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. Emphasis is placed on a creative and imaginative approach to automotive electronics system design.

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

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Type</th>
<th>Course</th>
<th>L–T–P</th>
<th>Cr</th>
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<tbody>
<tr>
<td>17AL 601</td>
<td>FC</td>
<td>Linear Algebra and Optimization for Signal Processing</td>
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<tr>
<td>17AL 602</td>
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<td>17HU 601</td>
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<td>Cultural Education*</td>
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* Non-credit course

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<td>FC</td>
<td>RTOS in Multi-core Environment</td>
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<td>Elective – I</td>
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Total Credits 16

#### Fourth Semester

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Total Credits 14

**TOTAL CREDITS: 66**
## LIST OF COURSES

### Foundation Core

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<td>17AL 605</td>
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### Subject Core

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### Electives

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<td>17AL 701</td>
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<td>17AL 702</td>
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<td>17AL 703</td>
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<td>Control of Power Converters and Electrical Machines</td>
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<td>17AL 706</td>
<td>Sensing for Autonomous Vehicles</td>
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<td>17AL 707</td>
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<td>17AL 708</td>
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### Project

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<td>17AL797</td>
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</table>
17AL601 LINEAR ALGEBRA AND OPTIMIZATION FOR SIGNAL PROCESSING

Convex set and convex function, Multivariate Taylor series expansion, optimality condition, Newton and quasi newton methods for unconstrained optimization, Constrained optimization, Lagrangian multiplier method, KKT conditions, Duality theorem, Alternating direction method of multipliers (ADMM), LP and Convex QP with ADMM, Formulating signal processing and pattern classification problems as optimization problems.
Introduction to Variational calculus, Variational mode decomposition, Daubechies’ synchrosqueezing transform.

TEXT BOOKS / REFERENCES:

17AL 602 AUTOMOTIVE EMBEDDED SYSTEMS

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.

TEXT BOOKS / REFERENCES:


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


TEXT BOOKS / REFERENCES:

17AL604 REAL TIME OPERATING SYSTEMS FOR MULTI-CORE ENVIRONMENT 3-0-1-4

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.

TEXT BOOKS/REFERENCES:

17AL605 DEEP LEARNING 3-0-0-3

Applications in security and Autonomous navigation.

TEXT BOOKS/REFERENCES:

17AL 610 PRINCIPLES OF AUTOMOTIVE SYSTEMS 3–0–0–3


TEXT BOOKS/REFERENCES:
3. Rudolf Limpert, “Brake design and Safety”. SAE Publications, 2015,

17AL611 AUTOMOTIVE GRADE PROCESSORS 3-0-1-4

TEXT BOOKS / REFERENCES:

17AL612 VEHICLE DYNAMICS AND CONTROL 3–0–1–4

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


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 experiments based on simulation tools.

TEXT BOOKS/REFERENCES:


17AL613 ELECTRIC VEHICLES AND ARCHITECTURES 3-0-0-3

Introduction to electric vehicles (EVs): Historical perspective. EV advantages and impacts. EV market and promotion: infrastructure needs, legislation and regulation, standardization, Functions electronically controlled in automotive.
Importance of energy efficiency / emission norms and fuel efficiency: Assessing economy of electric vehicles, Fuel economy vs fuel consumption Vs Green House Gas emissions.
Important electrical subsystem in vehicles: Basic components of a hybrid vehicle, Types of hybrids, Migration from 12V to 48V systems, Start/Stop Hybrid architecture types (Belt start Generator / Integrated Starter Generator), EV architectures.
Parallel Hybrid/ Series Hybrid (Range Extended Hybrid) Architectures: types, operating modes, torque coordination and control, generator/motor requirements. Introduction to power converter and motor control: case studies.
Batteries: Battery parameters. Types and characteristics of EV batteries. Battery testing and maintenance; charging schemes. Battery monitoring techniques. Open-circuit voltage and ampere-hour estimation. Battery load levelling, Chargers on-board/off-board chargers.

TEXT BOOKS / REFERENCES:

17AL 614 AUTOMOTIVE LABORATORY-I 0–0–1–1

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
17AL 615 AUTOMOTIVE LABORATORY- II 0–0–1–1
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

17AL 616 AUTOMOTIVE ELECTRONICS LABORATORY (OPEN LAB) 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.

17AL 701 VEHICULAR COMMUNICATION 3-0-0-3
Vehicle-to-X (V2X) Communication for Intelligent Transportation Systems (ITS) - safety and non-safety applications, use cases, network service requirements of different applications, V2X communication regimes; Standards and Technologies - layered architecture, infrastructure-based vs. infrastructure-less technologies, Long-Term Evolution (LTE), Dedicated Short Range Communication (DSRC), Wireless Access in Vehicular Environments (WAVE); Wireless Propagation and Channel Characteristics - path loss, shadowing, small-scale fading, delay spread and Doppler spread, coherence bandwidth and coherence time, techniques for combating wireless channel impairments; Physical Layer - digital modulation schemes in DSRC, design of OFDM in DSRC (symbol time, sub-carrier spacing, pilot spacing); Medium Access Control (MAC) - 802.11p EDCA, multi-channel operation in the WAVE MAC; Routing - flooding, broadcast storm problem, Geocast; Security and Privacy in Vehicular Networks; Vehicular Network Simulation - mobility models, bidirectionally coupled road traffic and communication network simulators for vehicular network simulation.

TEXT BOOKS / REFERENCES:

17AL702 VEHICULAR NETWORKS 3-0-0-3

TEXT BOOKS/REFERENCES:

17AL703 POWER CONVERTERS FOR AUTOMOTIVE APPLICATIONS 3-0-0-3
(Pre-requisite: 17AL613-Electric Vehicles and Architectures)

Overview of elementary power converter switches and power converters (non-isolated): BJT, Thyristors, MOSFETs, IGBT, IPM, IGCT. AC/DC converters single phase and three phase: Line commutated, uncontrolled and phase controlled converters (half bridge and full bridge), Performance factors, Line notching and distortion.

DC/DC converters isolated and non-isolated for automotive applications: buck, boost, buck-boost, SEPIC, SMPS concept, fly-back, forward, push-pull, soft switched bidirectional DC-DC converters, Typical specifications of power converters, design of power circuit to meet the specifications.

DC/AC converters three phase (focus on motor control): Voltage source inverters three phase Sinusoidal PWM and Space vector PWM, Multilevel inverters, Introduction to Cycloconverters, Matrix Converters.
Magnetic Design (Inductor, Transformer, Core material and properties, Planar technology)

Battery Management Systems, Simulation tools for power converters (PSIM/pSpice/Simulink); Relevant Automotive Standards, Automotive Design Considerations: Power conditioning in power converters, High temperature applications, properties of silicon carbide devices.

TEXT BOOKS/REFERENCES:

17AL704 ELECTRICAL MACHINES FOR AUTOMOTIVE APPLICATIONS  3-0-0-3
(Pre-requisite: 17AL703-Power Converters for Automotive Applications)

DC Brushed Motors Analysis: Generalized theory of rotating electrical machines, modeling, steady state and transient analysis of separately excited DC 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.

TEXTBOOK/REFERENCES:

17AL705 CONTROL OF POWER CONVERTERS AND ELECTRICAL MACHINES  3-0-0-3
(Pre-requisites: 17AL704-Electrical Machines for Automotive Applications, 17AL603-Digital Control Systems)

Concept of state space analysis, Power Converter Transfer Functions (closely related to Elective I): sate space representation and Transfer function model of a DC-DC converter, Type I, Type II, Type III compensators, Analog Implementation of compensators, Digital Microcontroller/DSP based implementation of compensators.
Control of Brushed DC Motors: Open and closed loop control of 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, Slip Power Recovery Drive (Vehicle power train control-Drive cycle performance and testing), Introduction to sensorless control.
Control of Synchronous Motors: v/f control, vector 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).

TEXT BOOKS /REFERENCES:

17AL706 SENSING FOR AUTONOMOUS VEHICLES 3-0-0-3


TEXT BOOKS / REFERENCES:

17AL707 MULTI-SENSOR DATA FUSION 3-0-0-3

Introduction to the importance of multi-sensor systems and data fusion -Data representations and uncertainty –Strategies and algorithms for data fusion -Review of probability for data fusion -Bayesian methods for estimation and data fusion: Examples for discrete cases - Bayesian methods for estimation and data fusion: Continuous Gaussian case -Recursive Bayesian methods for estimation and data fusion – Kalman filter theory -Data fusion using the Kalman filter – Performance Evaluation of Data Fusion system - Fuzzy logic and decision fusion - Monte Carlo methods -Data fusion process models and architectures -Data association

TEXT BOOKS/REFERENCES:

**17AL708 REINFORCEMENT LEARNING 3-0-0-3**

(Pre-requisite: 17AL605-Deep Learning)

Reinforcement learning and Markov Decision Processes (MDPs), Definition of MDPs, Exact algorithms: policy and value iteration, Search algorithms, Supervised learning and decision making, Optimal control and planning, Learning policies by imitating optimal controllers, Reinforcement learning definitions, value iteration, policy iteration, Reinforcement learning with policy gradients, Learning Q-functions: Q-learning, SARSA (State-Action-Reward-State-Action) and others, Advanced Q-learning algorithms. Introduction to Deep Reinforcement Learning (RL), Value-Based Deep RL, Policy-Based Deep RL, Model-Based Deep RL.

**TEXT BOOKS/REFERENCES:**


**17AL797 RESEARCH METHODOLOGY 1-0-0-1**


**TEXTBOOKS / REFERENCES:**


**17AL 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

17EN 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: