M.TECH. AUTOMOTIVE ELECTRONICS

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

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 more on the design of modern electronic hardware systems for automotive applications.

The Objectives of this Programme is;

1. To provide a thorough understanding of the automotive systems, vehicle dynamics, electrical and electronic systems (Embedded Systems) used in automobiles.
2. To develop the ability to analyze, simulate, design and verify electronic systems for controlling mechanical systems in automobiles.
3. To develop the ability to test and validate automotive electronic systems using modern software/ hardware tools.
4. To conceptualize automotive electronic technologies for future.

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. The Open Labs, an integral part of the curriculum, will see the students design and prototype an automotive sub-system, which is used exclusively in the Body Electronics/ Chassis Control/ Power train/ Navigation domains of Automotive Electronics. Additionally, most of the courses offered in the curriculum will be supported by a standard learning tool (Software/ Hardware) accepted by the scientific community. This Learning-by-Doing philosophy, envisioned by the university will add value to the program, so that the students are equipped to face the real world challenges of the Automotive Industry of the future.

CURRICULUM

First Semester

Course Code	Type	Course	L–T–P	Cr
MA 613	FC	Linear Algebra and Theory of Optimization	4–0–0	4
AL 601	FC	Automotive Embedded Systems	3–0–0	3
AL 602	FC	Automotive Control Systems	3–1–0	4
AL 610	SC	Fundamentals of Automotive Systems	3–0–0	3
AL 611	SC	Introduction to Computer Architecture	3–0–0	3
HU 601	HU	Cultural Education*		P/F
			Total Credits	**17**

* Non-credit course

Second Semester

Course Code	Type	Course	L–T–P	Cr
AL 612	SC	Automotive Power Electronics and Drives	3–0–1	4
AL 613	SC	Automotive Grade Processors	3–0–1	4
AL 614	SC	Real Time Operating Systems	3–0–1	4
AL 615	SC	Vehicular Networks and Communication	3–0–1	4
	E	Elective – I	3–0–0	3
AL 616	SC	Automotive Testing Systems Laboratory	0–0–1	1
EN 600	HU	Technical Writing*		P/F
			Total Credits	**20**

* Non-credit course

Third Semester

Course Code	Type	Course	L–T–P	Cr
	E	Elective – II	3–0–0	3
	E	Elective – III	3–0–0	3
AL 617	SC	Automotive Electronics Laboratory (OPEN LAB)	0–0–1	1
AL 798	P	Dissertation		8
			Total Credits	**15**

Fourth Semester

Course Code	Type	Course	L–T–P	Cr
AL 799	P	Dissertation		14
			Total Credits	**14**

TOTAL CREDITS: 66

LIST OF COURSES

Foundation Core

Course Code	Course	L–T–P	Cr
MA 613	Linear Algebra and Theory of Optimization	4–0–0	4
AL 601	Automotive Embedded Systems	3–0–0	3
AL 602	Automotive Control Systems	3–1–0	4

Subject Core

Course Code	Course	L–T–P	Cr
AL 610	Fundamentals of Automotive Systems	3–0–0	3
AL 611	Introduction to Computer Architecture	3–0–0	3
AL 612	Automotive Power Electronics and Drives	3–0–1	4
AL 613	Automotive Grade Processors	3–0–1	4
AL 614	Real Time Operating Systems	3–0–1	4
AL 615	Vehicular Networks and Communication	3–0–1	4
AL 616	Automotive Testing Systems Laboratory	0–0–1	1
AL 617	Automotive Electronics Laboratory (OPEN LAB)	0–0–1	1

Electives

Course Code	Course	L–T–P	Cr
AL 701	Automotive Sensors	3–0–0	3
AL 702	Multi Core Architectures for Automotive Applications	3–0–0	3
AL 703	Vehicle Dynamics and Control	3–0–0	3
AL 704	Introduction to Artificial Intelligence	3–0–0	3
AL 705	Automotive RADAR Systems	3–0–0	3
AL 706	Hardware Software Co–design for Automotive Applications	3–0–0	3
AL 707	Fuzzy Based System Design for Automotive Applications	3–0–0	3
AL 708	Digital Signal Processing	3–0–0	3
AL 709	Batteries and Fuel Cells	3–0–0	3
AL 710	Micro Electro–Mechanical Systems (MEMS)	3–0–0	3
AL 711	Introduction to Data Mining	3–0–0	3
AL 712	Digital Image and Video Processing	3–0–0	3

MA 613 LINEAR ALGBERA AND THEORY OF OPTIMIZATION 4–0–0–4

Review of Matrices – Geometry of Linear Equations – Gaussian Elimination – Special Matrices and Applications – Linear Algebra: Vector Spaces – Sub Spaces – Linear Independence – Spanning – Basis – Dimension – the four fundamental subspaces — Orthogonality –Perpendicular vectors and orthogonal subspaces – Inner Products –Projections onto lines, projections and least square applications – Orthogonal basis – Gram Schmidt Process – Change of Basis – Orthogonal complements – Projection on subspaces – Least Square Principle.

Linear Transformation: Positive Definite Matrices – Matrix Norm and Condition Number – QR Decomposition – Nilpotent transformations – Similarity of linear transformations – Diagonalization and its applications – Jordan form and rational canonical form – Introduction to Normed Linear Space – Banach Space and Hilbert Space

Mathematical Optimization – Least–Squares and Linear Programming – Convex and Non–linear Optimization – – Convex Sets – Optimization Problems in Standard Form – Convex Optimization Problems – quasi–convex optimization – Linear Optimization – Quadratic Optimization

Generalized Inequality Constraints – Semi Definite Programming – Vector Optimization – Duality, Approximation and fitting – Statistical estimation – Geometric Problems – Unconstrained Minimization – Gradient Descent Method – Steepest Descent Method – Equality Constrained Minimization – Newton's Method.

TEXT BOOKS / REFERENCES:

1. Gilbert Strang, "Linear Algebra and its Applications", Fourth Edition, Cambridge University Press, 2009.
2. David C Lay, "Linear Algebra and its Applications", Pearson Addison Wesley, 2002.
3. Howard Anton and Chris Rorres, "Elementary Linear Algebra", Tenth Edition, John Wiley Sons, 2010.
4. S. S. Rao, "Optimization Theory and Applications", Second Edition, New Age International Pvt. Ltd Publishers, 1995.
5. Kalyanmoy Deb, "Optimization for Engineering Design Algorithms and Examples", Prentice Hall of India, New Delhi, 2004.

AL 601 AUTOMOTIVE EMBEDDED SYSTEMS 3–0–0–3

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, Control systems, Power storage and generation, starting motor systems, comfort and control systems: HVAC, engine cooling, vehicle security, driver comfort and assistance, signaling and vision, safety system, instrumentation systems and diagnostics

Cruise control and adaptive cruise control systems – ABS, ESP, TCS, 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 Systems, Application IoT in automotives, Future of Automotive Embedded systems

TEXT BOOKS / REFERENCES:

1. Robert Bosch GmbH, "Bosch Automotive Electrics and Automotive Electronics – Systems and Components, Networking and Hybrid Drive", Fifth Edition, Springer Vieweg, 2007.
2. William Ribbens, "Understanding Automotive Electronics – An Engineering Perspective", Seventh Edition, Butterworth Heinemann, 2012.
3. V.A.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.
4. Tom Denton, "Automobile Electrical and Electronic Systems", Fourth Edition, Routledge, 2012.
5. Maleki A., "Embedded Software Engineering in Automotive and Truck Electronics," SAE Technical Paper 2009-01-2924, 2009, doi:10.4271/2009-01-2924.

AL 602 AUTOMOTIVE CONTROL SYSTEMS 3–1–0–4

Overview of control system: Modeling, Time/Frequency Response Analysis and Stability Analysis: PID, State Variable Analysis.

Model Based Diagnosis: Characteristics, Faults, fault modeling, Principles of Model based Diagnostics – Residual generator design, Residual Evaluation, engineering of diagnosis systems, Application Example. Vehicle control systems: ABS Control Systems– Torque balance at vehicle–road contact, control cycles of the ABS system, ABS cycle detection; Control of Yaw Dynamics– Derivation of simplified control law, Derivation of reference values.

Road and driver Models: Road Model–Requirements of the road model, definition of the course path, Road surfaces and wind strength; PID Driver model; Hybrid Driver Model–Vehicle control tasks, characteristics of human as a controller, Information handling, completer driver model.
Lab based simulations of Control systems

TEXT BOOKS / REFERENCES:

1. Kiencke, Uwe and Nielsen, Lars, "Automotive Control Systems for Engine, Driveline, and Vehicle", Springer, 2005.
2. I.J. Nagrath and M. Gopal, "Control Systems Engineering", Wiley Eastern Limited, New Delhi, 2008.
3. M. Gopal, "Modern Control System Theory", New Age International, 2005.
4. Katsuhiko Ogata, "Modern Control Engineering", Fifth Edition, Prentice Hall, 2010.

AL 610 FUNDAMENTALS OF AUTOMOTIVE SYSTEMS 3–0–0–3

Internal combustion engines – Ideal cycles & actual cycles – Reciprocating piston engines – Operating principles – Mixture formation – Combustion – Emissions – Charge cycle and

supercharging – Exhaust gas recirculation – engine cooling – Air filtration – exhaust systems – regulations – Exhaust gas measuring techniques

Braking System – Principles, Components – Hydraulic Systems – Hydraulic Valves and Switches – Brake Fluid and Lines Wheel Bearings – Drum and Disc Brake s – Parking Brake System – Power Brake System – Regenerative Braking Systems, Suspension System Components and Operation, Front and rear suspension – Electronic Suspension Systems, Steering systems – Columns and Gears – Steering Linkage – Power–Assisted Steering Operation, Drive Axle Shafts and CV Joints, Wheel Alignment Principles – Design features and standards of chassis systems

Basic Elements of Vehicle and Transmission Engineering – Selecting the Ratios – Overall Gear Ratio, Multi–plate clutches – Dry Clutches – Wet clutches Dual clutches – Hydrodynamic Clutches and Torque Converters. Matching Engine and Transmission, traction diagram, Geared Transmission with Dry Clutch and torque converter; Passenger Car Transmissions: Manual Passenger Car – Automated Manual Transmissions – Dual Clutch Transmissions – Automatic and Hybrid Drives – Continuously Variable Transmissions; Final drives – axle drives – Differential Gears and Locking Differentials – hub drives; Electronic Transmission Control
Lab sessions to introduce the Chassis/ Power train systems

TEXT BOOKS / REFERENCES:

1. Heywood J B, "Internal Combustion Engine Fundamentals", McGraw Hill International, 1993.
2. Naunheimer H, Bertsche B, Ryborz J and Novak W, "Automotive Transmissions", Springer 2011.
3. C.R.Burrows and K.A.Edge, "Power Transmission and Motion Control", John Wiley and Sons, 2002.
4. Abbot and Sheldon L, "Automotive Power Trains: Clutch, Manual Transmission, Transaxle and Final Drive", McGraw Hill, 1988.
5. Halderman, "Automotive Chassis Systems", Fifth Edition, Prentice Hall, 2008.

AL 611 INTRODUCTION TO COMPUTER ARCHITECTURE 3–0–0–3

Introduction: Technology trends affecting emerging architectures – Review of Computer Architecture Basics: RISC instruction set architectures – Multi–cycle data path and pipelining – Memory and memory hierarchies – General purpose multi–core architectures: Synchronization primitives – Shared memory – Vector processing (SIMD) – Programming paradigms

Multicore DSP and System on Chip architectures : Cradle Technologies – IBM Cell – Programming Cell – Multicore Graphics architectures: nVidia CUDA – Programming GPUs – Software configurable architectures : Tensilica– Stretch Processor Architectures: MIPS, SPARC, POWER PC, ITANIUM, ARM, FPGA, DSP Processors

TEXT BOOKS / REFERENCES:

1. J. L. Hennessy and D. A. Patterson, "Computer Architecture: A Quantitative Approach", Fourth Edition, Morgan Kaufmann, 2006.
2. J. Šilc, B. Robic and T. Ungerer, "Processor Architecture: From Dataflow to Superscalar

and Beyond "Fourth Edition, Springer, 1999.
3. Trimberger, Stephen, M. (Ed.), "Field Programmable Gate Array Technology", Springer, 1994.

AL 612 AUTOMOTIVE POWER ELECTRONICS AND DRIVES 3–0–1–4

Evolution of the distribution electrical system: Electrical and electronic systems in the vehicle, Conventional system of electrical distribution in automobiles, Peaking power sources and energy storages: fuel cells, Batteries (lead, nickel, lithium), super capacitors, flywheel and hybridization of energy storage Role of power electronics in vehicles, Characteristics of power semiconductor switches– power diodes, power transistors and thyristors, Selection of devices

Power Electronic Converters: AC– DC Converters, DC–DC Converters, AC–AC Converters, DC–AC Converters Electric propulsion system: DC motor drives: Basic characteristics, Combined armature voltage and field control, Operating modes, Chopper drives, Regenerative braking, Effects of changes in supply voltage and load torque, closed loop control systems

Induction motor drives: Conventional methods, Stator voltage control, Rotor resistance control, Slip power recovery, Static Kramer drives and Static Scherbius drive, V/f control, Closed loop control. Introduction to vector control and direct torque control schemes, Special machines: Brushless DC motor, Switched reluctance motor, PMSM, Introduction to the relevant converter circuits. Introduction to Kinetic Energy Recovery Systems (KERS)

TEXT BOOKS / REFERENCES:

1. R. Krishnan, "Electric Motor Drives, Modeling, Analysis and Control", Prentice Hall, NJ, 2001.
2. Gopal K. Dubey, "Fundamentals of Electrical Drives", Narosa Publishing House, 2001.
3. Iqbal Hussain, "Electric and Hybrid Electric Vehicles Design Fundamentals", Second Edition, CRC Press, 2010.
4. Muhammad H. Rashid, "Power Electronics, Circuits, Devices and Applications", Third Edition, Pearson Education Press, 2004.
5. Mehrdad Ehsani, Yimin Gao and Ali Emadi," Modern Electric, Hybrid Electric, and Fuel Cell Vehicles", Second Edition, CRC Press, 2009.

AL 613 AUTOMOTIVE GRADE PROCESSORS 3–0–1–4

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.

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 Inc., 2010.
3. Arnold S. Berger, "Embedded System Design", CMP Books, USA 2002.
4. Michael Barr, "Programming Embedded Systems with C and GNU", O Reilly, 2003.
5. Frank Vahid and Tony Givargis "Embedded System Design: A Unified Hardware/Software Introduction", John Wiley & Sons, 2002.

AL 614 REAL TIME OPERATING SYSTEMS 3–0–1–4

Introduction to Real–time Systems and Real Time Operating System Basics: Real–time systems– definitions and examples, real–time systems characteristics, timeliness, responsiveness, concurrency, determinism, correctness and robustness, requirements on RTOS, RTOS Vs General–purpose OS, RTOS characteristic, existing RTOS category, kernel architecture, functions of RTOS kernel.

Introducing tasks for concurrency: Task management, process, thread and task, task– basic notation in RTOS, task classification, task states, state transitions, task control block, context switching and latency, creating, controlling, deleting tasks, setting priorities, writing re–entrant codes, scheduling policies– fixed priority and dynamic priority scheduling algorithms. Inter–Task Communication and Synchronization: Inter task communication: with and without resource sharing, shared memory, message and message queues, inter–task communication via message queues, inter–task communication models, need for synchronization, semaphores–binary and counting semaphores, inheritance, inversion, ceiling, deadlocks and starvation, priority inversion and mutexes.

Time, Memory and Interrupt handling: Clocks in distributed RTS, timers and timer ticks, clock synchronization, watch dog timer, relative and absolute timer, interrupts– ISR under RTOS, ISR to task communication, memory/ device I/O management. Introduction to Multi threading and Multi processor scheduling

Case study: AUTOSAR, OSEK/VDX, Picking an RTOS for your project, RTOS trends today and for next five years.

Lab experiments based on standard RTOS

TEXT BOOKS / REFERENCES:

1. Philip A. Laplante, "Real Time System Design and Analysis," Third Edition, Prentice Hall of India, 2004.
2. Jane W.S. Liu, "Real–Time Systems", First Edition, Pearson Education, 2000.
3. Krishna and Shin, "Real Time Systems", Addison Wesley, 2001.
4. 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.

5. AUTOSAR Specification Available at: http://www.autosar.org/specifications/

AL 615 VEHICULAR NETWORKS AND COMMUNICATION 3–0–1–4

Vehicular Networks: Cross–system functions, Requirements for bus systems, Classification of bus systems, Applications in the vehicle, Coupling of networks, Examples of networked vehicles; Bus systems: CAN bus, CAN–FD, LIN bus, MOST bus Bluetooth, Flex Ray, Diagnostic interfaces: Implementation of Body electronics functionalities using Controllers.

Vehicular Communications: Intelligent Transportation Systems: IEEE 802.11p – ITS– IVC: Inter–Vehicle Communications – Mobile Wireless Communications and Networks – Architecture Layers – Communication Regimes. V2V: Vehicle–to–vehicle Communication, V2I:Vehicle to Infrastructure Communication – VANET: Vehicle Ad–hoc Network – WAVE: Wireless Access in Vehicular Environment – DSRC: Dedicated Short Range Communications. Information in the Vehicular Network – Routing – Physical Layer Technologies – Medium Access for Vehicular Communications – Security – Applications and Case Studies

Lab experiments based on various vehicular communication/ network protocols/standards

TEXT BOOKS / REFERENCES:

1. Dominique Paret, "Multiplexed Networks for Embedded Systems: CAN, LIN, FlexRay, Safe–by–Wire", Wiley, 2007.
2. Dominique Paret, "FlexRay and its Applications: Real Time Multiplexed Network", Second Edition, Wiley, 2012.
3. Popescu–Zeletin R, Radusch I and Rigani M.A, "Vehicular–2–X Communication", Springer, 2010.
4. Xiang W, "Wireless Access in Vehicular Environments Technology", Springer, 2015.
5. Luan T. H, Shen X. (Sherman) and Bai F, "Enabling Content Distribution in Vehicular AdHoc Networks", Springer, 2014.

AL 616 AUTOMOTIVE TESTING SYSTEMS LABORATORY 0–0–1–1

This laboratory session shall provide an idea about various testing systems used in the Automotive Industry. The list of experiments will be based on the facility available with the Testing Systems Lab.

AL 617 AUTOMOTIVE ELECTRONICS OPEN LABORATORY 0–0–1–1

During the third semester, the students shall design and prototype a system, which is exclusively, used in the Body Electronics/ Chassis Control/ Power train/ Navigation domains of Automotive Electronics. The work will be evaluated periodically throughout the semester.

EN 600 TECHNICAL WRITING P/F

Technical terms- Definitions- extended definitions- grammar checks- error detection- punctuation spelling and number rules - tone and style- pre-writing techniques - Online and offline library resources- citing references – plagiarism - Graphical representation - documentation styles- instruction manuals- information brochures- research papers, proposals – reports (dissertation, project reports etc.) - Oral presentations.

TEXT BOOKS / REFERENCES:

1. Hirish and Herbert L. "Essential Communication Strategies for Scientists, Engineers and Technology Professionals", Second Edition, New York: IEEE Press, 2002.
2. Anderson, Paul V., "Technical Communication: A Reader-Centered Approach", Sixth Edition, Cengage Learning India Pvt. Ltd., New Delhi, Reprint 2010.
3. Strunk, William Jr. and White E.B., "The Elements of Style" Alliyan & Bacon, New York, 1999.

AL 701 AUTOMOTIVE SENSORS 3–0–0–3

GPS: Basic navigation; GNSS segments; Satellite systems; Stand–alone and referenced positioning; Receiver systems; Topographic maps; Route planning; Waypoints; Trail mapping; Turn–by–turn guidance LIDAR: EM theory of EO systems; Radiation metrics; Optical modulation; Error correction codes; Channel models

AMOLED: Basic Principles; Controllers; Controllers; Noise management; ITO; OGS; Stylus Technologies; Touch less authentication; Biometric access control, MEMS: Introduction; Noise factor; Piezoelectric systems; Capacitive sensing; Signal amplification; Sensor specifications and Damping; Actuation; RF MEMS; Micro fabrication techniques

Virtual sensors: Models and algorithms for Efficient performance of sensor networks; Information pattern analysis; Real–world applications

TEXT BOOKS / REFERENCES:

1. Ivan G. Petrovski; "GPS, GLONASS, Galileo, and BeiDou for Mobile Devices: From Instant to Precise Positioning", Cambridge University Press, 2014.
2. Stephen W. Hinch, "Outdoor Navigation with GPS", Third Edition, Wilderness Press, 2010.
3. Sherman Karp and Larry B. Stotts: "Fundamentals of Electro–Optic Systems Design: Communications, Lidar, and Imaging"; Cambridge University Press, 2013.
4. Geoff Walker, "Fundamentals of Projected–Capacitive Touch Technology", Intel Corporation, 2004.
5. Vladimir L. Boginski, Clayton W. Commander, Panos M. Pardalos and Yinyu Ye (Eds.): "Sensors: Theory, Algorithms, and Applications (Springer Optimization and Its Applications) (Volume 61)", Springer, 2012.

AL 702 MULTI CORE ARCHITECTURES FOR AUTOMOTIVE APPLICATIONS 3–0–0–3

Review of Computer Design – Basics of Pipelining – Hazards –Measuring performance – Instruction level parallelism – prediction techniques – Static & Dynamic scheduling – Speculation – Limits of ILP. Thread–level parallelism, Multi–issue and Multi–core processors – Shared and Distributed memory Multiprocessor Architectures – Multi–core architectures for embedded systems.

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.

Freescale Dual Core 32–bit MPC5668G Architecture – System Timers – Enhanced DMA – Enhanced Serial Communication Interface – Peripherals

TEXT BOOKS / REFERENCES:

1. J.L. Hennessy and D.A. Patterson, "Computer Architecture: A Quantitative Approach", Fifth Edition, Morgan Kaufmann, 2011.
2. Georgios Kornaros, "Multi–core Embedded Systems", First Edition, CRC Press, Taylor and Francis Group, 2010.
3. Freescale e200z3 Power Architecture Core Reference Manual.
4. MPC5668x Microcontroller Reference Manual.

AL 703 VEHICLE DYNAMICS AND CONTROL 3–0–0–3

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 Maneuvers, 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: H2 Optimal Control, LQR Formulation for Active Suspension Design, Analysis of Trade–Offs Using Invariant Points, Performance of the Sky–Hook Damping Controller,

Control with Hydraulic Actuators; Semi–Active Automotive Suspensions: Theoretical Results: Optimal Semi–Active Suspensions, Interpretation of the Optimal Semi–Active Control Law, Calculation of Transfer Function Plots with Semi–Active Control Law; Rollover Prevention Control: Rollover Dynamics, Rollover Index and Active Rollover Prevention, Comparison of Performance with Various Rollover Indices

Lab experiments based on simulation tools.

TEXT BOOKS / REFERENCES:

1. Thomas D. Gillespie, "Fundamentals of Vehicle Dynamics", SAE International, 1992.
2. R. Rajamani, "Vehicle Dynamics and Control", Second Edition, Springer Verlag, 2012.
3. Uwe Kiencke and Lars Nielsen, "Automotive Control Systems: For Engine, Driveline, and Vehicle", Second Edition, Springer, 2005.
4. John C. Dixon, "Tyres, Suspension, and Handling", 2nd Revised Edition, SAE International, 1996.
5. Hans B. Pacejka, "Tyre and Vehicle Dynamics", Second Edition, Butterworth–Heinemann, 2006.

AL 704 INTRODUCTION TO ARTIFICIAL INTELLIGENCE 3–0–0–3

Introduction to basic principles of Artificial Intelligence, Knowledge representation: Formalized symbolic logics – Dealing with uncertainties – Statistical reasoning – Structured Knowledge – Object oriented representations

Knowledge organization and manipulation: Search and control strategies – Matching techniques – Indexing – Memory organization, Knowledge perception: Natural language processing – Pattern recognition – Visual image understanding – Expert systems

Knowledge acquisition: General learning model – Neural networks – Fuzzy logic systems – Genetic algorithms – Learning by induction – Artificial Intelligence for sensing, control and diagnostics in automotive systems – Programming techniques for Artificial Intelligence using PROLOG. – Application of Multi Sensor Data Fusion Techniques

TEXT BOOKS / REFERENCES:

1. Elaine Rich, Kevin Knight and Shivashankar B. Nair, "Artificial Intelligence", Third Edition, McGraw Hill, 2009.
2. Dan W. Patterson, "Introduction to Artificial Intelligence and Expert Systems", Prentice Hall of India Pvt. Ltd., 2001.
3. George F. Luger, "Artificial Intelligence, Structures and Strategies for Complex Problem Solving", Fifth Edition, Pearson, 2010.

AL 705 AUTOMOTIVE RADAR SYSTEMS 3–0–0–3

Electromagnetic Spectrum – Radar principle – Basic Radar Equation – Radar Cross Section – Types of Radar – Pulsed and CW Radar – Radar Equation for CW Radar – 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 Electromagnetic Compatibility Requirements for Automotive Electronics – EMC Basics– Radiation and Conducted Emissions – Radiated and Conducted Susceptibility – Product Requirements and Design Constraints – SAR – Case Studies.

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 Publishing Company Limited, Third Edition, Twenty First Reprint, 2008.
4. C.R.Paul, "Introduction to Electromagnetic Compatibility", Wiley India Private Limited, Second Edition, 2014.

AL 706 HARDWARE SOFTWARE CO–DESIGN FOR AUTOMOTIVE APPLICATIONS 3-0-0-3

Essential Issues in Co-design – Models and Architectures–Languages – Generic Co–Design Methodology –Hardware/Software Co–Synthesis Algorithms –Hardware/Software Partitioning – Co–Synthesis –Architecture Specialization Techniques – Modern Embedded Architectures – Examples of Emerging Architectures – Design Specification and Verification – Languages for System–Level Specification and Design, Hw/Sw co-design in Automobile applications, Implementation Case Studies, Performance Analysis.

TEXT BOOKS / REFERENCES:

1. Jorgen Staunstrup and Wayne Wolf, "Hardware/Software Co–Design: Principles and Practice", ISBN: 978–1–4419–5018–5
2. G. De Micheli, "Readings in Hardware Software Co–design" , Morgan Kaufmann, Academic Press, 2002.
3. Ti – Yen Yen and Wayne Wolf, "Hardware–Software Co–Synthesis of Distributed Embedded Systems", Kluwer, Springer, Reprint 2010.
4. Joris van den Hurk and Jochen A.G. Jess, "System Level Hardware/Software Co–Design: An Industrial Approach ", Springer, 1997

AL 707 FUZZY BASED SYSTEM DESIGN FOR AUTOMOTIVE APPLICATIONS 3–0–0–3

Introduction – Classical sets and Fuzzy sets, Classical Relations and Fuzzy Relations – Properties of Membership functions – Fuzzyfication – De–fuzzyfication – Development of membership functions –

Logic and Fuzzy systems – Automated methods – Decision Making– Fuzzy Classification – Fuzzy control systems design.

Fuzzy Control Approach for the Design of Active and Semi – Active Suspension – Fuzzy Modeling for Nonlinear System – Automotive Powertrain Control with Fuzzy Logic– Paradigms of Automotive Fuzzy Logic Applications – Fuzzy Maps: Managing Uncertainty in Sensor–Based Motion Planning – Fuzzy Control for Automotive Engine – Idle Speed Control

TEXT BOOKS / REFERENCES:

1. Timoty Ross, "Fuzzy Logic with Engineering Applications", Third Edition, McGraw Hill, 2010.
2. G. J. Klir and T. A. Folger, "Fuzzy Sets Uncertainty and Information," PHI IEEE, 1995.
3. Mohammad Jamshid, Andre Titli, Lofti Zadeh and Serge Boverie, "Applications of Fuzzy Logic : Towards High Machine Intelligence Quotient systems", Prentice Hall PTR, 1997.
4. Yaser and D. P. Filer, "Essentials of Fuzzy Modeling and Control", John Wiley, 1994.
5. John Yen and Reza Langari, "Fuzzy Logic: Intelligence, Control and Information", Pearson Education, 1998.

AL 708 DIGITAL SIGNAL PROCESSING 3–0–0–3

Classification of signals, Continuous – Discrete time; Even/Odd signals, Periodic/ Non-periodic signals, Deterministic/Random signals, Energy/Power signals; Basic operations on signals: Basic (Continuous/Discrete) signals – unit step, unit impulse, sinusoidal and complex exponential signals etc. Systems (Continuous/Discrete): Representation, Classification – Linear/Nonlinear, Causal/Noncausal, Time invariant/Time variant, with/ without memory; BIBO stability, Feedback system. LTI system – Response of LTI system, Convolution, Properties (Continuous/Discrete); LTI systems – Differential/Difference equation representation and solution.

Fourier series for periodic signals; Fourier transform – Properties of continuous time FT; Frequency response of continuous time LTI systems. Fourier analysis of discrete time signals and systems: Discrete time Fourier series –Discrete Time Fourier transform – Properties of DTFT; Frequency response of discrete time LTI systems. Laplace Transform analysis of systems: ROC, Inverse LT, Unilateral LT, Solving differential equation with initial conditions. Z–Transform: Definition, ROC, Inverse z–Transform, Properties, Transform analysis of LTI Systems. Sampling: Sampling theorem, Reconstruction of signal, Aliasing, Sampling of discrete time signals; Introduction to DFT – Fast Fourier Transform (FFT)

Digital Filter Design and Filter Realization: FIR and IIR filters Applications : Multirate digital signal processing – Evaluation of time domain and frequency domain features for machine vibration analysis

TEXT BOOKS / REFERENCES:

1. Simon Haykin and Barry Van Veen, "Signals and Systems", Second Edition, John Wiley and Sons, 2005.

2. J. G. Proakis and D. G. Manolakis, "Digital Signal Processing Principles, Algorithms Applications", Fourth Edition, Prentice Hall India Private Limited, 2007.
3. Alan V. Oppenheim, Alan S.Willsky and S, Hamid Nawab, "Signals and Systems", Prentice Hall India Private Limited, 1997.
4. Sanjit K. Mitra, " Digital Signal Processing", TMH, Third Edition,2009

AL 709 BATTERIES AND FUEL CELLS 3–0–0–3

Origin of potential – electrical double layer – reversible electrode potential–emf series–reference and indicator electrodes – Nernst equation – Butler–Volmer equation – Activation, concentration and IR over potentials – Tafel plots – Primary and secondary batteries: The chemistry, fabrication and performance aspects, packing classification and rating of zinc and lithium primary batteries–Lead acid, nickel, silver and lithium ion secondary batteries–VRLA batteries–Sodium–beta and Redox batteries for vehicles – Thermally activated reserve batteries

Fuel Cells: Working principle, fabrication of electrodes and other components, and environmental aspects of Proton Exchange Membrane Fuel Cells, Alkaline fuel cells, Phosphoric acid, Solid oxide, Molten carbonate, Direct methanol fuel cells – Reformation clean up and storage for hydrogen – Testing and Assessment of Batteries – Shelf life and service life **–** effect of temperature and pressure – effect of aging – memory effect – test conditions, mechanical and environmental, load and electromagnetic compatibility testing.. Selected international standards – performance characteristics –Peuckert discharge curves, Ragone plots,

Introduction to Fuel cell control systems, Battery management systems.

TEXT BOOKS / REFERENCES:

1. Dell, Ronald M Rand and David AJ, "Understanding Batteries", Royal Society of Chemistry, 2001.
2. M. Aulice Scibioh and B.Viswanathan, "Fuel Cells – Principles and Applications", University Press, India, 2006.
3. F. Barbir, "PEM Fuel Cells: Theory and Practice", Elsevier, Burlington, MA, 2005.
4. David Linden, Thomas B Reddy, "Handbook of Batteries", Third Edition, McGraw–Hill, 2001.
5. Derek Pletcher and Frank C. Walsh, "Industrial Electrochemistry", Blackie Academic and Professional, 1993.

AL 710 MICRO ELECTRO–MECHANICAL SYSTEMS (MEMS) 3–0–0–3

Introduction to MEMS Technology & Applications – Evolution of Micro-fabrication, Microsystems and Microelectronics, Microsystems Design and Manufacture: Inter– and Multi–disciplinary Nature, Microsystems and Miniaturization, Application of Microsystems in Automotive Industry – Sensors and Actuators; Fundamentals of Thin Film and Microsystems Fabrication Processes –

Photolithography, Ion Implantation, Diffusion, Oxidation, Chemical Vapor Deposition, Physical Vapor Deposition, Sputtering, Deposition by Epitaxy, Etching

Materials for MEMS and Microsystems, Techniques for Actuation and Sensing, Micro actuators, Micro sensors and Micro accelerometers, Scaling and Scaling Effects, Scaling of Forces, Piezoelectricity and Piezo resistivity, Engineering Mechanics for Microsystems Design – Introduction, Mechanical Vibration, Thermo mechanics, Fracture Mechanics and Thin Film Mechanics.

Overview of Micro manufacturing – Introduction, Bulk Micro manufacturing, Surface Micro machining, and the LIGA Process. MEMS for automotive applications – MEMS for passenger safety in automotive vehicles; MEMS sensors for automotive vehicle stability control applications; MEMS for automotive tire pressure monitoring systems; MEMS pressure and flow sensors for automotive engine.

TEXT BOOKS / REFERENCES:

1. Tai–Ran Hsu, "MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering", Second Edition, John Wiley & Sons, Inc., Hoboken, New Jersey, 2008.
2. M. Kraft and N M White, "MEMS for Automotive and Aerospace Applications", WP, 2013.
3. Caudill Mohamed Gad–El–Hak, Gad–el–Hak Mohamed, "The MEMS Handbook", Second Edition Series, CRC Press LLC, 2005.

AL 711 INTRODUCTION TO DATA MINING 3–0–0–3

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. Fundamentals of streaming data mining

k–nearest–neighbor, Support Vector Machines and Bayes classifiers, for linearly–separable, non–linearly separable and multi–class classification. Classifier accuracy Measures, evaluating the accuracy of a Classifier. Ordinary Least Squares based regression.

Cluster Analysis using k–Means, k–Medoids, single linkage, complete linkage, UPGMA, BIRCH, ROCK. Assessing clustering tendency, determining the number of clusters, measuring clustering quality. Concepts of data stream mining, Big data analytics, Case studies on application of data mining techniques in automotive industry.

TEXT BOOKS / REFERENCES:

1. Jiawei Han, Micheline Kamber and Jian Pei , "Data Mining : Concepts and Techniques", Third Edition, Morgan Kaufmann Publishers (Elsevier), 2011.

2. Sergios Theodoridis and Konstantinos Koutroumbas, "Pattern Recognition", Fourth Edition, Academic Press (Elsevier), 2011.
3. K.P Soman, Shyam Diwakar and V. Ajay, "Insight into Data Mining: Theory and Practice", PHI Learning Private Ltd., New Delhi, 2006.
4. K.P Soman, R. Loganathan and V. Ajay, "Machine Learning with SVM and Other Kernel Methods", PHI Learning Private Ltd., New Delhi, 2009.

AL 712 DIGIAL IMAGE AND VIDEO PROCESSING 3–0–0–3

(Prerequisite: Signal Processing for Automotive applications)

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

TEXT BOOKS/REFERENCES:

1. Rafael C. Gonzalez, "Digital Image Processing", Third Edition, PHI Private Limited, New Delhi, 2008.
2. John W. Wood, "Multidimensional Signal, Image, Video Processing and Coding", Elsevier, 2006.

AL 798 / 799 DISSERTATION 0-0-0-22

In Dissertation, the student will, with the help of a faculty member along with an Industry (TCS) Expert, identify a particular problem of interest in Automotive Electronics in the beginning of Second semester and study the state-of-the-art in the area of interest and develop a new technique /algorithm / device to obtain demonstrably better results than those presently available. The student shall submit a report in the end of Second semester, which contains a brief description, timeline, resources identified related to the work planned.

The evaluation of the dissertation will be based on the periodic reviews conducted throughout the Second year. Phase 1 evaluation (Presentation and Viva) of the Dissertation will be conducted by the Programme Coordinator and SME (Subject Matter Expert) at the end of Third Semester. Phase 1 of the dissertation will be worth 08 credits.

During the second phase of the Dissertation in the fourth semester, the student shall continue with the work initiated in Phase 1 to achieve the stated objectives of the project. At the end of this phase, the student shall submit a dissertation in the prescribed format. The Phase 2 (final) evaluation will be at the end of the fourth semester, which shall be attended by at least one eminent academician / researcher / technologist in the areas of Automotive Electronics. Phase 2 of the Dissertation will be worth 14 credits. In context of IP Protection, Research paper publication on a Scopus indexed Journal/ Conference by the candidate shall be based on prior approval from TCS and AMRITA.