

National Institute of Technology Raipur												
Course of Study and Scheme of Examination							B. Tech. 8th Semester				Branch:Electrical	
S. No.	Subject Code	Subject Name	Periods per Week			TA	Examination Scheme				Total Marks	Credits
			L	T	P		MSE/MTR		ESE/ESVE			
							Theory	Prac.	Theory	Prac.		
1		Program Elective	3	0	0	20	30		50		100	3
2		Program Elective	3	0	0	20	30		50		100	3
3		Open Elective	3	0	0	20	30		50		100	3
4		Open Elective	3	0	0	20	30		50		100	3

Program Electives	
Subject Code	Name of Subject
EL108201EL	Process Control
EL108202EL	Advanced Control System
EL108203EL	Electrical Machine Design
EL108204EL	Installation, Maintenance and Testing of Electrical Apparatus
EL108205EL	Advanced Electric Drives
EL108206EL	Power Converter Design
EL108207EL	Industrial Electronics
EL108208EL	Power System Dynamics
Open Electives	
Subject Code	Name of Subject
EL108301EL	Industrial Drives
EL108302EL	Illumination Engineering
EL108303EL	Energy Audit, Conservation and Management
EL108304EL	Introduction to Hybrid and Electric Vehicles
EL108305EL	Medical Signal & Image Processing
EL108305EL	PLC and SCADA

# Process Control

[8th Semester, Fourth Year]

**Course Description**

**Offered by Department**

Electrical

**Credits**

3-0-0, (3)

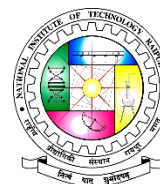
**Status**

Program Elective

**Code**

EL108201EL

[Pre-requisites: Control System Engineering (EL105101EL)]



## Course Objectives

1. To understand the various process and their control in industries.
2. To develop the knowledge of advanced control strategies with their applications.

## Course Content

### Unit 1 Process control introduction

Process variables, Signs & Symbols used in Process industries, classification of variables, Process Characteristics, Constraints in implementation of process control, terms used in process control, process measurement, Comparison of P, I, D, PI, PD, & PID controllers.

### Unit 2 Generation of control action in electronic and pneumatic controllers

Control valves, valve positioner, relief and safety valves, relays, volume boosters, pneumatic transmitters for process variable, Tuning of controllers–Zeigler Nichols and other techniques.

### Unit 3 Different control techniques and interaction of process parameters

Feed forward, cascade, ratio, override controls, batch continuous process controls, Feed forward Control scheme.

### Unit 4 Various process schemes / unit operations and their control schemes

Distillation columns, absorbers, heat exchangers, furnaces, reactors, mineral processing industries, etc. Use of control schemes for process optimization.

### Unit 5 Advanced control strategies with case studies

Use of DDC and PLC, Introduction to supervisory control, Conversion of existing control schemes in operating plants, data loggers.

## Course Materials

### Required Text: Textbooks

1. Dale Patrick, Stephen Fardo, "Industrial Process Control system", Delmar Cengage Learning, 2nd edition 1997.
2. R. P. Vyas, "Process Control and Instrumentation", Denett & Co., 7th edition, 2015.
3. Donald R Coughanower, Steven E LeBlanc, "Process System Analysis & Control", McGraw Hill Education, Third edition, 2017.
4. B. Wayne Bequette, "Process control, modeling, Design and simulation", Prentice Hall of India (P) Ltd., 2003.

### Optional Materials: Reference Books

1. Curtis d Jonson, "Process Control Instrumentation Technology", Pearson, 8th edition, 2015.
2. Surekha Bhanot, "Process Control: Principles and Applications", Oxford University Press, 2008.
3. Bela G. Liptak, "Instrument Engineers' Handbook, Volume Two: Process Control and Optimization", CRC.
4. D. Patranabis, "Principles of Process Control", McGraw Hill Education, 3rd edition, 2017.
5. D. P. Eckman, "Automatic Process control", Wiley India Pvt. Ltd, September 2009.
6. S. K. Singh, "Process Control: Concepts, Dynamics and Applications", Prentice Hall India Learning Private Limited, 2009.
7. S. Sundaram, "Process Dynamics and Control", Cengage, 1st edition, 2012.

**Mapping of course outcomes with program outcomes**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>
<b>CO1</b>	3	1	1	1	3	2	2	1	1	2	2	2
<b>CO2</b>	3	3	2	3	3	3	3	1	1	1	2	3

**Mapping of course outcomes with program specific outcomes**

	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>
<b>CO1</b>	3	2	1
<b>CO2</b>	3	3	2

# Advanced Control System

[8th Semester, Fourth Year]



## Course Description

### Offered by Department

Electrical Engineering

### Credits

3-0-0, (0)

### Status

Program Elective

### Code

EL108202EL

[Pre Requisite-Control System Engineering(EL105101EL)]

## Course Objectives

Making students

- Understand the working of various engineering system using modern modeling tools.
- Understand and apply the advanced concepts in controller design.

## Course Content

### UNIT I:

Non-Linear Control System Introduction, some common types of nonlinearities, comparison of linear and non-linear systems, properties of non-linear control systems, describing functions, stability analysis using describing functions, limit cycle, Lyapunov Stability Analysis of Linear and Nonlinear Systems, Second method of Lyapunov with four stability theorems.

### UNIT II:

State Space Analysis Basics: State and its non-uniqueness, Eigen values and its invariance, Diagonalization and Jordan canonical form, Cayley- Hamilton theorem, Computation of state transition matrix by (a)Inverse Laplace method (b)Cayley Hamilton method and (c) other methods. Controllability and observability of time invariant systems, State equations in CCF, OCF and Diagonal Canonical form, Decompositions of Transfer Functions, Effect of Pole-Zero cancellation in Transfer Function.

### UNIT III:

Control System Design by State Space Pole placement design, Ackermann's Formula for pole placement, Design of full and reduced order state observers, Design of Servo system.

### UNIT IV:

Discrete System Control Introduction, Impulse sampling and Data Hold, Reconstructing original signals from sampled signals, Pulse Transfer Function, Mapping between the s-plane and the z-plane, Dominant pole, Characteristic equation, Roots, Stability Analysis using Bilinear transformation Method of Jury's stability test, Solution of discrete time state equations.

### UNIT V:

Optimal Control Systems Parametric optimization problem using second method of Lyapunov, Quadratic optimal control problems, Matrix Riccati equation, Alternate approach to determine optimal feedback gain matrix, Solving optimal control problems using Hamiltonian and Pontryagin's Maximum Principle

## Course Materials

Test Books:

1. "Modern Control Systems Engineering", Ogata, PHI.
2. "Digital Control Systems", Benjamin. C Kuo; Oxford University Press, Second edition.
3. "Digital Control and State Variable Methods", M Gopal, McGraw Hill, Fourth Edition
4. "Linear Systems", Thomas Kailath, Prentice-Hall, 1980. ISBN: 0-13-536961-4.

## Course Outcomes(CO)

1. Analyse the response and stability of LTI systems in time domain using state equations.
2. Design state feedback controllers and observers to improve the response of LTI systems.
3. Describe the behavior and evaluate the stability of nonlinear systems.
4. Appreciate the significance of digital control in industrial applications
5. Infer the requirement of optimal control for meeting the design specifications in industrial control systems

### Mapping and Correlation of COs with POs

	PO1	PO2	PO3	PO4	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3		2	2		1			2	2	1	3
CO2	3	3	3	2	2	3	1	1	2	1		1	3
CO3	3	3		2	2		1			2	2	1	3
CO4	3	3	3	2	3	3	1	3	2	1		2	3
CO5	3	3	3	2	3	3	1	3		1		3	3

### Mapping and Correlation of COs with PSOs

	PSO1	PSO2	PSO3
CO1	3	1	1
CO2	3	3	2
CO3	3	1	1
CO4	3	3	2
CO5	3	3	1

# Electrical Machine Design



[8th Semester, Fourth Year]

## Course Description

<b>Offered by Department</b>	<b>Credits</b>	<b>Status</b>	<b>Code</b>
Electrical Engineering	3-0-0, (3)	Program Elective	EL108203EL

[Pre-requisites: Electrical Machines-II (EL105102EL)]

## Course Objectives

1. To impart the basic knowledge of design of the Electrical and Magnetic circuits.
2. To understand the design of DC machines.
3. To impart basic knowledge of design of transformers and AC machines.

## Course Outcomes( Cos)

1. Students can understand the importance of choice of Electrical Engineering Materials and various design criteria of electrical machines.
2. Student would be able to understand the performance prediction of electrical machines using design values.
3. Student would be able to learn about the design of electrical machines and their KVA outputs.
4. Student can analyse the various operating characteristics of electrical machines.
5. Student can study the temperature rise characteristics and methods of cooling of electrical machines.

## Course Content

### Unit 1 Introduction

Major considerations in Electrical Machine Design, Electrical Engineering Materials, Space factor, Choice of specific Electrical and Magnetic loadings, Thermal considerations, Heat flow, Temperature rise, Rating of machines, Standard specification.

DC Machines: Output Equations, Main dimensions, Magnetic circuit calculations, Carter's co-efficient, Net length of iron, Real and apparent flux density, Selection of number of poles, Design of armature, Design of commutator and brushes, Performance prediction using design values.

### Unit 2 Transformer

Output equations, Main dimensions, KVA output for single and three phase transformers, Window space factor, Overall dimensions, Operating characteristics, Regulation, No Load current, Temperature rise in transformers, Design of tank, Methods of cooling of transformers.

### Unit 3 Induction Motors

Output equation of induction motor, Main dimensions, Length of induction motor, Main dimensions, Length of air gap, Rules for selecting rotor slots of squirrel cage machines, Design of rotor bars and slots, Design of end rings, Design of wound rotor, Magnetic leakage calculations, Leakage reactance of poly-phase machines, Magnetizing current, Short circuit current, Circle diagram, Operating characteristics.

### Unit 4 Synchronous Machines

Output equations, Choice of loadings, Design of salient pole machines, Short circuit ratio, Shape of pole face, Armature design, Armature parameters, Equation of air gap length, Design of rotor, Design of damper winding, Determination of full load field MMF, Design of field winding, Design of turbo alternators, Rotor design.

## Course Materials

### Required Text: Textbooks

1. Sawhney, A.K., "A course in Electrical Machine Design", Shree Hari Publications, 2019.
2. Say, M.G., "The Performance and Design Of Alternating Current Machines", CBS, 2002.

### Optional Materials: Reference Books

1. Albert E. Clayton and Hancock, N.N, "The performance and Design of Direct Current Machines", CBS, 2004.
2. Shanmugasundaram A., "Electrical Machine Design Data Book", New Age International Private Limited, Second edition, 2015.
3. M. Ramamoorthy, "Computer aided Design of Electrical Equipment", East West Press Pvt. Ltd. Madras, 2008.

**Mapping and Correlation of COs with  
POs**

<b>COs \ POs</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>
<b>CO1</b>	3	3	2	2	3							2
<b>CO2</b>	3	2	3	3	3							2
<b>CO3</b>	2	2	2	2	3							2
<b>CO4</b>	3	3	2	2	3							2
<b>CO5</b>	3	2	1	1	3							2

# Installation, Maintenance and Testing of Electrical Apparatus

[8th Semester, Fourth Year]



## Course Description

Offered by Department	Credits	Status	Code
Electrical Engineering	3-0-0, (3)	Program Elective	EL108204EL
[Pre-requisites: Electrical Power System (EL103105EL), Electrical Measurement and Instrumentation (EL103101EL), Electrical Machine -II (EL105102EL)]			

## Course Objectives

To impart the knowledge in the field of installation, commissioning, maintenance and testing of electrical equipments/machines.

## Course Content

### Unit 1 Installation of Electrical Equipments

Introduction to various electrical apparatus, Unloading of electrical equipment at site, Inspection, Storage, Foundation, Alignment of electrical machines, Tools/Instruments necessary for installation, Inspection, storage and handling of transformer, switchgear and induction motor.

### Unit 2 Commissioning and Testing of Electrical Equipments

Various instruments required for testing, Tests before commissioning of electrical equipment : Electrical and Mechanical test, Specific tests on transformer, induction motor, alternator, Need of gradually loading of electrical equipment, Preparations before commissioning of power transformer, Commissioning power transformer, three phase induction motor, Transformer insulation oil: Properties as per IS, sampling, testing and filtering/purifying, standard tests as per IS, Measurement of insulation resistance.

### Unit 3 Maintenance of Electrical Equipments

General aspect of maintenance, Classification, Preventive maintenance concept, advantages, functions of the Maintenance Department, Breakdown maintenance concept, Reasons of failure of electrical equipment due to poor maintenance, Factors for preparing maintenance schedule, Frequency of maintenance, Maintenance schedule of transformer, induction motor, circuit breaker, overhead line storage Battery, Probable faults due to poor maintenance in various electrical apparatus.

### Unit 4 Troubleshooting

Causes of fault in electrical equipments Internal and external, Instruments and tools for troubleshooting, Common troubles in electrical equipment DC Machines, AC Machines, Transformers, Circuit breaker, underground cable, electrical Installation Need of trouble shooting chart, advantages, Troubleshooting chart DC Motor, DC Generator, Transformer, Synchronous Motor, Induction Motor, Circuit breaker, Troubleshooting chart for Domestic appliances electrical iron, ceiling fan, Washing machine, Air cooler, Vacuum cleaner.

### Unit 5 Electrical accidents and safety

Causes of electrical accidents, Factors affecting the severity of electrical shock, Actions to be taken when a person gets attached to live part, Safety regulations and safety measures, Indian electricity supply act 1948, 1956, Factory act 1948, Procedure of shut down for substation and power lines, Permit to work : certificate of (i) requisition for shut down, (ii) Permit to work and (iii) Line clear certificate, Instruction for the safety of persons working on a job with a permit to work, Fire extinguishers- For fixed installation and portable devices.

## Course Materials

### Required Text: Textbooks

1. Rao. S, "Testing Commissioning operation and maintenance of Electrical Equipments", Khanna Publishers, 6th edition, 1991.
2. Wadhwa C.L., Electrical power systems, New Age Internationals, First Edition, 2016.

### Optional Materials: Reference Books

1. Singh Tarlok, Installation, commissioning and maintenance of Electrical equipment, S.K. Kataria & Sons, Reprint 2013 edition, 2013.
2. Relevant IS Code for-Installation, maintenance and commissioning of electrical equipments/machines- Latest code M., Wiley-IEEE Press, 1998.



**Course Outcomes:**

After the completion of the course the student will be able to :

1. Understand various steps involved in installation of different electrical apparatus.
2. Know about various tests to be carried out before commissioning of electrical equipment.
3. Learn about the commissioning process of different electrical equipments.
4. Understand the Routine, Preventive and Breakdown Maintenance of electrical equipment.
5. Know about troubleshooting and causes of accidents and safety measures.

**Mapping of COs and POs**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>
<b>CO1</b>	3	3	3	3	3	3	3	1	1	2	1	2
<b>CO2</b>	3	3	3	3	3	3	3	1	1	2	1	2
<b>CO3</b>	3	3	3	3	3	3	3	1	1	2	1	2
<b>CO4</b>	3	3	3	3	3	3	3	1	1	2	1	2
<b>CO5</b>	3	3	3	3	3	3	3	1	1	2	1	2

**Mapping of COs and PSOs**

	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>
<b>CO1</b>	3	2	2
<b>CO2</b>	3	2	2
<b>CO3</b>	3	2	2
<b>CO4</b>	3	2	2

# Advanced Electric Drives



[8th Semester, Fourth Year]

## Course Description

Offered by Department	Credits	Status	Code
Department of Electrical Engg	3-0-0, (3)	Program Elective	EL108205EL

[Pre-requisites: Power Electronics (EL104103EL), Electrical Machines-III (EL106103EL)]

## Course Objectives

- Study about the separately excited DC motor drives in steady state and dynamic conditions
- Study about the scalar and vector control of IM drives
- Study about the PMSM drives, BLDC drives and SRM drives

## Course Content

### Unit-1 Separately Excited DC-motor Drives:

Study of Dynamics of DC motor through state-space Model, Simplified Model of a Power Converter, Review of controllers, need for anti-windup feature for integral controllers, Speed control of a separately excited DC drive with inner current loop and outer speed loop, Design of current loop with pole-zero cancellation, Design of speed loop with symmetrical optimization technique.

### Unit-2 Induction Motor drives:

Implementation of V/f control with slip compensation scheme, PWM and transformation - abc, alpha-beta and d-q, Modelling of inverter using switching function, Inverters. Review of dq0 model of 3-Ph IM with simulation studies, Principle of vector control of IM, Indirect vector control, Direct Torque Control of Induction Motor Drives Inverter.

### Unit-3 Permanent Magnet Drives:

PM Synchronous motors: Types, Construction, operating principle, Expression for torque, Model of PMSM, Implementation of vector control for PMSM, Introduction to BLDC drives.

### Unit-4 Switched Reluctance Motor Drives:

Review of Switched Reluctance Motor, converters for SRM drives, Control of SRM drives with hard and soft chopping techniques.

## Course Materials

### Required Text: Textbooks

1. Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, Analysis of Electric Machinery & Drive Systems, IEEE Press, 3<sup>rd</sup> Edition.
2. B.K. Bose, Modern Power Electronics & AC Drives, Pearson, First edition.
3. R. Krishnan, Electric Motor Drives: Modeling, Analysis and Control, Prentice Hall.
4. Peter Vas, Vector Control of Electric Drives, Oxford Publishers.

### Optional Materials: Reference Books

1. Bin-Wu, High-power Converters and AC Drives, IEEE Press, John Wiley & Sons
2. M. B. Patil, V. Ramanarayanan, V.T. Ranganathan, Simulation of Power Electronic Circuits, Narosa Publications, 2013.

## Course Outcomes

On completion of this course, the students will be able to:

- |     |  |
|-----|--|
| CO1 | Analyze and design separately excited DC motor drives in steady state and dynamic conditions           |
| CO2 | Analyze the steady state behaviour of induction motor drives with scalar and vector control            |
| CO3 | Analyze the permanent magnet drives and BLDC drives and to implement the vector control for PMSM drive |
| CO4 | Analyze SRM drives and to implement various chopping techniques used in control of SRM.                |

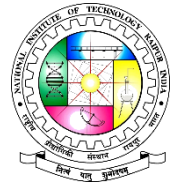
### Mapping of COs and POs

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>
CO1	3	3	3	3	2	1	2	-	-	-	-	3
CO2	3	3	3	3	3	1	2	-	-	-	-	3
CO3	3	3	3	3	3	1	2	-	-	-	-	3
CO4	3	3	3	3	3	1	2	-	-	-	-	3

### Mapping of COs and PSOs

	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>
<b>CO1</b>	3	1	1
<b>CO2</b>	3	1	1
<b>CO3</b>	3	1	1
<b>CO4</b>	3	1	1

# Power Converter Design



[8th Semester, Fourth Year]

## Course Description

Offered by Department

Electrical

[Pre-requisites: Power Electronics]

Credits

4-0-0, (4)

Status

PE

Code

EL108206EL

## Course Objectives

1. To understand the operations of different power converters
2. To enhance the knowledge of practical issues of power converters
3. To impart the ability of designing of converters for different applications

## Course Content

### Unit 1 AC – DC Converter

Switched mode AC-DC converters, Synchronous rectification – single and three phase topologies – switching techniques – high input power factor, reduced input current harmonic distortion. Improved efficiency with and without input-output isolation, performance indices design examples.

### Unit 2 DC-DC Converter

DC Power supplies and Classification; Switched mode dc power supplies - with and without isolation, single and multiple outputs; Closed loop control and regulation; Design examples on converter and closed loop performance.

### Unit 3 Multilevel Inverter

Concept, classification of multilevel inverters, Principle of operation, main features and analysis of Diode clamped, Flying capacitor and cascaded multilevel inverters, Modulation schemes.

### Unit 4 AC – AC Converter

Matrix converters. Basic topology of matrix converter; Commutation current path; Modulation techniques - scalar modulation, indirect modulation; Matrix converter as only AC-DC converter; AC-AC converter with DC link - topologies and operation - with and without resonance link -converter with dc link converter; Performance comparison with matrix converter with DC link converters.

### Unit 5 Soft-Switching Power Converters

Soft switching techniques. ZVS, ZCS, quasi resonance operation; Performance comparison hard switched and soft switched converters: AC-DC converter, DC-DC converter, DC-AC converter, Resonant DC power supplies. Design of Power Converters Components: Design of magnetic components-design of transformer - Design of Inductor and current transformer - Selection of filter capacitors - Selection of ratings for devices - input filter design - Thermal design.

## Course Materials

### Required Text: Text books

1. M.H.Rashid, Butterworth-Heinemann, "Power Electronics Handbook", 4th edition, 2017.
2. Fang Lin Luo, Fang Lin Luo, "Advanced DC/DC Converters", CRC Press, 1st edition, 2003.
3. Marian P.Kazmierkowski, R.Krishnan, FredeBlaabjerg, "Control in Power Electronics- Selected Problem", Academic Press, 1st edition, 2002.

### Optional Materials: Reference Books

1. Issa Batarseh, "Power Electronic Circuits", John Wiley and Sons, Inc.2004.
2. Krein Philip T, "Elements of Power Electronics", Oxford University Press, Second edition, 2017.
3. Robbins Mohan, Undeland, "Power Electronics: Converters, Applications, and Design", Wiley, Third edition, 2007.
4. L. Umanand, "Power Electronics: Essentials and Applications", Wiley, 2009.
5. Cyril W Lander "Power Electronics" McGraw-Hill Inc. US; 2nd edition.
6. B. K Bose "Modern Power Electronics and AC Drives" Pearson Education India, 1st edition, 2015.
7. Abraham I Pressman "Switching Power Supply Design" McGraw Hill Exclusive, CBS, 2015.
8. Daniel M Mitchell, "DC-DC Switching Regulator Analysis" McGraw Hill Publishing Company.

**Course Outcomes:**

**After the completion of the course the student will be able to**

1. Design rectifier with improved performance parameters.
2. Experiment on converter and it's closed loop performance.
3. Analyse multiinverter for grid integration.
4. Design advanced ac-ac converters wide range applications.

**Mapping of COs and POs**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>
<b>CO1</b>	3	3	3	3	3	2	2	2	1	1		3
<b>CO2</b>	3	3	3	3	3	2	2	2	2	2	2	3
<b>CO3</b>	3	3	3	3	3	3	3	3	2	2	2	3
<b>CO4</b>	3	3	3	3	3	3	3	3	2	2	2	3

**Mapping of COs and POs**

	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>
<b>CO1</b>	3	2	2
<b>CO2</b>	3	2	2
<b>CO3</b>	3	3	3
<b>CO4</b>	3	3	3

# Industrial Electronics

[8th Semester, Fourth Year]



## Course Description

Offered by Department	Credits	Status	Code
Electrical Engineering	3-0-0, (3)	Program Elective	EL108207EL

[Pre-requisites: Utilization of Electrical Energy(EL104105EL), PowerElectronics (EL104103EL)]

## Course Objectives

1. To acquire basic knowledge of various amplifiers and circuit operation.
2. To introduce different voltage control techniques in power converters and motor control.
3. To introduces various control scheme for traction system.

## Course Content

### Unit 1 Theory of Amplifiers

DC Amplifiers-Need for DC amplifiers, different terminologies of DC amplifiers, Darlington Emitter Follower, Cascade amplifier, Stabilization, DA with common current source, DA with common mode signal, Chopper stabilization, Operational Amplifiers, Ideal Specification of OP-Amp, Different terminologies, Instrumentation Amplifiers.

### Unit 2 Power Supply

Review of Diodes, SCR, performance parameter of power supply, Filtering, Voltage multiplier, regulated power Supply-Switched Mode & IC Regulators: Switched Mode voltage regulator, Servo Voltage Stabilizer, Fixed and Adjustable IC Voltage regulators, 3-terminal Voltage regulators, Uninterrupted power supply(Online, Offline).

### Unit 3 Motor Control

Voltage control at constant frequency, PWM control, Synchronous tap changer, Phase control of DC motor, Servomechanism, PLL control of a DC motor, recent advancement, and Applications.

### Unit 4 Conventional DC and AC Traction

Electric traction services, Load sharing between traction motors, important features of traction drives, Conventional DC and AC traction drives, recent technologies in traction system.

### Unit 5 Static converters for Traction

Semi-conductor converter-controlled drive for AC traction, Semiconductor chopper-controlled DC traction. Semi-conductor converter-controlled traction, advancement and applications.

## Course Materials

### Required Text: Textbooks

1. E. Openshaw Taylor, V. V. L. Rao, "Utilization of Electrical Energy", Universities Press.
2. Biswanath Paul, "Industrial Electronics and control:Including Programmable Logic Controller", Prentice Hall India Learning Private Limited, Third edition, 2014.

### Optional Materials: Reference Books

1. H.Partap , "Art and Science of Utilization of Electrical Energy", Dhanpat Rai & Sons, 2017.
2. E. Openshaw Taylor, "Utilisation of Electric Energy ", Orient Longman.
3. S. Sivanagaraju, " Generation and Utilization of Electrical Energy", Pearson Education, First edition 2010.

## Course Outcome:

On successful completion of the course the students will be able to:

1. Impart the basic knowledge of various amplifiers and its terminologies.
2. Understand the design concept of various power supplies used in industries and Labs.
3. Apply the knowledge of various control methods used in motors for railways and industries.
4. Illustrate the concept and application of converters in traction system.

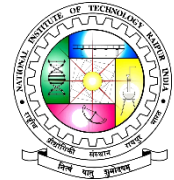
**Mapping of course outcomes with program outcomes**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>
<b>CO1</b>	2	3	3	2	2	1	1	3	2	1	2	3
<b>CO2</b>	3	3	3	3	2	2	1	3	3	1	2	3
<b>CO3</b>	3	3	3	3	2	2	1	3	3	1	2	3
<b>CO4</b>	3	3	3	3	2	2	1	3	3	1	3	3

**Mapping of course outcomes with program specific outcomes**

	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>
<b>CO1</b>	3	2	2
<b>CO2</b>	3	2	2
<b>CO3</b>	3	3	3
<b>CO4</b>	3	3	2

# Power System Dynamics



[8<sup>th</sup> Semester, Final Year]

## Course Description

Offered by Department	Credits	Status	Code
Electrical Engineering	3-0-0, (3)	Program Elective	EL108208EL

[Pre-Requisites-Electrical Power System (EL103105EL), Power System Analysis (EL105103EL)]

## Course Objectives

1. To understand power stability problems
2. To understand basic concepts of modeling and analysis of dynamical systems.
3. To develop Models of power system components - generators, transmission lines, excitation and prime mover controllers etc.
4. To analyze Stability of single machine and multi-machine systems using digital simulation and small-signal analysis techniques.
5. To determine the impact of stability problems on power systems.

## Course Content

### Unit –I: Introduction to Power System Stability

Definition of stability, classification of stability, Rotor angle stability, frequency stability, voltage stability, mid-term and long-term stability, classical representation of synchronous machine in a single machine infinite bus (SMIB) system, Modal Analysis of Linear Systems, Analysis using Numerical Techniques.

### Unit –II: Modeling of a Synchronous Machine

Physical Characteristics, Rotor Position Dependent model, D-Q Transformation, Model with Standard Parameters, Steady State Analysis of Synchronous Machine, Short Circuit Transient Analysis of a Synchronous Machine, Analysis of Synchronous Machine Connected to Infinite Bus.

### Unit –III: Modeling of Excitation, Prime Mover Systems, Transmission Lines and Loads

Physical Characteristics and Models for Excitation and Prime Mover Systems, Turbine governor, and exciter modeling, Control system components, Excitation System Controllers, Prime Mover Control Systems and their modeling, Transmission Line Modeling, Load Models.

### Unit –IV: Stability Analysis in Interconnected Power Systems

Stability of Single Machine Infinite Bus System and Multi-machine Systems, Stability of Relative Motion, Frequency Stability: Centre of Inertia Motion, Concept of Load Sharing: Governors, Power System Stability Analysis Tools, Transient Stability Program, Small Signal Analysis Program, Real-Time Simulators.

## Course Materials

### Required Text: Text books

1. Power System Dynamics, Stability & Control by K.R. Padiyar, B.S. Publications, Hyderabad.
2. Power System Stability and Control by P. Kundur, McGraw Hill Inc, New York.

### Optional Materials: Reference Books

1. Power System Dynamics & Stability by P. Sauer & M.A. Pai, Prentice Hall.
2. Power System Stability by Paul M. Anderson and A. A. Fouad, Wiley-interscience.
3. Power system stability by M. A. Pai and Peter W. Sauer, Pearson Education.



**Course Outcomes:**

On successful completion of the course the students will be able to:

1. Understand various types of stability of Power Systems and Develop dynamic mathematical modeling of a synchronous machine.
2. Describe and analyze the modeling of excitation and speed governing systems in a generator.
3. Analyze the small signal stability without controllers and with controllers.
4. Understand, Evaluate and apply various methods to enhance the stability of the power system.

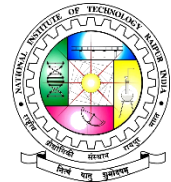
**Mapping of course outcomes with program outcomes**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>
<b>CO1</b>	3	3	2	2	3	1	1	2	2	2	2	3
<b>CO2</b>	2	2	3	2	2	2	2	1	2	2	2	3
<b>CO3</b>	3	3	3	3	3	1	1	1	2	1	1	3
<b>CO4</b>	3	3	2	3	3	1	2	1	2	2	3	2

**Mapping of course outcomes with program specific outcomes**

	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>
<b>CO1</b>	3	3	2
<b>CO2</b>	2	2	2
<b>CO3</b>	3	1	3
<b>CO4</b>	3	3	2

# Industrial Drives



[8th Semester, Fourth Year]

## Course Description

Offered by Department

Electrical

Credits

3-0-0, (3)

Status

Open Elective

Code

EL108301EL

[Pre-requisites: Basic Electrical Engineering (EL101022EL)]

## Course Objectives

1. To make the students significance of electrical drives in industry
2. To acquaint the students with the speed and torque control techniques.

## Course Content

### UNIT 1 Industrial Drives Fundamentals

Introduction, Classification of Industrial Drives, Requirements of Industrial Drives, Dynamics of Electrical Drives; Review of Torque-Speed Characteristics of DC and AC Motors including Motoring and Braking, Basics of Industrial Motor Control.

### Unit 2 DC Drives

Phase-Controlled DC Drives and control: Converter fed DC Drives; Control of DC Motor Drives; Torque Speed Characteristics of Converter-fed DC Drives, Chopper Controlled DC Drives (Single and Multi-quadrant Operation), Motoring and Braking operations, Ward Leonard Drive, Brushless DC motor Drives.

### Unit 3 AC Drives

Phase-Controlled AC Drives and control: Stator Voltage Control, Voltage Source Inverter (VSI) fed induction motor drive, Current Source Inverter (CSI) fed induction motor drive, Variable voltage variable frequency control of induction motor, Slip speed control of induction motor, Constant Volt/Hz control with slip speed regulation, Slip Power Recovery Scheme, Closed-loop control.

### Unit 4 Industrial Application of Electrical Drives

Electric Traction Drives: Requirement of Traction motors, Drives used Steel Mill, Cement Mill, Rolling Mill Drive, Kiln Drive, Textile Industry, Paper Industry, Crane Drives, Sugar Mill, Petrochemical Industry Losses in Electrical Drives, Energy efficient Operation of Drives, Improvement of power factor, Energy Savings with Variable Speed Drives Solar and Battery Powered Drives.

## Course Materials

### Required Text: Textbooks

1. Gopal K. Dubey, Narosa, "Fundamentals of Electrical Drives", Second Edition, 2010.
2. R. Krishnan, "Electric Motor Drives: Modeling, Analysis, and Control", Pearson Education India, 1st edition, 2015.
3. Vedam Subrahmanyam, "Electric Drives: Concepts and Applications", McGraw Hill Education, 2nd edition, 2017.
4. Theodore Wildi, "Electric Machines Drives and Power Systems", Pearson Education, 6th edition, 2013.

### Optional Materials: Reference Books

1. Ned Mohan, "Electric Machines and Drives: A First Course", Wiley, 2013.
2. Austin Hughes, "Electric Motors and Drives: Fundamentals, Types and Applications", Newnes (an imprint of Butterworth-Heinemann Ltd), 5th edition, 2019.
3. Juha Pyrhonen, Valeria Hrabovcova, R. Scott Semken, "Electrical Machine Drives Control: An Introduction", Wiley, 1st edition, 2016.

## Course Outcomes

1. Appraise the concept and different components of industrial drives and their role in our society.
2. Interpret the operating concept, control and analyze the performance of DC Drive systems.
3. Interpret the operating concept, control and analyze the performance of AC Drive systems.
4. To acquire the knowledge of different methods of speed control and braking of AC and DC drives and its influence on the operation of drives.
5. Infer the practical application, structure, different features, advantages of drives used in different industry.

**Mapping of the Course Outcome with Program Outcome**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>
<b>CO1</b>	3	3	3			3	2	2				3
<b>CO2</b>	3	3	3	3	3		2					3
<b>CO3</b>	3	3	3	3	3		2					3
<b>CO4</b>	3	3	3	3	3		2		1	1		3
<b>CO5</b>			3	3		3	3	2	3	1	2	3

**Mapping of the Course Outcome with Program Specific Outcome**

	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>
<b>CO1</b>	2	1	3
<b>CO2</b>	3	2	1
<b>CO3</b>	3	2	1
<b>CO4</b>	3	2	1
<b>CO5</b>	1	1	3

# Illumination Engineering

[8<sup>th</sup> Semester, Fourth Year]



## Course Description

Offered by Department

Electrical Engineering

[Pre-requisites: Basic Electrical Engineering EL101022EL]

Credits

4-0-0, (4)

Status

Open Elective (OE)

Code

EL108302EL

## Course Objectives

To make student understand the importance of illumination engineering in energy conservation and to guide them towards acquiring the knowledge regarding the fundamentals and elementary design aspects of artificial lighting.

## Course Content

### Unit-1 Fundamentals of illumination engineering:

Radiant energy, Nature of light, Plane angle, Solid angle, Relation between plane angle and solid angle, Luminous flux, Luminous intensity, Lumen, Candle power, Brightness or Luminance, Illumination, Uniform diffuse source, Mean horizontal candle power (M.H.C.P.), Mean spherical candle power (M.S.C.P.), Mean hemi-spherical candle power (M.H.S.C.P.), Reduction factor, Lamp efficacy, Specific consumption, Utilization factor, Space-height ratio, Coefficient of utilization, Maintenance factor, Depreciation factor, Waste light factor, Absorption factor, Beam factor, Reflection factor, Glare.

### Unit-2 Measurement and analysis of artificial lighting:

Laws of Illumination: inverse square law; cosine law; Lambert's law, Polar curves, Photometry: Photometer bench, Photometer heads, Lummer-bodhun photometer head, Flicker photometer, Integrating sphere, Illumination photometer, Energy radiation and luminous efficiency.

### Unit-3 Electric lamps

Incandescent lamp: heat radiation; filament materials; filament dimension measurement; coiled-coil filament; lamp characteristics, Arc lamp: carbon arc lamps; flame arc lamps; magnetic arc lamps, electric discharge lamps: excitation; ionization; lamps characteristics, Hot cathode lamp, Cold cathode lamp, Neon lamp, Sodium vapour lamp, Mercury vapour lamp, Halogen lamps, Fluorescent lamp: phosphor; starters; chokes; stroboscopic effect; its operation on DC, LEDs, LEDs in communication.

### Unit-4 Lighting fittings and schemes:

Requirements of good lighting, symmetrical fittings: A type fitting; B type fitting; C type fitting; D type fitting; E type fitting, Asymmetrical fittings, Factory lighting, Flood lighting, Street lighting: diffusion principle; specular reflection principle, Recommended illumination levels for different purposes.

## Course Materials

### Required Text: Text books

1. C.L. Wadhwa, "Generation, Distribution and Utilization of Electrical Energy", Revised 3<sup>rd</sup> Edition, 2012, New Age International Publisher
2. R. K. Rajpur, "Utilization of Electrical Power (including electric Drives and electric Traction)", 1<sup>st</sup> Edition, Reprint 2012, Laxmi Publications (P) LTD
3. 3. Chakrabarti, Soni, Gupta, Bhatnagar, "Power system Engineering", Dhanpatrai & Co., Second revised edition 2010, Reprint: 2014.

### Optional Materials: Reference Books

1. J.B. Gupta, R. Manglik, R. Manglik, "Utilisation of Electrical Energy and Traction", 1st Edition, 2012, S. K. Kataria and Sons
2. Tarlok Singh, "Utilization of Electric Energy", 2nd Edition, 2018, S.K. Kataria & Sons

## Course Outcomes

1. Apply an appropriate measurement and analysis technique of artificial lighting for different specific purposes.
2. Investigate on various types of electric bulbs as well as can evaluate their performance in terms of their colour rendering and luminous efficacy.
3. Develop a clear idea on various illumination techniques and hence can design lighting schemes for specific applications.
4. Select as well as apply an appropriate light fitting method for any specific application.

5. Identify, formulate, and figure out the need of research and development activities required for developing efficient artificial illumination.

**Mapping of course outcomes with program outcomes**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>
<b>CO1</b>	3	3	1	3	2	3	2	2	1	3	3	3
<b>CO2</b>	2	3	1	2	2	2	3	1	1	2	3	3
<b>CO3</b>	3	2	3	3	2	3	3	3	3	3	3	3
<b>CO4</b>	2	3	1	1	1	3	1	1	3	2	2	3
<b>CO5</b>	3	3	2	3	3	3	3	3	3	3	1	3

**Mapping of course outcomes with program specific outcomes**

	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>
<b>CO1</b>	3	2	2
<b>CO2</b>	2	2	2
<b>CO3</b>	3	3	3
<b>CO4</b>	2	2	2
<b>CO5</b>	3	3	3

# Energy Audit, Conservation and Management

[8th Semester, Fourth Year]



## Course Description

Offered by Department	Credits	Status	Code
Electrical Engineering	3-0-0, (3)	Open Elective	EL108303EL

[Pre-requisites: Utilization of Electrical Energy(EL104105EL)]

## Course Objectives

To know the necessity of conservation of energy, generalize the methods of energy management, illustrate the factors to increase the efficiency of electrical equipment, detect the benefits of carrying out energy audits.

## Course Content

### Unit 1 Basic Principles of Energy Audit

Energy audit- definitions, concept, types of audit, energy index, cost index, pie charts, Sankey diagrams, load profiles, Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit.

### Unit 2 Energy Management

Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting- Energy manager, Qualities and functions, language, Questionnaire – check list for top management.

### Unit 3 Energy Efficient Motors

Energy efficient motors, factors affecting efficiency, loss distribution, constructional details, characteristics – variable speed, variable duty cycle systems, RMS hp- voltage variation-voltage unbalance- over motoring- motor energy audit.

### Unit 4 Power Factor Improvement, Lighting and Energy Instruments

Power factor – methods of improvement, location of capacitors, power factor with nonlinear loads, effect of harmonics on power factor, power factor motor controllers – Good lighting system design and practice, lighting control, lighting energy audit – Energy Instruments- wattmeter, data loggers, thermocouples, pyrometers, lux meters, tongue testers, application of PLC's.

### Unit 5 Economic Aspects and Analysis

Economics Analysis-Depreciation Methods, time value of money, rate of return, present worth method , replacement analysis, life cycle costing analysis- Energy efficient motors- calculation of simple payback method, net present worth method- Power factor correction, lighting – Applications of life cycle costing analysis, return on investment .

## Course Materials

### Required Text: Textbooks

1. Energy Audit and Management, Volume-I, IECC Press.
2. Energy Efficiency in Electrical Systems, Volume-II, IECC Press.
3. W.R. Murphy, G. McKay Butter worth, " Energy management", Elsevier/bsp Books Pvt. Ltd., 2003.

### Optional Materials: Reference Books

1. Albert Thumann, P.E., C.E.M. William J. Younger, "Handbook of Energy Audits", River Publishers, 9th edition, 2012.
2. Paul o' Callaghan, "Energy management", McGraw-Hill Education, 1992.

**Course Outcomes:** After the completion of the course the student will be able to :

1. Understand the necessity of conservation of energy.
2. Know about various tests to be carried out for energy audit.
3. Lear about the methods of energy management.
4. Understand about Power Factor Improvement methods, Lighting and Energy Instruments.
5. Know about the Economic Aspects and Analysis.

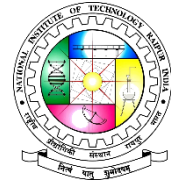
**Mapping of COs and POs**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>
<b>CO1</b>	3	3	3	3	3	3	3	1	1	2	1	2
<b>CO2</b>	3	3	3	3	3	3	3	1	1	2	1	2
<b>CO3</b>	3	3	3	3	3	3	3	1	1	2	1	2
<b>CO4</b>	3	3	3	3	3	3	3	1	1	2	1	2
<b>CO5</b>	3	3	3	3	3	3	3	1	1	2	1	2

**Mapping of COs and PSOs**

	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>
<b>CO1</b>	3	2	2
<b>CO2</b>	3	2	2
<b>CO3</b>	3	2	2
<b>CO4</b>	3	2	2

# Introduction to Hybrid and Electric Vehicles



[8th Semester, Fourth Year]

## Course Description

<b>Offered by Department</b>	<b>Credits</b>	<b>Status</b>	<b>Code</b>
Electrical Engineering	3-0-0, (3)	Open Elective	EL108304EL
[Pre-requisites: Basic Electrical Engineering (EL10I022EL)]			

## Course Objectives

1. To present a comprehensive overview of Electric and Hybrid Electric Vehicles.
2. To discuss electric propulsion system and its constituents.
3. To study about electric vehicle charging system and its configuration.

## Course Content

### Unit 1 Introduction to Vehicular Technology

Classification and Configuration of vehicular technology: Basics of vehicle performance, vehicle power source characterization, transmission characteristics of conventional vehicles. History electric and hybrid electric vehicles, social and environmental importance of electric and hybrid electric vehicles, impact of modern drive-trains on energy supplies. Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

### Unit 2 Electric Propulsion System and Its Constituents for Vehicular Electrification

Introduction of Electric propulsion system and its different components. Energy source and storage system such as battery, Ultra-capacitor, Flywheels and fuel cell. Electrical Motor like DC Motor, Induction Motor, Permanent Magnet Synchronous Motor and Switched Reluctance Motor, Power Electronic Converter like AC/DC, DC/AC and DC/DC converter and its control. Electronic control unit and signal processing.

### Unit 3 Sizing of the Drive Train and Energy Management

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies. Sizing the drive system: 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.

### Unit 4 Electric Vehicle Charging System

Charging system classification, Configuration and architecture, Selection and sizing of slow and fast charger and charger connectors, EV charging system standards and guidelines, Recent trends and advancement in electric vehicle charging system, Wireless charging system, public charging station, Integration of renewable energy system and storage system with grid connected charging system.

## Course Materials

### Required Text: Textbooks

1. Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 1st edition, 2016.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, "Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", Standards media, First Edition, 2009.

### Optional Materials: Reference Books

1. James Larminie, John Lowry, "Electric Vehicle Technology Explained", Wiley, 2nd edition, 2012.
2. Chris Mi, M. AbulMasrur, David Wenzhong Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", Wiley, 2nd edition, 2017.

## Course Outcome (CO's)

Student will be able to,

- 1 Learn and Understand configuration and working of Electric and Hybrid Electric Vehicle.
- 2 Describe the role of Electric Propulsion System in the development of Electric and Hybrid Electric Vehicle.
- 3 Design and analyses the various electric drive train and power management scheme
- 4 Appraise and asses the significance of the charging station for Electric and Hybrid Electric Vehicle.



**Mapping of COs and POs**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>
<b>CO1</b>	3	1	2	-	3	-	-	-	-	-	-	3
<b>CO2</b>	3	-	1	-	3	2	-	-	-	-	-	2
<b>CO3</b>	3	2	3	2	3	-	-	-	-	-	-	2
<b>CO4</b>	3	-	1	-	3	2	-	-	-	-	-	2

**Mapping of COs and POs**

	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>
<b>CO1</b>	3	3	2
<b>CO2</b>	2	3	2
<b>CO3</b>	3	3	2
<b>CO4</b>	3	3	2

# Medical Signal and Image Processing



[8th Semester, Fourth Year]

## Course Description

### Offered by Department

Electrical Engineering

### Credits

3-0-0, (3)

### Status

Open Elective

### Code

EL108305EL

[Pre-requisites: Signal & Systems (EL104104EL)]

**Course Objectives:** To have an understanding on the application of digital image and signal processing techniques on medical signal and images.

## Course Content

**Unit-1 Biomedical Signals and Images:** Medical Imaging Modalities (ultrasound, X-ray, CT, MRI, PET, and SPECT), MRI, Speech Signals, ECG, Data Acquisition: Sampling in time, aliasing, interpolation, and quantization, Power spectral density, Adaptive filter and algorithms, Current Clinical Problems.

**Unit-2 Image Processing Techniques:** Components of an image processing system, Digital image representation, Image Enhancement, thresholding and segmentation, Image Compression, Image restoration,

**Unit-3 Cardiological Signal Processing:** Introduction to electrocardiography, acquisition, lead system, ECG features and their estimation. Pre-processing, QRS Detection Methods, Rhythm analysis, Arrhythmia detection Algorithms, automated ECG analysis. ECG pattern recognition, Heart rate variability analysis, clinical applications.

**Unit-4 Neurological Signal Processing:** Introduction to brain potential and EEG Signals, its origin, characteristics, frequency division, and evoked potentials. Analysis and detection of spikes and spindles in different frequency bands, Auto Regressive (AR) method for transient detection in case of seizure and sleep stage analysis. Case study: Brain computer interfacing (BCI).

## Course Materials

### Required Text: Textbooks

1. W. Birkfellner, Applied Medical Image Processing: A Basic Course, CRC Press, Second Edition, 2014
2. Rangaraj M. Rangayyan "Biomedical Signal Analysis". IEEE Press, 2001.
3. D.C.Reddy, Biomedical Signal Processing- principles and techniques, Tata McGraw-Hill. 3. Biomedical Digital Signal Processing, Willis J.Tompkins, PHI.

### Optional Materials: Reference Books

1. I. Bankman, Handbook of Medical Image Processing and Analysis, Academic Press, Second Edition, 2008
2. Akay M, Biomedical Signal Processing, Academic: Press.
3. Cohen.A, Biomedical Signal Processing -Vol. I Time & Frequency Analysis, CRC Press
4. R C Gonzalez, Wintz Paul, "Digital Image Processing", Addison Wesley, 2nd Edition

## Course Outcomes

On successful completion of the course students will be able to:

1. Explain different medical image and signal modalities and their acquisition.
2. Demonstrate an understanding of different techniques in medical image processing.
3. Apply methods to extract relevant information from Cardiological Signals.
4. Apply methods to extract relevant information from Neurological Signal.

### Mapping of the COs and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	1	1	2		1		1	2	3
CO2	3	3	3	2	1	2		1		1	3	3
CO3	3	3	3	2	1	2		1		1	3	3
CO4	3	3	3	2	1	2		1		1	3	3

**Mapping of the COs and PSOs**

	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>
<b>CO1</b>	3	3	3
<b>CO2</b>	3	3	3
<b>CO3</b>	3	3	3
<b>CO4</b>	3	3	3