SHIVAJI UNIVERSITY KOLHAPUR

REVISED STRUCTURE AND SYLLABUS

THIRD YEAR (B. Tech) CBCS

ELECTRICAL ENGINEERING

To be introduced from the academic year 2020-21

(i.e. from June 2020) onwards

SHIVAJI UNIVERSITY, KOLHAPUR

CBCS STRUCTURE FOR T.Y.B. TECH. ELECTRICAL ENGINEERING

(Semester V and Semester VI)

SEMESTER – V (Duration – 6 Months)																				
Sr. No.	Course (SubjectTitle)	TEACHING SCHEME									EXAMINATION SCHEME									
		THEORY			Tutorial			PRACTICAL			THEORY					PRACTICAL				
																TW		POE		
		Credits	No. of lectures	Hours	Credits	No. of lectures	Hours	Credits	No. of lectures	Hours	Hours	Mode	Marks	Total Marks	Min	Max	Min	Max	Min	
1	PCC-EE301/ DEM	3	3	3	-	-	-	1	2	2		CIE	30	100	40	25	10	50	20	
												ESE	70							
2	OCE-EE301/ OE- I	2	2	2	-	-	-	1	2	2		CIE	30	100	40	25	10	-	-	
												ESE	70							
3	PCC-EE302/ ACM	3	3	3	-	-	-	1	2	2		CIE	30	100	40	25	10	50	20	
												ESE	70							
-4	PCC-EE303/ PS-II	3	3	3	-	-	-	1	2	2		CIE	30	100	40	50	20	-	-	
												ESE	70							
5	PCC-EE304/ ACS	3	3	3	-	-	-	1	2	2		CIE	30	100	40	-	-	-	-	
												ESE	70							
6	PCC-EE305/ S&S	3	3	3	1	1	1	-	-	-		CIE	30	100	40	25	10	-	-	
												ESE	70							
7	BSC-EE306/ MATLAB	1	1	1	-	-	-	1	2	2	-	-	-	-	-	75	30	-	-	
TOTAL		18	18	18	1	1	1	6	10	10				**500**		**200**		**100**		

SHIVAJI UNIVERSITY, KOLHAPUR

CBCS STRUCTURE FOR T.Y.B. TECH. ELECTRICAL ENGINEERING

(Semester V and Semester VI)

SEMESTER – VI (Duration – 6 Months)																				
Sr. No.	Course (Subject Title)	TEACHING SCHEME									EXAMINATION SCHEME									
		THEORY			Tutorial			PRACTICAL			THEORY					PRACTICAL			
																TW		POE	
		Credits	No. of lectures	Hours	Credits	No. of lectures	Hours	Credits	No. of lectures	Hours	Hours	Mode	Marks	Total Marks	Min	Max	Min	Max	Min
1	PCC-EE307/ DSP	4	4	4	-	-	-	-	-	-		CIE	30	100	40	-	-	-	-
												ESE	70						
2	OCE-EE302/ OE - II	2	2	2	-	-	-	1	2	2		CIE	30	100	40	25	10	-	-
												ESE	70						
3	PCC-EE308/ EMD	4	4	4	1	1	1	1	2	2		CIE	30	100	40	50	20	50	20
												ESE	70						
4	PCC-EE309/ PSSC	4	4	4	-	-	-	1	2	2		CIE	30	100	40	50	20	-	-
												ESE	70						
5	PCC-EE310/ ED	3	3	3	-	-	-	1	2	2		CIE	30	100	40	25	10	50	20
												ESE	70						
6	BSC-EE311/ EITM	-	-	-	2	2	2	1	2	2	-	-	-			50	20	-	-
TOTAL		**17**	**17**	**17**	**3**	**3**	**3**	**5**	**10**	**10**				**500**		**200**		**100**	

CIE- Continuous Internal Evaluation ESE – End Semester Examination

• Candidate contact hours per week : 30 Hours(Minimum)	• Total Marks for T.E. Sem V & VI :**1600**
• Theory and Practical Lectures : 60 MinutesEach	• Total Credits for T.E. Sem V & VI :**50**
• In theory examination there will be a passing based on separate head of passing for examination of CIE andESE.	
• There shall be separate passing for theory and practical (term work)courses.	

Note:

1. **BSC-EE:** Basic Science Course- Electrical Engineering arecompulsory.
2. **PCC-EE:**Professional Core course –Electrical Engineering arecompulsory.
3. **OCE-EE:**OpenCourse Elective for the students from other discipline

Semester V

Sr. No	Code No.	Subject	Credits
1.	PCC-EE301	Digital Electronics And Micro Processor	4
2.	OCE-EE301	Open Elective – I	3
3.	PCC-EE302	AC Machines	4
4.	PCC-EE303	Power System-II	4
5.	PCC-EE304	Advanced Control System	4
6.	PCC-EE305	Signals & Systems	4
7.	PCC-EE306	MATLAB	2
		Total	25

Semester VI

Sr. No	Code No.	Subject	Credits
1.	PCC-EE307	Digital Signal Processing	4
2.	OCE-EE302	Open Elective – II	3
3.	PCC-EE308	Electrical Machine Design	6
4.	PCC-EE309	Power System Stability And Control	5
5.	PCC-EE310	Electrical Drives- I	4
6.	PCC-EE311	Electrical Installations testing and maintenance	3
		Total	25

Open Elective – I (Any One)	
1	Electrical Appliances And Luminaries
2	Domestic /Industrial Electrical Installation, Estimation And Costing

Open Elective – II (Any One)	
1	Electrical Energy Audit And Conservation
2	PLC & SCADA

SHIVAJI UNIVERSITY, KOLHAPUR

THIRD YEAR B.TECH (ELECTRICAL) SEMESTER -V

DIGITAL ELECTRONICS AND MICROCONTROLLER

Course Code And Title	Teaching Scheme					Evaluation Scheme					
						Theory (Marks)		Practical(Marks)		POE(Marks)	
	L	T	P	Credit	Scheme	Max.	Min. for Passing	Max.	Min. for passing	Max.	Min. for passing
PCC-EE-301 **Digital Electronics And Microcontroller**	03	--	02	04	ISE	-	-	25	10	-	-
					MSE	30	12	-	-	-	-
					ESE	70	28	-	-	50	20

ISE: InSemesterEvaluation MSE: MidSemesterEvaluation ESE: End Semester Evaluation

Objectives:

1. To make students understand Number Systems, Logic gates and Boolean Algebra.
2. To make students to understand K-Map and NAND, NOR Implementation
3. To make students to develop the skills in Design using Combinational and Sequential Logic
4. To develop basic knowledge of Microprocessors, Microcontrollers and their features.
5. To provide skills for programming microcontroller for basic applications.
6. The course aims to enable students to interface and program different peripherals to microcontrollers.

Course Outcomes:

After completion of this course students will be able to:

1) **Understand[2], Assess[5]** and **solve[3]** basic binary math operations Number System, Logic Gates, Theorems, Properties of Boolean Algebra.
2) **Understand[2]**, **Solve[3]** and **Analyze[4]** 2, 3 and 4 variable K-Map
3) **Design** and **analyze** different types Adders, Substractors, FlipFlops and Counters.
4) **Apply[3]** Knowledge and Demonstrate various addressing modes and data transfer instructions.
5) **Analyze[4]** assembly language programs select appropriate assemble into machine a cross assembler utility of a microcontroller
6) **Design[6]** and **Analyze[4]** different types of Interfacing.

SECTION I

Unit 1: Boolean algebra & logic ***[08 hrs]***

Number Systems - Binary, Octal, Hexadecimal.Introduction to Logic Gates, Laws, De Morgan's Theorem and Rules of Boolean algebra.Boolean Functions. M – Notations, Equation Simplification using Reduction Techniques.

Unit 2: Simplification of Boolean functions ***[05 hrs]***

K – Maps, 2, 3 and 4 Variable Maps. Sum of Products and Product of Sums, Don't Care Conditions, NAND-NAND and NOR-NOR Implementation

Unit 3: Combinational logic & Sequential logic ***[12 hrs]***

Introduction, Binary Adders &Binary Substractors, Binary to Gray, BCD to Binary, BCD to Excess-3 and Vice Versa, Binary Parallel Adder, Decimal/BCD Adder, Comparators, Decoders, Encoders, Multiplexers, Demultiplexers, Seven Segment Display using 7446/7447,Flip Flops, Shift Registers, Various Counters, Moore Model and Mealy Model.

SECTION II

Unit 4: 8051 Architecture and Instructions ***[10 hrs]***

Architecture – Microprocessor and Microcontroller, Difference between Microcontroller and Microprocessor, Microcontroller - Features, Pins and Signals, Program and Data Memory Organization, System Clock. Special Function Registers, Program Status Word, Registers, I/O Ports and Addressing Modes.Data Transfer Instructions.Interrupts, Timer/Counter, Serial Communication.Introduction, Architecture and Block Diagram of PIC Microcontroller.

Unit 5: Assembly Programming Examples ***[07 hrs]***

Copy Block, Shift Block, Count no. of Nulls, Find Checksum, Sum of Natural Numbers, Sum of a Series, Fibonacci Series, Generate a Series. Count 1s in a Byte, Find Largest/ Smallest Integers of an Array. Bubble Sorting, Find Sum of Factorials. Compare with External Array, Reverse an Array. Sum of a Series, Generate Prime Numbers.

Unit 6: Interfacing ***[06 hrs]***

Keyboard, External Memory, Display Devices, DC Motor, Stepper Motor, Servomotor DAC/ADC Interfacing.

General Instructions:

1. The number of students per batch should be as per the university pattern for practicalbatches.
2. Minimum number of assignments should be 8 covering alltopics.

List of Experiments:

Minimum five experiments based on Hardware and five experiments based on Simulations and at least three experiments based on Interfacing.

Recommended Books:

1. Logic Design, A.P.Godse&D.A.Godse, Technical Publications, Pune
2. Digital Logic and Computer Design, Morris Mano, PHI publications
3. Modern digital electronics, R.P. Jain, TMH Publications
4. Fundamentals of digital circuits, Anand Kumar, PHI
5. The 8051 Microcontroller and embedded systems, Muhammad Ali Mazidi, Pearson Education.

Reference Books:

1. Digital Electronics: Principles & Integrated Circuits, A. K. Maini, Wiley Publications
2. Digital Systems- Principles and Design, Rajkamal, Pearson Education
3. The 8051 Microcontroller Architecture, Programming and Applications, Kenneth Ayala, Penram International, 2nd Edition
4. 8051 Microcontroller: Internals, Instructions, Programming and Interfacing, SubrataGhoshal, Peasrson Publications

SHIVAJI UNIVERSITY, KOLHAPUR

THIRD YEAR B.TECH (ELECTRICAL) – SEMESTER – V

AC MACHINES

Course Code And Title	Teaching Scheme					Evaluation Scheme					
						Theory (Marks)		Practical(Marks)		POE(Marks)	
	L	T	P	Credit	Scheme	Max.	Min.for Passing	Max.	Min.for Passing	Max.	Min.for Passing
PCC-EE-302 AC Machines	03	-	02	04	ISE	-	-	-	-	-	-
					MSE	30	12	-	-	-	-
					ESE	70	28	25	10	50	20

ISE: InSemesterEvaluation MSE: MidSemesterEvaluation ESE: End SemesterEvaluation

Objectives:

1. To give exposure to the students about the concepts of ACmachines including the Constructional details, principle of operation and performance analysis.
2. To learn the characteristics of induction machines and to learn how it can be employed for various applications.

Course Outcome:

At the end of this course, the students will be able to

1. **Analyze** the performance of 3-phase induction motors
2. **Determine and analyze** the Losses and efficiency and performance of alternators
3. **familiarize** with principle of operation and application of 1 -phase induction motors.
4. **Analyze** performance of special purpose motors and **Make use** of special designed motors for different applications
5. **Analyze** and **Evaluate** performance of different types of alternators
6. **Analyze** the performance of 3-phase induction motors

SECTION I

Unit 1: Introduction of Three phase Induction Motor ***(09 Hrs)***

Construction & types of 3 ph. Induction motors, Rotor quantities (emf ,current, frequency, p.f), torque equation, starting torque, running torque (numerical treatment) , Factors affecting torque, condition of maximum torque ,torque slip characteristics, Need of starters for 3 phase. Induction motors, types of starters (DOL, autotransformer, star-delta, rotor resistance starter, Speed control methods from stator side (Stator voltage control Stator Frequency control, Pole changing) & rotor side (rotor resistance control), Applications of 3 ph.Inductionmotors

Unit 2: Performance and Characteristics of Three phase Induction Motor ***(09 Hrs)***

Losses & efficiency of 3 phase induction motor, power flow diagram with numerical treatment, No load & blocked rotor test, equivalent circuit of 3 phase induction motor, Phasor diagram of 3 phase induction motor, performance of 3 phase induction motor using circle diagram, Concept of operation of 3 phase induction motor as induction generator, Double cage induction motor along with its characteristics, cogging & crawling of 3 phaseinductionmotor.

Unit 3: Single phase Induction Motors :(06 Hrs)

Double field revolving theory, Construction and working of single phase induction motor (Split phase, capacitor start/run, shadedpole, repulsion type ,series motor, universal motor and hysteresis motor) Torque slip characteristics of all the above.

SECTION II

Unit 4: Special Purpose Motors: **(05Hrs)**

Construction and working of Synchronous Reluctance motor, switched reluctance motor, BLDC motor, Permanent magnet Synchronous motor, stepper motors, AC and Dc servo motors

Unit 5: Three Phase Alternator(13 Hrs)

Construction, principle of operation of three phase alternator, emf equation, parameters of armature winding. (resistance& leakage reactance), armature reaction (at unity, lagging zero and leading zero power factor), concept of synchronous reactance and synchronous impedance. Equivalent circuit of 3 phase alternator, alternator on load (resistive, inductive & capacitive) OC test & SC test on 3 Phase alternator, short circuit ratio, voltage regulation methods (emf, mmf, zero power factor and direct loading method) with numerical treatment, Losses and efficiency, power flow diagram, need of parallel operation, conditions for

parallel operation, synchronizing procedures, hunting and oscillations in alternators,

Unit 6: Synchronous Motor (06 Hrs)

Principal of operation of three phase synchronous motor, staring methods of three phase synchronous motors (using prime mover and damper winding, Phasor Diagram of three phase synchronous motor at Unity, lagging and leading power factor, Effect of excitation on power factor and armature current, V & inverted V Curves, Operation of Synchronous motor as Synchronous Condenser, Application of three phasesynchronousmotor.

General Instructions:

1. Batch wise tutorials are to be conducted. The number of students per batch should be as per the university pattern for practicalbatches
2. Minimum number of assignments should be 6 covering all topics.

Recommended Books:

- Electrical Machines, S. K. Bhattacharya, Tata Mc-Graw-Hill publication
- Electrical Machines, I. J. Nagrath, D. P. Kothari, Tata Mc-Graw-Hill publication IV edition
- V. K. Mehta "Principles of Electrical Machines". S. Chand Publishers, New Delhi
- B. L. Theraja "A textbook of Electrical Technology" Volume II S. Chand Publishers, New Delhi

Reference Books:

- Electric Machinery, A. E. Fitzgerald, Mc-Graw Hill publications VIedition
- Electrical Machines, AshfaqHussain, DhanpatRai&Sons
- Electrical Machinery, P S Bhimbhra, Khanna Publications

List of Experiments:

Minimum eight experiments from the following list of experiments should be performed in the laboratory:

- Determination of efficiency & speed regulation of 3 phase SCIM by indirect loadingmethod
- Determination of equivalent circuit parameters of 3 Ph SCIM by conducting No Load& Blocked

Rotor Test.

- Determination of efficiency & speed regulation of 3 phase slip ring induction motor by direct loadingmethod.
- Determination of efficiency & speed regulation of 3 phase slip ring induction motor by indirect loadingmethod.
- Study of starters for 3 Ph inductionmotors
- Performance of three phase induction motor under single phasingfault
- Speed control methods of 3 Ph.SCIM
- Speed control methods of 3 Ph. Slip ringI.M
- Determination of efficiency & speed regulation of 1 phases inductionmotor
- Determination of Voltage regulation of an alternator by EMFmethod
- Determination of Voltage regulation of an alternator by MMFmethod
- Determination of Voltage regulation of an alternator by ZPFmethod
- Determination of Xd and Xq by Sliptest
- Performance of synchronous generator connected to infinite bus, under constant power and variable excitation & vice –versa
- Determination of V and Inverted V curves of a synchronousmotor
- Determination of efficiency of synchronous motor by indirectloading
- Determination of efficiency of synchronous motor by directloading
- Determination of load sharing by paralleloperation
- Determination of efficiency of Alternator by direct loadingmethod

SHIVAJI UNIVERSITY, KOLHAPUR

THIRD YEAR B.TECH (ELECTRICAL) SEMESTER -V

POWER SYSTEM-II

Course Code And Title	Teaching Scheme					Evaluation Scheme					
	L	T	P	Credit	Scheme	Theory (Marks)		Practical(Marks)		POE(Marks)	
						Max	Min. for Passing	Max	Min. for passing	Max	Min. for passing
PCC-EE-303 **Power System -II**	03	--	02	04	ISE	-	-	-	-	-	-
					MSE	30	12	-	-	-	-
					ESE	70	28	50	20	-	-

ISE: InSemesterEvaluation **MSE**: MidSemesterEvaluation **ESE**: End SemesterEvaluation

Objectives:

1. Develop analytical ability for Power system.
2. Analysis of symmetrical and Unsymmetrical fault conditions
3. Demonstrate different computational methods for solving problems of load flow
4. Power factor improvement techniques and substation engineering

Course Outcomes:

After completion of this course students will be able to:

1. Understand the need of power factor improvement and substation layout.
2. Identify sequence components and to draw sequence network of different Power system component
3. Analyze power system in P.U and will be able to represent power system with its components
4. Evaluate system fault Analysis

SECTION I

Unit 1: Power system Components ***(6 Hrs)***

Single phase representation of Balanced 3 phase Networks, OLD & Impedance & Reactance Diagram, Per Unit System- P.U. Representation of Transformer, P.U. Impedance Diagram of Power system, Steady State Model of Synchronous Machine, Representation of Loads, Numerical treatment expected

Unit 2: Symmetrical Fault Analysis ***(8 Hrs)***

Short circuit transients on transmission line Short Circuit on Unloaded Synchronous machine, Short Circuit on loaded Synchronous machine **,**Selection Checklist for circuit breaker, Short circuit MVA, Algorithm for Short circuit studies **,** Z- Bus Formulation, Numerical treatment expected

Unit 3: Symmetrical Components ***(8 Hrs)***

Sequence Impedances Synchronous machine. Sequence Impedances Transformer, Construction of Sequence network of Power Systems, Numerical treatment expected

SECTION II

Unit 4: Unsymmetrical Fault Analysis ***(10 Hrs)***

Symmetrical component analysis of Unsymmetrical Faults, Analysis of Single Line to Ground (LG) fault, Line-To-Line (LL) fault, Double-Line-To-Ground (LLG) fault, One conductor open fault, Bus Impedance Matrix for analysis of Unsymmetrical shunt faults, Numerical treatment expected

Unit 5: Load Flow Analysis ***(10 Hrs)***

Load flow problem, Gauss-Seidel Method, Newton-Raphson Method, Decoupled Load Flow studies, Fast Decoupled Load Flow studies. Comparison of Load Flow methods, Numerical treatment expected

Unit6: Power Factor Improvement and Substation Engineering ***(6 Hrs)***

Causes, Disadvantages of low power factor and power factor improvement Methods,Substation Grounding, Direct Lightning stroke shielding of substations, Role of Substations in Smart Grids.

General Instructions:

1. The number of students per batch should be as per the university pattern for practicalbatches.
2. Minimum number of assignments should be 8 covering alltopics.

List of Experiments

Minimum 10 experiments/simulations based on above curriculum should be performed.

Recommended Books:

1.Modern Power System Analysis , D. P. Kothari, I. J. Nagrath, Mc-Graw Hill Publications, Fourth Edition

2. Power System Analysis, HadiSaadat, Tata Mc-Graw Hill

3. Electric Power substations Engineering, John D. McDonald, CRC Press , Third Edition

Reference Books:

1. Electrical Transients in Power Systems, Greenwood, Wiley Publication II edition

2. Power System Stability Vol I/II/III, Kimbark, Wiley Publication

3. Electrical Power Systems, AshfaqHussain, CBS publishers, New Delhi V edition

4. Electric Power Systems: A first course, Ned Mohan, Wiley Publication

5. Power System Operation & Control, K. Uma Rao, Wiley Publication

SHIVAJI UNIVERSITY, KOLHAPUR
THIRD YEAR B.TECH (ELECTRICAL) – SEMESTER –V

ADVANCED CONTROL SYSTEM

Course Code and Titile	Teaching Scheme					Evaluation Scheme					
						Theory (Marks)		Practical(Marks)		POE(Marks)	
	L	T	P	Credit	Scheme	Max.	Min. for Passing	Max.	Min. for passing	Max.	Min. for passing
PCC-EE-304 **Advanced Control System**	03	---	02	04	ISE	---	---	---	----	---	---
					MSE	30	12	---	---	---	---
					ESE	70	28	---	---	---	---

ISE: In Semester Evaluation MSE: Mid Semester Evaluation ESE: End Semester Evaluation

Course Objectives:

1. To make students understand the concept of control design techniques, Compensation Techniques, design in frequency domain and design of PID control system
2. To study the control system design by root locus method
3. To study the control system design by Bode plot method
4. To make students understand the concept of state space analysis
5. Demonstrate the design of state space
6. To study the digital control system Z-Transform and sampling, mapping between S-Plane & Z-Plane, stability analysis, transient & steady state analysis.

Course Outcomes:

1. The students will be able to design a compensation techniques like Lag, Lead and Lead-Lag Controllers in frequency domain, design of PID controller
2. Derive and Design a Lead, Lag, and Lead-Lag Compensation using Root Locus
3. Derive and Design a Lead, Lag, and Lead-Lag Compensation using Bode Plot
4. Analyse the state space representation of digital control system, derive state space equation, and its Transfer function
5. Design a state space using controllability, Observability, Pole Placement techniques for controller, Pole placement technique by Transformation method, Direct Substitution Method and by Ackermann's formula
6. The students will be able tounderstand the digital control systemof Z-Transform and sampling, mapping between S-Plane & Z-Plane, stability analysis, transient & steady state analysis.

SECTION I

Unit –I Basics of Control Systems[6 Hrs]

Classical Control Design Techniques Compensation techniques –Lag, Lead, Lead-Lag Controllers design in frequency Domain, Design of PID control system.

Unit –II Control System Design by Root Locus [9Hrs]

Review of Root Locus, Cascade Lead compensation, cascade Lag compensation, cascade Lead-Lag compensation, Series and parallel compensation, Effect of addition of poles and zeros,Design of Lead compensation based on Root Locus approach, Design of Lag compensationbased on Root Locus approach, Design of Lead-Lag compensation based on Root Locusapproach, Root Locus of system with dead time.

Unit –III Control System Design by Bode Plot[9Hrs]

Review of Bode Plot, Stability of system from Bode Plot, Cascade Lead compensation, cascadeLag compensation, cascade Lead-Lag compensation, Design of Lead compensation based onBode Plot, Design of Lag compensation based on Bode Plot, Design of Lead-Lag compensationbased on Bode Plot.

SECTION II

Unit –IV State Space Analysis[6 Hrs]

State space representation of digital control system, Solving state space equation , Pulse transfer function.

Unit –V State Space Design[9Hrs]

Review of State Space, Controllability, Observability (Kalmans's test & Gilbert's test), Poleplacement technique for controller design, State Feedback Law, Pole placement technique byTransformation method, Direct Substitution Method and by Ackermann's formula.

Unit –VI Digital Control System [9Hrs]

Review of Z-Transform, Z-Transform method for solving different equations, impulse sampling & data hold, pulse transfer function, Sampling theorem, mapping between S-Plane & Z-Plane, stability analysis, transient & steady state analysis

General Instructions:

Term Work- Minimum 8 to 10 MATLAB based experiments based on above syllabus should be performed.

Text books:

1. Control system: Principles and Design, M. Gopal, Tata McGraw-Hill Publication.
2. Modern Control Engineering, K. Ogata, Eastern Economy,5th edition 2011.
3. Control System Engineering, I. J. Nagrath and M. Gopal, New Age publication, 5thedition, 2008.

Reference Books:

1. Automatic Control System, B. C.Kuo, Wiley Publication 8th edition.
2. Control System Engineering, Norman S. Nise, 4th Edition, John Wiley and Sons, 2004.
3. Digital Control and State Variable Methods, M.Gopal, Tata McGraw Hill, 3rd edition.
4. Control System Engineering, Gupta, Wiley Publications.
5. Control Engineering, K. P. Ramchandran, Wiley Publications.
6. Automatic Control Systems, Shridhar, Wiley Publications.

SHIVAJI UNIVERSITY, KOLHAPUR

THIRD YEAR B.TECH (ELECTRICAL) SEMESTER -V

SIGNALS AND SYSTEMS

Course Code and Title	Teaching Scheme					Evaluation Scheme					
						Theory (Marks)		Practical(Marks)		POE(Marks)	
	L	T	P	Credit	Scheme	Max.	Min. for Passing	Max.	Min. for passing	Max.	Min. for passing
PCC-EE-305 **Signals and Systems**	03	01	-	04	ISE	-	-			-	-
					MSE	30	12	-	-	-	-
					ESE	70	28	25	10	--	-

ISE: InSemesterEvaluation MSE: MidSemesterEvaluation ESE: End Semester Evaluation

Objectives:

1. This course intends to provide basic knowledge of theoretical structure, formal representation, computational methods, notation, and vocabulary of linear models.
2. It is aimed to impart skills to perform signal analysis with reference to spectrum analysis of deterministic signals

Course Outcomes: After completion of this course students will be able to:

1. **Define** CT and DT signals mathematically and **Classify** systems based on their properties
2. **Explain** concept of LTI system and **Evaluate** convolution.
3. **Make use of** Laplacetransform to analyze CT signals and systems.
4. **Make use of** Z transforms to analyze DT signals and systems.
5. **Determine** Fourier transforms for CT & DT.
6. **Explain** sampling theorem in time domain and frequency domain.

SECTION I

Unit 1: Introduction to signals & systems(6 Hrs)

Continuous & discrete signal: size of signal, signal operations, classification of signals, standard test signals, singularity functions. Continuous & discrete systems: Classification of systems, system models of Electrical systems

Unit 2: Description and analysis of system(7 Hrs)

Continuous & discrete systems: zero state response, zero input response, convolution sum and convolution integral, graphical representation of convolution, block diagram representation of differential and difference equation, FIR and IIR systems

Unit 3: System Analysis using Laplace transform(6 Hrs)

Laplace transform: A brief introduction to Laplace transform its properties and inverse Laplace transform, transfer function analysis, solution of LTI differential equation.

SECTION II

Unit 4: System analysis using Z-transform (6 Hrs)

A brief introduction to Z–transform, its properties & inverse – Z transform, connection between Laplace transform and Z–transform, transfer function analysis, solution of LTI difference equation, and stability in Z-domain.

U*nit 5: Fourier analysis of continuous & discrete signals(8 Hrs)*

Periodic representation by trigonometric Fourier series, Fourier spectrum, Dirichlet's condition, exponential Fourier series, exponential Fourier spectra, Parseval's theorem, Fourier transform and its properties, Relation between Fourier and Laplace Transform, Fourier spectrum. DTFT, Properties and symmetrical properties of DTFT, Convergence of DTFT: Gibb's Phenomenon.

Unit 6: Sampling(4 Hrs)

Representation of continuous time signals by its samples, The sampling theorem, Reconstruction of signals from its sample s using interpolation, The effect of under sampling, aliasing, Discrete time processing of continuous time signals, Sampling in the frequency domain.

General Instructions:

1. Minimum number of tutorials should be 8 covering alltopics.

Text Books:

1. **Linear systems and signals, B. P. Lathi, Oxford University Press, 2nd edition, 2005**
2. **Signals and systems, Simon Haykin, Wiley Publications**

Reference Books:

1. **Alan V. Oppenheim, Alan S. Wilsky, S. Hamid Nawab -'Signals & system' -IInd Edition - Pearson Education.**
2. **Ramesh Babu 'Signals &system' , SciTech Publication.**
3. **Michael J. Roberts.-'Fundamentals of signals & systems'- Tata McGraw Hill, 2007.**
4. **Continuous and Discrete Time Signals and Systems by Mandal and Asif, CambridgeUniversity Press**
5. **Signals and Systems by Dr.D.D.Shaha and Dr.A.C.Bhagali, MPH.**
6. **Signals and Systems by S. Palani, Ane Books Pvt. Ltd**

SHIVAJI UNIVERSITY, KOLHAPUR

THIRD YEAR B.TECH (ELECTRICAL) SEMESTER -V

MATLAB

Course Code and Title	Teaching Scheme					Evaluation Scheme					
						Theory (Marks)		Practical(Marks)		POE(Marks)	
	L	T	P	Credit	Scheme	Max.	Min. for Passing	Max.	Min. for passing	Max.	Min. for passing
BSC-EE-306 **MATLAB**	03	--	02	02	ISE	-	-	-	-	-	-
					MSE	-	-	-	-	-	-
					ESE	-	-	75	30	--	-

ISE: InSemesterEvaluation MSE: MidSemesterEvaluation ESE: End Semester Evaluation

Objectives:

Students are expected to solve Electrical Engineering problems using any available softwaretools such as MATLAB/Simulink, C, C++, PSIM, ETAP, PSCAD, MIPOWER, Power WorldSimulator, SKM Power Tools, VISIO, AUTOCAD, PSPICE, LABVIEW etc. Sample tasks are enlisted below.

Minimum 12 tasks should be performed as a part of term work.

1. Programming of at least 3 numerical methods for solving nonlinear equations.
2. Simulation of Electrical Machines such as transformers, DC machines and AC machines and evaluation of their performance parameters.
3. Simulation of electrical R-L-C networks, resonant circuits, filter circuits and plotting their input-output waveforms
4. Simulation of power system networks and its performance analysis (load flow analysis, short circuit analysis, transient analysis, stability analysis, relay coordination etc.)
5. Simulation of DC-DC, DC-AC, AC-DC and AC-AC converter circuits, plotting their input output waveforms and performing their analysis
6. Measurement techniques for electrical engineering parameters using suitable software
7. Simulation of hybrid power system (Wind, Solar, Solar Series/Parallel)
8. Design of typical control panel for industrial application

General Instructions:

1. The number of students per batch should be as perthe university pattern for practicalbatches.

Recommended Books:

1. Agam Kumar Tyagi, "Matlab and Simulink for Engineers" Oxford Higher Education, Oxford University Press. ISBN:9780198072447
2. Edward B. Magrab, Shapourazarm, BalakumarBalachandran, James Duncan, Keith Herold, Gregory Walsh "An Engineers Guide to MATLAB, 3/E" ISBN-10: 0131991108 • ISBN-13: 9780131991101, Pearson Education Ltd.
3. Holly Moore, "MATLAB for Engineers", Global Edition, 5/E, SBN-10: 1292231203 • ISBN-13: 9781292231204, Pearson Education Ltd.
4. L. Ashok Kumar, A. Kalaiarasi, Y. Uma, "Power Electronics with MATLAB" Cambridge University Press2017
5. Viktor Perelmuter, "Renewable Energy Systems: Simulation with Simulink® and SimPowerSystemsTM" CRC Press, Taylor & Francis

SHIVAJI UNIVERSITY, KOLHAPUR

THIRD YEARB.TECH (ELECTRICAL) SEMESTER –V

ELECTRICAL APPLIANCES AND LUMINORIES
(Open Elective -I)

Course Code and Title	Teaching Scheme					Evaluation Scheme					
						Theory (Marks)		Practical(Marks)		POE(Marks)	
	L	T	P	Credit	Scheme	Max.	Min. for Passing	Max.	Min. for passing	Max.	Min. for passing
OCE-EE-301 **ELECTRICAL APPLIANCES AND LUMINORIES**	02	-	02	03	ISE	-	-			-	-
					MSE	30	12	-	-	-	-
					ESE	70	28	25	10	--	-

ISE: InSemesterEvaluation MSE: MidSemesterEvaluation ESE: End Semester Evaluation

Objectives:

1. To expose students to Different domestic appliances and luminaries.
2. To familiarize procedure of troubleshooting and maintenance of electrical appliances

Course Outcomes:

After completion of this course students will be able to:

1) Apply Knowledge to maintain the different electrical appliances
2) Construct And repair domestic appliances
3) Design and troubleshooting of UPS and Inverters
4) Illustrate basic concepts of illumination.
5) Designing of lighting for domestic purpose
6) Designing of lighting for special purpose

SECTION I

Unit 1: Fundamentals of Domestic appliances (6 Hrs)

Principle of heating appliances, motoring appliances, construction, **dismantling, reassembling, testing and repairing of**: electrical iron, electric kettle, electric emersion heater, electric geysers, electric toasters, electric fans, battery operated torch, coffee percolator and electrical mixer.

Unit 2: Domestic appliances (6 Hrs)

construction, dismantling, reassembling, testing and repairing of:heat convector(blower), room cooler, electric washing machine, hair dryer, electric vacuum cleaner, emergency light, domestic refrigerator, water cooler, air conditioner (window type)

Unit 3: Study of UPS and inverter(6 Hrs)

Introduction to UPS**, Construction and operating principle of different UPS systems:** Standby, line interactive standby ferro, standby online hybrid, double conversion online, delta conversion online, elementsof UPS**:**Relay, transformer, battery, fuse/fuse holder, switches, sockets, panel indicator, meter

Introduction to inverter, working principle of inverter, Construction and operating principle of different inverters, classification of inverters, sine wave inverter and square wave inverter, testing and troubleshooting of inverters

SECTION II

Unit 4: Fundamentals of illumination(6 Hrs)

Basics of illumination, Laws of illumination, polar curves and its applications for designing the lamp, concept of photometry, measurement of illumination, **lighting calculation methods**: watt per meter square method lumens method point to point method

Unit 5: Types of Lamps (6 Hrs)

Incandescent lamp, fluorescent lamp, sodium vapour lamp, mercury vapour lamp metal halide lamp, neon lamps, LED, CFL,LASER Selection criteria for lamps.

Unit6: Lighting for special applications (6 Hrs)

Factory lighting, street lighting, flood lighting, Railway lighting, lighting for advertisement/ hording lighting, agriculture and horticulture lighting, health care centers, hospitals, decorating purpose stage lighting, aquarium and shipyards lighting and special purpose lamps used in photography video films

General Instructions:

- The number of students per batch should be as perthe university pattern for practicalbatches.
- Minimum number of assignments should be 6 covering alltopics

Recommended Books:

- **Study of Electrical Appliances and devices, K. B. Bhatia, Khanna Publishers**
- **Applied illumination engineering, Lindsey Jack L.,The Fairmont Press Inc.**
- **Lighting engineering; applied calculation, Simons R.H. Bean Robort, Architcctural Press**

Reference books:

- **Energy management in Illuminating systems, Kao Chen, CRC Press.**
- **Handbook of Industrial Lighting, Butterworths, Lyon Stanley**

SHIVAJI UNIVERSITY, KOLHAPUR

THIRD YEAR B. TECH (ELECTRICAL) SEMESTER -V

DOMESTIC /INDUSTRIAL ELECTRICAL INSTALLATION, ESTIMATION AND COSTING

(Open Elective – I)

Course Code and Title	Teaching Scheme					Evaluation Scheme					
						Theory (Marks)		Practical (Marks)		POE(Marks)	
	L	T	P	Credit	Scheme	Max.	Min. for Passing	Max.	Min. for passing	Max.	Min. for passing
OCE-EE-301 **Domestic /Industrial Electrical Installation, Estimation and Costing**	03	--	02	04	ISE	-	-	-	-	-	-
					MSE	30	12	-	-	-	-
					ESE	70	28	25	10	--	-

ISE: InSemesterEvaluation MSE: MidSemesterEvaluation ESE: End Semester Evaluation

Objectives:

7. This course is intended to provide basic knowledge of different material required for electrical installation
8. It intends to impart skills to select suitable electrical equipments for installation.
9. It develops ability of estimate and costing of electrical installation.

Course Outcomes: After completion of this course students will be able to:

7) **Explain & Evaluate** concept of domestic and industrial wiring
8) **Define & Explain** concepts of Estimating and concepts of contracting
9) **Analyze & Design** Estimating And Costing of Domestic And Industrial Wiring
10) **Explain & Evaluate** concept Estimating and Costing of Service Connection
11) **Analyze & Design** Estimation of Transmission line
12) **Analyze & Design** Estimation of Overhead and Underground Distribution System

SECTION I

Unit 1: Electrical Wiring ***(6 Hrs)***

Different types of wires, wiring system and wiring methods,Comparison of different types of wiring, Specifications of Different types of wiring materials, Accessories Different types of wiring tools.Domestic and industrial panel wiring, different types of wiring circuits, I.E. rules for wiring, Electricity supplyact-1948

Unit 2:Elements of Estimating and concepts of contracting ***(6Hrs)***

Introduction to estimation & estimation tools, Electrical Schedule of rates, catalogues, Survey and source selection, recording estimates. Determination of required quantity of material, Labor conditions, Determination of cost material and labor,Contingencies, Overhead charges, Profit, Purchase system, Purchase enquiry and selection of appropriate purchase mode, Comparative statement, Purchase orders, Payment of bills, Terms, conditions

types of contract system. Tendering procedure and preparation of simple tender, Procedure for inviting and scrutinizing tender, Importance of Earnest Money Deposit, Security Deposit and S.O.R. Indian Electricity Act and major applicable I.Erules.

Unit 3: Estimating And Costing of Domestic And Industrial Wiring ***(8 Hrs)***

Principles of circuit design in lighting and power circuits, Procedures for designing the circuits and deciding the number of circuits, Method of drawing single line diagram, Selection of type of wiring and rating of wires and cables, Load calculations and selection of size of conductor, Selection of rating of main switch, distribution board, protective switchgear ELCB and MCB and wiring accessories, Earthing of residential Installation, Sequence to be followed for preparing estimate, Preparation of detailed estimates and costing of residential installation, Important considerations regarding motor installation wiring, Determination of input power, input current to motors, rating of cables, rating of fuse, size of Conduit, size of distribution Board, main switch and starter. Preparation of detailed estimates and costing industrial installation, I.E. rules observed for abovewiring.

SECTION II

Unit 4: Estimating and Costing of Service Connection (Domestic and Industrial): (7Hrs)

Concept of service connection, Types of service connection and their features, Method of installation of service connection(1-phase and 3-phase), Lay out/ wiring diagram of service connection list of materials and accessories along with specifications required for given installation work, Estimation of service connection for domestic and industrial (1-phase and 3-phase) I.E. rules pertaining to abovewiring.

Unit 5: Estimation of Transmission line:(5Hrs)

Main components of overhead lines, Line supports, Factors governing height of pole, Conductor materials, Determination of size of conductor for overhead Transmission line, Cross arms, Pole brackets and clamps, Guys and Stays, Conductors configuration spacing and clearances, Span lengths, Overhead line insulators, Insulator materials Lightning Arrestors, Points to be considered at the time of erection of overhead lines, Erection of supports, Setting of stays, Earthing of lines, Guarding of overhead lines, Clearances of conductor from ground, Spacing between supports conductors,important specifications and sketches List of materials and accessories required for the given project estimate for material required I.E. rules pertaining to aboveproject

Unit 6: Estimation of Overhead and Underground Distribution System(4Hrs)

Survey work for estimationof overhead and underground distribution system.Planning and layout of project.List of materials and accessories required for the given project.Procedure for preparing estimate for 440 V, 3-phase, 4 wire or 3 wire overhead and underground distribution system.Necessary drawing/sketches of overhead and underground system.I.E.rules pertaining to aboveproject.

General Instructions:

3. The number of students per batch should be as perthe university pattern for practicalbatches.
4. Minimum number of assignments should be 6 covering alltopics.

Term work:

Minimum 6 number of assignments should be covering all topics

1. Draw different types of wiring circuits
2. Prepare a tender for installation of distribution transformer and give procedure for inviting and scrutinizing tender
3. Prepare detailed estimates and costing of residential installation & draw layout of it
4. Draw wiring diagram of domestic and industrial service connection (1-phase and 3-phase)
5. Sketches List of materials and accessories required for installation of Transmission line
6. Prepare estimation of 440V, 3-phase, 4 wire or 3 wire overhead and underground distribution system & draw layout of it

Recommended Books:

1. **A course in Electrical Installation, Estimating andcosting, JBGupta, S K Kataria and Sons.**
2. **Electrical InstallationandEstimating, SurjitSingh, Dhanpatrai AndSons.**

Reference Books:

1. **Electrical Design Estimating and Costing K. B. Raina, New Age International, 2007**

SHIVAJI UNIVERSITY, KOLHAPUR

THIRD YEAR B.TECH (ELECTRICAL) SEMESTER -VI

DIGITAL SIGNAL PROCESSING

Course Code and Title	Teaching Scheme					Evaluation Scheme					
						Theory (Marks)		Practical(Marks)		POE(Marks)	
	L	T	P	Credit	Scheme	Max.	Min. for Passing	Max.	Min. for passing	Max.	Min. for passing
PCC-EE-307 **Digital Signal Processing**	04	--	-	04	ISE	-	-	-	-	-	-
					MSE	30	12	-	-	-	-
					ESE	70	28	-	-	--	-

ISE: InSemesterEvaluation MSE: MidSemesterEvaluation ESE: End Semester Evaluation

Objectives:

1. Imparting Basic knowledge of Digital Signal Processing
2. To develop skills of filter design.
3. It is intended to learn basics of Digital Signal Processors
4. Overview of communication systems

Course Outcomes: After completion of this course students will be able to:

1. **Explain & Evaluate** concept of convolution, DFT & FFT
2. **Analyze & Design** DSP filters.
3. **Analyze & Construct**DSP filter.
4. **Illustrate** & **Distinguish** DSP processors
5. **Define & Explain** various modulation techniques

SECTION I

Unit 1: Discrete Fourier Transform(10 Hrs)

DFT, Properties of DFT, Circular Convolution and Circular Co-relation using DFT and IDFT, Analysis of LTI System using Circular Convolution, Linear Convolution using Circular Convolution. Overlap Save and Overlap add algorithm. FFT Algorithms – Radix 2: DIT-FFT and Radix 2: DIF.

Unit 2: FIR Filter Design & Realization(8Hrs)

Characteristics of FIR Filters. Properties of FIR Filters.FIR Design using Windowing Technique [Rectangular Window, Hamming Window and Hamming Window] FIR Design using Kaiser Window.FIR Design using Frequency Sampling Technique. FIR realization- Direct Form (Non-linear

phase and Linear phase), Cascade and Parallel realization

Unit 3: IIR Filter Design & Realization(8 Hrs)

Introduction to IIR Filters, IIR Filter Designing using Impulse Invariant method and Bilinear Transformation method, Butterworth Filter approximation, Frequency Transformation. IIR realization-Direct form I and II, Cascade and parallel realization

SECTION II

Unit4: DSP Processors ***(6 Hrs)***

Introduction, Architecture of DSP Processor, TMS320C67XX, Specifications, Comparison between general purpose and DSP Processors.

Unit 5:Amplitude Modulation ***(8 Hrs)***

Base-band and carrier communication, amplitude modulation -DSB, AM, AM, SSB, VSB, carrier acquisition, super heterodyne AM receiver.

Unit 6: Angle Modulation ***(8 Hrs)***

Concept of instantaneous frequency, band-width of angle modulated waves, generation of FM waves, demodulation of FM, Interference in angle modulated systems, FM receiver.

General Instructions:

Minimum number of assignments should be 8 covering alltopics.

Recommended Books:

1. **Digital Signal Processing Principles, Algorithms and Application – By John G Prokis, Manolakis, Pearson Education publication**
2. **Digital Signal Processing Salivahanam, AVallavaraj, C. Guanapriya, TMH**
3. **Modern Digital and Analog Communication systems B.P. Lathi, 3rd Edition, Oxford University Press 1998.**

Reference Books:

1. **Digital Signal Processing, Tarun Kumar Rawat (Oxford)**
2. **Digital Signal Processing SanjeetMitra, MGH**
3. **Digital Signal Processing- Dr. A. C. Bhagali,MPH**
4. **Digital Signal Processing- A. Anand Kumar.(PHI Publications)**
5. **Digital Signal Processing P. Ramesh Babu, Scitech publication**
6. **Communication Electronics, L.F. Frangel, Tata McGraw Hill 2002**
7. **Texas Instruments DIP Processor data sheet.**

SHIVAJI UNIVERSITY, KOLHAPUR

THIRD YEAR B.TECH (ELECTRICAL) SEMESTER -VI

ELECTRICAL MACHINE DESIGN

Course Code and Title	Teaching Scheme					Evaluation Scheme					
						Theory (Marks)		Practical(Marks)		POE(Marks)	
	L	T	P	Credit	Scheme	Max.	Min. for Passing	Max.	Min. for passing	Max.	Min. for passing
PCC-EE-308 **Electrical Machine Design**	04	01	02	06	ISE	-	-	-	-	-	-
					MSE	30	12	-	-	-	-
					ESE	70	28	50	20	50	20

ISE: InSemesterEvaluation MSE: MidSemesterEvaluation ESE: End Semester Evaluation

Objectives:

1. This course intends to provide basic knowledge of design process of simple Electrical machines.
2. It is aimed to impart skills to perform and apply basics of Electrical Engineering for design of Electrical machines
3. It is aimed to impart knowledge of software applications for electrical machine design.

.

Course Outcomes: After completion of this course students will be able to:

1) Recognize thefundamentals and essential standards to design electrical machine
2) Design of entire transformer in detail
3) Design of armature, field winding and Commutator of DC machines
4) Design of stator core ,stator winding and rotor bars of three phase induction motor
5) Design of different parts of synchronous machine
6) Design of transformer, induction motor, DC machines and synchronous machines using Computer application .

SECTION -I

Unit 1: Fundamentals of electrical Machine Design ***(08 Hrs)***

General consideration in the design, limitations in the design, output coefficient and theirstandard values for various machines, effect of size & ventilation on specific electric andmagnetic loading. Different Indian Standard Specifications (ISS).

i) Magnetic circuits – Formulae for air and iron parts, calculations for magnetic circuits ofelectric

machines, estimation of no load current, determination of leakage fluxes and reactancecalculations, design of electromagnets.

ii) Mechanical Design – design of shafts, choice and types of bearings, determination ofmechanical strength of rotors, design consideration of cooling fans and frames.

Unit 2: Design of Transformer ***(8 Hrs)***

Classification of transformer (Core type, Shell type transformer), Comparison of core and Shell Type transformer, Single phase & 3 Phase transformer connections, Core Cross Section, Cooling of transformer, transformer Insulation using Oil & other materials. Output equation of transformer, Relation between Core Area & Weight of iron & copper, Design for minimum cost, Design for minimum loss or maximum efficiency, variation of Output &losses in transformer with linear Dimensions, Design of Core (rectangular core, Square &stepped Cores), Variation of Core Diameter, Selection of core areas & type of core, Choice of Flux Density, design of winding, Windows Space Factor, Windows Dimensions, Overall Dimensions, Simplified Steps for transformer Design. Resistance of Winding, Mechanical Forces, No load currents, No load current of 1ph transformer, No load current of 3phase transformer, Design of Tank with Tubes, Core Design, Winding Design, Window Area

Unit 3: Design of DC Machines ***(8Hrs)***

Introduction & Applications, classification, Constructional Details, Stator, Armature,Commutator, Brush Gear, Design output Equation, Interdependence of specific & ElectricLoadings, Selection of no of poles, Core Length, Armature diameter, Length of air gap, No ofArmature coils, No of Armature Slots, Cross Section of Armature Conductors, Insulation ofarmature winding, Slots Dimensions, Poles Design (Area of poles, Height of Poles), length ofInter poles, Losses & Efficiency (Rotational Losses,Losses Stray load losses, Efficiency).Design of commutator and brush gear.

SECTION -II

Unit 4: Design of Three Phase Induction Motor ***(8 Hrs)***

Main Dimension, stator Winding,(Turns Per Phase, Stator Conductors), Shapes of Stator Slots, No of Stator Slots, Area of stator Slots, Length OfMean Turn, Stator Teeth, Stator Core, Rotor Design, length of air gap, Relation For Calculations of Length of air gap, No of Rotor Slots,(Rules For Selecting Rotor Slots, Reduction ofHarmonic torques), Design of rotor bars & Slots, (Rotor Bar Currents, Area of Rotor Bar, shapes& Size Of Rotor Slots, Rotor Slot Insulations), Design of End Rings.

Unit 5: Design of Synchronous Machine ***(8 Hrs)***

Construction of water wheel and turbo alternators. Different parts and materials used for Synchronous machine, choice of electric and magnetic loadings, Output equation. Determination of diameter and length, effect of short circuit ratio on machine performance.

Unit 6: Computer Applications in electrical machine design ***(8Hrs)***

Benefits of computer in machine design, methods of approach, optimization and computer aided design of three phase transformer, three phase induction motor, DC Motor and synchronous machine

Term work:

1. The term work shall consist of six drawing sheets and four sheets should be drawn using suitable software

Recommended Books:

1) A Course in Electrical Machine Design, A.K.Sawhney, DhanpatRai& sons New Delhi
2) 2.Principles of Electrical Machine Design, R. K. Agarwal, S. K. Katariya and sons.

Reference Books:

1. Electrical Machine Design Data Book, A Shanmugasundaram, G. Gangadharan, R Palani, 3rd Edition, Wiely Eastern Ltd., New Delhi
2. Computer Aided Design for Electrical Machines, Vishnu Murthy, B.S. Publications

SHIVAJI UNIVERSITY, KOLHAPUR

THIRD YEAR B.TECH (ELECTRICAL) SEMESTER -VI

POWER SYSTEM STABILITY AND CONTROL

Course Code and Title	Teaching Scheme					Evaluation Scheme					
	L	T	P	Credit	Scheme	Theory (Marks)		Practical(Marks)		POE(Marks)	
						Max	Min. for Passing	Max	Min. for passing	Max	Min. for passing
PCC-EE309 **Power System Stability and Control**	04	--	02	05	ISE	-	-	-	-	-	-
					MSE	30	12	-	-	-	-
					ESE	70	28	50	20	-	-

ISE: InSemesterEvaluation**MSE**: MidSemesterEvaluation**ESE**: End Semester Evaluation

Objectives:

1. Perform fundamental computation and modeling of power system control and stability.
2. Develop skills to model control devices that can be incorporated in power system simulations.
3. Analyze dynamic behavior of power control systems subject to various disturbances from the aggregated behavior of the many dynamic devices.

Course Outcomes:

After completion of this course students will be able to:

1. Understand Power System Dynamics Problems, Current Status & Recent Trends.
2. To develop ability to analyze and use various methods to improve stability of power systems.
3. Evaluate Methods of Improving Stability
4. To illustratethe automatic frequency and voltage control strategies for single and two area case.
5. To understand formulation of unit commitment and economic load dispatch tasks and solve it using optimization techniques
6. Explicate need of System State Classification, Security Analysis and Factors Affecting Power System Security.

SECTION I

Unit 1: Introduction to Power System Stability & Control(6 Hrs)

Power System Stability, Classification Power system Stability, State Operation & System Security :-Review, System Dynamics Problems Current Status & Recent Trends, System Model, Dynamics of Synchronous Machine [Swing equation]NUMERICALS EXPECTED.

Unit 2:Power system Stability(10 Hrs)

Factors affecting Transient Stability, Swing Equation Solution [Point By Point Method, Equal Area Criteria], Transient Stability Limit, Critical Clearing Angle and Critical Fault Clearing Time, Fault Shunts and Impedances of Fault Shunts, Multi Machine Stability, NUMERICALS EXPECTED.

Unit 3:Methods of Improving Stability(10 Hrs)

Transient Stability Enhancements:- High Speed Fault clearing, Reduction of transmission systemreactance , regulated shunt compensation , dynamic Braking , Reactor Switching, Controlled system Separation & Load Shedding – High Speed Excitation & Control, Discontinuous Excitation Control, Small Signal Stability Enhancement-Power system Stabilizers, Supplementary Control of SVC.

SECTION II

Unit 4:Power System Control(10 Hrs)

Load frequency control (Single and two area case) modeling of generator ,governor, prime mover, Load frequency control and economic dispatch, automatic generation control, steady state analysis and dynamics response of an isolated power systems, automatic voltage control, reactive power control.

Unit 5:Optimal Power System Operation(8Hrs)

Load duration curve, load factor, diversity factor, plant capacity factor, plant utilization factor,Load Forecasting, Optimal Unit commitment, Economic load Dispatch [with/without Transmission line Losses & Generator Limits], NUMERICALS EXPECTED.

Unit 6: Power System Security(4 Hrs)

System State Classification, Security Analysis, Contingency Analysis, Sensitivity Factors,Factors Affecting Power System Security.

General Instructions:

1. The number of students per batch should be as per the university pattern for practicalbatches.
2. Minimum number of assignments should be 8 covering alltopics.

List of Experiments

Minimum 10experiments /simulations based on above curriculum should be performed.

Recommended Books:

1. Modern Power System Analysis, D. P. Kothari, I. J. Nagrath, Mc-Graw Hill Publications, Fourth Edition 2012
2. Power System Analysis, HadiSaadat, Tata Mc-Graw Hill
3. Power System Operation and Control, Dr. K Uma Rao, Wiley India Publication

Reference Books:

1. Power System Stability and Control, PrabhaKundur, TMH Publications.
2. Computer Modeling of Electrical Power Systems, Arrilaga, Wiley Publications, 2ndedition
3. Power Generation, Operation and Control, Allen J. Wood, Wollenberg, Wiley India 2nd edition
4. Power System Dynamics, K. R. Padiyar, BS Publications, Second Edition
5. Electrical Power Systems, Weedy, Wiley Publications, 5th edition
6. Power System Harmonic Analysis, Arrilaga, Wiley Publications

SHIVAJI UNIVERSITY, KOLHAPUR

THIRD YEAR B.TECH (ELECTRICAL) SEMESTER -VI

ELECTRICAL DRIVES-I

Course Code and Title	Teaching Scheme					Evaluation Scheme					
						Theory (Marks)		Practical(Marks)		POE(Marks)	
	L	T	P	Credit	Scheme	Max.	Min. for Passing	Max.	Min. for passing	Max.	Min. for passing
PCC-EE-310 **Electrical Drives –I**	03	--	02	04	ISE	-	-	-	-	-	-
					MSE	30	12	-	-	-	-
					ESE	70	28	25	10	50	20

ISE: InSemesterEvaluation **MSE:** MidSemesterEvaluation **ESE:** End Semester Evaluation

Objectives:

1. To expose students to the operation, application and control of power conversion systems employing electric drive to cater to industrial needs.
2. To familiarize the operation principles, and design of starting, braking, and speed control converters arrangements for electric motors and their applications.
3. To provide strong foundation to asses performance of different industrial drives considering issues such as, energy efficiency, power quality, economic justification, environmental issues, and practical viabilities.

Course Outcomes:

After completion of this course students will be able to:

1. Understand the concept, classification, Parts and advantages of electrical drives with types of loads and conditions of dynamic and stability considerations.
2. Basics of DC motor and the speed control methods of D.C. motor by Single & Three-Phase Converters.
3. Outline of Chopper operation, configuration and control techniques to control the DC Motor.
4. Appraise the Voltage and frequency control method of Induction motor drive in Stator side control.
5. Appraise the rotor resistance control method of Induction motor drive in Rotor side control.
6. Appraise the speed and frequency control method of synchronous motor.

SECTION I

Unit 1: Introduction to Electrical drives:(4Hrs)

Concept of Electrical drive, Classification of Electrical drives, Parts of Electrical drive, Advantages of Electrical Drives, Types of loads and their characteristics, Motor load interaction, Dynamic conditions in Electrical drives, Stability considerations in Electrical drives

Unit 2: Control of DC motor ***(6Hrs)***

a) Single Converters

Introduction, review of Classification of dc motors and their speed control, Electric braking of dc motors, Block Diagram of Electrical Drive, Single phase Controlled Converter for Separately Excited dc motor Drives, DC series Motor Drives, Introduction to 4 quadrant operation of dc motor, Single phase Dual Converter for Four Quadrant Operation

b) Three-Phase Converters

Three phase semi converter Fed with Separately Excited dc Motor, Three Phase Full Converter Fed with Separately Excited dc motor, Three phase semi converter Fed dc Series Motor, Three Phase Full-converter Fed dc Series Motor

c) Chopper

Introduction, Principle of chopper Operation, Classification of Chopper Circuits (single quadrant and four quadrant operation of chopper), Performance of chopper Fed Separately Excited dc Motors, introduction to closed loop system

Unit 3:Induction Motor Drives: Stator side control: ***(8Hrs)***

a) **Stator voltage control:**

Introduction, review of types of 3 phase Induction motors, Torque-speed characteristic of 3 phase Induction motor, Stator Voltage Control using different 3 phase AC voltage controllers, Introduction to closed loop control using stator voltage control

b) **Stator Frequency control:**

Introduction, Variable Frequency Characteristics, Block Diagram of Variable Frequency Speed Control, V/f control, Voltage Source Inverter (VSI) fed induction motor drive, Braking and multi quadrant operation of VSI fed induction motor drive, Variable Frequency Control From a current Source inverter (CSI), comparison of VSI and CSI drives, Introduction of Closed loop speed Control for VSI fed

Induction Motor Drives, Basic operation of Pulse Width Modulated Inverter Fed Induction motor Drive

SECTION II

Unit 4:Induction Motor Drives: ***(6Hrs)***

Rotor side control:

Introduction, Conventional Rotor Resistance Control, Rotor Resistance Control using power converters, Slip Power Recovery Schemes (Static Kramer drive, Static Scherbius drive), Introduction to Vector control of Induction motor

Unit 5: Synchronous Motor Drives and Brushless DC Motor Drives: ***(6Hrs)***

Introduction, review of synchronous motor types & operation, Speed Control of Synchronous Machines in true synchronous mode, Load- commutated Inverter Fed Synchronous Motor Drive, Closed loop Speed control of Synchronous Motor using Load commutated Inverter, Operation of Voltage Source Inverter Fed Synchronous Motor Drive, Introduction to Brushless DC Drives.

Unit 6: Special Drives : ***(6Hrs)***

Switch Reluctance Motor Drives, Torque Equation, Converter Circuits, Operating modes and Applications. Solar Panel V-I Characteristics, Solar Powered Pump, Maximum Power Point Tracking and Battery operated Vehicles.

General Instructions:

1. The number of students per batch should be as per the university pattern for practicalbatches.
2. Minimum number of assignments should be 8 covering alltopics.

List of Experiments

Minimum eight experiments and two simulations based on above curriculum should be performed

Recommended Books:

1. Power Semiconductor Drives, S. Sivanagaraju, M. B. Reddy, A. M. Prasad, PHI, Delhi

2. Fundamentals of Electrical Drives, G. K. Dubey, CRC Press, II edition

3. Electric Drives, N. K. De, P. K. Sen

4. Electric Drives: Concepts & Applications, VedamSubrahmanyam, Tata Mc-Graw-Hill

Reference Books:

1. Electrical Machines & Drives, A First course, Ned Mohan, Wiley Publications

2. Power Electronics: Converters, Applications & Design, Ned Mohan, Wiley Publications

3. Power Electronics & Variable frequency drives: Technology & applications, Bose, Wiley Publications

4. Power Electronics: Circuits, Devices, and Applications, M. H. Rashid, Prentice Hall, III edition

5. Principles of Electric Machines & Power Electronics, P. C. Sen, Wiley Publications, II edition

6. B.K. Bose, "Modern Power Electronics and AC Drives", Prentice Hall of India Pvt. Ltd. Publications.

SHIVAJI UNIVERSITY, KOLHAPUR

THIRD YEAR B.TECH (ELECTRICAL) SEMESTER –VI

ELECTRICAL INSTALLATIONS TESTING ANDMAINTENANCE

Course Code and Title	Teaching Scheme					Evaluation Scheme					
	L	T	P	Credit	Scheme	Theory (Marks)		Practical(Marks)		POE(Marks)	
						Max.	Min. for Passing	Max.	Min. for passing	Max.	Min. for passing
PCC- EE-311 **Electrical Installation Testing & Maintenance**	--	02	02	03	**ISE**	-	-	-	-	-	-
					MSE	-	-	-	-	-	-
					ESE	-	-	50	20	--	-

ISE: InSemesterEvaluation MSE: MidSemesterEvaluation ESE: End SemesterEvaluation

Objectives:

1. Identification of tools and equipment's used for installation and maintenance of electricalequipment.
2. To understand practical aspects of condition monitoring and maintenance of various electrical equipment.
3. To make students aware of electrical safety and IErules
4. To increase interest towards electricalinstallation

Course Outcomes:

After completion of this course students will be able to:

1. Read and interprets electrical installationdrawings
2. Understand and apply IErules
3. To learn testing methods of various electricalequipment
4. Describe corrective and preventive maintenance of electricalequipment's.

SECTION I

Unit 1: Electrical Tools, Accessories, Electrical installations and IE rules :*(06Hrs.)*

Tools, Accessories and Instruments required for Installation, Maintenance and Repair Work, Safely Codes Causes and Prevention of Accidents, Artificial Respiration, Workmen's Safety Devices, General requirements of electrical installation, electrical engineering symbols, schematic, understanding of wiring diagram and its single line representation, IE rules related to electrical installation. Earthing / Grounding, NecessitytypesofEarthing.

Unit 2: Maintenance Strategies, Dielectric Theory, Insulating Materials, Failure Modes, and Maintenance Impact on Arc-Flash Hazards: ***(04 Hrs.)***

Introduction, Why Maintain and Test, Overview of Electrical Maintenance and Testing Strategies, Planning an EPM Program, Overview of Testing and Test Methods, Insulating Materials for Electrical Power Equipment, Maintenance of Protective Devices and their Impact on Arc-FlashHazardAnalysis

Unit 3: Domestic Installation: ***(04Hrs.)***

Introduction, Testing of Electrical Installation of a Building, Testing of Insulation Resistance to Earth, Testing of Insulation and Resistance between Conductors Continuity or Open Circuit Test, Short Circuit Test, Testing of Earthing Continuity, Location of Faults, IE Rules for DomesticInstallation**.**

SECTION - II

Unit 4: Maintenance of Cables: ***(04Hrs.)***

Cable Failures and Their Analysis, Field Testing of Medium-Voltage Cables, Latest Trends in Cable Condition Monitoring and Aging Assessment, Cable Fault Locating Methods

Unit 5: Condition Monitoring and Testing of Electrical Equipment: ***(04** Hrs.**)***

Failure modes of transformer, Condition monitoring of oil as per the IS/IEC standards, Filtration/reconditioning of insulating oil, Condition monitoring of transformer bushings, On load tap changer, dissolved gas analysis, degree of polymerization. Induction motor fault diagnostic methods – Vibration Signature Analysis, Motor CurrentSignatureAnalysis.

Unit 6: Industrial Installation**:*****(05Hrs.)***

Industrial load, Design considerations of electrical installation in small industry/factory/workshop, selection of size for wires, cables required for the machines and its controlling unit, length and size of cable required for the every industrial load, ratings of wiring accessories, main switch, bus bar MCB, ELCB etc. for industrial load, methods of earthing for industrial installation, list of material forindustrialinstallation

General Instructions:

1. The number of students per batch should be as per the university pattern for practical batches.
2. Minimum number of assignments should be 8 covering alltopics.

List of Experiments

1. Drawing of Electricsymbols
2. Single line diagram of Domestic wiring (of oneHouse)
3. Electrical load calculation of single house /apartment.
4. Operation of MCB andELCB
5. Study of different methods ofEarthing.
6. Study of electrical installation in smallindustry/factory/workshop
7. Preparation of Tender /Quotation
8. Preparation of Comparativestatement
9. One visit to understand Electrical wiring andInstallation.

Recommended Books:

1. **Paul Gill "Electrical Power Equipment Maintenance and Testing" Second Edition CRC Press, Taylor and FrancisGroup**
2. **Hemant Joshi, "Residential, Commercial and Industrial Electrical Systems: Equipment and Selection" Volume I, McGraw-HillPublication.**

Reference Books:

1. **Testing, Commissioning, Operationand**
2. **Handbook of Switchgears, BHEL, McGraw Hill, 1st Edition,2005**
3. **ISO, IS, BS standards, Data Sheets, IE Rules Handbook IS/International code: IS5909, 7733, 2174, 732,464**
4. **"Electrical Engineering Drawing", Surjit Singh, Part I, 1st Edirion, Ktsonbook**

SHIVAJI UNIVERSITY, KOLHAPUR

THIRD YEAR B.TECH (ELECTRICAL) SEMESTER -VI

ELECTRICAL ENERGY AUDIT AND CONSERVATION
(Open Elective -II)

Course Code and Title	Teaching Scheme					Evaluation Scheme					
						Theory (Marks)		Practical(Marks)		POE(Marks)	
	L	T	P	Credit	Scheme	Max.	Min. for Passing	Max.	Min. for passing	Max.	Min. for passing
OCE-EE-302 **Electrical Energy Audit and Conservation**	02	--	02	03	ISE	-	-	-	-	-	-
					MSE	30	12	-	-	-	-
					ESE	70	28	25	10	--	-

ISE: InSemesterEvaluation MSE: MidSemesterEvaluation ESE: End Semester Evaluation

Objectives:

1. Provides basic understanding of energy audit and conservation
2. Essential theoretical and practical knowledge about the concept of energy conservation.
3. Economic aspects of energy conservation project and energy audit
4. Different approaches of energy conservation in industries

Course Outcomes: After completion of this course students will be able to:

1) Prepare energy flow diagrams and energy audit report .
2) Carryout energy audit for Mechanical Systems.
3) Relevant tariff for reducing losses in facilities.
4) Interpret energy conservation policies in India.
5) Identify and evaluate the energy conservation opportunities in different electric system.
6) Identify and assess energy conservation opportunities in thermal system.

SECTION I

Unit I: Energy Audit system aspect ***(6 Hrs)***

General philosophy, current practices, need of energy audit and its types ,methodology of energy audit and approach, Energy audit (definition as per energy conservation act), specific energy consumption, Instruments for Audit and Monitoring Energy and Energy Savings, Types and Accuracy, energy flow diagram(Sankey) , simple payback period, energy audit procedure (walk through audit and detailed audit), energy audit report format

Unit II: Energy Audit in mechanical ***(7Hrs)***

Pumps, types and application, unit's assessment, improvement option, parallel and series operating pump performance. Energy Saving in Pumps & Pumping Systems.Bloomers (Blowers) types & application, its performance assessment, series & parallel operation applications & advantages. Energy Saving in Blowers Compressors, types & applications, specific power consumption, compressed air system,& economic of system changes. Energy Saving in Compressors & Compressed Air Systems, Cooling towers, its types and performance assessment & limitations, water loss in cooling tower. Energy Saving in Cooling Towers.

Unit III: Tariff ***(5Hrs)***

Types of tariff structure: LT and HT, special tariff, time-off-day tariff, Peak-of-day tariff, power factor tariff, maximum demand tariff, load factor tariff and availability based tariff (ABT), application of tariff system to reduce energy bill.

SECTION II

Unit IV: Energy Conservation basic ***(5 Hrs)***

Energy scenario: Primary and secondary energy, energy demand and supply, national scenario, energy conservation and energy audit: concept and difference, energy conservation Act 2001: relevant clauses of energy conservation, BEE and its role, MEDA and its role, star labeling: Need and its benefits

Unit V: Energy conservation in Electrical Machine ***(6 Hrs)***

Need for energy conservation in Induction motor and transformer, Energy conservation techniques in induction motor,Energy conservation techniques in Transformer, energy conservation equipment, Energy efficient motor: significant features, advantages ,application and limitation, Energy efficient transformer: amorphous transformer epoxy resin cast transformer/ Dry type of transformer

Unit VI: Energy Conservation in Mechanical System ***(7Hrs)***

Potential energy, conservation forces, distinction between conservative and non-conservative forces, potential energy functions, spring potential energy, conservation of mechanical energy: gravitation ,spring , conservative force and potential energy function, conservative force for a Hypothetical Potential Energy Function , energy diagram, gravitational potential energy , scape speed

General Instructions:

1. Minimum number of assignments should be 6 covering all topics.
2. Submit one Energy audit report.

Recommended Books:

1. Guide book no 1 to 4 for national certification examination for energy manager and energy auditor BEE 4th edition

2. India – the Energy sector Henderson , P.D. University press Delhi.
3. Principle of power Systems by V K Mehta S chand Publication
4. Energy Management: W.R.Murphy, G.Mckay, Butterworths Scientific
5. Industrial Energy Conservation : D.A. Reay (Pergammon Press)

Reference Books:

1. Energy Audit and Management, Volume-I, IECC Press
2. Energy Efficiency in Electrical Systems, Volume-II, IECC Press
3. Energy Management Principles, C.B.Smith, Pergamon Press
4. Industrial Energy Conservation, D.A. Reay, Pergammon Press
5. Energy Management Handbook, W.C. Turner, John Wiley and Sons, A Wiley Interscience
6. Efficient Use of Energy : I.G.C.Dryden (Butterworth Scientific)
7. Energy Economics -A.V.Desai (Wieley Eastern)
8. Industrial Energy Conservation Manuals, MIT Press, Mass, 1982
9. Energy Conservation guide book Patrick/Patrick/Fardo (Prentice Hall)

List of Experiment:

1. Computing efficiency of DC motor/Induction Motor/Transformer
2. Identify star labeled electrical apparatus and compare the data for various star rating.
3. Calculating the efficiency of boiler / blowers / compressors etc.
4. Study of APFC panel or Estimating the requirement of capacitance for power factor improvement.
5. Study of various energy efficient equipment like LED lighting devices, Energy Efficient motors, Electronics ballast etc.
6. Soft starting of an induction motor
7. Study of Variable frequency drive based IM speed control for energy conservation.
8. Industry visit with an aim of
    (i) Studying various energy Audit systems prevailing in a particular industry/Organization
    (ii) Identifying the various energy conservation methods useful in a particular industry
9. Studying the various energy conservation methods useful in power generation, transmission and distribution
10. Study of various measuring instruments used for energy audit : Lux meter, Power analyzer, flue gas analyzer
11. Prepare a technical report on energy conservation act 2003

SHIVAJI UNIVERSITY, KOLHAPUR

THIRD YEAR B.TECH (ELECTRICAL) SEMESTER –VI

PLC & SCADA
(Open Elective-II)

Course Code and Title	Teaching Scheme					Evaluation Scheme					
						Theory(Marks)		Practical(Marks)		POE(Marks)	
	L	T	P	Credit	Scheme	Max.	Min. for Passing	Max.	Min. for passing	Max.	Min. for passing
OCE-EE-302 **PLC & SCADA**	02	--	02	03	ISE	-	-	-	-	-	-
					MSE	30	12	-	-	-	-
					ESE	70	28	25	10	-	-

ISE: InSemesterEvaluation**MSE:** MidSemesterEvaluation **ESE:** End Semester Evaluation

Objectives:

4. To expose students to PLC, Input/Outputs and I/O Processings.
5. To familiarize the Ladder and Functional Programming, IL,SFC, and ST Programming methods, Jump and call, Timers, Counters and Shift Registers
6. To expose students Introduction to SCADA, system components architecture and Applications.

Course Outcomes: After completion of this course students will be able to:

7. Describe architecture and hardware connections of PLC
8. Basics of I/O Processing, Ladder and Functional Block Programming, IL,SFC and ST Programming, Internal Relays
9. Outline of Jump and Call, Timers, Counters, and Shift Registers
10. To describe introduction, evaluation, communication SCADA.
11. To describe system components, HMI and applications of SCADA.

SECTION I

Unit 1: Introduction to PLC: ***(7Hrs)***

Programmable logic controller hardware and internal architecture, PLC systems basic configuration and development, Input/output Devices, Examples of Applications, I/O Processing

Input/output units, Signal Conditioning, Remote Connections, Networks, Processing inputs, I/O Addresse

Unit 2: Ladder and Functional Block Programming ***(7Hrs)***

Ladder Diagrams, Logic Functions Latching, Multiple Outputs, Entering Programs, Function Blocks, Program examples

IL, SFC and ST ProgrammingMethods: Instruction Lists, Sequential Function Charts

Internal Relays: Internal Relays, Ladder Programs, Battery-Backed Relays, One-Shot Operation, Set and Reset, Master Control Relay

Unit 3: Jump & Call, Timers, Counters, Shift Registers ***(5Hrs)***

Jump, Subroutines, Types of Timers, On-Delay Timers, Off-Delay Timers, Pulse Timers, Retentive Timers, Programming Examples, Forms of Counter, Programming, Up- and Down-Counting, Timers with Counters, Sequencer, Shift registers, Ladder Programs

SECTION II

Unit 4: Introduction to SCADA ***(7Hrs)***

Introduction, Data Acquisition system(DAS)-single, double, sensors, signal conditioning, sample and hold circuit,ADC-intigrating,successive approximation, Evaluation of SCADA,communication of SCADA,selection criteria of DAS.

Unit 5: SCADA system components ***(5Hrs)***

Introduction, Remote Terminal Unit(RTU)-Evaluation, Architecture. Designstandards, selectioncriteria,Intelligent Electronic devices(IED), PLC, Data concentrators and merging unit, Master control centers, Global positioning systems (GPS)-Relevance to SCADA, Human Machine Interface(HMI)

Unit6: SCADA Architecture ***(5Hrs)***

Introduction, Communication Architecture, communication philosophies, systems reliability and availability, Applications-Oil and Gas Industry, Automobile Industry, Water pumping stations.

Recommended Books:

5. Programming Logic Controller, Fifth Edition by W. Bolton, Published by Elsevier
6. Programming Logic Controller by Vijay R. Jadhav,Khanna Book Publishing-New Delhi
7. Programmable Logic Controllers, by Frank D. Petruzella, Mcgraw Hill Publications
8. Industrial Automation with SCADA by K.S.Manoj, Notion press publications.

Reference Books:

7. John W Webb, Ronald Reis, "Programmable logic controller's principle and application", Pearson publication.
8. L.A Bryan and E.A Bryan, "Programmable Controller Theory and Applications"
9. Programmable Logic Controllers: Programming Methods And Applications, 1e,Hackworth, Pearson Education