ANNA UNIVERSITY

NON-AUTONOMOUS COLLEGE

AFFILIATED TO ANNA UNIVERSITY

M.E., POWER ELECTRONICS AND DRIVES

REGULATIONS 2025

PROGRAMME OUTCOMES (POs)

On successful completion of the programme, the graduate would have	
PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report / document.
PO3	Students should be able to demonstrate a degree of mastery in power electronics and drives.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On successful completion of the PG programme, the graduate would have	
PSO 1	Apply knowledge of basic science and engineering science to analyze, design and testing of power electronic systems and drives to achieve high power density and high efficiency.
PSO 2	Design analog and digital controllers for power electronic systems and extracting maximum energy and utilization of renewable energy system.

ANNA UNIVERSITY, CHENNAI

POST GRADUATE CURRICULUM (NON.AUTONOMOUS AFFILIATED INSTITUTIONS)

Programme: M.E., Power Electronics and Drives **Regulations:** 2025

Abbreviations:

BS – Basic Science (Mathematics, Physics, Chemistry)
ES – Engineering Science (General (**G**), Programme Core (**PC**), Programme Elective (**PE**))
SD – Skill Development
SL – Self Learning
OE – Open Elective

L – Laboratory Course
T – Theory
LIT – Laboratory Integrated Theory
PW – Project Work
TCP – Total Contact Period(s)

Semester I

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	MA25101	Applied Mathematics for Power Engineers	T	3	1	0	4	4	BS
2.	PX25101	Modelling and Analysis of Electrical Machines	LIT	2	1	2	5	4	ES (PC)
3.	PX25C01	Analysis of Power Converters	LIT	3	0	2	5	4	ES (PC)
4.	PX25102	Digital Controllers in Power Electronics Applications	LIT	3	0	2	5	4	ES (PC)
5.	PX25103	Advanced Power Semiconductor Devices	T	2	0	0	2	2	ES (PC)
6.	PX25104	Technical Seminar	-	0	0	2	2	1	SD
Total Credits							**23**	**19**	

Semester II

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.		Modeling and Design of SMPS	LIT	2	1	2	5	4	ES (PC)
2.		Analysis of Electrical Drives	LIT	2	1	2	5	4	ES (PC)
3.		Computer Aided Design of Electrical Machines	LIT	3	0	2	5	4	ES (PC)
4.		Programme Elective I	T	3	0	0	3	3	ES (PE)
5.		Industry Oriented Course I	--	1	0	0	1	1	SD
6.		Self Learning Courses	--	--	-	--	--	1	SD
						Total Credits	**19**	**17**	

Semester III

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.		Programme Elective II	T	3	0	0	3	3	ES (PE)
2.		Programme Elective III	T	3	0	0	3	3	ES (PE)
3.		Programme Elective IV	T	3	0	0	3	3	ES (PE)
4.		Open Elective	--	3	0	0	3	3	-
5.		Industry Oriented Course II	--	1	0	0	1	1	SD
6.		Project Work I	--	0	0	12	12	6	SD
7.		Internship	--	-	-	-	-	2	SD
						Total Credits	**25**	**21**	

Semester IV

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.		Project Work II	--	0	0	24	24	12	SD
						Total Credits	**24**	**12**	

Programme Elective Courses (PE)

S. No.	Course Code	Course Title	Periods Per Week			Total Contact Periods	Credits
			L	T	P		
1.		Wind Energy Conversion systems	3	0	0	3	3
2.		Embedded Systems for Power Electronic Applications	3	0	0	3	3
3.		EMI and EMC in Power Converters	3	0	0	3	3
4.		FPGA based control for Power Electronic converters	3	0	0	3	3
5.		Power Electronics for Renewable Energy systems	3	0	0	3	3
6.		Distributed Generation and Micro Grids	3	0	0	3	3
7.		FACTS	3	0	0	3	3
8.		Non-Linear Control of Power Electronic Circuits	3	0	0	3	3
9.		Non-Linear Dynamics in Power Electronic Circuits	3	0	0	3	3
10.		Smart Grid Technologies	3	0	0	3	3
11.		Modern Rectifiers and Resonant Converters	3	0	0	3	3
12.		Soft Computing Techniques	3	0	0	3	3
13.		High Power Converters	2	0	2	4	3
14.		Grid Integration of Renewable Energy Sources	3	0	0	3	3
15.		Power Quality	3	0	0	3	3
16.		Linear System Theory	3	0	0	3	3
17.		Special Electrical Machines	3	0	0	3	3
18.		Advanced Power Converters	3	0	0	3	3
19.		Advanced Battery Technology	3	0	0	3	3
20.		Electric Vehicles and Power Management	3	0	0	3	3
21.		PCB Design for Power Converters and Drives	3	0	0	3	3
22.		AI for Power Electronics	3	0	0	3	3
23.		Python Programming for Machine Learning	3	0	0	3	3
24.		Machine Learning and Deep Learning	3	0	0	3	3
25.		IoT for Smart Systems	3	0	0	3	3

Semester I

MA25101	Applied Mathematics for Power Engineers	L	T	P	C
		3	1	0	4

Course Objectives:

- Use the linear algebra concepts in Electrical Engineering problems
- To familiarize the students in the field of differential equations to solve boundary value problems associated with engineering applications.
- Formulate and solve engineering problems involving random variables
- To develop the ability to using Z-transform, Fourier series and Fourier transforms.

Linear Algebra: Vector spaces, norms, Inner Products, The Cholesky decomposition, Generalized Eigen vectors, Canonical basis, QR factorization, Singular value decomposition (SVD), Pseudo inverses, least squares method.

Activities: SVD to an engineering problem.

Calculus of Variations: Concept of variation and its properties, Euler's Equation, Functionals dependent on first and higher order derivatives, Functionals dependent on functions of several independent variables, Variational problems with moving boundaries, Direct methods: Ritz and Kantorovich methods

Activities: Optimal signal trajectories, Minimizing energy in communication channel models, Antenna design optimization, Variational methods for radiation pattern shaping, Control systems in electronics, Energy functional minimization for stable system design.

One Dimensional Random Variable: Random variables, Probability function, moments, moment generating functions and their properties, Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions, Function of a Random Variable.

Activities: Failure probability of beams/columns modelled using Binomial and Poisson distributions, Modelling vehicle arrivals at intersections using Poisson/Exponential random variables, Normal distribution applications in concrete compressive strength testing, with mean/variance modelling.

Z – Transforms: Definition, Standard Z-transforms, damping rule, Shifting rule, Initial value and Final value theorems (without proofs) and problems, Inverse Z-transform, Simple problems.

Activities: Solutions of difference equations.

Fourier Series: Fourier series: Periodic function as power signals, Convergence of series, Even and odd function: cosine and sine series, non-periodic function: Extension to other intervals, Power signals: Exponential Fourier series, Parseval's theorem and power spectrum.

Activities: Frequency spectrum and examples from engineering field.

Fourier Transforms: Infinite Fourier transforms. Fourier Sine and Cosine transforms. Inverse Fourier transforms, and simple problems. Dirac delta function – Convolution theorem.

Activities: Heat equation, Analyzing transient heat conduction in long rods.

References:
1. Bronson, R. (2011). Matrix operation. McGraw Hill.
2. Elsgolts, L. D. (2007). Calculus of variations. Dover Publications Inc.
3. Grewal, B. S. (2018). Higher engineering mathematics. Khanna Publishers.
4. Andrews, L. C., & Phillips, R. L. (2005). Mathematical techniques for engineers and scientists. Prentice Hall.
5. Papoulis, A., & Pillai, S. U. (2019). Probability, random variables and stochastic processes. McGraw Hill.

	Description OF CO	**PO**	**PSO1**	**PSO2**
CO1	To apply the linear algebra concepts in Electrical Engineering problems	PO1(2) PO3(3)		
CO2	To familiarize the students in the field of differential equations to solve boundary value problems associated with engineering applications.	PO1(2) PO3(2)		
CO3	Able to formulate and solve engineering problems involving random variables and random process	PO1(2) PO3(2)		
CO4	To develop Z-transform techniques for discrete time systems	PO1(3) PO3(2)		
CO5	To develop the ability to solve problems using Fourier series and Fourier transforms in Engineering applications	PO1(3) PO3(3)		

PX25101	Modeling and Analysis of Electrical Machines	L	T	P	C
		2	1	2	4

Course Objectives:

- To provide knowledge about the fundamentals of magnetic circuits & analyze the steady state and dynamic state operation of DC machine through mathematical modeling and simulation in digital computer.
- To provide the knowledge of theory of transformation of three phase variables to two phase variables & analyze the steady state and dynamic state operation of three-phase induction machines using transformation theory based mathematical modeling
- To analyze the steady state and dynamic state operation of three-phase synchronous machines using transformation

Principles of Electro Magnetic Energy Conversion: Magnetic circuits, permanent magnet, stored magnetic energy, co-energy, force and torque in singly and doubly excited systems, machine windings and air gap mmf, determination of winding and mechanical parameters of a machine.

Practical: Development of program for evaluating the parameters of machines in software environment

DC Machines: Elementary DC machine and analysis of steady state operation, Voltage and torque equations, dynamic characteristics of DC motors, Time domain block diagrams, transfer function of DC motor, responses.

Practical: Simulation of mathematical model of DC Machines in software environment

Reference Frame Theory: Historical background of Clarke and Park transformations, power invariance and phase transformation and commutator transformation, transformation of variables from stationary to arbitrary reference frame- variables observed from several frames of reference.

Practical: Simulation of mathematical model of transformation scheme in software environment

Induction Machines: Three phase induction machine, equivalent circuit and analysis of steady state operation free acceleration characteristics, voltage and torque equations in machine variables and arbitrary reference frame variables, analysis of dynamic performance for load torque variations, Multiphase Machines: Advantages, modelling of multiphase machines, applications

Practical: Simulation of mathematical model of Induction machines in software environment**.**

Synchronous Machines: Three phase synchronous machine and analysis of steady state operation- voltage and torque equations in machine variables and rotor reference frame variables (Park's equations), analysis of dynamic performance for load torque variations

Practical: Simulation of mathematical model of synchronous machines in software environment**.**

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%.

Assessment Methodology: Quiz (5%), Assignments (20%), Flipped Class (5%) Practical (30%) Internal Examinations (50%)

References:

1. Krause, P. C., Wasyzczuk, O., & Sudhoff, S. (2010). *Analysis of electric machinery and drive systems*. John Wiley.
2. Ramanujam, R. (2018). *Modelling and analysis of electrical machines*. I.K. International Publishing Pvt. Ltd.
3. Bimbhra, P. S. (2008). *Generalized theory of electrical machines*. Khanna Publishers.
4. Fitzgerald, A. E., Kingsley, C. Jr., & Umans, S. D. (1999). *Electric machinery*. Tata McGraw Hill.

	Description of CO	**PO**	**PSO1**	**PSO2**
CO1	Ability to optimally design magnetics required in power supplies and drive systems.	PO1(3) PO3(3)	3	1
CO2	Ability to acquire and apply knowledge of mathematics of machine dynamics in Electrical engineering.	PO1(3) PO3(3)	3	1
CO3	Ability to model, simulate and analyze the dynamic performance of electrical machines using computational software.	PO1(3) PO3(3)	3	1
CO4	Ability to verify the results of the dynamic operation of electrical machine system	PO1(3) PO2(2) PO3(3)	3	1

PX25C01	Analysis of Power Converters	L	T	P	C
		3	0	2	4

Course Objectives:

- To provide a comprehensive understanding of the operation, design, and control of hard switched and soft switched power electronic converters.
- To analyse and evaluate the performance of single-phase and three-phase power converters under various load conditions.
- To enhance practical skills through laboratory experiments that reinforce theoretical concepts and provide exposure to real-world converter operation and analysis.

Single-Phase Controlled Rectifiers: Semi and fully controlled rectifiers with R, RL, and RLE loads. Freewheeling diode effects: Continuous and discontinuous conduction modes. Inversion operation; Dual converter operation. PWM rectifiers. Performance parameters: Harmonics, ripple, distortion, power factor. Effect of source inductance.

Practical: Simulation and Experimention of single-phase half and fully controlled converters. / Gate drivers and firing circuits for single phase rectifiers./ Waveform analysis under various load conditions./ Input power factor and harmonic analysis.

Three-Phase Controlled Rectifiers: Three-phase semi and fully controlled rectifiers with R, RL, RLE loads. Freewheeling diode, inversion operation, continuous/discontinuous modes. Multi-pulse (6 and 12 pulse) and dual converters. Effect of source inductance and commutation overlap. Performance parameters

Practical: Simulation and Experimentation of three-phase line-commutated converters.

DC-DC Converters: Non-isolated topologies: Buck, Boost, Buck-Boost, Cuk. Isolated topologies: Single and multiple switch converters. Operation in CCM and DCM; Synchronous and interleaved converters.

Practical: Design and testing of driver circuits for DC-DC converters (totem pole/transformer based/boot strap/opto coupler based)

DC-AC Inverters: Single-phase and three-phase VSI and CSI; 120° and 180° conduction modes. PWM techniques: Sine PWM, Space Vector PWM, 60° PWM, Third harmonic PWM. Multilevel inverters: Diode-clamped, flying capacitor, cascaded H-bridge. Voltage control methods and harmonic elimination. Filter design and device selection.

Practical: Simulation and analysis of single phase and three-phase inverters / Generation of PWM pulses with different modulation techniques/ Harmonic spectrum and THD analysis.

AC-AC Converters: AC voltage controllers: Single-phase and three-phase with R, RL loads. Phase angle control and integral cycle control. Working principle of Resonant converters: ZVS, ZCS, quasi, and multi-resonant types. **Practical**: Simulation and Experimentation of AC voltage regulators / Simulation and experimentation of resonant converters
Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%.
Assessment Methodology: Quiz (5%), Assignments (20%), Flipped Class (5%) Practical (30%) Internal Examinations (50%)
References: 1. Rashid, M. H. (2017). *Power electronics: Circuits, devices and applications* (4th ed.). Prentice Hall India. 2. Bose, B. K. (2003). *Modern power electronics and AC drives* (2nd ed.). Pearson Education. 3. Umanand, L. (2010). *Power electronics: Essentials & applications* (1st ed.). Wiley. 4. Mohan, N., Undeland, T. M., & Robbins, W. P. (2007). *Power electronics: Converters, applications and design* (3rd ed.). John Wiley and Sons. 5. Bimbhra, P. S. (2022). *Power electronics* (7th ed.). Khanna Publishers.
E-resources: 1. https://onlinecourses.nptel.ac.in/noc24_ee88/preview.

	Description of CO	PO	PSO1	PSO2
CO1	Analyze the operation and performance of single-phase and three-phase rectifiers under various load conditions.	PO1(3) PO3(3)	3	2
CO2	Design and evaluate isolated and non-isolated DC-DC converter topologies for specific applications.	PO1(2) PO3(2)	3	3
CO3	Implement PWM techniques in single and three-phase inverters and assess performance.	PO1(3) PO3(2)	3	3
CO4	Examine and compare multilevel inverters and resonant converter architectures for high-power applications.	PO1(3) PO2(2) PO3(2)	3	1
CO5	Conduct experiments and simulations to validate theoretical concepts and evaluate real-time converter behaviour.	PO1(3) PO2(2) PO3(3)	3	3

PX25102	**Digital Controllers in Power Electronics Applications**	L	T	P	C
		3	0	2	4

Course Objectives:

- This course offers an understanding of dsPIC 30F4011 and TMS320F28379D microcontroller architectures, programming, and peripherals for digital control applications.
- To develop skills in interfacing, signal processing, and signal conditioning.
- Practical knowledge of PWM generation techniques and the control of power electronic converters using digital controllers.

Introduction to PIC Microcontrollers: dsPIC 30F4011 microcontroller – device overview-architecture, memory organisation, pin diagrams, I/O ports, Timers, Capture/Compare/PWM modules (CCP), Serial Communication, Analog-to-digital converter module, interrupts, simple programs, Device Programming using MPLAB.

Practicals: A to D conversion and PWM generation with PICkit4 or PICkit5 and Development board.

Introduction to DSP Based Digital Controller: Introduction to the Texas Instruments C2000 microcontroller platform; Architecture of the TMS320F28379D including CPU core and Control Law Accelerator (CLA); Basic memory types – Flash and RAM; Getting started with Code Composer Studio (CCS); Basic programming concepts and GPIO overview; Introduction to interrupts and simple Interrupt Service Routines (ISRs).

Practicals: A to D conversion, voltage sensing and PWM generation using TI Launchpad and CCS.

Interfacing, Signal Processing and Signal Conditioning: ADC module configuration and sampling techniques; DAC operations and interfacing methods; PWM generation and synchronization using ePWM modules; Event Capture (eCAP) and Quadrature Encoder Pulse (eQEP) modules. Signal conditioning circuit, Signal Conditioning - Necessity, Instrumentation amplifiers, isolation amplifier, Noise problems, shielding and grounding- Filters, Dynamic compensation, Linearization, sample and hold circuits- A/D and D/A Converters.

Practicals: Verifying practically quadrature Encoder pulse module usage, Instrumentation amplifier and other signal conditioning circuit using OPAMPs.

PWM Generation Techniques using Digital Controllers: PWM generation techniques: single pulse width, multiple pulse width, and sinusoidal pulse width, Interfacing digital controller with power converters for open and closed loop control.

Practicals: Sinusoidal and space vector PWM generation using PIC Microcontroller and suitable digital signal processors.

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%.
Assessment Methodology: Quiz (5%), Assignments (20%), Flipped Class (5%) Practical (30%) Internal Examinations (50%)
References: 1. Milivojevic, Z., & Saponjic, D. (n.d.). *Programming dsPIC microcontrollers in C*. Mikroelektronika. 2. Toliyat, H. A., & Campbell, S. (2004). *DSP based electromechanical motion control*. CRC Press. 3. Kuo, S. M., Lee, B. H., & Tian, W. (n.d.). *Real-time digital signal processing: Implementations and applications* (2nd ed.). 4. Singh, A., & Srinivasan, S. (2004). *Digital signal processing implementation*. Thomson Press. 5. Texas Instruments. (n.d.). *C2000 real-time microcontrollers peripherals reference guide* [Technical manual]. 6. Texas Instruments. (n.d.). *TMS320F2837xD dual-core real-time microcontrollers technical reference manual: LAUNCHXL-F28379D overview user's guide* [User guide].

	Description of CO	PO	PSO1	PSO2
CO1	Ability to understand dsPIC30F4011 architecture and programming, including memory, timers, communication, ADC, interrupts, and use of MPLAB.	PO1(3) PO2(1) PO3(2)	3	3
CO2	Ability to understand TMS320F28379D architecture and develop basic programs using CCS and C2000Ware.	PO1(3) PO3(2)	3	3
CO3	Configure ADC, DAC, PWM, Event Capture, and QEP modules in TMS320F28379D.	PO1(3) PO3(3)	3	3
CO4	Ability to develop signal conditioning using amplifiers, filters, and sample-and-hold circuits.	PO1(3) PO3(2)	3	3
CO5	Ability to develop PWM techniques and open and closed loop control of power converters using a digital controller.	PO1(3) PO3(2)	3	3

PX25103	Advanced Power Semiconductor Devices	L	T	P	C
		2	0	0	2

Course Objectives:

- To provide knowledge about wide bandgap devices, their characteristics and applications in DC-DC and DC-AC converters .
- To perform electrical and thermal modeling of wide bandgap devices and design EMI filters for high-frequency power converters.
- To understand general guidelines and best practices for single-layer and multilayer PCB design according to industrial standards.

Wide Band Gap Devices: Introduction to basic power devices, characteristics, advantages, and challenges in designing converters - Silicon Power MOSFETs, SiC Planar Power MOSFETs, SiC Trench-Gate Power MOSFETs, Need for GaN devices, basic GaN transistor structure, GaN vertical power HEMTs, and horizontal power HEMTs.

Activity: Assignment ; Selection of power devices for various applications.

SiC Power Device: Planer SiC Power Mosfets: Blocking characteristics, On, Resistance, Threshold voltage, Reliability- Shielded SiC Planner Power Mosfet, Device structure blocking mode, channel structure & On-Resistance- SiC Trench Power Mosfets: Blocking characteristics, On-Resistance, Threshold voltage, Reliability- Shielded Trench Power Mosfets characteristics - Introduction to silicon bipolar transistor (BJT) for achieving ultra-high voltage.

Activity: Visual Demonstration between Si and SiC device.

GaN Power Device: Pulsed static characterization: Turn-ON and Turn-OFF switching characteristics of GaN devices, hard switching loss analysis, Junction capacitance characterization, Gate drive for dynamic characterization: gate driver design, impact of gate resistance, dv/dt and di/dt immunity, etc. - protection design for double pulse test setup, Electrical and thermal modeling of GaN transistors, Cross-talk considerations, High-frequency design complexity, EMI filter design for high-frequency power converters - Heat sink design.

Activity: Quiz on Thermal design for power devices.

PCB Design: Power circuit design, driver circuit design considerations, single, layer and multilayer PCBs, separation of power and driver circuits, high-frequency power loop optimization - design examples.

Activity: schematic capture and PCB layout for buck, boost, and buck-boost DC-DC converter using industry standard EDA tools.

Applications of WBG Device : GaN in AC/DC and DC/AC power converters, GaN in switched, mode power amplifiers, wireless energy transfer, electric vehicle applications, and renewable energy applications.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (40%), Internal Examinations (50%)

References:

1. Lidow, A., Strydom, J., de Rooij, M. D., & Reusch, D. (2014). *GaN transistors for efficient power conversion*. Wiley.
2. Baliga, B. J. (2017). *Gallium nitride and silicon carbide power devices*. World Scientific Publishing Company.
3. Wang, F., Zhang, Z., & Jones, E. A. (2018). *Characterization of wide bandgap power semiconductor devices*. IET.
4. Di Polo Emilio, M. (2024). *GaN and SiC power devices*. Springer.
5. Hu, R. (2019). *PCB design and layout fundamentals for EMC*. Independently Published.

E-resources: https://nptel.ac.in/courses/108106480

	Description of CO	PO	PSO1	PSO2
CO1	Explain the fundamentals and applications of wide-bandgap semiconductor devices.	PO1(1) PO2(1)	3	2
CO2	Analyze the electrical characteristics of wide bandgap devices and design suitable driver circuits.	PO1(2) PO3(2)	3	2
CO3	Perform electrical and thermal modeling of wide bandgap devices and design effective EMI filters for high-frequency power converters.	PO1(3) PO3(1)	3	2
CO4	Apply best practices and industry standards in designing single-layer and multilayer PCBs.	PO1(2) PO2(1) PO3(2)	2	2
CO5	Design and evaluate DC-DC and DC-AC converters utilizing wide bandgap devices for real-time applications.	PO1(2) PO2(2) PO3(1)	3	3