Course guide

Name	INFORMATION AND COMMUNICATIONS TECHNOLOGY IN AUTOMOTIVE INDUSTRY		
Subject	APLICACIÓN DE LA INGENIERÍA		
Module	MATERIAS COMUNES A TODAS LAS MENCIONES		
Grade	GRADO EN INGENIERÍA DE TECNOLOGÍAS ESPECÍFICAS DE TELECOMUNICACIÓN		
Plan number	512	**Code number**	46675
Quarter	1st QUARTER	**Type**	OPTATIVE
Type degree	GRADE	**Year**	4º
Number of ECTS	6 ECTS		
Language	ENGLISH		
Instructors	JUAN CARLOS AGUADO MANZANO IGNACIO DE MIGUEL JIMÉNEZ		
Contact	PHONE: 983 185576 E-MAIL: juancarlos.aguado.manzano@uva.es PHONE: 983 185574 E-MAIL: ignacio.demiguel@uva.es		
Tutorials with the instructors	"See timetable in: https://www.uva.es/export/sites/uva/2.estudios/2.03.grados/2.02.01.oferta/estudio/Grado-en-Ingenieria-de-Tecnologias-Especificas-de-Telecomunicacion-00002/"		
Department	TEORÍA DE LA SEÑAL Y COMUNICACIONES E INGENIERÍA TELEMÁTICA		
Date of review by the Degree Committee	8th July 2023		

1. Context of the course

1.1 Introduction

Vehicle industry has introduced a great deal of electronics inside vehicles during the last decades. This massive presence of electronic devices inside cars has led to the development of its associated communications technology. This communications technology can be divided into intra-vehicle, inter-vehicle and vehicle to infrastructure communications.

These communications provide the users with tools to locate the vehicle, improve safety, avoid crashes, inform about traffic, calculate alternative routes in the case of traffic jams and, in general, improve the driver and passenger's comfort by integrating many entertainment technologies.

It is worth noting that this course has been developed in collaboration with Mercedes-Benz AG, and that many of the resources that will be used in the lab were granted by the company. Mainly, several infotainment benches of different car models will be used during the course, and therefore focusing it in intra-vehicle communications. During the course, the students will also use resources granted by Renault S.L.A., which are also focused in intra-vehicle communications. Moreover, the software that will be utilized in the labs is as well one of the used in Mercedes-Benz Technology Center and in the facilities of Renault in Valladolid, CANoe, from Vector company.

Thus, the student will acquire the fundamentals of intra-vehicle communications, starting point to learn about other communications in vehicles, and will learn about CANoe, one of the most used tools in car industry. At the end course, the students should be able to

- Analyze and decode the traces from Electronic Control Units (ECUs), which are part of the communication networks inside the car, particularly from CAN, MOST and UDS protocols.
- Interpret the data bases with information of every ECU of the Original Equipment Manufacturer (OEM).
- Program and emulate the behavior of ECUs by using the programming language CAPL.
- Design and emulate ECUs by using CANister.
- Diagnose ECUs.

1.2 Prerequisites

This is an intermediate course, intended for learners with a background in computer and electrical engineering.

To succeed in this course, you should have the following knowledge prerequisites:

- Intermediate programming experience, preferable in C.
- Familiarity with protocols, communications networks and telematic services.
- Basic use of laboratory equipment, mainly oscilloscopes.

2. Competences

2.1 General

- GE1. Capacity to work in different working places like laboratories and companies, supervised by specialized professionals.
- GE3. Capacity to develop methodologies and abilities of efficient autonomous learning to adapt and update new scientific advances and knowledge.
- GE2. Capacity to work in a multidisciplinary and multilingual group, being responsible for leading tasks in projects of their specialty and getting effective results.
- GC1. Capacity of organization, planning and time scheduling.
- GC2. Capacity to communicate orally and in writing, knowledge, procedures, results and ideas regarding telecommunication and electronics.
- GC3. Capacity to work in any context, individual or in group, learning or professional, local or international, observing the fundamental rights without distinction as to race, gender, language or religion, and the basic principles of accessibility and culture of peace.

3. Learning goals

At the end of the course the student should be able to:

- Use software tools for the analysis and design of commercial devices and ICT (Information and Communication Technologies) applications in vehicles.
- Analyze and decode traces of basic protocols in vehicles.
- Enumerate and describe the most important parameters of the physical layer of the basic protocols in vehicles.
- Enumerate and describe ICT applications and basic services in vehicles.
- Enumerate and describe basic elements of communications in intra-vehicular, inter-vehicular and vehicle to infrastructure communication networks.
- Design and program applications and devices for intra-vehicular communications.
- Use the documentation from OEM to develop and analyze ICT devices and applications in vehicles.

4. Table of activities in number of hours for the student

CLASS ACTIVITIES	HOURS	HOME ACTIVITIES	HOURS
Lectures	6	Viewing of multimedia resources	30
Seminars	2	Online tests	4
Laboratories	52	Individual study/work at home	56
Total at class	**60**	**Total at home**	**90**

5. Sections

Section 1: Intra-vehicular, inter-vehicular and vehicular to infrastructure communications. CAN protocol

ECTS: 1.7

a. Contextualization and justification

This section has three lessons and five laboratory works. It provides the student with all the necessary abilities and knowledge to become competent in intra-vehicular communications. Particularly, at the end of this section, not only will the student be able to enumerate and describe the most important characteristics of CAN protocol, but they will have also acquired by means of the lab works the necessary abilities and expertise to analyze traces of the protocol and emulate very simple behaviors of ECUs by using software. Moreover, they will be able to describe the general architecture of the intra-vehicle CAN networks in commercial vehicles.

Furthermore, in this section, some specific vehicle to infrastructure services are studied, particularly the e-Call service.

b. Learning goals

At the end of this sections, the student should be able to:

- Use commercial software tools to analysis CAN messages from car devices and car applications.
- Enumerate and describe the most important CAN protocol parameters of physical and upper layers.
- Enumerate and describe the basic communication elements of intra-vehicular network communications under CAN protocol.
- Design and program very simple pieces of code to emulate intra-vehicle communications.
- Use carmakers documentation to analyze car devices and car applications.
- Describe vehicle-to-infrastructure and vehicle-to-vehicle communication services
- Describe the architecture of intra-vehicle CAN networks

c. Contents

LESSON 1: Introduction to Vehicle Telematics

- Intra-vehicular communications.
- Vehicle to infrastructure and vehicle to vehicle communications.

LESSON 2: Intra-Vehicular communications. CAN Bus

- CAN: Controller Area Network.
- Data Exchange: messages, signals and car-makers data bases
- Higher layer protocols: Transport Protocol

LESSON 3: Introduction to CANoe

- Hardware and software
- Sniffing and analyzing
- Inserting new data from CANoe to the bus

LAB 1: Physical layer of the CAN bus.

LAB 2: CAN analysis: IGN signals, TeleAid Info-Call and Volume Control.

LAB 3: CAN analysis: Airbag signals.

LAB 4: CAN analysis: Real car trace.

LAB 5: Sending CAN messages using CANoe.

d. Teaching methods

- Lesson.
- Laboratory works.

e. Working plan

Please, refer to Annex I.

f. Evaluation

The evaluation of skills acquisition will be based on:

- Student attitude and participation in on-site/on-line course activities.
- Group report of every lab. This report must be handed over at the end of the lab.
- Online tests taken at home for every unit.

g. Basic bibliography

- Learning material provided by the instructors.
- “CANoe, DENoe. CAN.LIN.MOST.FLEXRay Manual” Versión 5.2, Vector Informatik
- Guide for Transport Protocol interpretation: “TP Telegram and Warning Types”

h. Complementary bibliography

- Wilfried Voss, *A Comprehensible Guide to Controller Area Network*,Second Edition, Copperhill media, 2005
- Dominique Paret, *Multiplexed Networks for Embedded Systems*, Wiley, 2007
- Gilbert Held, *Inter- and Intra-Vehicle Communications,* Auerbach Publications, 2008

i. Resources required

These are the resources to be used during the section, which will be provided by UVa or the instructors:

- Basic bibliography available in the web page (see section 1.g Basic Bibliography)
- Software “CANoe” of Vector
- Intra-vehicular communications sniffer: CANcase of Vector
- Benches donated by Mercedes-Benz
- An oscilloscope.
- Computers.

Section 2: Intra-vehicular communications. Other standards. Programming in CAPL

ECTS: 1.7

a. Contextualization and justification

This section consists of three lessons and three labs.

Regarding intra-vehicular communications using CAN, not only is it important to be capable of analyzing with the appropriate documentation and software what is happening in the vehicle, but it is necessary to create and emulate new devices and applications. As a consequence, in this section the students are provided with the necessary tools to carry out this kind of work in car industry. Moreover, although all car-makers share a general way to structure the networks architecture and the way the information about messages is saved, there are significant differences. In this section the students will face benches and documents from different car-makers.

Apart from CAN protocol, which is in charge of communications between security and comfort devices, there are other protocols inside the car that are geared towards the entertainment of the passengers. MOST is one protocol present in many premium class cars that facilitates communications between devices such as video and music players, which require a broader bandwidth than the allowed by CAN.

b. Learning goals

At the end of the section, the student should be able to:

- Use CANoe software to program new functionalities in devices and applications in cars.
- Analyze and decode MOST and D2B traces.
- Enumerate and describe most important parameters of the physical and upper layers for MOST and D2B.
- Use different car-makers documentation to develop and analyze devices and applications for cars.

c. Contents

LESSON 4: Programming in CAPL

- Simulating an ECU in CAPL
- Data bases in CANoe
- Programming in CAPL
- Design of graphical user interfaces with Panel Designer

LESSON 5: CANoe advanced options for emulating whole systems

LESSON 6: Intra-vehicular communications. Other standards

- Media Oriented System Transport protocol (MOST)

LAB 6: CAPL Program.

LAB 7: Captur Electronic Architecture: Controlling infotainment from CANoe

LAB 8: MOST Optical Bus Analyzer.

d. Teaching methods

- Flipped classroom.
- Laboratory works.

e. Working plan

Please, refer to Annex I.

f. Evaluation

The evaluation of skills acquisition will be based on:

- Student attitude and participation in on-site/on-line course activities.
- Group report of every lab. This report must be handed over at the end of the lab.
- Online tests taken at home for every unit.

g. Basic bibliography

- Learning material provided by the instructors.
- “CANoe, DENoe. CAN.LIN.MOST.FLEXRay Manual” Version 5.2, Vector Informatik
- Guide for Transport Protocol interpretation: “TP Telegram and Warning Types”
- “MOST Function Catalog” Version 2.0, MOST Corporation
- “MOST Especification” Version 2.5, MOST Corporation

h. Complementary bibliography

- Wilfried Voss, *A Comprehensible Guide to Controller Area Network*,Second Edition, Copperhill media, 2005
- Dominique Paret, *Multiplexed Networks for Embedded Systems*, Wiley, 2007
- Gilbert Held, *Inter- and Intra-Vehicle Communications,* Auerbach Publications, 2008

i. Resources required

These are the resources to be used during the section, which will be provided by Uva or the instructors:

- Basic bibliography available in the web page (see section 2.g Basic Bibliography)
- Software “CANoe” of Vector
- Intra-vehicular communications sniffer: CANcase of Vector for CAN, Optolyzer of Oasis for D2B and MOST
- Benches donated by Mercedes-Benz
- Computers.

Section 3: Design and diagnosis of ECUs

ECTS: 2.6

a. Contextualization and justification

This section consists of two lessons and two labs.

On the one hand, the students will design and program a whole ECU by using functional specifications provided by the instructors. During the online lectures, the student will learn how to use the software tools for rapid-prototyping of ECUs.

On the other hand, a crucial step of the design of new devices is to design the diagnosis processes necessary to asset the ECU is well-design and is working properly at any moment. Thus, in this section the UDS protocol, which allows to diagnose ECUs in vehicle, is introduced, together with the use of Data Loggers to record and then analyze diagnosis traces.

Finally, in this section the student should demonstrate that is able to work independently, and as a consequence the evaluation and the instructor role in the classroom change substantially regarding previous sections. More is explained in evaluation section.

b. Learning goals

At the end of the section, the student should be able to:

- Enumerate and describe the most important parameters for UDS protocol.
- Analyze and decode UDS traces.
- Design and program complex devices to emulate intra-vehicular communications
- Work autonomously in small projects that develop topics of the course.

c. Contents

LESSON 7: Design of ECUs

- Rapid-prototyping. Example CANister
- Advanced programming of CANister: C Functions

LESSON 8: ECU diagnosis

- Introduction. Diagnosis at a glance
- Self-diagnosis in ECUs: OSEK and Network Management
- Fundamentals of Unified Diagnostic System (UDS)

LESSON 9: Dataloggers

LAB 9: ECU simulation using CANister. Breathalyzer design and development.

LAB 10: Datalogger. Diagnostics.

d. Teaching methods

- Flipped classroom.
- Laboratory works.

e. Working plan

Please, refer to Annex I.

f. Evaluation

The evaluation of this section focuses on assessing the autonomy and performance level that the students has acquired during the course, so that they should be able to develop a work related to topics of the course, achieving a set of goals and without or little help from the instructors. This way, we want to simulate a work place environment in which the workers should solve as many problems as possible by themselves, and ask for help only when strictly necessary. Therefore, the evaluation will follow the next criteria:

- Reports and pieces of program realized by the students in group. The reports will be handed over to the instructors in the laboratory at the end of the lab.
- Attitude and participation of the student in the on-site course activities. The labs will be divided into different objectives that will be detailed in the instructions. Reaching each objective will be reward with a maximum mark, only if the student is able to reach them autonomously. In the case the group needs help to solve any of these objectives, the instructor will reduce the mark depending on how much help they have needed.

As in previous sections, the students should also be evaluated by

- Online tests taken at home for every unit.
- Participation of the student in the on-line course activities

g. Basic bibliography

- Learning material provided by the instructors.
- “CANoe, DENoe. CAN.LIN.MOST.FLEXRay Manual” Version 5.2, Vector Informatik
- Guide for Transport Protocol interpretation: “TP Telegram and Warning Types”
- “Canister Configurator Manual” Version 3.0, Vector Informatik
- CANdelaStudio View

h. Complementary bibliography

- Wilfried Voss, *A Comprehensible Guide to Controller Area Network*,Second Edition, Copperhill media, 2005
- Dominique Paret, *Multiplexed Networks for Embedded Systems*, Wiley, 2007
- Gilbert Held, *Inter- and Intra-Vehicle Communications,* Auerbach Publications, 2008

i. Resources required

These are the resources to be used during the section, which will be provided by Uva or the instructors:

- Basic bibliography available in the web page (see section 3.g Basic Bibliography)
- Software “CANoe” of Vector Informatik
- Intra-vehicular communications sniffer: CANCase of Vector Informatik
- Device to emulate an ECU, CANister, from Vector Informatik
- Benches donated by Mercedes-Benz
- An oscilloscope.
- Computers.
- DataLogger BluePilot from Telemotive

6. Timing

SECTIONS	ECTS	TIMING
Section 1: Intra-vehicular, inter-vehicular and vehicular to infrastructure communications. CAN protocol	1.7 ECTS	Weeks 1 to 4
Section 2: Intra-vehicular communications. Other standards. Programming in CAPL	1.7 ECTS	Weeks 5 to 9
Section 3: Design and diagnosis of ECUs	2.6 ECTS	Weeks 10 to 14

7. Grading system – Overview table

PROCEDURE	MINIMUM MARK WEIGHT	MAXIMUM MARK WEIGHT
Evaluation of works, reports, problems, attitude and student participation in training activities	10 %	40%
Evaluation of partial, final and/or lab tests	60%	90%

8. Final considerations

- The Annex I, mentioned in the course guide, describes the detailed Schedule of the course. It will be handed over at the beginning of the course.
- In this course, diverse material and documentation donated by Mercedes-Benz is used. The student must sign a confidential agreement at the beginning of the course. If the student does not sign this agreement, it implies the resignation of the student to be evaluated, participate in classes and access to all the material of the course. In the Annex of this course guide there is a copy of the agreement the student should sign, so that he/she can read before sign up in the course.
- Due to the limitation of resources, the number of students per classroom group is up to 10. The students enrolled in the course must be able to attend any of the classroom groups established in the timetable.

Confidential Agreement between the Aula Mercedes-Benz students and the ETSIT of Valladolid

In order to assure the intellectual property of Daimler AG, as well as of the strictness in the management of information and resources available in the Aula Mercedes Benz, the student is aware and accepts that:

I.- It is strictly forbidden the partial or complete copy of any file or data stored in the workstations.

II.- The documentation of the Aula Mercedes-Benz is intellectual property of Daimler AG. It is strictly forbidden the partial or complete copy/distribution to third parties of any theory, exercises nor annexes. The student will assure the confidentiality of the material entrusted to him. It is also forbidden the distribution of the login and passwords to access the Aula Mercedes-Benz web site private area. The ETSIT keeps the right to record and register any access to the Aula Mercedes-Benz web site private area.

III.- It is strictly forbidden to extract any devices or parts unless express authorization of the teachers/Aula technical staff. The Aula Mercedes-Benz laboratory has been equipped with a camera that registers any access to the room. The student is aware that the ETSIT keeps the right to keep a video record in order to guarantee the fulfillment of this article.

IV.- It is strictly forbidden to make any picture (cameras, mobiles phones…) of the Aula Mercedes-Benz devices or workstation screen captures.

V.- The student will follow at any moment the instructions and guidelines instructed by the teachers and Aula Mercedes technical staff.

VI.- The access to the Aula Mercedes-Benz is restricted and limited to the teachers, technical staff and students registered in the course "Tecnologías de la Información y las Comunicaciones en Automoción". The access of third parties or companies which are not directly related to the Aula Mercedes Benz will be previously communicated and authorized by Daimler AG.

ETSIT Valladolid, ____________________ (Date)

Teacher in charge:

Student:

E-mail:

(Signature)

(Signature)