Course Code	21ECE223T	Course Name	SATELLITE COMMUNICATION AND BROADCASTING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*study the background and orbital mechanics of satellite communication systems*
CLR-2:	*investigate satellite links and identify areas to improve link performance*
CLR-3:	*identify the various propagation effects and access techniques for satellite communication links*
CLR-4:	*interpret the applications of satellite communication in VSAT systems, satellite TV, and radios*
CLR-5:	*explore the concepts of satellite navigation and packet communication*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*interpret the concept and operation of satellite communication systems*	2	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-2:	*analyze satellite launching, link design, link availability, and interference*	-	2	3	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*examine the mechanism of multiple access techniques, propagation effects, and their impact on satellite communication*	2	-	2	-	-	-	-	-	-	-	-	-	2	-	-
CO-4:	*illustrate the practical implementation of VSAT and DBS systems*	3	2	-	-	-	-	-	-	-	-	-	-	-	-	3
CO-5:	*review the satellite communication navigation and global positioning system applications*	3	2	-	-	-	-	-	-	-	-	-	-	-	2	-

Unit-1 – Overview of Satellite Communication	***9 Hour***
Principle, historical developments, frequency allocations for satellite services. Orbital mechanics: Kepler's laws, orbital parameters, look angle determination, orbital perturbations, orbit control system, geostationary orbit, telemetry, tracking, command and monitoring, power systems, communication subsystems, transponders, satellite antennas, equipment reliability and space qualification	
Unit-2 – Satellite Link Design	***9 Hour***
Basic transmission theory, system noise temperature and G/T ratio, design of downlinks, satellite systems using small earth stations uplink design, carrier to noise (C/N) ratio, design of satellite links for specified C/N (with and without frequency re-use), link budget, system design examples	
Unit-3 – Propagation Effects and their Impact on Satellite-Earth Links	***9 Hour***
Quantifying attenuation and depolarization, rain and ice effects, cloud attenuation, tropospheric and ionospheric scintillation, prediction of XPD, propagation impairment countermeasures Multiple access techniques for satellite links: Multiple access, frequency division multiple access, time division multiple access, demand access multiple access, random access, code division multiple access	
Unit-4 – VSAT Systems	***9 Hour***
Network architectures, access control protocol, basic techniques, sat earth station engineering, calculation of link margins for VSAT star network, system design procedures. Direct broadcast satellite (DBS) TV and radio: C-band and Ku-band home satellite TV, DBS modulation, digital DBS-TV, DBS-TV system design, DBS-TV link budget, error control in digital DBS-TV, master control station and uplink, establishment of DBS–TV antennas, satellite radio broadcasting	
Unit-5 – Satellite Navigation and Global Positioning System (GPS)	***9 Hour***
Radio and satellite navigation, GPS position location principles, GPS receivers and codes, satellite signal acquisition, GPS navigation message, GPS signal levels, timing accuracy, GPS receiver operation, case study – IRNSS/NAVIC, case study – GAGAN (GPS Aided GEO Augmented Navigation) Satellite packet communication: Message transmission by FDMA, message transmission by TDMA, pure Aloha-satellite packet switching, slotted Aloha, packet reservation	

Learning Resources	1. D.Roddy, "Satellite Communications", McGraw Hill Education, 4th Edition, 2017. 2. T.Pratt, C.Bostian and J.Allnutt, "Satellite Communications", Wiley, 2nd Edition, 2013. 3. W. L. Pritchart, H. G. Suyderhoud and R. A. Nelson, "Satellite Communication Systems Engineering", Pearson Education, 2nd Edition, 2012.	4. G. D. Gordon and W. L. Morgan, "Communications Satellite Handbook", Wiley, 2010. 5. L. J. Ippolito Jr, "Satellite Communications Systems Engineering: Atmospheric Effects, Satellite Link Design and System Performance", John Wiley & Sons, 2nd Edition, 2017. 6. M.Richharia,"Satellite Communication Systems: Design Principles", Macmillan, 2nd Edition, 2003.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	25%	-	25%	-	25%	-
Level 3	Apply	35%	-	35%	-	35%	-
Level 4	Analyze	20%	-	20%	-	20%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
.1. Mr. Saivineeth, ML Accelerator Architect @ Google	1. Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai	1 Dr. Sachin Kumar, SRMIST
	2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu	

Text Books:

1. Dennis Roddy- 'Satellite Communication'- McGraw Hill International, 4th Edition, Reprint 2013
2. Wilbur L. Pritchard, Hendri G. Suyderhoud- Robert A.Nelson. 'Satellite Communication Systems Engineering'- Prentice Hall/ Pearson , Reprint 2013.

References:

1.Tri mT.Ha,"Digital Satellite Communication", 2nd Edition, Reprint 2012.
2.Anil K.mani, Varsha Agraval,"Satellite Communications", Wiley, Reprint 2011.
3.M.Richharia,"Satellite Communication Systems-Design Principles", Macmillan 2003
4.Timothy Pratt, Charles Bostian & Jeremy Allnutt,"Satellite Communications", John Wiley.

C). LEGEND:

L	- Lecture	PPT	- Power Point
BB	- Black Board	OHP	- Over Head Projector
pp	- Pages	Rx	- Reference

Sl. No	Lecture Hour	Topics to be covered	Teaching Aid Required	Book No./Page No
UNIT-I SATELLITE ORBITS				
1.	L1	Introduction to satellite communications, Kepler's laws, Newton's law	PPT	T_{X1}/pp 1-32 T_{X2}/pp 21-30,51-52 Rx_1/ pp 1-11,Rx_2/ pp 1-30
2.	L2	Orbital parameters, orbital perturbations, station keeping	BB	T_{X1}/pp 32 – 44,T_{X1}/pp 209-211 T_{X2}/pp 82-106,Rx_1/pp 32-41 Rx_2 /pp 30-50,Rx_2 /pp 85-86
3.	L3	Geo stationary and non-Geo-stationary orbits	BB	T_{X1}/pp 77-98,T_{X2}/pp 66-69, T_{X2}/pp117-124,Rx_2/pp 336-337
4.	L4	Look Angle determination, limits of visibility	PPT	T_{X1}/pp 78-85,T_{X1}/pp 87-89 Rx_1 /pp 41-44,Rx_2 /pp 93-94
5.	L5	Eclipse, sub satellite point, Sun transit outages	BB	T_{X1}/pp 64-66,T_{X1}/pp 92-94 Rx_1/ pp 46-48,Rx_2 /pp 90-92
6.	L6	Launch vehicles and propulsion	PPT	T_{X1}/pp 95-98,T_{X2}/pp 168-216 Rx_2/ pp 79-85
7.	L7	Principles of rocket propulsion	PPT	T_{X2}/pp 169-190,Rx_2 /pp 116-123
8.	L8	Injection into final orbit	PPT	T_{X2}/pp 197-199,Rx_4/pp 48-49
9.	L9	Launch vehicles for commercial satellites**, Local Mean Solar Time and Sun-Synchronous Orbit**	BB	T_{X2}/pp 199-216,Rx_4 pp 43-48 **T_{X1}/pp 66-70**
UNIT- II SPACE AND EARTH SEGMENT				
10.	L10	Space Segment**:** Structure, Primary power, Thermal subsystem	BB	T_{X1}/pp 199-202,T_{X1}/pp 211-212 T_{X2}/pp 220-238,Rx_2 / pp 123-126
11.	L11	Telemetry, Tracking and Command, Attitude Control	OHP	T_{X1}/pp 202-209,T_{X1}/pp 212-213 T_{X2}/pp 238-245,Rx_1/pp 59-65 Rx_2/pp 130-138
12.	L12	Propulsion sub system, Transponders	PPT	T_{X1}/pp 213-225

				T_{X2}/pp 245-255,419-445 Rx_4 pp 75-80,Rx_2 /pp 337-340
13.	L13	Earth segment: Transmitters, Receivers,	PPT	Rx_4 pp 80-86, T_{X2}/pp 448-460
14.	L14	Tracking systems, Terrestrial interface	BB	T_{X2}/pp 477-481 ,Rx_4 pp 68-70 Rx_4 pp 297-302
15.	L15	Receive only TV systems	OHP	T_{X1}/pp 239-243
16.	L16	Master antenna TV systems	BB	T_{X1}/pp 243-244
17.	L17	Transmit-Receive earth station	BB	T_{X1}/pp 246-250
18.	L18	Noise consideration for communication link design, **Estimating the mass of communication satellite**	BB	T_{X2}/pp 293-296 **T_{X2}/pp 265-269**
UNIT – III SATELLITE LINK DESIGN				
19.	L19	Link Power Budget equation	BB	T_{X1}/pp 356-366,Rx_1/ pp 130-136 Rx_2/ pp 283-286
20.	L20	Satellite Link:up link and down link	BB	T_{X1}/pp 367-375,Rx_1/pp 178-186
21.	L21	C/N ratio	BB	T_{X1}/pp 366-367,T_{X1}/pp 380-383 Rx_1/ pp 138-142
22.	L22	Interference analysis	PPT	T_{X1}/pp 399-419,Rx_1 /pp 136-156
23.	L23	Intermodulation	OHP	T_{X1}/pp 383-384,Rx_1/ pp 156
24.	L24	Intersymbol	BB	T_{X1}/pp 294-296,Rx_1/ pp 157
25.	L25	Cross polarization	PPT	T_{X1}/pp 128-130,Rx_1/pp 170
26.	L26	Terrestrial propagation	BB	Rx_4 /pp 297-302
27.	L27	Consideration: Noise consideration**, Space Domain Multiple Access**	BB	T_{X1}/pp 357-366, Rx_2/239-245
UNIT –IV SATELLITE ACCESS				
28.	L28	Modulation and multiplexing, Voice, Data and Video and Analog transmission system	BB	T_{X1}/pp 253-278,T_{X2}/pp 315-339 R_{X1}/pp 11-22
29.	L29	Digital transmission systems	PPT	T_{X1}/pp 283-311,Rx_4/pp 201-209
30.	L30	Single access, Multiple access	BB	T_{X1}/pp 424-425,R_{X1}/pp 22-25 Rx_2 /pp 213-214
31.	L31	Pre assigned and demand assigned FDMA	PPT	T_{X1}/pp 425-430, Rx_2/pp 215-218
32.	L32	Pre assigned and demand assigned TDMA	PPT	T_{X1}/pp 452-455
33.	L33	Reference bursts	BB	T_{X1}/pp 440-442,Rx_2/pp 223
34.	L34	CDMA, Direct sequence spread spectrum	BB	T_{X1}/pp 472-473,R_{X1}/pp 541-567
35.	L35	The code signal, Acquisition and tracking	BB	T_{X1}/pp 473-478
36.	L36	Spectrum Spreading and dispreading, **Satellite switched TDMA**	OHP	T_{X1}/pp 478-480, **T_{X1}/pp 467-472**

UNIT-V SATELLITE APPLICATIONS				
37.	L37	INTELSAT Series, INSAT	PPT	Rx_2/pp 357-360,Rx_2/ pp 369-370
38.	L38	VSAT	PPT	T_{X1}/pp 564-566 Rx_1/ pp 586—613,Rx_2/pp 353-356
39.	L39	Mobile satellite services: GSM, GPS	PPT	T_{X1}/pp 62-564 T_{X1}/pp 569-572,Rx_4/pp 458-482
40.	L40	INMARSAT	PPT	Rx_2/ pp 360-365
41.	L41	Satellite Navigational System, Direct Broadcast satellites (DBS),	OHP	T_{X1}/pp 531-557
42.	L42	Direct to Home Broadcast (DTH)	PPT	$Rx_{2/}$ pp 348-350
43.	L43	Digital Video Broadcast (DVB)	BB	R_{X3}/pp232,267,210 *www.radio-electronics.com › Radio broadcast technology*
44.	L44	Digital audio broadcast (DAB) ,Business TV(BTV)	BB	T_{X1}/pp551-557 *ethesis.nitrkl.ac.in/2884/1/209ec1099.pdf* *ece.ut.ac.ir/silab/srahmanian/pp01.pdf*
45.	L45	**Future trends in satellite application**	BB	**R_{X3}/pp407-414**

UNIT I - ORBIT DYNAMICS

TWO MARKS

1. **What are universal time and sidereal time?(R) (Co1) (Nov/Dec 2009)**

   Universal time: Universal time coordinated (UTC) is the time used for all civil time keeping purposes, and it is the time reference which is broadcast by the national Bureau of standards as a standard for setting clocks. It is based on an atomic time frequency standard. UT will be required in two forms: as a fraction of a day and in degrees. Given UT in the normal forms of hours, minutes, and seconds, it is converted to fractional days as UT_{day} = 1/24 (hours + minutes/60 + seconds/3600)

   Sidereal time: Sidereal time is time measured relative to the fixed stars. It will be seen that one complete rotation of the earth relative to the fixed stars is not a complete rotation relative to the sun. This is because the earth moves in its orbit around the sun.

2. **What is sub-satellite point? What is its significance?(U) (Co1) (Nov/Dec 2009)**

   The point on the earth vertically under the satellite is referred to as the sub-satellite point. The latitude and longitude of the subsatellite point and height of the satellite above the subsatellite point can be determined from knowledge of the radius vector r. The meridian plane which cuts the sub-satellite point. The height of the terrain above the reference ellipsoid at the satellite point is denoted $H_{ss.}$

3. **What is sun transit outage? (U) (Co1) (Nov/Dec 2009,May 2011)**

   The sun appears as an extremely noisy source which completely blanks out the signal from the satellite. This effect is called sun transit outage.

4. **What is the difference between a geostationary orbit and a geosynchronous orbit?(R) (Co1) (Nov/Dec 2009), (Apr/May 2010, May 2017)**

   Geostationary orbit: Satellite must travel eastward at the same rotational speed as the earth orbit must be circular.

   Geosynchronous orbit: Rotate in synchronism with the rotation of the earth. Geosynchronous orbit satellite does not have to be near geostationary. Geosynchronous satellites that are in highly elliptical orbits with comparatively large inclinations.

5. **List out the frequency bands used for satellite services. (R) (Co1) (Apr/May 2008, May 2017)**

   i. Fixed satellite service ii. Mobile satellite service iii. Navigational satellite service

Frequency range (GHz)	Band designation
0.1-0.3	VHF
0.3-1.0	UHF
1.0-2.0	L
2.0-4.0	S
4.0-8.0	C
8.0-12.0	X
12.0-18.0	Ku
18.0-27.0	K
27.0-40.0	Ka
40.0-75	V
75-110	W
110-300	mm
300-3000	µm

6. **State Kepler's second law of planetary motion.** (R) **(Co1)** (Apr/May 2008)

Kepler's second law states that, the line joining the planet to the sun sweeps out equal area in equal time.

7. **What is Geostationary satellites?(R) (Co1) (Apr/May 2008, Dec 2017)**

A satellite in a geostationary orbit appears to be stationary with respect to the earth. Three conditions are required for an orbit to be geostationary. i. the satellite must travel eastward at the same rotational speed as the earth. ii. The orbit must be circular. iii. The inclination of the orbit must be zero.

8. **A satellite is orbiting in the equatorial plane with a period from perigee to perigee of 12 hours. Given that the eccentricity is 0.002, calculate the semi major axis. The earth's equatorial radius is 6378.1414 Km.(AP) (Co1) (May/June 2009)**

Given data: e = 0.002, i= 0^o , P = 12 h, K1 = 66063.1704 km^2, a_E = 6378.1414 km, µ = 3.986005 X 1014 m^3/s^2

The mean motion is n= 2π / P = 2 π /12h =1.454 $X10^{-4}$ s^{-1}

Assuming this is the same as n_0, Kepler's third law gives a= $(\mu /n^2)^{1/3}$ = 26610 km.

9. **State Kepler's first law.(R)(Co1)(May/June 2007)**

Kepler's first law states that the path followed by a satellite around the primary will be an ellipse.

10. **Distinguish mean anomaly and true anomaly. (An) (Co1) (Apr/May 2010,June 2016)**

Mean anomaly	True anomaly
Mean anomaly M gives an average value of the angular position of the satellite with reference to the perigee. For a circular orbit, M gives the angular position of the satellite in the orbit.	The true anomaly is the angle from perigee to the satellite position, measured at the earth's center. This gives the true angular position of the satellite in the orbit as a function of time.

11. **What is meant by Julian zero time reference?(U) (Co1) (Apr/May 2010)**

Calendar time notation is not suited to computations where the timing of many events has to be computed. What is required is a reference time to which all events can be related in decimal days. Such a reference time is provided by Julian zero time reference.

12. **What is meant by Hohmann transfer orbit?(U) (Co1) (Apr/May 2010)**

The transfer orbit is selected to minimize the energy required for transfer, and such an orbit is known as a Hohmann transfer orbit. The time required for transfer is longer for this orbit than all other possible transfer orbits.

13. **What is INTELSAT?(R) (Co1)**

INTELSAT stands for International Telecommunication satellite. The organization was created in 1964 and currently has over 140 member countries and more than 40 investing entities. INTELSAT covers three main regions i. Atlantic Ocean region (AOR) ii. Indian Ocean Region (IOR) iii.Pacific Ocean Region (POR).

14. Define Domsats.(R) (Co1)

Domsat is an abbreviation for Domestic satellite. It is used to provide various telecommunication services, such as voice, data and video transmission within a country. In the U.S all Domsat are suited in geostationary orbit.

15. State Kepler's third law.(R) (Co1)

Kepler's third law states that the square of the periodic time of orbit is proportional to the cube of the mean distance between the two bodies. The mean distance is equal to the semimajor axis a. For the articial satellites orbiting the earth, Kepler's third law can ber written in the form $a^3 = \mu / n^2$ n- motion of satellite in radians per second μ - earth's geocentric gravitational constant.

16. Calculate the radius of a circular orbit for which period is 1 day. (Ap) (Co1) (Apr/May 2011)

There are 86,400 second in 1 day, and therefore the mean motion is

$n = 2\pi /86,400 = 7.27X\ 10^{-5}$ from keplers third law a = (3.986005 X 1014/(7.272 X10-5)^2)$^{1/3-}$

a= 42,241 km. $\mu = 3.986005 \text{ X } 10^{14}\ m^3/s^2$

17. Define subsatellite path ,Apogee , Line of asides and Perigee.(R) (Co1) (May 2011,Dec 2016)

Subsatellite path : This is the path traced out on the earth's surface directly below the satellite.

Apogee : The point of farthest from earth. **Line of asides**: The line joining the perigee and apogee through the center of the earth. **Perigee**: The point closest to the earth The perigee height is h_p. $r_p = a(1-e)$

$h_p = r_p - R$

18. Define Ascending node, Descending node, line of nodes and inclination.(R) (Co1)

Ascending node : The point where the orbit crosses the equatorial plane going from south to north. **Descending node:** The point where the orbit crosses the equatorial plane going from north to south. **Line of Nodes:** The line joining the ascending and desending nodes through the center of the earth. **Inclination :** The angle between the orbital plane and earth's equator plane. It is measured at the ascending node from the equator to the orbit going from east to north.

19. Define Prograde orbit, Retrograde orbit and Argument of perigee.(R) (Co1)

Prograde orbit : An orbit in which the satellite moves in the same direction as the earth's rotation. The prograde orbit is also known as a direct orbit**.**

Retrograde orbit : An orbit in which the satellite moves in a direction counter to the earth's rotation. **Argument of perigee :** The angle from ascending node to perigee, measured in the orbital plane at the earth's center in the dirction of satellite motion.

20. Find the time in Julian centuries from the reference time January 0.5,1900 to 13 h UT on 18 December 2000.(Ap) (Co1)

$T = JD\text{-}JD_{ref}/JC = 2451897.0417 - 2415020 / 36525 = 1.00963838.$

21. Give the expression for antenna elevation angle and azimuth angle.(U) (Co1) (May 2011,June 2016, Dec 2016)

Elevation angle $El = \arcsin (\rho_Z / \rho)$

Azimuth angle $\alpha - \arctan \left| \rho_E/\rho_S \right|$

22. What are the three condition to determine the look angles?(U) (Co1)

1.The earth station latitude, denoted here by λ_E 2.The earth station longitude, denoted here by Φ_E 3.The longitude of the subsatellite point, denoted here by Φ_{SS}.

23. A geostationary satellite is located at 90º W. Calculate the azimuth angle for an earth station antenna at latitude 35ºN and longitude 100ºW.(Ap) (Co1)

$\Phi_{SS} = -90^o \quad \Phi_E = -100^o \quad \lambda_E = 35^o \quad B = \Phi_E - \Phi_{SS} = -10^o$

24. Give the expression for limits of visibility.(U) (Co1)

$\theta = \arccos (\alpha_E/\alpha_{GSO}) = \arcsin 6378/42164 = 81.3^o$

12 MARKS

1. State and explain kepler's laws. Derive an expression for an orbit**. (U)(Co1) (Nov/Dec 2009,June 2016, Dec 2016) (May 2017, Dec 2017)**
2. i.What are orbital elements? Explain them. ii. Discuss the orbital perturbation**.(U) (Co1) (Nov/Dec 2009)**
3. What are look angles? Explain how they are determined?(U**(Co1)(/Dec2009,June 2016,Dec 2016, May 2017, Dec 2017)**
4. What are orbital elements? Derive the six orbital elements of satellite from Newton's law of motion. What is their significance?(U) **(Co1) (Apr/May 2008), (May/June 2007)**
5. How the satellites positions are estimated using the sub satellite points?(R) **(Co1) (Apr/May 2008)**

6. What are look angles and derive the expressions for azimuth and elevation.(E) **(Co1) (Apr/May 2008,Dec2017)**
7. i.State Kepler's three laws of planetary motion. Explain their relevance to artificial satellites orbiting the earth. ii.Define universal time and sidereal time iii. The cosmos 1675 satellite has an apogee height of 39342 Km and a perigee height of 613 Km. Determine the semimajor axis and the eccentricity of its orbits. Assume a mean earth radius of 6371 Km. (Ap**) (Co1) (May /June 2009)**
8. i.Discuss about frequency allocations for satellite services. ii. What are effects of a non spherical earth on the orbital mechanics of a satellite? iii. Calculate the radius of a circular orbit for which the period of 1 day. (U) **(Co1) (May /June 2009)**
9. i. In detail explain the launching procedure of satellite with a neat diagram. Ii. Briefly explain the effects of sun transit outage effects.(U) **(Co1) (May /June 2009,June 2016)**
10. i. Discuss the effects of non-spherical earth and atmospheric drag on satellite communications. ii. State and explain Kepler's laws.(R) **(Co1) (May /June 2009)**
11. Discuss about sun transit outage and geostationary orbit.(R) **(Co1) (May/June 2009)**
12. i.Explain elevation angle and azimuth angle. ii.Write short notes on sub satellite point.(U) **(Co1)**
13. Explain in detail limits of visibility and nongeosationary orbits.(U) **(Co1)**
14. Compare the advantages and disadvantages of different types of orbits.(An) **(Co1) (June 2016) (Dec 2017)**
15. Explain the basic geometry of the geostationary orbit with neat sketches.(U) **(Co1) (Dec 2016)**
16. Illuminate the limits of visibility and sun transit outage.(U) **(Co1) (Dec 2016)**

UNIT II – SPACE SEGMENT AND LINK DESIGN

TWO MARKS

1. **Define Noise Figure.(R)(Co2) (Nov/Dec 2009)**
   Noise figure is expressed in decibels Noise figure = [F] = 10 log F
2. **What is intermodulation noise? (R)(Co2) (Nov/Dec 2009,Dec 2016, Dec 2017)**
   Intermodulation distortion in high power amplifier can result in signal products which appear as noise & in fact is referred to as Intermodulation noise.
3. **What is meant by input back off of a transponder? (U)(Co2) (Apr/ May 2008)**
   To reduce the intermodulation distortion, the operating point of the TWT must be shifted closer to the linear portion of the curve, the reduction in input power being referred to as input back off.
4. **Give the formulae to compute the uplink carrier to noise ratio**. **(R)(Co2) (Apr/ May 2008)**
   $[C/N_0]$ = [EIRP] + [G/T] - [LOSSES] - [k]
5. **What is transponder? (R)(Co2) (May/June 2009, May 2017)**
   A transponder is the series of interconnected units which forms a single communication channel between the receiver and transmit antennas in a communication satellite. Some of the units utilized by a transponder in a given channel may be common to a number of transponders.
6. **The range between a ground station and a satellite is 42,000 km. Calculate the free space loss at a frequency of 6 GHz. (Ap)(Co2) (Apr/May 2010)**
   [FSL] = 32.4 + 20 log 42,000 + 20 log 6000 = 200.4 dB
7. **A LNA is connected to receive which has a noise figure of 12 dB. The gain of LNA is 30 dB and its noise temperature is 120 K. Calculate the overall noise temperature referred to the LNA input. (Ap)(Co2) (Apr/May 2010)**
   12 dB is a power ratio of 15.85:1, and therefore Te2 = 915.85 -1) X 290= 4306 K
   A gain of 40dB is a power ratio of 10^4:1 and therefore T_{in} = 120+(4306/104) = 120.43 K
8. **What is meant by momentum wheel stabilization? (R)(Co2) (Apr/May 2008)**
   The momentum wheel consists of a flywheel, the bearing assembly, the casting and an electric drive motor with associated electronic control circuitry. The flywheel is attached to the rotor consisting of a permanent magnet providing the magnetic field for motor action. The term momentum wheel is used for wheels that operate with nonzero momentum i.e. with momentum bias. Such a wheel provides passive stabilization for yaw and roll axes when the axis of rotation of the wheel lies along the pitch axis.

9. **A satellite downlink at 12GHz operated with a transmit power of 6W and an antenna gain of 48.2 dB. Calculate the EIRP in dBW. (Ap)(Co2) (May/June 2009)**
   [EIRP] = 10 log (6W/ 1W) + 48.2 = 56 dBW
10. **What is attitude control? (R)(Co2)**
    It is the system that achieves & maintains the required attitudes. The main functions of attitude control system include maintaining accurate satellite position throughout the life span of the system.
11. **Define spinning satellite stabilization. (R)(Co2)**
    Spin stabilization may be achieved with cylindrical satellite. The satellite is constructed so that it is mechanically balanced about one particular axis and is then set spinning around this axis. For geostationary satellites, the spin axis is adjusted to be parallel to the N-S axis of the earth. Spin rate is typically in the range of 50 to 100 rev/min.
12. **What TT & C subsystem? (U)(Co2)**
    The telemetry, tracking and command (TT&C) subsystem performs several routine functions onboard the spacecraft and therefore is a very vital subsystem. The **telemetry** function could be interpreted as measurement at a distance. Signal proportional to the quantity being measured is gathered, encoded and transmitted from the satellite to the TT&C earth station. The parameters most commonly monitored are: i.Voltage, current and temperature of all major subsystems. ii. Switch status of communication transponders. iii. Pressure of propulsion tanks. iv. Output from attitude sensors. v. Wheel speed.
13. **What is redundant receiver? (R)(Co2)**
    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 used at a given time.
14. **Define input demultiplexer. (R)(Co2)**
    The input demultiplexer separates the broadband input (500MHz) into the transponder frequency channels (1 through 12). The channels are usually arranged in even numbered and odd numbered groups. This provides greater frequency separation between adjacent channels in a group, which reduces adjacent channel interference. The output from the receiver is fed to the power splitter, which in turn feeds the two separate chains of circulators.
15. **What is power amplifier? (U)(Co2)**
    A separate power amplifier, consisting of a driver amplifier followed by a TWTA (traveling wave tube amplifier), provides the output power for each transponder channel. The driver amplifiers are incorporated with telecommandable step attenuators for gain setting of the transponder channels. The amplifiers operate in linear range and have capability to withstand RF overdrive in the uplink.
16. **What is antenna subsystem? (R)(Co2) (May 2011)**
    Directional beams which are required for communications are produced by parabolic reflector antennas. The gain of such an antenna relative to an isotropic radiator is given by:

$$G = \eta\left(\frac{\pi D}{\lambda}\right)^2$$

17. **Define LNA. (R)(Co2) (May/June 2007, May 2017)**
    The first stage of the receiver is a low noise amplifier. The spacecraft antenna is pointed towards a relatively warm earth having noise temperature of about 300 K. Therefore there is no advantage in reducing the noise temperature of LNA much below this level.
18. **Calculate the gain in decibels of a 3-m paraboloidal antenna operating at a frequency of 12GHz. Assume an aperture efficiency of 0.55. (Ap)(Co2)**
    $G = 0.55 \text{ X}(10.472 \text{ X } 12 \text{ X } 3^2) = 78168$ hence $[G] = 10\log 78168 = 48.9$ dB.
19. **Give the expression for link power budget. (R)(Co2) (May 2011)**
    $[P_R] = [EIRP] + [G_R] - [LOSSES]$ $[P_R]$ = received power dBW [EIRP] = equivalent isotropic radiated power, dBW.

20. 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. (Ap)(Co2)

The total link loss is the sum of all the losses

[LOSSES] =[FSL]+ [RFL]+ [AA]+ [AML] = 207+1.5+0.5+0.5= 209.5 dB.

21. **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. (Ap)(Co2)**

a.N_0 = (35+100) X1.38 X 10^{-23} = 1.86 X10^{-21} J b.P_N = 1.86 X10^{-21} X36 X10^6 = 0.067pW

22. Define noise factor. (R)(Co2)

An alternate way of representing amplifier noise is **'Noise Factor'** and it is defined as the ratio of the signal to noise power ratio at the input to the output. The noise factor expressed in dB is called **'Noise Figure'** from the definition noise factor is given by: $F = \frac{C_{in}/N_{in}}{C_{out}/N_{out}}$

23. What is carrier to noise ratio? (R)(Co2) (Dec 2016)

A measure of the performance of a satellite link is the ratio of the carrier power to the noise power at the receiver input. The ratio is denoted by *C/N* (or CNR) which is equal to received power divided by noise power.

In terms of decibels, $\left[\frac{C}{N}\right]$ = [Received power] – [Noise power]Using the relations explained above it can be written, $\left[\frac{C}{N}\right]$ = [EIRP] + [G_R] – [LOSSES] – [k] – [T_S] – [B]

24. Name some battery components used in satellite communication. (R)(Co2) (May 2011)

Nickel cadmium battery (Ni-Cd) , Nickel Hydrogen battery (Ni-H2)

25. What is station keeping? (U)(Co2) (May 2011, June 2016,Dec 2016, Dec 2017)

It is the term used for maintaining a satellite in its orbital position. The equatorial ellipticity of the earth causes geo stationary satellites to drift slowly along the orbit, to one of two stable points, at 75 E and 105 W. To counter this drift oppositely directed velocity component is imparted to the satellite by means of jets, which are pulsed once every 2 or 3 weeks. These maneuvers are termed **east-west station-keeping** maneuvers. A satellite, which is nominally geo stationary, also will drift in latitude; the main perturbing forces being the gravitational pull of the sun and the moon. To prevent the shift in inclination from exceeding specified limits. Jets may be pulsed at the appropriate time to return the inclination to zero. These maneuvers are termed **north-south station-keeping** maneuvers.

26. Define down link rain fade margin. (R)(Co2) (May 2011)

Rain fall introduces attenuation by absorption and scattering of signal energy, and the absorbed to attenuation introduces noise. Effective noise temperature of rain is, $T_{Rain} = T_a(1-1/A)$.This attenuation is given by $(N/C)_{Rain} = (N/C)_{CS}\ (A+(A-1)\ T_a/T_{S,CS})$

27. Give the two segments of basic satellite communication. (U)(Co2) **(Dec 2016)**

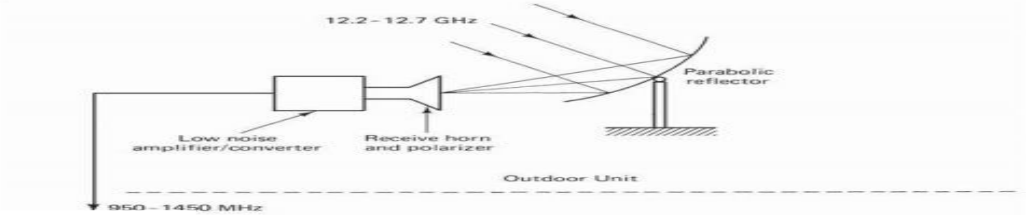
i.Space Segment ii. Earth segment

28. Define the term EIRP. (U)(Co2) **(Dec 2017)**

[EIRP] = Equivalent Isotropic Radiated Power, dBW

A key parameter in link budget calculations is the equivalent isotropic radiated power, conventionally denoted as **EIRP**.it is the product transmitter output power and gain of the lossless antenna. The EIRP describe the combination of transmitter and antenna in terms of an equivalent isotropic source with power PtGt W.

29. Sketch the Outdoor units for receive only home TV system. (**U)(Co2)** (Dec 2017)



12 MARKS

1. Explain the function of TT & C subsystem with neat diagram**. (U)(Co2) (Nov/Dec 2009,June 2016,Dec 2016, May 2017, Dec 2017)**
2. Explain the operation of input demultiplexer with block diagram. **(R)(Co2) (Nov/Dec 2009)**
3. With neat block diagram, explain the attitude and orbit control system present in space segment. **(R)(Co2) (Apr/May 2008) , (May/June 2009),(Apr/May 2010, Dec 2017)**
4. With neat block diagram, explain the power budget for a satellite link considering back off and rain fade margin. **(R)(Co2) (Apr/May 2008,June 2016)**
5. How does the system noise temperature affect the performance? Derive the expression for overall system noise temperature at the receiving earth station. **(U)(Co2) (Apr/May 2008,June 2016)**
6. i. Discuss about near geostationary orbits. ii. Determine the limits of visibility for an earth station situated at mean sea level, at latitude 48.42^{o} north and longitude 89,26 degrees west. Assume a minimum angle of elevation of 5^{o}. **(Ap)(Co2) (May/June 2009)**
7. i.What is the chief advantage of the TWTA used aboard satellites compared to the other types of high power amplifiers? What are the main disadvantages of TWTA? ii. What is thermal control? Why is it required? **(U)(Co2) (May/June 2009)**
8. In detail explain the following subsystems of spacecraft: i. Attitude and Orbit control ii. Telemetry, Tracking and Command. **(U)(Co2) (May/June 2007), (Apr/May 2010, Dec 2016, Dec 2017)**
9. Derive the expression for received power, C/N ratio and link power budget equation for satellite downlink with neat sketch. Also explain the implication observed using equation. **(An)(Co2) (May/June 2007,June 2016,Dec 2016) (Dec 2017)**
10. i. Discuss in detail various units of a transponder. ii. Discuss with neat diagram the Anik –E C band transponder. **(U)(Co2) (Apr/May 2010, May 2017)**
11. i. Write short notes on power supply ii. Briefly explain spinning satellite stabilization and momentum wheel stabilization. **(U)(Co2)**
12. Briefly explain satellite uplink and down link rain fade margin. **(R)(Co2)** (Dec 2016)
13. Determine the figure of merit (G/T) for a hypothetical satellite network and also derive the overall system noise temperature. **(U)(Co2)**
14. Discuss in brief about rain and ice effect in satellite link design. **(U)(Co2)**
15. Write short notes on polarization with its types. **(R)(Co2)**
16. Describe the east west and north-south station keeping maneuvers required in satellite station keeping. What are the angular tolerances in station keeping that must be achieved? **(An)(Co2)**
17. Write short notes on thermal and propulsion subsystem. **(R)(Co2) (June 2016, Dec 2017)**
18. Describe and Compare MATV and the CATV systems. **(U)(Co2) (June 2016,Dec 2016, Dec 2017)**

Explain the different types of noise to be considered in the design of satellite communication systems. **(U)(Co2) (June 2016,Dec 2016, Dec 2017)**

19. Explain in detail transmit receive earth stations. **(R)(Co2) (Dec 2016, Dec 2017**

UNIT III SATELLITE ACCESS

TWO MARKS

1. **Mention merits and de-merits of TDMA over FDMA? (R)(Co3) (Nov-2009,June 2016)**

Merits: i. The transponder traveling wave tube can be operated at maximum power output **or at** saturation. ii. TDMA networks have more flexibility in re-assigning channels and the changes can be made more quickly and easily.

De-Merits: i.Since the information is transmitted in bursts, TDMA is only suited for digital signals.
ii. Higher synchronization overhead.

2. **What is CDMA? (R)(Co3) (May-2009)**

CDMA is a multiple access technique based on 'spread spectrum modulation' which offers the opportunity to reject interference to a certain extent. Each user channel is spread to a wide bandwidth raising the bandwidth from typically a few KHz to a few MHz. **The resulting Spread spectrum signals are modulated onto a carrier frequency, which may be the same for all users** within the sub-network, such that all transmissions are overlaid simultaneously within the common transmission bandwidth, with the powers from each transmitter adding. It is of two types Spread spectrum multiple access, Pulse address multiple access.

3. What does the TDMA frame structure used for satellite links contain? (R)(Co3) (May-2007)

The TDMA frame structure contains guard time, carrier and bit-timing recovery, burst code word, station identification code, postamble along with the traffic data.

4. Compare centrally controlled and distributed control random access techniques. (An)(Co3)(May 2010)

With reference to FDMA, as seen earlier, the assignment may be carried out by 'polling' method or by 'call request'. If the call requests are serviced through a master earth station it is called **centrally controlled random access**. An alternative to centrally controlled random access is to have the control exercised at each earth station. This is called **distributed control random access**. A good illustration of such a system is provided by Spade system.

5. What is SPADE system? (U)(Co3) (May-2009)

SPADE stands for "Single Channel per carrier PCM Multiple Access Demand Assignment Equipment". The function of a SPADE is to bring all the ideas of multiplexing and multiple access within a single system. SPADE is a SCPC-DAMA (Demand Assignment Signaling Network) satellite network using distributed control. The system is fully variable allowing all circuits to be selected by any terminal on demand. Neither end of a circuit is permanently associated with any terminal but is assigned from the satellite channel pool as required and released again to the pool when no longer in need.

6. What are the limitations of FDMA-Satellite access? (U)(Co3) (May 2008, 2007) (Dec 2017)

a. inter-modulation products in the carrier bandwidth generated by non-linearity of the power amplifier (TWTA) b. FDMA networks have less flexibility in re-assigning channels and the changes cannot be made quickly and easily when compared with that of TDMA. c. In FDMA systems the limitations of guard band and TWTA back-off are not present. d. FDMA Systems are power limited.

7. **Distinguish between pre-assigned and demand-assigned TDMA satellite access. (An)(Co3)(May 2008, May 2011)**

PRE-ASSIGNED TDMA	DEMAND-ASSIGNED TDMA
It is a fixed assigned TDMA Satellite access	It is a variable assigned TDMA Satellite access
Here a station has periodic access to the channel independent of its actual need.	Dynamic assignment gives the station access to the channel only when it requires the access.
It is best applied to high capacity commercial system.	It is best suited if the traffic from a station tends to be burst like or irregular or of low traffic.

8. **What are the advantage and dis-advantage of FDMA. (U)(Co3)**

Advantage: a. There is no need for network timing. b. There is no restriction regarding the type of baseband signal or modulation.

Dis-advantage: a. Inter-modulation noise in the transponders leads to interference with other links sharing TWT, and hence reduces satellite capacity. b. Lack of flexibility in channel allocation, since for each change in allocation the receiver filters needs to be tuned. c. Requires uplink power control to maintain quality.

9. **What is a single access mode of operation? (R)(Co3) (Dec 2017)**

A transponder channel aboard 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.

10. What is a thin route service? (R)(Co3)

SCPC systems are widely used on lightly loaded routes, this type of service being referred to as a thin route service.

11. What is an important feature of Intelsat SCPC system? (U)(Co3)

The system is that each channel is voice activated. This means that on a two way telephone conversation only one carrier is operative at any one time.

12. What is preamble? (R)(Co3) (May 2011)

Certain time slots at the beginning of each burst are used to carry timing & synchronizing information. These time slots collectively are referred to as preamble.

13. What is postamble, decoding quenching? (R)(Co3) (May 2011)

In certain phase detection systems, the phase detector must be allowed time to recover from one burst before the next burst is received by it. This is termed as decoder quenching, and a time slot, referred to as postamble.

14. Define guard time. (R)(Co3) (Dec 2016)

It is necessary between bursts 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.

15. Define satellite switched TDMA? (R)(Co3)

Space division multiplexing can be realized by switching the antenna interconnections in synchronism with the TDMA frame rate, this being know as satellite switched TDMA.

16. What is a start of receiving frame? (U)(Co3) (June 2016)

At any given traffic station, detection of the unique word in the reference burst signals the start of receiving frame.

17. What is meant by burst position acquisition & burst position synchronization? (U)(Co3)

A station which is just entering or re-entering after a long delay to acquire its correct slot position.

18. What is a single access? (R)(Co3)

A transponder channel aboard a satellite may be fully loaded by a single transmission from earth station. Single access operation is used on heavy traffic routes and requires large length earth station antennas such as class A antenna.

19. What is a multiple access technique? (R)(Co3) (Dec 2017)

A transponder channel aboard a satellite may be fully loaded by a multiple carrier transmission from many earth stations. These may originate from a number of earth stations geographically separate, and each earth station may transmit one or more of the carriers. This mode of operation is termed as multiple access technique.

20. What is meant by frequency reuse? (R)(Co3)

The satellite as a whole to be accessed by earth stations widely separated geographically but transmitting on the same frequency i.e. known as frequency reuse.

21. What is meant by space division multiple access? (U)(Co3)(May 2010)

The satellite as a whole to be accessed by earth stations widely separated geographically but transmitting on the same frequency i.e. known as frequency reuse. This method of access known as space division multiple access.

22. What is an error detecting code? (R)(Co3)

A code which allows for the detection of errors is termed an error detecting code.

23. What is the function of burst code. (R)(Co3) (Dec - 2009)

Also known as unique word is a binary word, a copy of which is stored in each earth station. The recovered group of bits at the receiver is matched with BCW (Burst code word) and in turn provides accurate time reference**.**

24. **Define frame efficiency**. **(R)(Co3)**

It is a measure of the fraction of frame time used for the transmission of traffic. Frame efficiency is defined as ŋf=traffic bits/total bits. ŋf=1-(overhead bits/total bits)

25. What is meant by direct closed loop feedback? (R)(Co3)

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.

26. What is meant by feedback closed loop control? (U)(Co3)

The synchronization information is transmitted back to an earth station from a distant, that is termed feedback closed loop control.

27. What is meant by telephone load activity factor? (R)(Co3)

The fraction of time a transmission channel is active is known as the telephone load activity factor.

28. What is meant by digital speech interpolation? (R)(Co3)

The point is that for a significant fraction of the time the channel is available for other transmissions, advantages is taken of this in a form of demand assignment known as digital speech interpolation.

29. What are the types of digital speech interpolation? (U)(Co3)

i. Digital time assignment speech interpolation ii. Speech predictive encoded communications

30. What is meant by freeze out? (U)(Co3)

It has assumed that a free satellite channel will be found for any incoming speech spurt, but of course there is a finite probability that all channels will be occupied & the speech spurt lost. Losing a speech spurt in this manner is referred to as freeze out.

31. What is SS/TDMA? (R)(Co3)

A modern pattern is a repetitive sequence of satellite switch modes, also referred to as SS/TDMA.

32. What is processing gain? (R)(Co3)

The jamming or interference signal energy is reduced by a factor known as the processing gain.

33. What is meant by telephone load activity factor? (U)(Co3)

The fraction of time a transmission channel is active is known as the telephone load activity factor.

34. What is DSI? (R)(Co3)

The DSI gain is the ratio of the number of terrestrial channels to number of satellite channels. It depends on the number of satellite channels provided as well the design objectives stated above.

35. What are the advantages of SPEC method over DSI method? (R)(Co3) (Dec 2016)

The SPEC method over DSI method is that freeze out does not occur during overload conditions.

36. What is ratio of bit rate IF bandwidth? (R)(Co3)

Rb/BIF=m/1+p 'm' is the roll of factor m=1 for BPSK M=2 for QPSK.

37. What are the demerits of conventional approach method? (U)(Co3)

1. Excessive size & weight 2.Power consumption.

38. Define space division multiplexing. (R)(Co3)

The satellites in Geo-stationary orbit can be achieved through the use of antenna spot beams. The use of spot beam is also known as space division multiplexing.

39. What is SSMA? (R)(Co3) (May 2011)

In satellite switched TDMA more efficient of utilization of geostationary orbit can be achieved through the use of spot beam antennas. In SSMA the multiple access is improved by switching the antenna inter connection in synchronous with the TDMA frame rate.

40. State some advantages of CDMA. (U)(Co3) (May 2011)

i. Any uplink earth station can access the entire bandwidth of a transponder all the time. ii. It uses multiple spread spectrum multiple access. iii. The effect of jamming is less in CDMA.

41.**Define the term polarization. (U)(Co3) (Dec 2017)**

Property of certain electromagnetic radiations in which the direction and magnitude of the vibrating electric field are related in a specified way. Light waves are transverse: that is, the vibrating electric vector associated with each wave is perpendicular to the direction of propagation.

12 MARKS

1. i) In detail explain the functioning of a TDMA satellite system and a clear picture of the TDMA frame format used. Diagrams are necessary. ii) Write a detailed note on digital video broadcasting. **(R)(Co3)**
2. i) Discuss the type of modulation and multiplexing techniques involved in the transmission of voice and data signal ii) In what way the spread spectrum communication technique improves the performance of satellite. **(U)(Co3) (May 2007)**
3. i) Explain satellite switched TDMA (ii) Discuss the onboard signal processing for FDMA/TDMA operations. **(R)(Co3) (May 2010)**
4. i) Discuss the principles of CDMA. Explain the applications of CDMA in satellite communication. ii) Give a brief account of split TCP connections. **(U)(Co3) (May 2010,Dec 2016)**
5. i) Distinguish between pre-assigned TDMA and demand assigned TDMA in relation to a satellite Communication network**(U)(Co3)(Dec 2017)** (ii) Describe the FDMA system**. (An)(Co3) (Nov-2009, June 2016,Dec 2016)**
6. i) Explain the concept of spread spectrum techniques and mention its advantage (ii) with block diagram explain the CDMA system**. (U)(Co3) (Nov-2009)**
7. With a neat block diagram, explain the functioning of a SPADE system. **(R)(Co3) (May-2008)**
8. Explain the TDMA burst and frame structure of satellite system. Draw the necessary diagrams. **(U)(Co3) (May 2008,Dec 2016)**
9. i) Discuss in detail about direct sequence spread spectrum (ii) In a TDMA net work the reference burst and the preamble each requires 560 bits and the nominal guard intervals between bursts is equivalent to 120 bits. Given that there are eight traffic bursts and one reference burst per frame and the total frame length is equivalent to 108000 bits. Calculate the frame efficiency. (iii)Distinguish between pre-assigned and demand assigned traffic in relation to a satellite communication network.**(Ap)(Co3)(May2009,June 2016, May 2017)**
10. i) Discuss in detail about satellite links and TC (ii)Explain what is meant by asymmetric channels. Describe how asymmetric channels may be incorporated on intent connections via satellite. **(U)(Co3) (May 2009)**

11. Explain in detail about beam switched and satellite switched TDMA. **(R)(Co3)**
12. What are the different modulation voice and data modulation, multiplexing technique.**(R)(Co3)**.
13. In detail explain the analog and digital transmission system. **(R)(Co3)(Dec 2017)**
14. Explain the intermodulation noise in satellite communication systems. **(U)(Co3)(June2016, Dec2016, Dec 2017)**
15. Explain the principle behind spectrum spreding and disspreding and how this is used to minimize interference in a CDMA system**. (U)(Co3) (June 2016)**
16. Explain the sources of noise in satellite communication. Explain the important of noise temperature in link design. **(U)(Co3)(Dec 2017)**
17. Explain detail on digital transmission system and the concept of beam switching.**(U)(Co3)(Dec 2017)**
18. Explain FDMA in detail and enumerate the interference in FDMA. **(U)(Co3)(Dec 2017)**
19. Salient features of FDMA,TDMA AND CDMA. **(U)(Co3)(Dec 2017)**

UNIT IV – EARTH SEGMENT

TWO MARKS

1. **What is MATV? (R)(Co4)**

   A Master antenna TV (MATV) system is used to provide of DBS TV/FM channels to a small group of users**.** It consists of a signal outdoor unit feeding a number of indoors units. It is basically similar to home system. The advantage of outdoor unit is used to separate LNA/Cs and feeder cables are required for each sense of polarization.

2. **Define CATV. (R)(Co4) (May 2017)**

   The CATV (Community Antenna TV) system employs a single outdoor unit, with separate feeds available for each sense of polarization. The channel are made available simultaneously at the indoor receiver.

3. **What is ground control equipment? (U)(Co4)**

   The up and down converters form an interface between the RF and IF portions of transmitter and receivers segments of the satellite. The only operations that are normally carried out on RF signal are amplification and filtering with minimal combining and splitting. This part of the earth station is known as ground control equipment.

4. **Give the expression for C/N ratio. (U)(Co4) (May 2011)(Dec 2017)**

   The value of C/N depends on the required information rate, the required signal-to-noise ratio (or analog signals) or bit error rate (for digital signals), and the modulation system and associated bandwidth.

   $C/N = P_t G_t / kB [\lambda/4\pi R]^2 G_r/T_s$ G/T is Gain Temperature Ratio.

5. **What are factors to be considered for the design of an earth station? (An)(Co4)**

   (i).Type of service (ii).Type of communication requirements (iii). Required baseband signal quality at the destination (iv). Traffic requirements (v). Cost and reliability.

6. **What is EIRP? (R)(Co4)**

   Effective Isotopic Radiated Power (EIRP) is the product transmitter output power and gain of the lossless antenna. The EIRP describe the combination of transmitter and antenna in terms of an equivalent isotropic source with power PtGtW.

7. **What is TVRO? (R)(Co4)**

   The earth segment of a satellite communications system consists of the transmit and receive earth stations. The simplest of these are the home TV receive-only (TVRO) system. It consists of home receiver outdoor unit (ODU) and home receiver indoor unit (IDU). This service is known as direct broadcast satellite(DBS) services.

8. **What are the different types of antennas? (R)(Co4) (May 2011)**

   The different types of antenna used for satellite are i) double reflector antenna ii) horn antenna iii) aperture antenna.

9. **List out various types of antenna feeding. (U)(Co4)**

   Some of the antenna feeding types are i) Front Feed ii) Offset Feed iii) Beam Waveguide Feed.

10. **What is aperture antenna? Give an example for it. (R)(Co4)**

    An aperture antenna works on the concept of achieving gain and narrow beam by creating an electromagnetic field over the aperture that has uniform phase. Eg: Waveguide horn and reflector antenna.

11. What are the major four sub-systems of earth station? (U)(Co4)

The transmitter sub-system, receiver sub-system, antenna subsystem and tracking and pointing subsystem are the four major sub-systems of earth station.

12. What are the major equipments in an earth station? (R)(Co4)

1. Low Noise Amplifier (LAN) of the receiver and High Power Amplifier of the transmitter.

13. Why Cassegrain is popular for large earth station? (An)(Co4)

(i)The gain can be increased by approximately 1 dB relative to front end reflector, by shaping of the dual reflector system.(ii) Low antenna noise temperature can be achieved by controlling spill over and using short waveguide runs or beam waveguide feeds.

14. What is DBS? (R)(Co4)

The broadcasting directly to home TV receiver take place in Ku (12 GHz) band. This service is known as direct broadcast satellite (DBS) services.

15. What is polarization interleaving? (R)(Co4) (Dec 2016)

Some overlap occurs between channels but these are alternately polarized left hand circular and right hand circular or vertical/horizontal, to reduce interference to acceptable levels. This is referred to as a polarization interleaving.

16. Explain antenna mounting. (R)(Co4) (May 2011)

The antenna must be pointed at the satellite. Rarely, this pointing is fixed permanently; sometimes it is occasionally adjusted, and in some installations it is continually driven by a tracking system. Such tracking systems, we note that every earth station antenna must be capable of some adjustment in pointing, even if only for initial setup.

20. Define antenna Gain. (R)(Co4) (May 2011)

The gain of the antenna is ratio of maximum power flux density from a real antenna to the maximum flux density of an isotropic radiator. $\mathbf{G = \Psi_M / \Psi_i}$

12 MARKS

1. Explain in detail with neat diagram TVRO system. **(U)(Co4)**
2. With neat block diagram explain the operation of MATV and CATV. **(U)(Co4) (Dec 2017)**
3. Explain how the measurements on the following vital satellite parameters are carried out. (i) G/T measurement. (ii) C/N_o measurement. **(U)(Co4)** (May 2007) **(Dec 2017)**
4. Compare the performance of the various types of tracking system used in earth station. **(An)(Co4)**
5. In detail, explain the various equipments used in earth station. **(R)(Co4)**
6. Explain in detail Transmit-Receive earth stations. **(R)(Co4)** (May 2010). **(Dec 2017)**
7. A satellite TV signal occupies the full transponder bandwidth of 36 MHz, and it must provide a C/N ratio of 22 dB at the destination earth station. Given that the total transmission losses are 200 dB and the destination earth station G/T ratio is 31dB/K, calculate the satellite EIRP required. **(Ap)(Co4)** (May 2010).
8. Discuss in detail the various modules of a digital earth station segment? Explain the significance of each module and draw appropriate diagrams. **(U)(Co4)** (May 2007 **,May 2017**)
9. Draw the block diagram and explain the function of (i) Earth station (ii) Receive-only home system. **(R)(Co4)** (Nov - 2009 **May 2017**)
10. Explain in detail about i) double reflector antenna ii) horn antenna iii) aperture antenna. **(U)(Co4)**

UNIT V SATELLITE APPLICATIONS

TWO MARKS

1. Mention the objectives of Radarsat. (R)(Co5) (Nov-2009)

The objectives of Radarsat program, as stated by the Canadian Space Agency, are to

i.Provide application benefits for resource management and maritime safety ii.Develop, launch and operate an earth observation satellite with Synthetic Aperture Radar (SAR) iii.Establish Canadian mission control safety iv.Market Radarsat data globally through a commercial distributor v.Make SAR data available for research vi.Map the whole world with stereo radar Map Antarctica in two seasons.

2. **Mention the application of Radarsat. (U)(Co5)**

i.Shipping and fisheries ii.Ocean feature mapping iii.Oil pollution monitoring iv.Sea ice mapping (including dynamics) v.Iceberg detection vi.Crop monitoring vi.Forest management vii.Geological mapping (including SAR) viii.Topographical mapping ix.Land use mapping

3. How many satellites a geostationary orbit can hold in a maximum? (U)(Co5)

Geostationary satellites are still the most numerous satellites used in satellite communication application. The geostationary orbit could hold 180 such satellites if an average spacing of 2^o spacing is assumed.

4. What are some of the uses of geostationary satellites? (R)(Co5)

i.Direct-to-home (DTH) broadcasting, referred to as Direct Broadcast Satellite (DBS) services in US, represents one major development in the field of geostationary satellites ii.Very Small Aperture Terminals (VSATs) for business applications iii.Mobile Satellite Services (MSAT), which extends geostationary satellites services into mobile communications for vehicle, ships and aircraft.

5. What is Radarsat ? (R)(Co5) (Nov/Dec 2009)

Radarsat is a large polar-orbiting satellite designed to provide environmental monitoring services including earth resource remote sensing services. Possibly the most notable development in the area of non-geostationary satellites is Global Positioning Satellites (GPS) system which has come into everyday use for surveying and position location generally.

6. **Mention the Satellite Mobile Services around the Globe.(or) Name the services provided by GSM. (U)(Co5) (June 2016)**

Satellite Mobile Services around the globe offer telephone services with dual mode phones that operate on GSM standards. GSM stands for Global System for Mobile Communications; it is the most widely used standard for cellular and personal communication. Some of the GMS are a) Asian Cellular System (using Garuda Geostationary satellite) b) Ellipso c) Globalstar (48 satellites in LEO) d) MSAT (using MSAT-1 satellite) e) New ICO (12 satellites in MEO) f) Thuraya (Thuraya Geostationary Satellite).

7. Write about GPS system. (R)(Co5) (May 2011,June 2016)

In the Global Positioning Satellite (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 survey. In terrestrial surveying, it is only necessary to have three such markers to determine the three unknowns of latitude, longitude and altitude by means of triangulation. With GPS system, a time marker is also required, which necessitates getting simultaneous measurements from four satellites.

8.What is ECEF? (R)(Co5)

The geocentric-equatorial coordinate system is used with the GPS system, where it is called the earth-centered, earth fixed (ECEF) coordinate system. Here if the position of ‘three points’ relative to the coordinate system are known and the distance from the observer to each of these points can be measured, then the position of the observer relative to the coordinate system can be calculated.

9. What dilution of precision? (U)(Co5)

The range measurements made to three reference points clustered together will yield nearly equal values. Position calculation involves range differences, and where the ranges are nearly equal, any error is greatly magnified in the difference. This effect, brought about as a result of the satellite geometry, is known as dilution of precision (DOP). The GPS system has been designed to keep the PDOP factor less than 6 most of the time.

10.What is ephemeris? (R)(Co5)

Each satellite broadcasts its ephemeris, which contains the orbital elements needed to calculate its position and as previously mentioned, the ephemerides are updated and corrected continuously from an earth control station.

11.Give the application of Orbocomm. (R)(Co5) (May 2010)

The Orbital Communications Corporation (Orbocomm) system is a low earth orbiting (LEO) satellite system intended to provide ‘two-way message and data communications services’ and ‘position

determination'. Orbocomm system is capable of providing subscribers with a basic position determination service through used of Doppler positioning, which fixes position to within a few hundred meters.

12.What is bit rate? (R)(Co5)

The bit rate is equal to the number if samples per second (the sampling frequency f_s) multiplied by the number of bits per sample n: $R_b = f_s \times n$

13.What is MPEG compression standard? (R)(Co5)

MPEG stands for Moving Pictures Expert Group, a group within the International Standards Organization and the International Electrochemical Commission (ISO/IEC) that undertook the job of defining standards for transmission and storage of moving pictures and sound, The standards are concerned only with the bit stream syntax and the decoding process, not with how encoding and decoding might be implemented. Syntax covers such matters as bit rate, picture resolution, time-frame for audio and the packet details for transmission. eg: MPEG-1, MPEG-2, MPEG-4 and MPEG-7.

14.What is the signal-to-quantization noise ratio? (R)(Co5)

The signal-to-quantization noise ratio is given by, $(S/N)_q = 2^{2n}$ Where n is the number of bits per sample. In decibels this is $[S/N]_q = 10 \log 2^{2n} \approx 6n$ dB

15. Give application of Satellite? (U)(Co5) (May 2007, 2008, May 2017, Dec 2017)

i.Weather forecasting ii.Mobile satellite services – GSM, GPS. iii..Satellite Navigation System. iv.Direct Broadcast Satellite v.Direct to home Broadcast vi.Digital Audio Broadcast vii.Business TV viii.Digital Video Broadcast

16. What are the various compression standards used in satellite applications? (U)(Co5) (May 2008)

i.MPEG – 1, MPEG – 2, MPEG – 4, MPEG - 7 ii.JPEG, JPEG – 2000

17. What is transponder capacity? (R)(Co5) (Dec - 2009)

DBS television is also known as DTH (Direct To Home) TV. It needs more channels. So, audio and video components of a TV program are digitized. So, compression technique is used. Bandwidth is reduced to this compression symbol rate which can be transmitted in a given bandwidth is given by, $R_s = (B_{IF}/1+P)$, P = Roll off factor Here P is assumed as 0.2 BW = 24 MHz $R_s = (24 \text{ X } 10^6)/(1+0.2) = 20 \times 10^6$ symbols/second. Bit rate that can be carried in 24 MHz channel using QPSK is given as R_B. $R_B = 2 \times R_s = 40$ Mbps.

18. What is the orbital spacing of satellites? (U)(Co5) (May-2009)

Orbital spacing is the spacing between two satellites in orbit so that there will not be interference between the uplink and down link signals, antenna beams of the two satellites. For high power satellites, the orbital spacing is 9^o. So, it is considered that, there is no adjacent interference. DBS services are also spaced by 9^o. The orbital position of DBSC Satellite is 175^o.

19. What are VSATs? (R)(Co5) (May-2009, May 2017)

VSAT stands for very small aperture terminal system. This is the distinguishing feature of a VSAT system, the earth station antenna is typically less than 2.4 m in diameter. The small receive only terminal of direct broadcast satellite or direct to home system could be termed VSAT, but the appellant is usually reserved for private networks, mostly providing two way communications facility. Typical user groups include banking and financial institutions, ATMs, airline, hotel booking agencies and large retail stores with geographically dispersed outlets.

20. What are the requirements of a broadcast receiver? (R)(Co5) (May 2010)

The processing power and memory configuration of the receiver must be suitable for the routine operation of FTA digital satellite reception, (DVB-S), together with the embedded operation of MHEG-5 Version 1.06 NZ-variant applications, and the provision of the routine replacement of all software via 'through-the-air-download". The related parameter limits specified in this section are believed to be the minimum necessary to achieve these requirements; however vendors are invited to vary these parameters if they can demonstrate that all functional requirements can be met with their own varied configuration.

21. What are the major types of INTELSAT? (R)(Co5)

The INTELSAT-I, INTELSAT-II, INTELSAT-III, INTELSAT-IV, INTELSAT-V and INTELSAT-VI.

22. Give the expression for calculation of bit rate for digital television. (U)(Co5)

Bit rate for digital television depends on the picture format and is given by,

Uncompressed Bit Rate = (No. of Pixels in a frame) x (No. of frames per second)

X (No. of bits used to encoded each pixel)

If number of bits/pixel = 16 bits. Then, colour depth/pixel = 2^{16} = 65,536 colours.

23. What is INMARSAT? (R)(Co5) (Dec 2017)

INMARSAT is an organization that has provided mobile communication throughout the world in a big way. INMARSAT systems for mobile communication have been operating such as INMARSAT-A /B/C/M, INMARSAT-Aero and INMARSAT-D. INMARSAT-A provided circuit-switched telephone and telex services between PSTN and suitably equipped ships. These satellites provides service supports a low-speed, store-and-forward, two-way message service for land and maritime applications.

24. What is GRAMSAT? (R)(Co5) (May 2011)

Under GRAMSAT programme the State capital is connected to districts and blocks. Gujarat, Karnataka, Madhya Pradesh, Orissa, Rajasthan and Andaman and Nicobar islands use this system extensively. Training and development communication channel (TDCC) programme was implemented in various States of India with one-way video and two-way audio technology. The teaching-end includes a studio and an uplink facility. The participants at the classroom-end located nationwide receive lectures through simple dish antennas and have facility to interact with lecturers using telephone line. GRAMSAT is a part of TDCC.

25. List the advantages of DTH. (U)(Co5) (May 2011)

Introduce a large number of new interactive applications between user and service provider. ii. Large number of entertainment programmes over a single delivery platform iii. A large number of channels are digitally compressed, encrypted and beamed from very high power satellites iv. The programme can be directly received at homes. V. DTH transmission eliminates local cable operator completely.

26.Mention the three region to allocate the frequency for satellite services. (U)(Co5) (Dec 2016)

INTELSAT covers three main regions i. Atlantic Ocean region (AOR) ii. Indian Ocean Region (IOR) iii.Pacific Ocean Region (POR).

12 MARKS

1. Give a note on the following satellite applications (i) Business TV **(Dec 2017)** (ii) DAB (Digital Audio Broadcast) (iii) Internet application. **(U)(Co5)(May 2007)**
2. Elaborate on the mobile satellite services? What are the performance requirements to meet by the satellite for supporting such services. Give the necessary diagrams and examples. **(U)(Co5)(May 2007)**
3. In detail, give an account of various compression standards used in the satellite context. **(R)(Co5)(May 2008)**
4. What is the meant by DTH? What are the design issues to be considered for launching DTH systems? **(R)(Co5) (May 2008,June 2016,Dec 2016, May2017, Dec 2017)**
5. i. For a 24 MHz bandwidth transponder and allowing for a roll off factor of 0.2, what is the Symbol rate? (ii) Discuss in detail about MPEG compression standards. (iii) The EIRP of a 240 W transponder is 57 dBw. Calculate the approximate gain of the antenna. Suppose if this transponder is switched to 120 W. What will be the new EIRP, given the same antenna is used? **(Ap)(Co5) (May 2009)**
6. i) Discuss in detail about Global Positioning Satellite System. (ii) Write brief notes on the advantage of using satellites in LEOs, MEOs and GEOs for mobile satellite communications. **(U)(Co5) (May 2009)**
7. i) Draw the block diagram of Home Receiver indoor unit and explain its function. (ii) Explain the application of GPS System**. (R)(Co5) (Dec 2009) (Dec 2017)**
8. Explain the following: (i) MPEG compression standards (ii) Satellite Mobile Services**. (R)(Co5) (Dec 2009)**
9. i) Give a brief account of MPEG compression standards. (ii) With a block diagram explain Home receiver indoor unit. **(U)(Co5) (May 2010)**
10. Write short notes on: (i) VSAT **(Dec 2017)** (ii) Radarsat (iii) GPS System. **(R)(Co5) (May 2010,June 2016,Dec 2016)**
11. Discuss the various INTELSAT series and INSAT with its application. **(U)(Co5)**
12. Explain in detail about the mobile satellite services using GSM and GPS technologies. **(R)(Co5)** (June 2016**, May2017**)
13. In detail explain INMARSAT, the navigational satellite. **(U)(Co5) (Dec 2016)**
14. Explain about the EDUSAT and GRAMSAT with its application. **(U)(Co5)**
15. Write short notes on i. Digital audio broadcast ii. Digital video broad cast. **(R)(Co5)**
16. Explain direct broadcast satellite in detail. **(U)(Co5)** (**June 2016**)