –I‖ and instruction –j‖ occurs when instruction –j‖ writes a register or memory location that instruction –I‖ reads.
8	**What is tree height reduction?** BTL1 Tree height reduction is an optimization techniques which reduces the number of operations or code length. It increases parallelism of the code.
9	**What are the tasks in finding the dependence in a program? (Apr/May 2017)** BTL1 Finding the dependence in a program are of three tasks: • Have good scheduling of code. • Determine which loop might contain parallelism. • Eliminate name dependence.

10	**What is loop level parallelism?** BTL1 To increase amount of parallelism available among instructions is to exploit parallelism among iterations of a loop. This type of parallelism is often called loop level parallelism
11	**What is name dependence?** BTL1 Name dependence occurs when two instructions use the same register or memory location called a name, but there is no flow of data between the instructions associated with that name.
12	**Evaluate briefly the processor that is used to ensemble hardware resources.**BTL5 A vector processor is an ensemble of hardware resources, including vector registers, functional pipelines, processing elements and register counters, for performing vector operations. Vector processing occurs when arithmetic or logical operations are applied to vectors. The conversion from scalar processing to vector code is called vectorization.
13	**What are the boon of vector processors?** BTL2 • Require lower instruction bandwidth. Reduced by fewer fetches and decodes. • Easier addressing of main memory. Load/Store units access memory with known patterns. • Elimination of memory wastage. • Simplification of control hazards. Loop-related control hazards from the loop are eliminated.
14	**Define convoy.** BTL1 • It is the set of vector instructions that could potentially execute together. • We can estimate performance of a section of code by counting the number of convoys. • The instructions in a convoy must not contain any structural hazards; if such hazards were present, the instructions would need to be serialized and initiated in different convoys. • To keep the analysis simple, we assume that a convoy of instructions must complete execution before any other instructions (scalar or vector) can begin execution.
15	**What are the limitations of ILP?** -BTL2 The hardware model, limitation on the window size and maximum issue count, the effects of realistic branch and jump prediction, the effects of finite registers, the effect of imperfect alias analysis.
16	**Define vector execution time.** BTL1 The execution time of a sequence of vector operations primarily depends on three factors: • The length of the operand vectors • Structural hazards among the operations • The data dependences.
17	**What are the disadvantages of supporting speculation in hardware?** BTL2 It has a high complexity and additional hardware are required.
18	**What is poison bit?** BTL2 Poison bits are a set of status bits that are attached to the result registers written by the specified instruction when the instruction causes exceptions. The poison bits causes a fault

	then a normal instruction attempts to use the register.
19	**What is software pipelining?** BTL1 Software pipelining is a technique for reorganizing loops that each iteration in the software pipelined code is made from instruction chosen from different iterations of the original loop.
20	**What is global code scheduling?** BTL2 Global code scheduling aims to compact code fragment with internal control structure into the shortest possible sequence that preserves the data and control dependence. Finding a shortest possible sequence is finding the shortest sequence for the critical path.
21	**Mention the idea behind hardware-based speculation. (Apr/May 2017)**BTL1 • It combines three key ideas: • Dynamic branch prediction to choose which instruction to execute, • Speculation to allow the execution of instructions before control dependence are resolved. Dynamic scheduling is used to deal with the scheduling of different combinations of basic blocks.
22	**List out the primary components of VMIPS.**BTL4 • Vector registers • Vector functional units • Vector load/store unit • A set of scalar registers
23	**What is loop unrolling?** BTL1 A simple scheme for increasing the number of instructions relative to the branch and overhead instructions is loop unrolling. Unrolling simply replicates the loop body multiple times, adjusting the loop termination code.
24	**Explain the idea behind dynamic scheduling. Also write advantages of dynamic scheduling.** BTL4 In dynamic scheduling the hardware rearranges the instruction to reduce the stalls while maintaining dataflow and exception behaviour. Advantages: it enables handling some cases when dependence are unknown at compile time It allows code that was compiled with one pipeline in mind and run efficiently on a different pipeline.
25	**Write the concept behind using reservation station? (Nov/Dec 2017)**BTL2 Reservation station fetches and buffers an operand as soon as available, eliminating the need to get the operand from a register.
	PART-B
1	**Draw and explain the basic architecture of VMIPS. (Apr/May 2016) (13M)** BTL4 **Answer: Page 264 - John L. Hennessy** **History (1M):** • Cray-1 • Foundation

Definition:(2M)

- Instruction set architecture VMIPS
- Scalar portion
- Vector portion
- Logical vector extension

Vector registers (2M)

- Vector register
- Fixed-length bank
- 64 elements
- Each 64 bits wide
- Crossbar switches.

Vector functional units (2M)

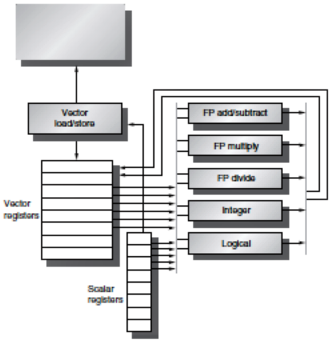
- Fully pipelined
- New operation
- Structural hazards
- Data hazards
- Register accesses.

Vector load/store unit(2M)—

- Vector memory unit loads
- Stores a vector
- Initial latency

A set of scalar registers(2M)

- Vector functional units
- Vector load/store unit
- 32 general-purpose registers
- 32 floating-point
- Scalar register file
- **Diagram (2M):**



2 **Explain Vector length and Vector mask registers and how they handle loops.(13M)** BTL2

Answer: Page 274 - John L. Hennessy

Vector-Length Registers: Handling Loops Not Equal to 64 (8M)

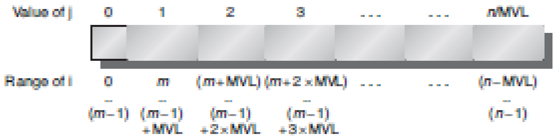
Definition (2M):

- Natural vector length

- Vector register

Explanation with example (3M+2M):

- Real vector length
- Vector operation
- Compile time.
- Different vector lengths
- **Diagram (1M):**



Vector Mask Registers: Handling IF Statements in Vector Loops: (5M)

Definition (2M):

- Amdahl’s law
- Programspeedup
- Vectorization levels

Explanation - example (3M):

- IF statements
- Vector mode
- Control dependences
- Sparse matrices
- Conditional execution

3 **Explain the SIMD instruction set extensions for multimedia(Nov/Dec 2018)(13M)** BTL3

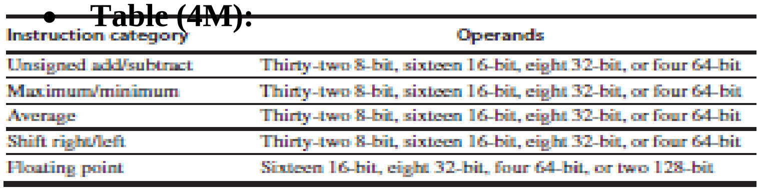
Answer: Page 282 - John L. Hennessy

Definition: (3M)

- SIMD Multimedia Extensions
- Narrower data types
- 32-bit processors

Explanation: (6M)

- 8 bits representation
- Three primary colors
- Transparency.
- Carry chains
- **Table (4M):**



Instruction category	Operands
Unsigned add/subtract	Thirty-two 8-bit, sixteen 16-bit, eight 32-bit, or four 64-bit
Maximum/minimum	Thirty-two 8-bit, sixteen 16-bit, eight 32-bit, or four 64-bit
Average	Thirty-two 8-bit, sixteen 16-bit, eight 32-bit, or four 64-bit
Shift right/left	Thirty-two 8-bit, sixteen 16-bit, eight 32-bit, or four 64-bit
Floating point	Sixteen 16-bit, eight 32-bit, four 64-bit, or two 128-bit

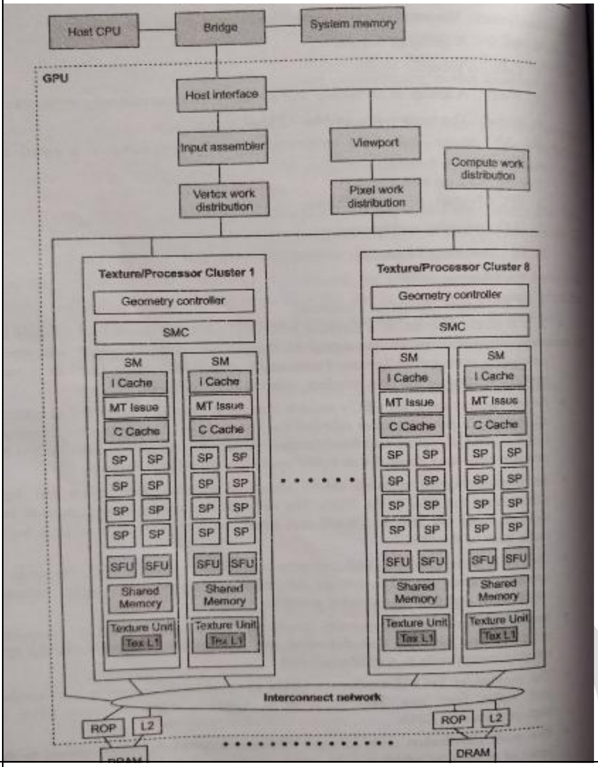
4 **Point out the programming of Graphics Processing Units (GPU). (Apr/May 2017) (13M)** BTL4

Answer: Page 288 - John L. Hennessy

GPU Definition: (2M)

	• Parallel floating-point units • High-performance computing • More accessible. **Explanation: (5M)** • Potential • Programming language • Multimedia applications • Conventional C code explanation - example (6M)
5	**Describe the NVIDIA GPU Computational Structures.(13M)** BTL1 **Answer: Page 291 - John L. Hennessy** **Explanation: (4M)** • Misleading names • Twin goals • Understandable • CUDA terminology • OpenCL. • NVIDIA GPUs. • **Table (9M)**
PART-C	
1	**Identify and explain the process of detecting and enhancing Loop-level Parallelism. (Nov/Dec 2016) (15M)** BTL5 **Answer: Page 315 - John L. Hennessy** **Definition (3M)** • Source level analyzation • Compiler generated **Explanation (10M)** • Dependences existence determination • Loop iterations • Data accesses • Loop-carried dependence **Example (2M)** • Finding dependencies • Eliminating dependent computations
2	**Discuss GPU architecture with a neat diagram. (Apr/May 2017) (15M)** BTL2 **Answer: Page 291 - John L. Hennessy** **GPU working (9M):** • Vector architectures • Data-level parallel problems • Gather-scatter data transfers • Mask registers • GPU processors • Multithreading - single multithreaded SIMD processor

- Hide memory latency.
- Diagram (6M)



3 **Explain Data Level Parallelism in Vector Architecture in detail. (Apr/May 2017) (15M)** BTL1

Answer: Page 264 - John L. Hennessy

Vector architecture: (5M)

- Data elements scattered a
- Large, sequential register files
- Register–register operations
- Independent data elements.

Vector-Length Registers: Handling Loops Not Equal to 64 (10M)

Definition (2M):

- Vector register processor
- Natural vector length
- Vector register
- Real vector length

Explanation (4M):

- Real program length
- Particular vector operation
- Unknowncompile time
- Different vector lengths
- **Example (4M):**

```
for (i=0; i<n; i=i+1)
Y[i] = a * X[i] + Y[i];
```

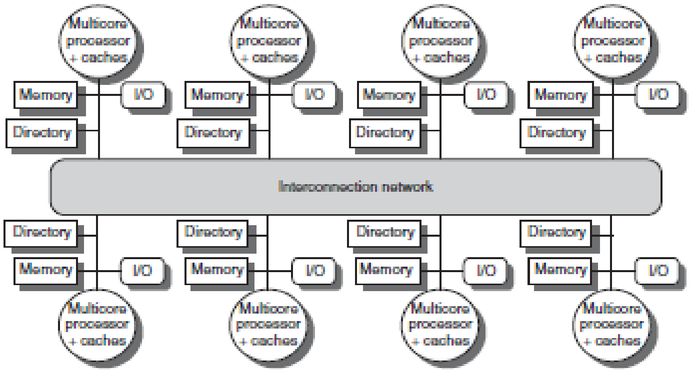
UNIT IV THREAD LEVEL PARALLELISM

Symmetric and Distributed Shared Memory Architectures – Performance Issues –Synchronization – Models of Memory Consistency – Case studies: Intel i7 Processor, SMT & CMP Processors.

PART*A

1	**What are multiprocessors? Mention the categories of multiprocessors?** BTL3 Multiprocessors are used to increase performance and improve availability. The different categories are SISD(Single Instruction and Single Data stream), SIMD(Single Instruction and Multiple Data stream), MISD(Multiple Instruction and Single data stream) MIMD(Multiple Instruction and Multiple Data stream)
2	**Define threads.(Apr/May 2016)**BTL1 These are multiple processors executing a single program and sharing the code and most of their address space. When multiple processors share code and data in the way, they are often called threads.
3	**What is cache coherence problem?** BTL1 Two different processors have two different values for the same location.
4	**What are the ways to maintain cache coherence? OR what are the ways to enforce cache coherence?** BTL2 Directory based protocol, Snooping based protocol.
5	**What are the ways to maintain cache coherence using snooping protocol?((Apr/May 2016)**BTL2 Write invalidate protocol, write update or write broadcast protocol.
6	**What is write invalidate and write update protocol?**BTL1 • Write invalidate provide exclusive access to caches. These exclusive caches ensure that no other readable or writable copies of an item exist when the write occurs. • Write updates protocol updates all cached copies of a data item when that item is written.
7	**Illustrate are the disadvantages of using symmetric shared memory.(Nov/Dec 2016)**BTL3 Compiler mechanisms are very limited, and create large latency for remote memory access fetching multiple words in a single cache block will increase the cost.
8	**Mention the information available in the directory.**BTL4 The directory keeps the state of each block that is cached. It keeps track of which caches have copies of the block.
9	**What are the states of cache block in directory based approach?**BTL2 Shared, Un-cached and Exclusive.
10	**What are the uses of having a bit vector?** BTL3 When a block is shared, the bit vector indicates whether the processor has the copy of the block. When block is in exclusive state, bit vector keep track of the owner of the block.
11	**When do we say that a cache block is exclusive? (Apr/May 2017)**BTL1 When exactly one processor has the copy of the cache block, and it has written the block, then the processor is called the owner of the block. During this phase the block will be in exclusive state.
12	**Explain the types of messages that can be sent between the processors and directories.**BTL3 Local Node: node where the requests originates Home Node: Node where memory location and directory entry of the address resides. Remote Note: the copy of the block in the third node called remote node.
13	**What is consistency? And what are the models used for consistency?** BTL2 Consistency says in what order processor must observe the data writes of another processor. Models used for Consistency: Sequential Consistency Model, Relaxed Consistency Model
14	**What is sequential consistency?** BTL1 Sequential consistency requires that the result of any execution be the same, as if the memory

	accesses executed by each processor were kept in order and the accesses among different processors were interleaved.
15	**What is relaxed consistency model? (Apr/May 2016)**BTL1 Relaxed consistency model allows reads and writes to be executed out of order. Three sets of ordering are: W->R Ordering – Total store ordering W->W Ordering – Partial ordering R->W and R->R Ordering – Weak ordering
16	**Explain coarse grained and fine grained multithreading.**BTL1 Coarse Grained: it switches only on costly stalls (or) event. Thus it is much less likely to slow down the execution of an individual thread. Fine Grained: it switches threads between threads on each instruction, causing the execution of multiple threads to be interleaved.
17	**What is memory?**BTL2 Memory is a device used to store the data ad instructions required for any operation.
18	**What is bandwidth?**BTL2 The maximum amount of information that can be transferred to or from the memory per unit time is called bandwidth.
19	**Define a cache.** BTL1 It's a small fast intermediate memory between the processor and the main memory.
20	**List the mapping techniques of cache.**BTL3 Mapping techniques are direct mapping, fully associative and set associative.
21	**What is write stall?**BTL1 When the processor must wait for writes to complete during write through, the processor caches is said to write stall.
22	**Define mapping functions.**BTL1 The correspondence of memory blocks in cache with the memory blocks in the main memory is defined as mapping functions.
23	**What is address translation?**BTL2 The conversion of virtual address to physical address is termed as address translation.
24	**What is temporal locality?**BTL2 Recently referenced items are likely to be referenced again in the near future. This is often caused by special program constructs such as iterative loops, process stacks, temporary variables or subroutines.
25	**Define spatial locality.**BTL1 This refers to the tendency for a process to access items whose addresses are near one another.
PART*B	
1	**Illustrate Symmetric Shared Memory Multiprocessors and its performance.(Nov/Dec 2016) (13M)** BTL3 **Answer: Page 366 - John L. Hennessy** **Definition (3M)** • Multicore • Snooping coherence protocol **Commercial workload (4M)** • Processor count • Cache size • Block size

	• Miss rate **Performance Measurements(3M)** • DSS numbers • Six different queries • Resource stalls • Branch mis-predict • Memory barrier • TLB misses. **Multiprogramming - OS Workload (3M)** • Multi-programmed workload • User activity • OS activity
2	**Explain Distributed Shared Memory and how a directory is added to each node to implement cache coherence.(Apr/May 2017) (13M)** BTL2 **Answer: Page 380 - John L. Hennessy** **Definition: (3M)** • Snooping protocol • Directory protocol **Explanation (6M):** • Shared • Uncached • Modified **Diagram (4M):** 
3	**Analyse the implementation of coherence using locks. (Nov/Dec 2018)(13M)** BTL4 **Answer: Page 389 - John L. Hennessy** **Need for locks (4M)** • Atomic operation • Coherence mechanisms • Implement spin locks **Explanation - example (9M)** • No cache coherence • Lock variables • Atomic exchange

```
lockit: DADDUIR2,R0,#1
        EXCHR2,0(R1) ;atomic exchange
        BNEZR2,lockit ;already locked
```

4 **Point out the programmer's view on models of memory consistency. (13M)** BTL4

Answer: Page 393 - John L. Hennessy

Need for memory consistency model: (5M)

- Sequential consistency model
- High-performance implementation.
- Synchronized.

Relaxed Consistency Models: The Basics (4M)

- Allows reads and writes
- Synchronization operations
- Enforce ordering

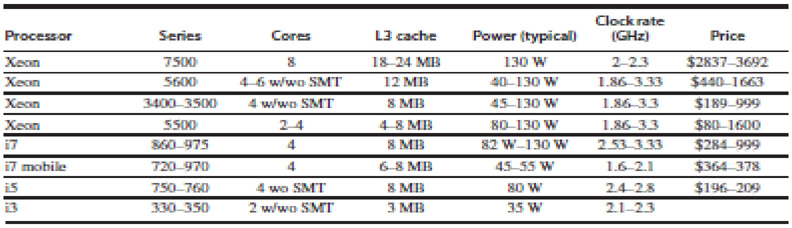
Final Remarks - Consistency Models (4M)

- Built support
- Relaxedconsistency model
- Standard synchronization libraries
- Write synchronized programs

5 **Evaluate the characteristics of Intel Nehalem Micro-architecture. (13M)** BTL5

Answer: Page 411 - John L. Hennessy

- **Table (7M)**



Processor	Series	Cores	L3 cache	Power (typical)	Clock rate (GHz)	Price
Xeon	7500	8	18–24 MB	130 W	2–2.3	$2837–3692
Xeon	5600	4–6 w/wo SMT	12 MB	40–130 W	1.86–3.33	$440–1663
Xeon	3400–3500	4 w/wo SMT	8 MB	45–130 W	1.86–3.3	$189–999
Xeon	5500	2–4	4–8 MB	80–130 W	1.86–3.3	$80–1600
i7	860–975	4	8 MB	82 W–130 W	2.53–3.33	$284–999
i7 mobile	720–970	4	6–8 MB	45–55 W	1.6–2.1	$364–378
i5	750–760	4 wo SMT	8 MB	80 W	2.4–2.8	$196–209
i3	330–350	2 w/wo SMT	3 MB	35 W	2.1–2.3	

Explanation (6M)

- ILP
- Optimizing compilers
- Exploit ILP
- Parallel software
- Architectures

PART*C

1 **Explain about the synchronization techniques used in multiprocessor system. (Apr/May 2017) (15M)** BTL3

Answer: Page 387 - John L. Hennessy

Synchronization: The Basics (5M)

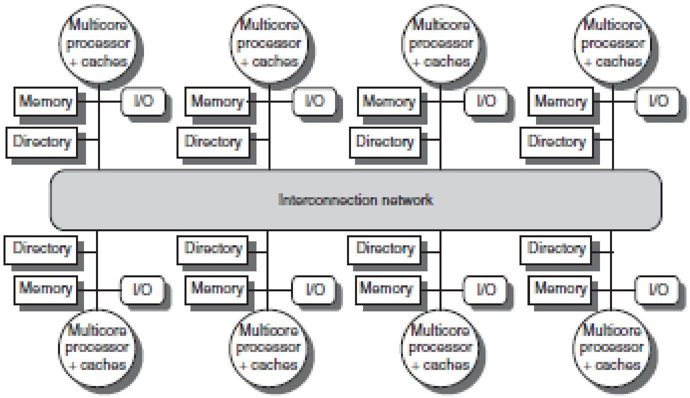
- Implement synchronization
- Multiprocessor
- Hardware primitives
- Basic synchronization primitives

Basic hardware primitives - example (5M)

- Alternative formulations
- Hardware primitives
- Locks
- Barriers

Implementing Locks Using Coherence - example (3M+2M)

- Spin locks
- Low latency

2	**Discuss about the models of memory consistency. (Apr/May 2017) (15M)** BTL2 **Answer: Page 393 - John L. Hennessy** **Need for memory consistency model (5M)** • Viewpoint • Synchronized • Shared data **Relaxed Consistency Models: The Basics (5M)** • Sequentially consistent **Final Remarks on Consistency Models (5M)** • Release consistency • Highly multiprocessor specific • Error prone
3	**With a neat diagram, explain the distributed shared memory architecture. (Nov/Dec 2016)(15M)** BTL2 **Answer: Page 378 - John L. Hennessy** **Definition (3M)** • Directory protocol • Handling a read miss • Clean cache block **Explanation (8M)** • Shared • Uncached • Modified **Diagram (4M)** 

UNIT V MEMORY AND I/O

Cache Performance – Reducing Cache Miss Penalty and Miss Rate – Reducing Hit Time – Main Memory and Performance – Memory Technology. Types of Storage Devices – Buses – RAID – Reliability, Availability and Dependability – I/O Performance Measures.

PART*A

1	**What is cache miss and cache hit? (Apr/May 2016)**BTL1 • Cache Miss: When the CPU finds a requested data item in the cache, it is called cache miss. • Cache Hit: When the CPU finds a requested data item is available in the cache, it is called cache hit.
2	**What is “write through” and “write back cache”?** BTL1 • Write through cache: The information is written to both the block in the cache and to the block in the lower level memory. • Write Back Cache: The information is written only to the block in the cache. The modified cache block is written to main memory only when it is replaced.
3	**What is Miss Rate and Miss Penalty?** BTL2 • Miss Rate is the fraction of cache access that results in a miss. • Miss Penalty depends on the number of misses and clock per miss.
4	**Write the equation of Average memory access time.** BTL3 Average memory access time = hit time + miss rate * Miss Penalty
5	**What is stripping?** BTL1 Spreading multiple data over multiple disks is called stripping, which automatically forces accesses to several disks.
6	**What is disk mirroring? Write the drawbacks of disk mirroring.** BTL1 • Disks in the configuration are mirrored or copied to another disk. With this arrangement data on the failed disks can be replaced by reading it from the other mirrored disks. • Drawback: writing onto the disk is slower since the disks are not synchronized, seek time will be different. • It imposes 50% space penalty hence expensive.
7	**Mention the factors that measure I/O performance.** BTL4 Diversity capacity, response time, throughput, interference with CPU execution.
8	**What is transaction time?** BTL1 The sum of entry time, response time and think time is called transaction time.
9	**State little law.** BTL3 Little law relates the average number of tasks in the system. It relates to Average arrival rate of new tasks with the average time to perform a task.
10	**What are the steps to design an I/O system? (Apr/May 2017)**BTL1 • Naïve cost – performance design and evaluation • Availability of naïve design • Response time • Realistic cost performance, design and evaluation • Realistic design for availability and its evaluation
11	**Give the classification of buses.** BTL2

	I/O buses – these buses are lengthy and have any types of devices connected to it. CPU memory buses – They are short and generally of high speed.
12	**What is bus master?** BTL1 Bus master are devices that can initiate the read or write transaction. Eg. Processor – processor are always has the bus master ship.
13	**Mention the advantages of using bus master.** BTL3 It offers higher bandwidth by using packets, as opposed to holding the bus for full transaction.
14	**What is split transaction?** BTL1 The idea behind this is to split the bus into request and replies, so that the bus can be used in the time between request and the reply.
15	**What are the measures of latency in memory technology?** BTL2 Access Time: Is the time between when a read is required and when the desired word arrives. Cycle Time: Is the minimum time between requests to memory.
16	**What are the techniques to reduce hit time?** BTL1 The techniques to reduce hit time are: • Small and simple cache: Direct mapped • Avoid address translation during indexing of the cache • Pipelined cache access • Trace cache.
17	**List the method to improve the cache performance. (Nov/Dec 2016)** BTL3 Improving the cache performance following methods are used: a. Reduce the miss rate. b. Reduce the miss penalty. c. Reduce the time to hit in the cache.
18	**What is split transactions?** BTL1 With multiple masters, bus can offer higher bandwidth by using packets, as opposed to holding the bus for the full transaction. This technique is called split transactions.
19	**What is transfer time?** BTL1 Transfer time is the time it takes to transfer a block of bits, typically a under the read/write head.
20	**How the conflicts misses are divided?** BTL3 Four divisions of conflict misses are: • **Eight way:** Conflict misses due to going from fully associative to eight way associate. • **Four way:** Conflict misses due to going from eight way associative to four way associate. • **Two way:** Conflict misses due to going from four associative to two way associate. • **One way:** Conflict misses due to going from two associative to one way associate.

21 **What is sequence recorded?** BTL2

The sequence recorded on the magnetic medics is a sector number, a gap, the information for that sector including error correction code, a gap, the sector number of the next sector and so on.

22 **Write the formula to calculate the CPU time.** BTL3

CPU execution time = (CPU clock cycles + Memory stall cycles) x Clock cycle time.

23 **What is RAID?** BTL1

RAID is Redundant Array of Independent Disks. It is also called as redundant array of inexpensive disks. It is a way of storing the data in different places on multiple hard disks.

24 **Explain the term availability and dependability. (Apr/May 2016)** BTL2

Availability is a measure of the service accomplishment with respect to the alternation between the two states of accomplishment and interruption.

Dependability is the quality of delivered service such that reliance can justifiable be placed on this service.

25 **Differentiate between write through cache and snoopy cache.** BTL3

In write through cache, it is easy to find the recent value of a data item since all written data are always sent to the memory, from which the most recent value of a data item can always be fetched. In a snoopy cache, each cache watches the memory bus for any requests for a line that they have.

PART*B

1 **Which has the lower miss rate: a 16 KB instruction cache with a 16 KB data cache or a 32 KB unified cache? Use the miss rates in the given figure belowto help calculate the correct answer, assuming 36% of the instructions are data transfer instructions. Assume a hit takes 1 clock cycle and the miss penalty is 100 clock cycles. A load or store hit takes 1 extra clock cycle on a unified cache if there is only one cache port to satisfy two simultaneous requests. Using the pipelining terminology, the unified cache leads to a structural hazard. What is the average memory access time in each case? Assume write-through caches with a write buffer and ignore stalls due to the write buffer. (13M)**BTL5

Answer: Page :B-16 - John L. Hennessy

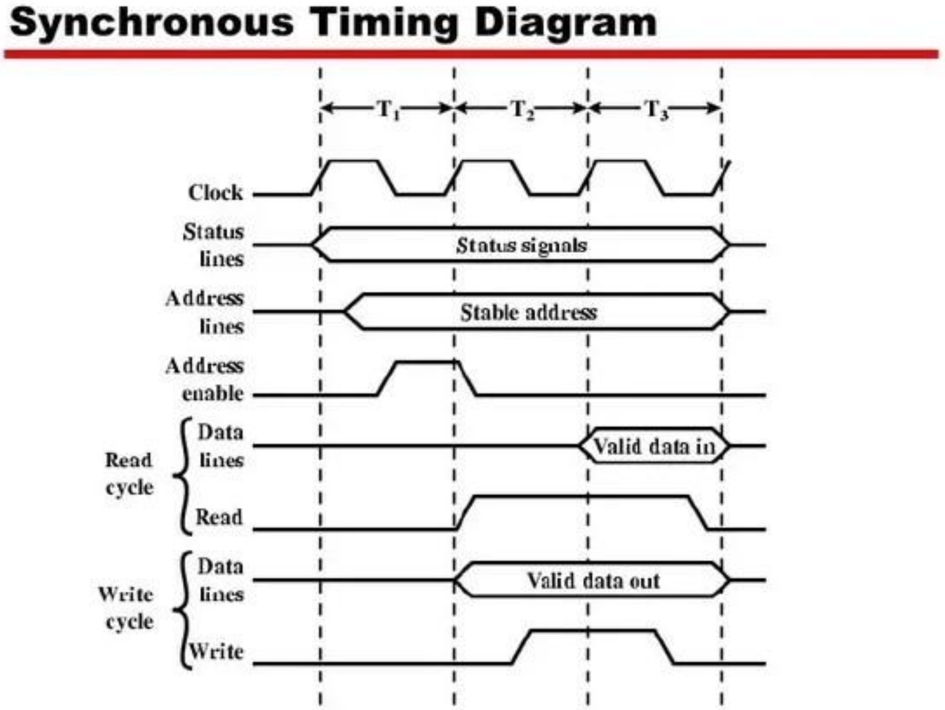
Size(KB)	**Instruction Cache**	**Data Cache**	**Unified Cache**
8	**8.16**	**44.0**	**63.0**
16	**3.82**	**40.9**	**51.0**
32	**1.36**	**38.4**	**43.3**
64	**0.61**	**36.9**	**39.4**
128	**0.30**	**35.3**	**36.2**
256	**0.02**	**32.6**	**32.9**

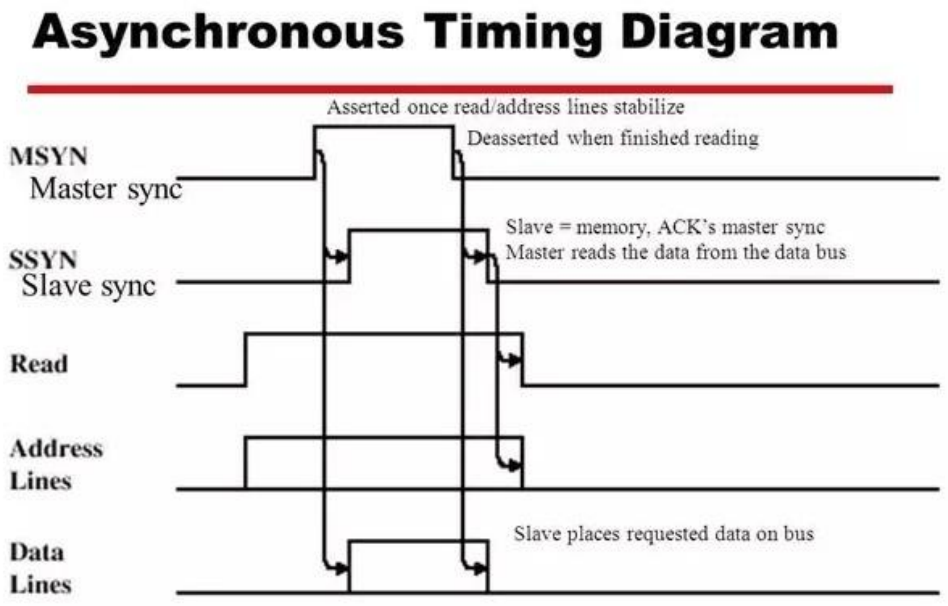
Formula (3M)

Average memory access time = Hit time + Miss rate × Miss penalty

Solving (10M)

2	**Examine the ways to reduce miss penalty and miss rate.(Apr/May 2016, Nov/dec 2018)(13M)**BTL3 **Answer: Page :B-22 - John L. Hennessy** **Definition (3M)** • Average memory access time formula • Present cache optimizations • Improve cache performance • Average memory access time = Hit time + Miss rate × Miss penalty **Categories with explanation (6M)** • Six cache optimizations • Reducing the miss rate • Reducing the miss penalty • Reducing the time - hit cache **Divisions of conflict misses (4M)** • Eight-way • Four-way • Two-way • One-way (direct mapped)
3	**Describe cache performance and write down the formula to calculate average memory access time. (Apr/May 2017) (13M)**BTL1 **Answer: Page :96 - John L. Hennessy** **Definition (2M):** • Instruction count • Evaluate processor performance • Indirect performance measures **Explanation (3M)** • Evaluating memory hierarchy performance • Miss rate • Hardware performance • Instruction count **Formula with explanation (2M)** • Memory hierarchy performance • Average memory access time = Hit time + Miss rate × Miss penalty • Average memory access time - processor performance (3M) • Miss penalty - out of order execution processors (3M)
4	**List out the categories of memory technology and explain them.(13M)**BTL3 **Answer: Page :216 - John L. Hennessy** **SRAM Definition (4M)** • SRAM - static RAM • Random access memory (RAM) • Retains data bits **Explanation (9M)** • Dynamic RAM (DRAM)

	• Stores bits in cells • Capacitor • Transistor
5.	**Explain Synchronous and Asynchronous bus timing.(Nov/Dec 2016)(13M)**BTL2 **Answer: Page :5-30–I.A.Dhotre** **Synchronous bus - diagram: (7M)** • Transmitter • Receivers • Data bits • Constant Rate  **Asynchronous bus - diagram: (6M)** • Not synchronized by clock. • Data transfer • Character oriented • Low – speed transmission.



PART*C

1

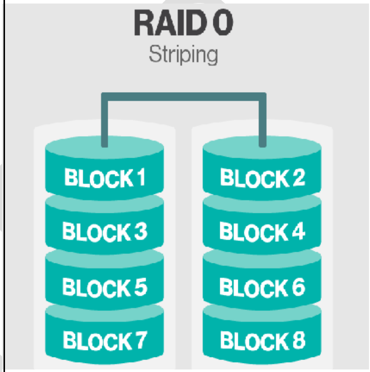
Describe about various RAID levels with diagram. (Apr/May 2017) (15M)BTL2

Answer: Page :5-34 – I.A.Dhotre

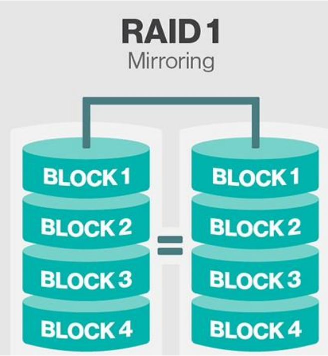
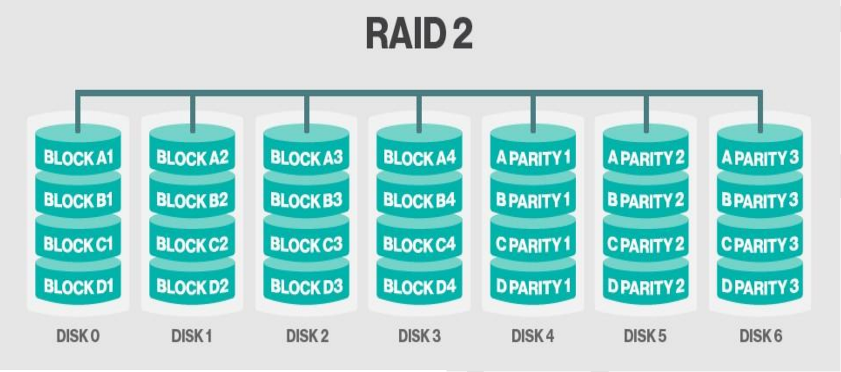
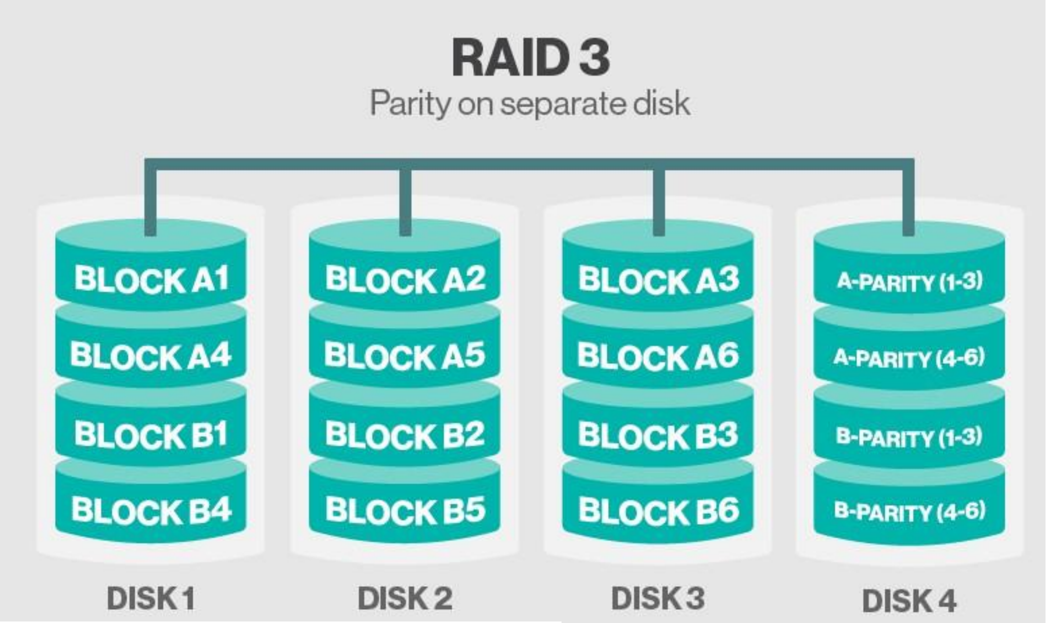
RAID Definition (2M)

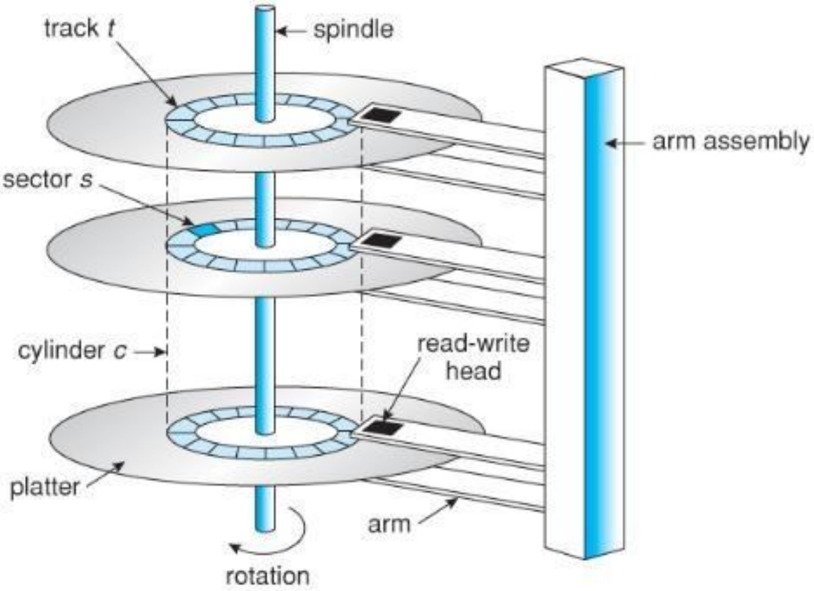
- Combine physical drive
- Single hard drive
- Operating system
- Data storage infrastructure

RAID level 0: Striping (2M)



RAID level 1: Mirroring and performance improvements(2M)

	 RAID level 2: Memory style error code organization (2M)  RAID level 3:Bit-level parity (2M)  RAID level 4:Block interleaved parity (2M) RAID level 5:Interleaved distributed parity (2M) RAID level 6: P+Q Redundancy (1M)
2	**List out the different types of storage devices and explain them. (15M)** BTL3 **Answer: Page :5-23 – I.A.Dhotre** **Magnetic disk - diagram (8M)**

	 **Magnetic Tape(4M)** • Magnetically coated plastic strip • Store music • Backup **Optical Disc (3M)** • Digital format • Laser assembly • Optical media • Blu-ray (BD) – Compact Disc (CD) – Digital Versatile Disc (DVD)
3	**Describe the various basic cache optimization technique with example. (Apr/May 2017)(15M)** BTL3 **Answer: Page :5-2 – I.A.Dhotre** **Definition (3M)** Average memory access time = Hit time + Miss rate × Miss penalty **Categories - explanation (9M)** • Reducing the miss rate • Reducing the miss penalty • Reducing the time – cache HIT **Divisions of conflict misses (3M)** • Eight-way • Four-way • Two-way • One-way (direct mapped)
4	**List and explain various I/O performance measures. (Nov/Dec 2016) (15M)**BTL2 **Answer: Page :5-42 – I.A.Dhotre** **Need of I/O Performance (3M)**

	• No counterparts • CPU design • Unique measures • I/O throughput • Latency **Explanation (6M)** • I/O performance • Interference • Overhead • Handling I/O interrupts **Throughput versus Response Time (6M)** • Three parts • Entry time • System response time • Think time
5	**Explain the categories of misses and how will you reduce cache miss rate. (Nov/Dec 2016)(15M)** BTL4 **Answer: Page :5-8 – I.A.Dhotre** **Cache performance Explanation- formula(6M)** • Instruction count • Evaluate processor performance • Miss rate • Instruction count • Average memory access time = Hit time + Miss rate × Miss penalty **Reducing Cache Miss Rate (9M)** • Compiler-controlled prefetch • Hardware prefetching • Non-blocking • Lockup-free • Re-fetching data • Indexing the cache

EC6015 RADAR AND NAVIGATIONAL AIDS L T P C 3 0 0 3

OBJECTIVES:

- ✓ To apply Doppler principle to radars and hence detect moving targets, cluster, also to understand tracking radars
- ✓ To refresh principles of antennas and propagation as related to radars, also study of transmitters and receivers.
- ✓ To understand principles of navigation, in addition to approach and landing aids as related to navigation

UNIT I INTRODUCTION TO RADAR EQUATION (9)

Introduction- Basic Radar –The simple form of the Radar Equation- Radar Block Diagram- Radar Frequencies – Applications of Radar – The Origins of Radar - Detection of Signals in Noise- Receiver Noise and the Signal-to-Noise Ratio-Probability Density Functions- Probabilities of Detection and False Alarm- Integration of Radar Pulses- Radar Cross Section of Targets- Radar cross Section Fluctuations – Transmitter Power-Pulse Repetition Frequency- Antenna Parameters- System losses – Other Radar Equation Considerations.

UNIT II MTI AND PULSE DOPPLER RADAR (9)

Introduction to Doppler and MTI Radar- Delay –Line Cancellers- Staggered Pulse Repetition Frequencies –Doppler Filter Banks - Digital MTI Processing - Moving Target Detector - Limitations to MTI Performance - MTI from a Moving Platform (AMIT) – Pulse Doppler Radar – Other Doppler Radar Topics- Tracking with Radar –Monopulse Tracking –Conical Scan and Sequential Lobing - Limitations to Tracking Accuracy - Low-Angle Tracking – Tracking in Range - Other Tracking Radar Topics -Comparison of Trackers - Automatic Tracking with Surveillance Radars (ADT).

UNIT III DETECTION OF SIGNALS IN NOISE (9)

Matched –Filter Receiver –Detection Criteria – Detectors –-Automatic Detector - Integrators - Constant-False-Alarm Rate Receivers - The Radar operator - Signal Management - Propagation Radar Waves - Atmospheric Refraction -Standard propagation - Nonstandard Propagation - The Radar Antenna - Reflector Antennas - Electronically Steered Phased Array Antennas – Phase Shifters - Frequency-Scan Arrays.

Radar Transmitters and Receivers - Introduction –Linear Beam Power Tubes - Solid State RF Power Sources - Magnetron - Crossed Field Amplifiers - Other RF Power Sources – Other aspects of Radar Transmitter **-** The Radar Receiver - Receiver noise Figure – Super heterodyne Receiver - Duplexers and Receiver Protectors- Radar Displays.

UNIT IV RADIO DIRECTION AND RANGES (9)

Introduction - Four methods of Navigation **-** The Loop Antenna - Loop Input Circuits - An Aural Null Direction Finder - The Goniometer - Errors in Direction Finding - Adcock Direction Finders - Direction Finding at Very High Frequencies - Automatic Direction Finders – The Commutated Aerial Direction

Finder - Range and Accuracy of Direction Finders **-** The LF/MF Four course Radio Range - VHF Omni Directional Range (VOR) - VOR Receiving Equipment - Range and Accuracy of VOR – Recent Developments.

Hyperbolic Systems of Navigation (Loran and Decca) - Loran-A - Loran-A Equipment - Range and precision of Standard Loran - Loran-C - The Decca Navigation System -Decca Receivers - Range and Accuracy of Decca - The Omega System

UNIT V SATELLITE NAVIGATION SYSTEM (9)

Distance Measuring Equipment - Operation of DME - TACAN - TACAN Equipment **-** Instrument Landing System - Ground Controlled Approach System - Microwave Landing System(MLS) The Doppler Effect - Beam Configurations - Doppler Frequency Equations - Track Stabilization - Doppler Spectrum - Components of the Doppler Navigation System - Doppler range Equation - Accuracy of Doppler Navigation Systems. Inertial Navigation **-** Principles of Operation - Navigation Over the Earth – Components of an Inertial Navigation System - Earth Coordinate Mechanization - Strapped-Down Systems - Accuracy of Inertial Navigation Systems-The Transit System - Navstar Global Positioning System (GPS)

TOTAL: 45 PERIODS

OUTCOMES: Upon completion of the course, students will be able to:

- ✓ Explain principles of navigation, in addition to approach and landing aids as related to navigation
- ✓ Derive and discuss the Range equation and the nature of detection.
- ✓ Describe about the navigation systems using the satellite.

TEXTBOOKS:

1. Merrill I. Skolnik ," Introduction to Radar Systems", 3rd Edition Tata Mc Graw-Hill 2003.
2. N.S.Nagaraja, “Elements of Electronic Navigation Systems”, 2nd Edition, TMH, 2000.

REFERENCES:

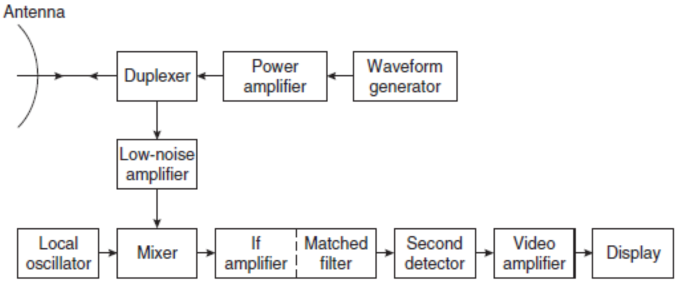
1. Peyton Z. Peebles:, "Radar Principles", John Wiley, 2004
2. J.C Toomay, " Principles of Radar", 2nd Edition –PHI, 2004

Sub Code: EC6015 **Year/Semester: IV/07**

Subject Name: Radar & Navigational Aids **Subject Handler: Mr.V.Yokesh**

<table>
<tr><th colspan="2">UNIT I - INTRODUCTION TO RADAR EQUATION</th></tr>
<tr><td colspan="2">Introduction- Basic Radar –The simple form of the Radar Equation- Radar Block Diagram- Radar Frequencies –Applications of Radar – The Origins of Radar - Detection of Signals in Noise- Receiver Noise and the Signal-to-Noise Ratio-Probability Density Functions- Probabilities of Detection and False Alarm- Integration of Radar Pulses- Radar Cross Section of Targets- Radar cross Section Fluctuations- Transmitter Power-Pulse Repetition Frequency- Antenna Parameters- System losses – Other Radar Equation Considerations.</td></tr>
<tr><th colspan="2">PART * A</th></tr>
<tr><th>Q.No.</th><th>Questions</th></tr>
<tr><td>1.</td><td>What is radar? List a few applications of radar. (BTL – 1)
RADAR means Radio Detection And Ranging. Radar is an electromagnetic system for the detection and location of objects. It operates by transmitting a particular type of waveform and detects the nature of the echo signal.
The major areas of radar application are described below
• Air traffic control
• Ship safety
• Remotely sensing
• Law enforcement
• Military</td></tr>
<tr><td>2</td><td>Define range to target. (BTL - 1)</td></tr>
</table>

	The range to the target is given by $R = \frac{cT_R}{2}$ where T_R= round-trip time. It is the time it takes for the radar signal to travel to the target and back. c = speed of light = $3 \times 10^8 m/s$
3	**A radar signal takes 100 µs to travel towards and back. Find the range to the target.** (BTL - 3) The range to the target is given by $R = \frac{cT_R}{2}$ where c = speed of light = $3 \times 10^8\ m/s$ Round-trip time, $T_R = 100\ \mu s$ So the range to the target is $R = \frac{cT_R}{2} = \frac{3 \times 10^8 \times 100 \times 10^{-6}}{2} R = 15{,}000 = 15$ k
4	**Define second-time-around echoes.** (BTL - 1) • Echoes that arrive after transmission of the next pulse are called *second-time-around echoes*. • Echoes that arrive after pulse repetition period are called *second-time-around echoes*.
5	**Define maximum unambiguous time.** (BTL - 1) The range beyond which the target appears as second-time-around echo is called *maximum unambiguous range* $R_{un} = \frac{cT_p}{2} = \frac{c}{2f_p}$ where T_p= Pulse Repetition Period f_p= Pulse Repetition frequency, *prf* c = speed of light = $3 \times 10^8 m/s$ The maximum distance at which the return trip to a target is completed before the next pulse is sent

	by the radar is called *maximum unambiguous range.*
6	**Radar transmits the radar pulse signal with pulse repetition frequency of 1 kHz. Calculate the maximum unambiguous time.** (BTL - 3) **Solution** Pulse repetition frequency, $f_p = 1000$ Hz Maximum unambiguous range is given by $R_{un} = \frac{cT_p}{2} = \frac{c}{2f_p} = \frac{3 \times 10^8}{2 \times 1000} = 150{,}000 = 150 \text{ km}$
7	**Draw the simple block diagram of pulse radar.** (BTL - 1) 
8	**Write the expression for the simple form of range equation.** (BTL - 1) The fundamental form of the radar equation is $R_{max} = \left[\frac{P_t G A_e \sigma}{(4\pi)^2 S_{min}}\right]^{1/4}$ where P_t = Transmitter Power (Watts) G = Maximum gain of the antenna (no unit) A_e = Effective area of the antenna (m^2) σ = Radar cross-section of target (m^2) S_{min} = Minimum detectable signal
9	**Define radar cross section (RCS) of target. List the three distinct regions of scattering behavior for the RCS of target.** (BTL - 1) The radar cross section of target is defined as $\sigma = \frac{power\ reflected\ towards/unit\ solid\ angle}{incident\ power\ density/4\pi}$ The radar cross section of target represents the magnitude of the echo signal returned to the radar by the target.

	The three distinct regions of scattering behavior for the RCS of target. - **Rayleigh region:** When the wavelength is large compared to the objects dimension, scattering is said to be in the *Rayleigh region*. - **Optical region:** When the wavelength is small compared to the objects dimension, scattering is said to be in the *optical region* - **Mie or resonance region:** In *resonance region*, the radar wavelength is comparable to the objects dimension.
10	**Define noise figure.** (BTL - 1) The noise figure F_n of a receiver is defined by the equation $F_n = \frac{\text{noise out of practical receiver}}{\text{noise out ideal receiver at std temp } T_0} = \frac{N_0}{kT_0 B_n G_n}$ where N_0 = noise output from receiver G_n = available gain
11	**Define false alarm and missed detection.** (BTL - 1) ***False alarm:*** If the threshold level is set too low, noise might exceed it and be mistaken for a target. This is called a *false alarm*. ***Missed detection:*** If the threshold is set too high, weak echo signal may not exceed the threshold and will not be detected. This is called *missed detection*.
12	**Define probability of false alarm and probability of detection.** (BTL - 1) ***Probability of false alarm*** The probability that noise will cross the threshold and be called a target when only noise is present. The probability of a false alarm is $P_{fa} = exp\left(-\frac{{V_T}^2}{2\Psi_0}\right)$ where V_T is threshold voltage Ψ_0 is the mean square value of the noise voltage. ***Probability of detection*** The probability of detecting the signal is the probability that the envelope R will exceed the threshold V_T.

13	**Define integration. What are the types of integration?** (BTL - 1) - The process of summing all the radar echo pulses for the purpose of improving detection is called *integration*. - The main purpose of Pulse Integration in radar is to improve signal-to-noise ratio. **Types of integration** There are two types of integrations 1. Predetection, or coherent integration 2. Postdetection, or noncoherent integration
14	**What is integration efficiency of post detection integration?** (BTL - 1) The integration efficiency for postdetection integration is defined as $E_i(n) = \frac{(S/N)_1}{n(S/N)_n}$ where n = number of pulses integrated $(S/N)_1$= single pulse SNR $(S/N)_n$= SNR per pulse
15	**What is integration improvement factor?** (BTL - 1) The improvement in the signal-to-noise ratio when n pulses are integrated postdetection is called the *integration improvement factor*. The integration improvement factor is given by $I_i(n) = nE_i(n)$ where $E_i(n)$ = integration efficiency for postdetection integration
16	**Write the radar range equation in terms of average power and also represent the same for total energy of n pulses.** (BTL - 2) $R_{max}^4 = \frac{P_{av}GA_e\sigma nE_i(n)}{(4\pi)^2kT_oF_n(B\tau)(S/N)_1f_p}$ $R_{max}^4 = \frac{E_pGA_e\sigma nE_i(n)}{(4\pi)^2kT_oF_n(B\tau)(S/I)_1} = \frac{E_TGA_e\sigma E_i(n)}{(4\pi)^2kT_oF_n(B\tau)(S/N)_1}$
17	**Define Pulse Repetition Frequencies.** (BTL - 1) The pulse repetition frequencies (prf) are often determined by the maximum unambiguous range beyond which targets are not expected.

18	**List out the Antenna Parameters.** (BTL - 1) • Antenna Gain • Effective Area and Beam width • Revisit Time • Beam Shape • Cosecant – squared Antenna Pattern
19	**Define Antenna Gain.** (BTL - 1) The antenna gain G(θ, ϕ) is a measure of the power per unit solid angle radiated in a particular direction by a directive antenna compared to the power per unit solid angle which would have radiated by an omnidirectional antenna with 100 percent efficiency. The gain of an antenna is $G(\theta, \phi) = \frac{power\ radiated\ per\ unit\ solid\ angle\ at\ an\ azimuth\ \theta\ and\ an\ elevation\ \phi}{power\ accepted\ by\ the\ antenna\ from\ the\ transmitter/(4\pi)}$
20	**What are the different types of radar antenna patterns?** (BTL - 1) • Pencil Beam • Fan Beam • Stacked Beam • Shaped Beam
21	**What are the various system losses that are available radar?** (BTL - 1) Microwave Plumbing Losses • Transmission Line Loss • Duplexer Loss Antenna Losses • Beam – shape Loss • Scanning Loss • Radome • Phased Array Loss Signal Processing Losses • Limiting Loss • Straddling Loss

	• Sampling Loss • Collapsing Loss • Operator Loss
22	**Mention some of the applications of Radar.** (BTL - 3) • Military • Remote Sensing • Air Traffic Control (ATC) • Law Enforcement and Highway Safety • Ship Safety • Space • Aircraft safety and Navigation
	PART * B
1.	**Derive the simple form of radar range equation. (7M)** (BTL - 2) **Answer: Page No. 3 & 4 - Merrill I.Skolnik** The radar equation relates the range of radar to the characteristics of the transmitter, receiver, antenna, target, and environment. The radar equation determines the maximum range at which any radar can detect target. This equation can be used as an important tool in designing radar system. $R_{max} = \left[\frac{P_t G A_e \sigma}{(4\pi)^2 S_{min}}\right]^{1/4}$ - (7M) where P_t = Transmitter Power (Watts) G = Maximum gain of the antenna (no unit) A_e = Effective area of the antenna (m^2) σ = Radar cross-section of target (m^2) S_{min} = Minimum detectable signal
2.	**With neat block diagram explain the operation of pulse radar. (10M)** (BTL - 1) **Answer: Page No. 5 & 6 - Merrill I.Skolnik** Pulse Radar – 2M

	Block Diagram of a Conventional pulse radar with a super heterodyne receiver – 8M
3.	**Derive the expression for range of radar in terms of noise figure and minimum detectable SNR $(\boldsymbol{SNR})_{\boldsymbol{min}}$. (13M)** (BTL - 2) **Answer: Page No. 16 - Merrill I.Skolnik** $Noise\ Figure\ \ F_n = \frac{S_{in}/N_{in}}{S_{out}/N_{out}}$ - 8M $R^4_{max} = \frac{P_t G A_e \sigma}{(4\pi)^2 k T_o B F_n (S/N)_{min}}$ – 5M
4.	**Radar operates at 10GHZ and peak power of 500KW. Its minimum receivable power is 0.1 pW. Its antenna has effective (capture) area of 5sqm and radar cross section of target is 20sqm. Find maximum range of radar. (13M)** (BTL - 4) **Answer: Page No. 16 - Merrill I.Skolnik** Frequency, $f = 10$ GHz, $\lambda = c/f = \frac{3\times10^8}{10\times10^9} = 0.03\ m$ Transmitter Power, $P_t = 500$ kW Effective area of the antenna, $A_e = 5\ m^2$ Radar cross-section of target, $\sigma = 20\ m^2$ Minimum detectable signal, $S_{min} = 0.1$ pW $= 0.1 \times 10^{-12}$W Maximum gain of the antenna is $G = \frac{4\pi A_e}{\lambda^2} = \frac{4\pi\times5}{0.03^2} = 69813.17$ $\mathrm{R_{max}} = \left[\frac{\mathrm{P_t G A_e \sigma}}{(4\pi)^2 \mathrm{S_{min}}}\right]^{1/4}$ – 2M $\mathrm{R_{max}}$ = 685 Km.
5.	**Radar operates at 10GHZ and peak power of 500KW. The receiver of the radar has noise figure 6dB and IF bandwidth of the receiver is 3MHz. The antenna has effective (capture)**

area of 0.5sqm and radar cross section of target is 20sqm. Find maximum range of radar. (13M) (BTL - 4)

Answer: Page No. 33 in Merrill I.Skolnik

$$R_{max}^4 = \frac{P_t G A_e \sigma}{(4\pi)^2 k T_o B F_n (S/N)_{min}} - 2\text{M}$$

Answer –

6\. **Derive the expression for probability of false alarm in terms of false alarm time. Derive the expression for probability of detection. (13M)** (BTL - 2)

Answer: Page No. 23 - 28 - Merrill I.Skolnik

Probability of False Alarm

The receiver noise at the input of to the IF amplifier is described by the Gaussian probability density function with mean value of zero, or

$$p(v) = \frac{1}{\sqrt{2\pi\Psi_0}} exp\left(-\frac{v^2}{2\Psi_0}\right)$$

When Gaussian noise is passed through the IF amplifier, the probability density function of the envelope R is given by a form of the Rayleigh pdf:

$$p(R) = \frac{R}{\Psi_0} exp\left(-\frac{R^2}{2\Psi_0}\right)$$

$$Derive: Probability\ of\ False\ Alarm\ \ P_{fa} = exp\left(\frac{-V_T^2}{2\varphi_o}\right) - 8\text{M}$$

Probability of Detection

Echo signal of amplitude A - along with noise at the input to the IF filter. Output of the envelope detector - probability-density function given by

$$p_s(R) = \frac{R}{\Psi_0} exp\left(-\frac{R^2 + A^2}{2\Psi_0}\right) I_0\left(\frac{RA}{\Psi_0}\right)$$

$$Derive: Probability\ of\ Detection\ P_d = \int_{V_T}^{1} p_s(R)dR - 5\text{M}$$

7\. **Define integration? Why integration of radar pulses is necessary? Explain the types of integration. Give the expression for integration efficiency for post integration. Define**

integration improvement factor and integration loss. Express the range equation in terms of integration efficiency. (13M) (BTL - 1)

Answer: Page No. 29 – 33 - Merrill I.Skolnik

Definition for integration – 2M

Process of summing all the radar echo pulses - improving detection is called *integration*.

Necessities for integration – 2M

Improve signal-to-noise ratio.

Types of integration – 2M

- ***Predetection integration or coherent integration***
  Integration before the detector. Predetection integration - phase of the echo signal to be known and preserved. n pulses - same SNR - perfectly integrated - ideal lossless predetection integrator - the integrated SNR would be n times the SNR of a single pulse.

- ***Post detection integration or noncoherent integration***
  Integration after the detector. Phase information is destroyed - postdetection integration does not preserve RF phase. If n pulses - integrated using postdetection integrator, the integrated - less than n times the SNR of a single pulse. This loss - due to the nonlinear action of the second detector.

Integration improvement Factor – 2M

Improvement in the signal-to-noise ratio when n pulses are integrated postdetection. The integration improvement factor is given by

$$I_i(n) = nE_i(n)$$

Radar Equation when n pulses are integrated – 5M

$$R_{max}^4 = \frac{P_t G A_e \sigma}{(4\pi)^2 k T_o B F_n (S/N)_n}$$

8\. **What is radar cross section of target? Explain it in detail. (7M)** (BTL - 1)

Answer: Page No. 33 – 35 - Merrill I. Skolnik

Define Radar Cross section of target – 2M

Radar cross section of a target - (fictional) area intercepting that amount of power - scattered equally in all directions - produces an echo at the radar equal to that from the target.

Three distinct regions of radar cross section of target – 5M

- ***Rayleigh region***
  Wavelength - large compared to the objects dimension - The radar cross section in Rayleigh region - proportional to f^4 - determined by the volume of the scatterer.
- ***Optical region***
  Wavelength - small compared to the objects dimension. The radar cross section - determined by the shape of the object.
- ***Resonance region***
  Radar wavelength is comparable to the objects dimension.

9. **Explain about transmitted power and pulse repetition frequency. (13M)** (BTL - 1)

Answer: Page No. 52 – 53 - Merrill I.Skolnik

Average power is defined as the average transmitter power over the duration of the total transmission.

$$P_{av} = \frac{P_t \tau}{T_p} = P_t \tau f_p = E_p \tau$$

Where

P_t=Peak power
τ =Pulse width
T_p= Pulse Repetition Period (PRP)
f_p= Pulse Repetition Frequency (PRF)
E_p= Energy per pulse

The range equation in terms of average power is obtained by substituting P_t in the above equation

$$R_{max}^4 = \frac{P_{av} G A_e \sigma n E_i(n)}{(4\pi)^2 k T_0 (B\tau) F_n (S/N)_1 f_p}$$

The range equation in terms of energy per pulse is given by

$$R_{max}^4 = \frac{E_p G A_e \sigma n E_i(n)}{(4\pi)^2 k T_0 (B\tau) F_n (S/N)_1}$$

The range equation in terms of total energy of n pulses is given by

$$R_{max}^4 = \frac{E_T G A_e \sigma E_i(n)}{(4\pi)^2 k T_0 (B\tau) F_n (S/N)_1}$$

Pulse repetition frequency – 3M

	Multiple – time – around echoes that give rise to ambiguities in range. – 5M
10.	**Discuss in detail about the various antenna parameters. (13M)** (BTL - 1) **Answer: Page No. 54 – 56 - Merrill I.Skolnik** • Antenna Gain – 2M • Effective area and Beam width – 3M • Revisit time – 2M • Beam Shape – 3M • Cosecant squared Antenna Pattern – 3M
	PART * C
1	**Describe briefly the behavior of the radar cross section of a rain drop and a large aircraft with respect to its dependence on a (a) frequency and (b) viewing aspect. (15M)** (BTL - 3) **Answer: Page No. 33 – 40 - Merrill I.Skolnik** Radar cross section of a target – 2M Radar cross section of a target - (fictional) area intercepting that amount of power - when scattered equally in all directions - produces an echo at the radar equal to that from the target. Classification of targets – 3M • Simple Targets • Complex Targets Simple targets (Rain drop) – 5M The sphere, cylinder, flat plate, corner reflectors rod and cone are examples of simple target. Complex targets (Aircraft) – 5M Radar cross section of targets - aircraft, missiles, ships, ground vehicles, buildings, and terrain can vary considerably depending - viewing aspect and frequency.
2	**Describe the chief characteristic of the radar echo from a target when its cross section is in the (a) Rayleigh Region, (b) resonance region and (c) Optical region.** **Answer: Page No. 33 & 34 - Merrill I.Skolnik** Rayleigh Region – 5M Wavelength - large compared to the objects dimension. Radar cross section in Rayleigh region is

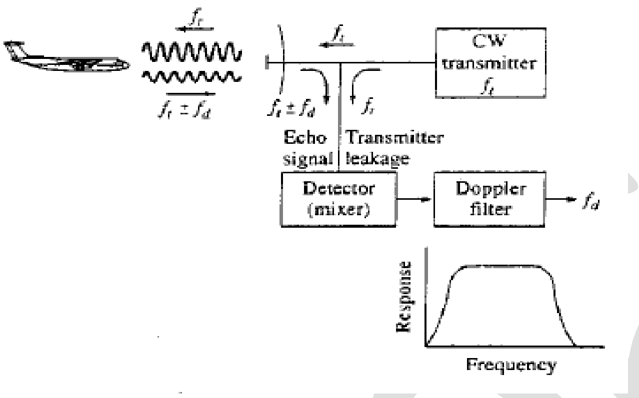
	proportional to f^4 - determined by the volume of the scatterer Resonance Region – 5M Radar wavelength - comparable to the objects dimension. Optical Region – 5M Wavelength - small compared to the objects dimension. Radar cross section - determined by the shape of the object.
3	**Explain in detail about various system losses. (13M)** (BTL - 1) **Answer: Page No. 56 – 60 - Merrill I. Skolnik** Microwave Plumbing Losses – 4M • Transmission Line Loss • Duplexer Loss Antenna Losses – 3M • Beam – shape Loss • Scanning Loss • Radome • Phased Array Loss Signal Processing Losses – 3M • Limiting Loss • Straddling Loss • Sampling Loss • Collapsing Loss Operator Loss – 3M

UNIT II - MTI AND PULSE DOPPLER RADAR

Introduction to Doppler and MTI Radar- Delay –Line Cancellers- Staggered Pulse Repetition Frequencies –Doppler Filter Banks - Digital MTI Processing - Moving Target Detector - Limitations to MTI Performance - MTI from a Moving Platform (AMIT) – Pulse Doppler Radar – Other Doppler Radar Topics- Tracking with Radar –Monopulse Tracking –Conical Scan and Sequential Lobing - Limitations to Tracking Accuracy - Low-Angle Tracking - Tracking in Range - Other Tracking Radar Topics - Comparison of Trackers - Automatic Tracking with Surveillance Radars (ADT).

PART * A

Q.No.	Questions
1.	**What is CW Radar? What are its uses and drawback?** (BTL - 1) The CW radar transmits continuous, electromagnetic waves and receives reflected echo signals from the objects. The CW radar uses Doppler frequency shift to detect moving target. So it is called CW Doppler radar. The CW Doppler radar is used to find ▪ azimuth angle and elevation angle ▪ Velocity of the target. ▪ The CW Doppler radar cannot measure range.
2	**Draw the block diagram of CW Radar.** (BTL - 1) Block diagram of a simple CW radar is shown below

	
3	**What is MTI Radar?** (BTL - 1) Radar that has prf low enough to avoid range ambiguities is called an MTI radar. ▪ MTI radar has low prf ▪ It has no range ambiguities. It has Doppler ambiguities.
4	**Define Pulse Doppler radar.** (BTL - 1) Radar that increases its prf high enough to avoid the problem of blind speed is called a **Pulse Doppler Radar.** ▪ Pulse Doppler radar has high prf. ▪ It has no Doppler ambiguities. ▪ It has range ambiguities Pulse Doppler radar uses Doppler frequency shift to detect the moving targets.
5	**Draw the block diagram of MTI Radar.** (BTL - 2)

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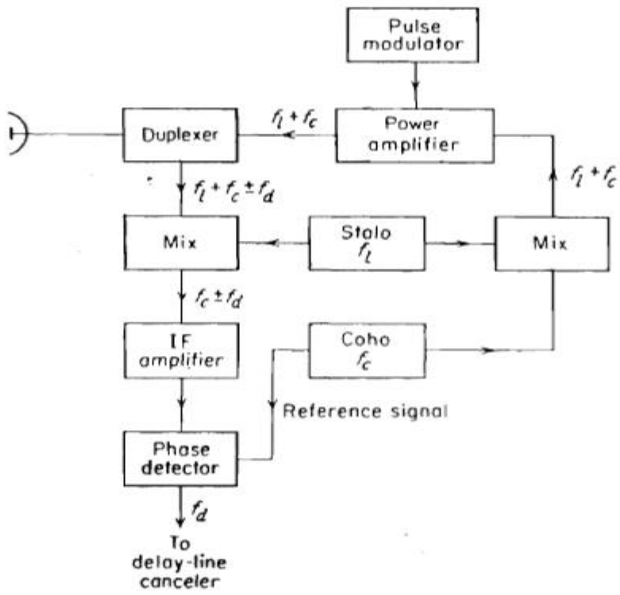

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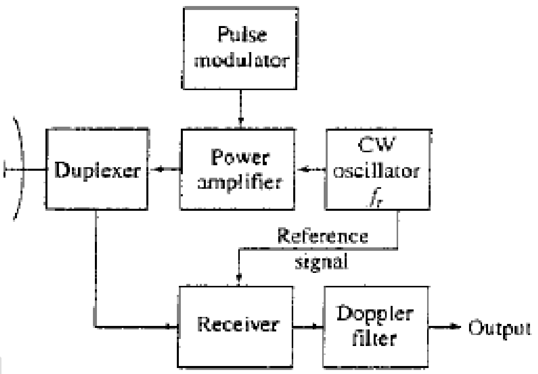
<i>Draw the block diagram of basic Pulse Radar.</i> (BTL - 2)



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What is Delay Line Canceller? Draw the block diagram of single delay line canceler. (BTL - 2)

Delay-line canceller is an example of a time-domain filter that rejects stationary clutter at zero frequency.
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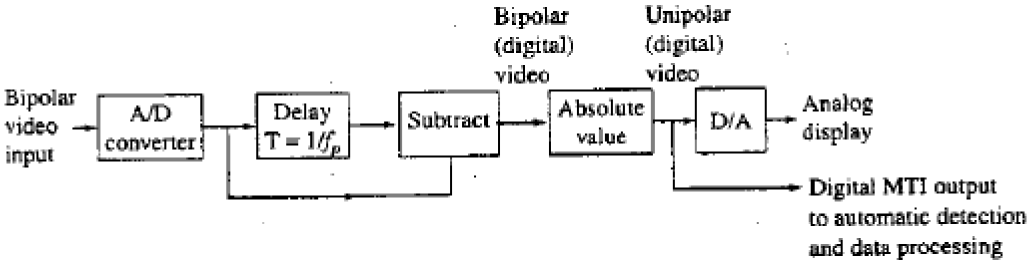
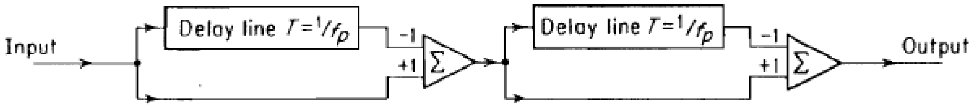
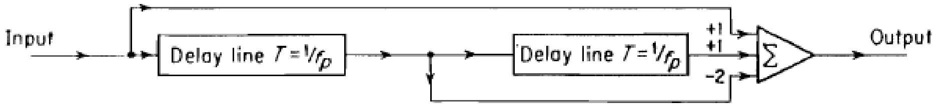
	
8	**What is Blind Speed? State the methods to reduce blind speed.** (BTL - 1) Blind speeds are target speeds where the target will not be detected and there will be uncanceled clutter residue. Blind speeds are result of the limitations (properties) of single delay-line canceler 1. The frequency response has zero response when moving targets have Doppler frequencies at the *prf* and its harmonics 2. The clutter spectrum at zero frequency is not a delta function.
9	**What are the methods for reducing the effects of Blind Speeds?** (BTL - 1) ***Methods for reducing the effects of blind speeds*** There are four methods for reducing the effects of blind speeds: 1. Operate the radar at long wavelengths 2. Operate the radar with high prf. 3. Operate the radar with more than one prf. 4. Operate the radar with more than one RF frequency
10	**Define MTI improvement factor.** (BTL - 1) MTI improvement factor is defined as “The signal-to-clutter ratio at the output of the clutter filter divided by the signal-to-clutter ratio at the input of the clutter filter, averaged uniformly over all target velocities of interest.” $\text{MTI improvent factor} \;=\; \mathrm{I_f} = \left.\frac{(\text{signal/clutter})_{\text{out}}}{(\text{signal/clutter})_{\text{in}}}\right\|_{\mathrm{f_d}} = \left.\frac{\mathrm{C_{in}}}{\mathrm{C_{out}}} \times \frac{\mathrm{S_{out}}}{\mathrm{S_{in}}}\right\|_{\mathrm{f_d}}$
11	**Draw double delay-line canceler and three-pulse canceler.** (BTL - 2) **Double delay-line canceler**

	 **Three-pulse canceler** 
12	**What is staggered PRF?** (BTL - 1) The pulse repetition frequency might be switched - Scan-to-scan - Dwel-to-dwel - Pulse-to-pulse When the *prf* is switched pulse to pulse, it is known as a **staggered prf.** In staggered prf, the period of the pulse is alternated on every other pulse.
13	**What is use of employing different PRFs in design of MTI Doppler filters?** (BTL - 1) The use of more than one pulse repetition frequency offers additional flexibility in the design of MTI Doppler filters. - It reduces the effect of the blind speeds**.** - It also allows a sharper low-frequency cutoff in the frequency response than might be obtained with a cascade of single-delay-line cancellers.
14	**What is Doppler filter bank? Give its advantages?** (BTL - 1) A Doppler filter bank is a set of contiguous filter for detecting target. **Advantages** A filter bank has advantage over the single filter. 1. Multiple moving targets can be separated from one another in a filter bank. When the clutter and target echo signal appear in different Doppler filters, the clutter echo will not interfere with the detection of the desired moving target. 2. A measure of the target's radial velocity can be obtained. 3. The narrowband Doppler filters rejects more noise than the MTI delay-line canceler and

	provide coherent integration.
15	**What is moving target Detector (MTD)?** (BTL - 1) The moving target Detector (MTD) ia an example of an MTI processing system that takes advantage of the various capabilities offered by digital techniques to produce improved detection of moving target in clutter.
16	**What are the types of tracking radar systems?** (BTL - 1) There are 4 types of radar that can provide the tracks of target. • Single-target tracker (STT) • Automatic detection and track (ADT) • Phased array radar tracking • Track while scan (TWS)
17	**Define Mono Pulse Tracker.** (BTL - 1) A monopluse tracker is defined as one in which information concerning the angular location of a target is obtained by comparison of signals received in two or more simultaneous beam. A measurement of angle may be made on the basis of a single pulse; hence the name monopulse.
18	**What are the methods by which monopulse angle measurement can be made?** (BTL - 1) There are two methods by which a monopulse angle measurement can be made. 1. Amplitude-comparison monopulse 2. Phase comparison monopulse
19	**What is Amplitude-comparison monopulse and Phase-comparison monopulse?** (BTL - 1) **Amplitude-comparison monopulse** method compares the amplitude of the signals simultaneously received in multiple squinted beams to determine the angle. In **Phase-comparison monopulse**, two antenna beams are used to obtain an angle measurement in one coordinate. The two beams look in the same direction and cover the same region of space.
20	**What is Low angle tracking?** (BTL - 1) Tracking a target at low elevation angles is called low angle tracking. Radar that tracks at low elevation angle illuminates the target via two paths. One is the direct path. The other is reflection

	from the earth's surface.
	PART * B
1.	**Draw and explain simple CW Radar, Pulse Doppler radar, and MTI radar. (13M)** (BTL - 2) Answer: Page: 70 – 74 - Merrill I. Skolnik Block diagram of CW radar – 4M CW radar transmits - continuous electromagnetic waves - receives reflected echo signals from the objects. CW radar - Doppler frequency shift to detect moving target. Block Diagram of Pulse Doppler Radar – 4M A radar - increases its prf high enough - avoid the problem of blind speed is called a **Pulse Doppler radar** Block Diagram of MTI radar – 5M A radar - *prf* low enough - avoid range ambiguities is called an **MTI radar**.
2.	**Explain in detail about Delay line canceller. (13M)** (BTL - 1) Answer: Page: 106 – 110 - Merrill I.Skolnik **Delay Line canceller – 2M** Delay-line canceler - example of a time-domain filter - rejects stationary clutter at zero frequency. **Frequency response of single delay line canceller – 3M** The frequency response of the single delay-line canceler is given by $H(f) = 2\ sin(\pi f_d T_p)$ **Blind Speeds – Definition – 2M** The radial velocity of the target at which the MTI response is zero. Blind speeds - target speeds where the target - not be detected - there will be uncanceled clutter residue. **Methods to reduce Blind Speeds – 2M** There are four methods for reducing the effects of blind speeds:

1. Operate the radar at long wavelengths
2. Operate the radar with high prf.
3. Operate the radar with more than one prf.
4. Operate the radar with more than one RF frequency

Clutter Attenuation – 2M

The clutter attenuation is a useful measure of the performance of an MTI radar in canceling clutter.

MTI Improvement Factor – 2M

The signal-to-clutter ratio - output of the clutter filter divided by the signal-to-clutter ratio - input of the clutter filter, averaged uniformly over all target velocities of interest.

$$MTI\ improvent\ factor\ = I_f = \left.\frac{(signal/clutter)_{out}}{(signal/clutter)_{in}}\right|_{fd} = \left.\frac{C_{in}}{C_{out}} \times \frac{S_{out}}{S_{in}}\right|_{fd}$$

$$= CA \times average\ gain$$

3. **Write short notes on Staggered Pulse repetition frequencies. (8M)** (BTL - 1)

Answer: Page: 114 – 117 - Merrill I. Skolnik

Frequency Response of a single delay – line canceller with two different prfs – 5M

The use of more than one pulse repetition frequency offers additional flexibility in the design of MTI doppler filters.

- Reduces the effect of the blind speeds**.**
- Allows a sharper low-frequency cutoff - frequency response - obtained with a cascade of single-delay-line cancellers.

Frequency Response of the filter – 3M

$$H(f) = w_0 + w_1 e^{j2\pi f T_1} + w_2 e^{j2\pi f(T_1+T_2)} + \cdots + w_n e^{j2\pi f(T_1+T_2+\cdots+T_n)}$$

4 **Write short notes on Doppler Filter Banks (7M)** (BTL - 1)

Answer: Page: 117 – 119 - Merrill I. Skolnik

Need for Doppler Filter Bank – 2M

Doppler filter bank - set of contiguous filter for detecting target.

	Advantages of Filter Bank – 2M 1. Multiple moving targets - separated from one another in a filter bank. When the clutter and target echo signal appear in different Doppler filters, the clutter echo will not interfere with the detection of the desired moving target. 2. A measure of the target's radial velocity can be obtained. 3. The narrowband Doppler filters rejects more noise than the MTI delay-line canceler - provide coherent integration. **Frequency response of the N filters of the filter bank – 3M** The magnitude of the frequency response function is $$\lvert H_k(f)\rvert = \left\lvert\sum_{i=1}^{N} e^{-j2\pi(i-1)[fT-k/N]}\right\rvert$$
5.	**Describe in detail about the block diagram of a digital MTI Doppler signal processor and explain how blind speed in an MTI radar. (13M)** (BTL - 2) Answer: Page: 119 – 121 - Merrill I.Skolnik **Block Diagram of Digital MTI Doppler Signal Processor. – 6M** **Advantages offered by digital MTI processing – 2M** ▪ Compensation for "blind phase" - causes a loss due to the difference in phase between the echo signal and the MTI reference signal. This is achieved by use of I and Q processing. ▪ Greater dynamic range can be obtained. ▪ There is no problem in making the delay times in the digital memory synchronous with the radar's prf. ▪ Digital processors - obtained with many different filter characteristics. Digital processors can be made reprogrammed. ▪ Digital MTI is more stable - reliable than MTI. **Blind phases, I and Q channels. – 5M**
6.	**Explain in detail about Moving Target Detector (13M)** (BTL - 2) Answer: Page: 7 – 9 - Merrill I.Skolnik Original MTD – 3M

	Coherent Processing Interval – 3M Filter Bank – 3M Clutter Map – 2M Adaptive Thresholds – 2M
7.	**Discuss in detail about MTI from a Moving Platform. (13M)** (BTL - 1) Answer: Page: 140 – 142 - Merrill I.Skolnik Compensation for Clutter Doppler Shift (TACCAR) – 3M Compensation for Clutter Doppler Spread (DPCA) – 3M Compensation for Antenna Scan Modulation – 3M Space – time Adaptive processing (STAP) – 2M
8.	**Explain in detail about Pulse Doppler Radar. (7M)** (BTL - 1) Answer: Page: 139 - 140 - Merrill I.Skolnik Pulse Doppler Radar – Definition – 2M Different prf Doppler radar – 5M ▪ *High – prf Pulse Doppler radar* ▪ *Medium – prf Pulse Doppler Radar* ▪ *Low – prf*
9.	**What is mono pulse tracking? Discuss in detail how the amplitudes of signals simultaneously received in multiple squinted beams are compared to determine the angle. (13M)** (BTL - 2) Answer: Page: 160 - 166 - Merrill I.Skolnik Monopulse tracker – 2M Radar in which information concerning the angular location of a target- obtained by comparison of signals received in two or more simultaneous beam.

	Amplitude – comparison Monopulse – 6M ▪ *Block Diagram* ▪ *Hybrid Junction* ▪ *Monopulse in two angle coordinates* ▪ *Automatic Gain Control* Phase – comparison Monopulse – 5M In **Phase-comparison monopulse**, two antenna beams are used - obtain an angle measurement in one coordinate. The two beams look in the same direction - cover the same region of space. For the two beams - look in the same direction, two antennas - used in phase-comparison monopulse.
10.	**With neat diagrams explain the operation of sequential lobing and conical scan. (13M)** (BTL - 2) Answer: Page: 153 - 158 - Merrill I.Skolnik Sequential Lobing – 7M One way of obtaining the direction and the magnitude of the angular error in one coordinate is by alternately switching the antenna beam between two positions. This is called **lobe switching**, **sequential switching**, or **sequential lobing.** Conical Scan – 6M Radar in which the squinted beam - continuously rotated to obtain angle measurements in two coordinates for tracking the target. The conical scan antenna is also known as **con-scan**. ▪ *Block Diagram* ▪ *Automatic Gain Control*
	PART * C
1	**What does a medium – prf pulse Doppler radar do better than a high – prf pulse Doppler radar? What does a high – prf radar do better than a medium – prf pulse Doppler radar. (15M)** (BTL - 3) Answer: Page:114 – 115 - Merrill I.Skolnik Pulse Doppler radar – 2M

	Prf in Doppler Radars – 3M Comparison of Medium and High prf pulse Doppler radar – 5M Comparison of High and Medium prf pulse Doppler radar – 5M
2	**Compare the amplitude – comparison monopulse tracker and the conical scan tracker with respect to accuracy at long, medium and short ranges; complexity; the number of pulses usually used for an angle measurement; type of application where each might be preferred. (15M)** (BTL - 3) Answer: Page: 153 – 158 & 160 – 166 - Merrill I.Skolnik Comparison of amplitude – comparison monopulse tracker and conical scan – 7M Pulses used for angle measurement – 4M Applications – 4M
3	**Write short notes on Low angle Tracking. (7M)** (BTL - 1) Answer: Page No. 172 - 176 - Merrill I.Skolnik Low – angle tracking illustrating the surface – reflected path and the targets image below the surface – 3M Regions identified according to elevation angle – 4M ▪ *Side lobe Region* ▪ *Main – beam region* ▪ *Horizon region*

UNIT III - DETECTION OF SIGNALS IN NOISE

Matched –Filter Receiver –Detection Criteria – Detectors —-Automatic Detector - Integrators - Constant-False-Alarm Rate Receivers - The Radar operator - Signal Management - Propagation Radar Waves - Atmospheric Refraction -Standard propagation - Nonstandard Propagation - The Radar Antenna - Reflector Antennas - Electronically Steered Phased Array Antennas – Phase Shifters - Frequency-Scan Arrays.\

Radar Transmitters and Receivers - Introduction –Linear Beam Power Tubes - Solid State RF Power Sources - Magnetron - Crossed Field Amplifiers - Other RF Power Sources – Other aspects of Radar Transmitter.- The Radar Receiver - Receiver noise Figure – Super heterodyne Receiver - Duplexers and Receiver Protectors- Radar Displays.

PART * A

Q.No.	Questions
1.	**What is Matched Filter?** (BTL - 1) Maximizing the output peak-signal-to-noise (power) ratio of radar maximizes the detectability of a target. A linear network that does this is called a **matched filter**.
2	**What is correlation receiver?** (BTL - 1) The output of a matched filter is the cross-correlation between the received signal and the

	transmitted signal. So it is possible to implement the matched filter as a cross correlation process. This is known as **correlation receiver**
3	**What is Neyman – Pearson Observer? What is likelihood ratio?** (BTL - 1) **Neyman – Pearson Observer** ▪ Neyman – Pearson Observer is the usual procedure for establishing the decision threshold at the output of the radar receiver. ▪ In Neyman-Pearson observer, the probability of a Type I error (false alarm) is fixed, and the probability of Type II error (missed detection) is minimized. *Likelihood ratio* Likelihood ratio is defined as the ratio two probability density functions, with and without signal present. $L_r(v) = \frac{p_{sn}}{p_n}$ p_{sn}= probability density function for signal-plus-noise p_n= probability density function for noise alone
4	**What is detector? What are the types of detector?** (BTL - 1) The detector is portion of the radar receiver that extracts the modulation from the carrier in order to decide whether the signal is present or not. *Types of detector* • Optimum envelope detector • Logarithmic detector • I,Q detector • Coherent detector
5	**What is integrator? What are the various types of integrators used in radar system?** (BTL - 1) Integrator sums all the radar echo signals (pulses) for the purpose of improving detection. *Types of integrators* ✓ Moving window integrator

	✓ Binary integrator ✓ Batch integrator ✓ Feedback integrator
6	**What is CFAR receiver?** (BTL - 2) Constant False Alarm rate Receiver is an electronic device which maintains the false alarm constant by automatically raising the threshold level to keep the clutter echoes and external noise from overloading the automatic tracker with unnecessary information
7	**What is refraction?** (BTL - 1) Refraction is bending of electromagnetic waves. Refraction of radar waves in atmosphere is due to the variation of velocity of propagation with altitude
8	**Define Refractive Index.** (BTL - 1) Index of refraction (refractive index) is a measure of the velocity of propagation. $indesx\ of\ refraction = \frac{velocity\ of\ propagation\ in\ free\ space}{velocity\ of\ propagation\ in\ specific\ medium}$
9	**What are the techniques to measure refractivity?** (BTL - 1) Techniques to measure refraction are ✓ Radiosonde ✓ Helicopter probes ✓ Small rocket probes ✓ Refractometer
10	**What is Electronically Steered Phase Array Antenna? List its advantages.** (BTL - 1) Phase array is a directive antenna made up of a number of individual antennas, or radiating elements. It has the advantage of steering the beam electronically by changing the phase of the current at each radiating element. *Advantages* ✓ Rapid beam-steering

	✓ Large peak and large average power ✓ Multiple-target detection ✓ A convenient means to employ solid-state transmitters ✓ Lower radar cross section
11	**What is phase shifter?** (BTL - 1) The beam of linear array can be steered in angle by changing the phase of the current at each element. This is achieved by phase shifter. Phase shifters are also called Phasor.
12	**What are the types of Phase Shifters** (BTL - 1) *Types of phase shifters* 1. Diode phase shifters ✓ Digitally switched lines ✓ Hybrid coupled ✓ Loaded-line ✓ Varactor phase shifters 2. Ferrite phase shifters ✓ Reggia-Spencer phase shifter ✓ Latching ferrite shifter ✓ Twin-ferrite latching phase shifter ✓ Dual-mode ferrite phase shifter
13	**What is Klystron?** (BTL - 1) The klystron is a RF power source. It is an example of linear-beam-tube. It is basically a vacuum tube which operates on the concept of velocity modulation of electrons. It has high gain and good efficiency. It is capable of high peak power and high average power.
14	**What is Traveling-wave-tube?** (BTL - 1) Traveling wave tube is a linear-beam-tube, with cathode, RF circuit, and collector separated from one another. The chief advantage of TWT is that it has wide bandwidth.
15	**What is magnetron?** (BTL - 1) Magnetron is high-power RF power source. It is a power oscillator. It is a crossed-field device in that its electric field and magnetic field are perpendicular to one another. The compact size and

	efficient operation of magnetron allowed radar to be small enough to be used in military aircraft, and submarines.
16	**What are the advantages of Solid state RF Power sources?** (BTL - 1) The advantages of Solid state RF Power sources are ▪ Individual solid-state devices have long MTBF (mean time between failures) ▪ Maintenance is relatively easy with the modular construction of solid state. ▪ Very wide bandwidths can be obtained. ▪ No cathode heater is required
17	**What are Duplexer and Receiver Protectors?** (BTL - 1) *Duplexer* ▪ Pulse radar can time share a single antenna between the transmitter and receiver by employing a fast-acting switching device called a **duplexer**. ▪ On transmission the duplexer must protect the receiver from damage, and on reception it must channel the echo signal to the receiver and not to the transmitter. For high-power applications, duplexer is a gas-discharge device called TR (Transmit-Receive) switch. *Receiver Protectors* In addition to duplexer, a receiver may require diode or ferrite limiters to limit the amount of leakage that gets by the TR switch. These limiters are called **receiver protectors**. It provides protection from the high-power radiation of other radar that enters the radar antenna.
	PART * B
1.	**What is matched filter? Derive the expression for its frequency response, impulse response and output. (13M)** (BTL - 2) Answer: Page: 369 – 375 - Merrill I.Skolnik Definition – 2M Matched Filter Frequency Response – 2M

	Matched Filter Impulse Response – 2M Derivation of Matched – filter Frequency Response – 4M Output Signal from Matched Filter – 3M
2.	**Write short notes on detection criteria**. **(7M)** (BTL - 1) Answer: Page: 376 - 382 - Merrill I.Skolnik Neyman Pearson Observer – 2M Likelihood – Ratio Receiver – 1M Inverse Probability Receiver – 2M Sequential Observer & Sequential Detection – 2M
3.	**Explain in detail about various types of detectors. (13M)** (BTL - 2) Answer: Page: 382 - 386 - Merrill I.Skolnik Optimum Envelope Detector Law – 4M Logarithmic Detector – 3M I, Q Detector – 4M Coherent Detector – 2M
4.	**What is integrator? Explain the various types of integrators used in radar system. (13M)** (BTL - 1) Answer: Page: 390 - Merrill I.Skolnik Moving Window Integrator – 4M Binary Integration – 3M Batch integrator – 3M Feedback Integrator – 2M
5.	**Explain about CFAR Receiver. (8M)** (BTL - 1) Answer: Page No. 392 – 395 in Merrill I.Skolnik

	Constant False Alarm Rate (CFAR) receiver maintains a constant false-alarm rate by adaptively changing the threshold. Cell Averaging CFAR – 3M CFAR Loss – 2M Clutter Edges – 3M
6.	**Briefly list the various parts of Signal Management that occur throughout the radar system. (13M)** (BTL - 1) Answer: Page: - Merrill I.Skolnik Component parts of Radar Signal Management – 6M Resources for Signal Management – 5M Constraints – 2M
7.	**Explain in detail about Reflector Antennas. (13M)** (BTL - 1) Answer: Page - 235 – 240 - Merrill I.Skolnik Paraboloid – 3M Offset – fed Reflector – 3M Cassegrain Antenna – 3M Parabolic Reflector – 4M
8.	**Explain in detail about Electronically Steered Phase Array Antennas (8M)** (BTL - 1) Answer: Page: 278 – 283 - Merrill I.Skolnik Electronically Steered Phase Array – Introduction – 3M Radiation Pattern of Phased Arrays – 5M
9.	**Explain in detail about Phase Shifters. (8M)** (BTL - 1) Answer: Page: 286 – 296 - Merrill I.Skolnik Key Points: About Phase Shifters – 3M

	Types of Phase Shifters – 5M (i) Diode Phase Shifters (ii) Ferrite Phase Shifters (iii) Other Phase Shifters
10.	**Explain in detail about klystron, Traveling wave tube, and magnetron. (13M)** (BTL - 1) Answer: Page: 192, 200 & 206 - Merrill I.Skolnik Klystron – 5M Travelling wave tube – 4M Magnetron – 4M
	PART * C
1	**Draw the block diagram of a correlation receiver. Explain why the correlation receiver can be considered equivalent to the matched filter receiver in detection performance. Under what conditions, if any, might one choose to implement a correlation receiver rather than a matched filter receiver? (15M) (BTL - 3)** Answer: Page:369 – 375 - Merrill I.Skolnik Block diagram of a correlation receiver – 5M Correlation receiver can be considered equivalent to the matched filter receiver in detection performance – 5M Implement a correlation receiver rather than a matched filter receiver – 5M
2	**How does the performance of a radar operator making detection decisions by viewing the e-raw video output of a radar display compare to the performance of an automatic detector? (15M) (BTL - 3)** Answer: Page: 388 - 391 in Merrill I.Skolnik Need for Automatic Detectors – 2M Classification of Automatic detectors – 13M
3	**Explain in detail about Linear Beam Power Tubes. (13M)** (BTL - 1) Answer: Page: 192, 200 & 206 - Merrill I. Skolnik

	Klystron – 7M Travelling Wave Tubes – 6M

UNIT IV - RADIO DIRECTION AND RANGES

Introduction - Four methods of Navigation - The Loop Antenna - Loop Input Circuits - An Aural Null Direction Finder - The Goniometer - Errors in Direction Finding - Adcock Direction Finders - Direction Finding at Very High Frequencies - Automatic Direction Finders – The Commutated Aerial Direction Finder - Range and Accuracy of Direction Finders - The LF/MF Four course Radio Range - VHF Omni Directional Range (VOR) - VOR Receiving Equipment - Range and Accuracy of VOR – Recent Developments.

Hyperbolic Systems of Navigation (Loran and Decca) - Loran-A - Loran-A Equipment - Range and precision of Standard Loran - Loran-C - The Decca Navigation System -Decca Receivers - Range and Accuracy of Decca - The Omega System

PART * A

Q.No.	Questions
1.	**Define Navigation.** (BTL - 1) Navigation is the art of directing the movements of craft from one point to another along a desired path.
2	**Define electronic navigational aids.** (BTL - 1) Navigational systems which employ electronics in some way for directing the movements of craft from one point to another along a desired path is called electronic navigation system.
3	**What are the four methods of navigation?** (BTL - 1) 1. Navigation by pilotage 2. Celestial or astronomical navigation 3. Navigation by dead –reckoning 4. Radio navigation
4	**What is astronomical navigation?** (BTL - 1) Astronomical or Celestial navigation is accomplished by measuring the angular position of celestial bodies.
5	**What is navigation by dead reckoning?** (BTL - 1)

	The position of the craft at any instant of time is calculated from the previously determined position, the speed of its motion with respect to earth along with the direction of its motion and the time elapsed.
6	**What is the important source of antenna effect? How the antenna effect is minimized?** (BTL - 1) The important source is the asymmetry of the loop antenna with respect to the ground. To minimize the antenna effect, the centre of the loop is earthed and its output is thereby balanced.
7	**What is Direction Finder? Mention the types of Direction Finder.** (BTL - 1) (i) Manual Direction Finder • Loop DF • Aural Null DF • Goniometer • Adcock DF (ii) Automatic Direction Finder • The radio compass • A VHF phase comparison automatic direction finders
7	**Give the disadvantage of loop direction finder?** (BTL - 1) 1. The loop is small enough to be rotated easily. This results in small signal pickups. 2. To facilitate manual operation, the loop is located near the receiver.
8	**What are the errors arising in direction finders?** (BTL - 2) 1. Errors due to abnormal polarization of the incoming wave 2. Errors due to abnormal propagation 3. Site errors 4. Instrumental errors
9	**Define mountain effect?** (BTL - 1) In air borne direction finders, mountainous terrain may cause errors when there is simultaneous reception of signal from the transmitter by a direct path and by reflection from the mountain side. This is called mountain effect.
10	**What is the need of Adcock direction finders?** (BTL - 1) The Adcock direction finders are designed to eliminate polarization errors by dispensing with the horizontal members.

11	**What are the types of automatic direction finders?** (BTL - 1) 1. The radio compass 2. A VHF phase comparison automatic direction finders
12	**What are the two types of radio ranges in use?** (BTL - 1) 1. Low frequency four course radio range 2. VHF Omni directional radio range
13	**What are the sources of errors in VOR system?** (BTL - 1) 1. Ground station and aircraft equipment 2. Site irregularities 3. Terrain features 4. Polarization
14	**Define hyperbolic system of navigation?** (BTL - 1) Hyperbolic systems are based on the measurement of the difference in the time of arrival of electromagnetic waves from two transmitters to the receiver in the craft.
15	**What are the different hyperbolic navigational systems?** (BTL - 1) Different hyperbolic navigational systems are • LORAN • DECCA • OMEGA.
16	**Define LORAN? What is the operating frequency of LORAN-C?** (BTL - 1) ▪ LORAN is **L**ong **R**ange **N**avigational **A**id. ▪ LORAN is a pulse system. ▪ The ground station transmits a train of pulses with fixed time relation between them and at the receiver. These pulses are identified and the delay between them is measured on a cathode ray oscilloscope. ▪ LORAN-C operates in the band 90-110 KHZ.
17	**Define DECCA navigation system?** (BTL - 1) In Decca system, the measurement of the time difference in the reception of signals from two stations is achieved by measuring the phase difference between the signals of the two stations.

18	**What are the advantages of OMEGA system?** (BTL - 1) 1. At low frequency in the 10KHZ range, the coverage is increased 2. Loss of power at this frequency is low.
	PART * B
1.	**Explain the four methods of navigation in detail? (13M)** (BTL - 1) Answer: Page: 2 – 5 - N S Nagaraja 1. Navigation by pilotage – 4M The navigator fixes his position on a map by observing the known visible landmarks. 2. Celestial or astronomical navigation – 3M Accomplished - measuring the angular position of celestial bodies. The navigator measures the elevation of the celestial bodies with a sextant and notes the precise time at which the measurement is made with a chronometer. 3. Navigation by dead –reckoning – 3M The position of the craft at any instant of time is calculated from the previously determined position, the speed of its motion w.r.t earth along with the direction of its motion and the time elapsed. ***Dead – Reckoning (DR) stands for 'deduced calculation'*** 4. Radio navigation – 3M This method is based on the use of electromagnetic waves to find the position of the craft.
2.	**What is Direction Finder? Derive an expression for resultant voltage for a loop antenna along with the procedure for Direction Finding. (13M)** (BTL - 2) Answer: Page: 6 - 10 - N S Nagaraja Direction Finder – 2M Loop Antenna • Its Setting – 3M Voltages are induced in the vertical members of the loop, but not in its horizontal members as the wave is vertically polarized.

	• Phasor Diagram – 3M The resultant voltage around the loop is thus $e_1 - e_2 = 2a\varepsilon \cos\left(\omega t - \frac{\pi}{\lambda}\, b\, cos\theta\right) - \cos\,(\omega t + \frac{\pi}{\lambda}\, b \cos\theta)$ $= \sqrt{2}\, a\varepsilon\, 2\, sin\left(\frac{\pi}{\lambda}\, b \cos\theta\right) \sin\omega t$ • Polar Diagram – 3M The output amplitude is proportional to cos θ. The polar diagram of the loop antenna is, therefore a figure – of – eight. • Polar Diagrams of combined vertical antenna and loop antenna – 2M
3.	**Write short notes on Aural Null Direction Finders & Goniometer (8M)** (BTL - 2) Answer: Page: 12 – 13 - N S Nagaraja **Input circuit of Aural Null Direction Finder – 4M** The input circuit - manually operated loop direction-finder. This circuit illustrate one method by which the voltage required for sense finding - obtained an introduced in to the loop circuit. **Sketch of Goniometer – 4M** It uses two fixed loops, mutually perpendicular - combining their outputs in a 'goniometer'. The loops, being fixed - as large as practicable - goniometer can be placed along with the receiver in any convenient location.
4.	**Explain the errors arising in direction finders? (13M)** (BTL - 2) Answer: Page: 14 – 19 - N S Nagaraja 1. Polarization Error – 3M 2. Errors due to abnormal propagation – 4M 3. Site errors – 4M 4. Instrumental errors – 2M
5.	**Explain in detail about Adcock Directional Finder and its advantages over loop antenna. (8M)** (BTL - 2)

	Answer: Page: 19 – 20 - N S Nagaraja Adcock Direction Finders – 8M **Polarization errors arise** owing to the **voltage picked up - horizontal members of the loop**. The Adcock antenna - designed to eliminate polarization error - dispensing with the horizontal members.
6.	**What are advantages of Automatic Direction Finders and explain any one type in detail. (7M)** (BTL - 1) Answer: Page No. 21 – 29 - N S Nagaraja Advantages of Automatic Direction Finders - 2M Manually operated direction finders - simple in construction - needs an operator always - aircrafts this is not possible. Disadvantage - speed of operation at very high speed - cause errors in direction finding. Radio Compass (Or) VHF Phase comparison Automatic Direction – Finder – 5M
7.	**Explain the basic principle of VOR along with its Block diagram (13M)** (BTL - 2) Answer: Page No. 35 – 40 - N S Nagaraja Basic Principle – 2M Range transmitter radiates two patterns - distinguishable by different modulations - one of which is Omni-directional - caries the modulation of a reference 30 Hz sinusoid - second pattern is figure-of-eight one, and therefore, the combination gives rise to a rotating cardioid at the receiving point, the rotating cardioid, after demodulation, gives a 30 Hz signal of variable phase, while the Omni- directional signal gives a 30 Hz signal of fixed reference phase. Block diagram of VOR ground Equipment – 6M Modulation Eliminator Circuit – 5M
8.	**Explain in detail about VOR Receiving Equipment (7M)** (BTL - 2) Answer: Page: 40 - 42 - N S Nagaraja

	Instrumentation part of VOR receiver – 7M The air-borne equipment - utilize the VOR facility consists of a **broad band Omni-directional antenna, a multichannel amplitude modulated receiver** which can be tuned over the required band, and an instrumentation unit - processes the receiver output to obtain the course indication.
9.	**Explain in detail about LORAN - A Navigational system. (8M)** (BTL - 2) Answer: Page: 48 – 51 - N S Nagaraja The sequence of transmission and reception of LORAN – A – 4M **LORAN A** operates in higher MF band around 2MHz. LORAN A Display – 3M LORAN A Equipment – 1M
10.	**Write short notes on LORAN C. (6M)** (BTL - 2) Answer: Page No. 53 – 54 in N S Nagaraja About LORAN – C – 2M Loran – C operates in the band 90 -110 kHz. LORAN C Pulses – 4M
12.	**Write short notes on OMEGA system (7M)** (BTL - 1) Answer: Page: 62 – 63 - N S Nagaraja About OMEGA System – 3M Transmission format of omega stations – 4M
	PART * C
1	**Show that the voltage indices in the loop when it is derived on the basis of the rate of change of magnetic flux linking the loop is the same as the given equation. (15M)** (BTL - 3) Answer: Page: 6 – 10 - N S Nagaraja Loop Antenna – 4M Deriving the resultant voltage around the loop – 11M

2	**Explain in details about Decca Navigation Systems and its Receivers. (15M)** (BTL - 3) Answer: Page: 54 – 61 - N S Nagaraja Decca Navigation System – 6M Decca Chain – 4M Decca receivers – 5M
3	**Explain in detail about Decca system. (13M)** (BTL - 1) Answer: Page: 54 – 59 - N S Nagaraja Decca Chain (Normal Transmission and Lane Identification) – 7M Operates in LF band (between 70 and 120 kHz) - employs unmodulated continuous waves. The measurement of the time difference - reception of signals from two stations - fixes the position on a hyperbola, is accomplished - measuring the phase difference between the signals of the two stations, the radiations of which are phase – locked, instead of the time interval between the pulses, as in Loran. Decca receiver – 6M

<table>
<tr><td colspan="2">UNIT V - SATELLITE NAVIGATION SYSTEM</td></tr>
<tr><td colspan="2">Distance Measuring Equipment - Operation of DME - TACAN - TACAN Equipment - Instrument Landing System - Ground Controlled Approach System - Microwave Landing System(MLS) The Doppler Effect - Beam Configurations -Doppler Frequency Equations - Track Stabilization - Doppler Spectrum - Components of the Doppler Navigation System - Doppler range Equation - Accuracy of Doppler Navigation Systems. Inertial Navigation - Principles of Operation - Navigation Over the Earth – Components of an Inertial Navigation System - Earth Coordinate Mechanization - Strapped-Down Systems - Accuracy of Inertial Navigation Systems-The Transit System - Navstar Global Positioning System (GPS)</td></tr>
<tr><td colspan="2">PART * A</td></tr>
<tr><td>Q.No.</td><td>Questions</td></tr>
<tr><td>1.</td><td>Give the Secondary Radar systems? BTL – 1
1. DME (Distance Measuring Equipment)
2. TACAN (Tactical Air Navigation)</td></tr>
</table>

2	**Define TACAN?** BTL – 1 TACAN provides both range and bearing information with the same radiation.
3	**What are the types of landing aids?** BTL – 1 1. Instrument landing system 2. Microwave Landing system 3. Ground controlled approach.
4	**What is meant by Localizer?** BTL – 2 The localizer operates in the VHF band (108-110 MHZ) and consists of a transmitter with an antenna system. The radiation of which has two lobes, one with a predominant modulation of 90 Hz and other with 150 Hz.
5	**What are the types of Radar present in the Ground controlled approach systems?** BTL – 1 1. Surveillance radar element 2. Precision approach radar
6	**What are the disadvantages of ILS?** BTL – 1 1. Provides a single approach path along the extended centre line of the runway. 2. It is site sensitive and subject to distortion and bending of the approach path due to site irregularities.
7	**What are the basic elements of a MLS system?** BTL - 1 1. Azimuth beam equipment 2. Elevation beam equipment

	3. Distance measuring equipment
8	**What is meant by Doppler navigation?** BTL - 1 It employs the Doppler Effect to determine the velocity of the craft in a frame of coordinates fixed with respect to the aircraft.
9	**Define Frequency trackers?** BTL - 1 The frequency tracker locates the centre of the noise like Doppler spectrum and gives the output the pure signal of this frequency.
10	**Define inertial navigation?** BTL - 1 Inertial navigation is a system of dead reckoning navigation in which the instruments in the craft determines its accelerations and by successive integration, obtain its velocity and displacement.
11	**What are the features of Navigation over earth?** BTL - 1 1. The system of coordinated should be fixed with reference to earth. 2. The coordinate system most convenient for use is latitude and longitude. 3. Avery large gravitational fields is present at the surface of the earth.
12	**What are the components of inertial navigation systems?** BTL - 1 1. Accelerometers 2. Gyros and stabilized platforms
13	**Define DECTRA?** BTL - 1 DECTRA is a Decca tracking and ranging. This is a long range hyperbolic navigational system working at a frequency of about 70 KHz. The system is designed to provide navigation information over a long route, particularly along the sea.
14	**Define CONSOL?** BTL - 1 IT is a rotating beacon operating in the LF/MF band which employs a system of three antennas producing a multi lobed pattern which is switched to produce a number of equi signals as in the radio range.
15	**Define CONSOLAN?** BTL - 1 CONSOLAN is same as CONSOL except that a two antenna system is used instead of three antennas.

16	**What are Marker Beacons?** BTL - 1 These are Radio beacons which are intended to mark some salient points.
17	**Define SHORAN?** BTL - 1 Short Navigation System is a secondary radar system in which fix is obtained by the craft, which carriers the

	interrogator, by simultaneously interrogating two ground beacons.
18	**What is meant by Radio Sextant?** BTL - 1 This is a Sextant operating on the radio frequency emission of heavenly bodies, like a radio telescope.
19	**What are the disadvantages of low frequency four course radio ranges?** BTL - 1 1. Limited number of courses (four) 2. Poor signal/noise ratio 3. Fatigue caused by listening to the tones 4. Difficulty of identifying the course
20	**What is meant by Doppler tolerant waveform?** BTL - 1 A Doppler tolerant waveform is one whose signal to noise ration out of its matched filter is independent of the Doppler frequency shift. Such waveforms are called as Doppler invariant
21	**Define synthetic Aperture Radar?** BTL - 1 SAR produces a high-resolution image of a scene of the earth's surface in both range and cross rage. It can produce images of scenes at long range and in adverse weather that are not possible with infrared or optical sensors.
22	**What are the target recognition applications?** BTL - 2 1. Military combat identification 2. Ballistic missile target discrimination 3. Meteorological observation 4. Battlefield surveillance
	PART * B

1.	**Mention the types of Secondary Radar Systems. Briefly explain about any one secondary radar systems in detail. (13M)** BTL - 2 Answer: Page: 65 – 75 - N S Nagaraja Introduction about DME (3M) Operation of DME • DME Transmissions (4M) • Air – borne DME Interrogator (4M) • DME Beacon (2M) **(OR)**

	Introduction about TACAN (6M) TACAN Equipment (7M)
2.	**Explain the Instrument Landing systems? (13M)** BTL - 1 Answer: Page: No. 78 – 86 - N S Nagaraja • Localizer (3M) • Glide slope system (3M) • Receiving equipment (3M) • Course sharpness and width (2M) • Marker beacon (2M)
3.	**Explain in detail about Microwave Landing System. (13M)** BTL - 1 Answer: Page: 90 – 96 - N S Nagaraja • Basic elements of the Microwave Landing System (5M) • Beam Scanning Technique in MLS (4M) • Antenna system for MLS (4M)
4.	**Explain in detail about Ground – Controlled Approach System (13M)** BTL - 2 Answer: Page: 87 – 90 in N S Nagaraja • Surveillance Radar Element (6M) • Precision Approach Radar (7M)
5.	**Discuss the Doppler navigation with a neat block diagram. (8M)** BTL - 1 Answer: Page: 98 – 104 - N S Nagaraja • Doppler Effect (2M) • Doppler frequency equations (3M) • Block diagram and explanation (3M)

6.	**Discuss in detail about the components of the Doppler Navigation System.(13M)** BTL - 1 Answer: Page: 107 – 114 - N S Nagaraja • Block diagram of Doppler Radar Navigation System (4M) • Doppler Radar Equipment (2M) • Continuous Wave Doppler Radar (2M) • Frequency – Modulated Continuous – Wave Doppler Radar (2M) • Frequency Trackers (3M)
7.	**Explain the concept of inertial navigation systems? (13M)** BTL - 1 Answer: Page:118 – 121 - N S Nagaraja • Principles of Operation (2M) • Block diagram of Inertial Navigation System (5M) • Accelerometer (3M) • Gyros and Stabilized Platforms (3M)
8.	**Discuss in detail about the Components of Inertial Navigation System (7M)** BTL - 2 Answer: Page: 121 – 128 - N S Nagaraja • Accelerometer (4M) • Gyros and Stabilized Platforms (3M)

9.	**Discuss the Satellite Navigational systems in detail? (9M)** BTL - 2 Answer: Page: 133 – 137 - N S Nagaraja • Transit System (2M) • Doppler Profiles of Satellites (2M) • Doppler Counts (2M) • Loci of the receivers position on the earth's surface (2M) • Bending of rays in ionosphere and troposphere (1M)

10.	**Explain the operation of cavity magnetron and discuss the importance of performance chart and Ricke Diagram (13M)** BTL - 2 Answer: Page: 130 - N S Nagaraja • Magnetron construction (5M) • Explanation (3M) • Pi –mode (2M) • Ricke diagram (3M)
	PART * C
1	**Discuss in detail about Navstar Global Positioning System (13M)** BTL – 2 Answer: Page: - 137 – 149 - N S Nagaraja • Basic Principles of Operation (3M) • Signal Structure (3M) • Data Message (3M) • Velocity Determination (3M) Accuracy of Position Determination (3M)
2	**Discuss in detail about the earth Coordinate Mechanism. (15M)** BTL - 2 Answer: Page: 128 – 132 in N S Nagaraja Four – axis stable platform (5M) Earth Coordinate System (5M) Mechanism of navigation in the latitude and longitude system of coordinates (5M)