VISION OF THE DEPARTMENT

The vision of Anna University is to be a world class institution by producing professionals with high technical knowledge, professional skills and ethical values, and remain as a preferred partner to the industry and community for their economic and social development through excellence in teaching, research and consultancy. Anna University shall be recognized as a point of reference, a catalyst, a facilitator, a trend setter and a leader in technical education.

MISSION OF THE DEPARTMENT

To produce full fledged Electrical and Electronics Engineers to cater to the needs of the modern industries and be useful for building the nation.
1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):
   i. To prepare the students for successful career in electrical power industry, research and teaching institutions.
   ii. To analyze power electronic supply/ machine drive problems.
   iii. To design and develop the power electronic converter/drive systems.
   iv. To develop the ability to analyze the dynamics in power electronic converters/drives systems
   v. To introduce them to the sustainable energy generation technologies.
   vi. To promote student awareness for the lifelong learning and introduce them to professional ethics.

2. PROGRAMME OUTCOMES (POs):
   On successful completion of the programme, the graduate would have attained the

<table>
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<tr>
<td>1.</td>
<td>Engineering Knowledge</td>
<td>Apply knowledge of basic science and engineering science in the design and testing of power electronic systems and drives.</td>
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<tr>
<td>2.</td>
<td>Problem Analysis</td>
<td>Formulate, simulate and design of power electronic converters and drives to meet the performance criteria.</td>
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<tr>
<td>3.</td>
<td>Design / Development of Solutions</td>
<td>Design of power converters and energy efficient drive systems.</td>
</tr>
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<td>4.</td>
<td>Conduct investigations of complex problems</td>
<td>Design the magnetics and controllers, conduct experiments to validate the design on power converters and drives for various industrial applications.</td>
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<td>5.</td>
<td>Model tool usage</td>
<td>Model and analyze power electronic systems and drives using computational softwares.</td>
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<tr>
<td>6.</td>
<td>The Engineer and Society</td>
<td>To design power electronic systems and drives to meet the requirements of the societal needs.</td>
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<td>7.</td>
<td>Environment and Sustainability</td>
<td>To design power electronic systems and electric generators for efficient extraction and utilization of various renewable energy sources.</td>
</tr>
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<td>8.</td>
<td>Ethics</td>
<td>Interact with industry, business and society in a professional and ethical manner</td>
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<tr>
<td>9.</td>
<td>Individual and team work</td>
<td>Function in a multi-disciplinary team</td>
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<td>10.</td>
<td>Communication</td>
<td>Proficiency in oral and written Communication to present technical subjects</td>
</tr>
<tr>
<td>11.</td>
<td>Project Management and Finance</td>
<td>Implement cost effective and cutting edge technologies in Power Electronics and Drives system</td>
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<td>12.</td>
<td>Life-long learning</td>
<td>Continue professional development and learning as a life-long activity.</td>
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3. PROGRAMME SPECIFIC OUTCOMES (PSOs):

By the completion of power electronics and drives program the student will have the following programme specific outcomes

1. Foundation of power electronics and drives: Ability to comprehend the need for various power electronics converters and applying the fundamental principles for analysing the different modes of their operation.
2. Adjustable speed electric drives: Ability to analyse, design, simulate and test the various range of drive schemes.
3. Renewable energy extraction and effective utilisation: Ability to understand the power generation from various renewable sources, to analyse the schemes for extracting the maximum power and to know the importance of energy storage systems.
4. Design of controllers: Ability to understand the requirement of modern control technologies applicable to power electronics systems and drives to achieve the desired performance specifications.
5. Design and conduct experiments towards research: Ability to use knowledge in development of new power electronic converters with high power density and efficiency and also in the design and development of high speed drives.

4. PEO / PO Mapping:

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Attested

Director
Centre for Academic Courses
Anna University, Chennai-600 025
### ANNA UNIVERSITY, CHENNAI
### UNIVERSITY DEPARTMENTS
### REGULATIONS – 2019
### CHOICE BASED CREDIT SYSTEM
### M.E. POWER ELECTRONICS AND DRIVES (FULL TIME)
### CURRICULUM AND SYLLABUS I TO IV SEMESTERS

#### SEMESTER I

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**TOTAL NO OF CREDITS: 70**
ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
REGULATIONS – 2019
CHOICE BASED CREDIT SYSTEM
M.E. POWER ELECTRONICS AND DRIVES (PART TIME)

CURRICULUM AND SYLLABUS I TO VI SEMESTERS

SEMESTER I

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PRACTICALS

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TOTAL 8 2 4 14 10

*Audit Course is optional

SEMESTER II

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PRACTICALS

| 5.    | PE5211      | Power Electronics and Drives Laboratory | PCC | 0 | 0 | 4 | 4               | 2        |

TOTAL 11 1 4 16 12

*Audit Course is optional

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025
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| 4.    | PE5213      | Mini Project with Seminar                   | EEC       | 0 0 6            | 6                      | 3       |

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|       |             |                                             |           |                  |                        |         |
| 4.    | PE5311      | Project Phase I                             | EEC       | 0 0 12           | 12                     | 6       |

|       |             | TOTAL                                       |           |                  |                        |         |
|       |             |                                             |           |                  |                        |         |
|       |             |                                             |           | 9 0 12           | 21                     | 15      |

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025
### PROGRAM CORE COURSES (PCC)

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**RESEARCH METHODOLOGY AND IPR COURSES (RMC)**

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(Out of 6 Courses one Course must be selected)

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AUDIT COURSES (AC)
Registration for any of these courses is optional to students

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COURSE OBJECTIVES:

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

UNIT I PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION

Magnetic circuits, permanent magnet, stored magnetic energy, co-energy - force and torque in singly and doubly excited systems – machine windings and air gap mmf– determination of winding resistances and inductances of machine windings – determination of friction coefficient and moment of inertia of electrical machines.

UNIT II DC MACHINES

Elementary DC machine and analysis of steady state operation - Voltage and torque equations – dynamic characteristics of permanent magnet and shunt DC motors – electrical and mechanical time constants - Time domain block diagrams -transfer function of DC motor-responses – digital computer simulation of permanent magnet and shunt DC machines.

UNIT III REFERENCE FRAME THEORY

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

UNIT IV INDUCTION MACHINES


UNIT V SYNCHRONOUS MACHINES


TOTAL: 60 PERIODS
COURSE OUTCOMES:
CO1 Ability to optimally design magnetics required in power supplies and drive systems.
CO2 Ability to acquire and apply knowledge of mathematics of machine dynamics in Electrical engineering.
CO3 Ability to model, simulate and analyze the dynamic performance of electrical machines using computational software.
CO4 Ability to formulate, design, simulate power supplies and loads for complete electrical machine performance
CO5 Ability to verify the results of the dynamic operation of electrical machine systems

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TEXT BOOKS:
2. R Ramanujam, “Modelling and Analysis of Electrical Machines”, I.K International Publishing Pvt. Ltd., New Delhi, 2018

REFERENCES:

PE5152 ANALYSIS OF POWER CONVERTERS

COURSE OBJECTIVES:
- To provide the mathematical fundamentals necessary for deep understanding of power converter operating modes.
- To provide the electrical circuit concepts behind the different working modes of power converters so as to enable deep understanding of their operation.
- To provide required skills to formulate and design inverters for generic load and for machine loads.
- To equip with required skills to derive the criteria for the design of power converters starting from basic fundamentals.
- To analyze and comprehend the various operating modes of different configurations of power converters

UNIT I SINGLE PHASE AC-DC CONVERTER
harmonics, ripple, distortion, power factor – effect of source impedance and overlap-reactive power and power balance in converter circuits

UNIT II THREE PHASE AC-DC CONVERTER 12

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 to drive system – Current source inverters.

UNIT V MODERN INVERTERS 12

TOTAL : 60 PERIODS

COURSE OUTCOMES:
CO1 Ability to acquire and apply knowledge of mathematics in power converter analysis
CO2 Ability to model, analyze and understand power electronic systems and equipment
CO3 Ability to formulate, design and simulate phase controlled rectifiers for generic load and for machine loads
CO4 Ability to formulate, design, simulate switched mode inverters for generic load and for machine loads
CO5 Ability for device selection and calculation of performance parameters of power converters under various operating modes

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REFERENCES:

PE5153 MODELLING AND DESIGN OF SMPS

COURSE OBJECTIVES:
- To perform steady state analysis of Non-Isolated DC-DC DC-DC converter.
- To perform steady state analysis of Isolated DC-DC converter.
- To understand different converter dynamics.
- To design controllers for DC DC converters.
- To design magnetics for SMPS applications.

UNIT I ANALYSIS OF NON-ISOLATED DC-DC CONVERTERS
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 other topologies, SEPIC topologies - design examples.

UNIT II ANALYSIS OF ISOLATED DC-DC CONVERTERS
Introduction - classification - forward- flyback- pushpull- halfbridge- fullbridge topologies- design of SMPS

UNIT III CONVERTER DYNAMICS

UNIT IV CONTROLLER DESIGN

UNIT V DESIGN OF MAGNETICS

COURSE OUTCOMES:
CO1 Ability to design Non-Isolated DC-DC.
CO2 Ability to design Isolated DC-DC converter.
CO3 Ability to derive transfer function of different converters.
CO4 Ability to design controllers for DC DC converters.
CO5 Ability to design magnetics for SMPS applications.

TOTAL : 45 PERIODS
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**REFERENCES:**


**RM5151 RESEARCH METHODOLOGY AND IPR LT P C 2002**

**COURSE OBJECTIVES:**

To impart knowledge and skills required for research and IPR:
- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

**UNIT I RESEARCH PROBLEM FORMULATION**

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

**UNIT II LITERATURE REVIEW**

Effective literature studies approaches, analysis, plagiarism, and research ethics.

**UNIT III TECHNICAL WRITING /PRESENTATION**

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 INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR)**

UNIT V  INTELLECTUAL PROPERTY RIGHTS (IPR)  


TOTAL: 30 PERIODS

COURSE OUTCOMES:
1. Ability to formulate research problem
2. Ability to carry out research analysis
3. Ability to follow research ethics
4. Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity
5. Ability to understand about IPR and filing patents in R & D.

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REFERENCES:

PE5161  POWER CONVERTERS LABORATORY  

COURSE OBJECTIVES:
- To provide the requisite knowledge necessary to appreciate the dynamical equations involved in the analysis of different PED configurations.
- To understand the dynamics and different operating modes of power converters studied in the core courses on power converters.
- To analyze, design and simulate different rectifier circuits for generic load and for machine loads.
- To formulate, design, simulate power supplies for generic load and for machine loads.

LIST OF EXPERIMENTS:
1. Simulation of single phase half wave controlled converter fed RLE load.
2. Simulation of single phase fully controlled converter fed RLE load.
3. Simulation of three phase half controlled converter fed RL load.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025
5. Study of single phase Fully Controlled Rectifier, Half Controlled Rectifier with different Loads.
6. Study of Three phase Fully Controlled Rectifier, Half Controlled Rectifier with different Loads.
7. Simulation of single phase VSI fed RL/RC load.
8. Design of UPS.
9. Design of SMPS.
10. Simulation of multilevel inverter topologies.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

CO1: Ability to solve dynamic equations involved in power electronics.
CO2: Ability to acquire and apply knowledge of mathematics and converter/machine dynamics in Electrical engineering.
CO3: Ability to model and analyze different rectifier circuits using computational software and to understand their various operating modes.
CO4: Ability to model and analyze different rectifier circuits using computational software and to understand their various operating modes.
CO5: Ability to formulate, design, simulate power supplies for generic load and for machine loads.

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REFERENCES:


PW5261 RENEWABLE ENERGY LABORATORY

COURSE OBJECTIVES
Students will be able to:

- Study the performance of various renewable energy sources.
- Obtain hands-on experience on various wind turbine operation.
- Analyze the grid integration issues of renewable energy sources.
- To analyze the performance characteristics of DFIG and PMSG.
- To design and model PV system integration with grid.

1. Performance characteristics of solar PV panel.
2. Performance of PV panel in series and parallel combination.
3. VI characteristics of fuel cell.
5. Performance characteristics of DFIG.
6. Performance characteristics of PMSG.
7. MPPT tracking of DFIG based WT.
8. MPPT tracking of PMSG based WT.
9. Grid integration of RES.

**TOTAL 60 PERIODS**

**COURSE OUTCOMES**

CO1: Students will understand the characteristics of various renewable energy sources.

CO2: Students will be able to program different MPPT algorithm and understand their merits and demerits.

CO3: Students will learn control of DFIG.

CO4: Students will learn control of PMSG.

CO5: Students will design and model PV system integration with grid.

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**PE5201 ANALYSIS OF ELECTRICAL DRIVES**

**COURSE OBJECTIVES:**

To understand steady state operation and transient dynamics of a motor load system

- To study and analyze the operation of the converter/chopper fed DC drive, both qualitatively and quantitatively
- To analyze and design the current and speed controllers for a closed loop solid state DC motor drive.
- To understand the drive characteristics for different load torque profiles and quadrants of operation
- To understand the speed control of induction motor drive from stator and rotor sides.
- To study and analyze the operation of VSI &CSI fed induction motor control and pulse width modulation techniques

**UNIT I DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS**

DC motor- Types, induced emf, speed-torque relations; Speed control – Armature and field speed control; Ward Leonard control – Constant torque and constant horse power operation -Introduction to high speed drives and modern drives. Characteristics of mechanical system – dynamic equations, components of torque, types of load; Requirements of drives characteristics - stability of drives–multi-quadrant operation; Drive elements, types of motor duty and selection of motor rating.
UNIT II  CONVERTER AND CHOPPER CONTROL  9
Principle of phase control – Fundamental relations; Analysis of series and separately excited DC motor with single-phase and three-phase converters – performance parameters, performance characteristics. 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 III  CLOSED LOOP CONTROL  9
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. Simulation of converter and chopper fed DC drive.

UNIT IV  VSI AND CSI FED STATOR CONTROLLED INDUCTION MOTOR CONTROL  9
AC voltage controller – six step inverter voltage control-closed loop variable frequency PWM inverter fed induction motor (IM) with braking-CSI fed IM variable frequency motor drives – pulse width modulation techniques – simulation of closed loop operation of stator controlled induction motor drives.

UNIT V  ROTOR CONTROLLED INDUCTION MOTOR DRIVES  9

TOTAL:  45 PERIODS

COURSE OUTCOMES:
CO1 Ability to acquire and apply knowledge of mathematics and converter/machine dynamics in Electrical engineering.
CO2 Ability to formulate, design, simulate power supplies for generic load and for machine loads.
CO3 Ability to analyze, comprehend, design and simulate direct current motor based adjustable speed drives.
CO4 Ability to analyze, comprehend, design and simulate induction motor based adjustable speed drives.
CO5 Ability to design a closed loop motor drive system with controllers for the current and speed control operations.

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REFERENCES:

PE5251 SPECIAL ELECTRICAL MACHINES

COURSE OBJECTIVES:
- To review the fundamental concepts of permanent magnets and the operation of permanent magnet brushless DC motors.
- To introduce the concepts of permanent magnet brushless synchronous motors and synchronous reluctance motors.
- To develop the control methods and operating principles of switched reluctance motors.
- To introduce the concepts of stepper motors and its applications.
- To understand the basic concepts of other special machines.

UNIT I PERMANENT MAGNET BRUSHLESS DC MOTORS

UNIT II PERMANENT MAGNET SYNCHRONOUS MOTORS

UNIT III SWITCHED RELUCTANCE MOTORS
Constructional features –Principle of operation- Torque prediction–Characteristics Power controllers – Control of SRM drive- Sensor less operation of SRM – Applications.

UNIT IV STEPPER MOTORS

UNIT V OTHER SPECIAL MACHINES
Principle of operation and characteristics of Hysteresis motor – AC series motors – Linear motor – Applications.

TOTAL : 45 PERIODS

COURSE OUTCOMES:
- CO1 Ability to model and analyze power electronic systems and equipment using computational software.
- CO2 Ability to optimally design magnetics required in special machines based drive systems using FEM based software tools.
CO3 Ability to analyse the dynamic performance of special electrical machines
CO4 Ability to understand the operation and characteristics of other special electrical machines.
CO5 Ability to design and conduct experiments towards research.

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PE5252 VECTOR CONTROL OF AC MACHINES L T P C
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COURSE OBJECTIVES:
- To study the space phasor model of alternating current machines.
- To understand the field oriented control for permanent magnet synchronous machines.
- To analyse the concept of vector control based salient pole machines.
- To provide the knowledge about concept and control techniques of induction motor.
- To develop the flux oriented control circuit for induction motor.

UNIT I SPACE PHASOR MODEL OF AC MACHINES
Introduction-Smooth Air gap machine and salient pole machines- flux linkage space phasors- voltage equation- expression for electromagnetic torque.

UNIT II VECTOR CONTROL OF PM SYNCHRONOUS MACHINE
PMSM with surface mounted magnets- control scheme for of rotor oriented controlled PMSM with interior magnets-stator flux oriented control- rotor oriented control

UNIT III VECTOR CONTROL OF SALIENT POLE MACHINE WITH ELECTRICALLY EXCITED ROTOR

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025
Magnetizing flux oriented control — variable frequency operation of salient pole synchronous machine-rotor oriented control of reluctance machines—considerations of the effects of main flux saturation

UNIT IV  STATOR FLUX ORIENTED CONTROL OF INDUCTION MACHINE  12
Squirrel cage machine - Electromagnetic torque-voltage equations, doubly fed induction machines-control-static converter cascade, magnetizing flux oriented control of induction machine.

UNIT V  ROTOR FLUX ORIENTED CONTROL OF INDUCTION MACHINE  12
Control by a VSI — voltage equation—decoupling circuits—electromagnetic torque-voltage equations—current controlled PWM inverter- control by CSI — current controlled operation - control of slip ring induction machines

TOTAL :  60  PERIODS

COURSE OUTCOMES:
CO1: Ability to carry out space phasor model for electrical machines.
CO2: Able to synthesis the vector controller for permanent magnet synchronous machines.
CO3: Able to compute and analyse the controllers of salient pole machines.
CO4: Able to understand and select the various control schemes suitable for induction motor.
CO5: The students acquire the flux oriented control concept of induction motor.

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TEXT BOOKS:

REFERENCES:

PE5211  POWER ELECTRONICS AND DRIVES LABORATORY  L  T  P  C
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COURSE OBJECTIVES:
- To design and simulate power supplies for generic load and for machine loads
- To design magnetics used in power supplies and drive systems
- To conduct load tests in drive system
- To conduct experiments and enhance understanding of different power electronic controller for power supplies and motor drive applications.
• To generate PWM rating signals and to study drive circuits used in Power electronic converters.

**LIST OF EXPERIMENTS:**
1. Speed control of Converter fed DC motor.
2. Speed control of Chopper fed DC motor.
5. Speed control of BLDC motor.
6. DSP based speed control of SRM motor.
7. Simulation of Four quadrant operation of three-phase induction motor.
8. Voltage Regulation of three-phase Synchronous Generator.
9. AC voltage Controller based speed control of induction motor.
10. Study of driver circuits and generation of PWM signals for three phase inverters.

**TOTAL : 60 PERIODS**

**COURSE OUTCOMES:**
- CO1 Ability to formulate, design, simulate power supplies for generic load and for machine loads.
- CO2 Ability to optimally design magnetics required in power supplies and drive systems.
- CO3 Ability to conduct harmonic analysis and load tests on power supplies and drive systems.
- CO4 Ability to design and conduct experiments towards research.
- CO5 Ability to understand the various power electronic controllers used in drive systems.

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**PE5212 MICROCONTROLLER AND DIGITAL SIGNAL PROCESSING LABORATORY**

**COURSE 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 write an assembly language program to convert Analog input to Digital output and Digital input to Analog output.
- To perform interfacing experiments with μC8051/ PIC μC /DSP
LIST OF EXPERIMENTS:

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.  
4. Programming exercises on serial communication using assembly/ embedded C language  

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

5. Simple arithmetic operations: Multi precision addition / subtraction, using binary/ BCD, signed / unsigned, multiplication /division.  
8. Programming exercises on serial communication using assembly/ embedded C language.

Experiments with Fixed Point Digital Signal Processor kits:

9. Simple arithmetic operations: Multi precision addition / subtraction, using binary/ BCD, signed / unsigned, sorting of numbers, multiplication /division.  
12. Generation of firing pulses for control of a 3-phase VSI using Sinusoidal PWM or Space Vector PWM.  

TOTAL : 60 PERIODS

COURSE OUTCOMES:

CO1 Ability to perform simple arithmetic operations using the assembly language of µc8051 employing different addressing modes  
CO2 Ability to perform simple arithmetic operations using the assembly language of PICµC employing different addressing modes  
CO3 Ability to perform simple arithmetic operations using the assembly language of Digital signal processor employing different addressing modes  
CO4 Ability to write assembly language program to convert Analog input to Digital output and digital input to analog output using µc8051/PICµc/DSP  
CO5 Ability to perform interfacing experiments with µc8051/PICµc/DSP

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[Harvested]
TEXT BOOKS:
1. Muhammad Ali Mazidi & Janice Gill Mazidi, "PIC programming"

REFERENCES:

PE5001 POWER SEMICONDUCTOR DEVICES

COURSE OBJECTIVES:
- To select proper power semiconductor device for power electronic circuit 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 devices.
- To understand the protection and firing circuit for different devices.
- To know about the wide band gap power switching devices.

UNIT I INTRODUCTION
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 characteristics, switching characteristics – rating.

UNIT II CURRENT CONTROLLED DEVICES
BJT’s – Construction, static characteristics, switching characteristics; Power darlington- 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-driving circuit for BJT and Thyristor.

UNIT III VOLTAGE CONTROLLED DEVICES
Power MOSFETs and IGBTs – Principle of voltage controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs – driving circuits-Basics of GTO, MCT, FCT, RCT and IGCT.

UNIT IV DEVICE PROTECTION
Necessity of isolation - Over voltage, over current and gate protections; Design of snubbers. Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour – phase cooling; Guidance for heat sink selection – Electrical analogy of thermal components, heat sink types and design – Mounting types.

UNIT V WIDE BANDGAP DEVICES
Features of silicon carbide and gallium nitride devices. SiC JFET- SiC MOSFET-GaN based transistors-Applications of SiC and GaN based devices.
TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1 Ability to select the switching device suitable for given power electronic converter.
CO2 To be able to understand the principle of voltage controlled devices.
CO3 To be able to understand the principle of current controlled devices.
CO4 Ability to understand the control protection and firing circuits required for different switching devices.
CO5 Ability to know about wide band gap devices.

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PE5002 MODERN RECTIFIERS AND RESONANT CONVERTERS

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.

[Signature]  
Director
Centre for Academic Courses
Anna University, Chennai-600 025

Attested
UNIT II  PULSE WIDTH MODULATED RECTIFIERS  

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 $\eta$.

UNIT III  RESONANT CONVERTERS  


UNIT IV  DYNAMIC ANALYSIS OF SWITCHING CONVERTERS  

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  

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

COURSE OUTCOMES:

CO1 Ability to acquire and apply knowledge of mathematics in power converter analysis and understanding of harmonic standards
CO2 Ability to analyze and understand power electronic systems and equipment
CO3 Ability to analyze, design and simulate resonant converters for low power applications
CO4 Ability to analyze, design and simulate resonant converters for low power applications
CO5 Ability to design and implement different controllers and switching schemes for the control of converters

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TEXTBOOKS:

2. William Shepherd and Li Zhang “Power Converters Circuits”MarceldEkkerin, C.
3. Simon Ang and Alejandro Oliva “Power- Switching Converters” Taylor & Francis Group

REFERENCE:

PE5003 NONLINEAR DYNAMICS FOR POWER ELECTRONIC CIRCUITS

COURSE OBJECTIVES:
- To understand the nonlinear behavior of power electronic converters.
- To understand the techniques for investigation on nonlinear behavior of power electronic converters.
- To analyse the nonlinear phenomena in DC to DC converters.
- To analyse the nonlinear phenomena in AC and DC Drives.
- To introduce the control techniques for control of nonlinear behavior in power electronic systems.

UNIT I BASICS OF NONLINEAR DYNAMICS

UNIT II TECHNIQUES FOR INVESTIGATION OF NONLINEAR PHENOMENA
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
Border collision in the Current Mode controlled Boost Converter, Bifurcation and chaos in the Voltage controlled Buck Converter with latch, Bifurcation and chaos in the Voltage controlled Buck Converter without latch, Bifurcation and chaos in Cuk Converter. Nonlinear phenomenon in the inverter under tolerance band control

UNIT IV NONLINEAR PHENOMENA IN DRIVES
Nonlinear Phenomenon in Current controlled and voltage controlled DC Drives, Nonlinear Phenomenon in PMSM Drives.

UNIT V CONTROL OF CHAOS
Hysteresis control, Sliding mode and switching surface control, OGY Method, Pyragas method, Time Delay control. Application of the techniques to the Power electronics circuit and drives.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
- CO1 Ability to understand, model and simulate chaotic behavior in power electronic systems.
- CO2 Ability to investigate the various techniques of nonlinear phenomena
- CO3 Ability to analyze the nonlinear phenomena in DC-DC converter
CO4 Ability to analyze the non linear phenomena in Drives  
CO5 Ability to mitigate chaotic behavior noticed in power system.

TEXT BOOKS:
2. Steven H Strogatz, Nonlinear Dynamics and Chaos, Westview Press

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PE5004 DSP BASED SYSTEM DESIGN  
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COURSE OBJECTIVES:
- To provide the requisite knowledge for the designing of control/triggering/closed loop circuitry employing embedded controller readily available.
- To provide with the requisite knowledge for the interfacing of the digital controllers with power electronics system for better control.
- To understand the architecture, programming methods and their special features as relevant to PE Drives.
- To understand design of DSP controlled systems especially for the PE interface.
- To provide knowledge about the digital implementation of conventional controllers.

UNIT I MOTOR CONTROL SIGNAL PROCESSORS  
Introduction- Core architecture of 2000 family of Digital Signal Processors- System configuration registers - Memory mapping in microcontroller mode.

UNIT II ASSEMBLY LANGUAGE PROGRAMMING  
Instruction set – Addressing modes-Programming techniques – simple programs: Arithmetic and interfacing examples, program using MAC, SQRA instruction, use of Look-Up Tables.

UNIT III PERIPHERALS OF SIGNAL PROCESSORS  
General purpose Input/Output (GPIO) Functionality- Interrupts –Built in analog to digital converter and its sequence control.

UNIT IV EVENT MANAGER AND DRIVE CONTROL  
Event Managers (EVA, EVB), Timers, full compare units, capture units- PWM signal
UNIT V  APPLICATIONS OF SIGNAL PROCESSORS

Voltage regulation of DC-DC converters- Stepper motor and DC motor control- Clarke’s and parks transformation-Space vector PWM- Implementation of digital P, PI and PID controllers.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Ability to understand the features in the core architecture of 2000 family DS Processors
CO2 Ability to write simple assembly language program using Digital signal processor instruction set
CO3 Ability to understand features relevant to power electronic drives in the DS Processors
CO4 Ability to write program for PWM signal generation using event manager of DS processors.
CO5 Ability to develop programs for the embedded control of electrical drives.

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PE5005  CONTROL OF POWER ELECTRONIC CIRCUITS  L T P C
3 0 0 3

COURSE OBJECTIVES:

• To study the basics of control for power electronic circuits.
• To understand the principles behind flatness based control and sliding mode control.
• To know about the controller design for power converter circuits.
• To understand the principles behind sliding mode control
• To gain the knowledge related with flatness based controller design

UNIT I  CONTROLLER DESIGN FOR BASIC DC-DC CONVERTERS- PART I

Introduction, Review of Linear Control Theory, Linearization of Various Transfer Function Blocks, Feedback Controller Design in Voltage-Mode Control, Peak-Current Mode Control, Feedback Controller Design in DCM
UNIT II  CONTROLLER DESIGN FOR BASIC DC-DC CONVERTERS- PART II  9
Introduction, Linear Feedback Control- Pole Placement by Full State Feedback, Pole Placement Based on Observer Design, Reduced Order Observers, Generalized Proportional Integral Controllers- Hamiltonian Systems Viewpoint - Application to power converters

UNIT III  CONTROLLER DESIGN FOR BASIC AC-DC CONVERTER CIRCUITS  9
Introduction, Operating Principle of Single-Phase PFCs, Control of PFCs, Designing the Inner Average-Current-Control Loop, Designing the Outer Voltage-Control Loop, Example of Single-Phase PFC Systems

UNIT IV  SLIDING MODE CONTROL  9

UNIT V  FLATNESS BASED CONTROL  9
Flatness, the use of the differential flatness property, Controller development using flatness- Application to power converters

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Ability to design controller for front end power factor corrector circuits
CO2 Ability to design controllers for UPS application.
CO3 Ability to design controllers for AC-DC converters
CO4 Ability to design sliding mode control for power converters
CO5 Ability to design flatness based control for power converters.

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COURSE OBJECTIVES:
- To get Introduced to the fundamentals of microcontroller based system design.
- To learn I/O and other built in features available in microcontroller.
- To know Microcontroller based system design, applications.
- To learn I/O interface in system Design
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired for improved employability skills

UNIT I  8051 ARCHITECTURE  9

UNIT II  8051 PROGRAMMING  9

UNIT III  PIC MICROCONTROLLER  9

UNIT IV  PERIPHERAL OF PIC MICROCONTROLLER  9

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

COURSE OUTCOME:
CO1 Ability to understand the features of microcontroller 8051
CO2 Ability to write programs using 8051 assemble language, utilizing its build in features
CO3 Ability to understand the features of PIC microcontroller.
CO4 Ability to use the peripherals builtin the PIC microcontroller through programming
CO4 Ability to grasp the interfacing concepts involving in the design of microcontroller based systems.
TEXTBOOKS:

REFERENCES:

PE5072 ADVANCED POWER CONVERTERS  L T P C
3 0 0 3

COURSE OBJECTIVES:
- To study the operation of voltage lift circuits
- To study the operation of super lift circuits
- To study the operation of ultra lift converters and multiple quadrant converters
- To study the principle of bidirectional dual active bridge converters
- To study the working principle of impedance source converter.

UNIT I VOLTAGE-LIFT CONVERTERS 9
Introduction- Self-lift and reverse self-lift circuits- Cuk converter, Luo converter and SEPIC converters- continuous and discontinuous conduction mode.

UNIT II POSITIVE OUTPUT & NEGATIVE OUTPUT SUPER-LIFT LUO-CONVERTERS 9
Main series- Elementary Circuit, Re-Lift Circuit, Triple-Lift Circuit, Higher-Order Lift Circuit-. Continuous conduction and discontinuous conduction mode.

UNIT III ULTRA LIFT CONVERTERS AND MULTIPLE-QUADRANT OPERATING LUO-CONVERTERS 9
Ultra-Lift Luo- Converter- Operation - Continuous conduction and discontinuous conduction Mode and of Ultra-Lift Luo-Converter-Instantaneous Values- Multiple quadrant operating Luo Converters- Circuit explanations-modes of operation

UNIT IV BIDIRECTIONAL DUAL ACTIVE BRIDGE DC–DC CONVERTERS 9
Application of Bidirectional DC–DC Converter-Classification of Bidirectional DC–DC Converter -Working Principle of Hybrid-Bridge-Based Dual active bridge (DAB) converter-Performance- Voltage match control- Principle of Dual-Transformer based DAB converter-Three-Level bidirectional DC–DC converter

UNIT V IMPEDANCE SOURCE CONVERTER 9
TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1 Ability to understand the working of voltage lift circuits.
CO2 Ability to design super lift converters
CO3 Ability to design ultra-lift converters
CO4 Ability to understand the working and design of bi-directional DC-DC converters
CO5 Ability to understand the concepts related with impedance source converter

TEXT BOOKS:
1. Advanced DC/DC Converters, 2nd Edition, Fang Lin Luo, Hong Ye, CRC press, 2018
3. High-Frequency Isolated Bidirectional Dual Active Bridge DC-DC Converters with Wide Voltage Gain, Deshang Sha, Guo Xu, Springer 2019.

REFERENCES:
1. Essential DC/DC Converters, 1st Edition, Fang Lin Luo, Hong Ye, CRC, 2005

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PE5073 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

COURSE OBJECTIVES:
• To provide knowledge about the stand alone and grid connected renewable energy systems.
• To equip with required skills to derive the criteria for the design of power converters for renewable energy applications.
• To analyse and comprehend the various operating modes of wind electrical generators and solar energy systems.
• To design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.
• To develop maximum power point tracking algorithms.

UNIT I INTRODUCTION
Introduction to renewable energy systems, environmental aspects of electric energy conversion, impacts of renewable energy generation on environment, GHG Effect, Qualitative study of different renewable energy resources Ocean, Biomass, Hydrogen
energy systems and Fuel cells.

UNIT II POWER ELECTRONIC CONVERTERS FOR RENEWABLE ENERGY 9
Solar: Block diagram of solar photo voltaic system: line commutated converters (inversion mode) - Boost and buck-boost converters.
Wind: three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters.

UNIT III PHOTO VOLTAIC ENERGY CONVERSION SYSTEMS 9
Introduction, Photo Voltaic (PV) effect, Solar Cell, Types, Equivalent circuit of PV cell, PV cell characteristics (I/V and P/V) for variation of insolation, temperature and shading effect, Stand-alone PV system, Grid connected PV system, Design of PV system-load calculation, array sizing, selection of converter/inverter, battery sizing.

UNIT IV WIND ENERGY CONVERSION SYSTEMS 9
Introduction, Power contained in wind, Efficiency limit in wind, types of wind turbines, Wind control strategies, Power curve and Operating area, Types of wind generators system based on Electrical machines-Induction Generator and Permanent Magnet Synchronous Generator(PMSG), Grid Connected-Single and Double output system, Self-excited operation of Induction Generator and Variable Speed PMSG.

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS AND MPPT 9
Energy Storage systems, Need for Hybrid Systems, Features of Hybrid Systems, Range and types of Hybrid systems (Wind-Diesel, PV-Diesel and Wind-PV), Case studies of PV-Maximum Power Point Tracking (MPPT) and Wind Energy system

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Ability to understand different renewable energy systems
CO2 Ability to design and simulate power electronics converters used for interfacing Renewable energy systems
CO3 Ability to design standalone renewable energy system employing embedded energy storage and MPPT strategy.
CO4 Ability to design grid connected renewable energy system.
CO5 Ability to extract maximum power using different MPPT algorithms

TEXTBOOKS:

REFERENCES:
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 mitigation techniques using custom power devices such as DVR & UPQC

UNIT I   INTRODUCTION
Introduction – Characterisation 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

UNIT III  CONVENTIONAL LOAD COMPENSATION METHODS

UNIT IV   LOAD COMPENSATION USING DSTATCOM
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


TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Ability to understand consequences of Power quality issues.
CO2 Ability to conduct harmonic analysis of single phase and three phase systems supplying nonlinear loads.
CO3 Ability to design passive filter for load compensation.
CO4 Ability to design active filters for load compensation.
CO5 Ability to understand the mitigation techniques using custom power devices such as distribution static compensator (DSTATCOM), dynamic voltage restorer (DVR)& UPQC.

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1. Power Quality - R.C.Duggan
2. Power system harmonics – A.J. Arrillaga
3. Power Electronic Converter Harmonics – Derek A. Paice

PW5071  ELECTRIC VEHICLES AND POWER MANAGEMENT  LT P C
3 0 0 3

COURSE OBJECTIVES:

- To provide knowledge about electric vehicle architecture and power train components.
- To know the concepts of dynamics of electrical vehicles
- To impart knowledge on vehicle control for standard drive cycles of hybrid electrical vehicles (HEVs)
- To understand the concept of energy storage systems.
- To provide knowledge about different energy sources and energy management in HEVs.

UNIT I  HYBRID ELECTRIC VEHICLE ARCHITECTURE AND POWER TRAIN COMPONENTS  9

UNIT II MECHANICS OF HYBRID ELECTRIC VEHICLES
Fundamentals of vehicle mechanics - tractive force, power and energy requirements for standard drive cycles of HEV's - motor torque and power rating and battery capacity.

UNIT III CONTROL OF DC AND AC MOTOR DRIVES
Speed control for constant torque, constant HP operation of all electric motors - DC/DC chopper based four quadrant operation of DC motor drives, inverter based V/f Operation (motoring and braking) of induction motor drives, vector control operation of Induction motor and PMSM, Brushless DC motor drives, Switched reluctance motor (SRM) drives

UNIT IV ENERGY STORAGE SYSTEMS

UNIT V HYBRID VEHICLE CONTROL STRATEGY AND ENERGY MANAGEMENT
HEV supervisory control - Selection of modes - power spilt mode - parallel mode - engine brake mode - regeneration mode - series parallel mode - energy management of HEV's.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1: Learned the electric vehicle architecture and power train components.
CO2: Acquired the concepts of dynamics of electrical vehicles
CO3: Able to understand the vehicle control for standard drive cycles of hybrid electrical vehicles (HEVs).
CO4: Ability to design and select energy storage systems.
CO5: Acquired the knowledge of different energy sources and energy management in HEVs.

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PW5074 ENERGY STORAGE TECHNOLOGIES LT P C 3 0 0 3

COURSE OBJECTIVES:
- To understand the various types of energy storage Technologies.
- To analyze thermal storage system.
- To analyze different battery storage technologies
- To analyze the thermodynamics of Fuel Cell
To study the various applications of energy storage systems.

UNIT I INTRODUCTION
Necessity of energy storage – types of energy storage – comparison of energy storage technologies – Applications.

UNIT II THERMAL STORAGE SYSTEM
Thermal storage – Types – Modeling of thermal storage units – Simple water and rock bed storage system – pressurized water storage system – Modelling of phase change storage system – Simple units, packed bed storage units - Modelling using porous medium approach, Use of TRNSYS.

UNIT III ELECTRICAL ENERGY STORAGE
Fundamental concept of batteries – measuring of battery performance, charging and is charging of a battery, storage density, energy density, and safety issues. Types of batteries – Lead Acid, nickel – Cadmium, Zinc Manganese dioxide - Mathematical Modelling for Lead Acid Batteries – Flow Batteries.

UNIT IV FUEL CELL

UNIT V ALTERNATE ENERGY STORAGE TECHNOLOGIES

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1: Gained knowledge of various storage technologies.
CO2: Able to design a thermal storage system.
CO3: Ability to model battery storage system.
CO4: Learned to analyze the thermodynamics of fuel cell.
CO5: Gained Knowledge of various applications of storage technologies and perform the selection based on techno-economic view point.

REFERENCES
COURSE OBJECTIVES:
- To study about the integration of various renewable energy sources into the grid.
- To analyse various grid issues due to renewable energy sources.
- To analyse the dynamics of network due to wind farm
- To provide knowledge about power system stabilizers.
- To provide knowledge about grid connected and standalone PV system

UNIT I INTRODUCTION
Introduction to renewable energy grid integration - Concept of mini/micro grids and Smart grids - Different types of grid interfaces - Issues related to grid integration of small and large scale of synchronous generator based - induction generator based and converter based sources together - Network voltage management - Power quality management (voltage dips, harmonics, flickers, and reactive power control) - Frequency management - Influence of WECS on system transient response - Interconnection standards and grid code requirements for integration.

UNIT II NETWORK INFLUENCE OF GENERATION TYPE
- Network voltage management
- Thermal/Active power management
- Network power quality management
- Transient system performance
- Fault level issues
- Protection

UNIT III INFLUENCE OF WIND FARMS ON NETWORK DYNAMIC PERFORMANCE

UNIT IV POWER SYSTEM STABILIZERS AND NETWORK DAMPING CAPABILITY OF WIND
A Power System Stabilizer for a Synchronous Generator - A Power System Stabilizer for a DFIG - A Power System Stabilizer for a FRC Wind Farm.

UNIT V STAND ALONE AND GRID CONNECTED PV SYSTEM

COURSE OUTCOMES:
CO1: Know about the integration of various renewable energy sources into the grid.
CO2: Able to analyze various grid issues due to renewable energy sources.
CO3: Able to analyze the dynamics of network due to windfarm
CO4: Know about power system stabilizers.
CO5: Able to design the grid connected and standalone PV system.

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TOTAL: 45 PERIODS
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PW5076 MICRO-GRID OPERATION AND CONTROL LT P C 3 0 0 3

COURSE OBJECTIVES:
- To illustrate the concept of micro sources and storage.
- To study concept of AC microgrid and its controllers.
- To study concept of DC microgrid and its controllers.
- To study concept of hybrid microgrid and its controllers.
- To study concept of islanding and impact on protection.

UNIT I MICRO SOURCES AND STORAGE

UNIT II AC MICROGRID
Hierarchical Control: Primary, Secondary and Tertiary Control – Primary Control: Droop Control, Virtual Synchronous Generator Control for VSC – Secondary Control – Simulation Studies

UNIT III DC MICROGRID
Hierarchical Control: Primary, Secondary and Tertiary Control – Primary Control: Droop Control, Virtual Inertia Control – Secondary Control: Centralized and Decentralized Control – Simulation Studies

UNIT IV HYBRID MICROGRID
Hybrid AC/DC Microgrid Structure: AC Coupled, DC Coupled, AC-DC Coupled – Control Strategies: different modes of operation, during transition – Simulation Studies

UNIT V MICROGRID PROTECTION

COURSE OUTCOMES:
CO1: Ability to analyze micro-sources and storage systems.
CO2: Able to analyse the configurations and control aspects of AC microgrid.
CO3: Understand and analyse the configurations and control aspects of DC microgrid.
CO4: Acquired knowledge about configurations and control aspects of Hybrid microgrid.
CO5: Learned the protection aspects of microgrid.

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PW5077 RENEWABLE ENERGY TECHNOLOGY  LT P C 3 0 0 3

COURSE OBJECTIVES
- To Provide knowledge about various renewable energy technologies
- To enable students to understand and design a PV system.
- To provide knowledge about wind energy system.
- To Provide knowledge about various possible hybrid energy systems
- To gain knowledge about application of various renewable energy technologies

UNIT I INTRODUCTION
9
Primary energy sources, renewable vs. non-renewable primary energy sources, renewable energy resources in India, Current usage of renewable energy sources in India, future potential of renewable energy in power production and development of renewable energy technologies.

UNITII SOLAR ENERGY
9

UNIT III WIND ENERGY
9
Wind energy principles, wind site and its resource assessment, wind assessment, Factors
influencing wind, wind turbine components, wind energy conversion systems (WECS), Classification of WECS devices, wind electric generating and control systems, characteristics and applications. Hybrid systems - safety and environmental aspects, economic aspects.

UNIT IV BIO-ENERGY

UNIT V OTHER TYPES OF ENERGY
Energy conversion from Hydrogen and Fuel cells, Geo thermal energy Resources, types of wells, methods of harnessing the energy, potential in India. OTEC, Principles utilization, setting of OTEC plants, thermodynamic cycles. Tidal and wave energy: Potential and conversion techniques, mini-hydel power plants and their economics.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Attained knowledge about various renewable energy technologies
CO2: Ability to understand and design a PV system.
CO3: Understand the concept of various wind energy system.
CO4: Gained knowledge about various possible hybrid energy systems
CO5: Attained knowledge about various application of renewable energy technologies

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2. Tiwari and Ghosal/ Narosa, ‘Renewable energy resources’.
PS5251  
HVDC AND FACTS  

COURSE OBJECTIVES

- To impart knowledge on the need for HVDC and FACTS.
- To impart in-depth knowledge on the operation, modelling and control of thyristor based FACTS controllers.
- To have an in-depth knowledge on the operation, modelling and control of LCC based HVDC link.
- To have an in-depth knowledge on the operation, modelling and control of VSC based HVDC link and FACTS controllers.
- To analyze the interaction of AC-DC systems through Power flow analysis.

UNIT I  INTRODUCTION

Review of basics of power transmission networks-control of power flow in AC transmission line- Analysis of uncompensated AC Transmission line- 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- Review of basics of LCC and VSC HVDC system.

UNIT II  THYRISTOR BASED FACTS


UNIT III  ANALYSIS OF LCC HVDC CONVERTERS AND HVDC SYSTEM CONTROL


UNIT IV  VOLTAGE SOURCE CONVERTER BASED FACTS AND HVDC CONTROLLERS

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 Unified and Interline power flow controllers (UPFC) - Modelling of UPFC and IPFC for power flow and transient stability studies- ApplicationsVSC based HVDC: Operation, Modelling for steady state and dynamic studies.

UNIT V  POWER FLOW ANALYSIS OF AC/DC SYSTEMS

Per unit system for DC Quantities - Modelling of DC links - Solution of DC load flow-Solution of AC-DC power flow:Sequential and Simultaneous methods.

TOTAL: 60 PERIODS

COURSE OUTCOMES

Students will be able to:

CO1: Understand the basics of power transmission networks and need for HVDC and FACTS controllers.
CO2: Analyze the operation, control and application of thyristor based FACTS controllers.
CO3: Analyze the operation, control and application of LCC based HVDC link.
CO4: Analyze the operation, control and application of VSC based HVDC link.
CO5: Model HVDC and FACTS for Power Flow studies.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025
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### COURSE OBJECTIVES

Students will be able to:
- Understand concept of smart grid and its advantages over conventional grid
- Know smart metering techniques
- Learn wide area measurement techniques
- Understanding the problems associated with integration of distributed generation & its solution through smart grid.
- To familiarize the high performance computing for Smart Grid applications

### UNIT I  INTRODUCTION TO SMART GRID

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, Functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, National and International Initiatives in Smart Grid.

### UNIT II  SMART GRID TECHNOLOGIES (Transmission)

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control
UNIT III       SMART GRID TECHNOLOGIES (Distribution)  9
DMS, Volt/VAr control, Fault Detection, Isolation and service restoration, Outage management,
High-Efficiency Distribution Transformers, Phase Shifting Transformers, and Plug in Hybrid Electric
Vehicles (PHEV).

UNIT IV       SMART METERS AND ADVANCED METERING INFRASTRUCTURE  9
Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI
protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit
(PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection.

UNIT V       HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS  9
Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband
over Power line (BPL), IP based Protocols, Computing algorithms for Smart grid, IOT, Cyber
Security for Smart Grid.

TOTAL: 45 PERIODS

COURSE OUTCOMES
Students will be able to:
CO1: Understand on the concepts of Smart Grid and its present developments.
CO2: Analyze about different Smart Grid transmission technologies.
CO3: Analyze about different Smart Grid distribution technologies.
CO4: Acquire knowledge about different smart meters and advanced metering infrastructure.
CO5: Develop more understanding on LAN, WAN and Cloud Computing for Smart Grid applications.

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PS5076       WIND ENERGY CONVERSION SYSTEM       LT P C
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COURSE OBJECTIVES
- To learn about the basic concepts of wind energy conversion system
- To learn the design and control principles of Wind turbine.
- To understand the concepts of fixed speed wind energy conversion systems.
- To understand the concepts of Variable speed wind energy conversion
systems.
- To analyze the grid integration issues.

UNIT I  INTRODUCTION
Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin’s theory-Aerodynamics of Wind turbine

UNIT II  WINDTURBINES
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-Schemes for maximum power extraction.

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

UNIT IV  VARIABLESPEED SYSTEMS
Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modelling -Variable speed variable frequency schemes.

UNIT V  GRIDCONNECTED SYSTEMS
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.

COURSE OUTCOMES
Students will be able to:
CO1: Attain knowledge on the basic concepts of Wind energy conversion system.
CO2: Attain the knowledge of the mathematical modelling and control of the Wind turbine
CO3: Develop more understanding on the design of Fixed speed system
CO4: Study about the need of Variable speed system and its modelling.
CO5: Learn about Grid integration issues and current practices of wind interconnections with power system.

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5. N. Jenkins,‘’ Wind Energy Technology” John Wiley &Sons, 1997

PS5073 DISTRIBUTED GENERATION CONTROL AND AUTOMATION

COURSE OBJECTIVES
Students will be able to:
- learn about distributed generation (DG) and distribution automation
- gain knowledge about planning and designing of distribution system
- understand the concepts of grid integration and control of DG
- familiarize the concepts of economic aspects of DG
- analyze the application of SCADA in automation

UNIT I DISTRIBUTED GENERATION

UNIT II GRID INTEGRATION AND CONTROL OF DG
Recent trends in power electronic DG interconnection. General power electronic DG interconnection topologies for various sources and control. Control of DG inverters, current control and DC voltage control for stand-alone and grid parallel operations. Protection of the converter, Control of grid interactive power converters, phase locked loops, synchronization and phase locking techniques, current control, DC bus control during grid faults, converter faults during grid parallel and stand-alone operation.

UNIT III ISSUES AND ECONOMIC ASPECTS OF DG

UNIT IV IMPLEMENTATION OF SCADA IN AUTOMATION
Introduction to SCADA, Monitoring and supervisory functions, SCADA applications in Utility Automation, SCADA System Components, RTU, IED, PLC, Communication Network, SCADA Server, SCADA/HMI Systems, Various SCADA architectures, single unified standard architecture- IEC 61850, SCADA Communication, open standard communication protocols.

UNIT V DISTRIBUTION AUTOMATION AND COMPONENTS
Distribution automation planning, communication, Wireless and wired Communications-DA Communication Protocols, Architectures and user interface, sensors, Supervisory Control and Data Acquisition Systems (SCADA), Case Studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Students will be able to:
CO1: describe the principle and operation of different distributed generation
CO2: Attain knowledge in grid integration of distributed generation and control and will enhance their capability of planning and designing of distribution system.
CO3: analyze the impact of distributed generators on the performance of distribution system
CO4: gain knowledge about SCADA in automation
CO5: familiarize with the components of distribution automation

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PS5074

OPTIMISATION TECHNIQUES

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COURSE OBJECTIVES
Students will be able to:
- understand the classification of optimization
- study the linear programming models and solution techniques
- study the different non-linear programming problem solution techniques
- understand the concept of dynamic programming
- study the fundamentals genetic algorithm and its applications.

UNIT I
INTRODUCTION
Definition, Classification of optimization problems, Classical Optimization Techniques, Single and Multiple Optimization with and without inequality constraints.

UNIT II
LINEAR PROGRAMMING (LP)
Simplex method of solving LPP, revised simplex method, duality, Constrained optimization, Theorems and procedure, Linear programming, mathematical model, solution technique, duality.

UNIT III
NON LINEAR PROGRAMMING
UNITIV DYNAMIC PROGRAMMING (DP) 9
Multistage decision processes, concept of sub-optimization and principle of optimality, Recursive relations, Integer Linear programming, Branch and bound algorithm

UNITV GENETIC ALGORITHM 9
Introduction to genetic Algorithm, working principle, coding of variables, fitness function, GA operators; Similarities and differences between Gas and traditional methods; Unconstrained and constrained optimization using genetic Algorithm, real coded gas, Advanced Gas, global optimization using GA, Applications to power system.

TOTAL: 45 PERIODS

COURSE OUTCOMES
Students will be able to:
CO1:learn about different classifications of optimization problems and techniques.
CO2:attain knowledge on linear programming concepts
CO3:understand the application of non-linear programming in optimization techniques
CO4:understand the fundamental concepts of dynamic programming
CO5:gain knowledge about Genetic algorithm and its application to power system optimization.

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REFERENCE BOOKS

CO5152 INTELLIGENT CONTROLLERS L T P C
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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.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025
UNIT I  OVERVIEW OF ARTIFICIAL NEURAL NETWORK (ANN) & FUZZY LOGIC

UNIT II  NEURAL NETWORKS FOR MODELLING AND CONTROL
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

UNIT IV  GENETIC ALGORITHM
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
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

COURSE OUTCOMES:
Ability to
CO1: Understand the basic architectures of NN and Fuzzy sets
CO2: Design and implement ANN architectures, algorithms and know their limitations.
CO3: Identify and work with different operations on the fuzzy sets.
CO4: Develop ANN and fuzzy logic based models and control schemes for non-linear systems.
CO5: Understand and explore hybrid control schemes and PSO

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COURSE OBJECTIVES
- To analyse the properties of materials, microstructure and fabrication methods.
- To design and modeling of Electrostatic sensors and actuators.
- To teach the characterizing thermal sensors and actuators through design and modeling.
- To understand 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 – 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

UNIT III THERMAL SENSING AND ACTUATION  9
Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applications.

UNIT IV PIEZOELECTRIC SENSING AND ACTUATION  9
Piezoelectric effect-cantilever piezo electric actuator model-properties of piezoelectric materials Applications.

UNIT V CASE STUDIES  9
Piezoresistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.-NEMS Devices

TOTAL : 45 PERIODS

COURSE OUTCOMES:
At the end of this course, the students will demonstrate the ability
CO1: To analyse the learning process to design of micro sensors, embedded sensors & actuators
CO2: To analyse the electrostatic sensors and actuators through MEMS and NEMS devices
CO3: To analyse the thermal sensors and actuators through MEMS and NEMS devices
CO4: To analyse the piezoelectric sensors and actuators through MEMS and NEMS
CO5: Design of piezoresistive sensors for biomedical and micro fluidic applications

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Director
REFERENCES
4. M.H.Bao “Micromechanical transducers: Pressure sensors, accelerometers and gyroscopes”,

CO5151 CONTROL SYSTEM DESIGN

COURSE OBJECTIVES
To educate the students on
- Analysis and design of controllers for linear systems defined in transfer function and state space from.
- Application of optimal control and filtering concepts for linear systems continuous and discrete domain.

UNIT I ANALYSIS OF LINEAR SYSTEMS

UNIT II DESIGN OF SISO SYSTEM
Design Specifications –In continuous domain – Limitations – Controller Structure – Multiple degrees of freedom – PID controllers and Lag-lead compensators- Design – Discretization and direct discrete design - Design in continuous and discrete domain

UNIT III STATE SPACE DESIGN

UNIT IV OPTIMAL CONTROL
Introduction: Classical control and optimization, formulation of optimal control problem,

UNIT V OPTIMAL FILTERING
Filtering – Linear system and estimation – System noise smoothing and prediction – Kalman Filter –Recursive estimation.

TOTAL: 60 PERIODS

COURSE OUTCOMES:
Ability to
CO1: Analyse controllers for linear systems defined in transfer function and state space forms.
CO2: Design controllers for linear systems defined in transfer function and state space forms.
CO3: Apply state space forms to continuous and discrete systems.
CO4: Apply optimal control to linear systems in continuous and discrete systems
CO5: Apply filtering concepts to linear systems in continuous and discrete systems.
TEXT BOOKS:

REFERENCES:

CO5075 SYSTEM THEORY

COURSE OBJECTIVES
- To educate on modeling and representing systems in state variable form.
- To educate on solving linear and non-linear state equations.
- To illustrate the role of 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 equation for Dynamic Systems - Time invariance and linearity- Non uniqueness of state model-State Diagrams - Physical System and State Assignment.

UNIT II SOLUTION OF STATE EQUATIONS  9
UNIT III CONTROLLABILITY AND OBSERVABILITY
Controllability and Observability - Stabilizability and Detectability-Test for Continuous time Systems- Time varying and Time invariant case-Output Controllability-Reducibility-System Realizations.

UNIT IV STABILITY

UNIT V MODAL CONTROL
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.

COURSE OUTCOMES
CO1: To understand the concept of State-State equation for Dynamic Systems and the uniqueness of state model.
CO2: To understand the concept of the uniqueness of state model.
CO3: Analyse Controllability and Observability for Time varying and Time invariant case
CO4: Analyse the linear systems in state space
CO5: Design controllers in state space

REFERENCES:
COURSE OBJECTIVES
- To introduce various model structures for system identification.
- To impart knowledge on parametric and non-parametric identification.
- To introduce non-linear identification techniques.
- To introduce the concept of adaptation techniques and control.
- To illustrate the identification and adaptive control techniques through case studies.

UNIT I Models for Identification 9

UNIT II Non-parametric and Parametric Identification 9

UNIT III Non-linear Identification 9

UNIT IV Adaptive Control and Adaptation Techniques 9

UNIT V Case Studies 9
Inverted Pendulum, Robot arm, process control application: heat exchanger, Distillation column, application to power system, Ship steering control.

TOTAL : 45 PERIODS

COURSE OUTCOMES
Ability to
CO1: model LTI system and to analyse the Non-linear state-space model of a black box.
CO2: analyse frequency, spectral, correlation and transient response of a system.
CO3: Identify the Open & closed Loop of a Non-linear system by Neural network and Fuzzy Logic controller.
CO4: Realize different tuning parameters for adaptive control and adaptive technique.
CO5: Apply different control techniques to various applications

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3. Astrom and Wittenmark,” Adaptive Control “, PHI

HV5151 ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING LT P C 3 0 0 3

COURSE OBJECTIVES:
- To refresh the fundamentals of Electromagnetic Field Theory
- To provide foundation in formulation and computation of Electromagnetic Fields using analytical and numerical methods.
- To impart knowledge in fundamentals of FEM
- To compute and analyze the field quantities using FEM
- To formulate, solve, analyze and optimize the design of electrical components

UNIT I INTRODUCTION
Review of basic field theory – Maxwell’s equations – Constitutive relationships and Continuity equations – Laplace, Poisson and Helmholtz equation – principle of energy conversion – force/torque calculation

UNIT II BASIC SOLUTION METHODS FOR FIELD EQUATIONS
Limitations of the conventional design procedure, need for the field analysis based design, problem definition, boundary conditions, solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods- Finite Difference Method.

UNIT III FORMULATION OF FINITE ELEMENT METHOD (FEM)
Variational Formulation – Energy minimization – Discretisation – Shape functions –Stiffness matrix –1D and 2D planar and axial symmetry problems

UNIT IV COMPUTATION OF BASIC QUANTITIES USING FEM PACKAGES

UNIT V DESIGN APPLICATIONS

L=45: T=0, TOTAL = 45 PERIODS

COURSE OUTCOMES:
CO1 Ability to understand the field theory concepts
CO2 Ability to formulate and compute Electromagnetic Fields from Maxwell’s equations.
CO3 Ability to formulate FEM problems from the fundamental concepts
CO4 Ability to compute the respective field using FEM (post processing)
CO5 Ability to check and optimize the design of electrical power equipment
REFERENCES


ET5071 ADVANCED DIGITAL SIGNAL PROCESSING LT P C 3 0 0 3

COURSE OBJECTIVES:

- To expose the fundamentals of digital signal processing in frequency domain & its application
- To teach the fundamentals of digital signal processing in time-frequency domain & its application
- To teach the fundamentals of audio signal processing & its application
- To discuss on Application development with commercial family of DS Processors
- To involve Discussions/ Practice/ Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT I INTRODUCTION TO DIGITAL SIGNAL PROCESSING 6
Introduction to Digital Signal Processing System - Discrete Time Sequences - Time-Invariant & Time-variant Systems, Decimation and Interpolation - The Sampling Process - Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT) - Basics of Digital Filters - FIR Filters, IIR Filters - adaptive filter based on LMS.

UNIT II WAVELET TRANSFORM 9
Introduction to continuous wavelet transform - discrete wavelet transform - orthogonal wavelet decomposition - Multiresolution Analysis - Wavelet function-DWT, bases, orthogonal Basis- Scaling function, Wavelet coefficients - Multirate signal processing and their relationship to filter banks - Digital filtering interpolation (i) Decomposition filters, (ii) reconstruction, the signal- Example MRA-Haar & Daubechies wavelet.

UNIT III AUDIO SIGNAL PROCESSING 12
Introduction to Speech and Audio Processing - Speech Signal Processing - Pitch-period estimation, all-pole and all-zero filters - convolution - autoregressive model, autocorrelation estimation, General structure of speech coders; Requirements of speech codecs - quality, LPC model of speech production - LPC encoders and decoders - Power spectral density, periodogram, Spectral measures of audio signal.

UNIT IV ARCHITECTURES OF COMMERCIAL DIGITAL SIGNAL PROCESSORS 12
Introduction, categorisation of DSP Processors - one case example Architecture Processor for Fixed Point (Blackfin), Floating Point & Speech Processor - Basics of Architecture – study of functional variations of Computational building blocks (with comparison onto their MAC, Bus Architecture, I/O interface, application).
UNIT V IMPLEMENTATION OF DSP BASED SYSTEMS

Introduction - Interfacing processor- Memory Interface-I/O Interface-Mapping of DSP algorithm onto hardware -Design of Filter-FFT Algorithm- Application with DSP based Interfacing- Power Meter; DSP as motor control

NOTE: Discussions/Miniproject/Practice on Workbench : Signal analysis transforms, Filter design concepts with simulation tools as Matlab /Labview/ VLSI/CCS/other suites to understand the commercial DSP processor technology and practice in programming.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1: The concepts of Time and frequency analysis of Signal Transforms based on signal types.
CO2: The fundamentals of Time-Frequency Transforms are introduced
CO3: Analyze the quality and properties of speech based on DSP
CO4: Study features through comparison on commercial available DSProcessors
CO5: Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in signal processing for embedded systems design.

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OBJECTIVES:
- To understand the basics of business analytics and its life cycle.
- To gain knowledge about fundamental business analytics.
- To learn modeling for uncertainty and statistical inference.
- To understand analytics using Hadoop and Map Reduce frameworks.
- To acquire insight on other analytical frameworks.

UNIT I  OVERVIEW OF BUSINESS ANALYTICS  9

Suggested Activities:
- Case studies on applications involving business analytics.
- Converting real time decision making problems into hypothesis.
- Group discussion on entrepreneurial opportunities in Business Analytics.

Suggested Evaluation Methods:
- Assignment on business scenario and business analytical life cycle process.
- Group presentation on big data applications with societal need.
- Quiz on case studies.

UNIT II  ESSENTIALS OF BUSINESS ANALYTICS  9

Suggested Activities:
- Solve numerical problems on basic statistics.
- Explore chart wizard in MS Excel Case using sample real time data for data visualization.
- Use R tool for data visualization.

Suggested Evaluation Methods:
- Assignment on descriptive analytics using benchmark data.
- Quiz on data visualization for univariate, bivariate data.

UNIT III  MODELING UNCERTAINTY AND STATISTICAL INFERENCE  9
Suggested Activities:
- Solving numerical problems in sampling, probability, probability distributions and hypothesis testing.
- Converting real time decision making problems into hypothesis.

Suggested Evaluation Methods:
- Assignments on hypothesis testing.
- Group presentation on real time applications involving data sampling and hypothesis testing.
- Quizzes on topics like sampling and probability.

UNIT IV      ANALYTICS USING HADOOP AND MAPREDUCE FRAMEWORK

Suggested Activities:
- Practical – Install and configure Hadoop.
- Practical – Use web based tools to monitor Hadoop setup.
- Practical – Design and develop MapReduce tasks for word count, searching involving text corpus etc.

Suggested Evaluation Methods:
- Evaluation of the practical implementations.
- Quizzes on topics like HDFS and extensions to MapReduce.

UNIT V      OTHER DATA ANALYTICAL FRAMEWORKS

Suggested Activities:
- Practical – Installation of NoSQL database like MongoDB.
- Practical – Demonstration on Sharding in MongoDB.
- Practical – Install and run Pig
- Practical – Write PigLatin scripts to sort, group, join, project, and filter data.
- Design and develop algorithms to be executed in MapReduce involving numerical methods for analytics.

Suggested Evaluation Methods:
- Mini Project (Group) – Real time data collection, saving in NoSQL, implement analytical techniques using Map-Reduce Tasks and Result Projection.

TOTAL: 45 PERIODS

OUTCOMES:
On completion of the course, the student will be able to:
- Identify the real world business problems and model with analytical solutions.
- Solve analytical problem with relevant mathematics background knowledge.
- Convert any real world decision making problem to hypothesis and apply suitable statistical testing.
- Write and Demonstrate simple applications involving analytics using Hadoop and MapReduce
- Use open source frameworks for modeling and storing data.
- Apply suitable visualization technique using R for visualizing voluminous data.
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OE5092 INDUSTRIAL SAFETY LT P C 3 0 0 3

OBJECTIVES:
- Summarize basics of industrial safety
- Describe fundamentals of maintenance engineering
- Explain wear and corrosion
- Illustrate fault tracing
- Identify preventive and periodic maintenance

UNIT I INTRODUCTION 9
Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT II FUNDAMENTALS OF MAINTENANCE ENGINEERING 9
Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.
UNIT III WEAR AND CORROSION AND THEIR PREVENTION


UNIT IV FAULT TRACING

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, i. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT V PERIODIC AND PREVENTIVE MAINTENANCE

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

OUTCOMES:

CO1: Ability to summarize basics of industrial safety
CO2: Ability to describe fundamentals of maintenance engineering
CO3: Ability to explain wear and corrosion
CO4: Ability to illustrate fault tracing
CO5: Ability to identify preventive and periodic maintenance

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REFERENCES:


OE5093 OPERATIONS RESEARCH

OBJECTIVES:

- Solve linear programming problem and solve using graphical method.
- Solve LPP using simplex method
- Solve transportation , assignment problems
- Solve project management problems
- Solve scheduling problems
UNIT I  LINEAR PROGRAMMING  
Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

UNIT II  ADVANCES IN LINEAR PROGRAMMING  
Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis

UNIT III  NETWORK ANALYSIS – I  
Transportation problems -Northwest corner rule, least cost method,Voges’s approximation method - Assignment problem -Hungarian algorithm

UNIT IV  NETWORK ANALYSIS – II  
Shortest path problem: Dijkstra’s algorithms, Floyd’s algorithm, systematic method -CPM/PERT

UNIT V  NETWORK ANALYSIS – III  
Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models

TOTAL: 45 PERIODS

OUTCOMES:
CO1: To formulate linear programming problem and solve using graphical method.
CO2: To solve LPP using simplex method
CO3: To formulate and solve transportation, assignment problems
CO4: To solve project management problems
CO5: To solve scheduling problems

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OE5094  COST MANAGEMENT OF ENGINEERING PROJECTS  
L T P C  3 0 0 3

OBJECTIVES:
- Summarize the costing concepts and their role in decision making
- Infer the project management concepts and their various aspects in selection
- Interpret costing concepts with project execution
- Develop knowledge of costing techniques in service sector and various budgetary control techniques
- Illustrate with quantitative techniques in cost management
UNIT I  INTRODUCTION TO COSTING CONCEPTS  9
Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.

UNIT II  INTRODUCTION TO PROJECT MANAGEMENT  9
Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member, Importance Project site: Data required with significance, Project contracts.

UNIT III  PROJECT EXECUTION AND COSTING CONCEPTS  9
Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

UNIT IV  COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL  9
Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.

UNIT V  QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT  9
Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

TOTAL: 45 PERIODS

OUTCOMES
CO1 – Understand the costing concepts and their role in decision making
CO2 – Understand the project management concepts and their various aspects in selection
CO3 – Interpret costing concepts with project execution
CO4 – Gain knowledge of costing techniques in service sector and various budgetary control techniques
CO5 – Become familiar with quantitative techniques in cost management

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REFERENCES:
2. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988
OBJECTIVES:
• Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
• Identify the various reinforcements used in composite materials.
• Compare the manufacturing process of metal matrix composites.
• Understand the manufacturing processes of polymer matrix composites.
• Analyze the strength of composite materials.

UNIT I INTRODUCTION
Definition – Classification and characteristics of Composite materials - Advantages and application of composites - Functional requirements of reinforcement and matrix - Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II REINFORCEMENTS
Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers - Properties and applications of whiskers, particle reinforcements - Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures - Isostrain and Isostress conditions.

UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES

UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITES

UNIT V STRENGTH
Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first ply failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TOTAL: 45 PERIODS

OUTCOMES:
• CO1 - Know the characteristics of composite materials and effect of reinforcement in composite materials.
• CO2 – Know the various reinforcements used in composite materials.
• CO3 – Understand the manufacturing processes of metal matrix composites.
• CO4 – Understand the manufacturing processes of polymer matrix composites.
• CO5 – Analyze the strength of composite materials.
REFERENCES:

OE5096 WASTE TO ENERGY L T P C
3 0 0 3

OBJECTIVES:
- Interpret the various types of wastes from which energy can be generated
- Develop knowledge on biomass pyrolysis process and its applications
- Develop knowledge on various types of biomass gasifiers and their operations
- Invent knowledge on biomass combustors and its applications on generating energy
- Summarize the principles of bio-energy systems and their features

UNIT I INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE
Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNIT II BIOMASS PYROLYSIS
Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT III BIOMASS GASIFICATION

UNIT IV BIOMASS COMBUSTION
Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNIT V BIO ENERGY
Properties of biogas (Calorific value and composition), Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production -Urban waste to energy conversion - Biomass energy programme in India.

TOTAL: 45 PERIODS

OUTCOMES:
CO1 – Understand the various types of wastes from which energy can be generated
CO2 – Gain knowledge on biomass pyrolysis process and its applications
CO3 – Develop knowledge on various types of biomass gasifiers and their operations
CO4 – Gain knowledge on biomass combustors and its applications on generating energy
CO5 – Understand the principles of bio-energy systems and their features
REFERENCES:

AUDIT COURSES (AC)

AX5091 ENGLISH FOR RESEARCH PAPER WRITING L T P C 2 0 0 0

OBJECTIVES
- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNIT I INTRODUCTION TO RESEARCH PAPER WRITING 6
Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT II PRESENTATION SKILLS 6

UNIT III TITLE WRITING SKILLS 6
Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS 6
Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT V VERIFICATION SKILLS 6
Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first-time submission

TOTAL: 30 PERIODS

OUTCOMES
CO1 – Understand that how to improve your writing skills and level of readability
CO2 – Learn about what to write in each section
CO3 – Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

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AX5092 DISASTER MANAGEMENT L T P C 2 0 0 0

OBJECTIVES
• Summarize basics of disaster
• Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
• Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
• Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
• Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION 6
Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS 6

UNIT III DISASTER PRONE AREAS IN INDIA 6
Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT 6
Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT 6
Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People’s Participation in Risk Assessment. Strategies for Survival
OUTCOMES
CO1: Ability to summarize basics of disaster
CO2: Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5: Ability to develop the strengths and weaknesses of disaster management approaches

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AX5093 SANSKRIT FOR TECNICAL KNOWLEDGE
OBJECTIVES
- Illustrate the basic sanskrit language.
- Recognize sanskrit, the scientific language in the world.
- Appraise learning of sanskrit to improve brain functioning.
- Relate sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.
- Extract huge knowledge from ancient literature.

UNIT I ALPHABETS
Alphabets in Sanskrit

UNIT II TENSES AND SENTENCES
Past/Present/Future Tense - Simple Sentences

UNIT III ORDER AND ROOTS
Order - Introduction of roots

UNIT IV SANSKRIT LITERATURE
Technical information about Sanskrit Literature
OUTCOMES
- CO1 - Understanding basic Sanskrit language.
- CO2 - Write sentences.
- CO3 - Know the order and roots of Sanskrit.
- CO4 - Know about technical information about Sanskrit literature.
- CO5 - Understand the technical concepts of Engineering.

REFERENCES
1. “Abhyaspustakam” – Dr. Vishwas, Samskrita-Bharti Publication, New Delhi
2. “Teach Yourself Sanskrit” Pratham Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication

AX5094 VALUE EDUCATION

OBJECTIVES
Students will be able to
- Understand value of education and self-development
- Imbibe good values in students
- Let the should know about the importance of character

UNIT I

UNIT II

UNIT III

UNIT IV
OUTCOMES
Students will be able to
- Knowledge of self-development.
- Learn the importance of Human values.
- Developing the overall personality.

Suggested reading
OBJECTIVES
Students will be able to:
- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals’ constitutional role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

UNIT I
HISTORY OF MAKING OF THE INDIAN CONSTITUTION:
History, Drafting Committee, (Composition & Working)

UNIT II
PHILOSOPHY OF THE INDIAN CONSTITUTION:
Preamble, Salient Features

UNIT III
CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES:

UNIT IV
ORGANS OF GOVERNANCE:
Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT V
LOCAL ADMINISTRATION:

UNIT VI
ELECTION COMMISSION:
Election Commission: Role and Functioning, Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

OUTCOMES
Students will be able to:
- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- Discuss the passage of the Hindu Code Bill of 1956.

Suggested reading
1. The Constitution of India, 1950 (Bare Act), Government Publication.
OBJECTIVES
Students will be able to:
- Review existing evidence on there view topic to inform programme design and policy
- Making under taken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

UNIT I  INTRODUCTION AND METHODOLOGY:
Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions - Overview of methodology and Searching.

UNIT II  THEMATIC OVERVIEW
Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

UNIT III  EVIDENCE ON THE EFFECTIVENESS OF PEDAGOGICAL PRACTICES
Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches - Teachers’ attitudes and beliefs and Pedagogic strategies.

UNIT IV  PROFESSIONAL DEVELOPMENT
Professional development: alignment with classroom practices and follow up support - Peer support - Support from the head teacher and the community - Curriculum and assessment - Barriers to learning: limited resources and large class sizes

UNIT V  RESEARCH GAPS AND FUTURE DIRECTIONS
Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment - Dissemination and research impact.

OUTCOMES
Students will be able to understand:
- What pedagogical practices are being used by teachers informal and informal classrooms in developing countries?
- What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
- How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

Suggested reading


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<th>STRESS MANAGEMENT BY YOGA</th>
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**OBJECTIVES**
- To achieve overall health of body and mind
- To overcome stress

**UNIT I**
Definitions of Eight parts of yoga.(Ashtanga)

**UNIT II**
Yam and Niyam - Do’s and Don’t’s in life - i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Ahinsa, satya, astheya, bramhacharya and aparigraha.

**UNIT III**
Asan and Pranayam - Various yog poses and their benefits for mind & body - Regularization of breathing techniques and its effects-Types of pranayam

**TOTAL: 30 PERIODS**

**OUTCOMES**
Students will be able to:
- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

**SUGGESTED READING**
1. ‘Yogic Asanas for Group Tarining-Part-I”Janardan Swami Yoga bhyasi Mandal, Nagpur
2. “Rajayoga or conquering the Internal Nature” by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

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<th>PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS</th>
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**OBJECTIVES**
- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To awaken wisdom in students

**UNIT I**
Neetisatakam-holistic development of personality - Verses- 19,20,21,22 (wisdom) - Verses-29,31,32 (pride & heroism) – Verses- 26,28,63,65 (virtue) - Verses- 52,53,59 (don’t’s) - Verses- 71,73,75,78 (do’s)
UNIT II
Approach to day to day work and duties - Shrimad Bhagwad Geeta: Chapter 2-Verses 41, 47, 48 - Chapter 3-Verses 13, 21, 27, 35 Chapter 6-Verses 5,13,17,23, 35 - Chapter 18-Verses 45, 46, 48.

UNIT III
Statements of basic knowledge - Shrimad Bhagwad Geeta: Chapter 2-Verses 56, 62, 68 Chapter 12 -Verses 13, 14, 15, 16,17, 18 - Personality of role model - shrimad bhagwad geeta - Chapter 2-Verses 17, Chapter 3-Verses 36,37,42 - Chapter 4-Verses 18, 38,39 Chapter 18 – Verses 37,38,63

OUTCOMES
Students will be able to
- Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and man kind to peace and prosperity
- Study of Neet is hatakam will help in developing versatile personality of students.

Suggested reading
1. Gopinath, Rashtriya Sanskrit Sansthanam P, Bhartrihari’s Three Satakam, Niti-sringar-vairagya, New Delhi, 2010