**Birla Institute of Technology & Science, Pilani**

**Work Integrated Learning Programmes Division**

**M. Tech Automotive Electronics**

## **I Semester 2019-20**

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| **Course Title** | Automotive Control Systems |
| **Course No(s)** | AEL ZG510 |
| **Credit Units** | 5 |
| **Credit Model** | Instruction + Student Preparation |
| **Instructor-In-Charge** |  |

**Course Description**

Introduction to vehicle electronics, semiconductor diodes, FETs, rectifiers, small signal amplifiers, circuit models, automotive applications and case studies, automotive micro controllers, auto sensors and actuators, vehicle electronics, feedback control, control strategy, analog and digital controllers, expert systems and neural networks, advanced topics in EMC, vehicle communication networks, automotive control system design, transmission and powertrain, brake, traction, suspension, active safety and supplementary restraint systems, intelligent vehicle systems and ADAS..

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| **COURSE OBJECTIVES** | |
| **CO1** | Learn the working of various components, sensors and actuators used by control systems |
| **CO2** | Educate about various automotive micro controllers, control systems and control strategy |
| **CO3** | Introduce the CAN network and various systems built around the CAN network |

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| **LEARNING OUTCOMES** | |
| **LO1** | Comfortable selecting, designing and working with electronic components and systems |
| **LO2** | Able to design and develop simple control systems for automotive mechatronics |
| **LO3** | Understand the strategy and working of various automotive systems like ABS, EBD etc., |
| **LO4** | Understand and analyze connected car technlogy and ADAS systems |
| **LO5** | Apply the concepts using Ricardo Ignite and MATLAB. |

**Text Book(s):**

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| **T1** | U Kiencke, L Nielsen, “Automotive Control Systems for Engine, Driveline, and Vehicle”, Springer. |
| **T2** | Ronald K. Jurgen, “Automotive Electronics Handbook”, McGraw-Hill, Inc. |

**Reference Book(s) & other resources:**

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| **R1** | Allan W.M. Bonnick, “Automotive Computer Controlled systems, Diagnostic tools and techniques” |
| **R2** | Bechfold, Understanding Automotive electronics, SAE, 1998. |
| **R3** | William, B. Ribbens, Understanding Automotive electronics, ButterWorth Heinemann 1998. |
| **R4** | Robert N. Brandy, Automotive computers and Digital Instrumentation, Prentice Hall Eaglewood Cliffs, New Jersey, 1988. |

**Content Structure: Current**

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| **Session** | **Area** | **Topic** | **Reference** |
| 1 | **Vehicle Electronics1** | Semiconductor diodes, FETs, Rectifiers, Small signal amplifiers |  |
| 2 | Circuit models, Automotive applications and case studies |  |
| 3 | **Automotive Microcontrollers** | Introduction to modern computer logic  Programming inputs and Outputs |  |
| 4 | Interrupts and system design. Typical controllers used |  |
| 5 | **Auto Sensors and Actuators** | Types of sensors, Sensors calibration |  |
| 6 | Signal attenuation, Shielding |  |
| 7 | **Vehicle Electronics2** | Feedback control, Control strategy |  |
| 8 | Analog and digital controllers, Expert systems and neural networks |  |
| 9 | **Advanced Topics in EMC** | Basics of EMC, Component segregation, cable routing,  Grounding, Shielding, common impedance coupling |  |
| 10 | Classification of EMC environments, EMC test methods |  |
| 11 | **Vehicle Communication Networks** | Various networks used, topology, basic architecture of CAN |  |
| 12 | Security protocols, Vulnerabilities |  |
| 13 | **Automotive Control Systems** | Engine, Transmission, Powertrain, Brake control systems |  |
| 14 | Traction, Suspension control systems, active safety systems |  |
| 15 | **Intelligent Vehicle Systems and ADAS** | In vehicle electronic sensors, connected cars and application  Collision avoidance systems |  |
| 16 | Active cruise control, Self-driving applications |  |

**Revised Objectives**

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| **COURSE OBJECTIVES** | |
| **CO1** | Learn the fundamentals of control strategy development for automotive systems |
| **CO2** | Understand the various functional requirements of automotive applications |
| **CO3** | Introduce the concept of model based control development and testing |

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| **LEARNING OUTCOMES** | |
| **LO1** | Develop control strategy for ICE and other automotive sub systems |
| **LO2** | Able to design and develop control systems for automotive applications |
| **LO3** | Develop plant models for evaluating control strategies |
| **LO4** | Develop MIL and HIL testing frameworks and analyse results |
| **LO5** | Gain proficiency in use tools like Ricardo Wave, Ricardo Ignite and Simulink |

**Content Structure: Revised**

**Mode – Class Room Discussions**

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| **Topic No** | **Topic Title** | **Reference** |
| 1.1 | Introduction to control systems, examples and need. Concepts of control system design, development process |  |
| 1.2 | Over-View of course structure, defining pre-requisites, supplementary study material and time lines |  |
| 1.3 | Introduction to Automotive IC Engines and Electronic Fuel Control, Fundamentals of ICE control |  |

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| **Topic No** | **Topic Title** | **Reference** |
| 2.1 | SI Engine Modelling – Fundamental Equations and their significance |  |
| 2.2 | Air-fuel Ratio & Flame Propagation |  |
| 2.3 | Emissions Formation & Control |  |

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| **Topic No** | **Topic Title** | **Reference** |
| 3.1 | CI Engine Modelling – Comparison with SI Engine |  |
| 3.2 | Direct Injection and Lean Burn – CI vs GDI |  |
| 3.3 | Emissions Formation & Control |  |

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| **Topic No** | **Topic Title** | **Reference** |
| 4.1 | SI Engine Control Requirements |  |
| 4.2 | Lambda Control Circuit & Engine Model for Lambda Control |  |
| 4.3 | Adaptive Lambda Control |  |

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| **Topic No** | **Topic Title** | **Reference** |
| 5.1 | Knock Control in SI Engines |  |
| 5.2 | Knock Sensor, Conditioning & Control |  |
| 5.3 | Cylinder Balancing & Adaptation of injection map |  |

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| **Topic No** | **Topic Title** | **Reference** |
| 6.1 | Engine Mis-Fire Detection |  |
| 6.2 | Kalman Filter Design |  |
| 6.3 | Crankshaft Torque Balance |  |

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| **Topic No** | **Topic Title** | **Reference** |
| 7.1 | Power Train Modelling – Manual and Automatic Gearboxes |  |
| 7.2 | Drive Cycles and Significance of Gear Ratios |  |
| 7.3 | Testing methodology, statutory requirements and standards |  |

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| **Topic No** | **Topic Title** | **Reference** |
| 8.1 | Steer by Wire – EPS control development |  |
| 8.2 | Drive by Wire – Electronic Throttle Control |  |
| 8.3 | Brake by Wire – Electronic Brake Control |  |

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| **Topic No** | **Topic Title** | **Reference** |
| 9.1 | Plant Modelling, Requirements and Applications |  |
| 9.2 | Plant Modelling using Simulink and Simscape |  |
| 9.3 | Data Driven vs Mathematical Models |  |
| 9.4 | Data Extraction Methods – Testing vs Simulation |  |

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| **Topic No** | **Topic Title** | **Reference** |
| 10.1 | 1D Model using Ricardo Wave – Design of Experiments and Data Collection |  |
| 10.2 | Full System simulation using Ricardo Ignite – MIL Testing |  |
| 10.3 | Co-Simulation of Wave & Simulink Models – MIL Testing |  |

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| **Topic No** | **Topic Title** | **Reference** |
| 11.1 | HIL Testing fundamentals, applications and use cases |  |
| 11.2 | Developing HIL testing frame-work for control strategy evaluation |  |
| 11.3 | Automating HIL Test Scripts – Pass / Fail Scenarios |  |

**Evaluation Scheme:**

**Legend:** EC = Evaluation Component; AN = After Noon Session; FN = Fore Noon Session

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| **No** | **Name** | **Type** | **Duration** | **Weight** | **Day, Date, Session, Time** |
| EC-1 | Quiz | online | 2 weeks | 10% |  |
| Assignments / Experiential lab | Virtual / Remote | 2 weeks | 20% |  |
| EC-2 | Mid-Semester Test | Closed Book | 2 hours | 30% |  |
| EC-3 | Comprehensive Exam | Open Book | 3 hours | 40% |  |

**Elearn portal:** https://elearn.bits-pilani.ac.in.

Students are expected to visit the Elearn portal on a regular basis and stay up to date with the latest announcements and deadlines.

**Contact sessions:** Students should attend the online contact sessions as per the schedule provided on the Elearn portal.

**Evaluation Guidelines:**

1. EC-1 consists of Quizzes, assignments, project
2. For Closed Book tests: No books or reference material of any kind will be permitted.
3. For Open Book exams: Use of books and any printed / written reference material (filed or bound) is permitted. However, loose sheets of paper will not be allowed. Use of calculators is permitted in all exams. Laptops/Mobiles of any kind are not allowed. Exchange of any material is not allowed.
4. If a student is unable to appear for the Regular Test/Exam due to genuine exigencies, the student should follow the procedure to apply for the Make-Up Test/Exam which will be made available on the Elearn portal. The Make-Up Test/Exam will be conducted only at selected exam centres on the dates to be announced later.
5. Syllabus for Mid-Semester Test (Closed Book): Contact Hours 1 to 8
6. Syllabus for Comprehensive Exam (Open Book): Contact Hours 1 to 16

It shall be the responsibility of the individual student to be regular in maintaining the self-study schedule as given in the course handout, attend the online lectures, and take all the prescribed evaluation components such as Quizzes, Assignments, Project, Mid-Semester Test and Comprehensive Examination according to the evaluation scheme provided in the handout.

**Instructor-in-charge**

**(AEL ZG510)**