SRI VENKATESWARA COLLEGE OF ENGINEERING,

(An Autonomous Institution, Affiliated to Anna University, Chennai – 600025)

M.E., Power Electronics and Drives

CURRICULUM AND SYLLABUS

REGULATION – 2022

CHOICE BASED CREDIT SYSTEM

Curriculum Revision No:		Board of Studies recommendation date :	07/10/2022	Academic Council Approved date:	08/10/2022
Salient Points of the revision	01.	Inclusion of core courses in Electric Vehicles and Power Management			
	02.	Inclusion of Design Laboratory for Power Electronics Systems			

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REGULATIONS 2022

M. E. POWER ELECTRONICS & DRIVES

CHOICE BASED CREDIT SYSTEM

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

I. Contribute professionally in fields of Power Electronic and related domains.

II. Manage and execute research and development projects leading to technological solutions that address industries and society.

III. Succeed in pursuing higher studies in engineering domains.

PROGRAM OUTCOMES (POs)

1. An ability to independently carry out research /investigation and development work to solve practical problems.
2. An ability to write and present a substantial technical report/document.
3. Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PEO's–PO's MAPPING:

POs	PEOs		
	I	II	III
1.	✓	✓	✓
2.		✓	
3.	✓	✓	✓

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REGULATIONS 2022

CHOICE BASED CREDIT SYSTEM

M.E. POWER ELECTRONICS AND DRIVES

CURRICULUM AND SYLLABUS FOR SEMESTERS I TO IV

SEMESTER I

Sl. No.	Course Code	Course Title	Category#	Periods Per Week				Total Hours	Prerequisite	Position
				L	T	P	C			
Theory Subjects										
1.	PD22101	Analysis of Electrical Machines	PC	3	1	0	4	5	NONE	F
2.	PD22102	Analysis of Power Converters	PC	3	1	0	4	5	NONE	F
3.	PD22103	Modeling and Design of SMPS	PC	3	0	0	3	4	NONE	F
4.	PD22104	Electric Vehicles and Power Management	PC	3	1	0	4	5	NONE	F
5.	****	Professional Elective – I	PE	3	0	0	3	4		M
Practical Subjects										
6.	PD22111	Power Converter Laboratory	PC	0	0	4	2	4	NONE	F
7.	PD22112	Microcontroller Laboratory	PC	0	0	4	2	4	NONE	F
			Total	**15**	**3**	**8**	**22**	31	-	-

SEMESTER II

Sl. No.	Course Code	Course Title	Category#	Periods Per Week				Total Hours	Prerequisite	Position
				L	T	P	C			
Theory Subjects										
1.	PD22201	Analysis of Electrical Drives	PC	3	1	0	4	5	NONE	F
2.	PD22202	Control System Design for Power Electronics	PC	3	1	0	4	5	NONE	F
3.	GR22251	Introduction to Research Methodology and IPR	MC	3	0	0	3	3	NONE	F
4.	****	Professional	PE	3	0	0	3	4		M

		Elective – II								
5.	****	Professional Elective – III	PE	3	0	0	3	4		M
Practical Subjects										
6.	PD22211	Power Electronics and Drives Laboratory	PC	0	0	4	2	4	NONE	F
7.	PD22212	Design Laboratory for Power Electronics Systems	PC	0	0	4	2	4	NONE	F
			Total	**15**	**3**	**8**	**21**	**28**	**-**	**-**

SEMESTER III

Sl. No.	**Course Code**	**Course Title**	**Category#**	**Periods Per Week**				**Total Hours**	**Prerequisite**	**Position**
				L	**T**	**P**	**C**			
Theory Subjects										
1.	****	Professional Elective – IV	PE	3	0	0	3	4		M
2.	****	Professional Elective – V	PE	3	0	0	3	4		M
3.	****	Professional Elective – VI	PE	3	0	0	3	4		M
Practical Subjects										
4.	PD22311	Project Work Phase I	EE	0	0	12	6	12		F
			Total	**9**	**0**	**12**	**15**	**24**	**-**	**-**

SEMESTER IV

Sl. No.	**Course Code**	**Course Title**	**Category#**	**Periods Per Week**				**Total Hours**	**Prerequisite**	**Position**
				L	**T**	**P**	**C**			
Practical Subjects										
1.	PD22411	Project Work Phase II	EE	0	0	28	14	28		F
			Total	**0**	**0**	**28**	**14**	**28**	**-**	**-**

Total Credits: 72

PROFESSIONAL ELECTIVES (PE)

Sl. No.	Course Code	Course Title	Category	L	T	P	C	Total Hours	Prerequisites	Position
Semester I Professional Elective I										
1	PD22001	Power Semiconductor Devices	PE	3	0	0	3	4	NONE	M
2	PD22003	Soft Computing Techniques	PE	3	0	0	3	4	NONE	M
3	PD22005	Electromagnetic Field Computation and Modelling	PE	3	0	0	3	4	NONE	M
4	PD22007	System Design using Microcontroller	PE	3	0	0	3	4	NONE	M
5	PD22009	System Theory	PE	3	0	0	3	4	NONE	M
Semester II Professional Electives II and III										
6	PD22002	Analog and Digital Controllers	PE	3	0	0	3	4	NONE	M
7	PD22004	Flexible AC Transmission Systems	PE	3	0	0	3	4	NONE	M
8	PD22006	Modern Rectifiers and Resonant Converters	PE	3	0	0	3	4	NONE	M
9	PD22008	Power Quality	PE	3	0	0	3	4	NONE	M
10	PD22010	Electromagnetic Interference and Compatibility	PE	3	0	0	3	4	NONE	M
11	PD22012	Special Electrical Machines	PE	3	0	0	3	4	NONE	M
12	PD22014	Power Electronics for Renewable Energy Systems	PE	3	0	0	3	4	NONE	M
13	PD22016	Non Linear Control	PE	3	0	0	3	4	NONE	M
Semester III Professional Electives IV, V and VI										
14	PD22011	Distributed Generation and Micro grid	PE	3	0	0	3	4	NONE	M
15	PD22013	High Voltage Direct Current Transmission	PE	3	0	0	3	4	NONE	M

16	PD22015	Solar and Energy Storage Systems	PE	3	0	0	3	4	NONE	M
17	PD22017	Wind Energy Conversion Systems	PE	3	0	0	3	4	NONE	M
18	PD22019	Energy Management and Auditing	PE	3	0	0	3	4	NONE	M
19	PD22021	Non-Linear Dynamics for Power Electronics Circuits	PE	3	0	0	3	4	NONE	M
20	PD22023	Smart Grid	PE	3	0	0	3	4	NONE	M
21	PD22025	Robotics and Control	PE	3	0	0	3	4	NONE	M
22	PD22027	MEMS for Power Electronics	PE	3	0	0	3	4	NONE	M
23	PD22029	IoT for Power Electronic Systems	PE	3	0	0	3	4	NONE	M

The Course category may be any one of the following:

i) Professional Core (PC)

ii) Professional Elective (PE)

iii) Employability Enhancement (EE)

iv) Mandatory Course (MC)

PD22101 ANALYSIS OF ELECTRICAL MACHINES

L	T	P	C
3	1	0	4

COURSE OBJECTIVES:

- To understand the principles of electromechanical energy conversion in electrical machines and to know the dynamic characteristics of DC motors
- To study the concepts related with AC machines, magnetic noise and harmonics in rotating electrical machines.
- To interpret the principles of reference frame theory
- To study the principles of three phase, doubly fed and 'n' phase induction machine in machine variables and reference variables.
- To understand the principles of three phase, synchronous machine in machine variables and reference variables.

UNIT I ELECTROMECHANICAL ENERGY CONVERSION AND DC MACHINES 12

Energy conservation - stored magnetic energy, co-energy - force and torque in singly and doubly excited systems – Elementary DC machine and analysis of steady state operation - Voltage and torque equations – dynamic characteristics - DC motors – Time domain block diagrams - solution of dynamic characteristic by Laplace transformation

UNIT II AC MACHINES -CONCEPTS 12

Distributed Windings - Winding Functions - Air-Gap Magneto motive Force -Rotating MMF - Flux Linkage and Inductance -Resistance -Voltage and Flux Linkage Equations for Distributed Winding Machines--magnetic noise and harmonics in rotating electrical machines. Modeling of 'n' phase machine.

UNIT III REFERENCE FRAME THEORY 12

Historical background – phase transformation and commutator transformation – transformation of variables from stationary to arbitrary reference frame - variables observed from several frames of reference.

UNIT IV INDUCTION MACHINES 12

Three phase induction machine and doubly fed 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 –Transformation theory for 'n' phase induction machine.

UNIT V SYNCHRONOUS MACHINES 12

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 –digital computer simulation of machines.

TOTAL: 60 PERIODS

TEXT BOOK:

1. Paul C. Krause, Oleg Wasyzczuk, Scott S, Sudhoff, “Analysis of Electric Machinery and Drive Systems”, John Wiley, Second Edition, 2010.

REFERENCES:

1. Stephen D. Umans, “Fitzgerald & Kingsley’s Electric Machinery”, Tata McGraw Hill, 7th Edition, 2020.
2. Bogdan M. Wilamowski, J. David Irwin, The Industrial Electronics Handbook, Second Edition, Power Electronics and Motor Drives, CRC Press, 2011
3. R. Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, Pearson Education, 1st Imprint, 2015.
4. R. Ramanujam, Modeling and Analysis of Electrical Machines, I.k.International Publishing House Pvt. Ltd, 2018

Sl. No.	**COURSE OUTCOMES** On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Understand the principles of electromechanical energy conversion and characteristics of DC motors	**2**
CO2.	Know the concepts related with AC machines and modeling of ‘n’ phase machines	**2**
CO3.	Interpret the concepts of reference frame theory.	**4**
CO4.	Apply procedures to develop induction machine model in both machine variable form and reference variable forms	**3**
CO5.	Apply the procedures to develop synchronous machine model in machine variables form and reference variable form.	**3**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	**POs**		
	1	**2**	**3**
1.	2	2	3
2.	2	2	3
3.	3	2	3
4.	3	3	3
5.	3	3	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22102 ANALYSIS OF POWER CONVERTERS

L	T	P	C
3	1	0	4

OBJECTIVES:

- To provide the mathematical fundamentals necessary for deep understanding of power converter operating modes.
- To equip with required skills to derive the criteria for the design of power converters starting from basic fundamentals.
- To provide the electrical circuit concepts behind the different working modes of converter so as to enable deep understanding of their operation
- To impart required skills to formulate and design converters for generic load and for machine loads.
- To impart knowledge on multilevel inverters and modulation technique

UNIT I SINGLE PHASE AC-DC CONVERTER 12

Static Characteristics of power diode, SCR and GTO, half controlled and fully controlled converters with R-L, R-L-E loads and freewheeling diodes – continuous and discontinuous modes of operation - inverter operation and its limit –Sequence control of converters – performance parameters – effect of source impedance and overlap-reactive power and power balance in converter circuit.

UNIT II THREE PHASE AC-DC CONVERTER 12

Half controlled and fully controlled converters with R, R-L, R-L-E loads and freewheeling diodes – inverter operation and its limit – performance parameters – effect of source impedance and overlap - 12 pulse converter –Applications - Excitation system- DC drive system.

UNIT III SINGLE PHASE INVERTERS 12

Introduction to self-commutated switches : MOSFET and IGBT - Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques – Design of UPS - VSR operation.

UNIT IV THREE PHASE INVERTERS 12

180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters: single, multi pulse, sinusoidal, space vector modulation techniques – VSR operation-Application – Induction heating, AC drive system – Current source inverters.

UNIT V MODERN INVERTERS AND BOOST INVERTERS 12

Multilevel concept – diode clamped – flying capacitor – cascaded type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters – PWM techniques for MLI – Single phase &Three phase Impedance source inverters.

TOTAL: 60 PERIODS

REFERENCES:

1. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Pearson, fourth Edition, 10th Impression 2021.
2. Jai P. Agrawal, "Power Electronics System Theory and Design", Pearson Education, First Edition, 2015
3. Bimal.K.Bose "Modern Power Electronics and AC Drives", Pearson Education, Second Edition, 2003
4. Ned Mohan, T.M.Undeland and W.P.Robbins, "Power Electronics: converters, Application and design", 3rd edition Wiley, 2007.
5. Philip T. Krein, "Elements of Power Electronics" Indian edition Oxford University Press-2017
6. P.C.Sen, "Modern Power Electronics", S.Chand Publishing 2005.
7. P.S.Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2003
8. Bin Wu, Mehdi Narimani, "High-Power Converters and AC Drives", Wiley, 2nd Edition, 2017

Sl.No.	COURSE OUTCOMES On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Analyze single-phase converters for different loads.	4
CO2.	Analyze three-phase converters for different loads.	4
CO3.	Expertise in the operation of single phase inverters and modulation techniques of Voltage source inverters	4
CO4.	Expertise in the operation of three phase inverters and modulation techniques of Voltage source inverters	4
CO5.	Acquire knowledge on multilevel inverters and modulation techniques.	4

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	**2**	**3**
1.	3	-	3
2.	3	-	3
3.	3	-	3
4.	3	-	3
5.	3	-	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22103 MODELING AND DESIGN OF SMPS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To inculcate knowledge on steady state analysis of Non-Isolated DC-DC converter
- To perform steady state analysis of Isolated DC-DC converter
- To educate on different converter dynamics
- To impart knowledge on the design of controllers for DC-DC converters
- To familiarize the design magnetics for SMPS applications

UNIT I ANALYSIS OF NON-ISOLATED DC-DC CONVERTERS 9

Buck, Boost, Buck- Boost and Cuk converters: Principles of operation – Continuous conduction mode– Concepts of volt-sec balance and charge balance – Analysis and design based on steady-state relationships – Introduction to discontinuous conduction mode - SEPIC topology - design concepts and examples - Applications to Battery operated vehicle, PV system.

UNIT II ANALYSIS OF ISOLATED DC-DC CONVERTERS 9

Introduction - classification- forward- flyback- push pull – half bridge – full bridge topologies design of SMPS - Applications to Battery operated vehicle

UNIT III CONVERTER DYNAMICS 9

AC equivalent circuit analysis – State space averaging – Circuit averaging – Averaged switch modeling – Transfer function model for buck, boost, buck-boost and cuk converters – Input filters.

UNIT IV CONTROLLER DESIGN 9

Review of P, PI, and PID control concepts – gain margin and phase margin – Bode plot based analysis – Design of controller for buck, boost, buck-boost and cuk converters

UNIT V DESIGN OF MAGNETICS 9

Basic magnetic theory revision – Inductor design – Design of mutual inductance – Design of transformer for isolated topologies – Ferrite core table and selection of area product – wire table – selection of wire gauge

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Robert W. Erickson & Dragon Maksimovic, "Fundamentals of Power Electronics", Third Edition, 2020.

REFERENCES:

1. John G. Kassakian, Martin F. Schlecht, George C. Verghese, "Principles of Power Electronics", Pearson, India, New Delhi, 2010
2. Simon Ang and Alejandra Oliva, "Power-Switching Converters", CRC press, 3rd edition, 2011.
3. Philip T Krein, "Elements of Power Electronics", Oxford University Press, 2017.
4. Ned Mohan, "Power Electronics: A first course", Wiley, 2011, 1st edition.
5. IssaBatarseh, Ahmad Harb, "Power Electronics- Circuit Analysis and Design, Second edition, 2018

6. V.Ramanarayanan, “Course material on Switched mode power conversion”, 2007
7. Alex Van den Bossche and Vencislav Cekov Valchev, “Inductors and Transformers for Power Electronics”, CRC Press, 1st edition, 2005.
8. W. G. Hurley and W. H.Wolfle, “Transformers and Inductors for Power Electronics Theory, Design and Applications”, 2013 Wiley, 1st Edition.

Sl.No.	**COURSE OUTCOMES** On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Analyse and design Non-Isolated DC-DC converter	**4**
CO2.	Analyse and design Isolated DC-DC converter	**4**
CO3.	Derive transfer function of different converters	**4**
CO4.	Design controllers for DC-DC converters	**5**
CO5.	Design magnetics for SMPS application	**5**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	**2**	**3**
1.	2	-	2
2.	2	-	2
3.	3	-	3
4.	3	-	3
5.	3	-	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22104 ELECTRIC VEHICLES AND POWER MANAGEMENT

L	T	P	C
3	1	0	4

COURSE OBJECTIVES:

- To understand the concept of electrical vehicles and its operations.
- To understand the need for energy storage in hybrid vehicles
- To provide knowledge about various possible energy storage technologies that can be used in electric vehicles.

UNIT I ELECTRIC VEHICLES AND VEHICLE MECHANICS 12

Architecture of EV's and HEV's –Classification of Electric vehicles: based on propulsion systems, energy sources and energy carriers- classification of Hybrid electric vehicles – Fundamentals of vehicle mechanics.

UNIT II POWER TRAIN COMPONENTS AND POWER FLOW CONTROL 12

Comparisons of EV with internal combustion Engine vehicles, Power train components and sizing, Gears, Clutches, Transmission and Brakes. – Power flow control in hybrid drive-train topologies – Power flow control in electric drive-train topologies.

UNIT III PROPULSION UNITS 12

Requirements of EV motor compared to industrial motor – DC/DC chopper based four quadrant operations of DC drives – Inverter based V/f Operation (motoring and braking) of induction motor drive system – Induction motor and permanent magnet motor based vector control operation – Brushless DC motor drives – Switched reluctance motor (SRM) drives - Sizing of propulsion motor.

UNIT IV EV ENERGY STORAGE SYSTEM 12

Energy storage technologies in electric and hybrid electric vehicles - battery, flywheel, fuel cell, ultra-capacitors - comparison of different energy storage technologies Hybridization of different energy storage devices. Battery Parameters, Battery modeling for E-vehicles.

UNIT V EV BATTERY CHARGING AND BATTERY MANAGEMENT TECHNOLOGY 12

Charging schemes for EV: Normal charging, opportunity charging and fast charging – Need for Charging algorithms - CCCV, Multistage charging , Pulse charging – Wireless power transfer schemes – Vehicle to grid technology – Peak shaving and coordinated charging – Battery management system: Battery parameters – SoC measurement – Battery cell balancing.

TOTAL: 60 PERIODS

TEXT BOOKS:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, Second edition, 2011.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, Third edition 2018.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, Second edition 2012.

REFERENCES:

1. Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer, 2013.
2. C.C. Chan and K.T. Chau, Modern Electric Vehicle Technology, OXFORD University Press, 2001.

Sl.No.	**COURSE OUTCOMES** On the successful completion of the course, the students will be able to:	**RBT LEVEL**
CO1.	Comprehend the architecture of Electric Vehicles and vehicle mechanics	**2**
CO2.	Understand the power train components and its sizing for Electric Vehicle and Hybrid Electric Vehicle	**2**
CO3.	Design a control methodology for DC/AC Drives used in electric vehicle.	**4**
CO4.	Identify, select and model suitable energy storage systems used for electric vehicle application.	**4**
CO5.	Select and analyze different energy management strategies and charging technologies in EVs	**4**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	**POs**		
	1	**2**	**3**
1.	3	-	3
2.	3	2	3
3.	3	-	3
4.	3	-	3
5.	3	2	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22111 POWER CONVERTER LABORATORY

L	T	P	C
0	0	4	2

COURSE OBJECTIVES:

- To provide an insight on the switching behavior's of power electronic switches.
- To analyze, design and simulate different power converters studied in the core courses on power converters
- To make the students acquire knowledge on mathematical modelling of power electronic circuits and implementing the same using simulation tools.

LIST OF EXPERIMENTS

1. Study of switching characteristics of Power electronic switches i.) SCR ii.) MOSFET.
2. Single phase AC to DC Half and Fully Controlled Converter with different Loads
3. Three Phase AC to DC Half and fully controlled Converter
4. Generation of PWM gate pulses for DC-DC converter and single-phase voltage source inverter.
5. Simulation of single phase half and full converter with RLE Load
6. Simulation of three phase half and full converter with RL Load
7. Simulation of Buck converter and Boost converter
8. Simulation of Flyback DC-DC converter
9. Simulation of single- phase and three-phase Voltage Source Inverter with R & RL Load
10. Simulation of multilevel inverter topologies with R load

TOTAL: 60 PERIODS

LIST OF EQUIPMENT:

1. Device characteristics (for SCR, MOSFET with built in / discrete power supply and meters) – 1 each
2. Single phase SCR based half controlled converter and fully controlled converter along with built-in firing circuit/module and meter – 1 each
3. IGBT based single phase PWM inverter module/Discrete Component –1
4. IGBT based Driver circuit for 3Φ Inverter –1
5. MOSFET based Driver circuit for 3Φ Inverter -1
6. DSPIC 4011 Microcontroller kit - 1
7. Digital Storage Oscilloscope –5
8. Isolation Transformer – 3
9. Single phase Auto transformer –3
10. Components (Inductance, Capacitance) 3 set for each
11. Multimeter – 5
12. LCR meter – 3

13. Rheostats of various ranges
14. Work tables – 10
15. Desktop PC with MATLAB/PSIM software - 5

Sl.No.	**COURSE OUTCOMES** On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Analyze the switching behavior of various power electronics devices.	**4**
CO2.	Design the various power electronic circuits and experimentally analyze its performance.	**4**
CO3.	Design the pulse generation circuits for single phase inverter circuits.	**4**
CO4.	Examine the performance of various power electronic converters for any application using simulation tools.	**4**
CO5.	Design and simulate isolated DC-DC converters for designing the power supplies	**4**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	**POs**		
	1	**2**	**3**
1.	3	-	-
2.	3	2	3
3.	3	-	3
4.	3	2	3
5.	3	2	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22112 MICROCONTROLLER LABORATORY

L	T	P	C
0	0	4	2

OBJECTIVES

- To perform simple arithmetic operations using assembly language program and study the addressing modes & instruction set of µC 8051/ PIC µC /DSP
- To develop skills in simple program writing in assembly languages
- To perform interfacing experiments with µC8051/ PIC µC /DSP

LIST OF EXERCISES

Programming with 8-bit micro-controller µC8051 using trainer kit/ In-Circuit Prog board/ Assembler package/ IDE:

1. Simple arithmetic operations: Multi precision addition / subtraction, using binary/ BCD, signed / unsigned, multiplication /division.
2. Interface Experiments: Sensor interfacing (analog and digital) Stepper motor controller interface.
3. Programming exercises using built-in timers using assembly/ embedded C language.
4. Programming exercises on serial communication using assembly/ embedded C language
5. Programming with 8-bit micro-controller PICµC using trainer kit/ In Circuit Prog board/ Assembler package/ IDE:
6. Simple arithmetic operations: Multi precision addition / subtraction, using binary/ BCD, signed / unsigned, multiplication /division.
7. Interface Experiments: Sensor interfacing (analog and digital) Stepper motor controller interface.
8. Programming exercises using built-in timers using assembly/ embedded C language.
9. Programming exercises on serial communication using assembly/ embedded C language.

TOTAL: 60 PERIODS

REFERENCES:

1. Muhammad Ali Mazidi & Janice GilliMazidi, " PIC programming"
2. Muhammad Ali Mazidi & Janice GilliMazidi, ‘The 8051 Micro Controller and Embedded Systems’, Pearson Education, 2007.
3. Kenneth Ayala, ‘The 8051Microcontroller’, Thomson, 2005.

LIST OF EQUIPMENT

1. 8051 Micro Controller Trainer Kit with power supply
2. PIC Micro Controller Trainer Kit with power supply
3. Stepper motor Interface board
4. 8251 Interface board
1. ADC and DAC

Sl.No.	COURSE OUTCOMES On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Perform simple arithmetic operations using the assembly language of µC8051 employing different addressing modes.	**3**
CO2.	Perform simple arithmetic operations using the assembly language of PICµC employing different addressing mode.	**3**
CO3.	Interface stepper motor with µC8051/PICµC.	**4**
CO4.	Design and implement built-in timers of µC8051/PICµC.	**4**
CO5.	Implement serial communication facility of µC8051/PICµC.	**4**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	**2**	**3**
1.	3	2	3
2.	3	2	3
3.	3	2	3
4.	3	2	3
5.	3	2	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22201 ANALYSIS OF ELECTRICAL DRIVES

L	T	P	C
3	1	0	4

OBJECTIVES:

- To study and analyze the operation of the converter / chopper fed DC drives, both qualitatively and quantitatively.
- To analyze and design the current and speed controllers for a closed loop solid state DC motor drive
- To familiarize the students on the operation of VSI and CSI fed induction motor drives.
- To understand the field oriented control of induction machines.
- To impart knowledge on the control of synchronous motor drives

UNIT I CONVERTER AND CHOPPER CONTROL 12

Principle of phase control – Fundamental relations; Analysis of series and separately excited DC motor with single-phase and three-phase converters – waveforms, performance parameters, performance characteristics- Implementation of braking schemes, Introduction to time ratio control and frequency modulation; Chopper controlled DC motor – performance analysis, multi-quadrant control – Chopper based implementation of braking schemes - Related problems.

UNIT II CLOSED LOOP CONTROL 12

Modeling of drive elements – Equivalent circuit, transfer function of self, separately excited DC motors; Linear Transfer function model of power converters; Sensing and feeds back elements - Closed loop speed control – current and speed loops, P, PI and PID controllers – response comparison. PLL and Microcontroller based drives - Simulation of converter and chopper fed DC drive.

UNIT III CONTROL OF INDUCTION MOTOR DRIVES 12

AC voltage controller circuit – six step inverter voltage control-closed loop variable frequency PWM inverter with dynamic braking-CSI fed variable frequency drives –Pulse width modulation techniques-Static rotor resistance control - injection of voltage in the rotor circuit – static scherbius drives - power factor considerations – modified Kramer drives - sub-synchronous and super-synchronous speed operation of induction machines – simulation of closed loop operation of stator & rotor controlled induction motor drives.

UNIT IV FIELD ORIENTED CONTROL OF INDUCTION MACHINES 12

Field oriented control of induction machines – Theory – DC drive analogy – Direct and Indirect methods – Flux vector estimation - Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy.

UNIT V SYNCHRONOUS MOTOR DRIVES 12

Wound field cylindrical rotor motor – Equivalent circuits – performance equations for operation from a voltage source – starting and braking - V curves - Self-control - margin angle control-torque control-power factor control-Permanent Magnet synchronous motor - Brushless excitation systems

TOTAL: 60 PERIODS

TEXT BOOKS:

1. Gopal K Dubey, “Power Semiconductor controlled Drives”, Prentice Hall Inc., NewJersy, 1989.
2. R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice-Hall of India

Pvt. Ltd., New Delhi, 2010.
3. Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education, Asia2002.

REFERENCES:

1. Gopal K.Dubey, "Fundamentals of Electrical Drives", Narosal Publishing House, New Delhi, Second Edition, 2009
2. Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw-Hill publishing company Ltd., New Delhi, 2002.
3. P.C Sen "Thyristor DC Drives", John wiely and sons, New York, 1981.
4. W.Leonhard, "Control of Electrical Drives", Narosa Publishing House, 1992
5. Murphy J.M.D and Turnbull, "Thyristor Control of AC Motors", Pergamon Press, Oxford, 1988

Sl.No.	COURSE OUTCOMES On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Analyse and design a converter for DC drive	4
CO2.	Model and design a controller for DC drive	4
CO3.	Design and simulate VSI and CSI fed induction motor drives.	4
CO4.	Expertise in the field oriented control of Induction motor drives.	3
CO5.	Formulate the control schemes for synchronous motor drives.	3

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	2	3
1.	3	-	3
2.	3	-	3
3.	3	-	3
4.	3	-	3
5.	3	-	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22202 CONTROL SYSTEM DESIGN FOR POWER ELECTRONICS

L	T	P	C
3	1	0	4

COURSE OBJECTIVES:

- To explore conceptual bridges between the fields of Control Systems and Power Electronics
- To study control theories and techniques relevant to the design of feedback controllers in Power Electronics

UNIT I MODELLING OF DC-TO-DC POWER CONVERTERS 12

Modelling of Buck Converter , Boost Converter ,Buck-Boost Converter, Cuk Converter, Sepic Converter, Zeta Converter, Quadratic Buck Converter ,Double Buck-Boost Converter, Boost- Boost Converter General Mathematical Model for Power Electronics Devices

UNIT II SLIDING MODE CONTROLLER DESIGN 12

Variable Structure Systems. Single Switch Regulated Systems Sliding Surfaces, Accessibility of the Sliding Surface Sliding Mode Control Implementation of Boost Converter ,Buck-Boost Converter, Cuk Converter, Sepic Converter, Zeta Converter, Quadratic Buck Converter, Double Buck-Boost Converter, Boost-Boost Converter

UNIT III APPROXIMATE LINEARIZATION CONTROLLER DESIGN 12

Linear Feedback Control, Pole Placement by Full State Feedback , Pole Placement Based on Observer Design, Reduced Order Observers , Generalized Proportional Integral Controllers, Passivity Based Control , Sliding Mode Control Implementation of Buck Converter , Boost Converter ,Buck-Boost Converter

UNIT IV NONLINEAR CONTROLLER DESIGN 12

Feedback Linearization Isidori's Canonical Form ,Input-Output Feedback Linearization ,State Feedback Linearization, Passivity Based Control , Full Order Observers , Reduced Order Observers

UNIT V PREDICTIVE CONTROL OF POWER CONVERTERS 12

Basic Concepts, Theory, and Methods, Application of Predictive Control in Power Electronics, AC-DC-AC Converter System, Faults and Diagnosis Systems in Power Converters.

TOTAL: 60 PERIODS

REFERENCES

1. Hebertt Sira-Ramírez PhD, Ramón Silva-Ortigoza, "Control Design Techniques in Power Electronics Devices", Springer2012
2. Mahesh Patil, PankajRodey, "Control Systems for Power Electronics: A Practical Guide", Springer India, 2015.
3. Blaabjerg José Rodríguez, "Advanced and Intelligent Control in Power Electronics and Drives" , Springer, 2014
4. Enrique Acha, Vassilios Agelidis, Olimpo Anaya, TJE Miller, "Power Electronic Control in Electrical Systems", Newnes,2002
5. Marija D. Aranya Chakrabortty, Marija , "Control and Optimization Methods for Electric Smart

Grids”, Springer,2012.

Sl.No.	**COURSE OUTCOMES** On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Understand an overview on modern linear control strategies for power electronics devices.	**2**
CO2.	Design appropriate controllers for modern power electronics devices.	**4**
CO3.	Understand the concept and overview on modern nonlinear control strategies for power electronics devices.	**2**
CO4.	Model modern power electronic converters for industrial applications.	**4**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	**2**	**3**
1.	3	-	3
2.	3	-	3
3.	3	-	3
4.	3	-	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

GR22251 INTRODUCTION TO RESEARCH METHODOLOGY AND IPR

L	T	P	C
3	0	0	3

OBJECTIVES:

- To impart knowledge on formulation of research problem, research methodology, ethics involved in doing research and importance of IPR protection.

UNIT I RESEARCH METHODOLOGY 9

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations. Effective literature studies approaches, analysis Plagiarism, Research ethics.

UNIT II RESULTS AND ANALYSIS 9

Importance and scientific methodology in recording results, importance of negative results, different ways of recording, industrial requirement, artifacts versus true results, types of analysis (analytical, objective, subjective) and cross verification, correlation with published results, discussion, outcome as new idea, hypothesis, concept, theory, model etc.

UNIT III TECHNICAL WRITING 9

Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V PATENT RIGTS AND NEW DEVELOPMENTS IN IPR 9

Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Ranjit Kumar, "Research Methodology- A step by step guide for beginners", Pearson Education,Australia, fourth edition, 2014
2. Ann M. Korner, "Guide to Publishing a Scientific paper", Bioscript Press 2008
3. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

REFERENCES:

1. Kothari, C. R., "Research Methodology - Methods and Techniques", New Age International publishers, New Delhi, fourth edition, 2019
2. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science &engineering students", Juta & Company, 1996.
3. Robert P. Merges, Peter S. Menell and Mark A. Lemley, "Intellectual Property in New Technological Age", Aspen Publishers, 2016.

COURSE OUTCOMES: On the successful completion of the course, students will be able to		**RBT* Level**
CO1	Critically evaluate any research article based upon research methodology.	**5**
CO2	Correlate the results of any research and develop hypothesis, concept, theory and model.	**3**
CO3	Developing a research proposal, research presentation and review article in the field of engineering.	**4**
CO4	Enumerate the importance of intellectual property right in research.	**4**
CO5	Develop proposal for patent rights and identify the new developments in IPR	**4**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	**POs**		
	1	**2**	**3**
1.	3	2	-
2.	3	2	-
3.	3	3	2
4.	3	3	2
5.	3	3	2

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22211 ELECTRICAL DRIVES LABORATORY

L	T	P	C
0	0	4	2

COURSE OBJECTIVES:

- To design and analyze various DC and AC drives.
- To generate the firing pulses for converters and inverters using digital processors
- Design of controllers for linear and nonlinear systems
- Implementation of closed loop system using hardware simulation

LIST OF EXPERIMENTS

1. Study of Chopper Fed DC Motor.
2. Study of AC single phase motor speed control using TRIAC.
3. PWM inverter fed three phase induction motor control using PSPICE/MATLAB/PSIM software.
4. VSI/CSI fed induction motor drive analysis using MATLAB/PSPICE/PSIM software.
5. Study of V/f control operation of three phase induction motor.
6. Study of permanent magnet synchronous motor drive fed by PWM inverter using software.
7. Experimentally study the characteristics of BLDC motor.
8. Regenerative/ Dynamic braking operation for DC motor study using software.
9. Regenerative/ Dynamic braking operation for AC motor study using software.
10. PC/PLC based AC/DC motor control operation.
11. Design and implementation of wiper motor characteristics for vehicle.
12. Study of inverter Air Conditioner.
13. Simulation of various drives used in EV Propulsion system.

TOTAL: 60 PERIODS

REFERENCES

1. Ned Mohan,T. M. Undelandand W.P Robbin, "Power Electronics: converters, Application and design", John Wiley and sons. Wiley Indiaedition, 2006.
2. Rashid M.H.,"Power Electronics Circuits, Devices and Applications", Prentice Hal India, New Delhi, 1995.

Sl.No.	COURSE OUTCOMES On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Simulate different types of machines, converters in a system.	4
CO2.	Analyze the performance of various electric drive systems.	4
CO3.	Design power converters for drive application and analyze towards research.	4
CO4.	Choose the Electric drives for the specific application based on the drive requirements.	4
CO5.	Understand the various power electronic controllers used in drive systems.	2

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	2	3
1.	3	3	3
2.	3	3	3
3.	3	3	3
4.	3	3	3
5.	3	3	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22212 DESIGN LABORATORY FOR POWER ELECTRONICS SYSTEMS

L	T	P	C
0	0	4	2

COURSE OBJECTIVES:

- To design power converter after selecting the suitable component for typical applications
- To design non-isolated and isolated switching mode regulators
- To simulate analyse and test different switching mode regulators

LIST OF EXPERIMENTS:

1. Selection and Design of components (Inductor, Capacitor, transformers and devices) for power converters
2. Design and testing of Isolated converter design and verification (100 W)
3. Design and testing of Non-isolated converter design and verification (100 W)
4. Mini Project Demonstration with applications

TOTAL: 60 PERIODS

Sl.No.	**COURSE OUTCOMES** On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Ability to independently carryout research and development work in power converters	4
CO2.	Demonstrate a degree of mastery over the design and fabrication of switching regulators.	4
CO3.	Apply conceptual basis required for design and testing of various	3
CO4.	Develop a solution by interacting with industry problem of societal importance as mini project designed.	5
CO5.	Analyze different possible solution to the same practical problem.	4

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	2	3
1.	3	3	3
2.	3	3	3
3.	3	3	3
4.	3	3	3
5.	3	3	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22001 POWER SEMICONDUCTOR DEVICES

L	T	P	C
3	0	0	3

OBJECTIVES:

- To improve power semiconductor device structures for adjustable speed motor control applications.
- To understand the static and dynamic characteristics of current controlled power semiconductor devices
- To understand the static and dynamic characteristics of voltage controlled power semiconductor devices
- To enable the students for the selection of devices for different power electronics applications
- To understand the control and firing circuit for different devices.

UNIT I INTRODUCTION 9

Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – (SOA); Device selection strategy – On-state and switching losses – EMI due to switching - Power diodes - Types, forward and reverse characteristics, switching characteristics – rating.

UNIT II CURRENT CONTROLLED DEVICES 9

BJT's – Construction, static characteristics, switching characteristics; Negative temperature coefficient and second breakdown; - Thyristors – Physical and electrical principle underlying operating mode, Two transistor analogy – concept of latching; Gate and switching characteristics; converter grade and inverter grade and other types; series and parallel operation; comparison of BJT and Thyristor – steady state and dynamic models of BJT &Thyristor

UNIT III VOLTAGE CONTROLLED DEVICES 9

Power MOSFETs and IGBTs – Principle of voltage controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs - and IGCT. High current effects, Negative differential resistance (NDR), self-heating, filament formation and safe operating area (SOA).

UNIT IV GaN and SiC POWER MOS DEVICES 9

New semiconductor materials for devices - Advantage of high bandgap materials, High bandgap material physics, various GaN/SiC devices, device physics and design essentials, GaN/SiC device manufacturing technology; breakdown voltage and on-resistance trade-off, parasitic capacitance and resistances, DC, RF and switching characteristics; quasi-saturation behavior, self-heating effects and safe operating area (SOA).

UNIT V FIRING, THERMAL PROTECTION & CIRCUITS 9

Necessity of isolation, pulse transformer, optocoupler – Gate drives circuit: SCR and MOSFET - Over voltage, over current and gate protections; Design of snubbers. Guidance for hear sink selection – Thermal resistance and impedance –Electrical analogy of thermal components, heat sink types and design – Mounting types- switching loss calculation for power device.

TOTAL: 45 PERIODS

TEXT BOOKS

1. Mohan, Undeland and Robins, "Power Electronics – Concepts, applications and Design, John Wiley and Sons, Singapore, 2000.
2. Silicon Carbide Power Devices, B. Jayant Baliga, World Scientific, 2005

REFERENCES

1. B.W Williams 'Power Electronics Circuit Devices and Applications'..
2. Rashid M.H., " Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004
3. MD Singh and K.B Khanchandani, "Power Electronics", Tata McGraw Hill, 2001.
4. Joseph Vithayathil, Power Electronics: Principles and Applications, Delhi, Tata McGraw- Hill, 2010.

Sl.No.	**COURSE OUTCOMES** On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Characterize power semiconductor diode and its switching.	**4**
CO2.	Realize a power converter using a current controlled device.	**4**
CO3.	Realize a power converter using a voltage controlled device	**4**
CO4.	Understand wide bandgap materials for high power MOS applications	**4**
CO5.	Design of electrical protection circuits and thermal protection.	**5**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	**2**	**3**
1.	-	-	3
2.	3	-	3
3.	3	-	3
4.	3	3	3
5.	3	3	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22003 SOFT COMPUTING TECHNIQUES

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

To educate the students on

- Design of ANN and fuzzy set theory.
- Analysis and implementation of ANN and Fuzzy logic for modeling and control of Non-linear system and to get familiarized with the Matlab toolbox.
- Impart the knowledge of various optimization techniques and hybrid schemes with the ANFIS tool box.

UNIT I OVERVIEW OF ARTIFICIAL NEURAL NETWORK (ANN) & FUZZY LOGIC 9

Review of fundamentals - Biological neuron, Artificial neuron, Activation function, Single Layer Perceptron – Limitations – Multi Layer Perceptron – Back propagation algorithm (BPA); Fuzzy set theory – Fuzzy sets – Operation on Fuzzy sets - Scalar cardinality, fuzzy cardinality, union and intersection, complement (yager and sugeno), equilibrium points, aggregation, projection, composition, fuzzy relation – Fuzzy membership functions.

UNIT II NEURAL NETWORKS FOR MODELLING AND CONTROL 9

Generation of training data - optimal architecture – Model validation- Control of non-linear system using ANN- Direct and Indirect neuro control schemes- Adaptive neuro controller –Case study - Familiarization of Neural Network Control Tool Box.

UNIT III FUZZY LOGIC FOR MODELLING AND CONTROL 9

Modeling of nonlinear systems using fuzzy models (Mamdani and Sugeno) –TSK model - Fuzzy Logic controller – Fuzzification – Knowledge base – Decision making logic – Defuzzification- Adaptive fuzz y systems-Case study-Familiarization of Fuzzy Logic Tool Box.

UNIT IV GENETIC ALGORITHM 9

Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other search techniques like Tabu search, Ant-colony search and Particle Swarm Optimization.

UNIT V HYBRID CONTROL SCHEMES 9

Fuzzification and rule base using ANN–Neuro fuzzy systems-ANFIS –Optimization of membership function and rule base using Genetic Algorithm and Particle Swarm Optimization - Case study– Familiarization of ANFIS Tool Box.

TOTAL: 45 PERIODS

REFERENCES:

1. LaureneV.Fausett, “Fundamentals of Neural Networks, Architecture, Algorithms, and Applications”, Pearson Education, 2008.
2. Timothy J.Ross, “Fuzzy Logic with Engineering Applications”, Wiley, Third Edition, 2010.
3. David E.Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning”, Pearson Education, 2009.
4. W.T.Miller, R.S.Sutton and P.J.Webrose, “Neural Networks for Control”, MIT Press, 1996.
5. George J.Klir and Bo Yuan, “Fuzzy Sets and Fuzzy Logic: Theory and Applications”, Prentice HalI, First Edition, 1995.

Sl.No.	**COURSE OUTCOMES** On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Understand the basic architectures of NN and Fuzzy sets	**2**
CO2.	Design and implement ANN architectures, algorithms and know their limitations.	**4**
CO3.	Identify and work with different operations on the fuzzy sets.	**3**
CO4.	Develop ANN and fuzzy logic based models and control schemes for non-linear systems.	**4**
CO5.	Understand and explore hybrid control schemes and PSO	**2**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	**POs**		
	1	**2**	**3**
1.	3	2	3
2.	3	2	3
3.	3	2	3
4.	3	2	3
5.	3	2	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22005- ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To refresh the fundamentals of Electromagnetic Field Theory
2. To provide foundation in formulation and computation of electromagnetic field equations using analytical methods
3. To impart knowledge in the concept of problem formulation and computation of electromagnetic field equations using numerical methods.
4. To compute and analyze the field quantities using FEM.
5. To formulate, solve, analyze and optimize the design of electrical components.

UNIT I REVIEW OF FIELD THEORY 9

Permanent Magnets: An Introduction – Intrinsic and Normal Hysteresis Characteristics – Representation of the B-H curve – Maxwell's Equations: Differential and Integral forms – Constitutive relationships and Continuity equation – Laplace and Poisson equation – Principle of Energy Conversion: Force/Torque calculation.

UNIT II BASIC SOLUTION METHODS FOR FIELD EQUATIONS 9

Need for the Field Analysis based design – Problem definition – Boundary conditions – Solution by Analytical methods-Direct integration method – Variable separable method – Solution by Numerical methods- Finite Difference Method.

UNIT III FORMULATION OF FINITE ELEMENT METHOD (FEM) 9

Variational Formulation – Finite Element Method: Overview – Discretization – Shape function – Stiffness matrix – 2D Planar and Axial symmetry problems.

UNIT IV ELECTROMAGNETIC CAD PACKAGE 9

Elements of a CAD System –Pre-processing – Modelling – Meshing – Material properties- Boundary Conditions – Setting up solution – Post processing.

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UNIT V ANALYSIS OF ELECTRICAL APPARATUS WITH CAD PACKAGE 9

Cylindrical Magnetic Device – Single Phase Transformer – Switched Reluctance Motor

TOTAL: 45 PERIODS

REFERENCES:

1. Matthew. N.O. Sadiku, "Elements of Electromagnetics", Fourth Edition, Oxford University Press, First Indian Edition 2007.
2. K.J. Binns, P.J. Lawrenson, C.W Trowbridge, "The analytical and numerical solution of Electric and magnetic fields", John Wiley & Sons, 1993.
3. Nicola Bianchi , "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005.
4. Nathan Ida, Joao P.A. Bastos , "Electromagnetics and calculation of fields", Springer-Verlage, 1992.
5. S.J Salon, "Finite Element Analysis of Electrical Machines" Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, Chennai, India.

6. Silvester and Ferrari, “Finite Elements for Electrical Engineers” Cambridge University press, 1983.

Sl.No.	**COURSE OUTCOMES** On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Explain and interpret the concept of Electromagnetic Field Theory.	**2**
CO2.	Formulate the field problem and apply analytical and numerical method for solving Electromagnetic field problems.	**4**
CO3.	Formulate Finite Element Methodology for solving Electro Magnetic field problem	**4**
CO4.	Estimate the basic Electromagnetic field quantities using FEM.	**4**
CO5.	Design electrical apparatus using FEM	**3**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	**2**	**3**
1.	2	2	2
2.	3	3	3
3.	3	3	3
4.	3	3	3
5.	3	3	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22007 SYSTEM DESIGN USING MICROCONTROLLER

L	T	P	C
3	0	0	3

OBJECTIVES:

- To expose the students to the fundamentals of microcontroller based system design.
- To teach I/O and RTOS role on microcontroller.
- To learn PIC Microcontroller based System Design
- To introduce Microchip PIC 8-bit peripheral system design.
- To give case study experiences for microcontroller based applications.

UNIT I 8051 ARCHITECTURE 9

Architecture – memory organization – addressing modes – instruction set – Timers - Interrupts - I/O ports, Interfacing I/O Devices – Serial Communication.

UNIT II 8051 PROGRAMMING 9

Assembly language programming – Arithmetic Instructions – Logical Instructions –Single bit Instructions – Timer Counter Programming – Serial Communication Programming Interrupt Programming – RTOS for 8051 – RTOS Lite – FullRTOS – Task creation and run - LCD digital clock/thermometer using FullRTOS. Introduction to IDE based assembler programming.

UNIT III PIC 16 MICROCONTROLLER 9

Architecture – memory organization – addressing modes – instruction set – PIC programming in Assembly & C –I/O port, Data Conversion, RAM & ROM Allocation, Timer programming, practice in MP-LAB.

UNIT IV PERIPHERAL OF PIC 16 MICROCONTROLLER 9

Timers – Interrupts, I/O ports- I2C bus-A/D converter-UART- CCP modules -ADC, DAC and Sensor Interfacing –Flash and EEPRO Memories

UNIT V SYSTEM DESIGN –CASE STUDY 9

Interfacing LCD Display – Keypad Interfacing - Generation of Gate signals for converters and Inverters - Motor Control – Controlling DC/ AC appliances – Measurement of frequency- Standalone Data Acquisition System

TOTAL: 45 PERIODS

TEXTBOOKS:

1. Kenneth J Ayala, “The 8051 Microcontroller”, Thomson press, 2007
2. Muhammad Ali Mazidi, RolinD.Mckinlay, Danny Causey ‘ PIC Microcontroller and Embedded Systems using Assembly and C for PIC18’, Pearson Education 2008

REFERENCES:

1. Rajkamal, “Microcontrollers Architecture, Programming, Interfacing & System Design”, Pearson, 2012.
2. MykePredko, “Programming and customizing the 8051 microcontroller”, Tata McGraw Hill, 2001
3. Muhammad Ali Mazidi, SarmadNaimi, SepehrNaimi, “The AVR Microcontroller and Embedded Systems’ Using Assembly & C”, PearsonEducation, 2014
4. Muhammad Ali Mazidi, Janice G. Mazidi and Rolin D. McKinlay, “The 8051 Microcontroller and

Embedded Systems”, Prentice Hall, 2005.
5. John Iovine, “PIC Microcontroller Project Book”, McGraw Hill, 2000.

Sl.No.	**COURSE OUTCOMES** On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Understand the features of microcontroller 8051	**2**
CO2.	Develop programs using 8051 assemble language, utilizing its built in features	**4**
CO3.	Understand the features of PIC microcontroller.	**2**
CO4.	Apply the peripherals built in the PIC microcontroller through programming for application design.	**3**
CO5.	Understand the interfacing concepts involving in the design of microcontroller based systems.	**2**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	**2**	**3**
1.	3	-	3
2.	3	-	3
3.	3	-	3
4.	3	-	3
5.	3	-	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22009 SYSTEM THEORY

L	T	P	C
3	0	0	3

OBJECTIVES

- To educate on representing systems in state variable form
- To educate on solving linear and non-linear state equations
- To exploit the properties of linear systems such as controllability and observability
- To educate on stability analysis of systems using Lyapunov's theory
- To educate on modal concepts and design of state and output feedback controllers and estimators.

UNIT I STATE VARIABLE REPRESENTATION 9

Introduction-Concept of State-State equations for Dynamic Systems - Time invariance and linearity-Non uniqueness of state model- Physical Systems and State Assignment – free and forced responses-State Diagrams-transfer function from state model, MATLAB Simulation study

UNIT II SOLUTION OF STATE EQUATIONS 9

Existence and uniqueness of solutions to Continuous-time state equations - Solution of Nonlinear and Linear Time Varying State equations - State transition matrix and its properties – Evaluation of matrix exponential System modes- time response of continuous time system from state transition matrix- Role of Eigen values and Eigen vectors, MATLAB Simulation study.

UNIT III PROPERTIES OF CONTROL SYSTEM 9

Controllability and Observability, Stabilizability and detectability Test for Continuous time Systems-Time varying and Time invariant case- Output Controllability Reducibility- System Realizations-MATLAB Simulation study

UNIT IV MODAL ANALYSIS 9

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems - The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers. MATLAB simulation study

UNIT V NON LINEARITIES AND STABILITY ANALYSIS 9

Introduction-Equilibrium Points- BIBO Stability-Stability of LTI Systems- Stability in the sense of Lyapunov - Equilibrium Stability of Nonlinear Continuous-Type of nonlinearity – Phase plane analysis –construction of Phase trajectories- Lyapunov Functions for Nonlinear Continuous-Time Autonomous Systems – Krasovskil's and Variable-Gradiant Method. MATLAB simulation study.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. M. Gopal, "Modern Control System Theory", 5th Edition, New Age International, 2009.
2. K. Ogatta, "Modern Control Engineering", 5th Edition, Pearson Publisher, 2015.
3. D. Roy Choudhury, "Modern Control Systems", New Age International, 2005.
4. John J. D'Azzo, C. H. Houpis and S. N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Taylor Francis, 2003.
5. C.T. Chen, "Linear Systems Theory and Design'' Oxford University Press, 3rd Edition,1999.

REFERENCES:

1. Z. Bubnicki, “Modern Control Theory”, Springer, 2005.
2. John S. Bay, “Fundamentals of Linear State Space Systems”, McGraw-Hill, 1999.
3. M. Vidyasagar, “Nonlinear Systems Analysis”, 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey

Sl. No.	COURSE OUTCOMES On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Represent the time-invariant systems in state variable forms	**3**
CO2.	Solve nonlinear and linear state equations	**4**
CO3.	Analyze whether the system is stabilizable, controllable, observable and detectable.	**4**
CO4.	Design state feedback controller and state observers	**4**
CO5.	Analyze the stability of certain class of non-linear system	**4**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	**2**	**3**
1.	3	-	3
2.	3	-	3
3.	3	-	3
4.	3	-	3
5.	3	-	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22002 ANALOG AND DIGITAL CONTROLLERS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

1. To provide a overview of the control system and converter control methodologies
2. To provide an insight to the analog controllers generally used in practice
3. To introduce Embedded Processers for Digital Control
4. To study on the driving techniques, isolation requirements, signal conditioning and protection methods
5. To provide a Case Study by implementing an analog and a digital controller on a converter

UNIT I CONTROL SYSTEM – OVERVIEW 9

Feedback and Feed-forward control, Right Half Plane Zero, Gain margin and Phase Margin, Stability, Analysis and Transfer function of PI and PID controllers and its effects. Voltage mode control, Peak Current mode Control, Average Current mode Control for Converters – Need, advantages and disadvantages.

UNIT II ANALOG CONTROLLERS 9

Major components of a controller – Op-Amp based PI and PID controller – Proportional, Integral and Differential gains in terms of Resistance and Capacitance, Error Amplifiers, PWM generator using Ramp or Triangular generator and comparator, and Driver, Voltage mode controller design using UC3524, Peak Current mode controller design using UC3842, Average Current mode controller design usingUC3854.

UNIT III DIGITAL CONTROLLERS 9

Micro Controllers and Digital Signal Controllers for Converter Control Application, Interface Modules for Converter Control – A/D, Capture, Compare and PWM, Analog Comparators for instantaneous over current detection, interrupts, Discrete PI and PID equations, Algorithm for PI and PID implementation, Example Code for PWM generation.

UNIT IV SIGNAL CONDITIONING, DRIVER, ISOLATION AND PROTECTION 9

Voltage feedback sensing circuits, Hall effect sensors and Shunts for current feedback sensing, Low offset Op-Amps for signal conditioning, Single and dual supply op-amps, Totem pole drivers, Need for isolated drivers, Optically isolated drivers, low side drivers, high side drivers with bootstrap power supply, Vcesat sensing, CT based Device current sensing and pulse blocking.

UNIT V CONTROLLER IMPLEMENTATION 9

Analog and Digital Controller Design for Buck Converter – Power circuit transfer function and bode plot, PI controller bode plot, Combined bode plot with required Gain and Phase margins, Implementation of Analog controller and Digital controller.

TOTAL: 45 PERIODS

REFERENCES

1. I.J. Nagrath and M. Gopal, “Control Systems Engineering”, New Age International Publishers
2. Robert W. Erickson, Dragan Maksimović “Fundamentals of Power Electronics” , SpringerLink,2020.
3. Simon Ang, Alejandro Oliva, “Power-Switching Converters”, Third Edition, CRC Press, 2011.
4. Marian K. Kazimierczuk, “Pulse–width Modulated DC–DC Power Converters”, Publisher, Wiley–Blackwell, 2nd Edition, 2015.
5. TI / Microchip / Agilent Application notes, Reference Manuals and Datasheets.

Sl.No.	COURSE OUTCOMES On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Identify the effect of PID controllers in system stability.	4
CO2.	Design and apply analog controller for applications.	4
CO3.	Design and apply Digital controller for applications.	4
CO4.	Design suitable signal conditioning circuits and drivers for hardware.	4
CO5.	Implement controller design in hardware.	4

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	2	3
1.	3	-	3
2.	3	-	3
3.	3	-	3
4.	3	-	3
5.	3	-	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22004 FLEXIBLE AC TRANSMISSION SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To emphasis the need for FACTS controllers.
- To learn the characteristics, applications and modelling of series and shunt FACTS controllers.
- To analyze the interaction of different FACTS controller and perform control coordination.

UNIT I INTRODUCTION 9

Review of basics of power transmission networks - Control of power flow in AC transmission lines. Analysis of uncompensated AC Transmission lines - Passive reactive power compensation: Effect of series and shunt compensation at the mid-point of the line on power transfer - Need for FACTS controllers - Types of FACTS controllers – IEEE definitions.

UNIT II STATIC VAR COMPENSATOR (SVC) 9

Configuration of SVC: TCR, FC-TCR and TSC-TCR, V-I characteristics - Voltage regulation by SVC - Modelling of SVC for load flow analysis and stability studies - Design of SVC to regulate the mid-point voltage of a SMIB system - Applications: transient stability enhancement and power oscillation damping of SMIB system with SVC connected at the mid-point of the line.

UNIT III THYRISTOR AND GTO THYRISTOR CONTROLLED SERIES CAPACITORS (TCSC and GCSC) 9

Concepts of Controlled Series Compensation – Operation of TCSC and GCSC - Analysis of TCSC and GCSC – Modelling of TCSC and GCSC for load flow and stability studies - Applications of TCSC and GCSC.

UNIT IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS 9

Static Synchronous Compensator (STATCOM) - Static Synchronous Series Compensator (SSSC) - Operation of STATCOM and SSSC - Power flow control with STATCOM and SSSC - Modelling of STATCOM and SSSC for power flow and transient stability studies - Operation of Dynamic Voltage Restorer (DVR), Unified and Interline Power Flow Controllers (UPFC and IPFC) - Modelling of UPFC and IPFC for load flow and transient stability studies - Applications.

UNIT V CONTROLLERS AND THEIR COORDINATION 9

FACTS Controller interactions – SVC-SVC interaction - Co-ordination of multiple controllers using linear control techniques – Optimal placement of FACTS devices.

TOTAL: 45 PERIODS

REFERENCES

1. A.T.John, "Flexible AC Transmission System", Institution of Electrical and Electronic Engineers (IEEE), 1999.
2. Narain G.Hingorani, Laszio. Gyugyl, "Understanding FACTS Concepts and Technology of Flexible AC Transmission System", Standard Publishers, Delhi 2001.
3. V.K. Sood, "HVDC and FACTS controllers - Applications of Static Converters in Power System", 2004, Kluwer Academic Publishers.
4. Mohan Mathur, R., Rajiv. K. Varma, "Thyristor - Based FACTS Controllers for Electrical Transmission Systems", Wiley India Pvt. Ltd., 2011.
5. K.R.Padiyar," FACTS Controllers in Power Transmission and Distribution", New Academic Science, 2009.

Sl.No.	**COURSE OUTCOMES** On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Realize the concept of reactive power compensation and operating principles of various types of FACTS controllers	**4**
CO2.	Model Static VAR Compensator and apply to the transmission lines	**4**
CO3.	Model and apply Thyristor Controlled Series Capacitor for power flow control	**4**
CO4.	Model voltage source converter based facts controllers and apply to the transmission lines	**4**
CO5.	Analyze the interactions among various FACTS Controllers	**4**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	**2**	**3**
1.	3	2	3
2.	3	2	3
3.	3	2	3
4.	3	2	3
5.	3	2	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22006 MODERN RECTIFIERS AND RESONANT CONVERTERS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To gain knowledge about the harmonics standards and operation of rectifiers in CCM &DCM.
- To analyze and design power factor correction rectifiers for UPS applications.
- To know the operation of resonant converters for SMPS applications.
- To carry out dynamic analysis of DC- DC Converters.
- To introduce the source current shaping methods for rectifiers

UNIT I POWER SYSTEM HARMONICS & LINE COMMUTATED RECTIFIERS 9

Average power-RMS value of a waveform-Power factor - AC line current harmonic standards IEC 1000-IEEE 519 - The Single phase full wave rectifier-Continuous Conduction Mode- Discontinuous Conduction Mode- Behaviour when C is large-Minimizing THD when C is small- Three phase rectifiers- Continuous Conduction Mode-Discontinuous Conduction Mode- Harmonic trap filters.

UNIT II PULSE WIDTH MODULATED RECTIFIERS 9

Properties of Ideal rectifiers-Realization of non-ideal rectifier-Control of current waveform- Average current control-Current programmed Control- Hysteresis control- Nonlinear carrier control-Single phase converter system incorporating ideal rectifiers- Modeling losses and efficiency in CCM high quality rectifiers-Boost rectifier-expression for controller duty cycle-expression for DC load current solution for converter Efficiency η.

UNIT III RESONANT CONVERTERS 9

Review on Parallel and Series Resonant Switches-Soft Switching- Zero Current Switching – Zero Voltage Switching -Classification of Quasi resonant switches-Zero Current Switching of Quasi Resonant Buck converter, Zero Current Switching of Quasi Resonant Boost converter, Zero Voltage Switching of Quasi Resonant Buck converter, Zero Voltage Switching of Quasi Resonant Boost converter: Steady State analysis.

UNIT IV DYNAMIC ANALYSIS OF SWITCHING CONVERTERS 9

Review of linear system analysis-State Space Averaging-Basic State Space Average Model- State Space Averaged model for Buck Converter, Boost Converter, Buck Boost Converter and Cuk Converter.

UNIT V CONTROL OF RESONANT CONVERTERS 9

Pulse Width Modulation-Voltage Mode PWM Scheme-Current Mode PWM Scheme-Design of Controllers: PI Controller, Variable Structure Controller, Optimal Controller for the source current shaping of PWM rectifiers.

TOTAL: 45 PERIODS

TEXTBOOKS:

1. Robert W. Erickson &Dragon Maksimovic "Fundamentals of Power Electronics" Second Edition, 2001 Springer science and Business media
2. William Shepherd and Li zhang "Power Converters Circuits" Marceld Ekkerin, C.
3. Simon Ang and Alejandro Oliva "Power- Switching Converters" Taylor &Francis Group

REFERENCE:

1. John G. Kassakian, Martin F. Schlecht, George C. Verghese, “Principles of Power Electronics”, Pearson, India, New Delhi, 2010.
2. Simon Ang and Alejandra Oliva, “Power Switching Converter”, Yesdee publishers, New Delhi, 2nd edition (first Indian Reprint), 2010.
3. Philip T Krein, “Elements of Power Electronics”, Oxford University Press
4. Ned Mohan, “Power Electronics: A first course”, John Wiley,2012
5. Issa Batarseh, Ahmad Harb, “Power Electronics- Circuit Analysis and Design, Second edition.

Sl.No.	COURSE OUTCOMES On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Apply the concept of various types of rectifiers.	4
CO2.	Simulate and design the operation of resonant converter and its importance.	4
CO3.	Identify the importance of linear system, state space model, PI controller.	4
CO4.	Design the DC power supplies using advanced techniques.	4
CO5.	Understand the standards for supply current harmonics and its significance.	2

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	2	3
1.	3	2	3
2.	3	2	3
3.	3	2	3
4.	3	2	3
5.	3	2	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22008 POWER QUALITY

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To provide knowledge about various power quality issues.
- To understand the concept of power and power factor in single phase and three phase systems supplying nonlinear loads.
- To equip with required skills to design conventional compensation techniques for power factor correction and load voltage regulation.
- To introduce the control techniques for the active compensation.
- To understand the mitigation techniques using custom power devices such as DSTATCOM, DVR & UPQC

UNIT I INTRODUCTION 9

Introduction – Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non-linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.

UNIT II ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM 9

Single phase linear and non-linear loads – single phase sinusoidal, non-sinusoidal source – supplying linear and nonlinear loads – three phase balanced system – three phase unbalanced system – three phase unbalanced and distorted source supplying non-linear loads – concept of power factor – three phase-three wire – three phase - four wire system.

UNIT III CONVENTIONAL LOAD COMPENSATION METHODS 9

Principle of load compensation and voltage regulation – classical load balancing problem : open loop balancing – closed loop balancing, current balancing – harmonic reduction and voltage sag reduction– analysis of unbalance – instantaneous of real and reactive powers – Extraction of fundamental sequence component from measured.

UNIT IV LOAD COMPENSATION USING DSTATCOM 9

Compensating single – phase loads – Ideal three phase shunt compensator structure – generating reference currents using instantaneous PQ theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced –Realization and control of DSTATCOM – DSTATCOM in Voltage control mode

UNIT V SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM 9

Rectifier supported DVR – DC Capacitor supported DVR – DVR Structure – Voltage Restoration – Series Active Filter – Unified Power Quality Conditioner.

TOTAL : 45 PERIODS

TEXTBOOKS:

1. Arindam Ghosh and Gerad Ledwich "Power Quality Enhancement Using Custom Power Devices",Kluwer Academic Publishers, First Edition, 2002
2. G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, Second Edition, 1994

REFERENCES:

1. R.C.Duggan "Electric Power Systems Quality", Tata MC Graw Hill Publishers, Third Edition, 2012
2. Arrillga "Power System Harmonics", John Wiely and Sons, 2003
3. Derek A.Paice "Power Electronic Converter Harmonics" IEEE Press, 1995

Sl.No.	**COURSE OUTCOMES** On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Comprehend the consequences of Power Quality issues.	**2**
CO2.	Conduct harmonic analysis of single phase and three phase systems supplying non-linear loads.	**4**
CO3.	Design passive filter for load compensation.	**4**
CO4.	Design active filters for load compensation.	**4**
CO5.	Understand the mitigation techniques using custom power devices such as distribution static compensator (DSTATCOM), dynamic voltage restorer (DVR) & UPQC.	**2**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	**POs**		
	1	**2**	**3**
1.	3	-	3
2.	3	-	3
3.	3	-	3
4.	3	-	3
5.	3	-	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22010 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY

L	T	P	C
3	0	0	3

OBJECTIVES:

- To provide fundamental knowledge on electromagnetic interference and electromagnetic compatibility.
- To study the important techniques to control EMI and EMC.
- To expose the knowledge on testing techniques as per Indian and international standards in EMI measurement.

UNITI INTRODUCTION 9

Definitions of EMI/EMC -Sources of EMI- Inter systems and Intra system- Conducted and radiated interference- Characteristics - Designing for electromagnetic compatibility (EMC)- EMC regulation typical noise path- EMI predictions and modeling, Cross talk - Methods of eliminating interferences.

UNIT II GROUNDING AND CABLING 9

Cabling- types of cables, mechanism of EMI emission / coupling in cables –capacitive coupling inductive coupling- shielding to prevent magnetic radiation- shield transfer impedance, Grounding – safety grounds – signal grounds- single point and multipoint ground systems hybrid grounds- functional ground layout – grounding of cable shields- -guard shields- isolation, neutralizing transformers, shield grounding at high frequencies, digital grounding- Earth measurement Methods

UNIT III BALANCING, FILTERINGAND SHIELDING 9

Power supply decoupling- decoupling filters-amplifier filtering –high frequency filtering- EMI filters characteristics of LPF, HPF, BPF, BEF and power line filter design -Choice of capacitors, inductors, transformers and resistors, EMC design components -shielding – near and far fields shielding effectiveness- absorption and reflection loss- magnetic materials as a shield, shield discontinuities, slots and holes, seams and joints, conductive gaskets-windows and coatings - grounding of shields

UNIT IV EMI IN ELEMENTS AND CIRCUITS 9

Electromagnetic emissions, noise from relays and switches, non-linearities in circuits, passive inter modulation, transients in power supply lines, EMI from power electronic equipment, EMI as combination of radiation and conduction

UNIT V ELECTROSTATIC DISCHARGE, STANDARDS AND TESTING TECHNIQUES 9

Static Generation- human body model- static discharges- ESD versus EMC, ESD protection in equipment- standards – FCC requirements – EMI measurements – Open area test site measurements and precautions- Radiated and conducted interference measurements, Control requirements and testing methods

TOTAL : 45 PERIODS

REFERENCES

1. V.P. Kodali, “Engineering Electromagnetic Compatibility”, S. Chand,1996
2. Henry W.Ott, “ Noise reduction techniques in electronic systems”, John Wiley & Sons,1989
3. Bernhard Keiser, “Principles of Electro-magnetic Compatibility”, Artech House, Inc. (685 canton street, Norwood, MA 020062 USA)1987
4. Bridges, J.E Milleta J. and Ricketts.L.W, “EMP Radiation and Protective techniques”, John Wiley and sons, USA1976.
5. William Duff G., & Donald White R. J, “Series on Electromagnetic Interference and Compatibility”.
6. Weston David A., “Electromagnetic Compatibility, Principles and Applications”,1991.

Sl.No.	**COURSE OUTCOMES** On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Identify the sources of Conducted and radiated EMI in Power Electronic Converters and consumer appliances.	**2**
CO2.	Analyze and suggest remedial measures to mitigate the problems.	**4**
CO3.	Assess the insertion loss and design EMI filters to reduce the loss.	**4**
CO4.	Design EMI filters, common-mode chokes and RC-snubber circuits measures to keep the interference within tolerable limits.	**4**
CO5.	Identify and analysis of electrostatic discharge, standards and various measurement techniques of EMI.	**4**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	**2**	**3**
1.	2	2	3
2.	2	2	3
3.	2	2	3
4.	2	2	3
5.	2	2	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22012 SPECIAL ELECTRICAL MACHINES

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To introduce the concepts of stepper motors and its applications.
2. To develop the control methods and operating principles of switched reluctance motors.
3. To review the fundamental concepts of permanent magnets and the operation of permanent magnet brushless DC motors.
4. To introduce the concepts of permanent magnet brushless synchronous motors and synchronous reluctance motors.
5. To understand the basic concepts of reluctance type and linear motors.

UNIT I STEPPER MOTORS **9**

Constructional features –Principle of operation –Types – Torque productions – Linear and Nonlinear analysis – static and dynamic characteristics – Drive circuits – Closed loop control –Applications.

UNIT II SWITCHED RELUCTANCE MOTORS **9**

Constructional features – Principle of operation – Torque equation–Characteristics–Power controllers – Determination of rotor position sensor – Control of SRM drive – Sensorless operation of SRM – sensorless rotor position estimation-inductance based estimation– Applications.

UNIT III PERMANENT MAGNET BRUSHLESS DC MOTORS **9**

Fundamentals of Permanent Magnets- Types- Principle of operation- Magnetic circuit analysis– EMF and Torque equations- Characteristics and control– Field weakening control– Applications.

UNIT IV PERMANENT MAGNET SYNCHROUNOUS MOTORS **9**

Principle of operation – EMF and Torque equations - Phasor diagram - Power controllers – Torque speed characteristics – Self-control, vector control, Current control schemes –Digital controllers– Applications.

UNIT V OTHER SPECIAL MACHINES **9**

Principle of operation and characteristics of Synchronous Reluctance Motor – Constant current control, constant angle control – Permanent magnet assisted Synchronous Reluctance Motor –Hysteresis motor – AC series motors –Linear Induction Motor – DC Linear motor –Applications.

TOTAL: 45 PERIODS

REFERENCES

1. R. Krishnan, 'Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application', CRC Press, New York, 2001.
2. T. Kenjo, ' Stepping motors and their microprocessor controls', Oxford University press, New Delhi, 2000
3. Krishnan, R., "Permanent magnet synchronous and brushless DC motor drives", CRC press, 2017.
4. T. Kenjo and S. Nagamori, 'Permanent magnet and Brushless DC motors', Clarendon press, London, 1988
5. D.P. Kothari and I.J. Nagrath, ' Electric machines', Tata McGraw hill publishing company, New Delhi, Third Edition, 2004.
6. Irving L. Kosow, "Electric Machinery and Transformers" Pearson Education, Second Edition, 2007
7. Boldea, Ion., "Linear electric machines, drives, and MAGLEVs handbook", CRC press, 2017.
8. T.J.E. Miller, 'Brushless magnet and Reluctance motor drives', Claredon press, London, 1989.

Sl.No.	**COURSE OUTCOMES** On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Apply the concepts of control schemes to design controller for stepper motor applications.	3
CO2.	Configure a switched reluctance motor drive for an application.	3
CO3.	Analyze the characteristics and control of a PMBLDC motor drive.	4
CO4.	Analyze the control schemes and develop a digital controller for permanent magnet synchronous motor drives.	4
CO5.	Acquire knowledge on the principle and characteristics of a reluctance and linear motor.	2

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	**2**	**3**
1.	3	-	3
2.	3	-	3
3.	3	-	3
4.	3	-	3
5.	3	-	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22014 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To provide knowledge about different types of renewable energy systems.
- To analyze the various electrical Generators used for the Wind Energy Conversion Systems.
- To design a power converter used in renewable energy systems such as AC-DC, DC-DC, and AC-AC converters.
- To understand the importance of standalone, grid-connected, and hybrid operation in renewable energy systems.
- To analyse various maximum power point tracking algorithms

UNIT I INTRODUCTION TO RENEWABLE ENERGY SYSTEMS 9

Classification of Energy Sources – Importance of Non-conventional energy sources – Advantages and disadvantages of conventional energy sources - Environmental aspects of energy - Impacts of renewable energy generation on the environment - Qualitative study of renewable energy resources: Ocean energy, Biomass energy, Hydrogen energy, - Solar Photovoltaic (PV), Fuel cells: Operating principles and characteristics, Wind Energy: Nature of wind, Types, control strategy, operating area.

UNIT II ELECTRICAL MACHINES FOR WIND ENERGY CONVERSION SYSTEMS (WECS) 9

Review of reference theory fundamentals –Construction, Principle of operation and analysis: Squirrel Cage Induction Generator (SCIG), Doubly Fed Induction Generator (DFIG) - Permanent Magnet Synchronous Generator (PMSG).

UNIT III POWER CONVERTERS AND ANALYSIS OF SOLAR PV SYSTEMS 9

Power Converters: Line commutated converters (inversion-mode) - Boost and buck-boost converters- selection of inverter, battery sizing, array sizing.

Analysis: Block diagram of the solar PV systems - Types of Solar PV systems: Stand-alone PV systems, Grid integrated solar PV Systems - Grid connection Issues

UNIT IV POWER CONVERTERS AND ANALYSIS OF WIND SYSTEMS 9

Power Converters: Three-phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid-Interactive Inverters - Matrix converter.

Analysis: Stand-alone operation of fixed and variable speed WECS - Grid integrated SCIG and PMSG based WECS.

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS 9

Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Diesel - PV, Wind- PV, Microhydel - PV, Biomass-Diesel systems - Maximum Power Point Tracking (MPPT).

TOTAL : 45 PERIODS

REFERENCES:

1. S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford University Press, 2005
2. Rashid .M. H "Power electronics Hand book", Academic press,2nd Edition, 2006.
3. Rai. G.D, "Non-conventional energy sources", Khanna publishers, 2010.
4. Rai. G.D," Solar energy utilization", Khanna publishers, 5th Edition, 2008.
5. Gray, L. Johnson, "Wind energy system", prentice hall of india, 1995.
6. B.H.Khan "Non-conventional Energy sources ",Tata McGraw-hill Publishing Company, New Delhi, 2017.

Sl.No.	**COURSE OUTCOMES** On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Analyze the impacts of renewable energy technologies on the environment and demonstrate them to harness electrical power.	**4**
CO2.	Select a suitable Electrical machine for Wind Energy Conversion Systems.	**4**
CO3.	Design the power converters such as AC-DC, DC-DC, and AC-AC converters for Solar energy systems.	**4**
CO4.	Design the power converters such as AC-DC, DC-DC, and AC-AC converters for Wind energy systems.	**4**
CO5.	Interpret the stand-alone, grid-connected, and hybrid renewable energy systems with MPPT.	**4**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	**2**	**3**
1.	3	-	3
2.	3	-	3
3.	3	-	3
4.	3	-	3
5.	3	-	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22016 NONLINEAR CONTROL

L	T	P	C
3	0	0	3

OBJECTIVES

- To impart knowledge on phase plane analysis of non-linear systems.
- To introduce Describing function based approach to non-linear systems.
- To educate on stability analysis of linear systems using Lyapunov's theory.
- To educate on stability analysis of systems using Lyapunov's theory.
- To investigate the concept of sliding mode control.

UNIT I PHASE PLANE ANALYSIS 9

Concepts of phase plane analysis- Phase portraits- singular points- Symmetry in phase plane portraits- Constructing Phase Portraits- Phase plane Analysis of Linear and Nonlinear Systems- Existence of Limit Cycles and uniqueness of solutions, Bifurcation, simulation of phase portraits in MATLAB.

UNIT II DESCRIBING FUNCTION 9

Describing Function Fundamentals-Computing Describing Functions- Common Nonlinearities and its Describing Functions- Nyquist Criterion and its Extension- Existence of Limit Cycles -Stability of limit Cycles. simulation of limit cycles in MATLAB.

UNIT III LYAPUNOV THEORY 9

Nonlinear Systems and Equilibrium Points-Concepts of Stability-Linearization and Local Stability- Lyapunov's Direct Method, Lyapunov's indirect method- stability analysis- Equilibrium Point Theorems-Invariant Set Theorems- Krasovski's Method-Variable Gradient Method-Physically – Control Design based on Lyapunov's Direct Method.

UNIT IV FEEDBACK LINEARZATION 9

Feedback Linearization and the Canonical Form- input-Output Linearization of SISO Systems and MIMO systems –State feedback control -Stabilization and Tracking-Inverse Dynamics and Non-Minimum-Phase Systems-Feedback Linearization of MIMO Systems Zero-Dynamics and Control Design. Simulation of tracking problems in MATLAB.

UNIT V SLIDING MODE CONTROL 9

Sliding Surfaces- Continuous approximations of Switching Control laws- The Modeling/Performance Trade-Offs- MIMO Systems. Sliding mode control-Stabilization, tracking and regulation via integral control, simulation of sliding mode controller in MATLAB

TOTAL: (L: 45): 45 PERIODS

TEXT BOOKS:

1. Hassan K.Khalil, "Nonlinear Control", 1st Edition, Pearson Publisher, 2015
2. Horacio Marquez, Nonlinear Control Systems: Analysis and design 1st Edition, Wiley- Inter-science Publisher, 2008

REFERENCES:

1. J A E Slotine and W Li, Applied Nonlinear control, PHI, 1991.
2. K. P. Mohandas, Modern Control Engineering, Sanguine, India, 2006
3. Hasan Khalil, “Nonlinear systems and control”, Prentice Hall.
4. S H Zak, “Systems and control”, Oxford University Press, 2003.
5. Torkel Glad and Lennart Ljung, “Control Theory – Multivariable and Nonlinear Methods”, Taylor &Francis, 2002.
6. G. J. Thaler, “Automatic control systems”, Jaico publishers, 2006

Sl.No.	**COURSE OUTCOMES** On the successful completion of the course, the students will be able to:	**RBT LEVEL**
CO1.	Identify the properties of non-linear control system and analyzing methods.	**3**
CO2.	Construct the phase plane and analyze the stability of nonlinear system.	**4**
CO3.	Derive describing function and analyze the stability of nonlinear system.	**4**
CO4.	Apply Lyapunov method of stability analysis.	**4**
CO5.	Acquire knowledge on Feedback linearization and sliding mode control for SISO & MIMO systems.	**3**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	**POs**		
	1	**2**	**3**
1.	3	2	3
2.	3	2	3
3.	3	2	3
4.	3	2	3
5.	3	2	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22011 DISTRIBUTED GENERATION AND MICROGRID

L	T	P	C
3	0	0	3

OBJECTIVES

- To familiarize with the concept of Distributed Generation
- To expose the various distributed energy resources
- To focus on the planning and protection of Distributed Generation
- To study the concept of MicroGrid and its modelling
- To analyze the impact of MicroGrid and major issues on MicroGrid economics

UNIT I INTRODUCTION TO DISTRIBUTED GENERATIONS (DG) 9

DG definition, Need for distributed generation, Current scenario in distributed generation, Distributed generation and the distribution system - Technical, Environmental and Economic impacts of distributed generation on the distribution system - Impact of distributed generation on the transmission system - Impact of distributed generation on central generation.

UNIT II DISTRIBUTED ENERGY RESOURCES 9

Combined heat and power (CHP) systems - Small-scale hydroelectric power generation - Solar PV systems-Wind Energy Conversion Systems -Fuel Cells- Micro-turbines- Biomass, and Tidal sources - Inverter interfaces - Energy storage elements: Batteries, ultra-capacitors, flywheels - Captive power plants.

UNIT III IMPACT OF GRID INTEGRATION 9

Requirement for grid interconnection - limits on operational parameters - Impact of distributed generation on network design- Voltage control techniques - Reactive power control - Harmonics - Power quality issues - Stability analysis - Protection of distributed generation.

UNIT IV CONCEPT OF MICROGRID 9

Concept and definition of Microgrid - Microgrid drivers and benefits, review of sources of Microgrid - A typical Microgrid configuration - AC and DC Microgrid - Power Electronics interfaces in DC and AC Microgrid - Energy Management Module (EMM) and Protection Co-ordination Module (PCM) - Modes of operation and control of Microgrid, grid connected and islanded mode - Modelling of Microgrid : Microturbine Model- PV Solar Cell Model- Wind Turbine Model- Role of Microgrid in power market competition.

UNIT V IMPACTS OF MICROGRID 9

Technical and economical advantages of Microgrid - Challenges and disadvantages of Microgrid Development - Management and operational issues of a Microgrid - Impact on market-Impact on environment-Impact on distribution system-Impact on communication standards and protocols. Microgrid economics-Emerging economic issues in Microgrid - Economic issues between Microgrid and bulk power system - Potential benefits of Microgrid economics - Introduction to smart Microgrid.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Nick Jenkins, Janaka Ekanayake , Goran Strbac , “Distributed Generation”, Institution of Engineering and Technology, London, UK,2010.
2. S. Chowdhury, S.P. Chowdhury and P. Crossley, “Microgrids and Active Distribution Networks”, The Institution of Engineering and Technology, London, United Kingdom, 2009.
3. Math H. Bollen , Fainan Hassan, “Integration of Distributed Generation in the Power System”, John

Wiley &Sons, New Jersey, 2011.
4. Magdi S. Mahmoud, Fouad M. AL-Sunni, "Control and Optimization of Distributed Generation Systems", Springer International Publishing, Switzerland, 2015.
5. NadarajahMithulananthan, Duong Quoc Hung, Kwang Y. Lee, "Intelligent Network Integration of Distributed Renewable Generation", Springer International Publishing, Switzerland, 2017.
6. Ali K., M.N. Marwali, Min Dai, "Integration of Green and Renewable Energy in Electric Power Systems", Wiley and sons, New Jersey, 2010.

REFERENCES:

1. H. Lee Willis, Walter G. Scott, "Distributed Power Generation – Planning and Evaluation",CRC Press, 2000.
2. M. Godoy Simoes, Felix A. Farret, "Renewable Energy Systems – Design and Analysis with Induction Generators", CRC press,2004.
3. John Twidell and Tony Weir, "Renewable Energy Resources" Taylor and Francis Publications, Third edition 2015.
4. Amir naser Yezdani, and Reza Iravani,"Voltage Source Converters in Power Systems: Modeling, Control and Applications", IEEE John Wiley Publications, 2010.
2. Chetan Singh Solanki, "Solar Photo-Voltaics", PHI learning Pvt. Ltd.,New Delhi,Third edition 2015.
3. J.F.Manwell, J.G.Mc Gowan "Wind Energy Explained, theory design and applications", Wiley publication,Second Edition, 2009.
4. D.D.Halland R.P.Grover, "Biomass Regenerable Energy",John Wiley, New York, 1987.

Sl.No.	COURSE OUTCOMES On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Understand the current scenario of Distributed Generation and the need to implement DG sources	2
CO2.	Gain Knowledge about the various DG resources.	2
CO3.	Evaluate the various impacts of DGs on system performance and analysis of stability	4
CO4.	Learn the concept of Microgrid and its modelling.	2
CO5.	Acquire knowledge on the impacts of Microgrid and major issues on MicroGrid economics	2

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	2	3
1.	3	-	3
2.	3	-	3
3.	3	-	3
4.	3	-	3
5.	3	-	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22013 HIGH VOLTAGE DIRECT CURRENT TRANSMISSION

L	T	P	C
3	0	0	3

OBJECTIVES:

- To impart knowledge on operation, modelling and control of HVDC link.
- To perform steady state analysis of AC/DC system.
- To expose various HVDC simulators.

UNIT I DC POWER TRANSMISSION TECHNOLOGY 9

Introduction - Comparison of AC and DC transmission – Application of DC transmission – Description of DC transmission system - Planning for HVDC transmission – Modern trends in DC transmission – DC breakers – Cables, VSC based HVDC.

UNIT II THYRISTOR BASED HVDC CONVERTERS AND HVDC SYSTEM CONTROL 9

Pulse number, choice of converter configuration – Simplified analysis of Graetz circuit - Converter bridge characteristics – characteristics of a twelve pulse converter- detailed analysis of converters. General principles of DC link control – Converter control characteristics – System control hierarchy - Firing angle control – Current and extinction angle control – Generation of harmonics and filtering - power control – Higher level controllers-Valve tests

UNIT III MULTI TERMINAL DC SYSTEMS 9

Introduction – Potential applications of MTDC systems - Types of MTDC systems - Control and protection of MTDC systems - Study of MTDC systems.

UNIT IV POWER FLOW ANALYSIS INAC/DCSYSTEMS 9

Per unit system for DC Quantities - Modelling of DC links - Solution of DC load flow - Solution of AC-DC power flow – Unified, Sequential and Substitution of power injection method.

UNIT V SIMULATION OF HVDC SYSTEMS 9

Introduction – DC LINK Modelling , Converter Modeling and State Space Analysis , Philosophy and tools – HVDC system simulation, Online and OFFline simulators — Dynamic interactions between DC and AC systems.

TOTAL: 45 PERIODS

REFERENCES:

1. P. Kundur, "Power System Stability and Control", McGraw-Hill,1993
2. K.R.Padiyar, , "HVDC Power Transmission Systems", New Age International (P) Ltd., New Delhi, 2002
3. J.Arrillaga, , "High Voltage Direct Current Transmission", Peter Pregrinus, London,1983
4. Erich Uhlmann, " Power Transmission by Direct Current", BS Publications,2004.
5. V.K.Sood , HVDC and FACTS controllers – Applications of Static Converters in Power System, APRIL 2004 , Kluwer Academic Publishers.

Sl.No.	COURSE OUTCOMES On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Understands the principle and types of HVDC system.	2
CO2.	Identify and Analyze suitable converters for HVDC system.	4
CO3.	Analyze the methodologies for control of HVDC converters.	4
CO4.	Acquire knowledge on MTDC system and the HVDC system simulation.	2
CO5.	Model HVDC system and run power flow analysis.	4

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	2	3
1.	3	-	3
2.	3	-	3
3.	3	-	3
4.	3	-	3
5.	3	-	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22015 SOLAR AND ENERGY STORAGE SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To study about solar modules and PV system design and their applications
- To deal with grid connected PV systems
- To discuss about different energy storage systems

UNIT I INTRODUCTION **9**

Characteristics of sunlight – semiconductors and P-N junctions –behavior of solar cells – cell properties – PV cell interconnection

UNIT II STANDALONE PV SYSTEM **9**

Solar modules – storage systems – power conditioning and regulation - MPPT- protection – standalone PV systems design – sizing

UNIT III GRID CONNECTED PV SYSTEMS **9**

PV systems in buildings – design issues for central power stations – safety – Economic aspect – Efficiency and performance - International PV programs.

UNIT IV ENERGY STORAGE SYSTEMS **9**

Impact of intermittent generation – Battery energy storage – Mathematical Modelling for Lead Acid Batteries – solar thermal energy storage – pumped hydroelectric energy storage.

UNIT V APPLICATIONS **9**

Water pumping – battery chargers – solar car – direct-drive applications –Space – Telecommunications.

TOTAL: 45 PERIODS

REFERENCES

1. Solanki C.S., "Solar Photovoltaics: Fundamentals, Technologies And Applications", PHI Learning Pvt. Ltd.,2015.
2. Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish, "Applied Photovoltaics",2007, Earthscan, UK.
3. Eduardo Lorenzo G. Araujo, "Solar electricity engineering of photovoltaic systems", Progensa,1994.
4. Frank S. Barnes & Jonah G. Levine, "Large Energy storage Systems Handbook", CRC Press,2011.
5. McNeils, Frenkel, Desai, "Solar & Wind Energy Technologies", Wiley Eastern, 1990 5 S.P. Sukhatme , "Solar Energy", Tata McGrawHill,1987.

Sl.No.	COURSE OUTCOMES On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Acquire knowledge on behavioral properties solar energy storage systems	**2**
CO2.	Design a standalone PV system	**4**
CO3.	Analyse the issues in grid connected PV systems	**4**
CO4.	Identify suitable energy storage systems based on performance	**4**
CO5.	Examine the different applications of solar energy.	**4**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	**2**	**3**
1.	3	2	3
2.	3	3	3
3.	3	3	3
4.	3	3	3
5.	3	3	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22017 WIND ENERGY CONVERSION SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To understand the concepts of fixed speed and variable speed, wind energy conversion systems
- To learn the design and control principles of wind turbine.
- To analyze the grid integration issues of grid connected systems.

UNIT I INTRODUCTION 9

Components of WECS - WECS schemes - Power obtained from wind - Simple momentum theory - Power coefficient - Sabinin's theory - Aerodynamics of Wind turbine – Wind potential in India and Worldwide.

UNIT II WIND TURBINES 9

HAWT-VAWT - Power developed - Thrust - Efficiency - Rotor selection - Rotor design considerations - Tip speed ratio - No. of Blades - Blade profile - Power Regulation - Yaw control - Pitch angle control - Stall control - Wake loss effect - Schemes for maximum power extraction.

UNIT III FIXED SPEED SYSTEMS 9

Generating Systems – Constant speed constant frequency systems - Choice of Generators - Deciding factors - Model of Wind Speed - Model wind turbine rotor - Drive Train model - Synchronous Generator and Squirrel Cage Induction Generator model for Steady state and Transient stability analysis.

UNIT IV VARIABLE SPEED SYSTEMS 9

Need of variable speed systems - Power-wind speed characteristics - Variable speed constant frequency systems - Variable speed variable frequency systems - DFIG and PMSG modeling.

UNIT V GRID CONNECTED SYSTEMS 9

Wind interconnection requirements, Low Voltage Ride Through (LVRT), Ramp rate limitations, and supply of ancillary services for frequency and voltage control - Current practices and industry trends, Wind interconnection impact on steady-state and dynamic performance of the power system including modeling issue – Technical and economic analysis factors.

TOTAL: 45 PERIODS

REFERENCES:

1. L.L.Freris "Wind Energy conversion Systems", Prentice Hall, 1990.
2. S.N.Bhadra, D.Kastha, S.Banerjee, "Wind Electrical Sytems", Oxford University Press, 2010.
3. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
4. E.W.Golding "The generation of Electricity by wind power", Redwood Burn Ltd., Trowbridge,1978.
5. N. Jenkins," Wind Energy Technology" John Wiley & Sons,1997.
6. S.Heir "Grid Integration of WECS", Wiley, 2006.

Sl.No.	COURSE OUTCOMES On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Acquire knowledge on aerodynamics and wind energy conversion systems.	2
CO2.	Design wind turbines and its associated control.	4
CO3.	Model the fixed speed wind energy conversion systems.	4
CO4.	Analyse the variable speed wind energy conversion systems.	4
CO5.	Examine Grid integration issues and impact of WECS on power system.	4

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	**2**	**3**
1.	3	2	3
2.	3	2	3
3.	3	2	3
4.	3	2	3
5.	3	2	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22019 ENERGY MANAGEMENT AND AUDITING

L	T	P	C
3	0	0	3

OBJECTIVES

- To understand the need for energy auditing.
- To understand of various loads involved based on power consumption for auditing.
- To know about different audit instruments used in practice.

UNIT I INTRODUCTION 9

Need for energy management – Role of energy manager and auditor – energy basics- designing and starting an energy management program – energy accounting -energy monitoring, targeting and reporting- energy audit process

UNIT II ENERGY COST AND LOAD MANAGEMENT 9

Important concepts in an economic analysis - Economic models-Time value of money-Utility rate structures- cost of electricity- Loss evaluation for transformer and motors - Load management: Demand control techniques-Utility monitoring and control system-HVAC and energy management-Economic justification.

UNIT III ENERGY MANAGEMENT FOR MOTORS, SYSTEMS, AND ELECTRICAL EQUIPMENT 9

Systems and equipment- Electric motors- Basics on DC and AC motors, Motor sizing for different duty cycles, Energy efficient motor, and payback analysis. Transformers- Basics and transformer losses, Loss ratio, energy saving recommendations, transformer sizing, and parallel operation. Reactors- energy saving opportunities. Quality of power and harmonics, Power factor improvement and benefits, Automatic Power factor controller, sizing of a capacitor, capacitor and synchronous machines for plant power factor improvement.

UNIT IV METERING FOR ENERGY MANAGEMENT 9

Relationships between parameters-Units of measure-Typical cost factors- Utility meters - Timing of meter disc for kilowatt measurement - Demand meters - Paralleling of current transformers - Instrument transformer burdens-Multitasking solid-state meters - Metering location vs. requirements- Metering techniques and practical examples.

UNIT V LIGHTING SYSTEMS & COGENERATION 9

Concept of lighting systems - The task and the working space -Light sources - Ballasts - Luminaries - Lighting controls-Optimizing lighting energy - Cost analysis techniques-Lighting and energy standards Cogeneration: Forms of cogeneration - feasibility of cogeneration- Electrical interconnection.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, “Guide to Energy Management”, Fifth Edition, The Fairmont Press, Inc., 2006
2. “IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities”, IEEE, 1996.

3. Amit K. Tyagi, "Handbook on Energy Audits and Management", TERI, 2003.

Reference Books:

1. Eastop T.D & Croft D.R, "Energy Efficiency for Engineers and Technologists", Logman Scientific & Technical, 1990.
2. Reay D.A, "Industrial Energy Conservation", 1st edition, Pergamon Press, 1977.

Sl.No.	COURSE OUTCOMES On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Acquire the background required for engineers to meet the role of energy managers and to acquire the skills and techniques required to implement energy management.	2
CO2.	Analyze the basic concepts of economic analysis and load management.	4
CO3.	Identify the energy management strategies on various electrical equipments.	4
CO4.	Explore the concepts of metering and metering location and techniques.	4
CO5.	Analyse the concept of lighting systems, light sources and various forms of cogeneration	4

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	2	3
1.	3	3	3
2.	3	3	3
3.	3	3	3
4.	3	2	3
5.	3	2	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22021 NON-LINEAR DYNAMICS FOR POWER ELECTRONIC CIRCUITS

L	T	P	C
3	0	0	3

OBJECTIVES

- To understand the nonlinear behavior of power electronic converters.
- To introduce the techniques for investigation on nonlinear behavior of power electronic converters
- To impart the nonlinear phenomena in DC to DC converters.
- To analyze the nonlinear phenomena in Drives.
- To familiarize the various control of chaos in power electronic systems.

UNIT I BASICS OF NONLINEAR DYNAMICS 9

Basics of Nonlinear Dynamics: System, state and state space model, Vector field- Modeling of Linear, nonlinear and Linearized systems, Attractors, Poincare map, Dynamics of Continuous time system, Lyapunov Exponent, Bifurcations, Bifurcations of smooth map, Bifurcations in piece wise smooth maps, border crossing and border collision bifurcation.

UNIT II TECHNIQUES FOR INVESTIGATION OF NONLINEAR PHENOMENA 9

Techniques for experimental investigation, Techniques for numerical investigation, Computation of averages under chaos, Computations of spectral peaks, Computation of the bifurcation and analyzing stability.

UNIT III NONLINEAR PHENOMENA IN DC-DC CONVERTERS 9

Border collision Bifurcations in the Current Mode controlled Boost Converter, Bifurcation and chaos in the Voltage controlled Buck Converter with latch, Routes to chaos in the Voltage controlled Buck Converter without latch, Nonlinear analysis of operation in Discontinuous Conduction mode(DCM), Nonlinear phenomena in the Cuk Converter

UNIT IV NONLINEAR PHENOMENA IN DRIVES 9

Nonlinear Phenomenon in Current controlled and voltage controlled DC Drives, Nonlinear Phenomenon in PMSM Drives and SRM Drive

UNIT V CONTROL OF CHAOS 9

Hysteresis control, sliding mode and switching surface control, OGY Method, Pyragas method, Time Delay control. Energy based control in Power Electronics, Ripple correlation control, Closed loop regulation of Chaotic operation, Control of Bifurcation and synchronization of chaos

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Hassan K.Khalil, "Nonlinear Control", 1st Edition, Pearson Publisher, 2015
2. Horacio Marquez, Nonlinear Control Systems: Analysis and design 1st Edition, Wiley- Inter-science Publisher, 2008

REFERENCES:

1. George C. Vargheese, Wiley – IEEE Press S Banerjee, Nonlinear Phenomena in Power Electronics, IEEE Press 3, 2001
2. Steven H Strogatz, Nonlinear Dynamics and Chaos, Westview Press
3. C.K.TSE Complex Behaviour of Switching Power Converters, CRC Press, 2003.

Sl.No.	COURSE OUTCOMES On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Identify & analyze various phenomena of nonlinear dynamics.	**4**
CO2.	Investigate various phenomena of nonlinear dynamics.	**4**
CO3.	Examine the behavior of non-linearity in DC-DC Converters	**4**
CO4.	Acquire knowledge on the non-linear phenomena in drives..	**4**
CO5.	Select and design suitable control for nonlinear phenomena.	**4**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	**POs**		
	1	**2**	**3**
1.	3	2	3
2.	3	2	3
3.	3	2	3
4.	3	2	3
5.	3	2	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD 22023 **SMART GRID**

L	T	P	C
3	0	0	3

OBJECTIVES:

- To understand various smart grid technologies.
- To understand evolution of meters and advanced metering infrastructure.
- To understand the role of automation in Transmission and Distribution System management.
- To analyze the role of power electronics system in Smart Grids.
- To introduce the recent trends and technologies of smart grid communication.

UNIT I INTRODUCTION TO SMART GRID **7**

Evolution of Electric Grid, Need for Smart Grid, Smart grid attributes, challenges and benefits, Overview of technologies required for the smart grid- National and International Initiatives in Smart Grid- Smart grid projects in India.

UNIT II SMART GRID INFRASTRUCTURE **10**

Introduction to Smart Meters- AMI Hardware components - communications infrastructure and protocols - Substation automation equipment: current transformer, voltage transformer, Intelligent Electronic Devices (IED), Bay controllers, Remote Terminal Unit (RTU), Switchgears, Ring Main Unit (RMU), Recloser and Sectionalizer - Transmission system: SCADA, Phasor Measurement Unit (PMU), Visualization techniques.

UNIT III DISTRIBUTION AND TRANSMISSION SYSTEM MANAGEMENT **10**

Distribution Automation & Management : Smart energy resources - smart substations, Substation and Feeder Automation, Effect of Partial and full automation in Fault isolation & Restoration and Loss of supply – Structure and components of Distribution Management System – Modelling & Analysis Tools – Applications: System operation & management – Outage Management System (OMS)
Transmission systems: Energy Management System (EMS), Data sources, Wide area Monitoring, Protection and Control (WAMPAC).

UNIT IV POWER ELECTRONICS IN SMART GRID **9**

Voltage and Current source Inverters (Qualitative analysis) – Distributed Generators & Electric Vehicles – Fault Current limiting- Shunt and series compensation – FACTS & HVDC – Energy Storage Technologies- Power Quality issues of Grid connected Renewable Energy Sources- Power Quality Audit.

UNIT V COMMUNICATION TECHNOLOGIES **9**

Switching Techniques - Communication Channels – Layered architecture & Protocols –Communication technologies- Standards for information exchange – Information Security: Encryption, decryption, Authentication, Digital signatures- Cyber security standards - Basics of Web Service, CLOUD Computing and IoT to make Smart Grids smarter.

TEXT BOOKS

1. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid:
Technology and Applications”, Wiley 2012.
2. Stuart Borlase “Smart Grid :Infrastructure, Technology and Solutions”, CRC Press 2012.

REFERENCES

1. Vehbi C. Güngör, DilanSahin, TaskinKocak, SalihErgüt, ConcettinaBuccella, Carlo Cecati, and Gerhard P. Hancke, “Smart Grid Technologies: Communication 38 Technologies and Standards” IEEE Transactions On Industrial Informatics, Vol. 7, No. 4, November 2011.
2. Xi Fang, SatyajayantMisra, GuoliangXue, and Dejun Yang “Smart Grid – The New and Improved Power Grid: A Survey” , IEEE Transaction on Smart Grids, vol. 14, 2012.

Sl.No.	**COURSE OUTCOMES** On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Understand the concepts of Smart Grid and its present developments.	2
CO2.	Identify the meters and protection components in Smart Grid.	4
CO3.	Analyze the effect of automation on Transmission and Distribution system.	4
CO4.	Analyze the role of power electronics system in Smart Grids.	4
CO5.	Analyze the recent trends and technologies in smart grid communication	4

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	2	3
1.	3	2	3
2.	3	2	3
3.	3	2	3
4.	3	2	3
5.	3	2	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22025 ROBOTICS AND CONTROL

L	T	P	C
3	0	0	3

OBJECTIVES:

- To introduce robot terminologies and robotic sensors.
- To educate direct and inverse kinematic relations.
- To educate on formulation of manipulator Jacobians and introduce path planning techniques.
- To educate on robot dynamics.
- To introduce robot control techniques.

UNIT I INTRODUCTIONAND TERMINOLOGIES 9

Definition – Classification - Robots components - Degrees of freedom - Robot joints – coordinates Reference frames – workspace -Robot languages – actuators – sensors - Position, velocity and acceleration sensors- Torque sensors - tactile and touch sensors - proximity and range sensors - vision system

UNIT II KINEMATICS 9

Mechanism - matrix representation - homogenous transformation - DH representation - A single-pass forward kinematics algorithm - Robot kinematic definition files - Inverse kinematics solution and programming-degeneracy and dexterity

UNIT III DIFFERENTIAL MOTION AND PATH PLANNING 9

Jacobian - differential motion of frames – Interpretation - calculation of Jacobian - Inverse Jacobian - Singularity and Redundancy - Robot Path planning - Introduction to Planning algorithms

UNIT IV DYNAMIC MODELLING 9

Lagrangian mechanics - Two-DOF manipulator - Lagrange-Euler formulation – Newton- Euler formulation - Comparison of Lagrange-Euler and Newton- Euler formulations – Inverse dynamics

UNIT V ROBOT CONTROL SYSTEM 9

Linear control schemes - joint actuators - decentralized PID control - computed torque control – force control hybrid position force control - Impedance/ Torque control - Optimal control problem

TOTAL: 45 PERIODS

REFERENCES

1. R.K. Mittal and I J Nagrath, “Robotics and Control”, Tata MacGraw Hill, Fourth edition.
2. Saeed B. Niku, ‘Introduction to Robotics ", Pearson Education, 2002.
3. Fu, Gonzalez and Lee Mcgrahill ,"Robotics ", international edition.
4. R.D. Klafter, TA Chmielewski and Michael Negin, "Robotic Engineering, An Integrated approach”, Prentice Hall of India, 2003.

Sl.No.	**COURSE OUTCOMES** On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Understand the components and basic terminology of Robotics.	**2**
CO2.	Model the motion of Robots and analyze the workspace and trajectory planning of robots.	**4**
CO3.	Develop application based Robots.	**4**
CO4.	Formulate models for the control of mobile robots in various industrial applications.	**4**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	**2**	**3**
1.	3	-	3
2.	3	-	3
3.	3	-	3
4.	3	-	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22027 MEMS FOR POWERELECTRONICS CIRCUITS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To teach the students properties of materials, microstructure and fabrication methods.
- To teach the design and modeling of Electrostatic sensors and actuators.
- To teach the characterizing thermal sensors and actuators through design and modeling
- To teach the fundamentals of piezoelectric sensors and actuators through exposure to different MEMS and NEMS devices

UNIT I MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONCEPTS **9**

Overview of micro fabrication – Silicon and other material based fabrication processes – Silicon plasma etching for micromachining- Concepts: Conductivity of semiconductors-Crystal planes and orientation stress and strain-flexural beam bending analysis-torsional deflections-Intrinsic stress- resonant frequency and quality factor.

UNIT II ELECTROSTATIC SENSORS AND ACTUATION **9**

Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators – Applications – Inter digitated Finger capacitor – Comb drive devices – Micro Grippers – Micro Motors.

UNIT III PIEZO ELECTRIC SENSING AND ACTUATION **9**

Piezoelectric effect - cantilever piezo electric actuator model- properties of piezo electric materials-Applications. Magnetic Actuators – Micro magnetic components – Case studies of MEMS in magnetic actuators- Actuation using Shape Memory Alloys – Piezo resistive sensors.

UNIT IV MICROMACHINING AND PASSIVE COMPONENTS **9**

Anisotropic Wet etching – Dry and Deep Reactive ion Etching- Isotropic Wet Etching – Surface micromachining- Passive components: Physical model of micro Inductor, Capacitor and Switches.

UNIT V MINIATURIZED DC-DC CONVERTERS **9**

Self-powered and high power devices - Modeling and simulation of Monolithic DC-DC Converters - Monolithic Converter Components: 3D Air core Inductor, Capacitor and Switches - Measuring DC-DC converters- Case Study Monolithic integrated Buck and Boost Converters

TOTAL: 45 PERIODS

TEXT BOOKS

1. Chang Liu, 'Foundations of MEMS', Pearson Education Inc., 2012.
2. Boston , "Micro machined Transducers Source book",WCB McGraw Hill, 1998.
3. M.H.Bao "Micromechanical transducers :Pressure sensors, accelerometers and gyroscopes", Elsevier, Newyork, 2000.
4. P. Rai Choudhury " MEMS and MOEMS Technology and Applications", PHI, 2012.
5. Stephen D. Senturia, "Micro system Design", Springer International Edition, 2011.

Sl.No.	**COURSE OUTCOMES** On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Understand material properties important for MEMS system performance	**4**
CO2.	Develop models and simulate electrostatic sensors and actuators	**4**
CO3.	Develop models and simulate piezo electric sensors and actuators	**4**
CO4.	Perform micromachining and realize passive electrical components	**4**
CO5.	Design and fabricate low power converters.	**5**

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	**2**	**3**
1.	3	-	-
2.	3	3	3
3.	3	3	3
4.	3	-	3
5.	3	3	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping

PD22029 IOT FOR POWER ELECTRONIC SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To understand basic concept of IoT architecture and various IoT sensors
- To analyze IoT power electronics applications
- To demonstrate typical applications of Embedded system enabled with IoT in automation.

UNIT I BASIC CONCEPTS OF IoT 9

Introduction and evolution of IoT from internet, IOT Physical Devices & Endpoints - Basic building blocks and Exemplary IOT Device: Raspberry Pi, Linux on Raspberry Pi, Raspberry Pi Interfaces - Serial, SPI, I2C, Programming Raspberry Pi with Python - Controlling LED with Raspberry Pi, Interfacing an LED and Switch with Raspberry Pi , Interfacing a Light Sensor (LDR) with Raspberry Pi , Other IoT Devices - Arduino with embedded C, Intel Galileo, pcDuino , BeagleBone Black , Cubieboard

UNIT II IOT POWER ELECTRONICS 9

Power Electronics with IoT – Introduction, Power electronics 2.0: IoT-connected and Al-controlled power electronics operating optimally for each user - IoT Assisted Power Electronics for Modern Power Systems – Benefits and disadvantages of IoT Power Electronics – Applications of IoT Power Electronics

UNIT III INDUSTRIES 9

Connecting sensors, actuators, control systems, and machines to optimize production and supply chain networks in manufacturing- automation of process controls in process industries- service information systems, and operator tools to increase productivity and safety. Impact of IoT: real time monitoring and controlling operations- deploying intelligent equipment, sensors, and controllers - Automation and control

UNIT IV ENERGY 9

Smart grid - automation, distribution, and monitoring - Advanced Infrastructure for Measuring – SCADA - Smart Inverters - Remote operation of devices that use energy - connecting solar panels, rainwater harvesters, smart roof, and windows in one system -Observable, automated, and controllable green energy using IoT sensors - IoT solutions in renewable energy power production

UNIT V ELECTRIC VEHICLE 9

Intelligent smart controllers - EV charging station locator - Smart charging stations - Battery monitoring and management - Vehicular traffic and smart parking – case studies

TOTAL: 45 PERIODS

OUTCOMES:

1. Articulate the main concepts, key technologies of IoT.
2. Analyze IoT power electronics applications.
3. Apply IoT in Industrial automation.
4. Apply IoT in smart grid & Energy Management.
5. Apply IoT in Electric Vehicle.

REFERENCES :

1. Arshdeep Bahga, Vijay Madisetti, "Internet of Things : A hands on approach", First Edition, Universities Press, 2015.
2. Honbo Zhou,"The Internet of Things in the Cloud: A Middleware Perspective", CRC Press, 2012.
3. Dieter Uckelmann Mark Harrison; Florian Michahelles, "Architecting the Internet of Things ", Springer, 2011.
4. Peter Waher, 'Learning Internet of Things', Packt Publishing, 2015
5. N. Ida, Sensors, Actuators and Their Interfaces, Scitech Publishers, 2014.

2. M. Takamiya, K. Miyazaki, H. Obara, T. Sai, K. Wada and T. Sakurai, "Power electronics 2.0: IoT-connected and Al-controlled power electronics operating optimally for each user," 2017 29th International Symposium on Power Semiconductor Devices and IC's (ISPSD), 2017, pp. 29-32, doi: 10.23919/ISPSD.2017.7988875.
3. S. K. Routray, A. Javali, A. Sahoo, L. Sharma, K. P. Sharmila and A. D. Ghosh, "IoT Assisted Power Electronics for Modern Power Systems," 2021 Third International Conference on Inventive Research in Computing Applications (ICIRCA), 2021, pp. 17-21, doi: 10.1109/ICIRCA51532.2021.9544584.
4. https://dhienergy.org/power-electronics-and-iot-what-exactly-is-it/

Sl.No.	COURSE OUTCOMES On the successful completion of the course, the students will be able to:	RBT LEVEL
CO1.	Articulate the main concepts, key technologies of IoT.	3
CO2.	Analyze IoT power electronics applications.	4
CO3.	Apply IoT in Industrial automation.	4
CO4.	Apply IoT in smart grid & Energy Management.	4
CO5.	Apply IoT in Electric Vehicle.	4

(1- Remember, 2- Understand, 3- Apply, 4- Analyze, 5- Evaluate, 6- Create)

COURSE ARTICULATION MATRIX

COs	POs		
	1	2	3
1.	2	1	2
2.	3	2	3
3.	3	2	3
4.	3	2	3
5.	3	2	3

3 – High Mapping, 2 – Moderate Mapping, 1 – Low Mapping