WM917-15 Networks and Communications for the Connected Car

21/22

Department
WMG
Level
Taught Postgraduate Level
Module leader
Matthew Higgins
Credit value
15
Module duration
2 weeks
Assessment
Multiple
Study location
University of Warwick main campus, Coventry

Description

Introductory description

This module aims to provide the students with an up to date, comprehensive knowledge of the main wired and wireless communications technologies that are used, or will be used, in current and future production consumer vehicles.

Module aims

Through providing a knowledge base of core telecommunications theories, the student is taken forward into the application domain, such that the various wired and wireless technologies in the context of the automotive space is understood. Key concepts of theory Vs application are discussed based upon the inference and understanding of the performance of the technologies both at the component and system level. Topics are introduced from both the theoretical and practical viewpoints to encourage independent critical evaluation of the subject matter.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

Introduction: Taxonomy of modern communications. OSI Model, Signalling Vs Communications. Context of Networks and Communications.

Telecommunications Theory:

- Pulse Modulation: Analog to digital conversion. Sampling, aliasing, and Nyquist, Equalisation. Digitisation, quantisation and errors. Encoding and decoding.
- Baseband and Passband Modulation: baseband and applications of baseband transmission. ISI. Pulse shaping Baseband to pass-band. Carrier waves. Basic modulation types. Error rates and bandwidth relationships.
- Coding Theory: Information theory, BER, Binary (non-)symmetric channel, basic coding schemes, Entropy, AWGN. Error detection and correction, basic ECC Shannon limits and/or capacity.
- Multiple Access: Single channel communications. Multiple access motivation and techniques. Multiple access in practice.

Wireless Technologies

- Link Budget and Channel: Spectrum Reuse. Noise, origins and types. Free space losses. Carrier to Noise Ratio. Propagation models.
- 4G LTE: Principles and motivation. Key characteristics. OFDM/multicarrier transmitter and receiver. 4G spectrum organisation, carrier aggregation, resource management and channel mapping.
- GNSS: Core principles and motivation in the context of automotive. Signal types. Performance. Interfaces. Standards and regulations. Automotive integration.
- WiFi and the Unlicensed Spectrum: The unlicensed spectrum and considerations. WiFi standards, MAC and PHY. Architectures. LTE-U, regulations. Move to higher frequencies.
- 5G: Key Technologies and Roadmap for 5G. Background and Demands. 5G Specifications. Absorptions and specific channel limitations. Convergence including IoT. Backward (and forward) compatibility.
- Radio Frequency (RF) In, and Around, the Vehicle: Real world issues on antenna placement. Real world issues with materials. Vehicular EMI and mitigation techniques. Compatibility and conformity. Use of other EM bands as alternatives e.g. THz or Optical.

Wired Technologies

- Flexray: Context and principle applications. Physical layer. Protocol - Message frames, headers addressing etc. Topology. Usage and compliance. API. Determinism.
- CAN: Context and principle applications. Physical layer (low speed and high speed), and architecture. Protocol - Message frames, headers, addressing, message IDs. Usage and standards compliance.
- LIN: Context and principle applications. Physical layer. Protocol - Message frames, headers, addressing etc. Topology. Usage and compliance. API.
- Ethernet: General Ethernet principles. Networking model, and comparison between other technologies. Terminology. Standards. Topologies e.g. bridges, nodes, stations etc. Common physical layers and IEEE 802.3.

Learning outcomes

By the end of the module, students should be able to:

- Critically evaluate different communication systems and how they might be integrated together within a connected and/or autonomous system
- Infer how the relative communications technologies interact with both the user, the vehicles control and the wider network.
- Evaluate a complete communication system within the wider automotive eco-system and understand what is currently considered as state-of-the-art, with an enhanced research view of the future
- An ability to apply relevant practical communications techniques appropriately and understand how their results may be used to inform judgements and develop and advance ideas and/or practice.
- Demonstrate the ability to design communication systems to support connectivity aspect of connected and/or autonomous systems within the backdrop of Intelligent Transportation Systems network.
- A comprehensive understanding of and competence in the use of appropriate channel modelling tools and techniques for the purpose of system performance prediction.

Indicative reading list

- JIANG H., Channel modeling in 5G wireless communication systems, (2020), ISBN: 9783030328696.
- TOSKAL A., 5G technology : 3GPP new radio, (2020), ISBN: 1119236290
- GOLDSMITH, A., Wireless Communications, Cambridge University Press, (2005), ISBN: 0521837162.
- TSE, D., Fundamentals of Wireless Communications, Cambridge University Press, (2005), ISBN: 0521845270.
- MATHEUS, K., Automotive Ethernet, Cambridge University Press, (2017), ISBN: 1107183227.
- PARET, D., Multiplexed Networks for Embedded Systems: CAN, LIN, FlexRay, Safe-by-Wire, (2007), ISBN: 0470034165.
- MEAD, N.R., Cyber Security Engineering: A Practical Approach for Systems and Software Assurance, (2016), ISBN: 0134189809.
- Wiley 5G Ref: The Essential 5G reference Online, (2019), ISBN: 9781119471509. (Optional Depending on Library Availability)

Subject specific skills

Equipment Handling, Equipment Usage, Calibration, Test and Measurement, Matlab Analysis.

Transferable skills

group work, time management, presentation skills, interaction with industrial experts.

Study

Study time

Type	Required
Lectures	26 sessions of 1 hour (17%)
Seminars	1 session of 1 hour (1%)
Tutorials	1 session of 1 hour (1%)
Practical classes	12 sessions of 1 hour (8%)
Other activity	20 hours (13%)
Assessment	90 hours (60%)
Total	150 hours

Private study description

No private study requirements defined for this module.

Other activity description

Preparation for the 4 x laboratory proforma results submissions (In-module Assignments for 30% of total mark. i.e. 7.5% each).

Costs

Category	Description	Funded by	Cost to student
Equipment and project costs	The laboratories may require disposables in the forms of cables and connectors which get damaged around the main equipment. The CAN laboratories are hands on and students should interact, re-wire and re-configure on the day. This may lead to further breakages. Potential for £1000 per year for replacements on such items. Dr Ahmet Er has previously approved this.	Department	£0.00

Assessment

You must pass all assessment components to pass the module.

Assessment group A1

	Weighting	Study time
Assessed Coursework	70%	90 hours
1 x 4000 word (Post Module Assignment, 70% of overall mark).		
Assessed coursework	30%	
Preparation for the 4 x laboratory proforma results submissions (In-module Assignments for 30% of total mark. i.e. 7.5% each), see section 5.		

Assessment group R

	Weighting	Study time
Assessed Coursework	100%	
1 x 4500 word (Post Module Assignment, 100% of overall mark).		

Feedback on assessment

PMA and IMA: Scaled ratings for Comprehension, Effort, and Presentation. Individual written feedback and overall marks.
Formative assessment will be provided during the laboratory activities and class interactions

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Availability

There is currently no information about the courses for which this module is core or optional.