INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

ELECTRONICS AND COMMUNICATION ANDENGINEERING

COURSE DESCRIPTOR

Course Title	SATELLITE COMMUNICATION				
Course Code	AEC522				
Programme	B.Tech				
Semester	VI	ECE			
Course Type	PROFESSIONAL ELECTIVE				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	-	3	-	-
Chief Coordinator	Dr. V Sivanagaraju, Professor, ECE				
Course Faculty	Dr. V Sivanagaraju, Professor, ECE				

I. COURSE OVERVIEW:

Satellites form an essential part of telecommunications worldwide. This Course will cover the fundamentals of Satellite communications, LEO satellites, MEO satellites, GEO satellites, and orbits. Transponders on communication satellites, link budget calculations, multiple access techniques and the propagation of radio waves through the earth's atmosphere. This course also covered the growth of VSAT systems and internet packet communications in satellite.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AEC009	V	Digital communications

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Satellite Communication	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✘	Chalk & Talk	✔	Quiz	✔	Assignments	✘	MOOCs
✔	LCD / PPT	✔	Seminars	✘	Mini Project	✔	Videos
✘	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE units and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Quiz/ Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	**Theory**		**Total Marks**
Type of Assessment	CIE Exam	Quiz / AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz / Alternative Assessment Tool (AAT):
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are be answered by choosing the correct answer from a given set of choices (commonly four). Marks shall be awarded considering the average of two quizzes for every course. The AAT may include seminars, assignments, term paper, open ended experiments, five minutes video and MOOCs.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineeringfundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lectures, Assignments, Exercises
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complexengineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Seminar
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Guest Lectures

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO 1	**Professional Skills:** An ability to understand the basic concepts in Electronics & Communication Engineering and to apply them to various areas, like Electronics, Communications, Signal processing, Antennas and Propagation, Embedded systems etc., in the design and implementation of complex systems.	3	Lectures and Assignments.
PSO 2	**Problem-Solving Skills:** An ability to solve complex Electronics and communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.	-	-
PSO 3	**Successful Career and Entrepreneurship:** An understanding of social-awareness & environmental-wisdom along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.	1	Guest lectures

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	Understand the communication space craft and orbits.
II	Interpret the access systems in communication satellites.
III	Understand the VSAT system technologies.
IV	Interpret packet communications in satellite.

IX. COURSE OUTCOMES (COs):

COs	Course Outcomes	CLO's	Course Learning Outcome
CO1	Discuss the satellite subsystems, spacecraft and orbits	CLO 1	Discuss the different satellite systems like Low earth orbit (LEO), Medium earth orbit (MEO) and Geo synchronous earth orbit (GEO).
		CLO 2	Understand how the satellite is locating with respect to earth and orbital perturbations due to earth's oblateness, moon and sun.

COs	Course Outcomes	CLO's	Course Learning Outcome
CO2	Analyze the design of Satellite link budget and discuss the satellite subsystems like telemetry, tracking and command system.	CLO 3	Understand the satellite sub systems like Telemetry, tracking and command system, power system, satellite antenna equipment, communications subsystem and transponders
		CLO 4	Analyze the design of satellite links for a specified C/N with and without frequency Re-use and link budget.
		CLO 5	Discuss the propagation effects like atmospheric absorption, cloud attenuation, troposphere and ionospeheric scintillation and low angle fading.
		CLO 6	Discuss the effects of rain, rain induced attenuation, rain induced cross polarization and interference.
CO3	Discuss the significance of different types of multiple access techniques in communication satellites.	CLO 7	Analyze the various multiple access techniques used in communication satellites like FDMA, TDMA and CDMA.
		CLO 8	Analyze the concept of demand assignment multiple access (DAMA), types of demand assignment and characteristics.
		CLO 9	Understand the significance of Spread Spectrum Multiple Access (SSMA), Direct sequence CDMA (DS-CDMA) or DS spread spectrum transmission and reception.
CO4	Analyze the earth station technology and constellation of NGSO	CLO 10	Understand and analyze the Earth Station technology transmitters, receivers, antennas, tracking systems, terrestrial interface, power test methods and lower orbit considerations.
		CLO 11	Analyze the Very Small Aperture Terminal (VSAT) network architecture, access control and multiple access selection.
		CLO 12	Analyze the constellation design of Non Geostationary Orbit (NGSO) coverage, frequency bands, delay and throughput.
CO5	Evaluate the future satellite communication systems and error control coding for digital satellite links	CLO 13	Understand the message transmission by FDMA using M/G/1 queue and message transmission by TDMA using pure aloha
		CLO 14	Apply the error control coding for digital satellite links like block codes and convolution codes.
		CLO 15	Evaluate the future satellite communication systems and introduction to satellite laser communication.

X. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AEC522.01	CLO 1	Discuss the different satellite systems like Low earth orbit (LEO), Medium earth orbit (MEO) and Geo synchronous earth orbit (GEO).	PO 1, PO2	2
AEC522.02	CLO 2	Understand how the satellite is locating with respect to earth and orbital perturbations due to earth's oblateness, moon and sun.	PO 1,PO2	2
AEC522.03	CLO 3	Understand the satellite sub systems like Telemetry, tracking and command system, power system, satellite antenna equipment, communications subsystem and transponders	PO 1, PO 2, PO4	2

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AEC522.04	CLO 4	Analyze the design of satellite links for a specified C/N with and without frequency Re-use and link budget.	PO 1, PO4	2
AEC522.05	CLO 5	Discuss the propagation effects like atmospheric absorption, cloud attenuation, troposphere and ionospeheric scintillation and low angle fading.	PO1, PO4	2
AEC522.06	CLO 6	Discuss the effects of rain, rain induced attenuation, rain induced cross polarization and interference.	PO 1, PO 2	2
AEC522.07	CLO 7	Analyze the various multiple access techniques used in communication satellites like FDMA, TDMA and CDMA.	PO 2, PO 4	1
AEC522.08	CLO 8	Analyze the concept of demand assignment multiple access (DAMA), types of demand assignment and characteristics.	PO 1, PO 4	2
AEC522.09	CLO 9	Understand the significance of Spread Spectrum Multiple Access (SSMA), Direct sequence CDMA (DS-CDMA) or DS spread spectrum transmission and reception.	PO 2, PO 4	1
AEC522.10	CLO 10	Understand and analyze the Earth Station technology transmitters, receivers, antennas, tracking systems, terrestrial interface, power test methods and lower orbit considerations.	PO 2, PO 4	1
AEC522.11	CLO 11	Analyze the Very Small Aperture Terminal (VSAT) network architecture, access control and multiple access selection.	PO 1, PO 2	2
AEC522.12	CLO 12	Analyze the constellation design of Non Geostationary Orbit (NGSO) coverage, frequency bands, delay and throughput.	PO 1, PO 2, PO 4	2
AEC522.13	CLO 13	Understand the message transmission by FDMA using M/G/1 queue and message transmission by TDMA using pure aloha.	PO 2, PO 4	1
AEC522.14	CLO 14	Apply the error control coding for digital satellite links like block codes and convolution codes.	PO 1, PO 4	2
AEC522.15	CLO 15	Evaluate the future satellite communication systems and introduction to satellite laser communication.	PO 1, PO 2	2
AEC522.16	CLO 16	Apply the concept of satellite communication to understand and analyze real time applications.	PO 4	2
AEC522.17	CLO 17	Acquire the knowledge and develop capability to succeed national and international level competitive examinations.	PO 2, PO 4	1

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XI. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

CLO	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	3	2											3		
CLO 2	3	2											3		
CLO 3	3	2		1									3		
CLO 4	3			1											
CLO 5	3			1											1
CLO 6	3	2											3		
CLO 7		2		1									3		
CLO 8	3	2											3		
CLO 9		2		1									3		
CLO 10		2		1									3		
CLO 11	3	2		1											
CLO 12	3	2		1											1
CLO 13	3	2													
CLO 14	3			1											1
CLO 15	3	2													
CLO 16				1									3		
CLO 17		2		1											1

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XII. ASSESSMENT METHODOLOGIES–DIRECT

CIE Exams	PO 1 PO 2 PO 4 PSO 1 PSO 3	SEE Exams	PO 1 PO 2 PO 4 PSO 1 PSO 3	Assignments	PO 1 PO 2 PO 4 PSO 1 PSO 3	Seminars	PO 1 PO 2 PO 4 PSO 1 PSO 3
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-						

XIII. ASSESSMENT METHODOLOGIES-INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XIV. SYLLABUS

Unit-I	COMMUNICATIONS SPACECRAFT AND ORBITS:
Overview of present and future trends of satellite communications introduction to satellite systems: Low earth orbit (LEO); Medium earth orbit (MEO); Geo synchronous earth orbit (GEO); Geostationary earth orbit (GEO); Orbital mechanics: Orbital elements; Locating the satellite with respect to the earth; Coverage angle; Slant range; Inclined orbits; Orbital perturbations due to earth's oblateness and moon and sun; Eclipse of GEO satellite; Sun transit outage.	
Unit-II	**SPACE SEGMENT:**
Placement of a communication satellite in GEO satellite sub systems: Telemetry, tracking and command system, power system, satellite antenna equipment, communications subsystem and transponders, TWT amplifier operation, satellite frequency bands and allocations; Satellite link: Basic transmission theory, system noise temperature and G/T ratio, basic link analysis, design of satellite links for a specified C/N with and without frequency Re-use , link budget; Propagation effects: Introduction, atmospheric absorption, cloud attenuation, troposphere and ionospeheric scintillation and low angle fading; Effects of rain: Rain induced attenuation, rain induced cross polarization interference.	
Unit-III	**COMMUNICATION SATTELLITE ACCESS SYSTEMS:**
Multiple Access: Frequency division multiple access (FDMA), Time division multiple access (TDMA), frame structure, burst structure, satellite switched TDMA, on-board processing, demand assignment multiple access (DAMA), types of demand assignment, characteristics. Code Division Multiple Access (CDMA) / Spread Spectrum Multiple Access (SSMA); Direct sequence CDMA (DS-CDMA) or DS spread spectrum transmission and reception, adjacent channel interference, inter modulation, handover, satellite diversity.	
Unit-IV	**EARTH STATION AND VSAT SYSTEMS TECHNOLOGY:**
Earth Station: Transmitters, receivers, antennas, tracking systems, terrestrial interface, power test methods, lower orbit considerations; VSAT (Very Small Aperture Terminal) Systems: Overview of VSAT systems, VSAT network architecture, access control, and multiple access selection. NGSO constellation design: Orbits, coverage, frequency bands, delay and throughput, non geostationary orbit (NGSO) constellation design and problems.	
Unit-V	**SATELLITE PACKET COMMUNICATION:**
Message transmission by FDMA: M/G/1 queue, message transmission by TDMA, pure aloha, satellite packet switching, slotted aloha, packet reservation, tree algorithm; Error control for digital satellite links: Error control coding, block codes, convolution codes, implementation of error detection on satellite links. Overview of future satellite communication systems, introduction to satellite laser communication, data relay communication satellites, satellite mobile services, applications.	
Text Books:	
1. Dennis roddy, ―Satellite Communications, 4th Edition, 2004. 2. Pratt. Bostian, Allnutt, ―Satellite Communications, Wiley India, 2nd Edition, 2006. 3. Gérard Maral, ―Satellite Communication Systems, 1993. 4. Tri T. Ha, Digital Satellite Communications 2nd edition, TMH, 1990.	
Reference Books:	
1. Rappaport T.S., ―Wireless communications, 2nd Edition, Pearson Education, 2010. 2. Bruce Elbert, ―Introduction to Satellite Communications, 1987. 3. M Richharia, Satellite Communication Systems 2nd edition, MacMillan, 2005.	

XV. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1	Describe the overview of present and future trends of satellite communications.	CLO 1	T2 – 1.3 to 1.4
2-3	Introduction to Low earth orbit (LEO), Medium earth orbit (MEO), Geo synchronous earth orbit (GEO), Geostationary earth orbit (GEO) systems.	CLO 1	TI—3.8
4-6	Recall orbital mechanics: Orbital elements, Locating the satellite with respect to the earth, Coverage angle, Slant range, Inclined orbits.	CLO 2	T2--2.1 to2.2
7-10	Analyze the orbital perturbations due to earth‘s oblateness and moon and sun, Eclipse of GEO satellite, Sun transit outage.	CLO 2	T2--2.3 to2.6
11-13	Understand the satellite sub systems like TTC & M, power systems, antennas and communications subsystems.	CLO 3	T2--3.1 to3.5
14-17	Apply the basic transmission theory to satellite link, system noise temperature, G/T ratio, basic link analysis link and budget.	CLO 4	T2--4.1 to4.4 & 4.7
18-20	Understand the Propagation effects and the effects of rain	CLO 5 CLO 6	T2--8.1 to8.4
21-24	Recognize the purpose of multiple access like Frequency division multiple access (FDMA), Time division multiple access (TDMA), satellite switched TDMA and demand assignment multiple access (DAMA)	CLO 7 CLO 8	T2--6.1 to6.5
25-27	Analyze the Code Division Multiple Access	CLO 9	T2--6.8
28-29	Understand the earth station technology.	CLO 10	T2--10.1 to10.5
30-32	Analyze the Very Small Aperture Terminal (VSAT) Systems.	CLO 11	T2--9.1 to9.5
33-35	Analyze the constellation design of non geostationary orbit (NGSO).	CLO 12	T2--10.4 to10.6
36-39	Understand the message transmission by FDMA	CLO 13	T4—8.2 to 8.7
40-43	Apply the error control coding for digital satellite links.	CLO 14	T2--7.3 to7.6
44-45	Evaluate the future satellite communication systems.	CLO 15	R3—12.3 to 12.5

XVI. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S No	Description	Proposed Actions	Relevance with POs	Relevance with PSOs
1	Satellite communications.	Seminars / NPTEL	PO 1, PO 2, PO 4	PSO 1
2	Design a model of spacecraft	Seminars / NPTEL	PO 2, PO 4	PSO 1
3	Understand the launch of space vehicle.	NPTEL/ Industrial visit	PO 2	PSO 1

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