

M.E. POWER ELECTRONICS AND DRIVES

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| Signature of the Chairman BOS EEE |

**KUMARAGURU COLLEGE OF TECHNOLOGY,
COIMBATORE – 641 049**

(An Autonomous Institution Affiliated To Anna University Chennai)

ELECTRICAL AND ELECTRONICS ENGINEERING

VISION

The Vision of the Department is to be a Centre of Excellence in Globalizing Power Engineering and Technology.

MISSION

The mission of the department is to Empower Youth by Imparting Technical Knowledge and Skills to Innovate, Transform and Globalize the Power Sector. It intended to equip the graduates with deftness to overcome challenges culminating in success in diverse competitive careers with societal impacts and values.

Kumaraguru College of Technology

Coimbatore – 641 049

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Regulations 2015

| CBCS – PG Curriculum | | | | | | | |
|---|-------------|---|-------------|---|---|---|-----------|
| Name of the PG Programme: Power Electronics and Drives | | | | | | | |
| <u>Foundation Courses (FC)</u> | | | | | | | |
| S. No. | Course Code | Course Title | Periods/Wk | | | | Preferred |
| | | | L | T | P | C | |
| 1. | P15MAT105 | Applied Mathematics for Electrical Engineers | 3 | 1 | 0 | 4 | 1 |
| 2. | P15PET102 | Advanced Power Semiconductor Devices | 3 | 0 | 0 | 3 | 1 |
| <u>Professional Core (PC)</u> | | | | | | | |
| S. No. | Course Code | Course Title | Periods /Wk | | | | Preferred |
| | | | L | T | P | C | |
| 1. | P15PET101 | Modeling and Analysis of Electrical Machines | 3 | 0 | 0 | 3 | 1 |
| 2. | P15PET103 | Analysis of Power Converters | 3 | 0 | 0 | 3 | 1 |
| 3. | P15PET104 | Analysis of Inverters | 3 | 0 | 0 | 3 | 1 |
| 4. | P15PET201 | Solid State DC Drives | 3 | 0 | 0 | 3 | 2 |
| 5. | P15PET202 | Solid State AC Drives | 3 | 0 | 0 | 3 | 2 |
| 6. | P15PET203 | Advanced Control Theory | 3 | 1 | 0 | 4 | 2 |
| 7. | P15PET204 | Special Electrical Machines and their Controllers | 3 | 0 | 0 | 3 | 2 |
| <u>Professional Electives (PE)</u> | | | | | | | |

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| S. No. | Course Code | Course Title | Periods / Wk | | | | Preferred Semester |
|--------|-------------|--|--------------|---|---|---|--------------------|
| | | | L | T | P | C | |
| 1. | P15PETE01 | PWM Converters and Applications | 3 | 0 | 0 | 3 | |
| 2. | P15PETE02 | Converters for Power Supply | 3 | 0 | 0 | 3 | |
| 3. | P15PETE03 | Emerging Trends in Power Conversion Technology | 3 | 0 | 0 | 3 | |
| 4. | P15PETE04 | Industrial Control Electronics | 3 | 0 | 0 | 3 | |
| 5. | P15PETE05 | Electric and Hybrid Vehicles | 3 | 0 | 0 | 3 | |
| 6. | P15PETE06 | High Voltage Direct Current Transmission | 3 | 0 | 0 | 3 | |
| 7. | P15PETE07 | Power Quality | 3 | 0 | 0 | 3 | |
| 8. | P15PETE08 | Power Electronics in Wind & Solar Power Conversion | 3 | 0 | 0 | 3 | |
| 9. | P15PETE09 | Flexible AC Transmission Systems | 3 | 0 | 0 | 3 | |
| 10. | P15PETE10 | Energy Storage System | 3 | 0 | 0 | 3 | |
| 11. | P15PETE11 | Wind Energy Conversion Systems | 3 | 0 | 0 | 3 | |
| 12. | P15PETE12 | Intelligent Control | 3 | 0 | 0 | 3 | |
| 13. | P15PETE13 | Digital Control in Power Electronics | 3 | 0 | 0 | 3 | |
| 14. | P15PETE14 | Advanced Optimization Techniques | 3 | 0 | 0 | 3 | |
| 15. | P15PETE15 | Advanced Embedded Systems | 3 | 0 | 0 | 3 | |

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|-----|------------|---|---|---|---|---|--|
| 16. | P15PETE16 | VLSI Design in Power Electronics | 3 | 0 | 0 | 3 | |
| 17. | P15PETE17* | Advanced Digital Signal Processing | 3 | 0 | 0 | 3 | |
| 18. | P15PETE18 | Microcontroller and DSP based System Design | 3 | 0 | 0 | 3 | |

Employability Enhancement Courses (EEC)

| S. No. | Course Code | Course Title | Periods /Wk & Credits | | | | Preferred Semester |
|--------|-------------|--|-----------------------|---|----|----|--------------------|
| | | | L | T | P | C | |
| 1. | P15PEP101 | Power Electronics Simulation Laboratory I | 0 | 0 | 4 | 2 | 1 |
| 2. | P15PEP201 | Power Electronics and Drives Laboratory | 0 | 0 | 4 | 2 | 2 |
| 3. | P15PEP301 | Advanced Power Electronics and Drives Laboratory | 0 | 0 | 4 | 2 | 3 |
| 4. | P15PEP302 | Project (Phase I) | 0 | 0 | 6 | 3 | 3 |
| 5. | P15PEP401 | Project (Phase II) | 0 | 0 | 24 | 12 | 4 |

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| SEMESTER I | | | | | | | | |
|---------------------------------|--------------------|--|-----------------|----------------------|----------|----------|----------|----------|
| S. No. | Course Code | Course Title | Category | Contact Hours | L | T | P | C |
| <u>Theory</u> | | | | | | | | |
| 1. | P15MAT105 | Applied Mathematics for Electrical Engineers | FC | 4 | 3 | 1 | 0 | 4 |
| 2. | P15PET101 | Modeling and Analysis of Electrical Machines | PC | 3 | 3 | 0 | 0 | 3 |
| 3. | P15PET102 | Advanced Power Semiconductor Devices | PC | 3 | 3 | 0 | 0 | 3 |
| 4. | P15PET103 | Analysis of Power Converters | PC | 3 | 3 | 0 | 0 | 3 |
| 5. | P15PET104 | Analysis of Inverters | PC | 3 | 3 | 0 | 0 | 3 |
| 6. | E1 | Elective I | PE | 3 | 3 | 0 | 0 | 3 |
| <u>Practical</u> | | | | | | | | |
| 7. | P15PEP101 | Power Electronics Simulation Laboratory I | EEC | 4 | 0 | 0 | 4 | 2 |
| <u>Total Credits: 21</u> | | | | | | | | |
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| SEMESTER II | | | | | | | | |
|---------------------------------|--------------------|---|-----------------|----------------------|----------|----------|----------|----------|
| S. No. | Course Code | Course Title | Category | Contact Hours | L | T | P | C |
| <u>Theory</u> | | | | | | | | |
| 1. | P15PET201 | Solid State DC Drives | PC | 3 | 3 | 0 | 0 | 3 |
| 2. | P15PET202 | Solid State AC Drives | PC | 3 | 3 | 0 | 0 | 3 |
| 3. | P15PET203 | Advanced Control Theory | PC | 3 | 3 | 1 | 0 | 4 |
| 4. | P15PET204 | Special Electrical Machines and their Controllers | PC | 3 | 3 | 0 | 0 | 3 |
| 5. | E2 | Elective II | PE | 3 | 3 | 0 | 0 | 3 |
| 6. | E3 | Elective III | PE | 3 | 3 | 0 | 0 | 3 |
| <u>Practical</u> | | | | | | | | |
| 7. | P15PEP201 | Power Electronics and Drives Laboratory | EEC | 4 | 0 | 0 | 4 | 2 |
| <u>Total Credits: 21</u> | | | | | | | | |
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SEMESTER III

| S. No. | Course Code | Course Title | Category | Contact Hours | L | T | P | C |
|---------------------------------|--------------------|--|-----------------|----------------------|----------|----------|----------|----------|
| <u>Theory</u> | | | | | | | | |
| 1. | E4 | Elective IV | PE | 3 | 3 | 0 | 0 | 3 |
| 2. | E5 | Elective V | PE | 3 | 3 | 0 | 0 | 3 |
| 3. | E6 | Elective VI | PE | 3 | 3 | 0 | 0 | 3 |
| 4. | S1 | Self study | PE | 3 | 0 | 0 | 0 | 3 |
| <u>Practical</u> | | | | | | | | |
| 5. | P15PEP301 | Advanced Power Electronics and Drives Laboratory | EEC | 4 | 0 | 0 | 4 | 2 |
| 6. | P15PEP302 | Project (Phase I) | EEC | 12 | 0 | 0 | 12 | 6 |
| <u>Total Credits: 20</u> | | | | | | | | |
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SEMESTER IV

| S. No. | Course Code | Course Title | Category | Contact Hours | L | T | P | C |
|---------------|--------------------|---------------------|-----------------|----------------------|----------|----------|----------|----------|
|---------------|--------------------|---------------------|-----------------|----------------------|----------|----------|----------|----------|

Practical

| | | | | | | | | |
|----|-----------|--------------------|-----|----|---|---|----|----|
| 1. | P15PEP401 | Project (Phase II) | EEC | 24 | 0 | 0 | 24 | 12 |
|----|-----------|--------------------|-----|----|---|---|----|----|

Total Credits: 12

ELECTIVES

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| S. No. | Course Code | Course Title | Category | Contact Hours | L | T | P | C |
|--|-------------|--|----------|---------------|---|---|---|---|
| Specialization 1 ** Advanced Power Electronics and Applications | | | | | | | | |
| 1. | P15PETE01 | PWM Converters and Applications | PE | 3 | 3 | 0 | 0 | 3 |
| 2. | P15PETE02 | Converters for Power Supply | PE | 3 | 3 | 0 | 0 | 3 |
| 3. | P15PETE03 | Emerging Trends in Power Conversion Technology | PE | 3 | 3 | 0 | 0 | 3 |
| 4. | P15PETE04 | Industrial Control Electronics | PE | 3 | 3 | 0 | 0 | 3 |
| 5. | P15PETE05 | Electric and Hybrid Vehicles | PE | 3 | 3 | 0 | 0 | 3 |
| Specialization 2 ** Power Electronics Applications in Power Systems | | | | | | | | |
| 1. | P15PETE06 | High Voltage Direct Current Transmission | PE | 3 | 3 | 0 | 0 | 3 |
| 2. | P15PETE07 | Power Quality | PE | 3 | 3 | 0 | 0 | 3 |
| 3. | P15PETE08 | Power Electronics in Wind & Solar Power Conversion | PE | 3 | 3 | 0 | 0 | 3 |
| 4. | P15PETE09 | Flexible AC Transmission Systems | PE | 3 | 3 | 0 | 0 | 3 |
| 5. | P15PETE10 | Energy Storage System | PE | 3 | 3 | 0 | 0 | 3 |
| 6. | P15PETE11 | Wind Energy Conversion Systems | PE | 3 | 3 | 0 | 0 | 3 |
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Specialization 3 ** Power Electronics Control Systems

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|----|------------|---|----|---|---|---|---|---|
| 1. | P15PETE12 | Intelligent Control | PE | 3 | 3 | 0 | 0 | 3 |
| 2. | P15PETE13 | Digital Control in Power Electronics | PE | 3 | 3 | 0 | 0 | 3 |
| 3. | P15PETE14 | Advanced Optimization Techniques | PE | 3 | 3 | 0 | 0 | 3 |
| 4. | P15PETE15 | Advanced Embedded Systems | PE | 3 | 3 | 0 | 0 | 3 |
| 5. | P15PETE16 | VLSI Design in Power Electronics | PE | 3 | 3 | 0 | 0 | 3 |
| 6. | P15PETE17* | Advanced Digital Signal Processing | PE | 3 | 3 | 0 | 0 | 3 |
| 7. | P15PETE18 | Microcontroller and DSP based System Design | PE | 3 | 3 | 0 | 0 | 3 |

Total Credits: 74

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| ONE CREDIT COURSES | | | |
|---------------------------|--------------------|--|--|
| S. No. | Course Code | Course Title | Industry that will offer the course |
| 1. | P15PEIN01 | Design Consideration for Variable Speed Drives | M/S, Versa Drives, CBE |
| 2. | P15PEIN02 | Recent Trends in Electric Drives | M/S, Versa Drives, CBE |
| 3. | P15PEIN03 | Development of Regulated Power Supply Circuits | Numeric Power Systems |
| 4. | P15PEIN04 | Backup Power Supply System for Aero Applications | MAK Control Corporation |

*** Common Elective subject for Power Electronics and Drives & Embedded System Technologies.**

**** All electives should be only in category PE**

***** Grouping of electives according to specialization is optional**

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SEMESTER I

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**ELECTRICAL AND
ELECTRONICS ENGINEERING
M.E – POWER ELECTRONICS
AND DRIVES
REGULATIONS 2015
SYLLABUS**

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P15MAT105

**APPLIED MATHEMATICS FOR
ELECTRICAL ENGINEERS**

| L | T | P | C |
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| 3 | 1 | 0 | 4 |

COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Construct the inverse of a rectangular matrix and generalized eigenvectors of a matrix.

CO2: Determine the maximum and minimum values of functional.

CO3: Apply the concepts of transforms (Discrete Fourier transform, Z-transform and wavelet transforms) to physical problems

CO4: Discuss the soft computing techniques with their operations and functions.

PRE-REQUISITE

1. Engineering Mathematics I
2. Engineering Mathematics II
3. Engineering Mathematics III

ADVANCED MATRIX THEORY

9+3 Hours

Matrix norms – Jordan canonical form – Generalized eigen vectors – Singular value decomposition – Pseudo inverse – Least square approximations.

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CALCULUS OF VARIATIONS

9+3 Hours

Euler's equation – Functionals dependent on first and higher order derivatives – Functionals dependent on functions of several dependent variables – Some applications – Direct method: Ritz method.

FOURIER ANALYSIS AND Z –TRANSFORMS

9+3 Hours

Discrete Fourier Transforms and its properties – Fourier series and its properties – Fourier representation of finite duration sequences – Z-transform – Properties of the region of convergence – Inverse Z-transform – Z-transform properties.

WAVELET TRANSFORMS

9+3 Hours

Continuous and discrete time wavelet transform – Definition and examples - Inverse transform of continuous and discrete time wavelet transform- Some applications.

SOFT COMPUTING METHODS

9+3 Hours

Fuzzy variables - Fuzzy relations – Neural networks – Genetic algorithms (basic concepts only)

Theory:45 Hrs

Tutorial: 15 Hrs

Total: 60 Hrs

REFERENCES

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1. Lewis D.W., “Matrix Theory”, Allied Publishers, Peebles Jr., P.Z., Chennai 1995.
2. Grewal B.S., “Higher Engineering Mathematics”, Khanna Publishers, 40th Edition 2007.
3. Raghuvver M. Rao, Ajit S. Bopardikar, “Wavelet Transforms introduction to theory and applications, Addition Wesley, 2003.
4. Rajasekaran S., Vijayalakshmi Pai G.A., “Neural Network, Fuzzy Logic and Genetic Algorithm”, Synthesis and Applications, Prentice Hall of India – 2008.
5. Bronson R., “Theory and problems of Matrix operations”, Schaums outline series, Tata McGraw Hill, New York, 2005.
6. Elsgolts L., “Differential equations and Calculus of variations”, University Press of Pacific, 2006.
7. Athanasios Papoulis, “Probability, Random Variables and Stochastic Processes”, McGraw Hill International Editions, 4th Edition 2002.
8. Sivanandam S. N., Deepa S.N., “Principles of Soft Computing”, Wiley India Pvt. Limited, 2007.

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P15PET101

**MODELLING AND ANALYSIS OF
ELECTRICAL MACHINES**

| L | T | P | C |
|----------|----------|----------|----------|
| 3 | 0 | 0 | 3 |

COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Outline the concept of magnetic circuits in electrical machines and the characteristics and specifications of different electrical machines

CO2: Design the DC machines for the given specifications

CO3: Design the induction, synchronous machines and transformers for the specifications

PRE-REQUISITE

1. Engineering Mathematics
2. Electrical Machines
3. Electric Utilization

ELEMENTS OF GENERALIZED THEORY

9 Hours

Essentials of Rotating Electrical Machines – Conventions – The basic two-pole Machine – The per unit system – Transformer with a movable secondary – Transformer and speed voltage in the armature – Kron’s primitive machine.

LINEAR TRANSFORMATIONS IN MACHINES

9 Hours

Invariance of power – Transformation from a displaced brush-axis – Transformation from three phase to two phases – Transformation from

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rotating axis to stationary axis – Physical concepts of park's transformations – Transformed impedance matrix – How to apply generalized theory – Electrical torque.

MODELING OF DC MACHINES

9 Hours

Theory of Operation – Induced EMF – Equivalent circuit and electromagnetic torque – Electromechanical modeling – State-space modeling – Block diagram and transfer functions – Measurement of motor constants.

MODELING OF INDUCTION MACHINES

9 Hours

Generalized representation application of Reference frame theory to three phase symmetrical induction machine - Direct and quadrature axis model in arbitrarily rotating Reference frame - Voltage and torque equations.

MODELING OF SYNCHRONOUS MACHINES

9 Hours

Wound field machines – Equivalent circuit – Developed torque – Salient pole machine characteristics – Dynamic $d^e - q^e$ machine model (Park model) – Permanent magnet machines – Sinusoidal surface magnet machine - Sinusoidal interior magnet machine – Trapezoidal surface magnet machine.

Theory:45 Hrs

Total: 45 Hrs

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REFERENCES

1. Dr. P. S. Bhimbra, “Generalized Theory of Electrical Machines”, Khanna Publication, 2000, New Delhi.
2. R. Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, New Delhi, Prentice Hall of India, 2001.
3. Charles Kingsley Jr., A.E. Fitzgerald and Stephen D. Umans, Electric Machinery, New York, McGraw - Hill Higher Education, 2010.
4. Paul C. Krause, Oleg Wasynczuk and Scott D. Sudhoff, Analysis of Electric Machinery and Drive Systems, New Jersey, Wiley Student Edition, 2013.
5. Bimal K Bose, “Modern Power Electronics and AC Drives”, Prentice Hall of India, 2007, New Delhi

P15PET102

**ADVANCED POWER
SEMICONDUCTOR DEVICES**

| L | T | P | C |
|----------|----------|----------|----------|
| 3 | 0 | 0 | 3 |

COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: To understand the behavior, characteristics of semiconductor devices operated as power switches.

CO2: Compare the capabilities and limitations of power devices, and decide them to suit the specification

CO3: Able to design control circuits, protection circuits and thermal management circuits

PRE-REQUISITE

1. Engineering Physics
2. Electron Devices Circuits
3. Power Electronics

DEVICES AND CHARACTERISTICS

9 Hours

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

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CURRENT CONTROLLED DEVICES

9 Hours

BJT's – Construction, static characteristics, switching characteristics; Negative temperature co-efficient and secondary breakdown; 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.

VOLTAGE CONTROLLED DEVICES

9 Hours

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

FIRING AND PROTECTING CIRCUITS

9 Hours

Necessity of isolation, pulse transformer, Opto-coupler – Gate drives circuit: SCR, MOSFET, IGBTs and base driving for power BJT. - Over voltage, over current and gate protections; Design of snubbers.

THERMAL PROTECTION

9 Hours

Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour – phase cooling; Guidance for heat sink selection – Thermal resistance and impedance - Electrical analogy of thermal components, heat sink types and design – Mounting types – Current and Voltage measurement using Hall sensors.

Theory:45 Hrs

Total: 45 Hrs

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REFERENCES

1. B.W Williams, “Power Electronics: Devices, Drivers, Applications and passive components”, 3rd Edition, McGraw Hill, 2006.
2. Rashid M.H., “Power Electronics: Circuits, Devices and Applications”, 3rd Edition, Pearson Education, 2014, New Delhi.
3. MD Singh and K.B Khanchandani, “Power Electronics”, 2nd Edition, Tata McGraw Hill, 2006.
4. Ned Mohan, Tore M. Undeland and William P.Robins, “Power Electronics – Concepts, applications and Design”, 3rd Edition, Wiley India, 2006.

P15PET103

**ANALYSIS OF POWER
CONVERTERS**

| L | T | P | C |
|----------|----------|----------|----------|
| 3 | 0 | 0 | 3 |

COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Understand the operation and various working modes of power converters.

CO2: Analyze the performance parameters of the power converters.

CO3: Design, develop and test the various power converter circuits.

PRE-REQUISITE

1. Power Electronics
2. Power Semiconductor Devices

SINGLE PHASE AC-DC CONVERTER

9 Hours

Uncontrolled, half controlled and fully controlled converters with RL, RLE loads and freewheeling diodes – continuous and discontinuous modes of operation – inverter operation – Dual converter - Sequence control of converters – performance parameters: harmonics, ripple, distortion, power factor – effect of source impedance and overlap.

THREE PHASE AC-DC CONVERTER

9 Hours

Uncontrolled and fully controlled – converter with R, RL, RLE - loads and freewheeling diodes – inverter operation and its limit – Dual converter – performance parameters – effect of source impedance and over lap

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DC-DC CONVERTERS

9 Hours

Principles of step-down and step-up converters – Analysis of buck, boost, buck-boost and Cuk converters – time ratio and current limit control – Full bridge converter – Resonant and quasi – resonant converters.

AC VOLTAGE CONTROLLERS

9 Hours

Principle of phase control: single phase and three phase controllers – various configurations – analysis with R and RL loads.

CYCLOCONVERTERS

9 Hours

Principle of operation – Single phase and three phase cyclo-converters – power circuits and gating signals.

Theory:45 Hrs

Total: 45 Hrs

REFERENCES

1. Ned Mohan, Tore M. Undeland and William P. Robins, “Power Electronics – Concepts, applications and Design”, 3rd Edition, John Wiley and Sons, 2006.
2. Rashid M.H., “Power Electronics: Circuits, Devices and Applications”, 3rd Edition, Prentice Hall India, 2013, New Delhi.
3. P.C.Sen, “Power Electronics”, 1st Edition, Tata McGraw Hill, 2007.
4. P. S. Bimbhra, “Power Electronics”, Khanna Publishers, 2012.

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P15PET104

ANALYSIS OF INVERTERS

| L | T | P | C |
|----------|----------|----------|----------|
| 3 | 0 | 0 | 3 |

COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: To design inverters for different applications.

CO2: To develop gating circuits for inverters

CO3: To understand the working of multilevel and resonant inverters.

PRE-REQUISITE

1. Power Semiconductor Devices
2. Electron Devices Circuits

SINGLE PHASE INVERTERS

9 Hours

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.

THREE PHASE VOLTAGE SOURCE INVERTERS

9 Hours

180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters – Space vector PWM inverters.

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CURRENT SOURCE INVERTERS

9 Hours

Operation of six-step thyristor inverter – inverter operation modes – load – commutated inverters – Auto sequential current source inverter (ASCI) – current pulsations – comparison of current source inverter and voltage source inverters

MULTILEVEL INVERTERS

9 Hours

Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters - comparison of multilevel inverters - application of multilevel inverters

RESONANT INVERTERS

9 Hours

Series and parallel resonant inverters - voltage control of resonant inverters – Class E resonant inverter – resonant DC – link inverters.

Theory:45 Hrs

Total: 45 Hrs

REFERENCES

1. M.H. Rashid, “Power Electronics: Circuits, Devices and Applications”, 3rd Edition, Pearson Education, 2014, New Delhi.
2. Jai P. Agrawal, “Power Electronics Systems”, 2nd Edition, Pearson Education, 2002.
3. P.C.Sen, “Power Electronics”, 1st Edition, Tata McGraw Hill India, 2007.
4. P.S. Bimbira, “Power Electronics”, Khanna Publishers, 2012, New Delhi.
5. Bimal K. Bose. “Modern Power Electronics and AC Drives”, 2nd Edition, Prentice Hall of India, 2005.

P15PEP101

**POWER ELECTRONICS
SIMULATION LABORATORY - I**

| L | T | P | C |
|----------|----------|----------|----------|
| 0 | 0 | 4 | 2 |

COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Design and develop a Matlab model for power converter circuits

CO2: Analyze the operation and performance of power converter circuits

CO3: Choose a power converter circuit for specific application

PRE-REQUISITE

1. Electron Devices and Circuits
2. Power Electronics
3. Analysis of Converters

LIST OF EXPERIMENTS:

1. Simulation of single phase half controlled converter.
2. Simulation of single phase fully controlled converter.
3. Simulation of three phase half controlled converter.
4. Simulation of three phase fully controlled converter.
5. Simulation of DC chopper.
6. Simulation of single phase inverter.
7. Simulation of three phase inverter.
8. Simulation of single phase AC voltage controller.
9. Simulation of three phase AC voltage controller.
10. Simulation of cyclo - converters.

Experiments can be done using MATLAB / PSIM Software's.

Experiments beyond the syllabus should be conducted

Practical:45 Hrs

Total: 45 Hrs

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SEMESTER II

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P15PET201

SOLID STATE DC DRIVES

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| L | T | P | C |
| 3 | 0 | 0 | 3 |

COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: The students will acquire knowledge of characteristics of rotating electrical Machines and power electronics modeling of drive system.

CO2: Analyze the steady-state operation of power electronic converters and to understand the basic requirements of industrial power electronics.

CO3: The students will be able to design, development and testing of DC drive system.

PRE-REQUISITE

1. Electrical Machines
2. Analysis of Power Converters

DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS 9 Hours

DC motor- Types, induced emf, speed-torque relations; Speed control – Armature and field speed control; Ward Leonard control – Constant torque and constant horse power operations. Characteristics of mechanical system – dynamic equations, components of torque, types of load; Requirements of drives characteristics – multi-quadrant operation; Drive elements, types of motor duty and selection of motor rating.

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CONVERTER CONTROL

9 Hours

Principle of phase control – Fundamental relations; Analysis of series and separately excited DC motor with single-phase and three-phase converters – waveforms, performance parameters, performance characteristics. Continuous and discontinuous armature current operations; Current ripple and its effect on performance; Operation with freewheeling diode; Implementation of braking schemes; Drive employing dual converter.

CHOPPER CONTROL

9 Hours

Introduction to time ratio control and frequency modulation; Class A, B, C, D and E chopper controlled DC motor – performance analysis, multi-quadrant control – Chopper based implementation of braking schemes; Multi-phase chopper; Related problems.

CLOSED LOOP CONTROL

9 Hours

Modeling of drive elements – Equivalent circuit, transfer function of self, separately excited DC motors; Linear Transfer function model of power converters; Sensing and feedback elements - Closed loop speed control - P, PI and PID controllers – response comparison.

DIGITAL CONTROL OF DC DRIVE

9 Hours

Phase Locked Loop and micro-computer control of DC drives – Program flow chart for constant horse power and load disturbed operations; Speed detection using tachometer and optical encoder - Gate firing schemes.

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Theory:45 Hrs

Total: 45 Hrs

REFERENCES

1. Gopal K Dubey, “Power Semiconductor controlled Drives”, Prentice Hall, 1989, New Jersey.
2. R. Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, 1st Edition, Pearson Education, 2001, New Delhi.
3. Gopal K. Dubey, “Fundamentals of Electric Drives”, 2nd Edition, Narosa Publishing House, 2015, New Delhi.
4. Vedam Subramaniam, “Electric Drives Concepts and Applications”, 2nd Edition, Tata McGraw Hill, 2011, New Delhi.
5. P.C.Sen, “Thyristor DC drives”, 1st Edition, John Wiley & Sons, 1991, New York.

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P15PET202

SOLID STATE AC DRIVES

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Describe the components of drives for AC motors

CO2: Present the control methodologies of AC drives

CO3: Choose an AC drive and apply the speed control methodology for an application

PRE-REQUISITE

1. Electrical Machines
2. Analysis of Inverters

CONVENTIONAL CONTROL OF INDUCTION MOTORS

9 Hours

Review of Induction Machine operation – Equivalent circuit – Performance of the machine with variable voltage, rotor resistance variation, pole changing and cascaded induction machines, slip power recovery – Static Kramer Drive.

VSI AND CSI FED INDUCTION MOTOR CONTROL

9 Hours

Concept of AC voltage controller fed induction motor – Energy conservation issues – V/F control – requirement for slip and stator voltage compensation. CSI fed induction machine – Operation and characteristics.

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FIELD ORIENTED CONTROL

9 Hours

Field oriented control of induction machines – Theory – DC drive analogy – Direct and Indirect methods – Flux vector estimation.

DIRECT TORQUE CONTROL

9 Hours

Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy.

SYNCHRONOUS MOTOR CONTROL

9 Hours

Synchronous motor control - Brush and Brushless excitation – Load commutated inverter fed drive.

Theory:45 Hrs

Total: 45 Hrs

REFERENCES

1. Bimal K. Bose. “Modern Power Electronics and AC Drives”, 2nd Edition, Prentice Hall of India, 2005.
2. Vedam Subramaniam, “Electric Drives Concepts and Applications”, 2nd Edition, Tata McGraw Hill, 2011, New Delhi.
3. R. Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, 1st Edition, Pearson Education, 2001, New Delhi.
4. Gopal K Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall, 1989, New Jersey.
5. Gopal K. Dubey, “Fundamentals of Electric Drives”, 2nd Edition, Narosa Publishing House, 2015.
6. W. Leonhard, “Control of Electrical Drives”, 3rd Edition, Narosa Publishing House, 2001.
7. Murphy J.M.D and Turnbull, “Thyristor Control of AC Motors”, 2nd Edition, Pergamon Press, 1988, Oxford.

P15PET203 ADVANCED CONTROL THEORY

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Develop transfer function model for discrete time system, find the stability of the discrete time systems

CO2: Exposed to analyze the system and find the state space model of any given systems

CO3: Analyze the stability of non – linear systems

PRE-REQUISITE

1. Control Systems
2. Engineering Mathematics

INTRODUCTION TO DIGITAL CONTROL SYSTEMS 9+3 Hours

Configuration of the basic digital control scheme-Principles of signal conversion-Basic discrete time signals-Time domain models for discrete time systems-Transfer function models-Stability on the Z-plane and the Jury stability criterion-Sampling as impulse modulation-Sampled spectra and Aliasing-Filtering

STATE VARIABLE REPRESENTATION AND SOLUTION OF STATE EQUATION 9+3 Hours

Introduction-State space formulation-state model of linear system-state diagram-state space representation using physical variable- state space representation using phase variable - state space representation using

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canonical variable-Solution of state equations-state space representation of discrete time systems.

STATE SPACE ANALYSIS AND DESIGN OF CONTROL SYSTEM

9+3 Hours

Definitions involving matrices-Eigen values and eigen vectors-Similarity transformation-Cayley-Hamilton theorem-Transformation of state model- Concepts of controllability and Observability-controllable phase variable form of state model-Control system design via pole place by state feedback – Observable phase variable form of state model-State observers.

NON LINEAR SYSTEMS

9+3 Hours

Introduction to non linear systems-Describing functions-Dead zone, saturation non linearity, Dead zone and saturation non linearity, relay with dead zone and hysteresis, backlash nonlinearity-Describing function analysis of non linear systems.

LYAPUNOV STABILITY ANALYSIS

9+3 Hours

Introduction-Basic concepts-stability definitions-Stability Theorems-Lyapunov functions for linear systems-A model reference adaptive systems-Discrete time system

Theory:45 Hrs

Tutorial: 15 Hrs

Total: 60 Hrs

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REFERENCES

1. M. Gopal, “Modern Control System Theory”, 3rd Edition, New Age International, 2014.
2. M. Gopal, “Digital control and state variable methods”, 3rd Edition, Tata McGraw Hill, 2006.
3. K. Ogata, “Modern Control Engineering”, 5th Edition, Prentice Hall of India, 2002, New Delhi.
4. John S. Bay, “Fundamentals of Linear State Space Systems”, 2nd Edition, McGraw Hill, 1999.
5. D. Roy Choudhury, “Modern Control Systems”, 2nd Edition, New Age International, 2005.
6. John J. D’Azzo, C. H. Houpis and S. N. Sheldon, “Linear Control System Analysis and Design with MATLAB”, 6th Edition, CRC Press, 2013.
7. Z. Bubnicki, “Modern Control Theory”, 2nd Edition, Springer, 2007.

P15PET204

**SPECIAL ELECTRICAL MACHINES
AND THEIR CONTROLLERS**

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Describe the construction and working of special electrical machines.

CO2: Identify the characteristics of different special electrical machines

CO3: Choose a particular electrical machine for the given requirements.

PRE-REQUISITE

1. AC Machines
2. Power Electronics

SYNCHRONOUS RELUCTANCE MOTORS

9 Hours

Constructional features: axial and radial air gap Motors. Operating principle, reluctance torque – phasor diagram, motor characteristics.

SWITCHED RELUCTANCE MOTORS

9 Hours

Constructional features, principle of operation. Torque equation, Power controllers, Characteristics and control Microprocessor based controller

PERMANENT MAGNET SYNCHRONOUS MOTORS

9 Hours

Principle of operation, EMF, power input and torque expressions, Phasor diagram, Power controllers, Torque speed characteristics, Self control, Vector control, Current control schemes.

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PERMANENT MAGNET BRUSHLESS DC MOTORS **9 Hours**

Commutation in DC motors, Difference between mechanical and electronic commutators, Hall sensors, Optical sensors, Multiphase Brushless motor, Square wave permanent magnet brushless motor drives, Torque and emf equation, Torque-speed characteristics, Controllers- Microprocessor based controller.

STEPPING MOTORS **9 Hours**

Constructional features, principle of operation, modes of excitation torque production in Variable Reluctance (VR) stepping motor, Dynamic characteristics, Drive systems and circuit for open loop control, Closed loop control of stepping motor.

Theory:45 Hrs

Total: 45 Hrs

REFERENCES

1. Miller, T.J.E. “Brushless Permanent Magnet and Reluctance Motor Drives”, 1st Edition, Clarendon Press, 1989, London.
2. T. Kenjo, “Stepping Motors and Their Microprocessor Controls”, 2nd Edition, Clarendon Press, Oxford University, 1994, London.
3. T. Kenjo and S. Nagamori, “Permanent Magnet and Brushless DC Motors”, 1st Edition, Clarendon Press, Oxford University, 1986, London.
4. Kenjo, T, “Power Electronics for the Microprocessor Age”, Oxford University Press, 1994.
5. B.K. Bose, “Modern Power Electronics & AC drives” 1st Edition, Pearson Education, 2003

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6. R. Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, 1st Edition, Prentice- Hall of India, 2010, New Delhi.
7. R. Krishnan, “Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design and Applications”, 1ST Edition, CRC Press, 2001.

P15PEP201

**POWER ELECTRONICS AND
DRIVES LABORATORY**

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Design and conduct an experiment for various power converter circuits

CO2: Analyze the operation and performance of power converter circuits

CO3: Apply power converter circuits for electric drives application

PRE-REQUISITE

1. Analysis of Power Converters
2. Analysis of Inverters
3. Solid State Drives (AC & DC)

LIST OF EXPERIMENTS:

1. Single phase half controlled Converter with RL and RLE loads.
2. Single phase fully controlled Converter with RL and RLE loads.
3. Three phase fully controlled Converter fed DC Shunt motor.
4. Four quadrant IGBT based chopper fed DC motor drive
5. Single phase PWM inverter
6. Three phase PWM inverter fed Induction motor Drive.
7. Resonant converters.
8. Series Inverter.
9. AC voltage controller.
10. BLDC motor drive.

Experiments beyond the syllabus should be conducted

Practical :45 Hrs

Total: 45 Hrs

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SEMESTER III

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P15PEP301

**ADVANCED POWER ELECTRONICS
AND DRIVES LABORATORY**

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: To design the closed loop control system for AC and DC drives and power supplies.

CO2: To choose the suitable controller for the specific application.

CO3: To apply the control technique for drives and power supply in simulation and real time environments

PRE-REQUISITE

1. Control Systems
2. Solid State Drives
3. Analysis of Power Converters and Inverters

LIST OF EXPERIMENTS:

1. Simulation of closed loop control of Converter fed DC motor.
2. Simulation of closed loop control of Chopper fed DC motor.
3. Simulation of closed loop control of VSI fed three-phase induction motor.
4. Simulation of closed loop control of Synchronous motors.
5. Simulation of Four quadrant operation of three-phase induction motor.
6. DSP based speed control of PMSM.
7. Realization of control logic for motor drives using FPGA.
8. Design of switched mode power supplies
9. Design of Buck boost converters
10. Harmonic Analysis of power converters

Experiments beyond the syllabus should be conducted

Practical :45 Hrs

Total: 45 Hrs

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P15PETE01

PWM CONVERTERS AND APPLICATIONS

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Model and Analyze the steady-state and transient behavior of power converters with various PWM techniques.

CO2: Design and Analyze the controllers for PWM power converters for an application

CO3: Choose the PWM converter to improve power quality.

PRE-REQUISITE

1. Power Converters

OVERVIEW OF CONVERTERS AND MODULATION 9 Hours

AC/DC and DC/AC power conversion, overview of applications of voltage source converters, pulse modulation techniques for bridge converters.

PWM TECHNIQUES 9 Hours

Bus clamping PWM, space vector based PWM, advanced PWM techniques, practical devices in converter; calculation of switching and conduction losses.

PWM INVERTERS 9 Hours

Compensation for dead time and DC voltage regulation; dynamic model of a PWM converter, multilevel converters; constant V/F induction motor drives.

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PWM APPLICATIONS

9 Hours

Estimation of current ripple and torque ripple in inverter fed drives; line – side converters with power factor compensation.

POWER QUALITY IMPROVEMENT

9 Hours

Active power filtering, reactive power compensation; harmonic current compensation.

Theory:45 Hrs

Total: 45 Hrs

REFERENCES

1. Ned Mohan, Tore M.Undeland and P.William Robbins, “Power Electronics; Converters, Applications and Design”, John Wiley and Sons, 2006.
2. Marian P. Kazmierkowski, R. Krishnan and Frede Blaabjerg, “Control in Power Electronics”, Academic Press Series, 2002.
3. Erickson R W,D.maksimovic, “Fundamentals of Power Electronics”, springer science & business media, 2001.
4. Joseph Vithyathil J, “Power Electronics: Principles and Applications”, Tata McGraw Hill, 2010.

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P15PETE02 CONVERTERS FOR POWER SUPPLY

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Select the type of SMPS and UPS needed for specific applications

CO2: Design the Component ratings of SMPS and UPS

CO3: Improve the power quality output of SMPS and UPS using improved filter design.

PRE-REQUISITE

1. Power Converters and Inverters

DC-DC CONVERTERS

9 Hours

Principles of step-down and step-up converters – Analysis and state space modeling of Buck, Boost, Buck- Boost and CUK converters- Introduction to SEPIC and Zeta converters.

ISOLATED SWITCHED MODE DC TO DC

9 Hours

CONVERTER

Introduction- single width isolated DC to DC converter- Forward converter, fly back converter, Cuk converter—multi switch isolated DC to DC converter- Push pull converter—full bridge converter—comparison of isolated switched mode DC to DC converter.

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SWITCHING MODE POWER CONVERTERS

9 Hours

Analysis and state space modeling of flyback, Forward, Luo, Half bridge and full bridge converters- control circuits and PWM techniques.

UNINTERRUPTABLE POWER SUPPLY

9 Hours

Classification- Stand by UPS—On line UPS system- Line interactive UPS – Universal UPS- Rotary UPS- Hybrid static/ Rotary UPS – Distributed UPS network – Comparison – Control Techniques – Voltage and current control of UPS inverter.

POWER CONDITIONERS & FILTERS

9 Hours

Introduction- Power line disturbances- Power conditioners –Filters: Voltage filters, Series-parallel resonant filters, filter without series capacitors, filter for PWM VSI, current filter, DC filters – Design of inductor and transformer for Inverter applications – Selection of capacitors.

Theory:45 Hrs

Total: 45 Hrs

REFERENCES

1. M.H. Rashid, “Power Electronics handbook”, Elsevier Publication, 2001.
2. Kjeld Thorborg, “Power Electronics – In theory and Practice”, 1st Edition, Overseas Press, 2005.
3. Philip T Krein, “ Elements of Power Electronics”, Oxford University Press

4. Ned Mohan Tore. M. Undeland, William.P.Robbins, “Power Electronics converters, Applications and design”, 3rd Edition, John Wiley and Sons, 2006
5. M.H. Rashid, “Power Electronics circuits, devices and applications”, 3rd edition Prentice Hall of India, 2013, New Delhi.
6. Andrzej M. Trzynadlowski, “Introduction to Modern Power Electronics”, 2nd Edition, Wiley India, 2012, New Delhi.

P15PETE03 **EMERGING TRENDS IN POWER**
CONVERSION TECHNOLOGY

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

- CO1:** Choose the PWM techniques.
- CO2:** Apply voltage lift techniques in dc-dc converters.
- CO3:** Analyze the FFT of multilevel inverters
- CO4:** Apply the harmonic mitigations methods.

PRE-REQUISITE

1. Control Systems
2. Power Electronics

SWITCHING TECHNIQUES

8 Hours

Gating signals – PWM techniques – Types – SPWM, SVPWM and SVM – choice of carrier frequency in SPWM – switch realization – switching losses – Efficiency Vs Switching frequency – applications – EMI and EMC considerations.

DC – DC CONVERTERS

10 Hours

Basic of DC – DC converter – Hard and Soft switching concepts – Digital switching techniques – Luo converter - principle of operation – Voltage lift techniques - MPPT algorithms – Sliding mode control - applications – Photovoltaic systems – Hybrid vehicles.

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ADVANCES IN INVERTERS

11 Hours

Overview of multilevel inverters – Hybrid multi level inverter- FFT analysis- Comparison of multilevel inverters - Applications of multilevel inverter - Principle of operation of impedance source inverter- Shoot thro zero state – Application – UPS – Adjustable speed drives.

MATRIX CONVERTER

8 Hours

Single phase and three phase – Direct indirect – Sparse and very sparse – Multilevel matrix converter – Z source matrix converter – applications – Wind mills – Adjustable speed drives industrial applications - Hybrid vehicles.

HARMONIC MITIGATIONS

8 Hours

Effects of harmonics – Harmonics eliminations – Selective harmonic elimination – Selective sine PWM carrier elimination – Power Factor control – Active power factor control – Hysteresis control – Voltage feedback control - Current feedback control.

Theory:45 Hrs

Total: 45 Hrs

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REFERENCES

1. Ned Mohan, Undeland and Robbin, “Power Electronics: Converters, Application and Design”, New York, John Wiley and Sons, 2006.
2. Kolar, J.W. Schafmeister, F. Round, S.D. Ertl, H. ETH Zurich and Zurich, “Novel Three-Phase AC–AC Sparse Matrix Converters”, Vol.22, No.5, IEEE Transactions on Power Electronics, Sept. 2007, pp 1649 – 1661.
3. R. Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice Hall of India, 2001, New Delhi.
4. D.M. Bellur, M.K. Kazimierczuk and O.H. Dayton, “DC-DC Converters for Electric Vehicle Applications”, Conference on Electrical Insulation and Electrical Manufacturing Expo, 22-24, Oct. 2007, Nashville, USA, pp 286 – 293.
5. S. Masoud Barakati, “Applications of Matrix Converters for Wind Turbine Systems”, Germany, VDM Verlag Publishers, 2008.

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P15PETE04

**INDUSTRIAL CONTROL
ELECTRONICS**

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Demonstrate proficiency in automation

programming/troubleshooting related to programmable logic controllers and digital controllers required for industrial employment.

CO2: Demonstrate problem solving skills used in ladder logic for development of industrial automation.

CO3: Students will be acquainted with knowledge of opto electronic based automated systems for case studies of various industries.

PRE-REQUISITE

1. Electron Devices and Circuits
2. Power Electronics

INTRODUCTION TO INDUSTRIAL INSTRUMENTS 9 Hours

Review of switching regulators and switched mode power supplies, uninterrupted power supplies- off-line and on-line topologies-UPS topologies, solid state circuit breakers, solid-state tap-changing of transformer.

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PROGRAMMABLE LOGIC CONTROLLERS

9 Hours

Process Controller- Relay Logic – Programmable Logic Controller- Basic Structure –Ladder Logic- Programming- PLC Internal Operation and Signal Processing- I/O Processing- Communication System for Industrial Automation- Intelligent System for Monitoring, Supervision and Control.

COMPUTER NUMERIC CONTROL & AUTOMATED SYSTEMS

9 Hours

Introduction to CNC Systems- Types –Analogue, Digital, Absolute and Incremental- Open Loop and Closed Loop - CNC Drives and Feedback Devices. Material Transport Systems – Process Monitoring – Conveyor Systems – Cranes and Hoists – Automated Storage and Retrieval Systems

OPTO ELECTRONIC DEVICES

9 Hours

Opto-Electronic devices and control , electronic circuits for photo-electric switches-output signals for photo-electric controls; Applications of opto-isolation, interrupter modules and photo sensors; Fibre-optics; Bar code equipment, application of barcode in industry.

INDUSTRIAL APPLICATIONS

9 Hours

Industrial Control Applications- Cement Plant – Thermal Plant- Water Treatment Plant- Steel Plant- Paper Industry.

Theory:45 Hrs

Total: 45 Hrs

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REFERENCES

1. Krishna Kant, “Computer-Based Industrial Control”, 2nd Edition, Prentice Hall of India, 2010.
2. Gray Dunning, “Introduction to Programmable Logic Controllers”, 3rd Edition, Delmar Publishers, 2007.
3. Frank D. Petruzella, “Programmable Logic Controllers”, 3rd Edition, McGraw Hill, 2010.
4. Michael Jacob, “Industrial Control Electronics – Applications and Design”, Prentice Hall, 1995.
5. Mikell P. Groover, “Automation, Production Systems and Computer Integrated Manufacturing”, 3rd Edition, Pearson Education, 2008.

P15PETE05 ELECTRIC AND HYBRID VEHICLES

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Understanding the basics of various aspects of hybrid and electric drive train such as their configuration, types of electric machines.

CO2: Analyze the characteristics and performance of hybrid and electric drive train using both dc and ac drives.

CO3: Apply the various energy management strategies to hybrid and electric vehicle.

PRE-REQUISITE

1. Power Conversion Techniques
2. Electrical Machines

OVERVIEW OF HYBRID VEHICLES

9 Hours

History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance.

ELECTRIC TRACTION

9 Hours

Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel

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efficiency analysis. Basic concepts of electric traction, introduction to various electric drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

MOTOR DRIVES

9 Hours

Introduction to electric components used in hybrid and electric vehicles, configuration and control of DC Motor drives, configuration and control of Introduction Motor drives, configuration and control of Permanent Magnet Motor drives, configuration and control of Switch Reluctance Motor drives, drive system efficiency.

HYBRID METHODS

9 Hours

Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, communications, supporting subsystems

ENERGY MANAGEMENT

9 Hours

Introduction to energy management strategies used in hybrid and electric vehicle, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy strategies.

Theory:45 Hrs

Total: 45 Hrs

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REFERENCES

1. Sira -Ramirez, R. Silva Ortigoza, “Control Design Techniques in Power Electronics Devices”, Springer, 2006.
2. Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, “Sliding mode control of switching Power Converters”, CRC Press, 2011.
3. Bimal K. Bose, “Power Electronics and Motor Drives”, Elsevier, 2006.
4. Ion Boldea and S.A Nasar, “Electric Drives”, CRC Press, 2005.

**P15PETE06 HIGH VOLTAGE DIRECT CURRENT
TRANSMISSION**

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

- CO1:** Compare HVAC and HVDC transmission based on reliability, technical performance and economic aspects.
- CO2:** Choose the best converter configuration for any pulse number
- CO3:** Analyze the working of Graetz circuit, with and without overlap.
About all the harmonics components of a typical HVDC system.
About the various simulation models of HVDC system valves

PRE-REQUISITE

1. Transmission and Distribution
2. Analysis of Power Converters and Inverters

DC POWER TRANSMISSION TECHNOLOGY

9 Hours

Introduction-comparison of AC and DC transmission application of DC transmission – description of DC transmission system planning for HVDC transmission-modern trends in DC transmission.

ANALYSIS OF HVDC CONVERTERS

9 Hours

Pulse number, choice of converter configuration-simplified analysis of Graetz circuit converter bridge characteristics – characteristics of a twelve pulse converter-detailed analysis of converters.

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CONVERTER AND HVDC SYSTEM CONTROL

9 Hours

General principles of DC link control-converter control characteristics-system control hierarchy-firing angle control-current and extinction angle control-starting and stopping of DC link-power control-higher level controllers-telecommunication requirements.

HARMONICS AND FILTERS

9 Hours

Introduction-generation of harmonics-design of AC filters-DC filters-carrier frequency and RI noise.

SIMULATION OF HVDC SYSTEMS

9 Hours

Introduction-system simulation: Philosophy and tools-HVDC system simulation modeling of HVDC systems for digital dynamic simulation.

Theory:45 Hrs

Total: 45 Hrs

REFERENCES

1. Padiyar, K.R., “HVDC Power Transmission System”, 2nd Edition, New Age International, 2011.
2. Rakosh Das Begamudre, “Extra high voltage AC transmission engineering”, 4th Edition, New Academic Science, 2011, New Delhi.
3. Arrillaga, J., “High Voltage Direct Current Transmission”, 2nd Edition, Peter Peregrinus, 1988, London.
4. S.Kamakshaiah, V. Kamaraju, “HVDC Transmission”, 5th Edition, Tata McGraw Hill, 2013.

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P15PETE07

POWER QUALITY

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: To understand the various power quality issues and mitigation techniques.

CO2: To be familiar with the conventional compensation techniques and active compensation techniques used for power factor correction and load voltage regulation.

CO3: To know the working of various power quality meters.

PRE-REQUISITE

1. Power System Analysis
2. Power Electronics

INTRODUCTION TO POWER QUALITY

9 Hours

Terms and definitions: Overloading, under voltage, sustained interruption; sags and swells; waveform distortion, Total Harmonic Distortion (THD), Computer Business Equipment Manufacturers Associations (CBEMA) curve.

VOLTAGE SAGS AND INTERRUPTIONS

9 Hours

Sources of sags and interruptions, estimating voltage sag performance, motor starting sags, estimating the sag severity, mitigation of voltage sags, active series compensators, static transfer switches and fast transfer switches.

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OVERVOLTAGES

9 Hours

Sources of over voltages: Capacitor switching, lightning, ferro resonance; mitigation of voltage swells: Surge arresters, low pass filters, power conditioners – Lightning protection, shielding, line arresters, protection of transformers and cables, computer analysis tools for transients, PSCAD and EMTP.

HARMONICS

9 Hours

Harmonic distortion: Voltage and current distortion, harmonic indices, harmonic sources from commercial and industrial loads, locating harmonic sources; power system response characteristics, resonance, harmonic distortion evaluation, devices for controlling harmonic distortion, passive filters, active filters, IEEE and IEC standards.

POWER QUALITY MONITORING

9 Hours

Monitoring considerations: Power line disturbance analyzer, per quality measurement equipment, harmonic / spectrum analyzer, flicker meters, disturbance analyzer, applications of expert system for power quality monitoring.

Theory:45 Hrs

Total: 45 Hrs

REFERENCES

1. Roger.C.Dugan, Mark.F.McGranagham, Surya Santoso, H.Wayne Beaty, “Electrical Power Systems Quality”, 3rd Edition, McGraw Hill, 2012.

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2. Math H J Bollen, “Understanding Power Quality Problem”, IEEE – Wiley, IEEE Press, 1999.
3. C. Sankaran, “Power Quality”, CRC press, 2002.
4. Alexander Kusko, “Power Quality in Electrical System”, CHIPS Press, 2007, Texas.
5. PSCAD User Manual.
6. Angelo Baghini, “Handbook of Power Quality”, Wiley.

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P15PETE08 **POWER ELCTRONICS IN WIND AND**
SOLAR POWER CONVERSION

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Choose a power converter for the control and conversion of wind and solar energy.

CO2: Use the skills, modern engineering tools necessary for engineering practice.

CO3: Design a system, component or process to meet desired needs.

PRE-REQUISITE

1. Power Electronics
2. Power Generation Systems
3. Renewable Energy Resources

INTRODUCTION

8 Hours

Trends in energy consumption - World energy scenario - Energy source and their availability – Conventional and renewable source - Need to develop new energy technologies- MNRE Rules and Regulations-TEDA-Wind and solar survey in India and World.

PHOTOVOLTAIC ENERGY CONVERSION

10 Hours

Solar radiation and measurements - Solar cells – Panels and their characteristics – Influence of insulation and temperature – PV arrays –

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Maximum power point tracking – Applications – Water pumping – Street lighting – DC-DC converters for solar PV systems.

WIND ENERGY SYSTEMS

8 Hours

Basic principle of Wind Energy Conversion System – Nature of Wind – Components of Wind Energy Conversion System –Generators for WECS- Classifications of WECS – Self excited induction generator - synchronous generator - Power conditioning schemes002E

GRID CONNECTED WECS AND SECS

11 Hours

Grid connectors – Wind farm and its accessories – Grid related problems – Generator control – Performance improvements - Different schemes – Matrix converters -Line commutated inverters- Multilevel inverters- Power converters for Grid connected WECS-Grid connected solar energy converter systems.

DISTRIBUTED POWER GENERATION SYSTEMS

8 Hours

Solar – PV – Hybrid systems – Selection of power conversion ratio – Optimization of system components – Storage - Reliability evolution – Types of Cogeneration processes – Power converters for distributed power systems.

Theory:45 Hrs

Total: 45 Hrs

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REFERENCES

1. S. Rao and B. B. Parulekar, “Energy Technology – Non Conventional, Renewable and Conventional”, 3rd Edition, Khanna Publishers, 1999, New Delhi.
2. Mukund R. Patel, “Wind and Solar Power Systems: Design, Analysis, and Operation”, 2nd Edition, CRC Press, 2005, London.
3. Ned Mohan Tore. M. Undeland, William. P. Robbins, “Power Electronics converters, Applications and design”, 3rd Edition, John Wiley and Sons, 2006.
4. M.H. Rashid, “Power Electronics Circuits, Devices and Applications”, 3rd Edition, Prentice Hall of India, 2004, New Delhi.
5. D. P. Kothari, K.C. Singal and Rakesh Ranjan, “Renewable Energy Sources And Emerging Technologies”, 2nd Edition, Prentice Hall of India, 2011, New Delhi.
6. Anbukumar kavitha and Govindarajan Uma, “Experimental Verification of Hopf Bifurcation in DC-DC Luo Converter”, Vol.23, No.6, IEEE Transactions on Power Electronics, 2008, pp. 2878-2883.
7. A. Mustafa, Al-Saffar, Esam H. Ismail, Ahmad J. Sabzali and Abbas A. Fardoun, “An Improved Topology of SEPIC Converter with Reduced Output Voltage Ripple”, Vol.23, No.5, IEEE Transactions on Power Electronics, September 2008, pp. 2377-2386

P15PETE09 **FLEXIBLE AC TRANSMISSION**
SYSTEM

| L | T | P | C |
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COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Understand the operation of shunt and series compensators

CO2: Suggest suitable FACTS controllers for power system stability improvement

CO3: Identify and overcome SSR problems using FACTS devices

PRE-REQUISITE

1. Power System Analysis
2. Power Converters
3. Power Inverters

FACTS INTRODUCTION

9 Hours

Introduction – Power flow control-Stability constraint of maximum transmission line loading-Reactive power constraint of maximum transmission line loading- Uncompensated line- Passive compensation.

SERIES COMPENSATORS

9 Hours

Objectives – Variable Impedance type series compensation – TCSC – TSSC switching converter type series compensators – SSSC

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SHUNT COMPENSATORS

9 Hours

Objectives of shunt compensation – Methods of controllable VAR generation – SVC and STATCOM – Saturated reactor – TCR – TSC – FCTCR

EMERGING FACTS CONTROLLERS

9 Hours

UPFC – Basic operating principles – Conventional transmission control capabilities – The Interline Power flow controller (IPFC) – Operating Principles - Control Structure

SPECIAL PURPOSE FACTS CONTROLLERS

9 Hours

Sub - Synchronous Resonance – NGH SSR damping scheme – TCBR – Thyristor controlled voltage limiter – Thyristor controlled voltage regulator – Thyristor controlled current limiter

Theory:45 Hrs

Total: 45 Hrs

REFERENCES

1. N. G. Hingorani, L. Gyugi, “Understanding FACTS - Concept and Technology of FACTS”, IEEE press books Standard Publishers distributors, 2001, New Delhi.
2. Mohan Mathur. R., Rajiv K. Varma, “Thyristor – Based FACTS Controllers for Electrical Transmission Systems”, IEEE press and John Wiley & Sons, Inc 2002.

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P15PETE10 ENERGY STORAGE SYSTEMS

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Know the energy storage schemes in electrical systems

CO2: Expose their knowledge in batteries, thermoelectric convertors

CO3: Demonstrate the different types and engineering issues in the fuel cells, super capacitors.

PRE-REQUISITE

1. Fundamental Chemistry
2. Material Science

OVERVIEW OF ENERGY SCENARIO

9 Hours

Prospect for both traditional and renewable energy sources - Detailed analysis of Indian energy market and future need through 2020 - energy, economic growth and the environment, implications of the Kyoto Protocol, and structural change in the electricity supply industry

STORAGE BATTERIES

9 Hours

Batteries - performance, charging and discharging, storage density, energy density, and safety issues, classical batteries - Lead Acid, Nickel-Cadmium, Zinc Manganese dioxide, and modern batteries -Zinc-Air, Nickel Hydride, Lithium Battery.

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THERMO ELECTRIC MATERIALS AND MEASUREMENT

9 Hours

Thermoelectric - electron conductor and phonon glass, classical thermoelectric materials (i) four-probe resistivity measurement, Seebeck coefficient measurement, and thermal conductivity measurement.

SUPER CAPACITORS

9 Hours

Super capacitors - types of electrodes and some electrolytes, Electrode materials – High surface area activated carbons, metal oxide and conducting polymers, Electrolyte - aqueous or organic, disadvantages and advantages of super capacitors - Compared to battery systems, applications - transport vehicles, private vehicles, and consumer electronics - energy density, power density, price, and market.

FUEL CELLS

9 Hours

Fuel cells - direct energy conversion - Maximum intrinsic efficiency of an electrochemical converter, physical interpretation - Carnot efficiency factor in electrochemical energy convertors, types of fuel cells - hydrogen oxygen cells, hydrogen air cell, alkaline fuel cell, and phosphoric fuel cell.

Theory:45 Hrs

Total: 45 Hrs

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REFERENCES

1. Tetsuya Osaka, Madhav Datta, “Energy Storage Systems for Electronics”, Gordon and Breach Science Publishers, 2000.
2. R. M. Dell, D.A.J. Rand, “Understanding Batteries”, RSC Publications, 2001.
3. James Larminie, Andrew Dicks, “Fuel Cell Systems Explained”, John Wiley, 2003.
4. D.M. Rowe, “Thermoelectrics Handbook: Macro to Nano”, CRC Press, 2006.

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P15PETE11

**WIND ENERGY CONVERSION
SYSTEMS**

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Expose their knowledge in wind turbines used in wind energy conversion system.

CO2: Demonstrate their knowledge in different systems used in wind energy conversion.

CO3: To expose the knowledge in grid connected wind energy systems.

PRE-REQUISITE

1. Electrical Machines
2. Renewable Energy Resources

INTRODUCTION

9 Hours

Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin's theory-Aerodynamics of Wind turbine

WIND TURBINES

9 Hours

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.

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FIXED SPEED SYSTEMS

9 Hours

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.

VARIABLE SPEED SYSTEMS

9 Hours

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG-PMSG -Variable speed generators modeling - Variable speed variable frequency schemes.

GRID CONNECTED SYSTEMS

9 Hours

Stand alone and Grid Connected WECS system-Grid connection Issues- Machine side & Grid side controllers-WECS in various countries

Theory:45 Hrs

Total: 45 Hrs

REFERENCES

1. L.L.Freris, "Wind Energy Conversion Systems", Prentice Hall, 1990
2. Ion Boldea, "Variable Speed Generators", Taylor & Francis group, 2006.
3. E.W.Golding, "The Generation of Electricity by Wind Power", Redwood burn, 1976, Trowbridge.
4. Siegfried Heir, "Grid Integration of Wind Energy Conversion Systems", 2nd Edition, Wiley, 2006.

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P15PETE12

INTELLIGENT CONTROL

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Explain the Artificial intelligence approach to Engineering problems.

CO2: Interpret intelligent control techniques to Engineering problem.

CO3: Design and Develop Intelligent controller for non linear system.

PRE-REQUISITE

1. Engineering Mathematics
2. Control Systems

SYSTEMS AND APPROACH

9 Hours

Approaches to intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule-based systems, the AI approach. Knowledge representation. Expert systems.

ARTIFICIAL NEURAL NETWORKS

9 Hours

Concept of Artificial Neural Networks and its basic mathematical model, McCulloch- Pitts neuron model, simple perceptron, Adaline and Madaline, Feed-forward Multilayer Perceptron. Learning and Training the neural network. Data Processing: Scaling, Fourier transformation, principal-component analysis and wavelet transformations. Hopfield network, Self-organizing network and Recurrent network. Neural Network based controller

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GENETIC ALGORITHM

9 Hours

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 and ant-colony search techniques for solving optimization problems.

FUZZY LOGIC SYSTEM

9 Hours

Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control. Fuzzification, inferencing and defuzzification. Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems. Self-organizing fuzzy logic control. Fuzzy logic control for nonlinear time-delay system.

FL AND NN APPLICATIONS

9 Hours

GA application to power system optimization problem, Case studies: Identification and control of linear and nonlinear dynamic systems using Matlab-Neural Network toolbox. Stability analysis of Neural-Network interconnection systems. Implementation of fuzzy logic controller using Matlab fuzzy-logic toolbox. Stability analysis of fuzzy control systems.

Theory:45 Hrs

Total: 45 Hrs

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REFERENCES

1. Jacek.M.Zurada, “Introduction to Artificial Neural Systems”, Jaico Publishing House, 2012.
2. Kosko, B. “Neural Networks and Fuzzy Systems”, Prentice Hall International, 2007.
3. Klir G.J. & Folger T.A. “Fuzzy sets, uncertainty and Information”, Prentice Hall of India, 2003.
4. Zimmermann H.J. “Fuzzy set theory-and its Applications”, Kluwer Academic Publishers, 2004.

P15PETE13 **DIGITAL CONTROL IN POWER**
ELECTRONICS

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

- CO1:** Design first order second order and zero order could transfer function for the given converters in Z-transform
- CO2:** Model the given type of AC/DC rectifier and DC/AC inverters in digital control
- CO3:** Model the given type of DC/DC converters and AC/AC converters in digital control and analyze the response of the system.

PRE-REQUISITE

1. Engineering Mathematics
2. Control Systems
3. Analysis of Power Converters and Inverters

MATHEMATICAL MODELING OF DIGITAL POWER 9 Hours
ELECTRONICS

Introduction - A zero-order hold (ZOH) for AC/DC controlled rectifiers - A first-order transfer function for DC/AC pulse-width-modulation - inverters - A second-order transfer function for DC/DC converters - A first-order transfer function for AC/AC (AC/DC/AC) converters - Open-loop Control for Digital Power Electronics - Introduction Stability analysis Unit-step function responses Impulse responses

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DIGITALLY CONTROLLED AC/DC RECTIFIERS **9 Hours**

Mathematical modeling for AC/DC rectifiers - Single-phase half-wave controlled AC/DC rectifier - Single-phase full-wave AC/DC rectifier - Three-phase half-wave controlled AC/DC rectifier - Three-phase full-wave controlled AC/DC rectifier - Three-phase double-anti-star with interphase - transformer - controlled AC/DC rectifier - Six-phase half-wave controlled AC/DC rectifier - Six-phase full-wave controlled AC/DC rectifier

DIGITALLY CONTROLLED DC/AC INVERTERS **9 Hours**

Mathematical modeling for DC/AC PWM inverters - Single-phase half-wave VSI - Single-phase full-bridge PWM VSI - Three-phase full-bridge PWM VSI - Three-phase full-bridge PWM CSI - Multistage PWM inverter - Multilevel PWM inverter

DIGITALLY CONTROLLED DC/DC CONVERTERS **9 Hours**

Mathematical modeling for power DC/DC converters - Fundamental DC/DC converter - Developed DC/DC converters - Soft-switching converters - Multi-element resonant power converters

DIGITALLY CONTROLLED AC/AC CONVERTERS **9 Hours**

Traditional modeling for AC/AC (AC/DC/AC) converters - Single-phase AC/AC converter - Three-phase AC/AC voltage controllers - SISO cyclo converters - TISO cyclo converters - TITO cyclo converters - AC/DC/AC PWM converters - Matrix converters - Closed-Loop Control for Digital

Power Electronics - Introduction - PI control for AC/DC rectifiers - PI control for DC/AC inverters and AC/AC (AC/DC/AC) - Converters - PID control for DC/DC converters

Theory:45 Hrs

Total: 45 Hrs

REFERENCES

1. Fang Lin Luo, Hong Ye, Muhammad Rashid, “Digital Power Electronics and Applications”, 1st Edition, ELSEVIER Academic Press, 2010.

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P15PETE14

**ADVANCED OPTIMIZATION
TECHNIQUES**

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Classify and design the optimization problem

CO2: Discriminate different types of advanced optimization techniques

CO3: Apply the optimization techniques to find the solution of engineering optimization problem

PRE-REQUISITE

1. Engineering Mathematics
2. Operations Research

INTRODUCTION

9 Hours

Introduction to Optimization- Concept of System and State- Performance Measure- Design Constraints- Condition for Optimality- Formulation of Objective Function-Classification of Optimization Problems.

NONLINEAR OPTIMIZATION TECHNIQUES

9 Hours

Optimization Techniques- Single Variable and Multi-Variable Optimization Techniques and Unconstrained Minimization- Golden section- Random Pattern and Gradient Search Methods- Interpolation Methods- Optimization with Equality and Inequality Constraints- Direct Methods- Indirect Methods using Penalty Functions- Lagrange Multiplier- Geometric Programming and Stochastic Programming.

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GENETIC ALGORITHM

9 Hours

Introduction to Evolutionary Computing- Genetic Algorithm- Biological Inspiration –Finer Evaluation- Selection methods- Reproduction- Genetic Operators- Cross Over- Mutation- Schema Processing- Fitness Scaling- Advanced Genetic Operators and Techniques in Genetic Search- Constrained Genetic Algorithms- Penalty Functions- Multi Objective Optimization- Applications in Pattern Recognition Computers, Communication and Signal Processing.

SIMULATED ANNEALING

9 Hours

Simulated Annealing- Algorithm- Initial Solution- Assess Solution- Randomly Tweak Solution- Acceptance Criteria- Temperature Schedule- Adjusting Algorithm Parameters-Application

ANT COLONY OPTIMIZATION AND TABU SEARCH

9 Hours

Ant Colony Optimization – Ant Algorithm- Natural Motivation- Initial Population- Ant Movement- Ant Town- Pheromone Evaporation – Adjusting Algorithm Parameters- Alpha(α)/Beta(β)/ Rho(ρ)- Number of Ants- Applications- Routing- Shortest Term Problem. Tabu Search- Principles- Short Term Memory- Long Term Memory- Tabu Thresholding- Special Dynamic Tabu Tenure Strategies- Hash Function.

Theory:45 Hrs

Total: 45 Hrs

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REFERENCES

1. Kalyonmoy Deb, “Optimization for Engineering Design”, 2nd Edition, Prentice Hall of India, 2012.
2. Pierre. D.A., “Optimization Theory with Applications”, John Wiley, 1969.
3. Rao.S.S. “Optimization Theory and Applications”, Wiley Eastern Ltd., 1979.
4. David.E.Goldberg, “Genetic Algorithms in Search, Optimization and Machine Learning”, International Student Edition, Addison Wesley Ltd., 1999.
5. Fred Glover, Manuel Laguna, “Tabu Search”, Kluwer Academic Publishers, 1997.
6. Tim Jones.M, “Artificial Intelligence Application Programming”, Dreamtech Press, 2003, New Delhi.
7. Sin Giresu. S. Rao, “Engineering Optimization”, John Wiley and Sons, 2009.

P15PETE15 ADVANCED EMBEDDED SYSTEMS

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

- CO1:** Distinguish between general purpose system and embedded system, classify various I/O devices and is able to interpret the protocols used in device communication
- CO2:** Outline RTOS concepts and able to apply the hardware and software knowledge to design and develop simple firmware modules.
- CO3:** Understand techniques for interfacing I/O devices to the embedded controller, including several specific standard I/O devices and will acquire the knowledge about different peripheral interfacing devices, their working and interfacing them with embedded controller.

PRE-REQUISITE

- 1. Microprocessors and Microcontrollers
- 2. Embedded Systems

INTRODUCTION AND REVIEW OF EMBEDDED HARDWARE 9 Hours

Terminology – Gates – Timing diagram – Memory – Microprocessor buses – Direct memory access – Interrupts – Built interrupts – Interrupts basis – Shared data problems – Interrupt latency - Embedded system evolution trends – Round-Robin – Round Robin with interrupt function – Rescheduling architecture – algorithm.

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REAL TIME OPERATING SYSTEM

9 Hours

Task and Task states – Task and data – Semaphore and shared data operating system services – Message queues timing functions – Events – Memory management – Interrupt routines in an RTOS environment – Basic design using RTOS.

EMBEDDED HARDWARE, SOFTWARE AND PERIPHERALS

9 Hours

Custom single purpose processors: Hardware – Combination Sequence – Processor design – RT level design – optimizing software: Basic Architecture – Operation – Programmers view – Development Environment – ASIP – Processor Design – Peripherals – Timers, counters and watch dog timers – UART – Pulse width modulator – LCD controllers – Key pad controllers – Stepper motor controllers – A/D converters – Real time clock.

MEMORY AND INTERFACING

9 Hours

Memory: Memory write ability and storage performance – Memory types – composing memory – Advance RAM interfacing communication basic – Microprocessor interfacing I/O addressing – Interrupts – Direct memory access – Arbitration multilevel bus architecture – Serial protocol – Parallel protocols – Wireless protocols – Digital camera example.

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CONCURRENT PROCESS MODELS AND HARDWARE 9 Hours
SOFTWARE CO - DESIGN

Modes of operation – Finite state machines – Models – HCFSL and state charts language – state machine models – Concurrent process model – Concurrent process – Communication among process –Synchronization among process – Implementation – Data Flow model. Design technology; Automation synthesis – Hardware software co-simulation – IP cores – Design Process Model.

Theory:45 Hrs

Total: 45 Hrs

REFERENCES

1. David. E.Simon, “An Embedded Software Primer”, Pearson Education, 2001.
2. Frank Vahid and Tony Gwargie, “Embedded System Design”, John Wiley & sons, 2002.
3. Steve Heath, “Embedded System Design”, 2nd Edition, Elsevier, 2004.

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P15PETE16

**VLSI DESIGN IN POWER
ELECTRONICS**

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Students able to understand the various steps of fabrication and characteristics of MOS transistor.

CO2: Students able to acquire the knowledge of layout design and CMOS switches

CO3: Students familiarize the VLSI design and simple system design and implementation through HDL.

PRE-REQUISITE

1. Microprocessors and Microcontrollers
2. Power Electronics

**VLSI DESIGN METHODOLOGY & MOS
TECHNOLOGY**

9 Hours

VLSI Design process - Architectural Design - Logical design - Physical design - Layout styles - Full custom - Semicustom approaches - An overview of wafer fabrication - Wafer processing - Oxidation- Patterning - Diffusion - Ion implantation - Deposition - Silicon gate nMOS process - CMOS processes - nWell - pWell - Twintub - Silicon on insulator.

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ELECTRICAL PROPERTIES OF MOS AND CMOS CIRCUITS **9 Hours**

MOS enhancement transistor - PMOS enhancement transistor - Threshold voltage - Threshold voltage equations - MOS device equations - Basic DC equations - Second order effects - MOS modules - Small signal AC characteristics - nMOS inverter - Steered Input to an nMOS inverter - Depletion mode and enhancement mode pullups - CMOS inverter - DC characteristics - Inverter delay - Pass transistor - Transmission gate.

MOS AND CMOS CIRCUIT DESIGN PROCESSES **9 Hours**

CMOS process enhancements - Interconnect - Circuit elements - Latch up - Latch up prevention techniques - Need for Layout design rules - Mead Conway design rules for the silicon gate nMOS process - CMOS nWell ,pWell design rules - Simple Layout examples - Sheet resistance - Area capacitance - Wiring Capacitance - Drive large capacitive loads.

LOGIC DESIGN **9 Hours**

Switch Logic - Pass Transistor and transmission gate - Gate Logic - Inverter - Two input NAND gate - NOR gate - Other forms of CMOS logic - Dynamic CMOS logic - Clocked CMOS logic - Precharged domino CMOS logic - Structured design - Simple combinational logic design examples - Parity generator - Multiplexers - Clocked sequential circuits - Two phase clocking - Charge storage - Dynamic register element - nMOS and CMOS - Dynamic shift register - Semi static register - JK flip flop circuit.

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VHDL PROGRAMMING

9 Hours

HDL introduction- top down approach - Y chart - VHDL constructs - data-types - array - package-conditional statements - case statement - generate statement - programs in digital circuits - time- PWM pulse generation- case study - design of inverter through VHDL.

Theory:45 Hrs

Total: 45 Hrs

REFERENCES

1. Douglas A Pucknell and Kamran Eshrarigian, “Basic VLSI Design”, 3rd Edition, Prentice Hall of India, 2004, New Delhi.
2. Neil H B West and Kamran Eshranghian, “Principles of CMOS VLSI Design: A system perspective Addison-Wesley”, 2nd Edition, India Reprint, 2000.
3. Amar Mukherjee, “Introduction to NMOS and CMOS VLSI system design”, Prentice Hall, 1996, USA.
4. Wayne Wolf, “Modem VLSI Design: Systems on Silicon”, 2nd Edition, Pearson Education, 2001.
5. Eugene D Fabricous, “Introduction to VLSI design”, McGraw Hill International Edition, 1990.

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P15PETE17

**ADVANCED DIGITAL SIGNAL
PROCESSING**

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: Acquire the basic concepts of discrete random signal processing

CO2: Estimate the spectrum and use the filters for noise cancellation and echo cancellation

CO4: Apply the basic concepts of multi-rate digital signal processing & wavelet transform

PRE-REQUISITE

1. Digital Signal Processing

DISCRETE RANDOM SIGNAL PROCESSING

9 Hours

Discrete Random Processes – Ensemble averages, stationary processes, Autocorrelation and Auto covariance matrices – Parseval’s theorem – Wiener-Khintchine relation – Power spectral density – Periodogram Spectral Factorization – Filtering random processes – Low pass filtering of white noise – Parameter estimation: Bias and consistency.

SPECTRUM ESTIMATION

11 Hours

Estimation of spectra from finite duration signals – Non- Parametric Methods – Correlation Method – Periodogram Estimator – Performance Analysis of Estimators – Unbiased, Consistent Estimators – Modified periodogram – Bartlett and Welch methods – Blackman – Tukey method - Parametric Methods – AR, MA, and ARMA model based spectral

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estimation – Parameter Estimation – Yule-Walker equations – Solutions using Durbin’s algorithm.

LINEAR ESTIMATION AND PREDICTION

8 Hours

Linear prediction – Forward and backward predictions – Solutions of the Normal equations – Levinson - Durbin algorithms – Least mean squared error criterion – Wiener filter for filtering and prediction – FIR Wiener filter and Wiener IIR filters – Discrete Kalman filter.

ADAPTIVE FILTERS

8 Hours

FIR adaptive filters – Adaptive filter based on steepest descent method – Widrow-Hoff LMS adaptive algorithm – Normalized LMS – Adaptive channel equalization – Adaptive echo cancellation – Adaptive noise cancellation – Adaptive recursive filters (IIR) – RLS adaptive filters – Exponentially weighted RLS – Sliding window RLS.

MULTIRATE DIGITAL SIGNAL PROCESSING

9 Hours

Mathematical description of change of sampling rate – Interpolation and Decimation – Decimation by an integer factor – Interpolation by an integer factor – Sampling rate conversion by a rational factor – Filter implementation for sampling rate conversion – Direct form FIR structures – Polyphase filter structures – Time variant structures – Multistage implementation of multirate system – Application to sub band coding – Wavelet transform and filter bank implementation of wavelet expansion of signals.

Theory:45 Hrs

Total: 45 Hrs

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REFERENCES

1. Monson H. Hayes, “Statistical Digital Signal Processing and Modeling”, Wiley India, 2008.
2. John G. Proakis and Dimitris G. Manolakis, “Digital Signal Processing”, 4th Edition, Prentice Hall of India, 2006, New Delhi.
3. John G. Proakis, Charles M. Rader, “Algorithms for Statistical Signal Processing”, Pearson Education, 2002, New Delhi.

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P15PETE18

**MICROCONTROLLER AND DSP
BASED SYSTEM DESIGN**

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COURSE OUTCOMES

After successful completion of this course, the students should be able to

CO1: To increase understanding and aid- retention of student to come up with good knowledge to cope up with recent trends and makes a remarkable impact on global economy.

CO2: Contemporary issues could be resolved using knowledge of Digital Signal Processing.

CO3: An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

PRE-REQUISITE

1. Microprocessor and Microcontroller
2. Digital Signal Processing

MICRO CONTROLLER AND INTERFACING

9 Hours

Overview of 8051 Microcontroller – Interfacing of ADC, DAC, LCD, RTC – Typical applications- DC motor speed control, speed measurement, Stepper motor control.

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PIC MICROCONTROLLER

9 Hours

PIC Processors - RISC concepts - PIC processors- overview-16F877 - Architecture – Elementary Assembly Language Programming- Interrupts – Timers – Memory – I/O ports – SPI – I²C bus - A/D converter - USART- PWM generation.

DSP ARCHITECTURE

9 Hours

DSP Architecture - Introduction to DSP architecture- computational building blocks - Address generation unit- Program control and sequencing- Speed issues- Harvard Architecture, Parallelism, Pipelining. TMS 320F2407- Architecture- Addressing modes- I/O functionality, Interrupts, ADC

DSP PERIPHERALS AND APPLICATIONS

9 Hours

Event managers- Elementary Assembly Language Programming- Typical applications-buck boost converter - Software and Hardware Development Tools - PWM generation.

REAL TIME SYSTEMS USING DSP

9 Hours

Voltage regulation of DC – DC converters – stepper motor and DC motor control – Space vector PWM generation for VSI

Theory:45 Hrs

Total: 45 Hrs

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REFERENCES

1. Mazidi & Mazidi, “Embedded System Design using 8051 Microcontroller”, 2nd Edition, Prentice Hall of India, 2005.
2. Ajay V Deshmukh, “Microcontrollers -Theory and Applications”, 1st Edition, Tata McGraw Hill, 2005, New Delhi.
3. Phillip A Laplante, “Real Time Systems Design and Analysis”, 4th Edition, John Wiley & Sons / IEEE Press, 2012.
4. Daniel W Lewis, “Fundamentals of Embedded Software”, 2nd Edition, Pearson Education, 2012.
5. Sen M Kuo, Woon Seng Gan, “Digital Signal Processors-Architecture, Implementation and Applications”, 1st Edition, Pearson Education, 2004.
6. H A Toliyat, S Campbell, “DSP Based Electro Mechanical Motion Control”, 1st Edition, CRC Press, 2003.
7. Avtar Singh, S Srinivasan, “Digital Signal Processing”, 1st Edition, Thomson / Brooks/ Cole, 2004.
8. Phil Lapsley, Bler, Sholam, E A Lee, “DSP Processor Fundamentals”, 2nd Edition, IEEE Press, 1997.

ONE CREDIT COURSES

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P15PEIN01

**DESIGN CONSIDERATION FOR
VARIABLE SPEED DRIVES**

Module I

Choosing the drive architecture – AC drive block diagram – BLDC drive block diagram

Module II

Components in drive systems

Module III

Selection of drive components – Thermal considerations

Theory:15 Hrs

Total: 15 Hrs

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P15PEIN02

**AUTOMOTIVE CONTROL
ELECTRONICS**

Engine Control Unit (ECU) – Safety and security systems –
Actuators and Embedded Control – Electric drives for automobiles –
Networking in Automobiles

Theory:15 Hrs

Total: 15 Hrs

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P15PEIN03

**DEVELOPMENT OF REGULATED
POWER SUPPLY CIRCUITS**

Classification and configuration of power supplies – Design and Practical consideration of SMPS – Design and Practical Consideration of UPS

Theory:15 Hrs

Total: 15 Hrs

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P15PEIN04 **BACKUP POWER SUPPLY SYSTEM**
FOR AERO APPLICATIONS

- Aero Electric power system
- Aircraft ground support system
- Backup Power Supply System

Theory:15 Hrs

Total: 15 Hrs

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