National Institute of Technology Raipur													
Course of Study and Scheme of Examination							B. Tech. 7th 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	EL107101EL	Modern Control System Engineering	3	1	0	20	30		50		100	4
2		Program Elective	3	0	0	20	30		50		100	3
3		Program Elective	3	0	0	20	30		50		100	3
4		Open Elective	3	0	0	20	30		50		100	3
5	EL107501EL	Project Work	0	0	8	40		20		40	100	4
6	EL107401EL	Electrical Machines-III Labortory	0	0	2	40		20		40	100	1
7	EL107701EL	Summer Internship II	-	-	-	40		20		40	100	2

Program Electives	
Subject Code	Name of Subject
EL107201EL	Digital Control System
EL107202EL	Power Appratus System
EL107203EL	Smart Grid Technology
EL107204EL	Felexible AC Transmission Systems
EL107205EL	HVDC Power Transmission
EL107206EL	Advanced Power System Protection
EL107207EL	Switch Mode Power Converter
EL107208EL	Policy and Planning of Power System

Open Electives	
Subject Code	Name of Subject
EL107301EL	Mechatronics
EL107302EL	Applied Optimization
EL107303EL	Process Control and Instrumentation
EL107304EL	Renewable and Distributed Energy Systems
EL107305EL	Soft Computing Techniques and Its Applications

Modern Control System Engineering

[7th Semester, Fourth Year]

Course Description

Offered by Department	Credits	Status	Code
Electrical Engineering	3-1-0, (4)	Program Core	EL107101EL

[Pre-requisites: Mathematics-II MA10I002MA, Mathematics-III EL103105EL]

Course Outcomes

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

1. Explain the advantages of modeling engineering systems in time domain by state space analysis.
2. Demonstrate basic nonlinearities and analyze stability of nonlinear systems.
3. Design the controllers using state space approach.
4. Design of optimal controllers for linear systems.
5. Illustrate the representation, analysis and controller design in digital domain.

Course Content

Unit 1 State Space Analysis

Introduction, State variable representation, Eigen-values and Eigen-vectors, Conversion of state variable models to transfer functions, Conversion of transfer function to different Canonical forms, Solution of state equations, Controllability and Observability, Kalman's and Gilbert's tests of controllability and observability, Effects of pole-zero cancellation.

Unit 2 Control System Design Using State Variable Methods

Introduction, State variable feedback structure, Pole Placement Design, Ackermann's formula for pole placement, Design of servo systems, Concept of observer, Design of full and reduced order state observers.

Unit 3 Discrete Control System

Introduction, Advantages of digital control, Basic computer control scheme, Principles of signal conversion, Impulse sampling and data hold, Reconstruction of original signals from sampled signals, Pulse transfer function, Mapping between the S-plane and the Z-plane, Stability analysis using bilinear transformation methods, Jury's stability test.

Unit 4 Non-Linear Control System

Introduction, Common types of nonlinearities, Comparison of linear and non-linear systems, Properties of non-linear control systems, Liapunov stability analysis of linear and non-linear systems, Second method of Liapunov with four stability theorems.

Unit 5 Optimal Control System

Optimal control problem, Classification of optimal control problems, Performance measures for optimal control problems, Selection of performance measures, Static optimization problem formulation, Direct method, Lagrange multiplier method, Optimization without constraints, Optimization with equality constraints.

Course Materials

Required Text: Text books

1. I. J.Nagrath and M.Gopal," Control System Engineering", New Age International Pvt. Ltd., Sixth edition 2018.
2. Benjamin.C. Kuo,"Digital Control Systems", Oxford University Press, Second edition, 2012.

Optional Materials: Reference Books

1. D. Roy Choudhury, "Modern Control Engineering" , Prentice Hall India Learning Private Limited, New title edition, 2005.
2. K.K. Agrawal, "Control System Analysis and Design", Khanna Publishers, First edition, 2004.
3. M.N. Bandyopadhyay, "Control Engineering Theory and Practice", Prentice Hall India Learning Private Limited, 2002.
4. Ajit. K. Mandal, "Introduction to Control Engineering: Modeling, Analysis and Design", New Academic Science Ltd, 3rd edition, 2016.

Mapping of course outcomes with program outcomes

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

Digital Control System

[7th Semester, Fourth Year]

Course Description

Offered by Department	Credits	Status	Code
Electrical Engineering	3-0-0	PE	EL107201EL

[Pre-requisites: Signal and Systems, Control System Engineering (EL105101EL)] Course

Objectives

Making the students

(i) Appreciate the advantages of digital control over analog control

(ii) Understand and apply the digital controller design techniques for given specifications.

Course Content

Unit-1 Introduction to digital systems:

Introduction, Discrete time system representation, Mathematical modelling of sampling process, Data reconstruction. Modelling of discrete time systems by pulse transfer function: Revising z-transform, Mapping of s- plane into z-plane, Pulse transfer function, Pulse transfer function of closed loop system, Sampled signal flow graph.

Unit-2 Response analysis of discrete time systems

Stability analysis of discrete time systems: Jury stability test, Stability analysis using bilinear transformation. Time response of discrete-time systems: Transient and steady state responses, Time response parameters of a prototype second order system. Design of sampled data systems: Root locus method,

Unit-3 Digital Controller Design

Controller design using root locus, Nyquist stability criterion, Bode plot, and Lead, Lag, and Lag-lead compensator design using Bode plot. Deadbeat response design: Design of digital control systems with deadbeat response, Practical issues with deadbeat response design, Sampled data control systems with deadbeat response.

Unit-4 State Space Modeling

Discrete space state model: Introduction of state variable model, Various canonical forms, Characteristic equation, State transition matrix, Solution of discrete state equation, and controllability, observability and stability of discrete state space models. State feedback design: Pole placement design, Full order tracking controller, Reduced-order observer. Output feedback design: Theory and applications.

Text books

1. M. Gopal, Digital Control and State Variable Methods, Tata McGraw Hill, 2003.
2. Franklin, Gene F., J. David Powell, and Michael L. Workman. Digital Control of Dynamic Systems. 3rd ed. Upper Saddle River, NJ: Prentice Hall, 1997.
3. K. J. Astrom and B. Wittenmark, Computer-Controlled Systems: Theory and Design, 1996, ISBN 13: 978-0133148992.
4. N.S. Nise, Control System Engineering, 3rd edition, Wiley & Sons, ISBN 0-471-36601-3, 2000.
5. M. Morari and E. Zafirou: Robust process control, Prentice Hall, 1989, ISBN 0-137-82153-0.
6. S. J. Elliott: Signal Processing for Active Control, Academic Press, 2001, ISBN 0-12-237085-6.

Optional Materials: Reference Books

1. C. L. Phillips and H. T. Nagle, Digital Control System Analysis and Design, 1998, ISBN 0-13-317729-7.
2. K. Ogata, Discrete Time Control systems, Prentice Hall, Second Edition, 2003.

Course Outcomes(CO)

1. Analyse discrete-time systems mathematically through the use of pulse transfer function and state equations.
2. Appreciate the advantage of designing controllers in digital domain
3. Apply fundamental principles of closed loop system and appreciate the use of feedback to improve system performance in digital domain.
4. Design digital controllers to improve the performance of continuous time systems.
5. Infer knowledge to succeed in any competitive examination as well as develop the lifelong learning process.

Mapping and Correlation of COs with POs

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

Power Apparatus Systems

[7th **Semester, Final Year**]

Course Description

Offered by Department	Credits	Status	Code
Electrical Engineering	3-0-0, (3)	Program Elective	EL107202EL

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

Course Objectives

1. To understand analyze various apparatus used in electrical power system.
2. To understand the basic concepts of earthing.
3. Design of earthing in power systems.
4. To understand surge protection schemes along with insulation coordination.

Course Content

Unit –I: Overhead Line Design

Types of Insulators, String Efficiency, Improvement of voltage distribution and String Efficiency, Line Supports, Types of Steel Towers, Cross Arms, Equivalent span, Types of Conductors and Conductor configurations, Spacing & Clearance, Selection of conductor size, Selection of ground wires.

Unit –II: Electrical Substation and Earthing

Types of Substation, Layout and Bus Bar schemes, Voltage levels, Substation equipment Protection &Control, Substation Earthing, Tolerance limits of body currents, Soil resistivity, Earth resistance, Tolerable & Actual Step & Touch Voltages, Design of Earthing Grid, Tower Footing Resistance, Measurement of soil & earth resistivity.

Unit –III: Power System Earthing

Ground versus isolated neutral, Solidly and effectively grounded system Resistance and Impedance Grounding, Resonant Grounding, Reactance Grounding, Voltage Transformer Grounding, Zigzag Transformer Grounding,Merits& Demerits of Various Grounding Systems. Grounding practice, over voltage phenomenon in isolated and grounded neutral system, Arcing ground, Effect of grounding on system over voltages.

Unit –IV: Surge Protection and Insulation Co-ordination

External and Internal over voltages mechanism of lighting discharge, wave shapes of stroke current line design based on direct stroke, over voltage protection, earth wire, Rod gap, T.F.R., Expulsion tube, surge diverters. General idea and Selection of B.I.L., International recommendation, Selection of arrester rating, Co-ordination of protector devices with apparatus insulation.

Course Materials

Required Text: Text books

1. Power System Analysis & Design, BR Gupta S. Chand Publications
2. Installation Commissioning & Maintenance of Electrical Equipments by Tarlok Singh, S.K. Kataria & Sons

Optional Materials: Reference Books

1. "Transmission & Distribution", Westinghouse
2. "A Course in Electrical Power", J.B. Gupta, Kataria Publications

Course Outcomes:

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

1. Understand the working of different types of overhead line components.
2. Evaluate the design parameters for substations.
3. Analyze and design various types of earthing systems.
4. Understand the concept and working of surge of protection devices and surge arrestors.

Mapping of course outcomes with program outcomes

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

Smart Grid Technology

[7th Semester, Fourth Year]

Course Description

Offered by Department	Credits	Status	Code
Electrical	3-0-0, (3)	Program Elective	EL107203EL

[Pre-requisites: Power System Analysis (EL105103EL), Power System Protection & Switchgear EL106101EL)]

Course Objectives

1. Introduce various aspects of the smart grid including, Technologies, Components, Architectures and Applications.
2. Explain communication infrastructure of smart grid.
3. Explain various integration aspects of conventional and non-conventional energy sources.

Course Content

Unit 1 Introduction to Smart Grid

Evolution of Electric Grid, Concept, Definitions, Need and Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid.

Unit 2 Energy Management System (EMS)

Smart substations - Substation Automation - Feeder Automation, SCADA – Remote Terminal Unit – Intelligent Electronic Devices – Protocols, Phasor Measurement Unit, Smart integration of energy resources – Renewable, intermittent power sources – Energy Storage. Distribution Management System (DMS) – Volt / VAR control – Fault Detection, Isolation and Service Restoration, Network Reconfiguration, Outage management System, Customer Information System, Geographical Information System.

Unit 3 Smart Grid Technologies

Smart Meters, Plug in Hybrid Electric Vehicles (PHEV), Smart Sensors, Home & Building Automation, Smart Substations, Substation Automation, Feeder Automation. Smart storage like Battery, SMES.

Unit 4 Micro Grids and Distributed Energy Resources

Concept of micro grid, need & applications of micro grid, formation of micro grid, protection & control of micro grid.

Unit 5 Information and Communication Technology for Smart Grid

Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN) Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid. Broadband over Power line (BPL). IP based protocols.

Course Materials

Required Text: Textbooks

1. Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley, 1st edition, 2010.
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", River Publishers, 1st edition, 2009.
3. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley, 2015.

Optional Materials: Reference Books

1. Jean Claude Sabonnadiere, Nouredine Hadjsaid, "Smart Grids", Wiley-ISTE, 1st edition, 2013.
2. Tony Flick and Justin Morehouse, "Securing the Smart Grid", Elsevier Inc. (ISBN: 978-1-59749-570-7), 2011.
3. Peter S. Fox-Penner, "Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities", Island Press, 1st edition, 2010.

Course outcomes:

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

1. Understand the smart grid components and architectures
2. Describe different measuring methods and sensors used in the smart grid
3. Understand and describe the efficient energy management systems
4. Understand and describe the different microgrids and smart grid technologies
5. Understand and describe the diffident communication protocols and technologies used for smart grids

Mapping of course outcomes with program outcomes

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

Flexible AC Transmission Systems

[7th Semester, Fourth Year]

Course Description

Offered by Department	Credits	Status	Code
Electrical Engineering	3-0-0, (3)	Program Elective	EL107204EL

[Pre-requisites: Power Electronics (EL104103EL)]

Course Objectives

To impart the knowledge and tackle the problem of regulatory constraints on the expansion of power transmission network by introduction of high power electronic controllers for regulation of power flow and voltages in the AC transmission network.

Course Content

UNIT 1 Introduction to Flexible AC transmission systems

Introduction of semiconductor devices, Flow of power in AC system, Steady state and dynamic problems in AC systems loading capability, controllable parameters, basic types of FACTS controllers, Flexible AC transmission systems (FACTS) Basic realities & roles.

UNIT 2 Voltage Source Converters (VSC)

Basic concepts of VSC, single-phase full wave bridge converter operation, single phase-leg operation, three-phase full wave bridge converter and its operation, transformer connections for 12-pulse, 24-pulse and 48-pulse operation.

UNIT 3 Current source converters (CSC)

Basic concepts, three-phase CSCs, three-phase full wave rectifier, comparison of VSC and CSC. Static shunt compensators: basic concepts, method of controllable VAR generation, Static VAR compensator, (SVC), application of SVC in power systems.

UNIT 4 Shunt Compensators

Introduction, mathematical model, working of STATCOM, V-I and V-Q characteristics, transient stability enhancement and exchange of real power using STATCOM, comparison of SVC and STATCOM, Merits of hybrid compensators.

UNIT 5 Series Compensators

Objectives of series compensation, variable impedance type series compensation, GTO thyristor controlled series capacitors (GCSC), thyristor controlled series capacitor (TCSC), basic concepts of GCSC and TCSC, static synchronous series compensator (SSSC). Introduction to Unified Power Flow Controller (UPFC).

Course Materials

Required Text: Textbooks

1. Narain G. Hingorani, "Understanding FACTS", Wiley India Pvt. Ltd., 2011.
2. Mathur, R.M. and Verma, R.K, "Thyristor-Based FACTS Controllers for Electrical Transmission Systems", Wiley-IEEE Press, 1st edition, 2002.

Optional Materials: Reference Books

1. Song, Yu, "FACTS for Transmission lines".
2. G.T. Heydt, "Power Quality", Stars in a Circle Publications, Indiana, 1994.
3. T.J.E. Miller, "Static Reactive Power Compensation", Wiley India Pvt. Ltd.,2010.
4. Padiyar. K. R, " FACTS Controllers in Power Transmission and Distribution" New Age Int. Publishers, 2007.

Course Outcomes*:*

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

1. Understand transmission bottle necks and the methods to overcome them.
2. Know the method of series and shunt compensation for improvement of power quality.
3. Simulate different FACTS controllers and analyzing their effects.
4. Undertake projects on power quality improvements using FACTS devices**.**

Mapping of COs and POs

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

HVDC Power Transmission

[7th Semester, Fourth Year]

Course Description

Offered by Department	Credits	Status	Code
Electrical Engineering	3-0-0, (3)	Program Elective	EL107205EL

[Pre-requisites: Power Electronics (EL104103EL)]

Course Objectives

1. To understand the usage of HVDC and AC transmission Systems
2. To identify and compare the operation of three pulse and six pulse converter station.
3. To acquire knowledge controllers for controlling the power flow through a dc link and effects of harmonics on the system.
4. To analyze concepts of converter fault and protection and converter control characteristics.
5. To compare the basic operation and performance of Multi Terminal DC System.

Course Content

Unit I HVDC Transmission basics

Introduction to DC Power Transmission, Necessities of HVDC interconnection, Comparison of HVDC and AC Transmission systems, DC link types, HVDC power system components, – Thyristors valve, dynamic characteristics, parallel & series connection of thyristors, Planning for HVDC transmission.

Unit II HVDC Converter Circuit Analysis

Rectification, choice of converter configurations, Analysis of Graetz circuit with and without overlap, voltage waveforms, Analysis of two and three valve conduction mode, Converter Bridge characteristics, Inverter mode of operation, voltage waveforms.

Unit III Principles of HVDC link control

Principles of DC link control, Converter Control characteristics, Control hierarchy Constant current Control, CEA Control, firing angle control of valves, starting, and stopping of a dc link, Power control, converter fault and protection against over current, over voltage in converter protection of DC Line and DC circuit breaker.

Unit IV Harmonics and Filters

Reactive power control: reactive power requirement in steady state, sources of re active power and reactive power control. Harmonics and Filters: Generation of harmonics, Characteristics and non-Characteristics harmonic, types of ac filter: single tuned and double tuned filter, high pass filter, DC smoothing reactor and filters

Unit V Multi-terminal Types of MTDC system

Introduction – Study of MTDC systems, comparison of series and parallel MTDC system, Potential applications of MTDC systems, Types of MTDC systems, Control and protection of MTDC systems.

Course Materials

Text Books:

1. High Voltage Direct Current Transmission by Arrillaga J, Peter Pregrinus, London, 2007.
2. Direct Current Transmission Vol.I by E. W. Kimbark., Wiley Interscience, 1971

Reference Books:

1. HVDC Transmission Systems Technology and System Interactions by K. R. Padiyar, New Age International Publishers.
2. Power Transmission by Direct Current by Erich Uhlmann, BS Publications, 2004

Mapping of course outcomes with program outcomes

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

Advanced Power System Protection

[7th Semester, Fourth Year]

Course Description

Offered by Department	Credits	Status	Code
Electrical	3-0-0, (3)	Program Elective	EL107206EL

[Pre-requisites: Power System Protection & Switchgear (EL106101EL)]

Course Objectives

1. Comprehensive exposure to philosophy and technology of protection system.
2. To provide the students with a broad understanding numerical protection system.
3. Students will understand the conversion process of time domain signal to frequency domain signal.
4. Students will have a basic understanding of equipment and system protection.
5. To provide the students with a broad understanding of measuring instruments and its application in power system protection.
6. To provide the students with a broad understanding of protection philosophy of different interconnected power system.

Course Content

Unit 1 Introduction

Faults, classification of fault, power system evolution, different attributes of protective function, overview of different protection schemes, system and equipment protection.

Unit 2 Numerical Protection

Introduction, block diagram, sampling theorem, filtering, phasor estimation techniques, frequency estimation, block diagram, sampling, anti-aliasing, phasor estimation techniques, frequency estimation.

Unit 3 Current Transformer and Potential Transformer

Introduction, construction, standards, ratios, measurement CT and protection CT, transient response, errors, saturation.

Unit 4 Equipment Protection

Line protection, transformer protection, generator protection, carrier-aided protection.

Unit 5 System Protection

Power swing, out-of-step protection, frequency relay, load shedding, wide area measurement system (WAMS), phasor measurement unit, concept of micro-grid and its protection system.

Course Materials

Required Text: Textbooks

1. Mason C. R., "The Art and Science of Protective Relaying", Wiley Eastern Limited.
2. Ravindranath B., Chander M. "Power system protection and switchgear", TMH New Age International Publishers, Second edition, 2018.
3. Van A. R. and Warrington C., "Protective Relays - Theory and Practice", Springer, Softcover reprint of the original 1st edition.,2014.
4. Paithankar Y.G., Bhide S.R. "Fundamentals of power system protection", Prentice Hall India Learning Private Limited, 2ND edition, 2010.
5. Badri Ram, Vishwakarma D.N., "Power system protection", McGraw Hill Education; 2ND edition,2017.

Optional Materials: Reference Books

1. J.L. Blackburn, "Protective Relaying: Principles and Applications", CRC Press, 4th edition, 2014.
2. A.G. Phadke J.S. Thorp, "Computer Relaying for Power Systems", Wiley India Pvt. Ltd, Second edition, 2012.

Course Outcomes (COs):

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

1. Explain the concept of numerical relaying and adaptive relaying.
2. Answer the transformation process of time domain signal into frequency domain signal.
3. Develop codes for numerical equipment and system protection schemes.
4. Explain the working of instrument transformers.
5. Demonstrate the application and working of communication-based protection logics.

Mapping of course outcomes with program outcomes

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

Switched Mode Power Converter

[7th Semester, Fourth Year]

Course Description

Offered by Department	Credits	Status	Code
Electrical Engineering	3-0-0, (3)	Program Elective	EL107207EL

[Pre-requisites: Power Electronics (EL104103EL), Control System Engineering (EL105101EL)]

Course Objectives

1. To understand various modes of operation of switched mode power converters
2. To analyze control aspects of switched mode power converters
3. To design various switched mode power converter and its components

Course Content

Unit 1 Switching devices and control of switched mode power converters

Power semiconductor devices for SMPS: static and switching characteristics, power loss evaluation, turn-on and turn-off characteristics, PWM control, Modeling and control of SMPS, duty cycle and current model control.

Unit 2 Non-Isolated switched mode power converters

Non-isolated dc-dc converter: buck, boost, buck-boost, Cuk, Sepic; continuous conduction mode and discontinuous conduction mode analysis; non-idealities in the switched mode power converters.

Unit 3 Isolated switched mode power converters

Isolated dc-dc converters: fly back, forward, push-pull, half bridge and full bridge topologies; transformer design for high frequency isolation, resonant switched mode power converters.

Unit 4 Design considerations

Selection of output filter capacitor, Selection of energy storage inductor, Design of High Frequency Inductor and High frequency Transformer, Selection of switches, Snubber circuit design, Design of driver circuits.

Course Materials

Required Text: Textbooks

1. H. W. Whittington, B. W. Flynn and D. E. MacPherson, "Switched Mode Power Supplies, Design and Construction", Universities Press, 2009 Edition.
2. Mohan N. Undeland . T & Robbins W., "Power Electronics Converters, Application and Design" Wiley, Third edition, 2007.
3. Umanand L., Bhat S.R., "Design of magnetic components for switched Mode Power Converters", newage publishers, First edition, 1992.
4. Robert. W. Erickson, D. Maksimovic, "Fundamentals of Power Electronics", Springer, 3rd edition, 2020.

Optional Materials: Reference Books

1. Krein P.T ., "Elements of Power Electronics", Oxford University Press, Second edition, 2017.
2. M. H. Rashid, "Power Electronics", Pearson Education, Fourth edition, 2017.

Course Outcome (CO's)

Student will be able to,

1 Learn and Understand the basic concept and operation of switch mode power converters.
2 Describe the role of switch mode power converters in various applications.
3 Design and analyses the various types of switch mode power converters.

Mapping of COs and POs

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

Policy and Planning of Power System

[7th Semester, Fourth Year]

Course Description

Offered by Department	Credits	Status	Code
Electrical Engineering	4-0-0, (4)	Program Elective (PE)	EL107208EL

[Pre-requisites: Generation of electrical Energy (conventional & non-conventional) EL103103EL, Electrical Power System EL103105EL]

Course Objectives

To make student understand the various tools for analyzing and evaluating generation planning, transmission expansion planning, distribution planning and load forecasting in electric power system.

Course Content

Unit-1 Power system components

General power systems, overview of generation; transmission; and distribution, Different business models of generation; transmission; & distribution, Local grid, State grid, Regional grid, Microgrid, National grid, Smart grid, Grid inter connection, Power: building blocks of economy, Energy metering.

Unit-2 Operation and control in power system

Economic aspects, Load curve, Load duration curve, Hot reserve, Spinning reserve, Utilization factor, Plant capacity factor, Diversity factor, Basic concepts of economic load dispatch and optimal unit commitment, Load frequency control, Reactive power compensation, Voltage control, Transmission system operator, Distribution system operator, Load dispatch centers, Power markets.

Unit-3 Policies and regulations

Regulation, Deregulation/Reregulation, Reform, International energy policies, International energy treaties, Impact of energy on economy, Energy and environmental policies, Global energy issues, Energy policy issues, Fossil fuels related issues and policies, Policies for promoting renewable energy, Power sector reforms, Restructuring of energy supply sector, Energy strategy for future, Energy Conservation related Acts & their features, Electricity Acts, Concept of regulatory commissions, Impact of global variation in energy productivity (National & Sector wise productivity) and its analysis, Impacts of different policies and regulations towards sustainable development of the power sector.

Unit-4 Power system planning

Time-horizon perspective of power system planning, Power system planning issues, some economic principles, Load forecasting: trend analysis; econometric modelling; end-use analysis, Single-bus generation expansion planning, Multi-bus generation expansion planning, Substation expansion planning, Network expansion planning, Reactive power planning, Power system planning under uncertainties, Recent trends in power system planning.

Course Materials

Required Text: Text books

1. Hossein, Seifi, mohammad Sadegh, Sepasian, "Electric Power System planning: Issues, Algorithms and Solutions", Springer-Verlag Berlin-2011.
2. A. S. Pawla, " Electric Power Planning", 2nd Edition, McGraw Hill Education
3. B. R. Gupta, Vandana Singhal, " Power System Operation and Control, S. Chand
4. Allen J.Wood , Wollenberg B.F, Gerald B sheble, "Power Generation, Operation and Control", 3rd Edition, Wiley
5. Alessandro Rubino, Alessandro Sapio, Massimo La Scala, "Handbook of Energy Economics and Policy", 1st Edition, Elsevier

Optional Materials: Reference Books

1. S Sivanaga Raju, G. Sreenivasan, "Power System Operation and Control", Pearson
2. Peter D. Cameron, Xiaoyi Mu, Volker Roeben, "The Global Energy Transition: Law, Policy and Economics for Energy in the 21st Century",
3. Edoy X.Wang and J.R.McDonald , "Modern Power Systems Planning", McGrawHill, London 1994.
4. James Momoh, Lamine Mili, "Economic Market Design and Plannin for Electric Power Systems", John Wiley and Sons, New Jersey, 2010.

Course Outcomes

1. Familiarize with the history and growth of electric supply Industry under different socio-political environment and the various models of power system evolved.

2. Understand and apply various economic principles/techniques for the efficient as well as economic operation of power system.
3. Analyze, apply, and promote various policies and regulations developed for the efficient planning, operation, and control of the power system.
4. Demonstrate and develop engineering solutions for the issues related to the planning and evaluation of an electric power system needed for successful design of a new system, or improvement of an existing one.
5. Identify, formulate, and figure out the need of research and development activities required for efficient planning and operation of power system.

Mapping of course outcomes with program outcomes

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

Mechatronics

[7th Semester, Fourth Year]

Course Description

Offered by Department	Credits	Status	Code
Electrical Engineering	3-0-0, (3)	Open Elective	EL107301EL

[Pre-requisites: Basic Electrical Engineering (EL101022EL), Physics II(PH101006PH)]

Course Objectives

1. To integrate concepts of electrical, mechanical and computer engineering in the design of mechatronics systems.
2. To be able to design, build, interface and control a mechatronic system for a set of specifications.

Course Content

Unit 1 Mechatronic system

Mathematical modeling of electrical, mechanical, electromechanical systems, pneumatic and thermal systems; Passive and active elements, lumped and distributed systems, Electromechanical energy conversion.

Unit 2 Sensors and actuators

Measurement devices; operation of sensor, transmitter and transducer; Classification and calibration of sensors; Displacement, position and motion sensors, Actuators; Electrical actuating devices, Industrial automation and PLC.

Unit 3 Signal conditioning and data acquisition system

Analog signal conditioning; Digital signal conditioning, Analog and Digital Data Acquisition Systems, Voltage, Current, Frequency, Temperature, Displacement, Pressure measurement using Data Acquisition System (DAS), Design of signal conditioning circuits, Application of Data Acquisition System in Power plant, Data Logger.

Unit 4 Embedded systems

8086 Microprocessor architecture; Assembly language instruction and programming; 8051 Microcontroller; 8085 / 8086 / 8051 Interfacing, Digital signal processor and FPGA.

Course Materials

Required Text: Text books

1. Curtis D. Johnson, "Process Control Instrumentation Technology" , Pearson Education India, 8th edition, 2015.
2. D. Patranabis, "Sensors and Transducers", Prentice Hall India Learning Private Limited, 2ND edition 2003.
3. A.K. Ray & K.M.Bhurchandi, "Advanced Microprocessors and peripherals- Architectures, Programming and Interfacing", McGraw-Hill Education (India) ,2009.

Course Outcomes

1. Appreciate the significance of monitoring, signal conditioning and computer interfacing for improving the reliability and performance of mechanical systems
2. Infer the steps in PLC based industrial automation
3. Write common programs in microcontroller and by using ladder logic
4. Design the various components of a mechatronic system for a given set of specification

Mapping of COs and POs

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

Applied Optimization

[7th Semester, Fourth Year]

Course Description

Offered by Department	Credits	Status	Code
Electrical	3-0-0, (3)	Open Elective	EL107302EL

[Pre-requisites: NIL]

Course Objectives

To expose students regarding the utility of optimization techniques for engineering design

Course Content

Unit 1 Introduction

Vectors, Matrices, Eigen values and Eigenvector, Optimization and Design, Formulation of objective function, Incorporating constraints in objective function, Engineering Applications of optimization.

Unit 2 Unconstrained Optimization Algorithm

Optimality criteria, Dynamic Optimization, Unidirectional search, Direct search methods, Gradient Search methods, Simplex search method, Hooke-Jeeves pattern search method, Optimization toolbox (MATLAB).

Unit 3 Constrained Optimization Algorithm

Kuhn Tucker Condition, Rosen's Gradient projection method, Penalty function method, Optimization toolbox (MATLAB).

Unit 4 Nontraditional and Machine Learning Based Optimization Algorithms

Genetic Algorithm, Differential Evolution and Particle Swarm Optimization, Formulation of optimization problem with multiple objectives, Pareto Optimality, NSGA (Non-sorted genetic algorithm), Machine Learning for optimization.

Course Materials

Required Text: Textbooks

1. S S Rao, "Engineering Optimization- Theory and Practice", newage publishers, Third edition, 2013.
2. Kalyanmoy Deb, "Optimization for Engineering Design, Algorithms and Examples", Prentice Hall India Learning Private Limited, Second edition, 2012.
3. Kalyanmoy Deb, "Multiobjective Optimization Using Evolutionary Algorithms", Wiley, 2010.

Course Outcomes

1. Infer the application of optimization techniques for engineering design
2. Formulate a design task as an optimization problem
3. Appreciate the specific attributes of gradient based and search based techniques
4. Infer the applicability of evolutionary optimization techniques
5. Apply optimization techniques to solve problems in different engineering domains

Mapping of COs and POs

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

Process Control & Instrumentation

[7th Semester, Fourth Year]

Course Description

Offered by Department	Credits	Status	Code
Electrical Engineering	3-0-0, (4)	Open Elective	EL107303EL

[Pre-requisites: Electrical Measurement and Instrumentation (EL103101EL), Control System Engineering (EL105101EL)]

Course Objectives

1. To give the students a comprehension of Process Control Instrumentation Design.
2. To give the students the knowledge about the most important issues in Design of Controllers.
3. To give the students a comprehension of the relation between Instrumentation and controller design in industrial applications.
4. To make the students able to analyze the control loops and to achieve the control actions with different Controllers.
5. To introduce the dynamics of various processes and modeling of physical processes.

Course Content

Unit 1 Process control

Introduction, Process variables, Degrees of freedom, Industrial variables and measurement systems, Sensors and Transducers for measurement of industrial variables like Pressure, Temperature, Level, Flow, Torque, Speed etc., Sensor principles, Sensor, scaling, Industrial signal conditioning systems, Amplifiers, Filters, A/D Converters for Industrial measurement systems, General industrial instruments, I/P and P/I Converters.

Unit 2 Design aspects and Hardware for a process control system

Modeling of chemical processes, development of a mathematical model, State variables and state equations, Transfer function of a process with single/multiple outputs, Process modeling, Characteristics of liquid systems, Gas systems, Thermal systems, interacting Non-interacting systems.

Unit 3 Control Systems for various processes

Development of control loops, Design aspects and selection criterion for field instruments and instrumentation scheme for Distillation column, Control of top and bottom product compositions, Reflux ratios, Control of chemical reactors, Control of Heat Exchanger, Steam Boiler, Design aspects of Instrumentation for Power, Water and Waste-Water Treatment, Food and Beverages, Pharmaceuticals Introduction to International Standards, Cement, Automobile and Building Automation.

Unit 4 Advanced control

Model predictive control, Batch Process control, Plant-wide control & monitoring, Instrumentation for process monitoring, Statistical process control, Introduction to Fuzzy Logic in Process Control, Introduction to OPC Introduction to environmental issues and sustainable development relating to process industries. PLC, DCS, SCADA.

Unit 5 Chemical and Biochemical sensors

Polymers, Chemically Modified Electrodes (CME), Affinity sensors, Potentiometric and Amperometric devices, Catalytic sensors, Gas sensors etc.

Course Materials

Required Text: Textbooks

1. R. P. Vyas, "Process Control and Instrumentation", Denett & Co., 7th edition, 2015.
2. Donald R Coughanower, Steven E LeBlanc, "Process System Analysis & Control", McGraw Hill Education, Third edition ,2017.
3. 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 Press, 4th edition, 2005.

Mapping of COs and POs

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

Renewable and Distributed Energy Systems

[7th Semester, Fourth Year]

Course Description

Offered by Department	Credits	Status	Code
Electrical	3-0-0, (3)	Open Elective	EL107304EL

[Pre-requisites: Basic Electrical Engineering Code (EL10I022EL)]

Course Objectives

1. To make the students appreciate the significance of distributed energy resources in the present scenario
2. To acquaint the students with fundamentals of the integration of renewable sources with the utility grid.

Course Content

UNIT 1 Wind Energy System

Introduction to renewable energy system, Environment aspects of energy utilization, World energy supplies, Wind resource assessment, Wind power system components, Power conversion technologies and applications, Characteristics and Power Generation from Wind Energy, Wind power estimation technique, Aerodynamics of wind turbine blades, Various aspects of wind turbine design, Wind turbine generators, Reactive power compensation, Site selection, Planning of wind farms, maintenance and operation, Environmental assessment.

Unit 2 Solar Energy System

Present and Future scope of Solar Energy, Solar radiation, Photo-voltaic effect, Type of PV cells, Electrical properties, Equivalent circuit, Cell characteristics, Effect of temperature variation, PV cell model, PV module, Grid connected and islanded system, Technical and non-technical consideration- system size and module choice, Stand-alone systems: Modules, Batteries, charge controllers.

Unit 3 Hydrogen as renewable energy and Hybrid Energy System

Source of Hydrogen, Fuel for Vehicle Hydrogen Production, Biological AND Biochemical methods of hydrogen production, Storage of Hydrogen, Fuel cell- Principle of working, construction and applications, Hybrid wind energy systems.

Unit 4 Distributed Generation (DG)

Overview and technology trends, Introduction to distribution systems, distribution system equipment, grounding, sequence analysis and fault calculations, relaying requirements for Distributed Generation (DG) system Intentional and unintentional islanding, power converter topologies for grid interconnection, filtering requirements. Selection of power converter components, Economic Aspects of Distributed Generation, Micro- grid with Distributed Energy Resources.

Course Materials

Required Text: Textbooks

1. Godfrey Boyle,"Renewable energy power for a sustainable future", Oxford University Press, Third edition, 2012.
2. Khan B. H., "Non-Conventional Energy Resources", McGraw Hill Education India Private Limited, Third edition, 2017.
3. 3. D.P. Kothari, K. C. Singal, Rakesh Ranjan,"Renewable energy sources and emerging technology", Prentice
4. Hall India Learning Private Limited, 2Nd edition, 2011.

Optional Materials: Reference Books

1. Twidell, J., Tony W., "Renewable Energy Resources", 2nd Edition, ROUTLEDGE BSP, 2019.
2. Kreith F., Kreider J.F.,"Solar Energy Handbook", McGraw-Hill Inc.
3. Nikos Hatziargyriou , "Micro-grids: Architectures and Control" ,Wiley, 2014.

Course Outcomes

1. Appraise the concept of renewable energy system and their role in our society.
2. Understand the operating concept, components and application of wind energy system.
3. Interpret the concept, application and analyze the performance of solar energy system.
4. Acquire the knowledge of construction, application and performance of hybrid energy system.
5. Infer the concept and utility of energy storage and micro-grid.

Mapping of COs and POs

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

Soft Computing Techniques and Its Applications

[7th Semester, Fourth Year]

Course Description

Offered by Department	Credits	Status	Code
Electrical Engineering	3-0-0, (3)	Open Elective	EL107305EL

[Pre-requisites: NIL]

Course Objectives

To explain the basic knowledge representation, problem solving, and learning methods of soft computing techniques and Artificial Intelligence, Applications of soft computing techniques in intelligent-system engineering, Assess the applicability in solving engineering problems.

Course Content

Unit 1 Introduction of soft computing techniques

Introduction of soft computing techniques, Conventional Hard computing, Origin and history of different soft computing techniques, it basic principle and comparison with hard computing.

Unit 2 Biological Neural Network

Introduction to Biological neural network, human brain, structure of Human Brain, its characteristics and functioning.

Unit 3 Artificial Neural Network & Its Applications

Introduction to Artificial Neural Network: Evolution of ANN, Basic neuron modeling, comparison between ANN and human brain, characteristics, neuron models/ Architectures, activation functions, Learning (Supervised & Unsupervised) strategies, Back propagation network, Kohonen's Self organization map, competitive network. Applications of Neural network.

Unit 4 Fuzzy Logic& Its Applications

Fuzzy Logic: Introduction to classical sets and operations, Fuzzy set theory and operations, Fuzzy set versus crisp set, Crisp relation & fuzzy relations, Membership functions, Fuzzy rule base, fuzzification and defuzzification methods, fuzzy inference systems, Applications of fuzzy logic.

Unit 5 Genetic algorithms and its applications

Genetic algorithm: Introduction, working principle, Basic operators and Terminologies like individual, gene, encoding, fitness function and reproduction, Genetic modeling: Significance of Genetic operators, cross over, mutation, GA optimization problems.

Course Materials

Required Text: Textbooks

1. Howard B Demuth, Mark H Beale, Orlando de Jesus, "Neural Network Design", 2ND edition, Martin Hagan, 2014.
2. S. N. Shivnandam, "Principles of soft computing", Wiley, Third edition, 2018.
3. S. Rajasekaran, G. A. Vijayalakshmi Pai, " Neural Networks, Fuzzy Systems and Evolutionary Algorithms: Synthesis and Applications ", PHI Learning, 2nd edition, 2017.

Optional Materials: Reference Books

1. Devendra K. Chaturvedi, "Soft Computing: Techniques and Its Applications in Electrical Engineering", Springer, 2008.
2. Edited by Kevin Warwick, Arthur Ekwue, Rag Aggarwal, "Artificial Intelligence Techniques in Power Systems (Energy Engineering)", Institution of Engineering and Technology, 1997.
3. El-Hawary, M., "Electric Power Applications of Fuzzy Systems", Wiley-IEEE Press, 1st edition, 1998.

Course Outcomes:

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

1. Learn the evolution of different Soft Computing techniques.
2. Know the details of different Soft Computing/ Artificial Intelligence (AI) techniques: Artificial Neural Network, Fuzzy systems and Genetic Algorithm.
3. Simulate different ANN, Fuzzy systems and Genetic Algorithm in Matlab software.
4. Undertake projects on Soft Computing/Artificial Intelligence application in power system, protection and power electronics area.

Mapping of COs and POs

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

Electrical Machines-III Lab

[7th Semester, Fourth Year][CBCS]

Course Description

Offered by Department	Credits	Status	Code
Electrical Engineering	0-0-2, (2)	Program Core	EL107401EL

[Pre-requisites: Electrical Machines-II Lab (EL105402EL)]

List of Experiments

1.To determine the negative sequence reactance of synchronous machine by rotating test.

2.To determine the negative sequence reactance of synchronous machine by line to line short circuit test.

3.To determine the negative sequence reactance of three phase alternator by static test.

4.To perform slip test on three phase alternator to determine d-axis reactance Xd and q – axis reactance Xq.

5.To perform open circuit and short circuit tests on a 3-Phase alternator for determination of positive sequence reactance.

6.To determine the zero-sequence impedance of a star-delta transformer.

7.To determine Zero Sequence reactance of 3-Phase alternator.

8.To determine zero sequence reactance of 3-Phase induction motor

9.Synchronization of alternator with grid (infinite bus).

10.To determine equivalent circuit parameters of a single-phase induction motor by performing no load and blocked rotor tests.

Course Outcomes (COs):

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

1.Demonstrate and explain the various methods of determination of negative sequence reactance of an alternator.

2.Demonstrate and execute the experimental determination of zero sequence reactance of 3-phase alternator, 3-phase induction motor and 3 -phase transformer.

3.Show and utilize the various methods of determination of positive sequence d-axis reactance (Xd) and q -axis reactance (Xq).

4.Experiment with synchronization of 3-phase alternator with the grid using various methods of synchronization.

5.Evaluate the various parameters of 1-phase Induction motor and analyze the performance.

CO- POs Mapping

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