ADVANCED SATELLITE COMMUNICATION TECHNIQUES - 2024/5

Module code: EEEM032

Module Overview

Expected prior/parallel learning: This module covers advanced topics on satellite communications and networks, following the Satellite Communication fundamentals (EEEM031). An alternate module containing suitable prior learning is, Space System Design (EEE3040).

Module purpose: This module covers advanced topics on satellite communications and networks. These networks are an important part of global information infrastructure providing broadcasting, mobile and broadband services to millions of homes and offices as well as disaster relieves and emergency communications services.

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: 68

Lecture Hours: 33

Tutorial Hours: 5

Laboratory Hours: 9

Guided Learning: 10

Captured Content: 25

Module Availability

Semester 2

Prerequisites / Co-requisites

None.

Module content

Indicative content includes the following:

1. Introduction

Introduction to concepts and terminologies on advanced satellite communications and networks, explain the Lab sessions and experiments, give the assignment and coursework.

2. Modulation and Channel coding

Review of the standard modulation formats (PSK, QAM) and introduction to variations used in satellite systems, such as OQPSK, MPSK, APSK. Introduction to Turbo Codes and Low DensityLow-Density Parity Check Codes (LDPC). Adaptive Coding and Modulation (ACM) in satellite systems. OFDM principles and LTE practical applications in satellite communications systems. Review of new DVB-S/S2/S2x standard modifications.

3. Digital Broadcasting

Review of analogue FM transmission of FDM-TV. Infrastructure of broadcasting - Digital TV - source encoding and MPEG compression leading to PES packets – DVB-S/S2/S2x channel coding and modulation. ACM and enhanced performance. Multiplexing in TV playout systems. Satellite radio systems (SDR) and SDAB. DMB and SDMB--architecture with gap fillers S-UMTS. DVB-SH options and applications of hybrid systems in S band.

4. Non-GEO satellite systems

Satellite constellation review and properties; network architectures - entities, mobility management, call control - handover issues and integration with GSM terrestrial system. Traffic and signalling channels. Business and regulatory aspects. IMT-2000-UMTS air interface and multimedia aspects of traffic.

5. Multiple Access

Cover all the multiple access techniques for satellites multiple access and related protocols and efficiency. These include, frequency division multiple access (FDMA), time division multiple access (TDMA), code division multiple access (CDMA), fix assignment access and on-demand assignment access (DAMA), and random access.

6. Satellite network routing and SDN

Cover satellite networking concepts, Basic Modem IP function IP address for IP traffic and network monitor and control (M&C), Bridge and gateway functions, Routing protocols for satellite networks such as RIP, OSPF, BGP, Traffic shaping and QoS routing including DiffServ and IntServ architectures, Protocol header compression, VLAN operation, Satellite network virtualisations, Network slicing in satellite networks, Satellite NFV, Satellite SDN.

7. SDN in Satellite networks

Cover VLAN operation, Satellite network virtualisations, Network slicing in satellite networks, Satellite NFV, Satellite SDN.

8. DVB-S/RCS standards for networking and security

Review of source coding (MPEG2) for Digital Video Broadcasting over Satellites (DVB-S); and the DVB-S systems and networking issues. Detailed presentation of MPEG multiplexing, transport streams and IP packet encapsulation (Multi Protocol Encapsulation, MPE), Unidirectional Lightweight Encapsulation (ULE). DVB-S with return channel (DVB-RCS). Security aspects for DVB-S and DVB-RCS.

9. Signal processing for satellite systems

Interference mitigation techniques, frequency reuse in multibeam satellites, precoding techniques to mitigate interference, basics of

beam hopping.

10. HTS and Advanced Payload Concepts

Review of development in commercial HTS systems. Multi beam antennas and types of frequency re-use. Interference scenarios and calculation. Capacity calculations in HTS. Smart gateway schemes and network diversity. Q/V band availability and optical up links.

Satellite payload issues and optimisation. Size/power trends in payloads FSS/MSS. Multi beam antennas (MBA's) - reflector geometries gain and polarisation, contoured beamsbeams, and phase array generation of spot beams, deployable, PIMS. System advantages of MBA's, connectivity--frequency hopping and SS-TDMA, interference issues. OBP-system advantages, MCDM's regeneration, switches, DSP configurations for FSS and MSS--technology examples mass/volume/power, flexibility. ISLs, optical and millimetre wave examples and payload trade-offs.

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 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 of satellite communications and networks, as well as the ability to analyse problems and apply measurements on the satellite testbeds.

The Assignment will assess the ability to use the satellite testbed for performance measurements, evaluations, and report. The laboratory experiment will evaluate the acquired technical skills and expertise required for performance characterisation of satellite communication systems.

Thus, the summative assessment for this module consists of:

· Assignment assessment is based on laboratory performance including preparations and writeup report in the context of group experiments on a satellite communications modem with 2 students in each of the group; each group of students will be scheduled in 3 time slots of 3 hours each, and each student submit his/her report within a week after completion of the experiments. Individual formal technical report on the experiments.

· Online written examination

Formative assessment and feedback

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

· During tutorials/tutorial classes

· By means of unassessed tutorial problem sheets (with answers/model solutions)

· During supervised laboratory sessions

· Via the marking of written reports

· Via assessed coursework

Feedbacks provided on the performance and technical report.

Module aims

- The aim of this module is to build onto the knowledge gained in EEEM031 "Satellite Communication fundamentals" and provides the student with a detailed understanding of the techniques used and applications in modern Satellite Communications and Networks. In addition, to provide the student with familiarity of simulation, analysis and measurement techniques used in the design and analysis of Satellite Communications links.
- The module also aims to provide opportunities for students to learn about the Surrey Pillars listed below.

Learning outcomes

Ref		Attributes Developed	
001	Explain the modulation and channel coding technique	K	M1
002	State the main standards and techniques for broadcasting services and technologies	KCPT	M1, M14
003	Describe the high throughput satellite systems	KC	M6
004	Evaluate radio resource management (RRM) methods for satellite networks	KCPT	M2, M14
005	Explain the network concepts and protocols and IP over satellites	KC	M2, M6
006	Explain the network security in the DVB-S/RCS standards	KC	M10
007	Explain Non-GEO satellite systems and advanced payload concepts	KC	M2
008	Explain the advanced payload concepts	KC	M2
009	Perform and evaluate measurements in real time satellite systems	PT	M12, 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 achieve the following aims:

- Students taking this module will have a detailed knowledge of modern satellite communication techniques and systems as well as an appreciation of all the current application areas.
- In particular, the students will have obtained the skill of carrying out simulations / measurements of a satellite communication link using a commonly available and industry standard software package or measurement equipment.

Learning and teaching methods include the following:

- Lectures
- Labs: sessions using a satellite system testbed.
- Assignment(s): report based on using the satellite system testbed.
  - Familiarisation with test equipment (spectrum analyser, BER test set etc)
  - Measurement for spectrum of various modulations and coding rates
  - Measurement of BER with changing C/N
  - Assessment of impact of interference

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: EEEM032

Other information

This module provides contents with knowledge through lectures and tutorials, and professional practical skills through practices in the laboratory, coursework and Lab report. It will help students to get particularly good learning, learn subject knowledge and skill and improve their capacity, covering the following aspects of the Surrey Pillars:

- Sustainability: this module is directly relevant to the SDG4 quality education for remote and rural areas as satellite provide global coverage for the students who may not be reached easily by normal terrestrial information infrastructure; to the SDG 9 industry, innovation & infrastructure as satellite has been considered as important part of the future 5G and 6G networks to support industrial IoT (IIoT) and global information infrastructure (GII); to the SDG 10 reduce inequality within & among countries as satellite has already been used to serve regions or countries which cannot be served economically to bridge the digital gaps for

broadband Internet services; to SDG 17 partnerships for the goals as satellite naturally provides support for global coverage and collaboration and has been used to achieved goal by the International Telecommunication Union (ITU).

- Global and culture capabilities: the nature of satellite is global that it need global collaboration and multicultural environment for working together. The module has laboratory sessions to allow student from different countries and culture to work together. This has also been promoted by the ITU in the UN.
- Resourcefulness and resilience: the module covers both technical aspect and current development of the sectors to allow students to be aware the potential development and opportunity. In addition, the module also provides information for students to be able to work in quite different sector as required.
- Digital capability: as an important part of communication infrastructure satellite can provide services to enable many individuals and organisations to be able to participate social and professional life in digital and connected world. The new generation of Mega LEO satellite constellations will be able to reach any people anywhere and any times.
- Employability: currently there are great demand for skilled engineers in the satellite industries including satellite operators, manufacture, services providers and terminal producers and relevant electronic companies.

Programmes this module appears in

Programme	Semester	Classification	Qualifying conditions
Electronic Engineering MEng	2	Optional	A weighted aggregate mark of 50% is required to pass the module
Electronic Engineering MSc	2	Optional	A weighted aggregate mark of 50% is required to pass the module
Electronic Engineering with Space Systems MEng	2	Optional	A weighted aggregate mark of 50% is required to pass the module
RF and Microwave Engineering MSc	2	Optional	A weighted aggregate mark of 50% is required to pass the module
Satellite Communications Engineering MSc	2	Compulsory	A weighted aggregate mark of 50% is required to pass the module
Space Engineering MSc	2	Optional	A weighted aggregate mark of 50% is required to pass the module