VIT

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

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SCHOOL OF ELECTRICAL ENGINEERING

M. Tech - Power Electronics and Drives

ACE Curriculum & Syllabus -2025

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VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

World class Education: Excellence in education, grounded in ethics and critical thinking, for improvement of life.
Cutting edge Research: An innovation ecosystem to extend knowledge and solve critical problems.
Impactful People: Happy, accountable, caring and effective workforce and students.
Rewarding Co-creations: Active collaboration with national & international industries & universities for productivity and economic development.
Service to Society: Service to the region and world through knowledge and compassion.

VISION STATEMENT OF THE SCHOOL OF ELECTRICAL ENGINEERING

To offer an education that provides strong fundamental knowledge and skills for employability and creates leaders who provide technological solutions to societal and industrial problems.

MISSION STATEMENT OF THE SCHOOL OF ELECTRICAL ENGINEERING

- To prepare students with strong critical thinking and employability skills through personalized experiential learning.
- To create innovators and entrepreneurs by fostering design thinking, creativity and cross-disciplinary research.
- To generate advanced knowledge leading to the solution of societal and industrial problems.

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M.Tech Power Electronics and Embedded Systems

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be engineering practitioners and leaders, who would help solve industry's technological problems.

2. Graduates will be engineering professionals, innovators or entrepreneurs engaged in technology development, technology deployment, or engineering system implementation in industry.

3. Graduates will function in their profession with social awareness and responsibility.

4. Graduates will interact with their peers in other disciplines in industry and society and contribute to the economic growth of the country.

5. Graduates will be successful in pursuing higher studies in engineering or management.

6. Graduates will pursue career paths in teaching or research.

M.Tech Power Electronics and Embedded Systems

PROGRAMME OUTCOMES (POs)

PO_01: Having an ability to apply mathematics and science in engineering applications

PO_02: Having an ability to design a component or a product applying all the relevant standards and with realistic constraints

PO_03: Having an ability to design and conduct experiments, as well as to analyze and interpret data

PO_04: Having an ability to use techniques, skills and modern engineering tools necessary for engineering practice

PO_05: Having problem solving ability- solving social issues and engineering problems

PO_06: Having adaptive thinking and adaptability

PO_07: Having a clear understanding of professional and ethical responsibility

PO_08: Having a good cognitive load management [discriminate and filter the available data] skills

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M.Tech Power Electronics and Drives

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M. Tech. (Power Electronics and Drives) Programme, graduates will be able to

- PSO1: Apply technical knowledge, skills and analytical ability to design, develop and test power electronic converters and drives using modern tools and technologies.

- PSO2: Solve the real world problems in the emerging fields like smart grid, renewable energy interfaces, and electric vehicles and to develop innovative technologies relevant to social, ethical, economic and environmental issues

- PSO3: Solve research gaps and provide solutions to socio-economic, and environmental problems.

M. Tech. Power Electronics and Drives: ACE Curriculum 2025

S.No	Category	No. of Credits
1	University Core	39
2	Professional Core	24
3	Professional Electives	14
4	Open Elective	03
Total Credits		80

University Core (39 Credits)

S.No	Course code	Course title	L	T	P	C
1	MAENG501	Technical Report Writing	1	0	4	3
2	MASTS503	Qualitative and Quantitative Skills Practice I	3	0	0	3
3	MASTS504	Qualitative and Quantitative Skills Practice II	3	0	0	3
4	MASET697	Project work	0	0	20	10
5	MAPED698	Internship I / Dissertation I	0	0	20	10
6	MAPED699	Internship II / Dissertation II	0	0	20	10

Professional Core Courses (24 Credits)

(6 Core Courses, each 4 Credits)

S.No.	Course Code	Course title	L	T	P	C
1	MAPED501	Analysis of Power Converters	3	0	2	4
2	MAPED502	Electric Drives and Control	3	0	2	4
3	MAPED503	Embedded Microcontrollers and Programming	3	0	2	4
4	MAPED504	DSP Control of Advanced Electric Drives	3	0	2	4
5	MAPED505	FPGA Programming and Applications	3	0	2	4
6	MAPED506	Embedded AI and Edge AI	3	0	2	4
Total Credits						**24**

Professional Elective Courses (14 Credits)

(Total : 4 Electives, 4 credits courses -2 No. and 3 credit courses – 2 No.)

S.No.	Course Code	Course title	L	T	P	C
1.	MAPED601	Advanced Semiconductor devices	3	0	0	3
2.	MAPED602	Switched Mode Power Conversion	3	0	0	3
3.	MAPED603	Hybrid and Electric Vehicles	3	0	2	4
4.	MAPED604	IoT System Design	3	0	2	4
5.	MAPED605	Machine Intelligence and Learning	3	0	0	3
6.	MAPED606	Battery Management System	3	0	0	3
7.	MAPED607	Model Based System Development	3	0	2	4
8.	MAPED608	Digital Twin with AI for Power Electronics	3	0	0	3
9.	MAPED609	Intelligent and Autonomous Vehicles	3	0	0	3
10.	MAPED610	Drones and Unmanned Aerial Vehicles	3	0	2	4
11.	MAPED611	Smart Microgrids	3	0	0	3
12.	MAPED612	EMI and EMC in Power Converters	3	0	0	3
13.	MAPED613	Solar Photovoltaic Conversion System	3	0	0	3
14.	MAPED614	Universal Automation	3	0	2	4

Semester wise courses

Fall (First) Semester

S.No.	Course Code	Course title	L	T	P	C
1	MAPED501	Analysis of Power Converters	3	0	2	4
2	MAPED502	Electric Drives and Control	3	0	2	4
3	MAPED503	Embedded Microcontrollers and Programming	3	0	2	4
4	MAPED6xx	Elective-I	3	0	2	4
5	MAPED6xx	Elective-II	3	0	0	3
Total Credits						**19**

Winter (Second) semester

S.No.	Course Code	Course title	L	T	P	C
1	MAPED504	DSP Control of Advanced Electric Drives	3	2	0	4
2	MAPED505	FPGA Programming and Applications	3	0	2	4
3	MAPED506	Embedded AI and Edge AI	3	0	2	4
4	MAPED6xx	Elective-III	3	0	2	4
5	MAPED6xx	Elective-IV	3	0	0	3
Total Credits						**19**

Professional Core Courses

Course code	Course Title	L	T	P	C
MAPED501	**Analysis of Power Converters**	3	0	2	4
Pre-requisite	Nil	Syllabus version			
		v.3			

Course Objectives

1. This course provides an in-depth understanding of the analysis of power converters.
2. Focus is on various power converter circuits and control strategies.
3. Advanced power converters and their PWM control techniques.

Expected Course Outcome

On the completion of this course the student will be able to

1. Analyze the performance of single phase and three phase controlled rectifiers.
2. Evaluate the performance of DC-DC and AC-AC converters for resistive and inductive loads.
3. Illustrate the operation of single-phase and three-phase power factor correction (PFC) converters.
4. Employ various PWM techniques for single-phase and three-phase inverters to enhance their performance
5. Describe the operation of various multilevel inverters.

Module:1	Phase controlled rectifiers	10 hours

Introduction to Advanced Semiconductor Devices and Gate Driver Circuits, Single Phase controlled converters- Continuous and discontinuous conduction mode, Analysis of supply side input current and power factor, Effect of source inductance. Three Phase fully controlled converters- Continuous and discontinuous conduction mode; Harmonic analysis; Effect of source inductance. Multi-quadrant converter, Multi-pulse converter. Design of passive filter for a ripple minimization. PWM Rectifiers – Current type PWM Rectifiers and Voltage type PWM Rectifiers.

Module-2	DC-DC and AC-AC Converters	8 Hours

Step-down DC-DC Converters, single quadrant, Two Quadrant and Four Quadrant converters. Step-up DC-DC Converter, Bi-directional DC-DC converters.

Single phase ac voltage controllers, Single phase PWM AC Voltage controller, harmonic analysis of output voltage. Three Phase AC Voltage controllers – Star and delta connection of Thyristors. Matrix Converters- Sparse Matrix Converters, Z-Source Matrix Converters.

Module:3	**PFC Converters**	**7 hours**
PWM Boost-Type Rectifiers, DC-Side PWM Boost-Type Rectifier, Constant-Frequency Control- Constant-Tolerance-Band (Hysteresis) Control, Source-Side PWM Boost-Type Rectifiers, Tapped-Transformer Converters, Single-Stage PFC AC/DC Converters- Operating Principles.		
Module: 4	**PWM Inverters**	**9 hours**
Single phase Square wave Voltage Source Inverter (VSI), Harmonic analysis of Inverter output voltage, Effect of Blanking time on inverter output voltage, Current Source Inverter (CSI). Three phase square wave VSI – 120^0 and 180^0 modes of operation, comparison. PWM Techniques: Sine-triangle PWM, Space vector PWM, comparison of SVM and regular sampled PWM -Naturally Sampled SVM- Placement of the Zero Space Vector – Discontinuous SVM- 120^0 Discontinuous Modulation- 60° and 30° Discontinuous Modulation- Space Vector Approach to Over-modulation. Current control PWM techniques: Hysteresis control, Predictive current control.		
Module: 5	**Multilevel Inverters**	**9 hours**
Multilevel Inverters: Diode-clamped, Flying Capacitor, Cascaded H-Bridge inverters. Basics of carrier based PWM techniques for MLIs – Three level naturally sampled Phase Disposition PWM (PDPWM) – Three level naturally sampled Phase Opposition Disposition PWM (PODPWM) – Alternative Phase Opposition Disposition PWM (APOD PWM) technique.		
Module:6	**Contemporary Topics**	**2 hours**
	Total Lecture hours:	**45 hours**
Text Book(s)		
1.	Andrzej M. Trzynadlowski,"Introduction to Modern Power Electronics", 3rd Edition, Wiley Publications, 2016.	
2.	Fang Lin Luo, Hong Ye, "Power Electronics- Advanced Conversion Technologies", CRC Press, 2018	
3	D.Graham Holmes and Thomas A. Lipo, "Pulse Width Modulation for Power Converters – Principles and Practice", IEE Press, John Wiley & Sons, 2023.	
Reference Books		
1.	Muhammad H. Rashid, "Power Electronics-Circuits, Devices and Applications", Prentice Hall India, New Delhi, 2017.	
3.	William Shepherd and Li Zhang, "Power Converter Circuits", Marcel Dekker Inc, New York, 2004.	

4.	Ned Mohan, Tore M. Undeland, "Power Electronics – Converters, Applications and Design", John Wiley & Sons, 2008.

Suggested Lab Experiments

1. Performance analysis of single phase thyristor based fully controlled converter with R and RL loads
2. Performance analysis of three phase thyristors based fully controlled converter with R and RL loads
3. Performance analysis of single phase PWM Rectifier for R and RL loads with different switching frequencies
4. Performance of single-phase ac voltage controller for R and RL loads
5. Performance analysis of three phase ac voltage controller for R-Load
6. Performance analysis of DC-DC buck converter for R load without and with filter
7. Performance analysis of DC-DC boost converter for R load without and with filter
8. Performance analysis of closed loop control of DC-DC boost converter for R-load
9. Performance analysis of single phase PWM Inverter for R and RL-Loads
10. Performance analysis of SiC based Three phase PWM Inverter for R and RL-Loads
11. Performance analysis of three phase IGBT based PWM Inverter for induction motor load
12. Performance analysis of 3-level voltage source inverter for R-Load
13. Performance analysis of bidirectional DC-DC converter for R-load
14. Implementation strategy of Space vector PWM for 3-phase PWM Inverter for R-Load using MATLAB/Simulink Embedded coder
15. Performance analysis of single-phase boost converter-based Power factor correction converter for R-Load.

Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT

Recommended by Board of Studies	23-05-2025		
Approved by Academic Council	No.	Date	

Course Code	Course Title	L	T	P	C
MAPED502	Electric Drives and Control	3	0	2	4
Pre-requisite	Nil	Syllabus version			
		v.2			

Course Objectives

1. This course aims to develop an in-depth understanding of the control and analysis of electric motor drives.
2. It emphasizes advanced drive control methods
3. Focuses on the applications of electric drives in industrial and electric vehicle sectors.

Expected Course Outcome

On the completion of this course, the student will be able to:

1. Analyse the dynamic and steady state control of dc motor drives under different operating conditions.
2. Apply various scalar control techniques of 3-phase induction motor drive that include stator side and rotor side control.
3. Evaluate the performance of three phase induction motor drives considering torque, speed, efficiency through FoC and DTC control schemes.
4. Apply modern control techniques such as vector control, direct torque control, and sensorless control to PMSM and BLDC Motor drives.
5. Develop control schemes for switched reluctance motor and Synchronous motor drives.

Module-1:	DC Motor drives	10 hours

Controlled rectifier fed DC motor drive, Single phase fully-controlled converter drives. Three phase fully-controlled converter drives. Multi-quadrant operation with fully-controlled converter. Chopper fed DC motor drive; Open loop and Closed loop control, four quadrant operations. Braking methods of DC motor drive.

Module.2:	Scalar control of Induction motor drive	9 hours

Stator side control- Stator voltage control, variable frequency control, V/f control, open-loop and closed loop control. Soft starting methods, Braking methods -plugging - dynamic braking - regenerative braking. Torque and power limitations. Rotor side speed control: Static rotor resistance control, Kramer’s drive, Scherbius drive, doubly fed induction motor drive – modes of operation.

Module:3	FoC and DTC of Induction Motor Drive	10 hours
D-Q model of three phase induction motor, Stator reference frame, Rotor reference frame and synchronously rotating reference frame, Equivalent circuits, Dynamic model of three phase induction motor in state space form with currents and flux linkages as state variables. Principle of Field-oriented Control (FoC), steady state equivalent circuit, decoupling circuits in rotor-flux oriented reference frame. Direct FOC; flux vector estimation-voltage model and current model. Indirect FOC. Principle of Direct Torque Control (DTC), torque expression with stator and rotor fluxes, voltage vector switching tables for DTC, space vector pulse width modulation based DTC.		
Module:4	**Control of PMSM and BLDC Motor Drives**	**7 hours**
Sinusoidal permanent magnet synchronous machine (PMSM) drives; surface permanent magnet and interior permanent magnet machines. FoC of PMSM. FoC flux weakening mode; maximum torque per ampere (MPTA) control, maximum power factor control. Direct torque control for PMSM. FoC and DTC of BLDC Motor drive.		
Module:5	**Control of SRM and Syn. RM**	**7 hours**
Switched Reluctance Motor Drive and Synchronous reluctance motor: Principle of operation, converter circuits, speed control and performance analysis.		
Module:6	**Contemporary Topics**	**2 hours**
Total Lecture hours:		**45 hours**

Textbook(s)	
1	Bimal K Bose, “Modern Power Electronics and AC Drives”, Pearson Education Asia, 2012.
2	R. Krishnan, “Electric Motor drives”, Second edition, Pearson Education India, 2015.
Reference Books	
1	Peter Vas “Sensorless Vector and Direct Torque Control”, Monographs in Electrical and Electronic Engineering, 1998.
2	Rik De Doncker, Duco W.J Pulle, and Andre Veltman, “Advanced Electric Drives”, Analysis, Modeling and Control, Springer, 2011.

Suggested Lab Experiments			
1. Conduct an experiment on Microcontroller based single phase fully controlled converter fed DC motor drive. 2. Conduct an experiment on Microcontroller based three phase fully controlled converter fed DC motor drive. 3. Conduct an experiment on Closed loop speed control of DC Motor drive 4. Conduct an experiment on V/f control of 3-phase induction motor drive 5. Conduct an experiment on speed control of BLDC Motor drive 6. Conduct an experiment on speed control of PMSM Motor drive 7. Conduct an experiment on speed control of SRM Motor drive 8. Conduct an experiment on chopper fed DC Motor drive 9. Conduct an experiment on SiC based MOSFET inverter fed 3-phase induction motor 12. Conduct an experiment on speed control of single phase induction motor drive 13. Conduct an experiment on speed control of BLDC hub motor 14. Speed control of slip ring induction motor using slip power recovery schemes.			
Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT			
Recommended by Board of Studies	23-05-2025		
Approved by Academic Council	No.	Date	

Course code	Course title		L	T	P	C
MAPED503	Embedded Microcontrollers and Programming		3	0	2	4
Pre-requisite	Nil	Syllabus version				
		v. 1				

Course Objectives

1. To impart embedded system concepts
2. To impart programming concepts
3. To emphasize embedded system and programming concept significance in the design process of embedded systems.

Course Outcomes

After completion of the course, students will be able to

1. Design an embedded system for power electronics applications
2. Analyse the operating system of a given system and debug.
3. Explain functional overview of ARM processors
4. Demonstrate the generation of triggering pulses for power converters using different peripherals through embedded C programming
5. Illustrate the interrupt programming for the ARM processor to vary the real time parameter.

Module:1	Introduction to Embedded systems	9 hours

Introduction to Embedded Systems: Embedded system processor - hardware unit - software embedded into a system. Embedded Design life cycle. Layers of Embedded Systems: Preprocessing, Compiling, Cross Compiling, Linking, Locating. Compiler Driver - Linker Map Files, Linker Scripts and scatter loading. Loading on the target. Embedded File System: Pre-Processor directives, Structures and Unions, Enumeration Pointers, Scope of Variables. Embedded C programming for power converter applications

Module:2	ARM Processors	9 hours

Arm processor architecture and pipelining. programmer's model. data paths and instruction decoding; Advanced Microcontroller Bus architecture; ARM instruction set; addressing modes; functional overview of ARM Cortex M; Pinouts and pin description, GPIOs; System configuration controller (SYSCFG). General Purpose Input and Output (GPIO); Analog to Digital Converter; Digital to Analog Converter; Programming.

Module:3	Timers and PWM	9 hours

Different modes of operation of Timers; Match Registers; Generation of PWM using Compare registers; Capture Control; Single and Double Edge Controlled PWM; programming to generate

triggering pulses for power converters.		
Module:4	**Interfacing and Interrupts**	**8 hours**
System Control; RTC, WatchDog Timer, USB 2.0 Full-Speed device controller with DMA, Communication interface; UART, I2C Bus Serial Interface, SPI, SSP Serial Interfaces, CAN. Exception handling overview; Interrupts; Interrupt Handling Schemes; External Interrupt, Timer Interrupt, PWM Interrupt, ADC Interrupt; Utility of interrupts in closed loop control of a real time system; programming.		
Module:5	**Multicore Processors**	**8 hours**
Overview of single core processor architecture and its limitations, Architectural Innovations, Need for Multi-core processor and its limitations, classification of multicores, multicore system software stack, GPUs as parallel computers – architecture of a modern GPU, overview of real-time operating systems and their role in embedded systems development		
Module: 6	**Contemporary Topics**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Dr. Yifeng Zhu, "Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C" Fourth edition E-Man Press LLC, 2023
2	Wayne Wolf "Computers as components : Principles of Embedded Computing System Design",The Morgan Kaufmann Series in Computer Architecture and Design,2017

Reference Books

1.	Joseph Yiu, "The Definitive Guide to ARM Cortex M3 and Cortex M4 Processors" Newnes, Elsevier, 2014
2.	Carl Hamacher, Zvonko Vranesic, Safwat Zaky, Naraig Manjikian, "Computer Organization and Embedded Systems", Mc Grawhill International Edition, 2012
3.	Shibu K.V, "Introduction to Embedded Systems", Tata Mc Grawhill, 2014
4.	Vincent Mahout, "Assembly Language Programming ARM Cortex M3" Wiley 2012
5.	Larry D. Pyeatt, "Modern Assembly Language Programming with the ARM Processor", Newnes, Elsevier 2016.

Suggested Lab Experiments

1. Embedded C programming for interfacing DAC
2. Embedded C programming for interfacing ADC
3. Interfacing ARM controller with DAC for the generation of analog sinusoidal signal
4. Single-phase half controlled converter control using ARM based controller

5. Temperature measurement through LM35 and ADC interfacing with ARM based controller.
6. Programming for ARM controller to generate triggering pulses for inverters
7. Generation of PWM pulse train for DC-DC chopper converter control using ARM controller
8. Program which uses timer interrupt and external interrupt to generate triggering pulses for variable frequency inverter.
9. Program to generate sine PWM using PWM interrupt
10. Program for controlling the speed of DC motor using ADC interrupt.
11. Program to control the DC motor through UART port of ARM Processor
12. Program for interfacing master and slave devices using SPI protocol
13. Program for interfacing two different ARM processor through I2C protocol.
14. Embedded C programming to connect different microcontrollers through CAN protocol
15. Interfacing of ARM controller with different sensors using I2C communication protocol.

Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT			
Recommended by Board of Studies	23-05-2025		
Approved by Academic Council	No.	Date	

Course Code	Course Title	L	T	P	C
MAPED504	**DSP Control of Advanced Electric Drives**	**3**	**0**	**2**	**4**
Prerequisite	Electric Drives and control	**Syllabus version**			
		v.1			

Course Objectives

1. To provide students in-depth understanding of the DSP control of electric motor drives
2. To provide a comprehensive knowledge on operational characteristics of axial flux and linear motors
3. To emphasize the application of axial flux motors in high-torque, compact systems and linear motors in high-speed transportation technologies such as the Hyperloop

Expected Course Outcome

On the completion of this course, the student will be able to:

1. Develop control algorithms through programming on DSP processors for motor control applications.
2. Interface the peripherals of the DSP processor and utilize the code composer studio for motor control applications.
3. Implement speed control strategies of Induction motor, PMSM and BLDC Motor drive using DSP processors.
4. Interpret the performance characteristics (torque-speed curves, losses, efficiency) of axial flux motors and assess their suitability for various applications such as EVs.
5. Explain the operating principles and types of linear motors, including Linear Induction Motors (LIMs) and Linear Synchronous Motors (LSMs), with a focus on their relevance to high-speed transport.

Module-1:	**Introduction to DSP Processors**	**8 hours**

Introduction-DSP architecture, Requirements of digital signal processing for power electronics, Introduction to Peripherals -Types of Physical Memory - The Components of the C2xx DSP Core - System configuration registers-Memory Addressing modes - Instruction set – Programming techniques – simple programs. Timers, PWM generation, ADC, Serial Communication, GPIO, Flash Memory

Module.2:	**Peripherals of DSP Processors and CCS**	**10 hours**

General purpose Input/output (GPIO) Functionality- Interrupts - A/D converter-Event Managers (EVA, EVB)- PWM signal generation.

Code Composer Studio Basics: Introduction to CCS as IDE for TI processors, Basics of CCS, Multiprocessing with CCS, Testing Program, debugging Breakpoints, points, Using file I/O Code Composer Studio Advanced Facilities: Memory map, Watch window, Integrated editor. Software Development Tools: Overview, description, object module, program loading and running, Assembler, Assembler directives, Macros, Linker, using C language Writing program for some simple objectives like initializing peripheral, timer interrupt and ISR for timer interrupt, PWM generation		
Module:3	**DSP-Based Control of Induction motor, PMSM and BLDC**	**9 hours**
DSP Implementation.- Space Vector Pulse Width Modulation, Constant V/Hz Control for Induction Motors. Field oriented Control of (FoC) of PMSM/BLDC motor drives. Performance analysis. Implementation aspects. Speed Sensorless FoC of PMSM/BLDC Motor drives.		
Module:4	**Axial Flux Motors**	**8 hours**
Comparison with radial flux machines, Key advantages: high torque density, compact form factor, Construction and Working Principles - Basic structure: rotor, stator, air gap, Single-rotor vs. double-rotor designs, Materials used: magnets, stator laminations, cooling systems. Control of Axial Flux Motors -Inverter configurations, Sensor and sensorless control techniques, Vector control and direct torque control (DTC). Applications of Axial Flux Machines, Electric vehicles (EVs), drones, aerospace propulsion.		
Module:5	**Liner Motors for High Speed Transport**	**7 hours**
Concept and vision of Hyperloop, Comparison with existing systems (Maglev, HSR, Vacuum Tube Trains), Global initiatives and key players (e.g., SpaceX, Virgin Hyperloop, Hardt). System Architecture and Subsystems-Overview of Hyperloop system design, Key subsystems: capsule (pod), tube, propulsion, levitation, guidance, and infrastructure, System integration challenges. Propulsion and Braking Systems-Linear Induction and Linear Synchronous Motors (LIM/LSM), Air propulsion vs. electromagnetic propulsion, Regenerative and emergency braking systems, Energy requirements and efficiency analysis.		
Module:6	**Contemporary Topics**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books	
1	Hamid A.Toliyat, Steven Campbell, "DSP based electromechanical motion control", CRC Press, Special Indian Edition.
Reference Books	
2	Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 2010

3	B. K. Bose, “Modern Power Electronics and AC Drives,” Prentice Hall, 2002.

Suggested Lab Experiments

1. Interface analog to digital converter (ADC) with DSP controller board
2. Development of sinusoidal PWM technique using DSP Controller board
3. Speed control of 3-phase induction motor using DSP controller
4. Speed control of 3-phase BLDC Motor using DSP controller
5. Speed control of 3-phase PMSM using DSP Controller
6. Speed control of multilevel inverter fed 3-phase induction motor using DSP controller
7. Sensorless FoC control of 3-phase induction motor using DSP controller
8. Sensorless FoC control of PMSM using DSP controller.
9. DTC control of 3-Phase Induction motor drive
10. DTC Control of PMSM drive
11. Performance analysis of Axial flux motor for EV application using MATLAB/Simulink
12. Performance analysis of Linear Induction Motor using MATLAB/Simulink

Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT			
Recommended by Board of Studies		23-05-2025	
Approved by Academic Council	No.	Date	

Course Code	Course Title		L	T	P	C
MAPED505	**FPGA Programming and Applications**		**3**	**0**	**2**	**4**
Pre-requisite	**Nil**	**Syllabus version**				
		v. 2				

Course Objectives

1. To enhance students' understanding of Field-Programmable Gate Arrays (FPGAs) and their architecture.
2. Applying FPGAs in advanced digital control system design for real-world engineering challenges.
3. To provide hands-on experience in developing and implementing complex control algorithms using FPGA platforms.

Course Outcome

On the completion of this course the student will be able to:

1. Interpret different components of the FPGA board.
2. Describe the various abstraction levels of Verilog HDL and VHDL for code development.
3. Model the combinational and sequential circuits in Verilog HDL and VHDL to control the power electronic circuits through different peripherals.
4. Implement Verilog HDL and VHDL program for interfacing external peripherals to FPGA board.
5. Develop open loop and closed loop control techniques for power electronics using Verilog HDL and VHDL code.

Module:1	**Introduction to FPGA**	**6 hours**

Development and evolution of digital devices - design and verification tools, Introduction to Field Programmable Gate Arrays – CPLD Vs FPGA, Abstraction levels of digital system design - Configurable logic Blocks (CLB), Input/Output Block (IOB), Programmable Interconnect Point (PIP), Wide edge decoder – Xilinx 4000 series - Overview of Spartan and Virtex FPGA boards. Significance of FPGA in Power Electronics

Module:2	**Verilog HDL and VHDL Programming**	**7 hours**

Introduction to Verilog HDL and VHDL; simulation using Xilinx Webpack - Modeling styles: Behavioral, Dataflow, and Structural Modeling, Gate delays, Switch-level Modeling, Hierarchal structural modeling. Verification of design files - Functional verification, simulation types, Test Bench design, Value change dump (VCD) files.

Module:3	**Programming for Combinational and Sequential Logic Circuits**	**12 hours**
Verilog HDL and VHDL program for combinational logic circuits – Adder/subtractor – Multiplexers – De-multiplexers – Encoders – Priority Encoder - Decoders – Comparators. Verilog HDL and VHDL program for sequential logic circuits - Flip-Flops, Shift Registers, Counters, Clock divider circuit – Generation of multi-phase clock- Generating triggering pulses for power converters, Open loop control of power converters, Finite State Machine Modelling.		
Module:4	**Interfacing Peripherals with FPGA Board**	**9 hours**
Verilog HDL and VHDL program for fixed point implementation of P, Pl, PID, etc. Modelling phase locked loop. Filter design. Interface ADC and DAC blocks with FPGA. Interface LCD, seven segment display, proximity sensor and rotary encoder for speed measurement. UART communication in FPGA.		
Module:5	**FPGA Applications to Power Electronic System**	**9 hours**
Closed loop control of power converters - Gate Pulse generation for DC-AC converter, AC-DC converter, PWM generation for Buck/boost Converter, Bidirectional DC-DC converter control, SPWM generation. Multi-level inverter control. Implementation of MPPT in FPGA. DC motor control, Induction Motor Control.		
Module:6	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Samir Palnitkar, “Verilog HDL: A Guide to Digital Design and Synthesis” Pearson, Second Edition, 2009.
2	Wayne Wolf, “FPGA-Based System Design”, Prentice Hall India Pvt. Ltd., 2005.

Reference Books

1	Frank Bruno; Guy Eschemann, “The FPGA Programming Handbook: An essential guide to FPGA design for transforming ideas into hardware using System Verilog and VHDL” , Packt Publishing, Second Edition, 2024.
2.	Woods, R., McAllister, J., Yi, Y. and Lightbody, G, “FPGA-based implementation of signal processing systems”, John Wiley & Sons, 2017.
3.	M. H. Rashid, “Power Electronics: Circuits, Devices and Applications”, Pearson, 3rd edition, 2013.
4.	J Bhasker, “A Verilog HDL Primer”, Second edition, Star Galaxy Publishing, 1999.

Suggested List of Experiments

1. Implement Verilog HDL and VHDL code with test-bench for various combinational circuits.
2. Implement multi-phase clock and multi-frequency clock circuit with test-bench using Verilog HDL and VHDL in FPGA board.
3. Implement sequence detector using FSM (Mealy and Moore) in using Verilog HDL and VHDL
4. Implement P, PI, PID controller for closed loop control of DC-DC converter using Verilog HDL and VHDL.
5. Interface analog to digital (ADC) converter with FPGA using Verilog HDL and VHDL.
6. Interface digital to analog converter (DAC) with FPGA using Verilog HDL and VHDL.
7. Implement voltage regulation technique for buck/boost converter using FPGA.
8. Performer analysis of single-phase rectifier with R and R-L load using FPGA.
9. Performer analysis of single-phase full- bridge inverter with R and R-L load using FPGA.
10. Implement two way power flow control technique for Bi-directional DC-DC converter using FPGA.
11. Speed control of DC motor using FPGA controller.
12. Speed control of three-phase induction motor using FPGA controller.
13. Performer analysis of three phase inverter in 180^0 and 120^0 conduction modes using FPGA.
14. Performer analysis of diode clamp Multi-level inverter using FPGA.
15. Implementation of maximum power point tracking for photovoltaic system using FPGA controller.

Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT			
Recommended by Board of Studies	23-05-2025		
Approved by Academic Council	No.	Date	

Course Code	Course Title	L	T	P	C
MAPED506	**Embedded AI and Edge AI**	**3**	**0**	**2**	**4**
Prerequisite	**Nil**	**Syllabus version**			
Anti-requisite					
		v. 1			

Course Objectives

1. To understand the limitations of resource constrained embedded systems
2. To introduce the development process of embedded AI and edge computing systems
3. To develop, deploy and inference the TinyML models for microcontrollers, edge devices and IOT devices for condition monitoring and control of power electronic systems.

Course Outcomes

After completion of the course, students will be able to

1. interpret the on-chip features of ARM Cortex-M processor and its programming
2. determine the suitable machine learning model for the given application
3. choose suitable processor and AI accelerator for the given application
4. outline the process of embedded AI and edge AI system development
5. identify the application of embedded AI system in the electric drives and power electronic systems

Module:1	**Introduction to Embedded AI and Edge AI**	**4 hours**

Review - Artificial Intelligence, Machine learning, deep learning. Introduction to TinyML, TensorFlow Lite. Difference between cloud-based AI and embedded AI. Resource constrained embedded systems. Overview of embedded AI and edge computing

Module:2	**ARM Cortex-M55 Processor**	**12 hours**

ARM Cortex-M55's Armv8.1-M architecture, processor core, programmer's model, instruction set, 4-stage pipeline, memory organization, memory protection unit (MPU), exception handling, ARM Helium vector instruction set, security zone, ARM Ethos-U55 microNPU

Embedded C programming - compiler optimizations, linker optimizations, debug & trace, floating point and DSP instructions. CMSIS-NN: convolution functions, activation functions, fully connected layer functions

Module:3	**Embedded AI**	**10 hours**

Basics of Python programming – NumPy, Matplotlib, TensorFlow. CNN Neural network

development using TensorFlow and Keras. Model optimization – quantization, weight pruning, weight clustering using TensorFlow Lite optimization toolkit. Image classification with CNNs. Development of Embedded Artificial Intelligence Systems - Assessment of system requirements, selection of ML model, data preparing and processing, model training and optimization, model deployment, security measures, testing and validation, continuous monitoring and optimization		
Module:4	**Edge AI**	**10 hours**
Kye components of edge computing-Intelligent edge sensing devices, edge gateways and nodes, data processing at the edge. Edge AI and ML technologies – AWT IoT Greengrass, Azure IoT Edge, IoT architecture with edge AI, tinyML as SaaS model. Industrial predictive maintenance		
Module:5	**Applications of Embedded AI**	**7 hours**
Space vector PWM controller using deep learning model, Deep learning based fault diagnostic system for a multilevel inverter, RNN based speed control of induction motor drive, deep reinforcement learning algorithm based PMSM motor control.		
Module: 6	**Contemporary Topics**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Vermesan, Ovidiu, Mario Diaz Nava, and Björn Debaillie, eds, "Embedded artificial intelligence: Devices, embedded systems, and industrial applications", CRC Press, 2023.
2	Situnayake, Daniel, and Jenny Plunkett, " AI at the Edge" , O'Reilly Media, Inc., 2023.
Reference Books	
1.	Martin, Trevor, "The designer's guide to the Cortex-M processor family", Newnes, *2022.*
2.	Li, Bin. "Embedded Artificial Intelligence." Embedded Artificial Intelligence: Principles, Platforms and Practices. Singapore: Springer Nature Singapore, 2024. 3-25.

Suggested list of Experiments

1. TinyML development with TensorFlow Lite using CMSIS-NN and Ethos-U55
2. Deploying a Convolutional Neural Network on Cortex-M board with CMSIS-NN
3. Running a deep learning computer vision model on cortex M board with CMSIS-NN
4. Development, deployment and testing of linear regression tinyML model on Embedded controller board
5. Development, deployment and testing of support vector machine tinyML model on Embedded controller board

6. Development, deployment and testing of decision trees tinyML model on Embedded controller board
7. Development, deployment and testing of sequential dense neural network model on Embedded controller board
8. Embedded AI integration with MATLAB – Getting started
9. Generation of C code for ARM Cortex-M processor with MATLAB embedded coder support package
10. Classifying images with CNNs using MATLAB
11. Classifying sequence data with RNNs using MATLAB
12. DC-DC Power converter aging severity detection using MATLAB
13. Fault detection of electric vehicle charger using MATLAB
14. Physical system modelling using long short-term memory (LSTM) neural network in Simulink
15. Building a “high-five” counter using deep learning

Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT			
Recommended by Board of Studies	23-05-2025		
Approved by Academic Council	No.	Date	

Professional Elective Courses

Course Code	Course Title	L	T	P	C
MAPED601	**Advanced Semiconductor Devices**	**3**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		v.2			

Course Objectives

1. To understand the physical principles and operational characteristics of advanced semiconductor devices such as SiC and GaN.
2. To analyze the performance parameters including breakdown voltage, ON-resistance, and safe operating area relevant to power electronics applications.
3. To evaluate the application of advanced semiconductor devices in the design and optimization of modern power electronic systems.

Expected Course Outcome

On the completion of this course the student will be able to

1. Identify appropriate power semiconductor switches based on its rating and device selection suitable for application
2. Design appropriate protection circuits to provide protection against over voltages and currents to safe guard the Power semiconductor switches.
3. Interpret important parameters governing the high speed performance of SiC devices and circuits
4. Analyze appropriate gate drivers for WBG devices for safe operation of the device under steady state and dynamic operations of the device.

Module	Title	Hours
Module:1	**Introduction to Semiconductor devices**	**7 hours**

Controlled Power semiconductor devices, types, steady state and dynamic models of MOSFET and IGBTs. Turn-on and Turn-off characteristics of MOSFET, IGBT and Thyristors, device datasheet.

Module	Title	Hours
Module:2	**Gate Driver and Protection Circuits for IGBT and MOSFET .**	**8 hours**

Isolation circuits, pulse transformer, opto-coupler – Gate drives circuit - Design of Snubbers; Thermal management; heat sink – selection, types and mounting types, simulation of gate drive circuits.

Module	Title	Hours
Module:3	**SiC Power MOSFET and IGBT**	**12 hours**

Characteristics of SiC planar power MOSFETs, Forward conduction and forward blocking, Dynamic

operation, Commercial specifications of SiC planar power MOSFETs, Reliability issues, Structure and characteristics of Trench MOSFETs, SiC IGBTs: Structure and Operation, Latch up and Safe Operating Area (SOA).		
Module:4	**GaN HFET**	**9 hours**
Basics of GaN High Electron Mobility Transistors (HEMT), Planner and Lateral GaN power HFET: On-resistance, switching characteristics, Gate control. Normally-off GaN HFET structure, Current Aperture Vertical Electron Transistors (CAVETs), Reliability of GaN-Based Power Devices, Switching Safe Operating Area (SSOA).		
Module:5	**Gate drivers for WBG devices and applications**	**7 hours**
Understanding the dynamic behavior of gate circuit. Effect of stray parameters on gate circuit, and switching behavior. Mitigation of EMI. Active gate driver – thermal management, EMI mitigation, and device paralleling, WBG devise based - Isolated converters. Effect of stray inductances and parasitic capacitance on converter performance		
Module:6	**Contemporary Topics**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	B. J. Baliga, “Gallium Nitride and Silicon Carbide Power Devices”, World Scientific, 2017
2.	G. Meneghesso, M. Meneghini, E. Zanoni, “Gallium Nitride-enabled High Frequency and High Efficiency Power Conversion,” Springer International Publishing, 2018.
3.	B. Jayant Baliga “Fundamentals of Power Semiconductor Devices”, Springer Science , 2008
Reference Books	
1.	F. Wang, Z. Zhang and E. A. Jones, “Characterization of Wide Bandgap Power Semiconductor Devices”, IETEnergy Engineering, ISBN-13: 978-1785614910 (2018)
2.	Rashid M.H., "Power Electronics: Circuits, Devices and Applications ", Pearson Education, 4th edition June 2014.
3.	Ned Mohan, Tore M. Undeland, “Power Electronics – Converters, Applications and Design”, John Wiley & Sons, 3rd edition 2007.
Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT	

Recommended by Board of Studies	23-05-2025		
Approved by Academic Council	No.	Date	

Course code	Course title	L	T	P	C
MAPED602	**Switched Mode Power Conversion**	**3**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		v.3			

Course Objectives

1. To provide a thorough understanding of switch-mode power converters, covering their topologies, steady-state and dynamic behaviour.
2. To understand the control methods, and design aspects, with a focus on practical applications.
3. To classify resonant converters and simulate SMPS applications using open-source tools.

Course Outcomes

After completion of the course, students will be able to

1. Analyze and develop circuit models for various non-isolated DC-DC converters under steady-state operating conditions.
2. Analyze different isolated DC-DC converters for steady-state operation
3. Design passive components of DC-DC converters
4. Develop and analyze dynamic models of switched-mode DC-DC converters using averaging techniques, and design control loops based on small-signal models.

Module:1	**Non-Isolated DC-DC converters**	**12 hours**

Buck, Boost, Buck-boost and Ćuk converters: Principles of steady-state analysis - Inductor volt-seconds balance and capacitor amp-seconds balance – Operation in Continuous Conduction Mode (CCM)- Voltage Gain – design of filter inductance & capacitance - boundary between continuous and discontinuous conduction – critical values of inductance/load resistance - Discontinuous Conduction Mode (DCM) -Voltage Gain in DCM - losses and efficiency calculations.

Module:2	**Isolated DC-DC converters**	**9 hours**

Single-switch and multi-switch transformer-isolated DC-DC converters. Fly back converter: Operation and waveforms in continuous & discontinuous conduction modes – Voltage gain. Forward converter in CCM: Basic forward converter with ideal transformer – practical forward converter with core reset – double ended forward converter. Push-Pull, Half-Bridge and Full-Bridge

converters: Operation in Continuous Conduction Mode (CCM). Voltagefed and current-fed converters.		
Module:3	**Design Consideration**	**8 hours**
Design of high frequency Inductor and transformer for SMPS application; Input filter design – practical magnetic design; design aspects to be considered for designing transformers for specific applications – flyback, forward converters. Design of dc bus capacitor – Selection of switches – Minimizing converter layout parasitics – Heat sink selection and thermal design – EMI issues.		
Module:4	**Dynamic Analysis and Control of Switching Converters**	**9 hours**
AC equivalent circuit modelling of converters: dynamic equation of buck, boost and buck- boost converters; Small signal model and converter transfer functions; Control of converters; voltage and current mode control; PWM controller Integrated circuits, Sliding Mode Control Implementation: Buck, Boost and Buck-Boost Converters.		
Module:5	**Resonant Converters and SMPS Applications**	**8 hours**
Classification: Series resonant circuit-parallel resonant circuits; Resonant switches; Zero voltage switching and Zero current switching; Soft switched bidirectional dual active bridge converters. Application - Low Input SMPS for Laptops, Computers and Portable Electronic devices, EV charging systems; Case studies: Power Supply design and simulation using open source tools and built-in Python libraries- NumPy, SciPy, and Matplotlib.		
Module: 6	**Contemporary Topics**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Robert W. Erickson and Dragan Maksimovic, "Fundamentals of Power Electronics", Springer, 3rd edition, 2020.
2	Ned Mohan, Undeland and Robbin, "Power Electronics 3ed (An Indian Adaptation): converters, Application and design" Wiley India Pvt Ltd, 3rd Edition, 2022
Reference Books	
1.	Philip T Krein, "Elements of Power Electronics ", Oxford University Press, 2nd Edition, 2017.
2.	Simon Ang, Alejandro Oliva, "Power-Switching Converters", CRC Press, Vol. No., 3rd Edition, 2010

Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT			
Recommended by Board of Studies	23-05-2025		
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	Course Title	L	T	P	C
MAPED603	**Hybrid and Electric Vehicles**	**3**	**0**	**2**	**4**

Prerequisite	**Nil**	**Syllabus version**
		v.2

Course Objectives

1. Providing knowledge on Electric vehicles and its architectures.
2. Concepts of Advanced Driver Assistance System
3. Charging methods of EVs.

Course Outcome

At the end of this course the student will be able to:

1. Apply vehicle dynamics concepts to hybrid and electric vehicles
2. Describe the different architectures of Hybrid Electric vehicles
3. Analyze various electric powertrain architectures
4. Develop ADAS to Electric and Hybrid Electric Vehicles
5. Comprehend the various charging methods of EVs and their constraints

Module:1	**Vehicle dynamics**	**9 hours**

Review of Conventional Vehicles; Social and environmental impacts of ICE vehicles;
Vehicle forces - Longitudinal forces and resistances - Rolling resistance, Aerodynamic drag, Traction force, Deceleration and speed control, brake drag, Road gradient forces. Performance characteristics - Maximum tractive effort - Power plant and Transmission characteristics - Braking performance- Brake force distribution, brake efficiency, braking distance, Anti-lock brake system and Traction control system.

Module:2	**Hybrid Electric Power trains**	**8 hours**

Classification: Micro, Mild and Full hybrid; Plug in HEV, case studies of HEV, Fuel economy improvement in HEVs, effect of driving cycles on fuel economy enhancement and emission reduction, driving cycles and road conditions on fuel economy, Engine OFF/ON decisions, engine operating point optimization, and Regenerating braking control.
Hybrid Electric Powertrains: Series hybrid, Parallel hybrid and Power split hybrid - Operating modes, Power flow control, and comparison.

Module:3	**Electric Vehicle Power Train Architectures**	**8 hours**

Components of electric vehicle; Electric drivetrain topologies based on Drain drivetrain architecture and Energy sources, complete structure of EV, Fuel cell electric vehicle powertrain, Fuel cell

combined with other energy storage systems. Solar electric vehicle powertrains. In wheel motors, design of in wheel motors. Components of e-axle and Design of e-axle system. Dynamics behavior of the vehicle based on the battery pack location - Dynamics aspects based on the motor location and power distribution - NVH challenges for the EV and HEV.		
Module:4	**Advancements in Vehicle dynamic Control systems**	**9 hours**
Role of ADAS, ADAS Levels, ADAS features - Adaptive Cruise Control, Adaptive Headlights, Antilock Brake Systems, Automatic Parking Assistance, Autonomous Emergency Braking, Blind Spot Monitor, Electronic Stability Control, Forward Collision Warning, Lane-departure Warnings, Lane Centering Steering, Lane-keeping assistance. ISO 26262		
Module:5	**EV Charging Systems**	**9 hours**
BMS- Functions, design considerations and various components; On-board and OFF board chargers; EV charging standards- CHAdeMO, CCS2, GB/T, Telsa fast chargers. EV Charger typical architectures, Battery swapping, Charging standards-IEC 65851, IS 17017 and interfaces- V2G Communication. Wireless EV charging and types-inductive wireless charging, capacitive wireless charging, resonant wireless charging system, dynamic wireless charging system. Solar-powered Charging Station.		
Module:6	**Contemporary Topics**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1	James Larminie, John Lowry “Electric Vehicle Technology Explained”, 2nd edition, Wiley publications, 2012.
2	Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay and Ali Emadi, "Modern Electric, Hybrid and Fuel Cell Vehicles: Fundamentals", CRC Press, 2010.
Reference Books	
1	Iqbal Hussain, "Electric and Hybrid Vehicles-Design Fundamentals", CRC Press, 2nd edition,2011.
2.	Chris Mi, MA Masrur, and D W Gao, "Hybrid Electric Vehicles- Principles and Applications with Practical Perspectives", Wiley, 2011.
3.	Davide Andrea, "Battery management Systems for Large Lithium-Ion Battery Packs", Artech House, 2010.
4	Ottorino Veneri “Technologies and Applications for Smart Charging of Electric and Plug-in Hybrid Vehicles”, Springer publishers, 2017.

Suggested Lab Experiments

1. Performing converter tests in the Electrical Vehicle (Hub Motor) Training system.
2. Testing of Charging & Discharging of Battery in Electric Vehicle
3. Speed control of Hub (BLDC) Motor in Forward & Reverse direction
4. Estimation of state of Charge of EV battery using MATLAB/Simulink
5. Embedded code generation for Simple Hybrid electric Vehicle system
6. Design and testing of BMS for Electric vehicle
7. Development of EV charger circuit and its analysis through MATLAB/Simulink
8. Performance characteristics of a fuel cell and its maximum power point
9. Performance Testing of Induction Motor drives for EVs
10. Performance Testing of PMSM drives for EVs
11. Regenerative Braking Analysis in Electric Vehicles
12. Modeling and Simulation of an Electric Vehicle Using MATLAB/Simulink (Vehicle dynamics, motor, battery, and controller modeling.)
13. Design and Analysis of On-board Battery Chargers
14. Sensorless Speed Control of Electric Motors for EV Applications
15. Testing of Hybrid Electric Vehicle (HEV) Configurations (Parallel, series, and series-parallel hybrid architectures.

Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT			
Recommended by Board of Studies	23-05-2025		
Approved by Academic Council		Date	

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Course code	Course Title	L	T	P	C
MAPED604	**IoT System Design**	**3**	**0**	**2**	**4**

Pre-requisite	**Nil**	**Syllabus version**
		v.1

Course Objectives

1. It introduces the concepts and architecture of IoT systems often used in industries.
2. It explore various networking protocols, communicating devices, data handling technologies and security standards in industrial IoT.
3. It aims to develop IoT solutions in hardware and software environment.

Course Outcomes

After completion of the course, students will be able to

1. Understand Industrial IoT concepts, components, and architecture.
2. Compare appropriate communication protocols for Industrial IoT applications.
3. Illustrate the tools and techniques to analyze data gathered by interfacing sensors.
4. Apply different learning approaches to solve real-world problems.
5. Analyze the security requirements of Industrial IoT solutions.

Module:1	**Overview of Concepts**	**7 hours**

Distingtion between IoT and IIoT; Historical evolution, IIoT vs Industry 4.0, IIoT Reference Architecture, Industrial Automation pyramid, Role of Edge and Fog Computing and Digital Twin.

Module:2	**Communication Protocols**	**9 hours**

Data-centric vs. device-centric protocols, Hardware level protocols- Ethernet, RS-232, RS-485, CAN, Software level protocols- MQTT, CoAP, AMQP, OPC UA, HTTP, Modbus, TCP, Fieldbus, Profibus, Profinet, WirelessHART, Wireless Communication Standards -LoRaWAN, ZigBee, IEEE 802.15.4 standard, BLE, 5G vs Wi-Fi 6, Cloud platforms.

Module:3	**Sensor Technologies and Data Analytics**	**9 hours**

Sensor Technologies, Sensors interfacing using Arduino boards, ESP8266, NodeMCU, Raspberry pi board, DAQ hardware and software, sampling techniques, Industrial-grade IoT gateways, Actuators in IIoT Systems, characteristics of IIoT data, data preprocessing techniques, IoT analytics.

Module:4	**Learning Techniques**	**9 hours**

Introduction to supervised learning, unsupervised learning, reinforcement learning, deep learning, federated learning, Machine Learning Models - Decision trees, Random Forests, Naive bayes, Gradient boosting, CNN

Module:5	**Security and Standards**	**9 hours**
IoT Security Challenges, CIA Triad, Authentication, Authorization, Accounting, Data encryption, TLS/SSL, DTLS, IPsec and VPNs, ISO/IEC 27001 standard, IEC 62443 standard, NIST Cybersecurity Framework, PKIs and digital certificates, GDPR and its impact on IIoT, Blockchain for IIoT Security, Smart contracts for secure transactions, STRIDE model.		
Module: 6	**Contemporary Topics**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Vijay Madisetti and Arshdeep Bahga, “Internet of Things (A Hands-on Approach)”, 1st Edition, 2014.
2	Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, Apress, 2016.

Reference Books

1.	Rajkumar Buyya, Amir Vahid Dastjerdi, “Internet of Things: Principles and Paradigms”, Morgan Kaufmann, 2016.
2.	William Stallings, “Wireless Communications and Networks”, 2nd Edition, Pearson.
3.	John Soldatos, “Building Blocks for IoT Analytics: Internet-of-Things Analytics”, River Publishers, 2017.

Suggested list of Experiments

1. Implementing Arduino for water quality monitoring application using different sensors and extracting the data.
2. Setting up of an IoT gateway for Raspberry Pi and ESP32 using MQTT protocol for exchanging data
3. Data acquisition in MATLAB from sensors and IoT devices
4. Interfacing of RS232 protocol for data transmission and reception with NodeMCU and
5. Modbus serial communication using RS485 communication protocol
6. Integrating several sensors to ESP8266 for smart industry implementation in both hardware and software environment.
7. Reading and preprocessing of data extracted from sensors using Python programming in Jupiter Notebook environment making it ready for machine learning.
8. Visualizing IoT data using Grafana and Jupiter Notebook
9. Incorporating machine learning algorithms and comparing their performance for a specific set of data using Python programming.
10. Integrating Node-RED to Rasberry Pi using MQTT protocol for industrial IoT application

11. Dashboard creation and visualization in Node-RED for data analytics 12. Parameter tuning of digital twin using MATLAB/Simulink design optimization.			
Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT			
Recommended by Board of Studies	23-05-2025		
Approved by Academic Council	No.	Date	

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Course code	Course title	L	T	P	C
MAPED605	**Machine Intelligence and Learning**	**3**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		v.1			

Course Objectives

1. To provide an overview of intelligent learning techniques intended for power electronics applications.
2. It aims to demonstrate intelligent techniques for real time applications pertaining to power electronics and drives.
3. To develop suitable intelligent control algorithms for power electronics and drives.

Course Outcomes

After completion of the course, students will be able to

1. Apply supervised and unsupervised learning methods for solving the engineering problems
2. Understand the concepts of machine learning and its process
3. Assess various machine learning algorithms
4. Analyze the reinforcement and optimization techniques for real time applications

Module:1	**Artificial Neural Networks**	**7 hours**
Mathematical model of a neuron; Neuron models: Single / multi-inputs; Activation functions; Network Architecture; Perceptron; Linear separability.		
Module:2	**Supervised & Unsupervised Learning**	**9 hours**
Multilayer perceptron; Back propagation algorithm; Dimensionality reduction: Linear discriminant analysis – Principal component analysis; k means clustering; Radial basis function network; Deep learning: CNN; RNN.		
Module:3	**Machine Learning**	**9 hours**
Basic statistics; Types of machine learning; Supervised learning: Regression – Classification; The machine learning process; Testing machine learning algorithms; Turning data into probabilities - The Naive Bayes classifier.		
Module:4	**Learning Methods**	**9 hours**
Probabilistic learning; Nearest Neighbour Methods; Support vector machines: Optimal separation; kernels. Ensemble learning: Boosting; Bagging. Constructing decision trees; Random Forests; Classification and Regression Trees (CART).		

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Module:5	**Reinforcement and Evolutionary Learning**	**9 hours**
Reinforcement learning: Overview; Markov decision processes; Values; The difference between SARSA and Q-learning. Evolutionary Learning: Genetic Algorithm; Particle Swarm Optimization.		
Module: 6	**Contemporary Topics**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Stephen Marsland, “Machine Learning – An Algorithmic Perspective”, 2nd Edition, Chapman and Hall / CRC Machine Learning and pattern Recognition Series, 2014.
2	Tom M. Mitchell, “Machine Learning”, 1st Edition, McGraw-Hill Education, India, 2013.
Reference Books	
1.	Shai Shalev-Shwartz and Shai Ben-David, “Understanding Machine Learning: From Theory to Algorithms”, 1st Edition, Cambridge University Press, USA, 2014.
2.	Saikat Dutt, Subramanian Chandramouli, Amit Kumar Das, “Machine Learning”,1st edition, Pearson Education, 2019.
3.	Nguyen, Prasad, Walker, and Walker, “A First Course in Fuzzy and Neural Control”, Chapman Hall /CRC Press, 2003.

Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT			
Recommended by Board of Studies	23-05-2025		
Approved by Academic Council	No.	Date	

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Course code	Course Title	L	T	P	C
MAPED606	**Battery Management System**	**3**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		v.2			

Course Objectives

1. To introduce the fundamental concepts of batteries, including key performance parameters and the essential functions of Battery Management Systems (BMS).
2. To develop foundational knowledge of battery modelling techniques for analyzing and predicting battery behavior in various applications.
3. To explore battery pack design principles and thermal management strategies to ensure safety, performance, and longevity in battery-powered systems.

Course Outcome

1. Comprehend various battery terminologies and definitions, and recognize the requirements of a Battery Management System (BMS).
2. Develop battery models and perform testing for various applications.
3. Analyze cell balancing techniques and battery state estimation methods such as State of Charge (SoC) and State of Health (SoH).
4. Design battery packs and their thermal management system for different applications while considering associated constraints.

Module:1	**Introduction to Battery systems**	**8 hours**

Batteries, Cells, modules; Battery terminologies; Nominal voltage and capacity, C rate, Energy and power; Cells connected in series; Cells connected in parallel; Electrochemical and lithium-ion cells; Rechargeable cell; Charging and Discharging Process; Overcharge and Undercharge; Modes of Charging, Battery Specifications.

Module:2	**Battery modelling and Testing**	**9 hours**

Equivalent circuit models (ECMs); Physics-based models (PBMs); Empirical modelling approach; Battery pack modelling; Lifetime: Effect of operating temperature on service life, Life cycle, reliability concerns. Boundary conditions, Time dependent 1D, 2D, 3D cell modeling, Comparison of different modelling techniques, Battery testing: Cell-preconditioning, Capacity test, OCV test, Hybrid pulse power characterization (HPPC) Test, Energy test.

Module:3	**Battery Management System**	**10 hours**

BMS Functions, SoC, SoH, SoP, SoE, Battery state of charge (SOC) estimation - OCV, Coulomb counting method, Luenburger observer method, Discrete Extended Kalman Filter, Sigma Point

Kalman Filter, Artificial Intelligence techniques. Cell Balancing; Causes of imbalance; Circuits for balancing; Active and passive cell balancing; Design requirements for balancing circuits. Beginning of Life and End of Life range estimation.		
Module:4	**Battery Pack Design**	**8 hours**
Battery sizing and selection for automotive application, Optimal selection, Energy requirements, vehicle specifications, Cell design and overall design and development of battery pack, Analog and digital sensors, communication protocols like daisy chain and CAN. Fault detection and safety, Reliability Analysis of the battery pack, Handling and Storage of Battery Packs, Life cycle of batteries, recycling of battery packs.		
Module:5	**Thermal Management of Battery Pack**	**8 hours**
Cooling and Heating required in battery Pack, Active vs passive strategies, Types of cooling, Control optimization for energy efficiency, Heat exchangers and thermal interface materials. Temperature requirements of protection and insulation, Thermocouplers and measurement equipment.		
Module:6	**Contemporary Topics**	**2 hours**
	Total Lecture hours:	**45**

Text Book(s)

1.	Plett, Gregory L, "Battery management systems, Volume I: Battery modeling", Artech House, 2015.
2.	Plett, Gregory L, "Battery management systems, Volume II: Equivalent-circuit methods", Artech House, 2015.

Reference Books

1.	Davide Andrea," Battery Management Systems for Large Lithium-ion Battery Packs" , Artech House, 2010
2.	Pop, Valer, et al., "Battery management systems: Accurate state-of-charge indication for battery-powered applications", Vol. 9. Springer Science & Business Media, 2008.
3.	Bergveld, H.J., Kruijt, W.S., Notten, P.H.L "Battery Management Systems -Design by Modelling", Philips Research Book Series 2002.

Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT			
Recommended by Board of Studies	23-05-2025		
Approved by Academic Council	No.	Date	

Course Code	Course Title	L	T	P	C
MAPED607	**Model Based System Development**	**3**	**0**	**2**	**4**
Pre-requisite	**Nil**	**Syllabus version**			
		v.1			

Course Objectives

1. It aims to provide knowledge on model based design of power electronics and drives.
2. To improve design accuracy, reduce development time, and enhance system reliability using real time interface controller.
3. It aims to develop Hardware-in-the-Loop Simulations (HIL) for Power Electronic systems.

Course Outcome

On the completion of this course the student will be able to:

1. Build mathematical models for components in a system.
2. Develop stateflow diagrams for system development.
3. Set up and run real-time simulations for Power Electronics and drives system.
4. Develop Hardware-in-the-Loop Simulations (HIL) for Power Electronic systems
5. Apply verification and validation methods to a model of a physical system.

Module:1	Introduction to Model-Based Design	7 hours

Understanding the MBD workflow: From modeling to code generation, Tools for Model-Based Design - Role of Simulink in system modeling, Overview of supporting toolboxes (Stateflow, Simulink Coder). Concept of Model-In-the-Loop (MIL) testing. Applications of MBD: Industry use cases in automotive (ECU design, ADAS), robotics (motion control), and industrial automation. Software Tools Overview.

Module:2	Stateflow for Logic Design	8 hours

Introduction to Stateflow, Exploring state machine concepts: states, transitions, and events. Real-world examples of decision-making logic in embedded systems, Designing Complex Logic, Hierarchical and parallel states, Using flow charts to represent decision processes, Integration with Simulink, Linking Stateflow charts with Simulink models for dynamic behavior simulation, Debugging and testing state machine logic

Module:3	Hardware-in-the-loop using Real time interface controller	9 hours

Hardware-in-the-loop: Simulink Model of the power converters; Real time interface controller Architecture; Front panel, Rear panel; Specifications; Real time controller Target Support; PWM pulses: Digital IN; Digital OUT, Accessing analog signals: ADC and DAC ports; measurement of

small-signal transfer functions; closed loop control of power converter; thermal resistance of heat sink; thermal modeling.		
Module:4	**Rapid control prototyping using Real time interface controller**	**9 hours**
Real time interface: Rapid control prototyping; PWM generation; Digital OUT Ports; Non-isolated and isolated converters; single phase and three phase inverters; Sensor signal Interface: output voltage feedback with ADC Ports; tuning of PID controllers		
Module:5	**Advanced MBD Techniques**	**10 hours**
Model Verification and Validation, Techniques for debugging and testing models, Understanding simulation modes (normal, accelerator, SIL/PIL), Ensuring requirements traceability with model-based testing, Code Generation, Generating optimized C/C++ code from Simulink models using Embedded Coder, Configuring settings for target-specific code generation, Optimization and Calibration, Working with fixed-point and floating-point arithmetic, Tuning model parameters and calibrating for performance		
Module:6	**Contemporary Topics**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Gabriela Nicolescu, Pieter Mosterman, " Model-Based Design for Embedded Systems", CRC Press
2.	Priyanka Pantankar, Swapnil Kulkarni, " Matlab/Simulink in-depth ,Model based design with Simulink and state flow", BPB Pulications,2022
3.	Dingyü Xue, YangQuan Chen, "System Design through Matlab®, Simulink®, and Stateflow®", Wiley publications,
Reference Books	
1	James B. Rawlings et al.,"Model Predictive Control: Theory, Computation, and Design", Nob Hill Publishing, 2018
2.	Mark Utting, Bruno Legeard, "Practical Model-Based Testing: A Tools Approach", Morgan Kaufmann Publishers, 2007

List of suggested experiments

1. Simulating the motion of a robotic arm
2. Design of an ON/OFF controller for a water pump system using MATLAB/Simulink

3. Temperature Control Using Stateflow and Simulink and generating C code for deployment on ARM Cortex-M hardware platforms
4. Implement logic to detect and respond to faults on Battery system using MATLAB/Simulink
5. Development of state flow diagram for a speed control of DC Motor drive and its performance analysis
6. Design, simulation, code generation, and deployment of a temperature control system using MATLAB/Simulink
7. Automatic Embedded C- code Generation for a Microcontroller using Simulink Coder to control operation of a DC-DC buck converter
8. Hardware-in-the-loop testing with DC to DC buck converter with CCM operation
9. Hardware-in-the-loop testing with closed loop control of boost converter
10. Hardware-in-the-loop testing of a single phase Inverter
11. Hardware-in-the-loop testing with three phase Inverter
12. Rapid control prototyping with DC to DC buck converter with CCM operation
13. Rapid control prototyping with DC to DC boost converter with CCM operation
14. Rapid control prototyping of single phase and three phase Inverters.

Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT			
Recommended by Board of Studies	23-05-2025		
Approved by Academic Council	No.	Date	

Course Code	Course Title	L	T	P	J	C
MAPED608	**Digital Twin with AI for Power Electronics**	**3**	**0**	**0**	**0**	**3**
Pre-requisite	**Nil**					**Syllabus version**
						v. 1

Course Objectives:

1. To provide a fundamental understanding of Digital Twin and identifying the appropriate Digital Twin solutions for industry applications
2. To develop students' ability to apply fundamental tools within modern artificial intelligence (AI) for industrial analytics
3. To evaluate the benefits, challenges, and ethical considerations associated with the adoption of Digital Twins and Industrial AI.

Expected Course Outcome:

On completion of this course, the students will be able to:

1. Understand the fundamental concepts and architecture of Digital Twins.
2. Identify the key components and technologies involved in building and deploying Digital Twins.
3. Explain the role of data acquisition, integration, and management in the context of Digital Twins.
4. Comprehend the principles and applications of Artificial Intelligence and Machine Learning in industrial settings.

Module:1	**Fundamentals of Digital Twins**	**8 hours**

Evolution of Digital Twins, Introduction to Digital twin, Basic concepts of Digital twins, Growth drivers for digital twin, Product & Process digital twins, Digital Model, Digital Shadow, Digital twin Prototype (DTP), Digital Twin Instance (DTI), Digital Twin Aggregate (DTA), Partial digital twin, Clone digital twin, augmented digital twin, Smart & Connected design, accelerating industry 4.0 using Digital Twin.

Module:2	**Enabling Technologies for Digital Twin**	**8 hours**

Sensor Technologies for Digital Twin; Digital Twin Enablement through IoT: IOT Architecture, Communications Protocol, IoT Data Management and Analytics; Cloud Computing and Edge Computing for Digital Twin; Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR) usage in Digital Twin Visualization.

Module:3	**Digital Twin Development Approaches and Data Types And Analysis**	**9 hours**
Physical based Approaches, Data driven Methods, Hybrid Approaches, Integrating Physical and Data-Driven Elements, Geometric, Behavioural Data, Historical, Synthetic, and Real-Time Data, Data Acquisition, Storage, and Processing, Data Analytics and Insights: Descriptive Analysis; Diagnostic Analysis; Predictive Analysis; Prescriptive Analysis; Data-Driven Decision-Making		
Module:4	**Introduction to Industrial AI**	**9 hours**
Fundamentals of Artificial Intelligence and Machine Learning Relevant to Industry; Types of Machine Learning; Handling Imbalanced Datasets in Industrial Applications; Data Pre-processing and Feature Engineering for Industrial Data; Introduction to Deep Learning and Neural Networks; Sequence Modeling in Industrial Processes.		
Module:5	**Application of AI in industry**	**9 hours**
Applications of AI in Predictive Maintenance, Anomaly Detection and Fault Diagnosis in Industrial Systems, Process Optimization and Efficiency Improvement through AI-driven Digital Twins, Resource Management and Energy Optimization, Supply Chain Optimization using Digital Twins and AI, Case Studies in Healthcare and Transportation, Ethical Considerations and Societal Impact of AI.		
Module:6	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Raj, Pethuru, and Preetha Evangeline David,"The digital twin paradigm for smarter systems and environments: The industry use cases", Academic Press, 2020.
2.	Khaled, Nassim, Bibin Pattel, and Affan Siddiqui, "Digital twin development and deployment on the cloud: developing cloud-friendly dynamic models using Simulink®/SimscapeTM and Amazon AWS", Academic Press, 2020.
3.	Fernandes, Steven Lawrence, and Tarun K. Sharma, "Artificial Intelligence in Industrial Applications", Springer International Publishing, 2022.

Reference Books

1.	Kühn Wolfgang, "Handbook of Digital Enterprise Systems: Digital Twins, Simulation and AI", World Scientific Publishing Co., 2019.
2.	Maryam Farsi, Alireza Daneshkhah, Amin Hosseinian-Far, Hamid Jahankahani, "Digital Twin Technologies & Smart Cities", Springer, 2020.
3.	N. Crespi, A. T. Drobot, and R. Minerva, "The Digital Twin: What and Why?, in The Digital Twin", Springer International Publishing, 2023.
4.	Jay Lee, "Industrial AI: Applications With Sustainable Performance", Springer Singapore, 2020

Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT			
Recommended by Board of Studies	23-05-2025		
Approved by Academic Council		Date	

Course code	Course title	L	T	P	C
MAPED609	**Intelligent and Autonomous Vehicles**	**3**	**0**	**0**	**3**
Pre-requisite	Hybrid and Electric Vehicles	**Syllabus version**			
		v.1			

Course Objectives

1. To introduced learners to the core concepts, architecture, control, and technologies behind intelligent and connected vehicle systems.
2. To explore the latest developments and standards on intelligent and connected vehicle ecosystems.
3. To evaluate the vehicle performance as per the Standards and Specifications

Course Outcomes

After completion of the course, students will be able to

1. Describe the architecture of connected vehicles, intra and inter connected vehicles
2. Understand the vehicular Adhoc network operations.
3. Analyze various sensor technologies, perception systems, and decision-making
4. Evaluate Vehicle-to-Everything (V2X) communication protocols as per the standards and specifications.

Module	Title	Hours
Module:1	**Connected Vehicles, Intra and Inter vehicle network**	**9 hours**

Basics of cyber physical system- Architecture of connected cars. Vehicle sensor with on-board platform. Topology of LIN- CAN- Flex ray- WIFI and GPS- Automotive Ethernet- GPRS and 5G application for automotive systems communications- SOME-IP and DO-IP.

Module	Title	Hours
Module:2	**Network Architectures and VANET**	**9 hours**

Overview of the Architecture- channel models- properties of vehicle to vehicle and vehicle to infrastructure communication- performance of 802.11 in V2X.
Vehicular Adhoc network operations- single-hop broadcasting and multi-hop broadcasting- mobile IP solution in VANET.

Module	Title	Hours
Module:3	**Perception and Sensor Technologies**	**9 hours**

Sensor types: LiDAR, RADAR, cameras, and ultrasonic sensors. Sensor fusion techniques for environment perception, Object detection, classification, and tracking algorithms. Challenges in

perception under varying environmental conditions, Introduction to datasets and benchmarks for perception systems.		
Module:4	**Vehicle-to-Everything (V2X) Communication**	**8 hours**
Fundamentals of V2V, V2I, and V2N communications, Communication protocols: DSRC, C-V2X, 5G, Network architecture and standards for vehicular communication, Security and privacy concerns in V2X systems, Integration of V2X communication with vehicle control system.		
Module:5	**Standards and Specifications**	**8 hours**
International and Indian standards on vehicle communication, autonomy, and data interoperability, :ISO 26262 (Functional Safety), ISO/SAE 21434 (Cybersecurity), and V2X communication standards including DSRC and C-V2X. Specifications: CAN, LIN, Ethernet, and MOST, Diagnostic standards UDS (Unified Diagnostic Services).		
Module: 6	**Contemporary Topics**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Murphey, Yi Lu, Ilya Kolmanovsky, and Paul Watta, eds, “AI-enabled Technologies for Autonomous and Connected Vehicles”, Springer Nature, 2022.
2	Paret, Dominique, and Hassina Rebaine, “Autonomous and Connected Vehicles: Network Architectures from Legacy Networks to Automotive Ethernet”, John Wiley & Sons, 2022.

Reference Books

1.	Mouftah, Hussein T., Melike Erol-Kantarci, and Sameh Sorour, eds,“Connected and Autonomous Vehicles in Smart Cities”, CRC Press, 2020.
2.	Luke Fletcher, Jamie Shotton, and Philip Torr, “Deep Learning for Autonomous Vehicles”, Cambridge University Press, 2024
3.	Junyi Li, Huawei Technologies, “5G V2X Communications”, Springer, 2021.

Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT

Recommended by Board of Studies	23-05-2025		
Approved by Academic Council	No.	Date	

Course code	Course title	L	T	P	C
MAPED610	**Drones and Unmanned Aerial Vehicles**	3	0	2	4
Pre-requisite	Nil	Syllabus version			
		v. 1			

Course Objectives

1. To equip students with expertise in drone flight dynamics, assembly, programming, and control operations.
2. To enable students to test and troubleshoot the advanced autonomous functionalities and real-world applications of UAVs.
3. To foster problem-solving skills and encourage innovative approaches to UAV deployment, bridging technical knowledge with industry-specific challenges.

Course Outcomes

After completion of the course, students will be able to

1. Understand the components, and classes of UAVs
2. Determine the dynamic relationships governing UAV flight
3. Design control strategies for UAV and their pitfalls
4. Analyze the sensors and actuators for data preprocessing
5. Understand the communication aspects involved in UAV technology.

Module:1	Introduction to UAV	7 hours
Definitions of Drone, Historical Development, Components of UAV systems and sub-systems, Classes and categories of UAV, Drone Applications and Safety, Ethical Concerns of UAVs.		
Module:2	**Aerodynamics and UAVs Performance**	**8 hours**
Basic Aerodynamic Equations, Air foils, lift, drag, moments, Aircraft Polar, The Real Wing and Airplane, Induced Drag, Total Air-Vehicle Drag, Flapping Wings, Rotary wings. Climbing Flight, Range, Endurance, Gliding Flight, Response to Air Turbulence		
Module:3	**Control strategies of UAVs**	**10 hours**
Modelling of unmanned vehicles considering basic forces, kinematics, and dynamics, AFCS of HTOL aircraft, Spatial stability of HTOL, AFCS control of Helicopter, Co-axial rotor helicopter, convertible rotor aircraft, payload control, Linearization, 2-D and 3-D control of Aerial robots, PID Control, LQR control, Motion planning, Collision-free Navigation, Sensing and Estimation, Vision-based Guidance for aerial robots.		

Module:4	**Real-time Data collection and processing**	**9 hours**
Discussion on different types of sensors used in unmanned vehicles (proximity, IMU, magnetometers, thermal imaging, vision, LiDAR, GPS, RTK, etc.) and their characteristics, Sensor data aggregation, and data pre-processing, Different types of actuators: motors, servos, harmonic drive, linear actuators.		
Module:5	**Mission Planning and Communication**	**9 hours**
MPCS Sub-systems, MPCS physical configurations, MPCS Architecture, Local Area Networks, Levels of Communication, Bridges and Gateways, Layout and Logical Structure, Communications Medium, Network Transmission and Access, Layer wise OSI Standard-Physical Layer, Data-Link Layer, Network Layer, Transport Layer, Session Layer, Presentation, Application Layer, Mission Planning.		
Module:6 :	**Contemporary Topics**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Paul Fahlstrom, Thomas J. Gleason, Mohammad H. Sadraey, “Introduction to UAV Systems”,Wiley, Fifth Edition, 2022.
2	Reg Austin, "Unmanned Air Systems: UAV Design, Development and Deployment", First Edition, Wiley Publishers, 2010.

Reference Books

1.	Richard K. Barnhart, Stephen B. Hottman, Douglas M. Marshall, Eric Shappee, “Introduction to Unmanned Aircraft Systems”, Third Edition, CRC Press, 2021.
2.	Mohammad H. Sadraey, “Design of Unmanned Aerial Systems”, First Edition, Wiley, 2020.

List of suggested experiments

1. Identify and study various parts of a drone (frame, motors, ESC, flight controller, propellers, battery, etc.)
2. Perform pre-flight checks, propeller direction checks, and battery safety to understand safety precautions and checklists before flying.
3. Configure a flight controller using software like Mission Planner or Betaflight and Calibrate ESCs, accelerometer, compass, and radio transmitter.
4. Learn basic manual flight control in stabilized mode (Take-off, hover, yaw, pitch, roll, and landing)
5. Program and execute a square or triangular path a basic waypoint-based autonomous mission (Mission Planner / QGround Control)

6. Study how GPS modules and telemetry transmit data, Connect and monitor drone GPS position and altitude in real-time. 7. Understand battery charging, capacity testing, and power distribution, measure current/voltage using multimeter and analyze flight time. 8. Use external sensors like ultrasonic, LiDAR, or barometer for obstacle detection or height measurement. Interface a sensor and log output on a microcontroller or GCS. 9. Simulation of a drone to model flight dynamics, including equations of motion, control algorithms, and sensor integration. 10. Practice basic navigation and waypoint programming in virtual environment, simulate drone flight using Gazebo, AirSim, or DroneSim Pro. 11. Model swarm UAV behavior for cooperative missions such as search-and-rescue or surveillance under Simulink environment.			
Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT			
Recommended by Board of Studies		23-05-2025	
Approved by Academic Council	No.	Date	

Course Code	Course Title	L	T	P	C
MAPED611	**Smart Microgrids**	**3**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		v.2			

Course Objectives

1. To equip students with expertise in modern control technologies for Microgrids, covering islanded and grid-connected operations, communication frameworks, and smart Microgrid infrastructure.
2. To develop, oversee, model dynamically, and analyze Microgrid systems while assessing communication frameworks for seamless integration
3. To enable students to assess and refine communication frameworks, optimizing data exchange and control mechanisms for seamless Microgrid integration with existing power networks

Expected Course Outcome

On the completion of this course the student will be able to:

1. Gain a comprehensive understanding of Microgrids, and networked Microgrids
2. Analyze the influence of smart technologies on Microgrids.
3. Design centralized and distributed control frameworks in Microgrids, with a focus one primary, secondary and tertiary control strategies.
4. Evaluate technical threats, communication protocols, to enhance security, reliability, and adaptive intelligence in modern power systems.

Module	Title	Hours
Module:1	**Microgrid Configurations and Smart Grid Introduction**	**8 hours**

Components of Microgrid; CERTS Microgrid Test Bed; Hybrid DC and AC Coupled Microgrid; Grid Connected Mode; Islanded mode; Battery Charging mode; Evolution of Electric Grid, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, National and International Initiatives in Smart Grid

Module	Title	Hours
Module:2	**Microgrid Control Techniques Processing**	**7 hours**

Mathematical model of microgrid; Impact of load characteristics; Hierarchical control: Primary, secondary and tertiary control; Local control; Centralized Control; Decentralized Control; Distributed control; PQ Control; Droop control methods; Frequency/Voltage Control; Inverter Output Impedance.

Module	Title	Hours
Module:3	**Smart grid technologies**	**8 hours**

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and

control, Distribution systems: DMS, Volt/VAR control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plugin Hybrid Electric Vehicles (PHEV).		
Module:4	**Smart meters and advanced metering infrastructure**	**8 hours**
Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit (PMU), Intelligent Electronic Devices (IED)&their application for monitoring & protection.		
Module:5	**Power quality and High Performance Computing**	**10 hours**
Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit. Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broad band over Power line(BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.		
Module:6	**Contemporary Topics**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Hasan Bevrani, Bruno Francois and Toshifumi Ise,(2017) “Microgrid Dynamics and Control” Wiley Press
2.	J. A. Momoh, “Smart Grid: Fundamentals of Design and Analysis” Wiley India, 1stEdition, 2015

Reference Books

1.	S. Bahrami, and A. Mohammadi. “Smart Microgrids”, Springer Nature Switzerland AG: Springer International Publishing, 2019.
2.	B. Singh, A. Chandra, and K. Al-Haddad, “Power Quality: Problems and Mitigation Techniques”, Wiley, 2015, 1st Edition

Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT

Recommended by Board of Studies	23-05-2025		
Approved by Academic Council	No.	Date	

Course code	Course Title	L	T	P	C
MAPED612	**EMC and EMI in Power Converters**	3	0	0	3
Pre-requisite	**Nil**	**Syllabus version**			
		v. 2			

Course Objectives

1. To develop an understanding of Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) in power converters, mitigation techniques, and regulatory considerations.
2. To analyze the role of EMI and EMC in ensuring the efficient, reliable, and safe operation of power converters.
3. To equip students with methods to design, test, and implement EMI/EMC solutions, enhancing system stability and compatibility in real-world applications.

Course Outcomes

After completion of the course, students will be able to

1. Understand EMI environment, sources and coupling mechanism
2. Analyze the different EMI standards
3. Identify the cause of EMI and suitable mitigation technique
4. Model and simulate the EMI environment & mitigation

Module:1	**Fundamentals of EMC/EMI & coupling principles**	**9 hours**

Introduction to EMI and EMC, Typical EMI environment, Sources and Victims of EMI, Conducted and Radiated EMI emission and susceptibility, Case Histories, Radiation hazards to humans, EMC Testing categories.
Electromagnetic field Coupling paths, Coupling via the supply network, Common mode coupling, Differential mode coupling, Impedance coupling, Inductive and Capacitive coupling, Radiative coupling, Ground loop coupling, Automotive transients.

Module:2	**EMI/EMC standards and regulations**	**9 hours**

Need for Standards, Generic/General Standards for Residential and Industrial environment, National and International EMI Standardizing Organizations; IEC, ANSI, FCC, AS/NZS, CISPR, BSI, CENELEC, ACEC, Military standards-MIL461E/462, Medical standards, automotive standards.

Module:3	**EMI in Power Converters & mitigation techniques**	**9 hours**
EMI phenomena in power switching devices, conducted EMI in power semiconductors, EMI in rectifier circuits, EMI in fast switching converters, EMI in inverter circuits, EMI in power supplies, EMI in motor drives, Broadband noise, Narrow band noise, radiation from PCB boards. EM Shielding, grounding, filters, soft switching, random modulation and chaotic PWM technique.		
Module:4	**EMI measurement and testing**	**8 hours**
EMI test shielded chamber and shielded ferrite lined anechoic chamber; Line impedance stabilization networks, conducted emission test setup, EMI receiver and spectrum analyser, Pre compliance immunity Test, conducted emission test, radiated emission test.		
Module:5	**EMI modelling and simulation**	**8 hours**
EMC/EMI Modelling Techniques and Applications, Virtual EMC Lab, EMI mitigation algorithm and programming.		
Module: 6	**Contemporary Topics**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Laszio Tihanyi "Electromagnetic Compatibility in Power Electronics", IEEE Press 1995.
2.	Henry W. Ott, "Electromagnetic Compatibility Engineering", John Wiley & Sons Inc, Newyork, 2009.
3.	V. Prasad Kodali, Engineering Electromagnetic Compatibility: Principles, Measurements, Technologies, and Computer Models, 2nd Edition, Wiley-IEEE Press, 2001.

Reference Books

1.	Dr Kenneth L Kaiser, "The Electromagnetic Compatibility Handbook", CRC Press 2005.
2.	Paul, C.R., "Introduction to Electromagnetic Compatibility", 2nd ed., Wiley (2010).
3.	Bogdan Adamczyk "Foundation of Electromagnetic Compatibility with practical applications", John wiley & sons, First edition,2017
4.	David A.weston "Electromagnetic compatibility", CRC press, Third edition, 2017.
5.	Hong Li, Zhong Li,Bo Zhang, Wallace K.S. Tang and Wolfgang A.Halang "Suppressing Electromagnetic interference in Direct current converters" IEEE circuits and system Magazine, 2009.

Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT			
Recommended by Board of Studies	23-05-2025		
Approved by Academic Council	No.	Date	

VIT
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

Course Code	Course Title	L	T	P	C
MAPED613	**Solar Photovoltaic Conversion Systems**	3	0	0	3
Pre-requisite	**Nil**	**Syllabus version**			
		v.2			

Course Objectives

1. To develop a comprehensive understanding of solar energy principles and solar photovoltaic (PV) energy conversion technologies.
2. To learn the methodologies for designing and analyzing PV systems, including performance evaluation under varying environmental conditions.
3. To understand the role and application of power electronics in solar energy conversion, including maximum power point tracking (MPPT) and grid integration.

Course Outcome

At the end of this course the student will be able to:

1. Apply new techniques for estimation of solar PV cell parameters.
2. Develop new tracking techniques and reconfiguration method for improved power extraction from solar PV systems
3. Design a photovoltaic system and its interface circuits for stand-alone, grid connected systems
4. Compute the cost analysis and payback period of solar PV installations and categorize various environmental impacts of PV.

Module:1	Solar PV Cell Fundamentals	7 hours

Principle of direct solar energy conversion, solar cell, types, material properties and construction methods, I-V characteristics of a PV module, new material for PV cells, solar PV modelling and equations, modelling techniques, performance parameters, cell efficiency, fill factor.

Module:2	Maximum Power Extraction Methods	9 hours

Formation of PV modules and arrays, series and parallel combinations, effect of shading, use of bypass and blocking diodes, need for maximum power tracking, effect of irradiation and temperature of PV characteristics, DC-DC converters, Tracking techniques and Array reconfiguration methods for maximum power extraction

Module:3	Standalone PV Systems	8 hours

Standalone PV systems: design, schematics, array and battery sizing, charge controller, Off-grid inverters, Balance of system (BOS) for power plant, Supporting structure, mounting and installation,

cables, maintenance and monitoring Typical application: design of home lighting system, and water pumping		
Module:4	**Grid Connected PV System**	**9 hours**
Interfacing with the power grid: schematics, interface components, Types of grid interface, Balance of system, Building integrated PV systems, analysis and performance, Grid interactive inverters, PV SYST, Preparing DPR including financial evaluation		
Module:5	**Cost Analysis, Standards and Communication**	**10 hours**
Cost analysis and pay back calculations: Different types of solar panels and collectors, Installation and operating costs, Environmental and safety issues, Protection system, Performance monitoring, Techno-economic analysis of solar PV power plants, Environmental considerations, Site selection and land requirements. IEEE Standard 1547; Elements of communication and networking: Architectures, standards, PLC, Zigbee, GSM, BPL, Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN)		
Module:6	**Contemporary Topics**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Michael Boxwell, "Solar Electricity Handbook – 2021 Edition: A simple, practical guide to solar energy – designing and installing solar photovoltaic systems", Greenstream Publishing, UK, 2021
2	Chetan Singh Solanki, "Solar PV technology and system", PHI learning private limited, 2015
Reference Books	
1	Ali Keyhani, Design of smart Power Grid Renewable Energy Systems", 3rd Edition John Wiley & Sons, 2019.
2.	D. Yogi Goswami, "Principle of Solar Engineering" 3rd Edition, CRC Press, 2015
3.	Sukhatme S. P., "Solar Energy", Tata McGraw Hills P Co., 3rd Editions 2008
4.	Roger Messenger, Amir Abtahi, "Photovoltaic Systems Engineering", 4th Edition, CRC Press, 2017.
5.	Kenneth C. Budka, Jayant G. Deshpand, Marina Thottan, "CommunicationNetworks for Smart Grids", Springer 2014.

Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT			
Recommended by Board of Studies	23-05-2025		
Approved by Academic Council	No.	Date	23-05-2025

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<tr><td>Course code</td><td colspan="2">Course Title</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>MAPED614</td><td colspan="2">Universal Automation</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>Pre-requisite</td><td>Nil</td><td colspan="5">Syllabus version</td></tr>
<tr><td></td><td></td><td colspan="5">v. 1</td></tr>
<tr><td colspan="7">Course Objectives</td></tr>
<tr><td colspan="7">1. To equip students to core automation concepts, tracing evolution its to Industry 4.0, exploring the automation hierarchy through key standards like IEC 61131-3 and IEC 61499.
2. To develop practical expertise in deploying distributed automation using Universal Automation practices, enabling students to design and implement scalable, interoperable control solutions
3. To equip students to analyze emerging technologies such as digital twins, IT/OT integration, and cloud-based control, fostering readiness for future industrial transformations.</td></tr>
<tr><td colspan="7">Course Outcomes</td></tr>
<tr><td colspan="7">On completion of this course, the students will be able to:
1. Explain the concepts of industrial automation, types of automation systems, and the structure of the automation pyramid in the context of Industry 4.0.
2. Compare IEC 61499 with IEC 61131-3 and describe the architecture and functional components of IEC 61499-based automation using Function Blocks.
3. Design and implement basic and composite function blocks using ECC (Execution Control Chart) and develop state-machine logic using Mealy and Moore models.
4. Demonstrate the ability to configure, deploy, and monitor distributed automation applications using standard event FBs, SIFBs, and UAR in multi-device environments.
5. Analyze advanced concepts in industrial automation such as digital twins, IT/OT convergence, and edge-cloud integration, and assess their implications on future automation architectures.</td></tr>
<tr><td>Module:1</td><td colspan="2">Introduction to Industrial automation</td><td colspan="4">8 hours</td></tr>
<tr><td colspan="7">What is industrial automation? Growth and progress from start to current era of industry 4.0, Automation pyramid and I4.0, types of automation (discrete and process control), introduction to existing implementation standard (IEC 61131 -3), industrial examples – use cases discussions, Introduction to UAO and IEC 61499.</td></tr>
<tr><td>Module:2</td><td colspan="2">IEC 61499 introduction and basics</td><td colspan="4">8 hours</td></tr>
<tr><td colspan="7">IEC 61499 vs IEC 61131-3(event execution, vendor agnostic capability, distributed automation), Building block of 61499 a basic FB and its components (Interface, ECC, states, algorithm, execution process</td></tr>
<tr><td>Module:3</td><td colspan="2">Automata based programming</td><td colspan="4">9 hours</td></tr>
<tr><td colspan="7">Types of state machine: Mealy and Moore, How to make a state machine? How to program a state</td></tr>
</table>

machine based on requirements?, time and sequence diagrams, implementation of a designed state machine in ECC. Testing of FBs (debugging and monitoring).		
Module:4	**Elements of 61499 and Universal Automation in Practice**	**9 hours**
Standard event FBs (E_CYCLE, E_Delay etc), Composite FB, SIFB, application design and system configuration, deployment across devices Building distributed systems across multiple devices, integrating with field devices using SIFBs (e.g., Modbus, OPC UA), use of common runtime (UAR) in different hardware, Plug-and-produce architecture examples, Case studies from UniversalAutomation.org.		
Module:5	**Advanced Topics and Future Trends**	**9 hours**
Digital twins and model-based engineering, IT/OT convergence with IEC 61499, Edge and cloud integration, Security in distributed automation, future roadmap of IEC 61499 and Universal Automation.		
Module: 6	**Contemporary Topics**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1. Valeriy Vyatkin, "EC61499 function blocks for embedded and Distributed Control Systems Design", Instrumentation Systems and Automation society, 3rd edition, 2015, ISBN:0979234301

Reference Books

1. Alois Zoiti and Thomas Strasser, "Real-time Execution for IEC 61499", CRC Press, 2017, ISBN: 1934394270

List of suggested experiments

1. Introduction to IEC 61499 Development Environment: Ecostuxure Automation Expert.
2. Design and Implementation of Basic Function Blocks (FB).
3. Programming Finite State machines (FSM) using Execution Control Chart (ECC).
4. Composite Function Block design.
5. Working with Standard Event FBs (E_Cycle, E_Delay)
6. Deployment on distributed devices using Universal Automation Runtime (UAR).
7. Integration with Field Devices using Service Interface FBs.
8. Debugging and Monitoring FBs.
9. Implementing a Plug-and-Produce Use case
10. Implement event-driven automation using IEC 61499.

VIT

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

Mode of Evaluation: CAT1, CAT 2 / Assignments / Quizzes /Seminar/Project/ FAT			
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