August, 2019

M.Tech. AUTOMOTIVE ELECTRONICS (2019)

About M.Tech- Automotive Electronics

India is becoming a premier Automobile hub of the world, with all the automobile giants having a presence in India. The quality and skills of the automotive engineers being developed needs to be sharpened in order to satisfy the stringent requirements of the Automobile industry. The M.Tech. Programme in Automotive Electronics of the Amrita School of Engineering, is focused on the design of modern electronic hardware systems for automotive applications.

In addition to the core courses (Foundation Core and Subject Core), a rich set of electives are included in the curriculum, to help the students to enhance their knowledge base in the area of automotive electronics. Additionally, most of the courses offered in the curriculum are supported by a standard learning tool (Software/ Hardware) accepted by the scientific community. This learning-by-doing philosophy adds value to the program, so that the students are well prepared to handle the challenges offered by the rapidly changing and evolvingautomotive industry.

Program Educational Objectives (PEOs):

- Ability to acquire knowledge and skills in electronics and computation in wider aspects of automotive domain so as to excel in modern industry, academia or research.
- Ability to comprehend, analyze, design and create novel solutions to problems in the areas of Automotive Electronics that are viable and acceptable technically, economically and socially.
- To exhibit professional competence and leadership qualities with a harmonious blend of ethics leading to an integrated personality development.

Programme Objectives:

PO1 An ability to independently carry out research/investigation and development work to solve practical problems.

PO2 An ability to write and present a substantial technical report/document.

PO3 Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO4 An ability to work in a team to take up the challenges in the field of vehicular communication, advanced driver assistance systems and vehicle electrification, giving due consideration to societal, environmental, economic and financial factors.

PO5 An ability to maintain lifelong learning and research by way of participating in professional activities with a high level of commitment.

Curriculum
Semester I

Course Code	Type	Course	L–T–P	Cr
19MA606	FC	Mathematical Methods for Automotive Electronics	3–0–3	4
19AL601	FC	Automotive Embedded Systems	3–0–3	4
19AL602	FC	Digital Control Systems	3–0–0	3
19AL611	SC	Principles of Automotive Systems	3–0–0	3
19AL612	SC	Automotive Grade Processors	3–0–3	4
19AL613	SC	Electric Vehicles and Architectures	3–0–0	3
19AL615	SC	Automotive Laboratory-I	0-0-3	1
19HU601	HU	Amrita Values Program*		P/F
19HU602	HU	Career Competency I*		P/F
		Credits		22

***** Non-credit course

Semester II

Course Code	Type	Course	L–T–P	Cr
19AL614	SC	Vehicle Dynamics & Control	3-0-3	4
19AL603	FC	Computational Intelligence for Automotive Systems	3–0–3	4
19AL604	FC	RTOS in Multi-core Environment	3–0–3	4
	E	Elective – I	3–0–0	3
	E	Elective – II	3–0–0	3
	E	Elective – III	3–0–0	3
19AL616	SC	Automotive Laboratory-II	0–0–3	1
19RM600	SC	Research Methodology	2-0-0	2
		Credits		24

Semester III

Course Code	Type	Course	L–T–P	Cr
19AL798	P	Dissertation		10
		Credits		10

Semester IV

Course Code	Type	Course	L–T–P	Cr
19AL799	P	Dissertation		10
TOTAL CREDITS (22+25+10+10**)**				66

L- Lecture; T-Tutorial; P-Practical

FC- Foundation Core; SC- Subject Core; E-Electives; P- Dissertation; P/F- Pass/Fail

List of Courses

Foundation Core

Course Code	Course	L–T–P	Cr
19MA606	Mathematical Methods for Automotive Electronics	3–0–3	4
19AL601	Automotive Embedded Systems	3–0–3	4
19AL602	Digital Control Systems	3–0–0	3
19AL603	Computational Intelligence for Automotive Systems	3–0–3	4
19AL604	RTOS in Multi-core Environment	3–0–3	4

Subject Core

Course Code	Course	L–T–P	Cr
19AL611	Principles of Automotive Systems	3–0–0	3
19AL612	Automotive Grade Processors	3–0–3	4
19 AL613	Electric Vehicles and Architectures	3–0–0	3
19AL 614	Vehicle Dynamics & Control	3-0-3	4
19AL615	Automotive Laboratory-I	0-0-3	1
19AL616	Automotive Laboratory-II	0-0-3	1

Electives

Course Code	Course	L–T–P	Cr
19AL701	Vehicular Communication	3–0–0	3
19AL702	Vehicular Networks	3–0–0	3
19AL703	Cryptography and Network Security	3-0-0	3
19AL704	Power Converters for Automotive Applications	2–0–3	3
19AL705	Electrical Machines for Automotive Applications	3–0–0	3
19AL706	Control of Power Converters and Electrical Machines	3–0–0	3
19AL707	Automotive Radar	3–0–0	3
19AL708	Sensing for Autonomous Vehicles	3–0–0	3
19AL709	Multi Sensor Data Fusion	3–0–0	3
19AL710	Deep Learning for automotive systems	3–0–0	3

19MA606 MATHEMATICAL METHODS FOR AUTOMOTIVE ELECTRONICS 3 0 3 4

Objectives:

- To introduce the mathematical methods applied for automotive systems.
- To provide a unified applied treatment of fundamental mathematics, seasoned with demonstrations using standard tools.
- To develop contemporary techniques for applications in the diverse areas to improve the analytical skills.
- To comprehend the computational concepts learned in mathematical methods through numerical simulations and programming.

Keywords: vectors, optimization, random process.

Contents:

Matrices and vectors – inverse and transpose – vector spaces – subspaces – linear independence – basis and dimension – orthogonal vectors and subspaces – matrix decompositions – QR decomposition- Singular value decomposition – Eigen values – Eigen vectors – Diagonalization of matrix.

Introduction to Optimization - linear optimization – unconstrained optimization – constrained optimization-KKT conditions-quadratic programming.

Introduction to Probability concepts- Two-dimensional jointly distributed random variables-random variables-multivariate probability distributions-covariance-regression models-Bayesian methods-random process-discrete time process.

Lab component: Gram Schmidt orthonormalization on vector spaces-solving a system of linear equations, Image compression using Singular value decomposition-optimization using Newton's method-formulating an SVM classification problem and its solution using quadratic programming-generation of random variables-Bayes classifier.

Outcomes:

CO1: Understanding mathematical methods and applying it to practical problems by investigating from different perspectives.

CO2: Enabling an analytical approach towards developing mathematical models in various domains.

CO3: To develop competency in implementation of algorithms and numerical analysis.

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	-	3	-	-
CO 2	3	-	3	-	-
CO 3	3	2	3	-	-

TEXT BOOKS / REFERENCES:

1. Gilbert Strang, *Linear Algebra and its Applications,* Fourth Edition, Cambridge University Press. 2009.
2. Todd K. Moon and Wynn C. Sterling, *Mathematical Methods and Algorithms for Signal Processing*, PHI, 2000.
3. C. Bender and S. Orszag, *Advanced Mathematical Methods for Scientists and Engineers,* Springer, 1998.
4. Papoulis. A and S.U. Pillai*, Probability Random Variables and Stochastic Processes,* Fourth Edition, Mc Graw Hill, 2002.

19AL601 **AUTOMOTIVE EMBEDDED SYSTEMS** **3–0–3–4**

Objectives:

- To understand various embedded systems used in various automotive domains
- To understand the basics of vehicular networks
- To design and develop a prototype of an automotive embedded system

Keywords: ADAS, Vehicle domains, In-vehicle networks

Contents:

Overview of automotive industry-automotive powertrain electronic systems: sensors and actuators- electronic control units-engine management-electronic ignition systems-engine management systems for diesel and petrol injection systems.Transmission systems: sensors, actuators & control-chassis and body electronic systems: sensors and actuators for chassis and body systems. Comfort and control systems: HVAC-engine cooling-vehicle security-driver comfort and assistance-signalling and vision- safety system.

Chassis control systems: ABS-ESP-TCS-ACC-active suspension system. Automatic transmission- X–by–wire systems – automotive alarm systems - vehicle immobilization & deactivation - driver information systems - parking systems - central locking system and electric windows. Occupants and driver safety systems: Seat belt lighteners and air–bags- fault tolerant schemes. ADAS and Autonomous Vehicles.

Introduction to Vehicular Networks: Controller Area Networks (CAN) - field of application- physical layer and bit coding-frame types and format-Bit stuffing and synchronization- error management. Overview of other communication protocols: LIN-Flex ray.

Lab Component: Simulation studies on implementation of chassis control systems. Studies on CAN/LIN communication.

Outcome:

CO1 Develop an understanding of the Embedded systems employed in Automotive industry along with various sensors used for automotive applications

CO2 Analyze the applicability of different types of embedded systems for aspects of vehicular electronics such as ADAS, Chassis control, HVAC etc.

CO3 Analyze the functioning and suitability of the CAN, LIN, Flex ray communication protocols for intra vehicular communication

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	-	-	-
CO2	3	1	-	2	1
CO3	2	-	-	2	

TEXT BOOKS / REFERENCES:

1. William Ribbens, “Understanding Automotive Electronics – An Engineering Perspective”, Eighth Edition, Butterworth Heinemann, 2017.
2. W. Hillier and David R. Rogers, “Hillier’s Fundamentals of Motor Vehicle Technology, Book 3 – Chassis and Body Electronics”, Fifth Edition, Nelson Thornes Ltd, 2007.
3. Tom Denton, “Automobile Electrical and Electronic Systems”, Fourth Edition, Routledge, 2012.
4. Dominique Paret, “Multiplexed Networks for Embedded Systems: CAN, LIN, FlexRay, Safe–by–Wire”, Wiley, First Edition, 2007.
5. Dominique Paret, “FlexRay and its Applications: Real Time Multiplexed Network”, Wiley, Second Edition, 2012.

19AL602 DIGITAL CONTROL SYSTEMS 3-0-0-3

Objectives:
- To developunderstanding of linear and non-linear electro-mechanical system dynamics.
- To introduce stability analysis for linear and non-linear systems in time and frequency domain.
- To introduce the controller design for satisfying closed-loop desired specifications.

Keywords: Modeling, linear, non-linear systems, stability, time domain, frequency domain, controller design.

Contents:

Modelling of sampled data systems: sampled data system- models of continuous time systems- naturally occurring discrete time systems- establishing connections- discretization of continuous time systems.

Linear Systems: basic concepts- basic discrete time signals- input–output convolution models. Z-transform: motivation and definition of z-transform- z-transform theorems and examples- transfer function- inverse of z-transform. Frequency domain analysis: basics- Fourier series and Fourier transforms -sampling and reconstruction- filtering -discrete Fourier transform

Transfer function approach to controller design: control structures - lead-lag controller - proportional controller – proportional – integral - derivative controller - stability and realizability.

Outcome:

CO 1: Ability to derive the linear and non-linear, electro-mechanical system dynamics.

CO 2: Ability to analyze the linear and non-linear system stability, in time and frequency domain.

CO 3: Ability to design a linear controller to satisfy the closed-loop desired specifications.

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	3	-	3	3
CO 2	3	3	-	-	-
CO 3	3	3	3	3	3

TEXT BOOKS/REFERENCES:

1.... 1. Kannan Moudgalya, “Digital Control”, John Wiley & Sons, 2007.
2. 2. Norman S. Nise, “Control Systems Engineering (6th Ed.)”, John Wiley & Sons, 2011.
3. 3. Richard C. Dorf, Robert H. Bishop, “Modern control systems”, 12th Ed, Pearson, 2010.

19AL603 COMPUTATIONAL INTELLIGENCE FOR AUTOMOTIVE SYSTEMS 3–0–3–4

Objectives:

- To introduce the basic concepts of machine learning and data analytics.
- To provide a thorough understanding of the mathematical foundations of machine learning models.
- To provide an understanding of model evaluation techniques selection of appropriate machine learning models for the given classification and regression tasks.

Keywords: Classification, clustering,SVMs, Artificial Neural Networks.

Contents:

Measuring the central tendency- measuring the dispersion of data- graphic displays of basic descriptive data summaries. Missing values- noisy data- data cleaning as a process. Data integration- data transformation. Data cube aggregation- attribute subset selection- dimensionality reduction using PCA.

Classification using k–nearest neighbor- Support Vector Machines(SVMs) and Bayes classifiers for linearly–separable- non–linearly separable and multi–class classification problems. Classifier accuracy Measures- evaluating the accuracy of a Classifier. Decision tree for classification and regression. Ordinary Least Squares based regression.

Artificial Neural Networks-network training local quadratic approximation-use of gradient information- gradient descent optimization; error back propagation. Introduction to deep learning neural networks- Theoretical advantages of deep architectures - Neural networks for deep architectures-Deep generative architectures. Case studies: Machine learning for enhancing pedestrian safety- understanding driving activity- and monitoring driver attention. Neural networks in automotive applications.

Lab component: Lab experiments based on Matlab/Python for generating data summaries, dimensionality reduction, design and evaluation of machine learning algorithms such as kNN, SVM, Naïve Bayes and ANN.

Outcome:

CO 1: Develop understanding of basic concepts of machine learning and data analytics.

CO 2: Ability to analyze and process datasets for machine learning applications.

CO 3: Ability to design machine learning models for automotive applications.

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	2	2	3	2
CO 2	3	2	2	3	2
CO 3	3	2	2	3	-

Text Books / References:

1. Danil Prokhorov (Ed.), *"Computational Intelligence in Automotive Applications"*, In- Studies in Computational Intelligence, Vol. 132, Springer-Verlag Berlin Heidelberg, 2008
2. Jiawei Han , Micheline Kamber , Jian Pei , "*Data Mining : Concepts and Techniques*", 3rd Edition, Morgan Kaufmann Publishers (Elsevier), 2011.
3. Earl Gose, Richard Johnsonbaugh, Steve Jost, "*Pattern Recognition and Image Analysis"*, Pearson Education India, 2015
4. Yoshua Bengio, "*Learning Deep Architectures for AI"*, Foundations and Trends in Machine Learning, Vol. 2, No.1, 2009.

19AL604 REAL TIME OPERATING SYSTEMS FOR MULTI-CORE ENVIRONMENT 3-0-3-4

Objectives:

- To develop a basic understanding on Real Time Operating Systems and its deployment.
- To understand the concepts of Instruction Level Parallelism and simultaneous execution of threads in a Multicore Processor.
- To analyze the functionalities of Multicore SoCs.

Keywords: RTOS, IPL, AUTOSAR, AMP, SMP, Semaphores

Contents:

Real time operating systems (RTOS) basics: Introduction to real time systems – characteristics- features and types- operating system basics- services- kernel architecture- functions of RTOS kernel- existing RTOS category. Tasks- Process and Threads- task classification- task states- state transitions- task control block- task management- task scheduling– fixed priority and dynamic priority scheduling algorithms. Inter–task communication and synchronization- semaphores–inheritance- inversion- ceiling- deadlocks and starvation- priority inversion and mutexes- how to choose a RTOS for an application.

Multi tasking and Multi-core architectures: The challenges of multitasking and real-time- achieving multitasking with sequential programming- Instruction level parallelism (ILP)- Static & Dynamic scheduling- Thread level parallelism- Multi–issue and Multi–core processors – Shared and Distributed memory Multiprocessor Architectures – mutex- semaphore and message queues- Multi–core architectures for embedded systems- Memory issues in multicore software- working with cache memory- memory contention- false sharing- memory consistency and inconsistency. Scheduler and multi-core scheduling- multiprocessing and multitasking.

Multi-core Systems-on-a-Chip: Amdahl's law- Fine-grained Vs Coarse-grained parallelism- Symmetric Vs Asymmetric Multiprocessing- operating systems for embedded multiprocessing-Symmetric Multiprocessing (SMP): operating systems support for SMP- Spinlocks- load balancing Vs Processor affinity- OpenMP. Asymmetric Multiprocessing (AMP): when to use AMP- operating systems for AMP- moving from uni-processing to AMP. RTOS for multi-core systems. Familiarization of AUTOSAR- OSEK/VDX.

Lab component:FreeRTOS Task Management – Queue Management – Interrupt Management – Resource Management – Memory Management.

Outcome:

CO 1: Develop understanding of RTOS and familiarization of automotive standards.
CO 2: Analyze common challenges in multitasking and in multicore architectures.
CO 3: Analyze design and functionality of multi-core SoCs.

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	2	-	3	-	2
CO 2	3	-	3	-	3
CO 3	3	2	3	2	3

TEXTBOOKS/REFERENCES:

1. Philip A. Laplante, "Real Time System Design and Analysis," Third Edition, PHI, 2004.
2. Jane W.S. Liu, "Real–Time Systems", First Edition, Pearson Education, 2000.
3. Kevin Roebuck, "AUTOSAR – Automotive Open System Architecture: High–Impact Strategies – What You Need to Know: Definitions, Adoptions, Impact, Benefits, Maturity, Vendors", Emereo Pty Limited, 2011.
4. J.L. Hennessy and D.A. Patterson, "Computer Architecture: A Quantitative Approach", Fifth Edition, Morgan Kaufmann, 2011.

Georgios Kornaros, "Multi–core Embedded Systems", First Edition, CRC Press, 2010.

19AL611 PRINCIPLES OF AUTOMOTIVE SYSTEMS 3-0-0-3

Objectives:

- To introduce the fundamentals of vehicle systems.
- To create a complete understanding of the individual systems of a vehicle.
- To help understand the various basic regulations governing the vehicle safety.

Keywords: Types of vehicle, Homolagation, Engines, Brake system, Transmission system.

Contents:

Introduction – type of vehicles-overview of testing and homologation standards. Internal combustion engines – ideal cycles & actual cycles – reciprocating piston engines – operating principles – mixture formation – combustion – modes of combustion – emissions charge cycle and supercharging/turbocharging – exhaust gas recirculation – air filtration – engine heat transfer. Test procedures and regulation for engines, emission regulations/standards, emission measurement and testing, other emission – particulate – crankcase – evaporative - refuelling.

Braking System:principles-components – hydraulic systems – drum and disc brakes –suspension system components and operation- front and rear suspension – steering systems – columns and gears – steering linkage – power assisted steering operation, alignment principles- fundamentals of NVH.

Basic elements of vehicle and transmission engineering: selecting the ratios -overall gear ratio, multi – plate clutches – matching engine and transmission. Passenger car transmissions: manual passenger car – automated manual transmissions – dual clutch transmissions – automatic and hybrid drives –continuously variable transmissions

Outcome:

CO 1: Ability to understand the fundamentals vehicle systems and regulations

CO 2: Ability to identify various components of a vehicle and explain its functions

CO 3: Ability to gain fundamental knowledge to develop electronic controls.

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	-	-	3	3
CO 2	3	3	3		
CO 3	3	3	3		3

TEXT BOOKS/REFERENCES:

1. Heywood J B, “Internal Combustion Engine Fundamentals”, McGraw-Hill, 1993.
2. Colin Ferguson R, “Internal Combustion Engines” John Wiley and Sons, 1989.
3. Rudolf Limpert, “Brake design and Safety”. SAE Publications, 2015,
4. Heinz Heisler, “Vehicle and Engine Technology”, Butterworth-Heinemann, 2010.

19AL612 AUTOMOTIVE GRADE PROCESSORS 3–0–3–4

Objectives:

- To develop a basic understanding on ARM Processors and its various families.
- To provide in-depth study of ARM Cortex M3 Processor and its programming concepts.
- To design and implement ARM Cortex M3 based Automotive Embedded Systems.

Keywords: ARM, ARM Cortex M3, Programmer's Model.

Contents

Introduction to ARM Processor: ARM processor–processor families – pipelining in ARM – ARM Cortex M, A & R series – ARM7 Vs ARM Cortex M series. ARM Cortex M3 processor: features of ARM Cortex M3 – ARM Cortex M3 architecture – programmer's model – interrupts and exceptions – operating modes – special registers – addressing modes – ARM instruction set – THUMB instruction set – basic ARM assembly Language Programs.

ARM peripherals &embedded C programming: introduction to embedded C – introduction to Keil IDE – GPIO – timers and counters – analog to digital converter – EEPROM data memory – UART – PWM interfacing: LED, temperature sensor, DC motor driver, LCD and keypad interface.

Power architecture from Freescale – register model- instruction model – interrupts and exceptions – memory management unit – instruction pipeline and execution timing – external core complex interfaces – power management.

Lab component:LPC2148 GPIO – UART – ADC – Interrupts. LPC1768 GPIO – ADC – DAC – PWM – Timers. DC Motor Driver - LCD - Keypad Interface.

Outcome:

CO 1: Develop understanding of ARM processor architecture.
CO 2: Understand coding techniques for developing an application using ARM processor.
CO 3: Design and develop an ARM processor based Embedded system.

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	2	-	3	-	2
CO 2	3	-	3	-	3
CO 3	3	3	3	3	3

TEXT BOOKS / REFERENCES:

1. Steve Furber, "ARM system On Chip Architecture", Addison Wesley, 2000.
2. Joseph Yiu, "The Definitive Guide to the ARM Cortex M3", Second Edition, Elsevier, 2010.
3. Arnold S. Berger, "Embedded System Design", CMP Books, 2002.
4. Michael Barr, "Programming Embedded Systems with C and GNU", O Reilly, 2003.
5. Freescale PowerPC Architecture Primer, Freescale Semiconductor, 2005.

19AL613 ELECTRIC VEHICLES AND ARCHITECTURES 3-0-0-3

Objectives:

- To review standards, drive cycles, impacts, economy of electric vehicles
- To develop an understanding of architecture of electric and hybrid electric vehicles
- To develop an understanding of various subsystems in electric and hybrid electric vehicles
- To introduce battery testing , maintenance and monitoring techniques

Keywords: Electric Vehicles, Hybrid Electric Vehicle, Energy Storage, Battery Management.

Contents:

Introduction to electric vehicles (EVs): EV advantages and impacts. EV market and promotion: infrastructure needs- legislation and regulation- standardization.Importance of energy efficiency: assessing economy of electric vehicles-fuel economy vs fuel consumption vs greenhouse gas emissions.

Important electrical subsystem in vehicles: basic components of a hybrid vehicle-migration from 12V to 48V systems-start/stop hybrid architecture types-EV architectures. Types of hybrids-parallel hybrid/ series hybrid architectures:types- operating modes- torque coordination and control- generator/motor requirements. Design of a Hybrid Electric Vehicle (HEV).Introduction to power converter and motor control: case studies.

Energy Storage: Introduction to energy storage requirements in hybrid and electric vehicles-different energy storage systems. Batteries andbattery parameters. Types and characteristics of EV batteries. Battery testing and maintenance; charging schemes. Battery monitoring techniques. Battery load levelling. Energy management strategies: Introduction to energy management strategies used in hybrid and electric vehicles. Chargers: on-board/off-boardchargers.

Outcome:

CO1 Review standards, impact and economy of Electric Vehicles
CO2 Familiarise architecture of Electric Vehicle and Hybrid Electric Vehicles
CO3 Understand significanceof various subsystems in electric and hybrid electric vehicles
CO4 Understand battery testing , maintenance and monitoring techniques

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	-	3	3	-
CO 2	3	-	3	-	3
CO 3	-	3	3	-	3
CO4	2	-	3	-	3

TEXT BOOKS / REFERENCES:

1. Iqbal Husain, “Electric and Hybrid Vehicles: Design Fundamentals”, CRC Press, 2005.
2. K. T. Chau, “Electric Vehicle Machines and Drives Design, Analysis and Application”, John Wiley and Sons, 2015.
3. Austin Hughes and Bill Drury, “Electric Motors and Drives, Fundamentals, Types and Applications”, 4th Edition, Elsevier, 2013.
4. James Larminie, John Lowry, “Electric Vehicle Technology Explained”, John Wiley and Sons, 2003.
5. C.C. Chan and K.T. Chau, “Modern Electric Vehicle Technology”, Oxford University Press, 2001.

19AL614 **VEHICLE DYNAMICS AND CONTROL** **3–0–3–4**

Objectives:

- To introduce the fundamentals of driver assistance systems.
- To create a complete understanding of various forces acting on the vehicle during acceleration and cornering and design various systems to control them.
- To simulate a given condition and calculate the various forces acting on it.

Keywords: Automated Highway System, Driver assistance systems, Longitudinal forces, Lateral forces.

Contents:

Introduction to driver assistance systems-active stability control- ride quality- technologies for addressing traffic congestion- emissions and fuel economy. Lateral vehicle dynamics: kinematic models- dynamic bicycle model- from body fixed to global coordinates. Lateral vehicle control: state feedback- steady state analysis.Understanding steady state cornering- the output feedback problem- compensator design with look ahead measurement. Longitudinal vehicle dynamics: longitudinal vehicle model- driveline dynamics- mean value engine models.

Longitudinal vehicle control: introduction- cruise control- control system architecture- adaptive cruise control- individual vehicle stability and string stability- string stability with constant spacing- string stability with constant time gap- controller for transitional manoeuvres- automated highway systems- longitudinal control for vehicle platoons- string stability with inter–vehicle communication- adaptive controller for unknown vehicle parameters.

Electronic stability control: vehicle model- control design for differential braking based systems- control design for steer–by–wire systems- independent all-wheel drive torque control-active automotive suspensions-semi–active automotive suspensions. Rollover prevention control: rollover dynamics- rollover index and active rollover prevention- comparison of performance with various rollover indices.

Lab component: lab experiments based on simulation tools - vehicle model creation - road course definition - measurement of longitudinal force during braking and acceleration - measurement of lateral force during cornering.

Outcome:

CO 1: Ability to understand the fundamentals vehicle dynamics
CO 2: Ability to identify various forces and control them
CO 3: Ability to gain fundamental knowledge to use the simulation tools.

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	-	-	3	3
CO 2	3	3	3		
CO 3	3	3	3		3

TEXT BOOKS/REFERENCES:

1. Heywood J B, “Internal Combustion Engine Fundamentals”, McGraw-Hill, 1993.
2. Colin Ferguson R, “Internal Combustion Engines” John Wiley and Sons, 1989.
3. Rudolf Limpert, “Brake design and Safety”. SAE Publications, 2015,
4. Heinz Heisler, “Vehicle and Engine Technology”, Butterworth-Heinemann, 2010.

19AL615 **AUTOMOTIVE LABORATORY-I** **0–0–3–1**

Objectives:

- To introduce various sub systems of an automobile.
- To introduce noise measurement techniques for automotive applications.
- To understand the process of performance analysis of an internal combustion engine.

Keywords: Engine, performance, noise, measurement.

Contents:

This laboratory session shall provide an idea about various subsystems used in the Automotive Industry. Students will be performing experiments to study different aspects of the following automotive subsystems:

1. Working of Engine and valve timing
2. Steering system, Brake and Transmission systems
3. Performance test on a SI Engine – Fuelled with Gasoline / LPG
4. Heat balance test on Diesel Engine
5. Retardation test on Diesel Engine
6. Environmental Noise measurement
7. Pass-by-Noise measurement and analysis
8. In-Cabin Noise measurement and analysis

Outcome:

CO1: Ability to understand basic functioning of powertrain in an automobile
CO2: Ability to test and calculate the engine parameters
CO3: Ability to understand the noise sources in an automobile

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	2	2	2	3	2
CO 2	2	2	2	3	2
CO 3	2	2	3	3	3

TEXT BOOKS/REFERENCES:

1. Heywood J B, “Internal Combustion Engine Fundamentals”, McGraw-Hill, 1993.
2. Colin Ferguson R, “Internal Combustion Engines” John Wiley and Sons, 1989.
3. Rudolf Limpert, “Brake design and Safety”. SAE Publications, 2015,
4. Heinz Heisler, “Vehicle and Engine Technology”, Butterworth-Heinemann, 2010.

19AL616 AUTOMOTIVE LABORATORY- II 0–0–3–1

Objectives:

- To understand various testing methods to check the performance of various automotive subsystems.
- To understand various vibration measurement processes in an automobile.
- To introduce the processes for carrying out performance and emission tests on an automobile.

Keywords: Vibration, emission, performance, measurement.

Contents:

This laboratory session shall provide an idea about various systems used in the Automotive Industry. Students will perform experiments on the following aspects of automotive systems:

1. Indian Driving cycle – Chassis dyno
2. Performance and emission test – 8 mode
3. Performance and emission test – 13 mode
4. Assess the Performance of Biofuel on engines
5. Assess the performance of Multiple coolant types on engines
6. Vibration measurement in Engines
7. Vibration measurement in Vehicles
8. Transfer path analysis
9. Psycho Acoustic Analysis

Outcome:

CO1: Ability to understand engine testing cycles

CO2: Ability to understand various emission parameters of petrol and diesel engines

CO3: Ability to identify the various vibration sources in an automobile.

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	2	2	2	3	2
CO 2	2	2	2	3	2
CO 3	2	2	3	3	3

TEXT BOOKS/REFERENCES:

1. Heywood J B, “Internal Combustion Engine Fundamentals”, McGraw-Hill, 1993.
2. Colin Ferguson R, “Internal Combustion Engines” John Wiley and Sons, 1989.
3. Rudolf Limpert, “Brake design and Safety”. SAE Publications, 2015,
4. Heinz Heisler, “Vehicle and Engine Technology”, Butterworth-Heinemann, 2010.

19RM100 RESEARCH METHODOLOGY 2-0-0-2

Objectives:

- To enable defining and formulating research approaches towards obtaining solutions to practical problems
- To facilitate development of scientific oral and written communication skills.
- To comprehend the concepts behind adhering to scientific ethics and values.

Keywords:
Research Classification; Research Design; Communication; Scientific Ethics

Contents:

Meaning of Research, Types of Research, Research Process, Problem definition, Objectives of Research,Research Questions, Research design, Approaches to Research, Quantitative vs. Qualitative Approach,Understanding Theory, Building and Validating Theoretical Models, Exploratory vs. ConfirmatoryResearch, Experimental vs Theoretical Research, Importance of reasoning in research.

Problem Formulation, Understanding Modeling & Simulation, Conducting Literature Review,Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval,Tools for identifying literatures, Indexing and abstracting services, Citation indexes

Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement SystemsAnalysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, FieldExperiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical DataAnalysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results

Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract,introduction, methodology, results and discussion, conclusion sections of a manuscript. References,Citation and listing system of documents

Intellectual property rights (IPR) - patents-copyrights-Trademarks-Industrial design geographical indication. Ethics of Research- Scientific Misconduct- Forms of Scientific Misconduct.Plagiarism, Unscientific practices in thesis work, Ethics in science

Outcome:
CO 1: Understand and apply some basic concepts of research and its methodologies
CO 2: Able to select and define appropriate research problem and parameters
CO 3: Demonstrate skills to draft a research paper (develop scientific writing skills)
CO 4: Comprehend the ethical practices in conducting research and dissemination of results in different forms.

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	3	3	-	-
CO 2	3	3	3	-	-
CO 3	3	3	3	-	3
CO 4	-	-	-	-	3

TEXT BOOKS/REFERENCES:

1. Bordens, K. S. and Abbott, B. B., *Research Design and Methods – A Process Approach*, 8thEdition, McGraw-Hill, 2011.
2. Tony Greenfield and Sue Greener., *Research Methods for Postgraduates*, 3rd Edition, John Wiley & Sons, Ltd. 2016.
3. Davis, M., Davis K., and Dunagan M., *Scientific Papers and Presentations*, 3rd Edition, Elsevier Inc. 2012.
4. Michael P. Marder, *Research Methods for Science*, Cambridge University Press, 2012.

19AL798 **DISSERTATION** **0 0 0 10**

Objectives:

- To apply the knowledge of computational and electronic concepts in various mechanical and electromechanical systems.
- To provide a platform for innovations in automotive electronics.
- To identify the state-of-the-art research challenges automotive electronic systems.

Contents:

Problems and concepts may be defined based on extensive literature survey by standard research articles. Significance of proposed problem and the state-of the art to be explored. Industry relevant tools may be used for demonstrating the results with physical meaning and create necessary research components. Publications in reputed journals and conferences may be considered for authenticating the results.

Outcome:

CO 1: Design and analysis of automotive electronic systems.
CO 2: Understand and apply the computational optimization in automotive systems.
CO 3: Conduct independent research in diverse areas of automotive electronics.
CO 4: Design and develop next generation automotive systems giving due consideration to societal, environmental, economic and financial factors.

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	3	3	1	3
CO 2	3	3	3	3	3
CO 3	3	3	2	2	-
CO 4	-	-	2	3	3

19AL799 **DISSERTATION** **0 0 0 10**

Objectives:

- To apply the knowledge of computational and electronic concepts in various mechanical and electromechanical systems.
- To provide a platform for innovations in automotive electronics.
- To identify the state-of-the-art research challenges automotive electronic systems.

Contents:

Problems and concepts may be defined based on extensive literature survey by standard research articles. Significance of proposed problem and the state-of the art to be explored. Industry relevant tools may be used for demonstrating the results with physical meaning and create necessary research components. Publications in reputed journals and conferences may be considered for authenticating the results.

Outcome:
CO 1: Design and analysis of automotive electronic systems.
CO 2: Understand and apply the computational optimization in automotive systems.
CO 3: Conduct independent research in diverse areas of automotive electronics.
CO 4: Design and develop next generation automotive systems giving due consideration to societal, environmental, economic and financial factors.

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	3	3	1	3
CO 2	3	3	3	3	3
CO 3	3	3	2	2	-
CO 4	-	-	2	3	3

Electives

19AL701VEHICULAR COMMUNICATION3-0-0-3

Objectives:

- To introduce students with the emerging technologies, standards and applications in the area of vehicular communication systems and networks.
- To make the students appreciate the challenges and design considerations of vehicle-to-anything (V2X) communications at various networking layers.
- To teach how to simulate various aspects of a vehicular communication network and investigate and compare the performances of various solutions.

Keywords: ITS, V2X, VANET, DSRC, WAVE, BSM, 802.11p, Geographic Routing.

Contents:

Applications of V2X: safety vs. non-safety. Use cases: traffic information systems- safety-critical applications. Service requirements of applications- Communication technologies- Mapping service requirements to communication technologies- Layering and Standards: fundamental principles of layering- DSRC/WAVE- ETSI ITS-G5 and ARIB architectures. DSRC standard: channelization- SAE J2735 message set dictionary- Basic Safety Message- IEEE 1609 WAVE stack for network service and multi-channel operation- IEEE 802.11p MAC and PHY-

Wireless radio propagation and channel characteristics: pathloss- shadowing and small-scale fading- delay spread and Doppler spread- coherence bandwidth and coherence time- impact of channel impairments on system design- Techniques for combating channel impairments- Digital modulation schemes in 802.11p- Design of OFDM parameters in 802.11p (symbol time- sub-carrier spacing- pilot spacing)- Transmit power control and transmit masks-

Routing in VANETs: flooding and the 'Broadcast Storm Problem'- Traditional MANET routing: topology based / table-driven routing protocols- proactive (DSDV) vs. reactive / on-demand (DSR- AODV- DYMO) routing protocols- Geographic routing protocols- Beaconing- DTN and peer-to-peer ideas for VANET routing- Vehicular network simulations using VEINS: mobility models- traffic flow models.

Outcome:

CO 1: Ability to understand and describe the basic theories, principles, technologies, standards and system architecture of vehicular networks

CO 2: Ability to analyze, design, and evaluate vehicular communication technologies for various kinds of safety and infotainment applications

CO 3: Gain professional/academic knowledge and skills

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	-	3	-	3
CO 2	3	-	3	-	3
CO 3	-	3	3	3	3

TEXT BOOKS/REFERENCES:

1. Christophe Sommer and Falko Dressler, *Vehicular Networking*, Cambridge University Press, 2014.
2. Hannes Hartenstein and Kenneth Laberteaux (eds.), *VANET Vehicular Applications and Inter-networking Technologies*, John Wiley & Sons, 2009.
3. Claudia Campolo, Antonella Molinaro and Riccardo Scopigno, *Vehicular ad hoc Networks: Standards, Solutions, and Research*, Springer, 2015.
4. Andrea Goldsmith, *Wireless Communications*, Cambridge University Press, 2005.
5. Theodore S. Rappaport, *Wireless Communications: Principles and Practice*, Second Edition, Prentice Hall, 2001.

19AL702 **VEHICULAR NETWORKS** **3-0-0-3**

Objectives:

- To understand various communication protocols used in automotive applications
- To analyse the CAN-FD and LIN based communication protocols with suitable hardware
- To design and develop a prototype of an automotive embedded system, which uses any of the communication protocol

Keywords: CAN-FD, LIN, MOST

Contents:

In-Vehicle Communication Networks: A Historical Perspective and Review, CANFD Protocol: Overview of CANFD bus architecture – Physical Layer – Topology – frame architecture – CAN vs CANFD - Bit stuffing and CRC – Delay compensation – Error Handling.

LIN Protocol: Overview – Frame Format – Bus Timing – Topology – Error detection – Sleep/Wake-up modes – Advanced Frames.

MOST Protocol: Overview - Physical Layer – Network and Fault Management – Diagnostics – Interface Controller – Applications – Overview of Automotive Ethernet protocols

Outcome:

CO1 Develop an understanding about the architecture of CANFD communication protocol
CO2 Understand the architecture of LIN communication protocol
CO3 Understand the architecture of MOST communication protocol

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	2	1			
CO2	2	1		2	1
CO3	2			2	

TEXT BOOKS/REFERENCES:

1. Richard Zurawski, "Industrial Communication Technology Handbook", 2nd Edition, CRC Press, 2014.
2. Gilbert Held, "Inter- and Intra-Vehicle Communications", Auerbach Publications, 2007.
3. Dominique Paret, Roderick Riesco, "Multiplexed Networks for Embedded Systems: CAN, LIN, FlexRay, Safe-by-Wire", John Wiley and Sons, 2007.
4. Chung-Ming Huang and Yuh-Shyan Chen, "Telematics Communication Technologies and Vehicular Networks: Wireless Architectures and Applications", Information Science Publishing, 2009.
5. Andreas Grzemba, "MOST- The Automotive Multimedia Handbook", Franzis Verlag GmbH, 2011.

19AL703 CRYPTOGRAPHY AND NETWORK SECURITY 3-0-0-3

Objectives:

- To introduce the fundamental principles of cryptography and security.
- To provide a strong mathematical foundation for cryptography and security such as number theory and finite field arithmetic.
- To teach the security mechanisms currently used in practice at various networking layers.

Keywords: Encryption, Cyphers, DES, AES, RSA, Hash function, MAC.

Contents:

Network security concepts- Introduction to Number Theory- Classical encryption techniques- Block ciphers- Data Encryption Standard (DES)- Finite fields- Advanced Encryption Standard (AES)- Stream ciphers- Asymmetric cyphers- Public-key cryptography- Rivest-Shamir-Adleman (RSA) scheme- Elliptic curve cryptography-

Cryptographic Data Integrity Algorithms: Hash functions- Message Authentication Codes (MAC)- Digital signatures- Mutual Trust: Key management and distribution- User authentication.

Network Security: Network access control and authentication protocols- Transport-level security- Wireless network security- IP security- Security and privacy-preserving mechanisms in vehicular networks.

Outcome:

CO 1: Ability to understand the fundamental principles behind cryptography and security

CO 2: Ability to apply mathematical techniques for the design and performance analysis of security mechanisms at various networking layers

CO 3: Ability to implement security algorithms in software

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	-	3	-	3
CO 2	3	-	3	-	3
CO 3	-	3	3	3	3

TEXT BOOKS/REFERENCES:

1. William Stallings, *Cryptography and Network Security*, 7th Ed., Pearson, 2017.
2. Xiaodong Lin, Rongxing Lu, *Vehicular Ad Hoc Network Security and Privacy*, Wiley, 2015.
3. David Forster, *Verifiable Privacy Protection for Vehicular Communication Systems*, Springer, 2017.

19AL704 POWER CONVERTERS FOR AUTOMOTIVE APPLICATIONS 2-0-3-3

Objectives:

- Introduce the Power electronic devices and their data sheet interpretations
- Teach the design of AC-DC, DC-DC and DC-AC converters for various automotive applications
- To introduce the concept of control of various power converter circuits.

Key Words: Power Semiconductor switches, Converters, Inverters, PWM control, Battery Management systems

Contents:

Overview of power semiconductor switches: Power BJT- Thyristors- Power Diodes- MOSFET- IGBT- IGCT- Intelligent Power Modules (IPM)- Wide band gap power semiconductor devices - Evaluation of Losses in Semiconductor switches- Interpretation of device data sheets - Power Computations for Non-sinusoidal Periodic Waveforms. AC-DC converters: Uncontrolled rectifiers – single and three phase - Performance parameters.

DC/DC converters for automotive applications: Design and analysis of Buck- Boost- Buck-Boost- Four quadrant dc-dc converter. Control of DC-DC converters. Low voltage electrical loads in EV and Auxiliary Power Modules - Converter Topologies for Auxiliary Power Modules: fly-back- forward- push-pull- Full bridge- bidirectional DC-DC converters for EV charging applications – Typical specifications of power converters- design of power circuit to meet the specifications.DC/AC converters: Voltage source inverters- single and three phase Sinusoidal PWM and Space vector PWM- DC side current- Current regulated PWM- Rectifier and inverter Mode of operation for G2V and V2G applications. Introduction to Multilevel inverters.

Design of Heat sinks- Snubber circuits *and* driver circuits. Magnetic Design (Inductor- Transformer- Core material and properties- Planar technology) Energy Storage Requirements for EV-Battery Management Systems- Simulation tools for power converters (pSpice/Orcad/Matlab-Simulink); Relevant Automotive Standards- Automotive Design Considerations: Power conditioning in power converters- High temperature applications.

Lab Component:

1. Switching characteristics of Power devices and power loss computations.
2. Simulation of Single and three phase uncontrolled rectifiers with RLE load, ac and dc side harmonic analysis and performance evaluation, filter design.
3. (i) Simulation and design verification of DC-DC converters (Buck, Boost, Buck boost and Auxiliary power modules), (ii) Simulation of Bidirectional converter for battery charging (iii) PWM generation for DC-DC converters (iv) current mode control for DC-DC converter
4. Voltage Control of single phase Voltage source Inverter with (i) square wave operation (ii) Unipolar and Bipolar Sine PWM, (iii) Hysteresis current control
5. Voltage Control of three phase Voltage Source Inverters with (i) Three phase Sine PWM, (ii) Space Vector PWM, (iii) Current regulated PWM
6. Design and simulation of Multi-Level Inverter (MLI) (i) Diode clamped MLI , (ii) Cascaded MLI
7. Simulation of Active and Passive Cell balancing for Battery packs.

Outcome:

CO1 Review of various power semiconductor devices, converters and their performance analysis

CO2 Design of various power electronic converters for automotive applications

CO3 Develop controls for AC-DC, DC-DC and DC-AC converters for automotive applications

CO4 Design of magnetic elements, protection and power conditioning circuits for power converters

CO5 Understand Battery Management Systems, automotive standards and simulation tools for Power Electronic system design.

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	-	3	2	2
CO 2	3	-	3	-	3
CO 3	3	1	2	2	1
CO4	3	1	2	2	1
CO5	2	2	3	2	2

TEXT BOOKS/ REFERENCES:

1. Emadi, Ali. "*Advanced electric drive vehicles*". CRC Press, 2014.
2. Ned Mohan, Tore M. Undeland and William P.Robbins, "*Power Electronics, Converters, Applications and Design*", Third Edition, John Wiley and Sons Inc., 2006.
3. John G. Kassakian, Martin F.Schlecht and George C.Verghese, "*Principles of Power Electronics*", Addison Wesley, 1991.
4. Muhammad H. Rashid, "*Power Electronics, Circuits, Devices and Applications*", Third Edition, PHI Pvt. Ltd., 2004.
5. Hart, Daniel W. *Power electronics*. Tata McGraw-Hill Education, 2011.
6. Shaffer, Randall. *Fundamentals of power electronics with MATLAB*. Firewall Media, 2013.
7. Bi, Wengang Wayne, Haochung Henry Kuo, Peicheng Ku, and Bo Shen, eds. "*Handbook of GaN Semiconductor Materials and Devices*". CRC Press, 2017.

19AL705 ELECTRICAL MACHINES FOR AUTOMOTIVE APPLICATIONS 3-0-0-3

Objectives:

- To review basic principles of electromechanical energy conversion
- To develop mathematical model of DC and AC Machines for transient and steady state conditions.
- To teach to apply reference frame theory to AC machines.
- To Analyze the dynamic behavior of AC& DC machines.
- To develop the analytical model of PMSM and SRM

Keywords: Electromagnetic energy conversion, Generalised Machine theory, Reference frame theory, Modeling of Electrical Machines

Contents:

Review of Electromagnetics: Review of field equations- Maxwell's equations-Principles of electromagnetic energy conversion.DC Brushed Motors Analysis: Generalized theory of rotating electrical machines- modeling- steady state and transient analysis of separately excited DC machines.

Transformations in AC machine analysis: Introduction to reference frame theory- Application of reference frame theory to three phase symmetrical induction machines- modeling- Torque calculation- steady state and transient analysis of induction machines.

Synchronous Motors Analysis: Steady state and transient behavior of synchronous machines. Brush-less DC Motors Analysis: Principle of working- Steady state operation- Torque calculation. Switched Reluctance Motors Analysis: Principle- Analysis- Steady state operation. Simulation Techniques and tools.

Outcome:

CO1 Review of the basic principles of electro-mechanical energy conversion.
CO2 Formulate the mathematical model of DC and AC Machines for transient and steady state conditions.
CO3 Apply reference frame theory to AC machines.
CO4 Analyze the dynamic behavior of AC& DC machines.
CO5 Explain the analytical model of PMSM and SRM

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	-	-	3	-	3
CO 2	3	2	3	-	3
CO 3	3	-	3	-	3
CO4	2	2	3	-	3
CO5	1	2	3	1	3

TEXTBOOK/REFERENCES:

1. P.C.Krause, "Analysis of Electric Machines and Drive Systems", Wiley International, 2002.
2. R. Krishnan, "Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design, and Applications" CRC Press, 2001.
3. B. Adkins, "Generalized Machine Theory", McGraw-Hill, 1964.
4. Ramu Krishnan, "Permanent Magnet Synchronous and Brushless DC Motor Drives", CRC Press, 2010.
5. Saurabh Kumar Mukerji, Ahmad Shahid Khan and Yatendra Pal Singh, "Electromagnetics for Electrical Machines", CRC Press, 2015.
6. K.T. Chau and Wenlong Li, " Overview of electric machines for electric and hybrid vehicles" Department of Electrical and Electronic Engineering, International Journal of Vehicle Design, Vol.64, No.1, pp.46-71.

19AL706 CONTROL OF POWER CONVERTERS AND ELECTRICAL MACHINES 3-0-0-3

Objectives:

- Introduce the design aspects of closed loop control of power converters through state space approach
- Teach the concept of scalar and vector control techniques of various ac and dc motors
- Teach the synchronization methods and control of grid connected converters for V2G and G2V

Key Words: State space Modelling, Induction and Synchronous Motors, Scalar and Vector controls, Reluctance and Brushless motors

Contents:

Concept of state space analysis- Power Converter Transfer Functions (closely related toElective I): state space representation and Transfer function model of a DC-DC converter- Type II compensator design- Analog Implementation of compensators- Digital Microcontroller/DSP based implementation of compensators.Control of Brushed DC Motors in EV applications: Open and closed loop control of chopper fed DC motors- Transfer function model of a separately excited DC motor. P- PI- PID controllers in DC motor control.

Control of Induction Motors: Scalar and Vector control Technique (FOC & DTC)- Introduction to sensorless control- Control for Regeneration mode. Control of Permanent Magnet Synchronous Motors: Review of SPM- IPM concepts- *v/f* control- vector control- MTPA control. Control of Brushless DC motors: Drive operation with inverter- Torque-speed curve- Machine dynamic model- Drive control- extended speed operation. Control of Switched Reluctance motors (in the context of vehicle power train control - Drive cycles performance and testing).

Closed loop control of Grid connected converters for V2G and G2V applications – Concept of Grid synchronization - Synchronous reference frame control and Hysteresis control.

Outcomes:

CO1 Understand the concept of state space modelling and analysis of dc-dc converters and their compensator design

CO2 Design analog and digital compensators for dc-dc converters

CO3 Analyse the open and closed loop control of various types of dc and scalar and vector controllers for ac motors

CO4 Design sensor and sensorless vector control for Induction and Permanent Magnet Synchronous machines

CO5 Implement scalar and vector control for special electrical machines like SRM, BLDC etc.

CO-PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	-	3	2	2
CO 2	3	-	2	-	2
CO 3	3	1	2	2	1
CO4	3	1	2	2	1
CO5	2	2	3	2	2

TEXT BOOKS /REFERENCES:

1. Krause, Paul C., Oleg Wasynczuk, Scott D. Sudhoff, and Steven Pekarek. *Analysis of electric machinery and drive systems*. Vol. 2. New York: IEEE press, 2002.
2. Krishnan, Ramu. *Electric motor drives: modeling, analysis, and control*. Vol. 626. New Jersey: Prentice Hall, 2001.
3. Bimal K. Bose, “Modern Power Electronics and AC Drives”, John Wiley & Sons, 2002.
4. Ehsani, M., Gao, Y., Longo, S. and Ebrahimi, K., *Modern electric, hybrid electric, and fuel cell vehicles*. CRC press, 2018.
5. Blaabjerg, Frede, ed. *Control of Power Electronic Converters and Systems*. Vol. 2. Academic Press, 2018.

6. Abu-Rub, Haitham, Atif Iqbal, and Jaroslaw Guzinski, eds. *High performance control of AC drives with MATLAB/Simulink models*. John Wiley & Sons, 2012.

19AL707 AUTOMOTIVE RADAR 3 0 0 3

Objectives:

- Understanding the components of a radar system and their relationship to overall system performance
- Understanding the classification of various types of radars
- Understanding the principles of operation of automotive and other types of radars.

Keywords:

Radar range equations, SNR, Doppler radars, Automotive, SAR

Contents:

Radar Principles: Frequency of operation, Radar range equation, Radar cross section-Radar echo, Prediction of radar range, Antenna systems, Loss factors, Jamming and clutter, Receiver and Transmitter parameters, Types of radar principles and operation, Phased array antenna radars, Analog and Digital beamforming radars

Automotive Radars: Classification of automotive radars, frequency of operations, Long range and short-range radar operations, Technical specifications, Direction of arrival estimation, case studies on various automotive radars and performance analysis

Radars for strategic applications: Principles of air-traffic controllers, satellite communication and launch vehicle radars for Telemetry, tracking and tele command systems, Case studies on various types of radars in strategic domains.

Outcome:

CO1: Ability to understand the principles of operation of radars

CO2: Enable and the system level design aspects components for radars

CO3: Understand the principles of radars used in various applications

CO4: Enable the research aptitude of radar principles and applying in project works

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	3	-	3	3
CO 2	3	3	3	3	3
CO 3	2	-	1	2	-
CO4	3	3	3	3	-

TEXT BOOKS/REFERENCES:

1. Skolnik M, *Introduction to Radar Systems*, Tata-Mcgraw Hill, 2003.
2. Kai Chang, *RF and Microwave Wireless Systems*., John Wiley & Sons, Inc. 2000
3. David K. Barton, *Modern Radar System Analysis*, Artech House,Inc., NY 1988.
4. Maria S. Greco, *Automotive Radar*, http://www.iet.unipi.it/m.greco/esami_lab/Radar/automotive_radar.pdf

19AL708 SENSING FOR AUTONOMOUS VEHICLES 3-0-0-3

Review of Signal Processing Techniques – Two dimensional signals and systems–Sampling in two dimensions–Two dimensional discrete transforms— DCT –DWT– Application to images –2D Hadamard Transform, Walsh Transform, KLT, Application to images- Z Transform and its properties, Application to images–Image Acquisition–Filtering in Spatial and Frequency domain–Image Compression.

3D signals and Systems–3D sampling and reconstruction–Digital Video Processing–Digital Video Compression – Case Studies: Pedestrian Detection Systems and ADAS.

Automotive Radar: Frequency Band Allocation and Standards – Elements of Automotive Radar – Antenna Systems and Requirements – Antenna Mounting – Radio Frequency Front End – Radar Signal Processors Requirements – Waveform Generation – Range Estimation – Case Studies. LIDAR: LIDAR based sensing-LIDAR Applications in Automotive systems.

Outcome:

CO1 Able to understand the principles of 2-D and 3-D digital signal processing.
CO2 Able to apply 2-D and 3-D digital signal processing techniques for image and video processing.
CO3 Able to understand the functioning of an automotive radar and LIDAR system.

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	-	-	3	-	3
CO 2	2	2	3	-	3
CO 3	2	-	3	-	3

TEXT BOOKS / REFERENCES:

1. Gregory L.Charvat, "Small and Short Range Radar Systems", CRC Press, 2014.
2. Byron Edde, "Radar – Principles, Technology, Applications", Pearson Education, LPE, Third Indian Reprint, 2005.
3. Merrill I.Skolnik, "Introduction to Radar Systems", Tata McGraw Hill, Third Edition, Twenty First Reprint, 2008.
4. C.R.Paul, "Introduction to Electromagnetic Compatibility", Wiley India Pvt. Ltd., Second Edition, 2014.
5. Rafael C. Gonzalez, "Digital Image Processing", Third Edition, PHI Pvt. Ltd., 2008.
6. John W. Wood, "Multidimensional Signal, Image, Video Processing and Coding", Elsevier, 2006.

19AL709 MULTI-SENSOR DATA FUSION 3-0-0-3

Objectives:

- To provide a thorough understanding of the mathematical foundations of data fusion methods.
- To apply appropriate data fusion methods to problems in automotive electronics.
- To gain hands-on experience of implementing data fusion algorithms.

Keywords: Bayesian methods, Kalman filtering, Fuzzy logic, Monte Carlo methods.

Contents:

Introduction to data fusion process: data fusion models- configurations and architectures. Probabilistic Data Fusion: Maximum Likelihood- Bayesian- and Maximum Entropy methods. Recursive Bayesian methods for estimation and data fusion: Kalman filter theory- Kalman filter as a natural data-level fuser.

Data fusion by nonlinear Kalman filtering; Information filtering; H_∞ filtering- Multiple hypothesis filtering: Data fusion with missing measurements- Possibility theory and Dempster-Shafer Method- Fuzzy Logic based Decision Fusion: Type 1 and Type 2 Fuzzy logic- Adaptive Neuro-Fuzzy Inference System (ANFIS) and generation of weights-

Decision Theory based Fusion: Bayesian decision theory- decision making with multiple information sources- Fuzzy approach- decision making based on voting- Performance Evaluation of Data Fusion systems: Monte Carlo methods.

Outcome:

CO 1: Ableto appreciate the benefits and shortcomings of various data fusion algorithms
CO 2: Abletoselect and apply appropriate data fusion techniques to problems in automotive electronics
CO 3: Abletonumerically implement data fusion algorithms accounting for computational issues

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	-	3	3	3
CO 2	3	-	3	3	3
CO 3	-	3	3	3	3

TEXT BOOKS/REFERENCES:

1. Jitendra R Raol, *Data Fusion Mathematics: Theory and Practice*, CRC Press, 2016.
2. David L. Hall, *Mathematical Techniques in Multisensor Data Fusion*, Artech House, Boston, 1992.
3. R. Brooks and S.S. Iyengar, *Multisensor Fusion: Fundamentals and Applications with Software*, Prentice Hall Inc., New Jersey, 1998.
4. James V. Candy, *Signal Processing: The Model Based Approach*, McGraw –Hill Book Company, 1987.

19AL710 DEEP LEARNING FOR AUTOMOTIVE SYSTEMS 3 0 0 3

Objectives:

- To introduce the idea of artificial neural networks and their architecture.
- To introduce techniques used for training artificial neural networks.
- To enable design of an artificial neural network for classification
- To enable design and deployment of deep learning models for machine learning problems

Keywords:
Neural Networks, Convolutional Neural Networks, Autoencoder, Long Short-Term Memory.

Contents:

Introduction to autonomous driving: Autonomous driving technologies- Autonomous driving algorithms-Perception in Autonomous Driving, Deep learning in autonomous driving perception. Artificial Neural Networks: The Neuron-Expressing Linear Perceptrons as Neurons-Feed-Forward Neural Networks- Linear Neurons and Their Limitations-Sigmoid, Tanh, and ReLU Neurons- Softmax Output Layers. Training Feed-Forward Neural Networks.-Gradient Descent-Delta Rule and Learning Rates- Gradient Descent with Sigmoidal Neurons- The Backpropagation Algorithm-Stochastic and Minibatch Gradient Descent- Test Sets, Validation Sets, and Overfitting- Preventing Overfitting in Deep Neural Networks. Local Minima in the Error Surfaces of Deep Networks- Model Identifiability- Spurious Local Minima in Deep Networks- Flat Regions in the Error Surface - Momentum-Based Optimization- Learning Rate Adaptation.

Convolutional Neural Networks: Architecture -Accelerating Training with Batch Normalization- Visualizing Learning in Convolutional Networks. Embedding and Representation Learning: Autoencoder Architecture- Denoising- Sparsity in Autoencoders. Models for Sequence Analysis: Recurrent Neural Networks- Vanishing Gradients- Long Short-Term Memory (LSTM) Units-Augmenting Recurrent Networks with Attention.

Deep Reinforcement Learning: Markov Decision Processes (MDP), Explore Versus Exploit, Policy Versus Value Learning, Pole-Cart example with Policy Gradients. Q-Learning and Deep Q-Networks, Improving and Moving Beyond DQN.

Outcomes:
CO 1: Able to understand the mathematics behind functioning of artificial neural networks
CO 2: Able to analyze the given dataset for designing a neural network based solution.
CO 3: Able to carry out design and implementation of deep learning models for signal/image processing applications.
CO4: Able to design and deploy simple TensorFlow-based deep learning solutions to classification problems.

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	-	3	-	3
CO 2	3	-	3	-	3
CO 3	-	3	3	3	3

TEXT BOOKS/REFERENCES:

1. Nikhil Buduma, *Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms*, O’Reilly, 2017.
2. Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu and Jean-Luc Gaudiot. “Creating Autonomous Vehicle Systems”, Morgan & Claypool Publishers,2018.
3. Ian Goodfellow, Yoshua Bengio and Aaron Courville, *Deep Learning*, MIT Press, 2016.
4. Aurélien Géron, *Hands-On Machine Learning with Scikit- Learn and TensorFlow*, O’Reilly, 2017.
5. Nikhil Ketkar, *Deep Learning with Python: A Hands-on Introduction*, Apress, 2017.