ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

Abbreviation used:

AC	Audit course	LC	Lab Course	PA	Practical Assessment
PC	Professional Core	PR	Project/ Practical/ Internship	L	Lecture
PE	Professional Elective	SE	Seminar/ Expert Lecture/ Etc.	T	Tutorial
OE	Open Elective	IA*	Internal Assessment	P	Practical
MC	Mandatory/ Common Course	EA	End-Semester Assessment		

Subject Code Format:

A1	A2	B3	C4	C5	C6
School/ Dept. (Offering) **BH:** Basic Sciences and Humanities **CS:** Computer Sciences **EE:** Electrical Sciences **EI:** Electronic Sciences **IP:** Infrastructure and Planning **MS:** Mechanical Sciences **BT:** Biotechnology **TE:** Textile Engineering		**Level** **1:** UG/ Int. Msc. (1st Year) **2:** UG/ Int. Msc. (2nd Year) **3:** UG/ Int. Msc. (3rd Year) **4:** UG/ Int. Msc. (4th Year) **5:** UG/ Int. Msc. (5th Year) **6:** PG (1st Year) **7:** PG (2nd Year) **8:** Ph.D.	**0:** AC **1:** PC **2:** PE **3:** OE **4:** MC **5:** LC **6:** PR **7:** SE **8:** **9:**	**Serial Number (01 to 99)** 01/ 03/…/ 19: Odd Sem. (ESM) 21/ 23/…/ 39: Odd Sem. (PED) 41/ 43/…/ 59: Odd Sem. (PSE) 61/ 63/…/ 79: Odd Sem. (Prog-4) 81/ 83/…/ 99: Odd Sem. (Prog-5) 02/ 04/…/ 20: Even Sem. (ESM) 22/ 24/…/ 40: Even Sem. (PED) 42/ 44/…/ 60: Even Sem. (PSE) 62/ 64/…/ 80: Even Sem. (Prog-4) 82/ 84/…/ 98: Even Sem. (Prog-5)	

1st Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PC 1	EE6121	Advanced Power Electronics Converter	3	0	0	3	40	60	-	100
2	PC 2	EE6123	Electric Drives	3	0	0	3	40	60	-	100
3	PE 1 (Any One)	EE6221	Storage Technology	3	0	0	3	40	60	-	100
		EE6223	Advanced Control System								
		EE6225	Power Quality								
4	MC 1	BH6401	Mathematical Methods in Engineering	3	0	0	3	40	60	-	100
5	MC 2	MS6403	Research Methodology and IPR	2	0	0	2	40	60	-	100
6	LC 1	EE6521	Advanced Power Electronics Lab	0	0	4	2	-	-	100	100
7	LC 2	EE6523	Power Electronics Simulation Lab	0	0	4	2	-	-	100	100
8	AC 1	Any One from the List of AC 1 (Appendix-I)		2	0	0	0	40	60	-	100
			Total	**16**	**0**	**10**	**18**	**240**	**360**	**200**	**800**

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

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Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
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2nd Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours L	T	P	Credit	Maximum Marks IA	EA	PA	Total
1	PC 3	EE6122	Switch Mode Power Conversion	3	0	0	3	40	60	-	100
2	PC 4	EE6124	Modeling, Analysis and Control of Electric Drives	3	0	0	3	40	60	-	100
3	PE 2 (Any One)	EE6222	AI and Machine Learning	3	0	0	3	40	60	-	100
		EE6224	Wind and Solar Energy System								
4	PE 3 (Any One)	EE6226	Advanced DSP	3	0	0	3	40	60	-	100
		EE6228	Smart Grid Technology								
		EE6230	FACTS and Custom Power Devices								
5	OE 1	Any One from the List of OE 1 (Appendix-I)		3	0	0	3	40	60	-	100
6	PR 1	EE6622	Project (Specialization Related)	0	0	4	2	-	-	100	100
7	LC 3	EE6522	Advanced Electric Drives Lab	0	0	4	2	-	-	100	100
8	AC 2	Any One from the List of AC 2 (Appendix-I)		2	0	0	0	40	60	-	100
			Total	**17**	**0**	**8**	**19**	**240**	**360**	**200**	**800**

3rd Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours L	T	P	Credit	Maximum Marks IA	EA	PA	Total
1	PE 4* (Any One)	EE7221	Grid Integration of Renewable Sources	3	0	0	3	40	60	-	100
		EE7223	Modeling and Simulation								
		EE7225	Electric and Hybrid Vehicles								
		EE7227	Industrial Automation and Control								
		EE7229	Intelligent Motor Controller								
2	PR 2	EE7621	Dissertation (Phase-I)	0	0	24	12	-	-	100	100
			Total	**3**	**0**	**24**	**15**	**40**	**60**	**100**	**200**

* Virtual/Online Course either offered by OUTR or available in MOOCs platform (No physical class)

4th Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours L	T	P	Credit	Maximum Marks IA	EA	PA	Total
1	PR 3	EE7622	Dissertation (Phase-II)	0	0	32	16	-	-	100	100
			Total	**0**	**0**	**32**	**16**	**-**	**-**	**100**	**100**

Credits and Maximum Marks

Sl. No.	Semester	Credits	Maximum Marks
1	1st	18	800
2	2nd	19	800
3	3rd	15	200
4	4th	16	100
	Total	68	1900

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

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Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

1st Semester

PC 1	EE6121	Advanced Power Electronics Converter	3	0	0	3

COURSE OBJECTIVES: Students should be able to

OB1. Understand the switching characteristic, gate drive circuit and protection of MOSFET and IGBT, operation of Switch Mode Rectifiers

OB2. Understand the concepts of different modulation techniques applied to multilevel inverters, operation of various types of MLIs and different current regulated techniques in Current regulated inverters

OB3. Understand different Resonant Converter topologies, Matrix converters and Z-source Converters

Module I

Power Switching Devices - MOS Field Effect Transistor (MOSFET), Switching Characteristics of the MOSFET, Insulated Gate Bipolar Transistor (IGBT), Switching Characteristics of the IGBT

Gate Drive Circuits for MOSFET, IGBT, Requirements of Gate Drive, Snubber Circuits for Power Switching Devices. Turn-off Snubber, Turn-on Snubber

Switched Mode Rectifier - Operation of Single Phase and Three Phase Bridges in Rectifier Mode. Control Principles. Control of the DC Side Voltage. Voltage Control Loop. The inner Current Control Loop.

Module II

Multi-Level Inverters of Diode Clamped Type, Flying Capacitor Type and Cascaded type; Basic Topology and waveforms, Improvement in harmonics, suitable modulation strategies -Space Vector Modulation, Minimum ripple current PWM method.

Hybrid Multilevel Inverters: Hybridization of Fundamental frequency switching (FFS) and PWM switching inverters: inverter topologies with an isolation transformer, PWM switching strategy; Transformerless hybrid inverter Current Regulated Inverte*r* -Current Regulated PWM Voltage Source Inverters.

Methods of Current Control. Hysteresis Control. Variable Band Hysteresis Control. Fixed Switching Frequency Current Control Methods.

Module III

Resonant converters: Zero Voltage Switching Clamped Voltage Topologies. Resonant DC Link Inverters with Zero Voltage Switching, Zero current switching resonant inverter.

Introduction to matrix converter and Z-source inverter: Principle and control strategy

Text:

1. Ned Mohan et. al : Power Electronics ,John Wiley and Sons
2. B K Bose : Modern Power Electronics and AC Drives, Pearson Edn (Asia)
3. M.H Rashid: Power Electronics, Pearson
4. M.H Rashid: Digital Simulation of Power Electronics, Pearson

References:

1. G K Dubey et. al :Thyristorised Power Controllers , Wiley Eastern Ltd.
2. P C Sen : Power Electronics , TMH

COURSE OUTCOMES: At the end of the course, the students will be able to

CO1: Analyze and understand the switching characteristic of power MOSFET and IGBT, Design their gate drive and protection circuits.

CO2: Understand and Analyze the operation of Switch Mode Rectifiers and application

CO3: Understand the concepts of different modulation techniques applied to multi level inverters, Analyze the operation of various types of MLIs and different current regulated techniques in Current regulated inverters

CO4: Understand the operation of different Resonant Converter topologies, Matrix converters and Z-source Converters with design and simulation of their performances

MAPPING OF COs WITH POs

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO-1		X	X				X	X
CO-2	X	X		X	X	X	X	
CO-3	X	X	X	X	X	X	X	X
CO-4		X	X	X	X		X	X

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

PC 2	EE6123	Electric Drives	3	0	0	3

COURSE OBJECTIVES: At the end of the Course the students should be able to

OB1. Understand the basic electrical drive system and its practical applications
OB2. Model and control the dc and ac drive systems
OB3. Design of converters for drive system
OB4. Understand scalar control of electrical drives

Module-I

Introduction to motor drives: Components of power electronic Drives- Criteria for selection of Drive components, Dynamics of Electrical Drives-Fundamentals of Torque Equations. Multi quadrant operations, Components of Load Torques, Classification of load torques, Steady state stability, Closed loop control of drives

Module-II

Converters and Chopper fed DC Motor Drives:
Modelling of dc machines, Steady state characteristics with armature and field control, Phase controlled converter fed D C Motor Drives- Steady state analysis of the 1-phase and 3-phase full converter fed DC motors Drive, Steady state analysis of the 1-phase and 3-phase semi converter fed DC motors Drive Transfer functions, Four quadrant dc motor drive.

Chopper- Controlled DC motor drive: Modelling of the chopper fed separately excited dc motor drives, Steady state analysis of chopper- controlled dc motor drives–continuous and discontinuous conduction operation, four quadrant operation, Transfer Functions

Module-III

Induction motor drives: Effect of supply voltage unbalance and harmonics on induction motor operation, speed control of 3-phase induction motor by varying stator frequency and voltage – variable frequency PWM-VSI drives- variable frequency CSI drives, Line frequency variable stator voltage drives, Direct torque and flux control of induction motor.

Synchronous motor drives: Open-loop control of synchronous motor, Self-controlled synchronous motor, CSI fed synchronous motor drive.

Industrial Drives: Stepper Motor Drives, Permanent Magnet Brushless DC Motor (PMBLDCM) drives, Switched Reluctance Motor Drives

Text Books:

1. Bimal.K. Bose, “Power Electronics and Variable frequency drives”, Standard Publishers Distributors, New Delhi, 2000
2. M. H. Rashid, "Power Electronics - Circuits, Devices and Applications", P.H.I Private Ltd. New Delhi, Second Edition, 1994
3. Bimal K Bose, “Modern Power Electronics and AC Drives” PHI
4. R. Krishnan, “Electric motor drives: modeling, analysis and control, Prentice-Hall, India.
5. G.K Dubey. “Fundamentals of Electric Drives”, Narosa Publishing House.
6. P.C. Sen,*Thyristor DC Drives*,Wiley-Interscience Pub., Digitized on Dec, 2006.

COURSE OUTCOMES: At the end of the Course the students will be able to

CO1: Understand and analyze the dynamics of drive systems and stability
CO2: Learn modeling and design of various converters for dc drive systems with performance evaluation
CO3: Understand and design the converter fed ac drive systems using induction machine, synchronous machine and some special ac machines like stepper motor, SR motor and BLDC motor and evaluation of their performances.

MAPPING OF COs WITH POs

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO-1		X	X				X	X
CO-2	X	X		X	X	X	X	
CO-3	X	X	X	X	X	X	X	X

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Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

PE 1	EE6221	Storage Technology	3	0	0	3

COURSE OBJECTIVES:

OB1. To gain knowledge about the need of different energy storage techniques and their industrial applications in the current energy scenario.

OB2. To analyze different emerging technologies in energy storage.

OB3. To design storage technologies in hybrid systems and electric vehicles.

Module I

Introduction to energy storage technology and energy storage processes

The need for energy storage - Types and general concepts Energy storage processes:

- Electrical energy storage – Super capacitors: Fundamentals and types of super capacitors
- Magnetic Energy Storage – superconducting systems,
- Thermal Energy Storage – phase change materials,
- Mechanical - Pumped hydro, Flywheels and Compressed air energy storage,
- Chemical - Hydrogen Storage, Production and storage alternatives, Other approaches to hydrogen storage.

Module II

Electrochemical energy storage

Thermodynamics, Kinetics and electrochemistry of battery Systems Primary, secondary and Flow batteries.

Module III

System design & Applications

- Energy storage for renewable energy sources - Battery sizing and stand-alone Applications
- Large scale applications/ Stationary (Grid applications) – Power and energy applications
- Small scale applications - Portable storage systems/medical devices
- Mobile storage applications
  - Electric vehicles - Introduction and types of EV's
  - Batteries and fuel cells – future technologies
- Hybrid systems for energy storage

Books and References:

2. Energy Storage - Technologies and Applications, *Ed: Ahmed Faheem Zobaa, ISBN978-953-51-0951-8, 328 pages, Publisher: InTech, 2013.*
3. J. Jensen and B. Sorenson. *Fundamentals of Energy Storage.* Wiley-Interscience,New York(1984)
4. Handbook of battery materials, Ed: C. Daniel, J. O. Besenhard, *2nd Edition, Wiley-VCH Verlag GmbH & Co. KgaA, 2011.*
5. Electric & Hybrid Vehicles, G. Pistoia, *Elsevier B.V, 2010*.

COURSE OUTCOMES:

CO1: Understand various storage technologies.

CO2: Able to analyze the reliability, technical efficiency and economic efficiency of an integrated system.

CO3: Exposure to modern innovative technologies applied for energy storage in fuel cell, hydrogen storage, electromagnetic storage etc.

CO4: Design of battery in electric vehicles and hybrid systems

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

PE 1	EE6223	Advanced Control System	3	0	0	3

Objectives of the course

OB1	To provide a concept on Advanced Control system analysis and design techniques using state variable method for Continuous-Time and Discrete-Time Systems
OB2	To analyse the behaviour of nonlinear control and adaptive control systems

Module I

Discrete-Time Systems

State Space Representations of Discrete Time Systems, Solution of Discrete Time State Equations, Discretization of Continuous Time State Equations, Digital PID Controller Controllability, Observability, Pole Placement by State feedback, Deadbeat response

Module II

Optimal Control (Continuous-Time and Discrete-Time Systems)

Performance Indices, Quadratic Optimal Regulator / Control Problems, Formulation of Algebraic Riccati Equation (ARE) for continuous and discrete time systems. Solution of Quadratic Optimal Control Problem using Lagrange Multiplies for continuous and discrete-time Systems, Evaluation of the minimum performance Index, Optimal Observer, The Linear Quadratic Gaussian (LQG) Problem, Pole Placement by State feedback using Optimal feedback Gain for Quadratic Regulator and LQG problem, Introduction to $H\infty$ Control.

Module III

Nonlinear and Adaptive Control

Stability: Basic concepts, Stability definitions and theorems, Lyapunov functions for LTI systems, Fractional Differentiation and its application

Model Reference Adaptive Control (using MIT Rule and Lyapunov Theory), Recursive Least Square Estimation, stochastic Self-Tuning Control (Minimum Variance and Pole-placement Control), Sliding Mode Control, Sliding mode control algorithms

Text Books

1. M. Gopal, Digital Control and State Variable Methods, Tata McGraw Hill, 3rd Edition, 2009
2. J. J. E. Slotine and W. Li, Applied Nonlinear Control, Prentice Hall, 1991.
3. D. S. Naidu, Optimal Control Systems, CRC Press, 2002.
4. K.J. Astrom and B. Wittenmark, Adaptive Control, Pearson, 2006.
5. R. T. Stefani, B. Shahian, C.J. Savant, G.H. Hostetter, Design of Feedback Control Systems, OUP, 2002.

Reference Books

1. K.Ogata, Modern Control Engineering, Prentice-Hall of India, 5th Edition, 2010
2. K.Ogata, Discrete-Time Control System, 2nd edition (2001), Pearson Education Publication
3. H.K. Khallil, Non Linear Systems, 3rd edition (2002), Pearson Education
4. B. Friedland, *Control System Design - An Introduction to State-Space Methods*, McGraw-Hill, 2007
5. S.H. Zak, Systems and Control, Oxford Univ. Press, 2003

COURSE OUTCOMES.

On successful completion, students will have the ability to

CO 1: Analyse the stability of discrete system and nonlinear system
CO 2: Design compensators using classical techniques and Optimal Control Law
CO 3: Analyse both linear and nonlinear system using state space methods
CO 4: Understand the concept and implementation of Adaptive Control

MAPPING OF CO'S WITH PO'S

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO-1	High	High	High	Medium	High	Medium	Medium	Low
CO-2	High	High	High	Medium	High	Medium	Medium	Low
CO-3	High	High	High	Medium	High	Medium	High	Low
CO-4	High	High	High	Medium	High	Medium	High	Low

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

PE 1	EE6225	Power Quality	3	0	0	3

COURSE OBJECTIVES:

OB1. To impart knowledge on issues of power quality and factors governing it.
OB2. To impart knowledge on impacts of poor power quality on the system and the consumers.
OB3. To impart knowledge on harmonics (cause, effect and compensating techniques).

Module I

Electric Power Quality Phenomena: Impacts of power quality problems on end users, Power quality standards, power quality monitoring.
Power Quality Disturbances: Transients, short duration voltage variations, long duration voltage variations, voltage imbalance, wave-form distortions, voltage fluctuations, power frequency variations, power acceptability curves.

Module II

Power Quality Problems in Power Systems: Poor load power factor, loads containing harmonics, notching in load voltage, dc offset in loads, unbalanced loads, disturbances in supply voltage.
Transients: Origin and classification- capacitor switching transient-lighting-load switching-impact on users, Protection and mitigation of transients.
Harmonics: Harmonic distortion standards, power system quantities under non sinusoidal conditions-harmonic indices-source of harmonics-system response characteristics-effects of harmonic distortion on power system apparatus –principles for controlling harmonics, reducing harmonic currents in loads, filtering, modifying the system frequency response- Devices for controlling harmonic distortion, inline reactors or chokes, zigzag transformers, passive filters, active filters.

Module III

Power Quality Conditioners: Shunt and series compensators, Distribution STATCOMS (DSTATCOMS) and Dynamic Voltage Restorers (DVRs), Rectifier supported DVR, DC Capacitor supported DVR, DVR Structure, Voltage Restoration – Series Active Filter – Unified power quality conditioners.

Suggested Books:

1. Ghosh Arindam and Ledwich Gerard, 'Power quality enhancement using custom power devices' Springer.
2. Arrillaga J., Watson N. R. and Chen S., 'Power System Quality Assessment' Wiley.
3. Caramia P, Carpinelli G and Verde P, 'Power quality indices in liberalized markets' – Wiley
4. Angelo Baggini 'Handbook of Power Quality' – Wiley.
5. G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 1994(2nd edition)
6. R.C. Duggan, 'Power Quality', TMH Publication, 2002

COURSE OUTCOMES (CO'S)

At the end of the course, students will be able to:

CO1: gain knowledge on issues of power quality and factors governing it.
CO2: gain knowledge on impacts of poor power quality on the system and the consumers.
CO3: gain knowledge on harmonics (cause, effect and compensating techniques).

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Syllabus (Effective from 2023-24)

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MC 1	BH6401	Mathematical Methods in Engineering	3	0	0	3

Refer Appendix-I for detailed Syllabus.

MC 2	MS6403	Research Methodology and IPR	2	0	0	2

Refer Appendix-I for detailed Syllabus.

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

LC 1	EE6521	Advanced Power Electronics Lab	0	0	4	2

COURSE OBJECTIVES:
Students should be able to
OB1. Understand the working of Controlled rectifiers, Choppers and AC Regulators
OB2. Understand multi quadrant operation of a Dual Converter.
OB3. Understand the different PWM schemes of inverters.

Sl. No	Experiments
1	To Study single-phase (i) fully controlled (ii) Half controlled bridge rectifiers with resistive and inductive loads
2	To Study three-phase (i) fully controlled (ii) Half controlled bridge rectifiers with resistive and inductive loads.
3	To study operation of IGBT/MOSFET based Buck chopper
4	To study operation Dual Converter with resistive and inductive loads.
5	To Study single-phase AC voltage regulator with resistive and inductive loads
6	To Study Three-phase AC voltage regulator with resistive and inductive loads
7	To Study various pwm based single-phase bridge inverter
8	To Study pwm based three-phase bridge inverter
9	Calculation of input power factor and displacement factor for single phase rectifier circuit
10	Development of firing angle table for +ve, -ve and zero sequence voltage for 3-ph inverter circuits
11	Performance calculation of various rectifier circuits

COURSE OUTCOMES:
Students will be able to
CO1: Understand and Analyze the performance parameters of converters.
CO2: Analyze Spectral content for Various PWM schemes.
CO3: Design the firing circuits employed for Power Electronic Converters.

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

LC 2	EE6523	Power Electronics Simulation Lab	0	0	4	2

COURSE OBJECTIVES:
Students should be able to
OB1. Simulate Controlled rectifiers and AC Regulators using MATLAB/PSIM.
OB2. Design switching schemes of switch mode DC-DC converters in MATLAB/PSIM.
OB3. Design different PWM schemes of inverters in MATLAB/PSIM

Sl. No	Experiments
1	To Study single-phase (i) fully controlled (ii) Half controlled bridge rectifiers with R, R-L, R-L-E loads using MATLAB/PSIM software
2	To Study three-phase (i) fully controlled (ii) Half controlled bridge rectifiers with R, R-L, R-L-E loads using MATLAB/PSIM software
3	To study Buck, Boost Regulator using MATLAB/PSIM software.
4	To study forward and flyback converter using MATLAB/PSIM software
5	To Study Dual converter with resistive and inductive loads using MATLAB/PSIM software
6	To Study Three-phase AC voltage regulator with resistive and inductive loads using MATLAB/PSIM software
7	To Study sinusoidal pwm based single-phase bridge inverter using MATLAB/PSIM software
8	To Study pwm based three-phase bridge inverter using MATLAB/PSIM software

COURSE OUTCOMES:
Students will be able to
CO1: Analyze the performance of converters in MATLAB/PSIM platform.
CO2: Control the switch mode regulators in MATLAB/PSIM platform.
CO3: Analyze Harmonic content of PWM based inverters in MATLAB/PSIM platform.

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

AC 1	Any One from the List of AC 1 (Appendix-I)	2	0	0	0

Refer Appendix-I for detailed Syllabus.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

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2nd Semester

PC 3	EE6122	Switch Mode Power Conversion	3	0	0	3

COURSE OBJECTIVES: At the end of the Course students should be able to

OB1. Understand the topology and operation of different types of switched mode converters
OB2. Understand and design various modeling approach of dc-dc converters
OB3. Current programmed control of dc-dc converters
OB4. Do steady state analysis and design of resonant SMPS

Module-I

DC-TO-DC Converters:

Series Controlled and Shunt Controlled Converters

Switched Mode Power Converters: Buck Converter, Boost Converter and Buck-Boost Converters in CCM and DCM Operation

Isolated dc to dc Converters: Forward Converter, Push-Pull converter, Half and Full Bridge Converter, Fly-back Converter

Steady state analysis of derived DC-DC converters (Cuk, SEPIC, Quadratic)

Module-II

DC-TO-DC Converter – Dynamics, Dynamic models, Modeling approach, Averaged Model of the Converter, Small Signal Model of the Converter, Generalised State Space Model of the Converters, Dynamic Model of Converters Operating in DCM

Switched mode voltage regulator specifications, block diagram and transfer functions of hard switched converters in CCM and DCM modes.

Current Programmed Control of DC to DC Converters: Determination of Duty Ratio for Current Programmed Control for Buck Converter, Boost Converter and Buck-Boost Converter

Module-III

Soft Switching Converters: Resonant Load Converters, SMPS Using Resonant Circuit, Steady State Modeling of Resonant SMPS, Resonant Switch Converters, Buck Converter with Zero Current Switching, Boost Converter with Zero Voltage Switching

PWM Converters with Auxiliary Switch, ZVT /ZCT PWM Converters: Isolated and Non-isolated topologies with auxiliary switch; Auxiliary Resonant Commutated Pole Inverters: ZVT and ZCT concepts used for Inverters; Resonant DC Link Inverters

Text:

1. Ned Mohan et. al : Power Electronics ,John Wiley and Sons
2 . B K Bose : Modern Power Electronics and AC Drives, Pearson Edn (Asia)
3. M.H Rashid: Power Electronics, Pearson
4. M.H Rashid: Digital Simulation of Power Electronics, Pearson
5. R. W. Erickson and D. Maksimovic, 'Fundamental of Power Electronics', Springer International Edition, 2005.

COURSE OUTCOMES: At the end of the course, the students will be able to

CO1: Understand the topology and operation of different types of switched mode converters
CO2: Understand the modeling of dc-dc converters and design the controllers
CO3: Current programmed control of dc-dc converters
CO4: Do steady state analysis and design of resonant SMPS

MAPPING OF COs WITH POs

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO-1		X	X				X	X
CO-2	X	X		X	X	X		
CO-3	X	X	X	X	X	X	X	X
CO-4		X	X		X	X	X	X

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED), Duration: 2 years (Four Semesters)

PC 4	EE6124	Modeling, Analysis and Control of Electric Drives	3	0	0	3

COURSE OBJECTIVES: At the end of the Course, the students should be able to

OB1. Understand the modeling of Induction and Synchronous machines in various reference frames

OB2. Understand the principle of vector control and analyze the ac drive systems

OB3. Understand and analyse various speed sensor- less vector control schemes applied to Induction and Synchronous machines

Module I

Dynamic Modeling of Induction and Synchronous Machines: abc and dq modeling, Stator Reference, Rotor Reference and Synchronously Rotating Reference Frame Models.

Module II

Control of Induction Motor (IM) Drive- Principle of vector control, Direct vector control and Indirect vector control schemes, Direct rotor-flux oriented control of IM, Indirect rotor-flux oriented control of IM, Speed controller design for an Indirect Vector Controlled Induction Motor Drive, Air-gap flux and Stator-flux oriented vector control schemes of Induction Motor, Flux observers, Speed sensor-less control

Module III

Vector control of synchronous motor, Cycloconverter fed wound field synchronous motor drives

Control of Surface Permanent Magnet Machine and interior permanent magnet machine, Vector Control of Permanent magnet synchronous motor (PMSM), Synchronous Reluctance Motor Drives

Essential Reading:

Texts: -

1. R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall.
2. P. S. Bhimbra, “Generalized Theory of Electric Machines”, Khanna Publication.
3. B. K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education.
4. G. K. Dubey, Power Semiconductor Controlled Drives, Prentice-Hall International, 1989.
5. P. C. Krause, O.Wasynczuk and S.D.Sudhoff, “Analysis of Electric Machinery and Drive Systems” Willy IEEE press 3rd edition

Supplementary Reading:

1. G. K. Dubey, *Fundamentals of Electrical Drives*, Narosa Publishing House, 2002.
2. W. Leonhard, *Control of Electrical drives,* Springer-Verlag, 1985.

COURSE OUTCOMES: At the end of the course, the students will be able to

CO1: Model and analyze various direct and indirect vector control schemes applied to Induction motor

CO2: Design the sensor less vector control of Induction and Synchronous motors with simulation

CO3: Analyze and simulate special types of drive machines such as Switched Reluctance motor and Synchronous Reluctance motors etc.

MAPPING OF COs WITH POs

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO-1		X	X		X		X	X
CO-2	X	X	X	X		X	X	
CO-3	X	X	X	X	X	X	X	X

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

PE 2	EE6222	AI and Machine Learning	3	0	0	3

COURSE OBJECTIVES:

OB1. To learn about biological foundations of Intelligent Systems
OB2. To learn about Artificial Neural Network
OB3. To learn about Fuzzy Logic
OB4. To know about GA and other Evolutionary Algorithms

Module I
Artificial Neural Networks and Deep Learning

Neural Network representations, appropriate problems for neural network learning
Supervised Learning: Perceptrons, representational power of perceptrons, perceptron training rule, Gradient Descent and Delta rule, Multilayer perceptron and backpropagation algorithm, Linear Regression: Linear regression and prediction of continuous data values, Recurrent Neural Networks, RBFN
Unsupervised Learning: Competitive Learning, K-Means clustering, Hierarchical Clustering
Support Vector machines: Classification of data points using support vectors

Module II
Fuzzy Inference Systems:

Basic Concepts of Fuzzy Logic, Fuzzy vs Crisp Set, Linguistic variables, Membership Functions, Operations of Fuzzy Sets, Fuzzy If-Then Rules, Variable Inference Techniques, Defuzzification, Basic Fuzzy Inference Algorithm, Fuzzy Neural Network
System Identification using Fuzzy and Neural Networks

Module III:
Genetic Algorithm:

Representing Hypothesis, Genetic operators, Population Evolution, Genetic programming,
Introduction to other evolutionary Algorithms like PSO, BFO etc

Text Books

1. Tom M Mitchell, Machine Learning, PHI LEARNING PVT. LTD-NEW DELHI, 2015
2. EthemAlpaydin, Introduction to Machine Learning, The MIT Press, 3rd Edition, 2015
3. Simon Haykins, Neural Networks, Prentice Hall
4. Timothy Ross, Fuzzy Logic with Engineering Application- McGraw Hill Publishers

Reference Books

1. R. Duda, P. Hart, and D. Stork. "Pattern Classification", 2nd edition, Wiley Interscience, 2001.
2. C. M. Bishop. "Neural Networks for Pattern Recognition", Oxford University Press, 1995.
3. T. Hastie, R. Tibshirani and J. Friedman, "Elements of Statistical Learning: Data Mining, Inference and Prediction". Springer-Verlag, 2001.
4. T. Cover and J. Thomas. "Elements of Information theory", Wiley Interscience, 1991.
5. Golding, “Genetic Algorithms”, Addison Wesley
6. Junhong NIE & Derek Linkers, “Fuzzy Neural Control”, PHI

COURSE OUTCOME.

On successful completion, students will have the ability to

CO1 Apply the concepts of Neural network for pattern recognition andclassification
CO2 Apply Fuzzy logic principles to take decisions and design controllers
CO3 Apply GA principles for solving optimization problems

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

PE 2	EE6224	Wind and Solar Energy System	3	0	0	3

COURSE OBJECTIVES:

1. To provide a broad overview of the technology covering aspects of wind energy conversion systems.
2. To develop clear understanding of the challenges in WECS and its mitigation techniques.
3. To understand the fundamentals of a solar cell
4. To analyze different techniques for maximum power extraction from the PV system
5. To gain knowledge of different PV based applications and their system design.

MODULE-I:

Wind and Solar PV System Fundamentals: Wind Energy, Wind Speeds and Scales, Terrain, Turbulence, Roughness, Site Selection, Principles of Aerodynamics of wind turbine blade, Power Content, Betz's Limit, Wind measurements, Wind data analysis, Wind resource estimation.

Photovoltaic effect: Principle of direct solar energy conversion into electricity in a solar cell. Solar cells, modules and arrays, fill factor, efficiency.

Solar PV modules: series and parallel connection of cells, modules and arrays and its mismatch. PV Modelling: Equivalent circuit of PV cell, output characteristics, Double and single diode models, PV module equivalent parameters, effect of solar irradiance and temperature on PV.

MODULE-II:

Classification of Wind Turbines

Vertical and Horizontal Axis types, Torque-Speed and Power-Speed Characteristics WT, Constant Speed and Frequency, Variable Speed and Frequency, Up Wind, Down Wind; Wind Turbine Control Systems: Pitch Angle Control, Stall Control, Yaw Control and Power Electronic Control, Control strategy.

CONTROL OF SOLAR PV SYSTEM

Incremental conductance algorithm, Perturb and observe approach, improvements of P&O algorithm, MPPT for rapidly changing irradiance conditions. Design of dc/dc converter, single phase and three-phase inverter with PV as a source. Grid support features of utility-scale PV with storage, Micro-grids, and frequency/voltage control in islanded mode of operation. Three phase PV inverters, Response of Abnormal Grid Conditions.

MODULE-III:

Wind Turbine Generators and Power Electronics Control: Gear and Rotor Coupled Generator Type WT, Conversion to Electrical Power: Excited Rotor Synchronous Generator/Permanent Magnet Synchronous Generator, Constructional Features, Steady State Equivalent Circuit Model and Equations, Doubly Fed Induction Generator, Induction Generator.

Power Electronics Converters, Reactive Power Compensation and Grid Connection Issues.

MODULE III: APPLICATION AND DESIGN OF PV SYSTEMS

Stand-alone, Grid Interactive and Hybrid solar PV system and its cost estimation. Solar Water Pumping System and Net Power Metering. Design of Solar Parks and use of Solar Electricity in solar cars, aircraft, space solar power satellites.

TEXT BOOKS

1. S. N. Bhadra, D. Kastha, S. Banerjee, Wind Electrical Systems, Oxford Univ. Press, New Delhi, 2005.
2. Wind energy Handbook, Edited by T. Burton, D. Sharpe, N. Jenkins and E. Bossanyi, John Wiley & Sons, 2001.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

PE 3	EE6226	Advanced DSP	3	0	0	3

MODULE-I

Classification of Signals: Multichannel and Multidimensional Signals, Continuous-Time Versus Discrete-Time Signals, Continuous-Valued Versus Discrete-Valued Signals, Deterministic Versus Random Signals, Concept of frequency in Continuous-Time and Discrete-Time Signals

Analysis of Discrete-Time LTI Systems:

Resolution of a Discrete-Time Signal into impulses, Response of LTI Systems to Arbitrary Inputs: The convolution sum, Causal LTI Systems, systems with Finite-Duration and Infinite-Duration Impulse Response, Recursive and Non-Recursive Discrete-Time Systems, LTI Systems characterized by Constant Coefficient Difference Equations

Correlation of Discrete-Time Signals:

Cross-correlation and Auto-Correlation Sequences, Properties of Cross-correlation and Auto-Correlation Sequences, Correlation of Periodic Sequences, Input-Output Correlation Sequences

MODULE-II

Transforms used in Signal Processing:

Discrete Fourier Transform, Its Properties, Use of DFT in Linear Filtering

Discrete Cosine Transform: Forward DCT, Inverse DCT, DCT as an Orthogonal Transform

Fast Fourier Transform: Divide and Conquer Approach to Computation of DFT, Radix-2 and Radix-4 FFT

Brief introduction to Short time Fourier Transform, Discrete Wavelet Transform, S-Transform and their applications

MODULE-III

Adaptive Signal Processing:

Least Mean Square Algorithm and its variants, Properties of LMS Algorithm, Recursive Least Square Algorithm and its variants, Kalman Filter Application of Adaptive Signal Processing to Power System

Time Series Prediction:

Nature of Time Series Data, AutoRegressive Moving Average (ARMA) Models, AutoRegressive Integrated Moving Average (ARIMA) Models for Forecasting & Estimation

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1 Learn about analysis and correlation of discrete-time signals
CO2 Learn about different Transforms used in signal processing
CO3 Learn about different estimation techniques
CO4 Know about time series prediction

TEXT/ REFERENCE BOOKS:

1. J. G. Proakis and D. G. Manolakis, “Digital Signal Processing”, Fourth Edition, Pearson
2. Simon Haykin, “Adaptive Filter Theory”, Fourth Edition, Pearson
3. A. Nagoor Kani, “Discrete-Time Signal Processing”, Prentice Hall
4. Alan V. Oppenheim, Ronald W. Schafer, “Discrete-Time Signal Processing”, Prentice Hall
   S. Mallat, “A wavelet Tour of Signal Processing: The sparse way: Academic Press, 2010

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

PE 3	EE6228	Smart Grid Technology	3	0	0	3

COURSE OBJECTIVES

OB1. To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
OB2. To familiarize with the power quality management issues in Smart Grid.
OB3. To familiarize with the high performance computing for Smart Grid applications

Module-I:

Evolution of Electric Power Grid, introduction to smart Grid, Concept, definitions, architecture and functions of Smart Grid. Need of Smart Grid. Difference between conventional & smart grid. Opportunities & Challenges of Smart Grid,

Introduction to Smart Meters, Real Time Pricing, Smart Appliances. Automatic Meter Reading(AMR). Outage Management System(OMS). Home & Building Automation, Substation Automation, Feeder Automation, Smart Sensors, Geographic Information System(GIS). Intelligent Electronic Devices(IED) & their application for Monitoring & Protection.

Module-II:

Phasor Measurement Units (PMU), Wide Area Measurement System(WAMS), Wide-Area based Protection and Control
Micro-grid concepts, need and application, Issues of Interconnection. Protection & control systems for micro-grid. Storage systems including Battery, SMES, Pumped Hydro. Compressed Air Energy Storage.

Module-III:

Variable speed wind generators, fuel-cells, micro-turbines. Integration of renewables and issues involved, Advantages and disadvantages of Distributed Generation.

Power Quality & EMC in smart Grid. Power Quality issues of Grid connected Renewable Energy Sources. Power Quality Conditioners for micro-grid. Web based Power Quality monitoring, Power Quality Audit

COURSE OUTCOMES:

After successfully completing this course a student will able to:

CO 1: Understand the fundamental element of the smart grid
CO 2: Explain various communication, networking, and sensing technologies involved in smart grid
CO 3: Explain various integration aspects of conventional and non-conventional energy sources.
CO 4: Explain distributed generation coordination including monitoring of smart grid using modern communication infrastructure
CO 5: Analyze Micro-grid as a hybrid power system with advantages and challenges in future.
CO 6: Be able to apply this knowledge in analysis and problem solving of smart grid architectures needs and challenges

Suggested Books:

1. Ali Keyhani, “Design of Smart power grid renewable energy systems”, Wiley IEEE,2011.
2. Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRCPress, 2009.
3. Stuart Borlase, “Smart Grid: Infrastructure, Technology and solutions “CRC Press.
4. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley.
5. Andres Carvallo, John Cooper, “The Advanced Smart Grid: Edge Power Driving Sustainability: 1”, Artech House Publishers July 2011
6. MladenKezunovic, Mark G. Adamiak, Alexander P. Apostolov, Jeffrey George Gilbert “Substation Automation (Power Electronics and Power Systems)”, Springer

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

PE 3	EE6230	FACTS and Custom Power Devices	3	0	0	3

COURSE OBJECTIVES:
OB1. To impart knowledge on flexible AC transmission system criteria, advantages, and control parameters.
OB2. To impart knowledge on various compensation techniques for control of FACTs devices.
OB3. To impart knowledge on various practices being followed in the real system scenario.

Syllabus:
Module 1:
Flexible AC Transmission System: Transmission inter connections, flow of power in ac systems, loading capability, dynamic stability considerations, basic types of FACTS controllers.

Module 2:
Static Shunt and Series Compensators: Objectives of shunt compensation, Static VAR compensators (SVCs), STATCOM configuration, Characteristics and control, Comparison between STATCOM and SVC. Objectives of series compensation, Variable Impedance type series compensators, switching converter type series compensators, external control for series reactive compensators.

Module 3:
Power Flow Control Techniques: Principle of operation and characteristics, independent active and reactive power flow control, comparison of UPFC with the series compensators and phase angle regulators, Principle of operation, characteristics and control aspects of IPFC.

Module 4:
Custom Power Devices: Introduction to custom power devices, DSTATCOM and DVR operating principles, Applications of DSTATCOM and DVRs in Distribution Systems.

Suggested Books:
1. Hingorani ,L.Gyugyi, ‘ Concepts and Technology of Flexible AC transmission system’, IEEE Press New York, 2000.
2. K.R.Padiyar, “FACTS controllers in power transmission and distribution”, New Age International Publishers, Delhi, 2007.

COURSE OUTCOMES (CO’S)
At the end of the course, the students will be able to
CO1: gain knowledge on flexible AC transmission system criteria, advantages, and control parameters.
CO2: gain knowledge on various compensation techniques for control of FACTs devices.
CO3: gain knowledge on various practices being followed in the real system scenario.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

OE 1	Any One from the List of OE 1 (Appendix-I)	3	0	0	3

Refer Appendix-I for detailed Syllabus.

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

PR 1	EE6622	Project (Specialization Related)	0	0	4	2

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

LC 3	EE6522	Advanced Electric Drives Lab	0	0	4	2

COURSE OBJECTIVES:
The students should be able to
OB1. Understand the scalar control techniques of dc and ac motors using staticconverters
OB2. Simulate the dc and ac drive systems using MATLAB/PSIM
OB3. Design of various converters for dc and ac drive systems

Sl. No	Experiments
1	Study of Thyristor controlled DC Drive
2	Study of AC single phase motor speed control using AC voltage controller
3	Study of V/f control operation of three phase induction motor
4	Study of static rotor resistance control of 3 phase induction motor
5	Regenerative/Dynamic Braking operation of DC motor drive using MATLAB/PSIM software.
6	PWM inverter fed three phase induction motor control using MATLAB/PSIM software.
7	Study of chopper fed DC motor drive using MATLAB/PSIM software.
8	Regenerative/Dynamic Braking operation of AC motor drive using MATLAB/PSIM software.

COURSE OUTCOMES: At the end of the course, the students will be able to
CO1: analyse braking operation of dc and ac drives in MATLAB/PSIM platform
CO2: control various converters for dc and ac drives
CO3: analyse ac voltage controller for ac motor speed control

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

AC 2	Any One from the List of AC 2 (Appendix-I)	2	0	0	0

Refer Appendix-I for detailed Syllabus.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

3rd Semester

PE 4	EE7221	Grid Integration of Renewable Sources	3	0	0	3

COURSE OBJECTIVES:

1) The main objective of the course is to provide students with the knowledge of the impacts caused by the integration of distributed renewable generation in the power system.
2) To provide student with the ability to use modern simulation tools to evaluate the performance of electric power systems with high penetration of renewable energy.

MODULE-I

Introduction to distributed generation/Micro Grid: General introduction to the concept of distributed generation, Standalone System, Integration of distributed renewable generation into the electricity system (Current status, challenges and prospects) and its impacts on the electrical system.

Network topologies with distributed generation: Description of the different network topologies where distributed renewable generation (Wind, Solar, Hydro, Tidal power) can be connected. Principles of design, operation.

MODULE-II

Power system Performance:

Impact of distributed generation on power system in terms of changes taking place and severity imposed, power quality issues, voltage quality issues, design of distributed generation.

Impact of distributed generation on power system in terms of overloading and losses, radial distribution networks, redundancy and meshed operation, losses, increasing the hosting capacity.

MODULE-III

Control of standalone system and Grid connected system (Voltage and frequency control). Phase Locked Loop, Islanding and reconnecting. Primary frequency control in large systems, Fault ride through.

Transmission system operation: Fundamental operation, Frequency control, Balancing and Reserves, Prediction of production and consumption, Restoration, Voltage stability, Angular stability.

Textbooks:

1. Bollen M.H.J., Hassan F., Integration of distributed generation in the power system. IEEE Press Series on Power Engineering. Wiley. Hoboken 2011.
2. Jenkins N., Allan R., Crossley P., Kirschen D., Strbac G., Embedded generation. IEE Power and Energy Series 31. London, 2000.
3. Jenkins N., Ekanayake J.B., Strbac G., Distributed generation. IET Renewable Energy Series 1. London 2010.
4. Keyhani A., Marwali M.N., Dai M., Integration of green and renewable energy in electric power systems. Wiley. Hoboken 2010.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

PE 4	EE7223	Modeling and Simulation	3	0	0	3

COURSE OBJECTIVEs:

OB1. To provide a basic understanding of Probability Theory,

OB2. To provide a basic understanding of applied Linear Algebra and optimization problems, viz., their formulation, analytic and computational tools for their solutions,

OB3. To learn about applications of Linear Algebra and Probability Theory in modelling and simulation environment

Module 1:

Probability and Random Process: Introduction, The Concept of a Random Variable, Functions of One Random Variable, Two Random Variables, Sequence of Random Variables, Statistics, Markov Chains

Module 2:

Linear Algebra: The geometry of linear equations, Elimination with matrices, Matrix operations and inverses, Vector spaces and subspaces, Orthogonality, Linear operators and matrix inverses: The LU factorization, The Cholesky factorization, Unitary matrices and the QR factorization, Projections and subspaces, Least squares approximations

Module 3:

Linear Algebra: Eigenvalues and eigenvectors, Linear dependence of eigenvectors, Diagonalization, Computation of eigenvalues and eigenvectors, Singular value decomposition: Matrix structure from the SVD, Pseudo-inverses and the SVD

Convex Optimization: Convex Sets, Convex Functions, Convex Optimization Problems, Unconstrained minimization, Equality Constrained Minimization

Text Book:

1. Probability, Random Variables and Stochastic Processes, by Papoulis and Unnikrishnan, Fourth Edition, 2002
2. Introduction to Linear Algebra, by Strang, Gilbert. 5th ed. Wellesley-Cambridge Press, 2016
3. Convex Optimization, by Stephen Boyd and LievenVandenberghe, Cambridge University Press, 2004

COURSE OUTCOMES:

CO1: Convert an Engineering statement problem into a precise mathematical probabilistic Statement

CO2: To understand matrix manipulations, vector space or subspace and orthogonal complement of a subspace

CO3: Use of various computational algorithms for unconstrained optimization, including steepest descent, Newton's method, conjugate-direction methods, and direct search methods

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

PE 4	EE7225	Electric and Hybrid Vehicles	3	0	0	3

COURSE OBJECTIVE:

1. Explain the fundamentals of electric and hybrid electric vehicle, their architecture and technologies.
2. Explain the design of converters and drives used for electric and hybrid electric vehicles
3. Discuss different converters used in electric vehicles and battery charging circuits.
4. Demonstrate different storage systems and its management.

Module-I

Introduction to Hybrid Electric Vehicles: Past, Present & Future of EV, Current Major Issues, Recent Development Trends, EV Concept, Key EV Technology, State-of-the Art EVs & HEVs, Comparison of EV Vs IC Engine.

Hybridization of the Automobile: Basics of the EV, HEV, PHEV and vehicle architectures. Power flow control in hybrid drive-train topologies and Fuel efficiency analysis. Fixed & variable gearing, single & multiple motor drive, In-wheel drives.

Vehicle Dynamics Fundamentals: Vehicle Kinematics, Vehicle Resistance: Rolling Resistance, Aerodynamic Drag, Grading Resistance, Dynamic Equation Tire–Ground Adhesion and Maximum Tractive Effort, Power Train Tractive Effort and Vehicle Speed.

Module-II

Power Electronics in HEVs: Rectifiers used in HEVs, voltage ripples; Buck converter used in HEVs, non-isolated bidirectional DC-DC converter, regenerative braking, voltage source inverter, current source inverter, isolated bidirectional DC-DC converter, PWM rectifier in HEVs, EV and PHEV battery chargers.

Electric Machines and Drives in HEVs: Fundamental of Drives and Control of EV Using Induction Motor, Permanent Magnet Motor, Switched Reluctance Motor, BLDC motor, Sizing of Traction Motors.

Module-III

Battery and Storage Systems: Different batteries for EV, Battery Characterization, Comparison of Different Energy Storage Technologies for HEVs.

EV Charging Technologies: Classification of different charging technology for EV charging station, introduction to Grid-to-Vehicle, Vehicle to Grid (V2G) operations.

Battery Management System (BMS): Need of BMS, Converter control for power management, Software-based high-level supervisory control, Mode of power transfer, Behaviour of drive motor.

Fuel Cell based energy storage and its analysis

Text Book:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003
2. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2014.

References:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
3. hris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd., 2011
4. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

PE 4	EE7227	Industrial Automation and Control	3	0	0	3

COURSE OUTCOMES

1. Students will have an appreciation of the necessity and difficulty of making choices between different sensors, actuators, inter connection protocols used for automation.
2. Students will be taught about different elements of industrial automation and their interconnections.
3. Students will be taught different controlling and supervising methods.

Module-I

Types of Automation Systems, Architecture of Industrial Automation Systems, Sensing and Actuation Elements, Industrial Sensors and Instrument Systems, Industrial Control Systems, Sequence / Logic Control, PLC: Hardware/Software, introduction & Instruction sets Digital and Analog IO modules PID tuning methods Implementing PID algorithm using Industrial Controllers, Supervisory Control, The Architecture of Elements: The Automation Pyramid

Module-II

Electrical Actuators: DC Motor Drives, Control of DC motor drives, stepper motor drives, BLDC Motor Drives Induction motor drives Energy Savings with Variable Speed Drives, Industrial Networking and communication standards Industrial field buses Introduction to SCADA System components: software, Data Acquisition, RTUs, database connectivity and report generating HMI development: data processing, control algorithm

Module-III

Higher Levels of Automation Systems, Introduction to Distributed Control System (DCS) Industrial DCS configuration Monitoring & controlling the plant through field bus.

TEXT BOOKS

1. S. Mukhopadhay, S. Sen ,and A. K. Deb, *Industrial Instrumentation Control and Automation*, JAICO , 2015
2. Krishna Kant, *Computer-Based Industrial Control*, Prentice Hall of India , 1997

REFERENCES

1. David Bailey, E. Wright, *Practical SCADA for Industry*, Newnes , 2003
2. W. Dunn, *Fundamentals of Industrial instrumentation and control system*, McGraw-Hill , 2005

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH
Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.
Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Power Electronics & Drives (PED),
Duration: 2 years (Four Semesters)

PE 4	EE7229	Intelligent Motor Controller	3	0	0	3

COURSE OUTCOMES:

CO1: Gaining an understanding of the functional operation of a variety of intelligent control techniques and their bio-foundations,

CO2: Learning analytical approaches to study properties (especially stability analysis), and use of the computer for simulation and evaluation.

CO3: To understand about different soft computing techniques such as neural network, fuzzy logic and evolutionary techniques for designing intelligent controllers

CO4: To pursue stability analysis of intelligent controllers

Module-I:

Fundamental concepts in control of electric drive systems, Intelligent Control algorithms used for electric drive systems, Fuzzy Logic Control: Introduction, fuzzy sets, fuzzy logic, fuzzy logic controller design, Fuzzy Modelling and identification, Fuzzy Logic Control of Drives

Module-II:

Artificial Neural Network control of Drives, Artificial Neural Networks Applications to System Identification & Control, learning with ANNs, single-layer networks, multi-layer perceptrons, ANNs for identification, ANNs for control., Adaptive Fuzzy Control Design. Neuro-fuzzy, evolutionary neuro and evolutionary fuzzy systems

Module-III:

Evolutionary Computation for Control & identification: Applications of EC methods to system identification and control. Genetic Algorithm based control of Drives
Hybrid Fuzzy/PI Control of Drives, Nonlinear Control of Power Converters and Drives

TEXT BOOKS

1. Rojer Jang, *Soft Computing*, PHI
2. D Driankov, H Hellendoorn and M Reinfrank, *n Introduction to Fuzzy Control*, Springer-Verlag, 2001.

REFERENCE BOOKS

1. K. Passino, *Biomimicry for Optimization, Control, and Automation*, Springer-Verlag, London, UK, 2005
2. S.H. Zak, *Systems and Control*, Oxford

School/ Department: School of Electrical Sciences

Course: M. Tech., Programme: Power Electronics & Drives (PED),

Duration: 2 years (Four Semesters)

PR 2	EE7621	Dissertation (Phase-I)	0	0	24	12

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
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Duration: 2 years (Four Semesters)

4th Semester

PR 3	EE7622	Dissertation (Phase-II)	0	0	32	16