SATELLITE COMMUNICATIONS FUNDAMENTALS - 2024/5

Module code: EEEM031

Module Overview

Expected prior/parallel learning: BEng-level understanding of digital telecommunications systems. MEng students might have partly acquired this through study of EEE3006 – Digital Communications.

Module purpose: Satellite communications are an important component of modern telecommunication systems. This module provides the student with an overall understanding of satellite communication systems, technologies and techniques and equips him/her with the design tools to enter employment in the sector.

The main goal of this module is to design a satellite communication link to fix or mobile users given a specified quality of service (QoS). To do so, one needs to take into account both telecommunication and satellite related parameters. In this module, you will learn about the satellite payload and how it operates, what is in the earth station and what are the characteristics of the satellite to earth link. In particular, we clearly state the differences in design compared to the terrestrial communication systems We also study in some details the modern satellite networks and constellations.

[EEE3006]: This module uses several techniques addressed in digital communications module such as coding and modulation.

[EEEM032]: This module is a prerequisite for the advanced satellite communication techniques.

[EEEM009],[EEEM059]: Even though other satellite applications such as earth observation or satellites for navigation and positioning are not addressed in this module, however, all such application will eventually need to stablish a communication line with earth. In this sense, this module is closely related to modules on space avionics and navigation, guidance and control.

Module provider

Computer Science and Electronic Eng

Module Leader

SUN Zhili (CS & EE)

Number of Credits: 15

ECTS Credits: 7.5

Framework: FHEQ Level 7

Module cap (Maximum number of students): N/A

Overall student workload

Independent Learning Hours: 90

Lecture Hours: 11

Tutorial Hours: 6

Guided Learning: 10

Captured Content: 33

Module Availability

Semester 1

Prerequisites / Co-requisites

None.

Module content

Indicative content includes the following.

Introduction to Satellite Systems

Radio Regulations, ITU-R/T, IFRB. Frequencies, interference management, space and ground segment components, earth stations, bus and payloads, antennas and coverage, transparent and non-transp,arent transponders. FSS, MSS, BSS applications areas and examples with state-of-the-art systems. GEO, HEO, LEO and hybrid orbits dynamics, echoes control and effect on services: speech, vision, data, and multimedia. Satellite Networking: SCPC, MCPC, and multiple access review. FDMA, TDMA, CDMA, RA, and where used. Traffic routing in single and multi beam satellites. Satellites versus other medium and where applicable. Control and operation of satellite systems, earth station planning, siting and maintenance.

Satellite Organisations and state-of-the-art Review

IGOS - INTELSAT, INMARSAT, EUTELSAT etc. ESA, NASA, NASDA role, regional and domestic systems, private organisation and consortia - the move to privatisation. Launcher organisations, manufacturers, operators and service providers - enterprise models. Review of FSS, BSS, MSS systems, state-of-the-art and current developments

Satellite Systems Planning

Basic transmission theory, FSL, antenna theory, gain, radiation patter, eirp, satellite look angles and ranges. Noise sources, noise temp, noise figure, sky noise G/T ratio and calculation C/N for up-path and down-path. Intermodulation, back-off, interference and C/I calculation. Effects of rain for FSS and multipath shadowing for MSS systems - calculation of margins. Link budget with overall C/N and availability. Meaning of QoS. Differences between GEO and non-GEO link budgets. Digital modulation PSK types and choice. Eb/No, BER coherent differential etc. modems, filtering and bandwidth calculation. FEC coding, code rates, code types. Error coding in trading off power and bandwidth - power and bandwidth limits. Relationship Eb/No with C/No and system QoS requirements. mPSK, QAM.A-PSK, OQPSK etc. Effects of non linear amps on waveform. Interference sources and C/N+I, Examples of link budget planning for desired QoS/availability.

Regulation of the Spectrum

Frequency assignments and limitations – work of ITU in fixed mobile and broadcast areas. Co-ordination procedures for GEO and for non-GEO systems and the management of interference. Orbit assignments and procedures. Latest WRC developments.

Satellite Systems Business

Who's Who in the business and who makes money. Financial planning - NPV and IRR techniques, project planning and scheduling. Building a business case and raising money for projects - the role of equity, debt and the banks. Risk analysis and management.

Satellite system futures

A state-of-the art update on current innovations and new systems proposals, standards issues and technology developments that shape satellite communications for the next 10 years.

Assessment pattern

Assessment type	Unit of assessment	Weighting
Coursework	ASSIGNMENT	30
Examination	2-HOUR INVIGILATED EXAM (OPEN BOOK)	70

Alternative Assessment

N/A

Assessment Strategy

The assessment strategy

The assessment strategy for this module is designed to provide students with the opportunity to demonstrate the learning outcomes. The written examination will assess the knowledge and assimilation of terminology, concepts and theory in satellite communications system design and business processes, as well as the ability to analyse problems and apply mathematical models to solve and predict problems. The assignment is designed to test the real life solution of design of a satellite system given both technical and business parameters. It represents what the satellite engineer will face in industry.

Thus, the summative assessment for this module consists of:

- Satellite systems design assignment with a report including results of calculations. Students are encouraged to discuss with visiting industrialists the current issues pertaining to the assignment.

- Invigilated exam

Formative assessment and feedback

For the module, students will receive formative assessment /feedback in the following ways;

- During lectures by question and answer sessions.
- During lectures/classes by working through the design exercises throughout the course.
- During Seminars by questions and answers with industrial lecturers.
- Via feedback on the assignment

Module aims

- This module aims to provide the student with a broad background across the whole of satellite communications including technology, markets and technical and business planning with detailed skills in the design and planning processes.

Learning outcomes

Ref		Attributes Developed	
001	Explain the structure, techniques, technology and key organisations involved in satellite communication systems	KPT	M1 M15
002	Design and plan satellite communication links for a prescribed QoS.	CPT	M5, M6
003	Explain modulation and coding as applied to different satellite communication systems.	KCT	M2, M3
004	Apply financial/business processes to determine the viability of satellite communication systems.	CPT	M4, M15
005	Describe the processes used to regulate spectrum and control interference intra/inter satellite communication systems.	CPT	M7, M8, M14
006	Apply knowledge of existing satellite systems and state of the art technology to the design of future systems and report in written format	KCPT	M5, M16, M17

Attributes Developed

C - Cognitive/analytical

K - Subject knowledge

T - Transferable skills

P - Professional/Practical skills

Methods of Teaching / Learning

The learning and teaching strategy is designed to:

- provide the students with knowledge of design of satellite communications and then to allow them to practice the application of this knowledge on a real system design
- provide the student with a wide knowledge of the state of the art in the subject and allow them to apply this to current engineering problems and to the design of future systems.

Learning and teaching methods include the following:

- A series of lectures on satellite communications including a structured series of design exercises which the students complete as they progress through the course.
- A system design assignment involving the planning and design of a real satellite communications system and business evaluation which tests the understanding of the above.

- A series of 4 industrial seminars which gives the students a feeling for the state of the art and of the practical problems and issues facing industry in this area.

Indicated Lecture Hours (which may also include seminars, tutorials, workshops and other contact time) are approximate and may include in-class tests where one or more of these are an assessment on the module. In-class tests are scheduled/organised separately to taught content and will be published on to student personal timetables, where they apply to taken modules, as soon as they are finalised by central administration. This will usually be after the initial publication of the teaching timetable for the relevant semester.

Reading list

https://readinglists.surrey.ac.uk
Upon accessing the reading list, please search for the module using the module code: EEEM031

Other information

The role of telecommunications in the economic development of nations is an undeniable fact and satellites are an important part of today's telecommunication infrastructure. In 2021, the global market size of satellite communications was of around 59 billion dollars. With a current growth rate of 9.5%, the revenue forecast for 2030 is of 159 billion dollars. This results in a high demand for skilled engineers in all sectors, including satellite operators, satellite manufacturers, regulatory bodies and service providers. An important feature of this module will be 6 hour of seminars by speakers from industry (often our alumni) and this, besides providing a first-hand knowledge on new technologies in satellite communications, may offer a possible link for future employment.

Decision making and problem solving is the core problem in designing a satellite communication link. Several parameters need to be optimized (i.e., number of satellites, orbits and power) for a given set of sometimes contrasting constrains such as quality of service, throughput and coverage.

With several thousand satellites orbiting the earth the collisions among satellites are becoming more likely. Besides that, given the short life-cycle of communication satellites, the immediate question is what are the environmental impacts of megaconstellations. In particular, the impact of space debris and how we can address that. We briefly discuss this and other actual problems such as digital divide and discuss the future of satellite communications.

Another aspect of satellite communication is the fact that Several organizations are involved in satellite communications, both governmental and private, each having their own interest that often contradicts the others. Such conflicts needs to be understood in both global and cultural context.

Programmes this module appears in

Programme	Semester	Classification	Qualifying conditions
Electronic Engineering MEng	1	Optional	A weighted aggregate mark of 50% is required to pass the module
Electronic Engineering MSc	1	Optional	A weighted aggregate mark of 50% is required to pass the module
Electronic Engineering with Space Systems MEng	1	Optional	A weighted aggregate mark of 50% is required to pass the module
RF and Microwave Engineering MSc	1	Optional	A weighted aggregate mark of 50% is required to pass the module
Satellite Communications Engineering MSc	1	Compulsory	A weighted aggregate mark of 50% is required to pass the module
Space Engineering MSc	1	Optional	A weighted aggregate mark of 50% is required to pass the module

Please note that the information detailed within this record is accurate at the time of publishing and may be subject to change. This record contains information for the most up to date version of the programme / module for the 2024/5 academic year.