VPKBIET

Vidya Pratishthan's Kamalnayan Bajaj Institute of Institute of Engineering and Technology, Baramati

Faculty of Science & Technology
Board of Studies
Electrical Engineering

TY B. Tech. Electrical Engineering
(Pattern: 2024)
(w.e.f. AY: 2026-27)

Vidya Pratishthan's
Kamalnayan Bajaj Institute of Engineering and Technology
Board of Studies: Electrical Engineering
Syllabus: Third Year (B. Tech.) Electrical Engineering
2024 Pattern w.e.f. AY: 2026-2027
SEMESTER-V

Course Type	Course Code	Course Name	Teaching Scheme			Examination Scheme and Marks							Credits			
			TH	PR	TUT	CAA	ISE	ESE	TW	PR	OR	Total	TH	PR	TUT	Total
PCC	EL24301TH	Electrical Machines- II	3	-	-	10	30	60	-	-	-	100	3	-	-	4
PCC	EL24301PR	Electrical Machines- II	-	2	-	-	-	-	-	30	-	30	-	1	-	
PCC	EL24302TH	Power System Analysis	3	-	-	10	30	60	-	-	-	100	3	-	-	4
PCC	EL24302PR	Power System Analysis	-	2	-	-	-	-	-	30	-	30	-	1	-	
PEC-I	EL24303TH	Programme Elective Course (NMCP / MCA)	3	-	-	10	30	60	-	-	-	100	3	-	-	4
PEC-I	EL24303PR	Programme Elective Course (NMCP / MCA)	-	2	-	-	-	-	-	-	30	30	-	1	-	
MDM	MD240XXTH	Multi-disciplinary minor	3	-	-	10	30	60	-	-	-	100	3	-	-	4
MDM	MD240XXPR	Multi-disciplinary minor	-	2	-	-	-	-	30	-	-	30	-	1	-	
PCC	EL24304TH	Electric Mobility	3	-	-	10	30	60	-	-	-	100	3	-	-	3
VSEC	EL24305TU	Solar and EV Lab	-	-	1	10	-	-	30	-	-	40	-	-	1	2
VSEC	EL24305PR	Solar and EV Lab	-	2	-	-	-	-	-	30	-	30	-	1	-	
AU	HS24301	Constitution of India	1	-	-	-	-	-	-	-	-	-	-	-	-	1
	Total		16	10	1	60	150	300	60	90	30	690	15	5	1	22

List of Electives and Multi-Disciplinary Minor

Code	Program Elective-I	Code	Multi-Disciplinary Minor
EL24303A	Numerical Methods and Computer Programming	AI24051	AI & Machine Learning
EL24303B	Microcontroller and its Applications		

Mrs. S. D. Rokade
Academic Coordinator

28/03/2026
Dr. G. S. Gadge
Head of Department

Dr. S. M. Bhosle
Dean Academics

Dr. A. H. Kolekar
Controller of Examination

Dr. S. B. Lande
Principal
Vidya Pratishthan's
Kamalnayan Bajaj Institute of
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VPKBIET BARAMATI
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Vidya Pratishthan's
Kamalnayan Bajaj Institute of Engineering and Technology
Board of Studies: Electrical Engineering
Syllabus: Third Year (B. Tech.) Electrical Engineering
2024 Pattern w.e.f. AY: 2026-2027

SEMESTER-VI

Course Type	Course Code	Course Name	Teaching Scheme			Examination Scheme and Marks							Credits			
			TH	PR	TUT	CAA	ISE	ESE	TW	PR	OR	Total	TH	PR	TUT	Total
PCC	EL24311TH	Control System Engineering	3	-	-	10	30	60	-	-	-	100	3	-	-	4
PCC	EL24311PR	Control System Engineering	-	2	-	-	-	-	-	-	30	30	-	1	-	
PCC	EL24312TH	Switchgear & Protection	2	-	-	10	-	60	-	-	-	70	2	-	-	3
PCC	EL24312PR	Switchgear & Protection	-	2	-	-	-	-	-	-	30	30	-	1	-	
PEC-IV	EL24313TH	Programme Elective Course (PSOC/SS)	3	-	-	10	30	60	-	-	-	100	3	-	-	4
PEC-IV	EL24313PR	Programme Elective Course (PSOC/SS)	-	2	-	-	-	-	-	-	30	30	-	1	-	
PEC-V	EL24314TH	Programme Elective Course (EIDCBM /CADEM)	3	-	-	10	30	60	-	-	-	100	3	-	-	4
PEC-V	EL24314PR	Programme Elective Course (EIDCBM/ CADEM)	-	2	-	-	-	-	-	-	30	30	-	1	-	
MDM	MD240XXTH	Multi-disciplinary minor	2		-	10		60	-	-	-	70	2	-	-	3
MDM	MD240PR	Multi-disciplinary minor	-	2	-	-	-	-	30	-	-	30	-	1	-	
OE	OE240XXTH	Open Electives	3	-	-	10	30	60	-	-	-	100	3	-	-	3
AU	HS24311	Democracy, Election, and Governance	1	-	-	-	-	-	-	-	-	-	-	-	-	1
		Total	17	10	0	60	120	360	30	0	120	690	16	5	0	22

List of Electives, Multi-Disciplinary Minor and Open Elective

Code	Program Elective-IV	Code	Program Elective-V
EL24313A	Power System Operation & Control	EL24314A	Electrical Installation, Design and Condition Based Maintenance
EL24313B	Signals and Systems	EL24314B	Computer Aided Design of Electrical Machine
Code	**Multi-Disciplinary Minor**	**Code**	**Open Elective**
ET24051	Embedded system	OE24017	Sustainability & Climate Change

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Bucket of Multidisciplinary Minor Courses and Open Electives

Multidisciplinary Minor Courses			
Course Code	**Course Name**	**Course Code**	**Course Name**
3 Credit MDM		**4 Credit MDM**	
AI24052	Data Science	GS24051	Nanotechnology
IT24051	Cyber security	ET24053	Internet of Things
IT24052	Full Stack Development	CE24051	Waste Management
EL24052	Industrial Automation	CO24052	High Performance Computing (Sem V+)
ET24051	Embedded Systems	CO24053	Computer Graphics & Gaming
EL24051	Photovoltaic Technology and Solar Power System	ME24052	Robotics & Automation
GS24052	Linear Algebra and Statistics	AI24051	AI & Machine Learning
CO24053	Object Oriented Programming	CO24051	Cloud Computing
IT24054	Data Structure	ET24052	Drone Technology
ET24054	Microprocessor	ME24051	3-D Printing
		CE24052	Green building & smart cities

Open Elective Courses			
Course Code	**Course Name**	**Course Code**	**Course Name**
OE24001	Digital Marketing	OE24011	Biotechnology
OE24002	Professional Leadership	OE24012	International Relations
OE24003	Organizational Behavior	OE24013	Universal Human Values
OE24004	Industrial Management	OE24014	Education Technology
OE24005	Disaster Management	OE24015	Design Thinking
OE24006	Energy Economics & Management	OE24016	Accounting & Finance
OE24007	Operations Research	OE24017	Sustainability & Climate Change
OE24008	Intellectual Property Rights	OE24018	Agriculture Technology
OE24009	Cyber Laws	OE24019	Architectural Technology
OE24010	Bioinformatics		

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EL24301: Electrical Machines-II		
Teaching Scheme: **TH: 03 Hrs/Week** **PR: 02 Hrs/Week**	**Credits:04**	**Examination Scheme:** **Course Activity: 10 Marks** **In-Semester Exam: 30 Marks** **End-Semester Exam: 60 Marks** **Practical Exam: 30 Marks**

Prerequisite Courses:

- Magnetic circuits, Force on current carrying conductor placed in magnetic field, Fleming Right hand & Left-hand rule.
- Working principle and construction DC Machines, transformer & 3-ph induction motor
- Phasor diagram and equivalent circuit of a single-phase transformer.

Course Objectives:

• Learn the construction and working principle ofthree-phase synchronous machines and 1-ph induction motors.

• Calculate voltage regulation of Alternator by different methods

• Study the applications of different machines in industrial, commercial, & social sectors.

• Determine the performance indices of AC series & single-phase motors by experimentation.

Course Outcomes

On completion of the course, learner will be able to

CO-1: Explain the construction and performance of three-phase synchronous machines.

CO-2: Analyze the performance of synchronous generators and evaluate voltage regulation using various methods.

CO-3: Demonstrate operation of synchronous motor at constant load and variable excitation (v curves & ^ curves) & constant excitation and variable load.

CO-4: Describe the construction, performance and applications of AC Series Motor and universal motor.

CO-5: Select appropriate special-purpose motors for different applications based on their construction, working principle, and characteristics.

CO-6: Explain the construction, performance and applications of single-phase induction motors with different self-starting methods.

Course Contents

Unit I: Three phase Synchronous generator **(07Hrs)**

Three phase Synchronous machines: Construction, rotating-armature type, salient-pole type and non-salient-pole type and their comparison, Excitation Methods. **Three phase Synchronous generator (cylindrical rotor type):** Principle of operation, Emf equation and winding factors (No derivation), rating of generator, Generator on no-load and on balanced load. Armature reaction and its effect under different load power factors. Voltage drop due to armature resistance, leakage flux and synchronous reactance, Per phase equivalent circuit and Phasor diagram, Power - power angle relation.

Three phase Synchronous generator (salient pole type): Armature reaction as per Blondel's two reaction theory for salient-pole machines, Direct-axis and quadrature-axis synchronous reactance's and their determination by slip test, Phasor diagram of Salient-pole generator and calculation of voltage regulation, Comparison between synchronous generator and induction generator, IEC standards of Synchronous machines.

Unit II: Voltage regulation and parallel operation of Three phase Synchronous generator **(07 Hrs)**

Performance of open circuit and short circuit test on synchronous generator, determination of voltage regulation by emf, mmf, and Potier triangle methods, Determination of voltage regulation by direct loading, Short circuit ratio, Parallel operation of 3-phase alternators: Necessity, conditions, Load sharing between two alternators in parallel (Descriptive treatment only),Process of synchronizing alternator with infinite bus-bar by lamp methods and by use of synchroscope (one dark & two equally bright method). Synchronizing current, power and torque (no numerical)

Unit III: Three phase synchronous motor **(07 Hrs)**

Principle of operation, Methods of starting, Equivalent circuit, significance of torque angle, Losses, efficiency and Power flow chart, Operation of 3-phase Synchronous motor with constant load and variable excitation ('V' Curves and 'inverted V' curves). Phenomenon of hunting and its remedies, Applications of 3-phase synchronous motors, Comparison of 3 phase synchronous motor with 3-phase induction motor.

Unit IV: A.C. series motor **(06 Hrs)**

Operation of D.C. series motor on a.c. supply, nature of torque developed, problems associated with AC. operation and remedies, Compensated series motor: Compensating winding, conductibility and inductively compensated motor, Approximate phasor diagram, Use of compoles for improving commutation. Ratings and applications of Compensated Series motors, Universal motors: ratings, performance and applications, comparison of their performance on A.C. and D.C. supply.

Unit V: Special purpose motors **(06 Hrs)**

Special Purpose Motors : Construction, principle of working, characteristics ratings and applications of Brush less D.C. motors, Stepper motors (permanent magnet and variable reluctance type only), Permanent Magnet motor (A.C. & D.C.),Switched reluctance motor, Linear induction motor, Introduction to Energy Efficient three phase Induction Motor and Super conducting Generator.

Unit VI: Single phase induction motor **(06 Hrs)**

Construction of single phase induction motor, double field revolving theory, Equivalent circuit and torque-slip characteristics on the basis of double revolving field theory,Tests to determine the parameters of equivalent circuit and calculation of performance characteristics of motor,Methods of self-starting,Types of single phase induction motors: Split-phase motors (Resistor split-phase motor, Capacitor-start motor, Capacitor start and capacitor run motor and permanent capacitor motor),Comparison of 1-phase induction motor with 3-phase induction motor

Books & Other Resources:

Text Books:

1. Nagrath and Kothari, Electrical Machines, 2nd Ed., Tata McGraw Hill.
2. S. K. Bhattacharya, Electrical Machines, Tata McGraw Hill.
3. P. S. Bimbhra, Electric Machinery, Khanna Publications.
4. B.R. Gupta and Vandana Singhal -Fundamentals of Electric Machines, New Age International (P) Ltd.
5. B. L Theraja –Electrical Technologyvol II , S. Chand publication.
6. V. K. Mehta and Rohit Mehta, Principles of Electrical Machines, S Chand Publication

7. Krishna Reddy –Electrical Machines vol.II and III, SCITECH publications.
8. Ashfaq Husain, Electrical Machines, Dhanpat Rai and Co.
9. M V Deshpande, Electrical Machines, Prentice Hall of India

Reference Books:

1. M.G. Say, Performance and Design of A.C. Machines (3rd Ed.), ELBS
2. J. B. Gupta - Theory and performance of Electrical Machines, S K Kataria Publications
3. Samarjit Ghosh, Electrical Machines, Pearson Publication.
4. E G Janardanan, Special Electrical Machines, Prentice Hall of India.
5. Suvarnsingh Kalsi Application of high Temperature super conductors to electric power equipments (Rotating Machines) Wiley publication.

Guidelines for Laboratory Conduction:

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2. Students should be informed about DO'S and DON'T and precautions before performing.

Guidelines for Students Lab Journal:

The Student's Lab Journal should contain following related to every experiment –

1. Theory related to the experiment.
2. Apparatus with their detailed specifications.
3. Connection diagram /circuit diagram.
4. Observation table/ simulation waveforms.
5. Sample calculations for one/two readings.
6. Result table.
7. Graph and Conclusions.
8. There should be continuous assessment for the TW.
9. Assessment must be based on understanding of theory, attentiveness during practical, understanding Session, how efficiently the student is able to make connections and get the results, and timely submission of journals.

Industrial Visit: Compulsory visit to Synchronous Machines / special purpose motors manufacturing company.

LIST OF PRACTICALS (Any 08 practicals are to be performed by the students. Out of these, any two practicals may be performed using software.)

1. Determination of Regulation of alternator by direct loading.
2. Determination of voltage regulation of cylindrical rotor alternator by following methods a) EMF method b) MMF method.
3. Determination of regulation of cylindrical rotor alternator by Potier method.
4. Determination of regulation of salient pole alternator by slip test.
5. V and inverted V curve of synchronous motor at constant load.
6. Load test on three phase synchronous motor.
7. Load test on Single -phase induction motor.
8. Load test on Single-phase series motor.
9. No load and blocked-rotor test on a single-phase Capacitor-start induction motor and Determination of its equivalent circuit parameters.
10. Synchronization of three phase alternator by Synchroscope method.
11. Speed control of BLDC Motor
12. Parameter estimation of alternator using MATLAB.

Note:

The list of experiments is not limited to the above, but a course coordinator may design a few new experiments based on recent technologies/trends in the relevant Engineering Domain. However, the course coordinator needs to get approval by the Program Assessment Committee and Chairman BOS/HOD well in time.

Course Activity (Any one of the following) :

1. Concept test
2. PowerPoint presentation

Mrs. P. N. Jaiswal
PAC Member 1

Mr. A. V. Golande
PAC Member 2

Mrs. V. V. Deokate
PAC Member 3

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EL24302: Power System Analysis		
Teaching Scheme: **TH: 03 Hrs/Week** **PR: 02 Hrs/Week**	**Credits:04**	**Examination Scheme:** **Course Activity: 10 Marks** **In-Semester Exam: 30 Marks** **End-Semester Exam: 60 Marks** **Practical Exam: 30 Marks**

Prerequisite Courses:

Knowledge of Fundamentals of Electrical Circuit Components, Engineering Mathematics, Power and Energy calculation, Power System Engineering

Companion Course, if any: Laboratory Practical

Course Objectives:

1. To describe the concepts of resistance and inductance of transmission lines and their impact on the performance of lines
2. To discuss the concept of capacitance of transmission lines and their impact on the performance of lines
3. To analyse the performance of transmission line models
4. To analyse different power system component in per unit system and load flow analysis
5. To evaluate and demonstrate symmetrical fault analysis in power system
6. To evaluate and demonstrate unsymmetrical fault analysis in power system

Course Outcomes

On completion of the course, learner will be able to:

CO-1: Describe the concepts of resistance and inductance of transmission lines and their impact on the performance of lines

CO-2: Discuss the concept of capacitance of transmission lines and their impact on the performance of lines

CO-3: Analyse the performance of transmission line models

CO-4: Analyse different power system component in per unit system and load flow analysis

CO-5: Evaluation and Demonstration symmetrical fault analysis in power system

CO-6: Evaluation and Demonstration unsymmetrical fault analysis in power system

Course Contents

Unit I: Resistance and Inductance of Transmission Line **(6 Hrs)**

A) **Resistance of Transmission Line:** Skin effect, and Proximity effect, Factors responsible for these effects

B) **Inductance of Transmission Line:** Internal & external flux linkages of single conductor, Inductance of single phase two wire line, Three phase line with symmetrical and unsymmetrical spacing, Concept of G.M.R. and G.M.D, Necessity of transposition.

Unit II: Capacitance of Transmission Line **(6 Hrs)**

Electric potential at single charged conductor, Potential at conductor in a group of charged conductors, Capacitance of single phase line, Capacitance of single phase line with effect of earth's surface on electric field, Concept of G.M.R. and G.M.D for capacitance calculations, Capacitance of three phase line with symmetrical and unsymmetrical spacing.

Unit III: Transmission Line Models and Their Performance Analysis **(6 Hrs)**

Classification of lines based on length and voltage levels, Modelling of short, medium, and long transmission lines, Generalized constant of transmission line, Concept of complex power, Surge impedance loading of transmission line, Phenomenon of Corona, Ferranti effect.

Unit IV: Per unit system and Load Flow Analysis **(7 Hrs)**

A) **Per unit system:** Single line diagram, Impedance and reactance diagrams and their uses, per-unit (pu) quantities, relationships, Advantages and application of per unit system. Numerical based on network reduction by using per unit system.

B) **Load Flow Analysis:** Network topology, Driving point and transfer admittance, concept of Z-bus and formulation of Y-bus matrix using bus incidence matrix method, Numerical based on Y bus Matrix, power- flow equations generalization to n bus systems, Classification of buses, Newton- Raphson method (polar method) Decoupled and Fast decoupled load flow (Descriptive treatment only).

Unit V: Symmetrical Faults Analysis **(7 Hrs)**

Synchronous generators: Construction, Working, Generator model, Steady state characteristics, Method of symmetrical components (positive, negative and zero sequences), Synchronous machine transients, Determination of transient constants, DC component of stator currents. Selection of circuit-breakers and current limiting reactors and their location in power system (Descriptive treatment only), Numerical on symmetrical fault calculation.

Unit VI: Unsymmetrical Fault Analysis **(7 Hrs)**

Symmetrical component analysis of unsymmetrical faults, Balanced and unbalanced faults, Representation of generators, lines and transformers in sequence networks. Computation of fault currents, Neutral grounding, bus impedance matrix method for analysis of unsymmetrical faults. Numerical on unsymmetrical fault calculation.

Industrial Visit: Visit to HV/EHV substation

Books & Other Resources:

Text Books:

1. J. B. Gupta, "Transmission and Distribution", S. K. Kataria & Sons, New Delhi.
2. V. K. Mehta, Rohit Mehta, "Principles of Power System", S. Chand Publication
3. A Chakraborty, M. L. Soni, P. V. Gupta, U.S. Bhatnagar, "A textbook on Power System Engineering", Dhanpatrai & Co., Delhi.
4. Hadi Saadat, Power System Analysis, 5th reprint, Tata McGraw Hill publishing Company Ltd, New Delhi, 2004.
5. Ashfaq Hussain, Electrical power system fifth edition, CBS Publishers & Distributors Pvt Ltd.

Reference Books:

1. Nagrath & Kothari, "Power System Engineering", Tata McGraw Hill Publications.
2. D. Das, "Electrical Power System", New Age Publication.
3. J. Grainger and W. D. Stevenson, "Power System Analysis", McGraw Hill Education, 1994.
4. Nagrath & Kothari, "Power System Engineering", Tata McGraw Hill Publications.
5. Arthur R. Bergen, Vijay Vittal, Power Systems Analysis, Prentice Hall of India, Inc., 2nd Edition, 2000

NPTEL Course:

1. NPTEL Power System Analysis, Prof. Debapriya Das IIT Kharagpur https://youtube.com/playlist?list=PLRWKj4sFG7-6gWwDMLI0Wy5DDRqyKP1uQ

Guidelines for Laboratory - Term work Assessment:

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The Student's Lab Journal should contain following related to every experiment –

1. Theory related to the experiment.
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3. Connection diagram /circuit diagram.
4. Observation table/ simulation waveforms.
5. Sample calculations for one/two readings.
6. Result table.
7. Graph and Conclusions.
8. There should be continuous assessment for the TW.
9. Assessment must be based on understanding of theory, attentiveness during practical, understanding Session, how efficiently the student is able to make connections and get the results, and timely submission of journals.

LIST OF PRACTICALS (Any 08 to be performed by the student)

1. Measurement of ABCD parameters of a medium transmission line with magnitude and angle.
2. Measurement of ABCD parameters of a long transmission line with magnitude and angle.
3. Performance study of the effect of VAR compensation using capacitor bank on the transmission line.
4. Design of PI and T model of medium transmission line and calculate performance analysis.
5. To understand basic principle of corona and obtain audible and visible corona inception and extinction voltage under non uniform field.
6. Formulation and calculation of Y- bus matrix of a given system using software.
7. Plotting of receiving end circle diagram to evaluate the performance of medium transmission line.
8. Solution of a load flow problem using Newton-Raphson method using software.
9. Solution of a load flow problem using Decoupled/Fast decoupled method using software.
10. Static measurement of sub-transient reactance of a salient-pole alternator.
11. Measurement of sequence reactance of a synchronous machine (Negative and zero).
12. Simulation of symmetrical fault of single machine connected to infinite bus.
13. Simulation of unsymmetrical fault of single machine connected to infinite bus.

Note: The list of experiments is not limited to the above, but a course coordinator may design few new experiments based on recent technologies/trends in the relevant Engineering Domain. However the course coordinator needs to get approval by the Program Assessment Committee and Chairman BOS/HOD well in time.

Course Activity (Any ONE of the following):

For the assessment of Course Activity, a student must complete at least ONE activity out of the following:

1. MATLAB program/simulation
2. Case study

Mr. D. S. Yeole	Mr. S. D. Shelar	Mr. R. S. Tarade
PAC Member 1	PAC Member 2	PAC Member 3

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EL24303A: Numerical Methods and Computer Programming		
Teaching Scheme: **TH: 03 Hrs/Week** **PR: 02 Hrs/Week**	**Credits:04**	**Examination Scheme:** **Course Activity: 10 Marks** **In-Semester Exam: 30 Marks** **End-Semester Exam: 60 Marks** **Oral: 30 Marks**

Prerequisite Courses:

1. Engineering Mathematics.
2. Basics of Electrical Engineering and Electrical Circuit Analysis.
3. Programming and Problem solving.

Course Objectives:

1. To understand the need of computational techniques and analyse errors involved in the computation.
2. To study various numerical techniques for the solution of transcendental and polynomial equations.
3. To understand the Interpolation method of fitting the data points to represent the value of a function.
4. To study different numerical techniques for solving various kinds of equations, including differentiation and integration.
5. To understand various numerical techniques for Solution of Linear Simultaneous Equations.
6. To understand various numerical techniques for Solution of Ordinary Differential Equations (ODE).

Course Outcomes

On completion of the course, learner will be able to:

CO-1: Explain types of errors in computation and their causes of occurrence.

CO-2: Evaluate roots of algebraic and transcendental equations using various numerical methods and develop algorithm for curve fitting.

CO-3: Apply numerical methods for various mathematical problems based on interpolation and develop algorithm.

CO-4: Evaluate numerical differentiation and integration problems using various numerical methods.

CO-5: Evaluate numerical problems and determine solutions of linear simulation equations.

CO-6: Apply numerical methods for various mathematical problems based on ordinary differential equations.

Course Contents

Unit I: Numerical Computations, Errors and Concept of root of equation (7 Hrs)

Basic principle of numerical computation and Engineering Mathematics. Floating point algebra with normalized floating point technique, Significant digits. Errors: Different types of errors, causes of occurrence and remedies to minimize them, Generalized error formula (Derivation and Numerical), Concept of roots of an equation. Descartes' rule of signs. Roots of Polynomial Equations using Birge-Vieta method.

Unit II: Solution of Transcendental, polynomial equation and Curve Fitting (6 Hrs)

Solution of Transcendental and polynomial equation using Bisection, Regula- Falsi, Newton-Raphson method for single variable and two variables. Curve fitting using least square approximation – First order and second order

Unit III: Interpolation (7 Hrs)

Forward, Backward, Central and Divided Difference operators, Introduction to interpolation.

A) Interpolation with equal Intervals - Newton's forward, backward interpolation formula (Derivations and numerical), Stirling's central difference formula (Only numerical).
B) Interpolation with unequal Intervals- Newton's divided difference formula and Lagrange's interpolation (Derivations and numerical).

Unit IV: Numerical Differentiation and Integration (7 Hrs)

A) Numerical Differentiation using Newton's forward and backward interpolation formula (Derivation and numerical).
B) Numerical Integration: Trapezoidal and Simpson's rules as special cases of Newton-Cote's quadrature technique for single integral. Numerical on double integrals using Trapezoidal, Simpson's $1/3^{rd}$ rule and Simpson's $3/8^{th}$ rule.

Unit V: Solution of Linear Simultaneous Equations (7 Hrs)

Solution of linear simultaneous equation: Direct methods - Gauss elimination method, concept of pivoting – partial and complete. Gauss Jordan method, Iterative methods - Jacobi method and Gauss Seidel method. Matrix Inversion using Gauss Jordan method.

Unit VI: Solution of Ordinary Differential Equation (ODE) (6 Hrs)

Solution of First Order Ordinary Differential Equation (ODE) using Taylor's series method, Euler's method, Modified Euler's method (Derivation and numerical). Runge-Kutta fourth order method (Numerical).

Books & Other Resources:

Text Books:

1. M. K. Jain, S.R.K. Iyangar, R. K. Jain, "Numerical Methods for Scientific and Engineering Computations", New Age Publications.
2. Dr. B. S. Grewal, "Numerical Methods in Engineering & Sciences", Khanna Publishers.
3. P. P. Gupta & G.S Malik, "Calculus of Finite Difference and Numerical Analysis", Krishna Prakashan Media Ltd, Meerut.
4. T. Veerarajan and T. Ramchandran, "Numerical Methods with Programs in C and C++", Tata McGraw Hill Publication.
5. S Arumugam, "Numerical Methods" Scitech Publication.

Reference Books:

1. J. B. Scarborough, "Numerical Mathematical Analysis", Oxford & IBH, New Delhi.
2. Steven Chapra, Raymond P. Canale, "Numerical Methods for Engineers", Tata McGraw Hill Publication.
3. S.S. Sastry, "Introductory methods of Numerical Analysis", PHI Learning Private Ltd.
4. P. Thangaraj, "Computer oriented Numerical Methods", PHI Learning Private Ltd.
5. Yashwant Kanitkar, "Let us Python", pbp publications.

Guidelines for Laboratory - Term Work Assessment:

1. The distribution of weightage of term work marks should be informed to students before the start of the semester.
2. Term work assessment should be on a continuous basis. At frequent intervals students are expected to inform about their progress/lagging.

Guidelines for Laboratory Conduction:

1. DO's and DON'TS, along with precautions, are needed to be displayed at prominent locations in the laboratory.
2. Students should be informed about DO'S and DON'T and precautions before performing.

Guidelines for Students Lab Journal:

The Student's Lab Journal should contain following related to every experiment –

1. Theory related to the experiment.
2. Apparatus with their detailed specifications.
3. Connection diagram /circuit diagram.
4. Observation table/ simulation waveforms.
5. Sample calculations for one/two readings.
6. Result table.
7. Graph and Conclusions.
8. There should be continuous assessment for the TW.
9. Assessment must be based on understanding of theory, attentiveness during practical, understanding Session, how efficiently the student is able to make connections and get the results, and timely submission of journals.

List of Practicals (Any 08 to be performed by the student)

Develop computer program for following experiments using **Python language**

1. Find number of positive roots and negative roots in RLC circuit using Descarte's rule of sign.
2. Develop algorithm, draw flow charts and write a program to implement Birge Vieta method for finding roots of equations in RLC circuit.
3. Develop algorithm, draw flow charts and write a program to implement Bisection method for finding current in circuit using KCL/KVL.
4. Fit a curve for finding voltage across capacitor during charging using least square method.
5. Develop algorithm, draw flowchart and write a program to apply Newton's forward interpolation method for finding voltage across capacitor during charging.
6. Find current through first order circuit (RL series) using Simpson's $1/3^{rd}$ Rule.
7. Find current through first order circuit (RL series) using Simpson's $3/8^{th}$ Rule.
8. Apply Gauss Jacobi Method for solving a set of equations in an electrical network using KVL.
9. Implement 4^{th} order Runge Kutta method for solving ordinary differential equations in RC series circuits with DC source.
10. Apply Gauss Seidal Method for solving a set of linear simultaneous equations in 2 loop networks with DC source.
11. Apply Gauss Jordan Method for solving a set of linear simultaneous equations in 2 or 3 loop networks with DC source.
12. Apply Modified Euler's method for solving ordinary differential equations in RC series circuit with DC source.

Note: The list of experiments is not limited to the above, but a course coordinator may design a few new experiments based on recent technologies/trends in the relevant Engineering Domain. However, the course coordinator needs to get approval by the Program Assessment Committee and Chairman BOS/HOD well in time.

Course Activities (Any ONE of the following):

For the assessment of Course Activity, a student must complete at least ONE activity out of the following:

1. Quiz based on numerical techniques.
2. Poster presentation on different algorithms.

Dr. H. M. Shaikh	Mr. S. D. Biradar	Mr. R. V. Panchal
PAC member 1	PAC member 2	PAC member 3

VPKBIET BARAMATI
Affiliated to S.P.P.U. Pune Id No./PU/PN/Engg./152/2000
PUNE (MS.)

EL24303B: Microcontroller and its Applications		
Teaching Scheme: **TH: 03 Hrs/Week** **PR: 02 Hrs/Week**	**Credits:04**	**Examination Scheme:** **Course Activity: 10 Marks** **In-Semester Exam: 30 Marks** **End-Semester Exam: 60 Marks** **Oral: 30 Marks**

Prerequisite Courses: Number system, Digital Electronics and Logic design, C programming language, Microprocessor Techniques.

Course Objectives:

The objectives of this course are

1. To study architectural details of PIC18FXXX microcontroller.
2. To study I/O ports and other IO peripherals, addressing modes and to develop ability to write an embedded C language programs for PIC18FXXX.
3. To study the concepts of timers, Special Hardware features of PIC18FXXX.
4. To study the concepts of timers, serial communication and interrupts of PIC 18FXXX.
5. To study applications of PIC18 through various interfacing devices like ADC, DAC, LCD, LED, etc.
6. To study real world applications interfacing PIC 18 Microcontroller.

Course Outcomes:

On completion of the course, learner will be able to

CO-1: Describe the architecture, features, and memory organization of the PIC18F Microcontroller Family.

CO-2: Summarize the addressing modes and develop and debug programs in Embedded C for various applications.

CO-3: Illustrate and develop programs using timers and special hardware peripherals of the PIC18FXXX microcontroller.

CO-4: Demonstrate interrupt handling and serial communication in PIC18FXXX and execute the corresponding programs.

CO-5: Implement and develop programs for various interfacing applications using the PIC18FXXX microcontroller.

CO-6: Design real-world applications using interfacing techniques with the PIC18FXXX microcontroller.

Course Contents

Unit 01: PIC Microcontroller Architecture (08 Hrs.)

Introduction: Introduction to microcontroller, Brief history of microcontrollers, Difference between microprocessor and microcontroller, Criteria for selection of microcontroller, **PIC18FXXX**: Features and architecture, comparison of PIC 18 series microcontrollers; PIC18F458/452 Pin out connection, Registers of PIC18F; **Program and data memory organization:** The Program Counter and Programmable ROM space in the PIC, File register and Access bank, Bank switching in PIC18.

Unit 02: Embedded C Programming of PIC microcontroller (07 Hrs.)

Addressing modes: Addressing modes with instruction example, Oscillator configurations, Reset operations, Brownout reset, Watchdog timer, Power down modes & Configuration registers, Embedded C concepts, Header and source files and pre-processor directives, Data types, data structures, Control loops, functions, bit operations. I/O port programming in C.

Unit 03: Special Hardware features and Timers Programming (06 Hrs.)

Various Timers in PIC 18, Timer 0,1,2 and 3 programming, CCP modes: Capture, Compare and PWM generation, Timers required for CCP Applications, Applications of CCP mode, Generation of waveform using Compare mode of CCP module. Period measurement of an unknown signal using Capture mode in CCP module, DC Motor speed control using PWM mode of CCP module

Unit 04: Interrupt and Serial port programming (06 Hrs.)

PIC Interrupts: Interrupt Vs Polling, IVT, Steps in executing interrupt, Sources of interrupts; Enabling and disabling interrupts, Interrupt registers, Priority of interrupts, Programming of: Timer using interrupts, External hardware interrupts, Serial communication interrupt. Basics of Serial communication protocols: Study of RS232, I2C, SPI, UART, Serial communication programming using Embedded C.

Unit 05: Real world Interfacing of PIC Microcontroller I (07 Hrs.)

Port structure. Interfacing of Electromechanical Relays, LED, Keyboard using PIC Microcontroller, PIC ADC, Programming of ADC using interrupts, Interfacing DAC with PIC18F458, Using PIC microcontroller interfacing of LCD (16x2) in 4-bit mode.

Unit 06: Real world Interfacing of PIC Microcontroller II (06 Hrs.)

Interfacing with Actuators (DC Motor, Stepper motor, Servomotor), Measurement of temperature and power using PIC microcontroller, Case study: Home protection, level and temperature monitoring.

Books & Other Resources:

Text Books:

1. PIC Microcontroller and Embedded Systems Using Assembly and C for PIC18 by Muhammad Ali Mazidi, Rolind D. McKinley, Danny Causey, Pearson Education.
2. Fundamentals of Microcontrollers and Applications in Embedded Systems with PIC by Ramesh Gaonkar, Thomson and Delmar learning, First Edition.
3. Programming And Customizing the PIC Microcontroller by Myke Predko, TATA McGraw-Hill.
4. PIC microcontroller: An introduction to software and Hardware interfacing by HanWay-Huang Thomson Delmar Learning.
5. Microcontroller Theory and Applications with PIC18F, M.Rafiquzzaman, John Wiley and Sons

Reference Books:

1. Ibrahim, Dogan, "PIC Microcontroller Projects in C: Basic to Advanced", Newnes, 1st Edition, 2014, Boston.
2. Bates, John, "PIC Microcontrollers: An Introduction to Microelectronics", Butterworth Heinemann, 3rd Edition, 2011, Oxford.
3. PIC18F458 datasheet
4. MPLAB IDE user guides
5. MICROCHIP Technical Reference Manual of 18F4520 Embedded Design with PIC 18F452 Microcontroller by John B. Peatman, Prentice Hall

MOOC / NPTEL Courses:

1. NPTEL Course "Microcontroller and Applications"

Link of the Courses:

1. https://nptel.ac.in/courses/117/104/117104072/
2. https://nptel.ac.in/courses/108/105/108105102/

Guidelines for Laboratory - Term work Assessment:

1. The distribution of weightage of term work marks should be informed to students before the start of the semester.
2. Term work assessment should be on a continuous basis. At frequent intervals students are expected to inform about their progress/lagging.

Guidelines for Laboratory Conduction:

1. DO's and DON'TS, along with precautions, are needed to be displayed at prominent locations in the laboratory.
2. Students should be informed about DO'S and DON'T and precautions before performing.

Guidelines for Students Lab Journal:

The Student's Lab Journal should contain following related to every experiment –

1. Theory related to the experiment.
2. Apparatus with their detailed specifications.
3. Connection diagram /circuit diagram.
4. Observation table/ simulation waveforms.
5. Sample calculations for one/two readings.
6. Result table.
7. Graph and Conclusions.
8. There should be continuous assessment for the TW.
9. Assessment must be based on understanding of theory, attentiveness during practical, understanding Session, how efficiently the student is able to make connections and get the results, and timely submission of journals.

List of Practicals (Any 8 to be performed by the student)

1. Introduction to PIC 18F kit and introduction to MPLAB software.
2. Write an embedded C program to perform addition, subtraction and multiplication of two hex numbers.

3. Develop and Execute Programs on Time delay.
4. Develop and execute programs on Different Interrupt handling.
5. Develop and execute programs on Serial Communication.
6. Write an embedded C program to interface LEDs and switch with PIC18F458. Blink the LEDs when button is pressed.
7. Write an embedded C program to interface the LCD [16 X 2] with PIC18F458
8. Generation of square, positive ramp, negative ramp, triangular waveforms using DAC interface
9. Write an embedded C program to interface buzzer and relay with PIC18F458.
10. Write an embedded C program to interface DC motor with PIC 18F458 and control its speed using PWM.
11. Write an embedded C program to interface stepper motor with PIC 18F458.
12. Write an embedded C program to interface LM35 temperature sensor with PIC 18F458 and display temperature on it.

Note:

The list of experiments is not limited to the above, but a course coordinator may design a few new experiments based on recent technologies/trends in the relevant Engineering Domain. However, the course coordinator needs to get approval by the Program Assessment Committee and Chairman BOS/HOD well in time.

Course Activity (Any one of the following):

1. Study of various Data sheets and its Presentation.
2. Free PIC Microcontroller Tutorial - Introduction to PIC18F Microcontroller | Udemy

Mrs. S. D. Rokade	Dr. J.S Rangole	Mr.K.S Bhagwat
PAC Member 1	PAC Member 2	PAC Member 3

VPKBIET BARAMATI Affiliated to S.P.P.U. Pune Id No. /PU/PN/ Engg./152/2000 PUNE (MS.)

EL24304: Electric Mobility		
Teaching Scheme: **TH: 03 Hrs/Week**	**Credits:03**	**Examination Scheme:** **Course Activity: 10 Marks** **In-Semester Exam: 30 Marks** **End-Semester Exam: 60 Marks**

Prerequisite Courses:

Engineering Physics, Basic Electrical Engineering

Course Objectives:

1. To recognize the need and importance of Electric Vehicles and understand the components of EV system.
2. To understand battery parameters, types of batteries for EVs & battery management system.
3. To understand and distinguish between various motor drives used in EVs as an Electric Propulsion Unit.
4. To describe EV battery testing procedure and discuss different aspects of battery recycling.
5. To distinguish between different EV charging standards and understand requirements and components of EV Charging Infrastructure.
6. To understand the concept and applications of Vehicle to Home, Vehicle to Grid and Vehicle to Vehicle infrastructure.

Course Outcomes:

On completion of the course, learner will be able to:

CO-1: Recognize the need and importance of Electric Vehicles and explain the components of EV system.

CO-2: Summarize battery parameters, types of batteries for EVs and battery management system.

CO-3: Discuss and distinguish between various motor drives used in EVs as an Electric Propulsion Unit.

CO-4: Describe EV battery testing procedure and discuss different aspects of battery recycling.

CO-5: Distinguish between different EV charging standards and discuss requirements and components of EV Charging Infrastructure.

CO-6: Describe the concept and applications of Vehicle to Home, Vehicle to Grid and Vehicle to Vehicle infrastructure.

Course Contents

Unit I: Basics of EV and Components of EV System **(7 Hrs)**

Need & Importance of EVs, Advantages & Challenges, Components of EV system: Battery pack, Motor, Controller, Converter Requirement of EV motors, Motors used in EVs: Construction & working Principles of DC Series Motor, Brushless DC Motor, Permanent Magnet Synchronous Motor (PMSM), 3 Phase Induction Motor, Switched Reluctance Motor.

Unit II: Battery Parameters, Types of Batteries for EVs and BMS **(6 Hrs)**

Concept of C rating, Wh and Ah rating, SOH, SOC, DOD ratings, Importance of power density and energy density, active and Passive cell balancing methods, Lithium-ion battery, Aluminium Air battery and Aluminium-ion battery ,Block Diagram and functions of BMS, SoC Estimation methods, Thermal Management of Battery.

Unit III: Electric Propulsion Unit **(6 Hrs)**

Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive efficiency.

Unit IV: Battery Testing and Recycling **(7 Hrs)**

Battery power testing for various Vehicles such as car, bus, truck, Battery capacity tester, Battery testing for urban and high way driving cycles, Technology and economic aspects of battery recycling, Battery Applications for Stationary and Secondary Use, Introduction of lithium recycling.

Unit V: EV Chargers and Charging Infrastructure **(7 Hrs)**

Battery Charging Methods: CC Method, CV Method, CCCV Method, Charging Levels: 01,02 & 03, Charging Standards: CCS, CHAdeMO, SAE J1772, IEC 60309, Bharat DC 001, Bharat AC 001. EV Charging Station: System block diagram, Topologies, Requirement of system, Working principle of EV charging, Types of EV charging systems & main components of EV chargers.

Unit VI: V2H, V2V and V2G **(6 Hrs)**

Vehicle to Home: Introduction, applications, V2H with demand response, Case Study of V2H. Vehicle to Grid: Introduction of V2G, V2G infrastructure in the smart grid, Role of aggregator for V2G, Case study of V2G, Vehicle to Vehicle: Introduction of V2V, Concept & structure.

Books & Other Resources:

Text Books:

1. "Electrical Vehicle", James Larminie and John Lowry, John Wiley & Sons, 2012
2. "Electric and Hybrid-Electric Vehicles", Ronald K. Jurgen, SAE International Publisher
3. "Power Electronics: Circuits, Devices and Applications" M. H. Rashid, Pearson Education, PHI 3rd Edition, New Delhi 2004
4. "Power Electronics", M. D. Singh, K. B. Khanchandani Tata McGraw-Hill Education,
5. "Fundamentals of Electrical Drives", G. K. Dubey, New Age International Publication

Reference Books:

1. "Electric and Hybrid Vehicles: Design Fundamentals", Iqbal Hussein, CRC Press.
2. "Electric Vehicle Technology Explained", James Larminie, John Lowry, Wiley, 2003
3. "Permanent Magnet Brushless DC Motor Drives and Controls", Chang Liang Xia, Wiley, 2012
4. "Permanent Magnet Synchronous and Brushless DC Motor Drives", Ramu Krishnan, CRC Press, 2009
5. "Electric Motors and Drives Fundamentals Types and Applications", Austin Hughes and Bill Drury, Elsevier, 2019
6. "Power Electronics Converters Applications and Design", Ned Mohan, T. Undeland & W. Robbins, John Willey & sons, Singapore, 2nd Edition Oxford University Press, New Delhi, 2005
7. "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals", Mehrdad Ehsani, Yimin Gao, Ali Emadi CRC Press, 2010

Course Activity (Any ONE of the following):

For the assessment of Course Activity, a student must complete at least ONE activity out of the followings:

1. Case Study
2. Poster Presentation

Mrs.V.V.Deokate
(PAC member 1)

Mrs.P.N.Jaiswal
(PAC member 2)

Mr.S.D.Shelar
(PAC member 3)

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Affiliated to S.P.P.U. Pune Id No./PU/PN/Engg./152/2000
PUNE (MS)

EL24305: Solar and EV Lab		
Teaching Scheme: **PR: 02 Hrs/Week** **TUT: 01 Hrs/Week**	**Credits:02**	**Examination Scheme:** **Course Activity: 10 Marks** **Practical Exam: 30 Marks** **Term-Work: 30 Marks**

Prerequisite Courses:

Knowledge of fundamentals of Solar Energy, basics of Electrical Engineering and Engineering Chemistry, Electric Mobility.

Course Objectives:

1. To understand the electrical characteristics of PV systems under varying light intensity, temperature, and configurations.
2. To design the solar photovoltaic system and simulate MPPT algorithms for optimized power extraction from PV panels.
3. To study speed control of electrical motor systems and battery performance under varying load and operational conditions.

Course Outcomes:

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

CO-1: Describe the performance of PV systems under varying light intensity, temperature, and configurations.

CO-2: Design the solar photovoltaic system and simulate MPPT algorithms for optimized power extraction from PV panels.

CO-3: Analyze speed control of electrical motor systems and battery performance under varying load and operational conditions.

Guidelines for Laboratory - Term work Assessment:

1. The distribution of weightage of term work marks should be informed to students before the start of the semester.
2. Term work assessment should be on a continuous basis. At frequent intervals students are expected to inform about their progress/lagging.

Guidelines for Laboratory Conduction:

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Guidelines for Students Lab Journal:

The Student's Lab Journal should contain following related to every experiment –

1. Theory related to the experiment.
2. Apparatus with their detailed specifications.
3. Connection diagram /circuit diagram.
4. Observation table/ simulation waveforms.
5. Sample calculations for one/two readings.
6. Result table.
7. Graph and Conclusions.
8. There should be continuous assessment for the TW.
9. Assessment must be based on understanding of theory, attentiveness during practical, understanding Session, how efficiently the student is able to make connections and get the results, and timely submission of journals.

LIST OF PRACTICALS (Any 08 experiments to be performed by the student)

1. To measure Voc and Isc of a solar PV panel and obtain I-V and P-V characteristics of PV modules: for single PV module.
2. To obtain I-V and P-V characteristics of PV modules: for series and parallel connection of PV modules.
3. To observe the I-V and P-V curve of a solar cell/module with different light intensities and with different operating temperatures.
4. To observe the I-V and P-V curve of a solar cell/module with different operating temperatures.
5. To design PV system for residential/commercial applications.
6. Demonstrate voltage conversion using a rectifier circuit (AC – DC) and inverter circuit (DC - AC).
7. To demonstrate voltage conversion using a DC-DC converter (Buck/Boost).
8. To obtain torque-speed characteristics of a PMSM/SRM motor.
9. To perform the speed control of BLDC motor.
10. To perform the speed control of 3 Phase Induction motor by Variable frequency method.
11. To plot the charging and discharging characteristics of a battery under different load conditions.
12. To determine the SoC of a battery pack by analyzing voltage and current readings at different discharge levels.

LIST OF TUTORIALS (Any 04 experiments to be performed by the student)

1. To study Solar PV Module and Its Specifications
2. To study Maximum Power Point Tracking (MPPT) Techniques
3. To study Solar Charge Controller
4. To study Solar Battery Storage System
5. To study Electric Vehicle (EV) Powertrain Components
6. To study EV Charging Methods and Charging Stations

Note: The list of experiments is not limited to the above, but a course coordinator may design a few new experiments based on recent technologies/trends in the relevant Engineering Domain. However, the course coordinator needs to get approval by the Program Assessment Committee and Chairman BOS/HOD well in time.

Books & Other Resources:

Text Books:

1. Chetan Singh Solanki, "Solar Photovoltaics: Fundamental, Technologies and applications", 2nd Edition, PHI Learning Pvt. Limited, New Delhi, 2011.
2. Solar Power Hand Book, Dr. H. Naganagouda (2014)
3. Renewable Energy Sources and Emerging Technologies, Kothari D.P. and Signal K.C New Arrivals –PHI; 2 Edition (2011)
4. "Electrical Vehicle", James Larminie and John Lowry, John Wiley & Sons
5. "Electric and Hybrid-Electric Vehicles", R. K. Jurgen, SAE International Publisher
6. "Power Electronics: Circuits, Devices and Applications" M. H. Rashid, Pearson Education

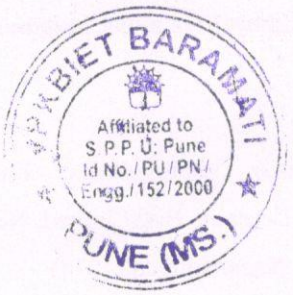
Reference Books:

1. "Solar Energy - Principles of thermal collection and storage", S. P. Sukhatme, TMH, 2008
2. Renewable Energy Technologies; A Practical Guide for Beginners
3. "Electric and Hybrid Vehicles: Design Fundamentals", Iqbal Hussein, CRC Press
4. "Power Electronics Converters Applications and Design", Ned Mohan, T. Undeland & W. Robbins, John Willey & sons
5. "Electric Motors and Drives Fundamentals Types and Applications", Austin Hughes and Bill Drury, Elsevier.

Course Activity (Any one of the following):

1. Case study
2. Power point presentation.

Mr. A. V. Golande	Mr. R. S. Tarade	Dr. H. M. Shaikh
Course Coordinator	PAC Member 1	PAC Member 2



EL24311: Control System Engineering		
Teaching Scheme: **TH: 03 Hrs/Week** **PR: 02 Hrs/Week**	**Credits:04**	**Examination Scheme:** **Course Activity: 10 Marks** **In-Semester Exam: 30 Marks** **End-Semester Exam: 60 Marks** **Oral: 30 Marks**

Prerequisite Courses: Applied Mathematics, Electrical Circuit analysis

Course Objectives: The course aims:

1. To understand basic concepts of the classical control theory.
2. To model physical systems mathematically
3. To analyse behaviour of system in time domain.
4. To study and analyse Stability Analysis techniques.
5. To analyse behaviour of system in frequency domain.
6. To understand concepts of State Space Analysis

Course Outcomes

On completion of the course, learner will be able to:

CO-1: Compare open loop and close loop control system and study the classification of control system.

CO-2: Construct mathematical model of Electrical and Mechanical system using differential equations and transfer function and develop analogy between Electrical and Mechanical systems.

CO-3: Determine time response of systems for a given input and perform analysis of first and second order systems using time domain specifications.

CO-4: Analyze closed loop stability of system in s-plane using Routh Hurwitz stability criteria and root locus.

CO-5: Analyze the systems in frequency domain and assess stability using Bode plot and Nyquist plot .

CO-6: Evaluate the controllability and observability properties of the system.

Course Contents

Unit I: Introduction to Control System **(7 Hrs)**

Introduction to automation and automatic control, Introduction to control system block diagram, Importance of Control Systems. Components of control system, Classification of control systems, types of control system: feedback, tracking, regulator system, servomechanism, feed forward system, Open loop control and closed loop control, SISO (Single Input Single

Output) and MIMO (Multiple Input Multiple Output), Significance of actuators and sensors, Types of actuators (Electrical, Hydraulic, Pneumatic), Types of sensors (analog and digital)

Unit II: Control System Representation **(6 Hrs)**

Mathematical representation and Transfer function of mechanical, electrical, thermal, hydraulic system, Pole zero concepts, Block diagram representation and reduction, Signal flow graph.

Unit III: Time Domain Analysis **(7 Hrs)**

Standard Test Signals, Concept of transient and steady state response, Types and Order of system, Time response of first order, second order systems, Analysis of steady state error, Second Order time response specifications, Effect of parameter variation on open loop and closed loop system response, sensitivity, Effect of feedback on system response, stability and disturbance.

Unit IV: Stability Analysis **(7 Hrs)**

Concept of stability, Effect of pole zero location on stability, Routh- Hurwitz criterion. Root Locus: Angle and magnitude condition, Basic properties of root locus. Construction of root locus, Stability analysis using root locus.

Unit V: Frequency Domain Analysis and Compensation Techniques **(8 Hrs)**

Concept of frequency domain behaviour, Bode Plot for analysing system in frequency domain. Frequency domain performance specifications. Correlation between time domain and frequency domain specification, Nyquist Plot, P, PI & PID control and its effect on overall system performance, Compensation Techniques: Lag, Lead, Lag-Lead compensator design based on bode plot.

Unit VI: State Space Approach **(7 Hrs)**

Representation of system in state space, converting transfer function model into state space model. Non uniqueness of state space model, Canonical representation, Eigenvalues, Solution of state equations, Concept of State feedback control, controllability, Observability, pole placement, Concept of the observer, Control system case study.

Books & Other Resources:

Text Books:

1. Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall of India.
2. M. Gopal, "Control Systems- Principle of Design", Fourth Edition, 2012, McGraw Hill.
3. I.J. Nagrath, M. Gopal, "Control System Engineering", New Age International Publishers, 6th edition, 2017

Reference Books:

1. D'AzzoHoupis, Logakusha, Huelsoman, "Linear System Analysis", McGraw Hill.
2. Richard C. Dorf and Robert H. Bishop, "Modern Control Systems", Pearson Education Inc.
3. Norman S Nise, "Control System Engineering", John Wiley & Sons.

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2. Students should be informed about DO'S and DON'T and precautions before performing.

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5. Sample calculations for one/two readings.
6. Result table.
7. Graph and Conclusions.
8. There should be continuous assessment for the TW.
9. Assessment must be based on understanding of theory, attentiveness during practical, understanding Session, how efficiently the student is able to make connections and get the results, and timely submission of journals.

List of Practicals (Any 8 to be performed by the student)

A) Minimum four experiments should be conducted

1. Experimental determination of DC servo motor parameters for mathematical modelling and transfer function
2. Experimental study of time response characteristics of R-L-C second order system. Validate the results using software simulation.
3. Experimental determination of frequency response of Lead compensator.
4. Experimental determination of frequency response of Lag compensator.
5. PID control of level/ Temperature/speed control system.
6. Experimental determination of transfer function of any one physical systems (AC Servomotor/Two Tank System/ Temperature control/ Level control)
7. Experimental analysis of D.C. Motor Position control system.

B) Minimum four experiments should be conducted (perform using software)

1. Stability analysis using a) Bode plot, b) Root locus and c) Nyquist plot.
2. Effect of P, PI and PID controllers on time response of second order system.
4. Effect of addition of pole-zero on root locus of the second order system.
5. Effect of addition of dominant and non-dominant poles on step response of second order system.
6. Obtain the State-space representation of the same system using Linear system analysis of MATLAB/ LabVIEW software.
7. Determine controllability and observability of the system using MATLAB/LabVIEW software.

Course Activity (Any one of the following):

1. Software Simulation
2. Quiz

Mrs. S. D. Rokade
PAC Member 1

Dr. H. M. Shaikh
PAC Member 2

Mrs.P.N Jaiswal
PAC Member 3

VPKBIET BARAMATI
Affiliated to S.P.P.U. Pune Id No./PU/PN/Engg./152/2000
PUNE (MS.)

EL24312: Switchgear and Protection		
Teaching Scheme: **TH: 02 Hrs/Week** **PR: 02 Hrs/Week**	**Credits:03**	**Examination Scheme:** **Course Activity: 10 Marks** **End-Semester Exam: 60 Marks** **Oral Exam: 30 Marks**

Prerequisite Courses:

Basic Electrical Engineering, Power System.

Companion Course, if any: Laboratory Practical

Course Objectives:

1. To study the fundamental principles of protective relaying and its importance in electrical power systems.
2. To develop the ability of students with various techniques and devices used for arc interruption.
3. To study the operational principles, including the mechanical and electrical aspects of circuit breakers.
4. Interpret and analyze block diagrams associated with static and digital relays.
5. To study the different types of faults in the transformer, alternator and 3-phase induction motor.
6. Impart knowledge about transmission line protection schemes and the characteristics of different types of distance relays.

Course Outcomes

On completion of the course, learner will be able to

CO-1: Explain the concepts of protective relaying and arc interruption techniques and their application in electrical power systems.

CO-2: Describe static and numerical relay concepts and analyze the operation and applications of circuit breakers in electrical power systems.

CO-3: Apply different protection schemes to power transformers and induction motors.

CO-4: Apply different types of protection schemes for transmission lines.

Course Contents

Unit I: Fundamentals of Protective Relaying and Arc Interruption **(07 Hrs)**

A) Fundamentals of Protective Relaying: Classification of relays, zones of protection, primary and backup protection, essential qualities of protective relaying, Trip circuit of circuit breaker, Various basic operating principles of directional over current, induction type relay, torque equation in induction type relay, current and time setting in induction relay, Numerical on TSM, PSM and operating time of relay.

B) Fundamentals of Arc Interruption: Ionization of gases, deionization, Electric arc formation, high and low resistance principles, arc interruption theories, arc voltage, recovery voltage, derivation and definition of restriking voltage and RRRV, interruption of capacitive current, current chopping, resistance switching

Unit III: Static and Numerical Relaying **(07 Hrs)**

A) Static and Numerical Relaying: Block diagram of static relay, merits and demerits of static relay. Numerical Relays: Block diagram of numerical relay, Sampling theorem, Anti-Aliasing Filter, Block diagram of PMU and its application. Wide area monitoring systems, Introduction to smart relaying system protection.

B) Circuit Breaker : Different ratings of circuit breaker (like rated voltage, rated current, rated frequency, rated breaking capacity symmetrical and unsymmetrical breaking, making capacity, rated interrupting duties, rated operating sequence, short time rating), Classification of high voltage circuit breakers, smart circuit breaker, Working and constructional features of ACB, SF_6, VCB- advantages, disadvantages and applications

Unit III: Equipment Protection **(06 Hrs)**

I. Power transformer protection: Types of faults in transformer, percentage differential protection in transformers, incipient faults, protection against over fluxing, protection against inrush current.

II. 3 phase induction motor protection: Abnormal conditions and causes of failures in 3 phase induction motor protection, single phasing protection, overload protection, short circuit protection.

Unit IV: Transmission Line Protection **(06 Hrs)**

Impedance relay, reactance relay, mho relay, quadrilateral relays, three stepped distance protection, effect of arc resistance, power swing on performance of distance relay, realization of distance relays(impedance, reactance, and mho relay) using numerical relaying algorithm (flowchart, block diagram).

Books & Other Resources:

Text Books:

1. Electrical Power Systems, C.L. Wadhwa, Newage Publishers.
2. Badri Ram, D. N. Vishwakarma, "Power System Protection and Switchgear", Tata McGraw Hill Publishing Co. Ltd.
3. Y. G. Paithankar, S. R. Bhide, "Fundamentals of Power System Protection", Prentice Hall of India.
4. Bhavesh Bhalja,R.P. Maheshwari, N.G. Chothani," Protection and Switchgear", Oxford University Press, 2011 Edition.
5. J.B.Gupta " Switchgear and Protection", S.K. Kataria and Sons.
6. Power system protection and switchgear by Oza, Nair, Mehta, Makwana.

Reference Books:

1. S. Rao, "Switchgear Protection and Power Systems", Khanna Publications.
2. J Lewis Blackburn, "Protective Relaying- Principles and Applications", Dekker Publications.
3. A.G. Phadke, J.S. Thorp,Computer relaying for Power System, Research Studies Press LTD, England. (John Willy and Sons Inc New York).
4. Mason C.R., "Art and Science of Protective Relaying", Wiley Eastern Limited.
5. Arun Ingole, "Switchgear and Protection", Pearson.

Online Resources :

1. Swayam course - Power system protection and switchgear.

https://archive.nptel.ac.in/courses/108/107/108107167

2. Free certified course - Fundamentals-of-electrical-switchgear

https://alison.com/course/fundamentals-of-electrical-switchgear

Industrial Visit:

Recommended industrial visit to switchgear training center/or relay manufacturing unit/or 220 kV substation/or sugar factory.

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5. Sample calculations for one/two readings.
6. Result table.
7. Graph and Conclusions.
8. Assessment must be based on understanding of theory, attentiveness during practical, understanding Session, how efficiently the student is able to make connections and get the results, and timely submission of journals.

LIST OF PRACTICALS (Any 08 to be performed by the student)

1. Study of switchgear/protective relay testing system.
2. To perform testing of fuse.
3. To perform testing of MCB.
4. To perform testing of MCCB.
5. To perform testing of contactor.
6. To perform testing of thermal overload relay.
7. To perform testing and plotting characteristics of IDMT type Induction over current relay.
8. To perform testing and plotting characteristics of digital over current relay.
9. Study of percentage differential protection of transformer (Merz Price Protection).

10. Study of bus-bar protection scheme.
11. To perform testing of three phase transmission line training system
12. Circuit breaker status indication from field input (V-lab).

Note :

The list of experiments is not limited to the above, but a course coordinator may design a few new experiments based on recent technologies/trends in the relevant Engineering Domain. However the course coordinator needs to get approval by the Program Assessment Committee and Chairman BOS/HOD well in time.

Course Activity (Any one of the following) :

1. Study of datasheet of relay/circuit breaker etc.
2. Design of protection scheme for substation/ residential/ commercial.

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PAC Member 1	PAC Member 2	PAC Member 3

KBIET BARAMATI
Affiliated to S.P.P.U: Pune Id No.: PU/PN/Engg./152/2000
PUNE (MS)

EL24313A: Power System Operation & Control		
Teaching Scheme: **TH: 03 Hrs/Week** **PR: 02 Hrs/Week**	**Credits:04**	**Examination Scheme:** **In-Semester Exam: 30 Marks** **End-Semester Exam: 60 Marks** **Course Activity: 10 Marks** **Oral Exam: 30 Marks**

Prerequisite Courses:

Basic Electrical Engineering, Basics of Power System, Power System Analysis & Electrical Machines.

Companion Course, if any: Laboratory Practical

Course Objectives:

1. To develop the ability to analyze and use various methods to improve stability of power systems.
2. To understand the need for control of reactive power and FACTs controllers with its evolution, principle of operation, circuit diagram and applications.
3. To illustrate the automatic frequency and voltage control strategies for single and two area case and analyze the effects, knowing the necessity of generation control.
4. To Understand the formulation of unit commitment and economic load dispatch and solve it using optimization techniques.
5. To study the various ways of energy control between interconnected utilities.
6. To provide an overview of the voltage stability define reliability aspects at all stages of the power system.

Course Outcomes

On completion of the course, learner will be able to

CO-1: Elaborate power system stability along with equal area criterion.

CO-2: Select appropriate FACTS devices for stable operation of the system.

CO-3: Explain the concept of automatic generation control.

CO-4: Analyze stability and optimal load dispatch using different techniques.

CO-5: Illustrate various ways of interchange of power between interconnected utilities.

CO-6: Explain the reliability and voltage stability of the system and suggest the methods to improve it.

Course Contents

Unit I: Power System Stability **(07 Hrs)**

Introduction to stability, dynamics of synchronous machine, swing equation, power angle equation and curve, types of power system stability (concepts of steady state, transient, dynamic stability), equal area criterion, applications of equal area criterion (sudden change in mechanical input, effect of clearing time on stability, critical clearing angle, short circuit at one end of line, short circuit away from line ends and reclosure), methods to improve steady state and transient stability, numerical based on equal area criteria.

Unit II: Reactive Power Management and FACTs Technology **(07 Hrs)**

Necessity of reactive power control, reactive power generation by a synchronous machine, effect of excitation, loading capability curve of a generator, compensation in power system (series and shunt compensation using capacitors and reactors), Problems with Series Compensation, synchronous condenser. Problems of AC transmission system, evolution of FACTs technology, principle of operation, circuit diagram and applications of SVC, TCSC, STATCOM and UPFC.

Unit III: Automatic Generation Control (AGC) **(07 Hrs)**

Introduction to the concept of AGC, complete block diagram representation of load frequency control of an isolated power system, steady state and dynamic response, control area concept, two-area load-frequency control, schematic and block diagram of the alternator voltage regulator scheme.

Unit IV: Economic Load Dispatch and Unit Commitment **(07 Hrs)**

A) Economic load dispatch: Introduction, revision of cost curve, incremental cost curve of thermal, method of Lagrange multiplier, exact coordinate equation (penalty factor), economic scheduling of thermal plant considering effect of transmission losses using Bmn coefficient. (Numerical on method of Lagrange multiplier, penalty factor, Bmn coefficient)

B) Unit commitment: Concept of unit commitment, constraints in unit commitment – spinning reserve, thermal and hydro constraints, methods of unit commitment – priority list

and dynamic programming, Numerical on priority list and dynamic programming method.

Unit V: Energy Control **(07 Hrs)**

Interchange of power between interconnected utilities (numerical), economic interchange evaluation, interchange evaluation with unit commitment, types of interchange, capacity and diversity interchange, energy banking, emergency power interchange, inadvertent power exchange, power pools.

Unit VI: Reliability & Voltage Stability of Power System **(07 Hrs)**

Definition of reliability of power system, hierarchical levels for reliability study, reliability evaluation of generation system, basic concepts related to voltage stability, classification of voltage stability, transmission system characteristics (PV curve), generator characteristics (QV curve), load characteristics, voltage collapse, voltage sag and swell.

Books & Other Resources:

Text Books:

1. Abhijit Chakrabarti, Sunita Halder, "Power System Analysis Operation and Control" 3rd Edition, 2010 Prentice Hall of India.
2. I. J. Nagrath, D. P. Kothari, "Modern Power System Analysis", 4th Edition, Tata McGraw Hill Publishing Co. Ltd.
3. P. S. R. Murthy, "Power System Operation & Control", Tata McGraw Hill Publishing Co. Ltd.
4. S. Sivangaraju & G. Sreenivasan, "Power System Operation and Control", 1st Edition, Pearson.
5. Narain G. Hingorani and Laszlo Gyugyi, "Understanding FACTs," IEEE Press.

Reference Books:

1. Prabha Kundur "Power system stability and control" Tata McGraw Hill.
2. Allen J. Wood and Bruce F. Wollenberg, "Power Generation, Operation, and Control," Wiley India Edition.
3. Dr. K. Uma Rao, "Power System Operation and Control," Wiley India.
4. C. L. Wadhwa, "Electrical Power System", New Age International Publisher.

Online Resources:

1. NPTEL Course on Power System Dynamics, Control and Monitoring by Prof. Debapriya Das, IIT Kharagpur (https://onlinecourses.nptel.ac.in/noc25_ee66/preview)
2. NPTEL Course on Power System Engineering by Prof. Debapriya Das, IIT Kharagpur (https://onlinecourses.nptel.ac.in/noc25_ee67/preview)

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5. Sample calculations for one/two readings.
6. Result table.
7. Graph and Conclusions.
8. There should be continuous assessment.
9. Assessment must be based on understanding of theory, attentiveness during practical, understanding Session, how efficiently the student is able to make connections and get the results, and timely submission of journals.

List of practicals (Any 08 to be performed by the student)

1. To determine Steady state Stability of synchronous motor (performance).
2. To determine Steady state stability of medium transmission line (performance).
3. To apply Equal Area Criteria for Analysis of Stability Under Sudden Rise in Mechanical Power Input.
4. To apply Equal Area Criteria for Analysis of Stability Under Fault condition.
5. To plot swing curve by point by point method for transient stability Analysis.

6. To Study Lagrange Multiplier Technique for Economic Load Dispatch by MATLAB Software.
7. To study reactive power compensation using any device.
8. To develop dynamic programming methods for unit commitment by MATLAB software.
9. To study load frequency control using an approximate and exact model by MATLAB software.
10. To study the single area load frequency control with integral control.
11. To study the two area load frequency control.
12. To study the optimum loading of generators considering transmission losses (penalty factor).

The list of experiments is not limited to the above, but a course coordinator may design a few new experiments based on recent technologies/trends in the relevant Engineering Domain. However, the course coordinator needs to get approval by the Program Assessment Committee and Chairman BOS/HOD well in time.

Industrial Visit: At least one industrial visit should be arranged to Load Dispatch Center / Power Station.

Course Activity (Any one of the following):

1. MCQ Test (GATE Preparation)
2. Technical Activity: NPTEL, Coursera, MATLAB Certification
3. Report submission on Case Study conducted

Mr. Sandeep. D. Shelar	Mr. Rohit S. Tarade	Mr. Dipak S.Yeole
Course Coordinator	PAC Member 1	PAC Member 2

VPKBIET BARAMATI Affiliated to S.P.P.U. Pune Id No./PU/PN/Engg./152/2000 PUNE (MS.)

EL24313B: Signals and Systems		
Teaching Scheme: **TH: 03 Hrs/Week** **PR: 02 Hrs/Week**	**Credits:04**	**Examination Scheme:** **Course Activity: 10 Marks** **In-Semester Exam: 30 Marks** **End-Semester Exam: 60 Marks** **Oral Exam: 30 Marks**

Prerequisite Courses:

Knowledge of Engineering Mathematics, Analog and Digital Electronics, Circuit Analysis.

Companion Course, if any: Laboratory Practical

Course Objectives:

1. To identify and classify different types of signals and systems.
2. To Analyze the impulse response and convolution properties of LTI systems
3. To apply Laplace Transform techniques for system analysis, including transfer function and pole-zero analysis.
4. To analyze discrete-time systems and assess stability using Z-transform.
5. To examine Fourier representations of signals and interpret frequency response for system analysis.
6. To explain sampling theorem, reconstruct signals from samples, and differentiate various modulation techniques.

Course Outcomes

On completion of the course, learner will be able to

CO-1: Identify and classify different types of signals and systems.

CO-2: Analyze LTI system properties and methods to examine impulse response, convolution, and system stability.

CO-3: Apply Laplace Transform techniques for system analysis, including transfer function and pole-zero analysis.

CO-4: Analyze discrete-time systems and assess stability using Z-transform

CO-5: Examine Fourier representations of signals and interpret frequency response for system analysis.

CO-6: Explain sampling theorem, reconstruct signals from samples, and differentiate various modulation techniques.

Course Contents

Unit 1: Introduction to Signals and Systems: **(07 Hrs)**

Definition and classification of signals: Continuous-time and discrete-time signals, periodic and aperiodic signals, even and odd signals, deterministic and random signals. Standard signals: Unit step, unit impulse, ramp, exponential, sinusoidal function. Properties of signals: Time shifting, scaling, and reversal, Classification of systems: Linear vs. nonlinear, time-invariant vs. time-variant, causal vs. non-causal, stable vs. unstable. Applications

Unit II: Linear Time-Invariant (LTI) Systems **(07 Hrs)**

Definition and properties of LTI systems, Impulse response and convolution integral for continuous-time systems, Convolution sum for discrete-time systems, Stability and causality conditions, Step response of LTI systems. Application: electric circuit analysis (RC, RL, and RLC circuits)

Unit III: Laplace Transform and System Analysis **(06 Hrs)**

Definition and properties of the Laplace transform, Region of Convergence (ROC), Inverse Laplace transform and application in system analysis, Transfer function and pole-zero analysis, Application: electrical network analysis.

Unit IV: Z-Transform and Discrete-Time System Analysis **(06 Hrs)**

Definition and properties of Z-transform, ROC and inverse Z-transform, Relationship between Laplace and Z-transform, Stability and causality in Z-domain, Application of Z-transform in discrete-time system analysis and control system design.

Unit V: Fourier Series and Fourier Transform **(07 Hrs)**

Fourier series representation of periodic signals (trigonometric & exponential forms), Fourier transform of continuous and discrete - time signals and its properties, Frequency response of LTI systems, Applications of Fourier transform in harmonics analysis of power system.

Unit VI: Sampling and Modulation Techniques **(06 Hrs)**

Sampling theorem and Nyquist criterion, Signal reconstruction from samples, Aliasing and

anti-aliasing filters, Basics of modulation: Amplitude modulation (AM), frequency modulation (FM), phase modulation (PM).

Books & Other Resources:

Text Books:

1. Simon Haykins and Barry Van Veen, "Signals and Systems", 2nd Edition, Wiley India.
2. H. P. Psu, Schaum's Outline of "Signals and Systems", 3rd Edition (Schaum's Outlines).
3. V. Oppenheim Alan, S.Willsky Alan, Nawab S.Hamid, "Signal and System" 2nd Edition, XI'AN Jiaotong University Press.

Reference Books:

1. B. P. Lathi, "Linear Systems and Signals", 2nd Edition, Oxford University Press, 2004.
2. Charles Phillips, "Signals , Systems and Transforms" , 3rd Edition, Pearson Education.
3. A. Anand Kumar, "Signal and Systems" 2nd edition, HPI Learning Pvt Ltd.

Online resources:

1. NPTEL Course on "Principles of Signals and Systems" By Prof. Aditya K. Jagannatham, IIT, Kanpur.

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Guidelines for Students Lab Journal:

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2. Apparatus with their detailed specifications.
3. Connection diagram /circuit diagram.
4. Observation table/ simulation waveforms.
5. Sample calculations for one/two readings.

6. Result table.
7. Graph and Conclusions.
8. There should be continuous assessment for the TW.
9. Assessment must be based on understanding of theory, attentiveness during practical, understanding Session, how efficiently the student is able to make connections and get the results, and timely submission of journals.

List of Practical (Any 08 to be performed by the student)

Note: Perform experiments using MATLAB/Python programming.

1. To generate square wave, triangular, exponential, sinusoidal, step, impulse, and ramp function.
2. To verify time shifting, time scaling, reflection operations on square wave, triangular, exponential, sinusoidal, step, impulse, and ramp function.
3. To evaluate the convolution of finite discrete time signals and to verify the commutative, associative, distributive, and identity property.
4. To evaluate the convolution integral of a given signal.
5. To compute frequency response of LTI system from impulse response.
6. To compute the frequency response of the LTI system by difference equation.
7. To analyze system stability of the given function using Laplace Transform.
8. To obtain time-domain response by using inverse Laplace transform.
9. To find the Z-transform of discrete signals and assess system stability using pole-zero plots.
10. To find recursive system equations in the time domain by inverse Z-transform.
11. To demonstrate the effect of sampling and aliasing.
12. To calculate AM and FM modulation and demodulation for a given sequence.

Note :

The list of experiments is not limited to the above, but a course coordinator may design a few new experiments based on recent technologies/trends in the relevant Engineering Domain. However the course coordinator needs to get approval by the Program Assessment Committee and Chairman BOS/HOD well in time.

Course Activity (Any one of the following):

1. Mini-Projects (Simulation) based on applications of Signals and Systems in Electrical Engineering, Power System.
2. Unit-wise Quiz.

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PAC Member 1	PAC Member 2	PAC Member 3

VPKBIET BARAMATI Affiliated to S.P.P.U. Pune Id No./PU/PN/Engg./152/2000 PUNE (MS.)

EL24314A: Electrical Installation, Design and Condition Based Maintenance		
Teaching Scheme: **TH: 03 Hrs/Week** **PR: 02 Hrs/Week**	**Credits:04**	**Examination Scheme:** **Course Activity: 10 Marks** **In-Semester Exam: 30 Marks** **End-Semester Exam: 60 Marks** **Oral Exam: 30 Marks**

Prerequisite Courses:

Basic Electrical Engineering, Power System Engineering, Power System Analysis, Electrical Machines I and Electrical Machines II.

Companion Course, if any: Laboratory Practical

Course Objectives:

1. To classify different types of distribution supply system and determine economics of distribution system.
2. To compare and classify various substations, bus-bars and earthing systems based on their function and application.
3. To identify and describe the maintenance strategies for transformer, induction motor, and alternator.
4. To evaluate the estimation and costing for internal wiring in residential and commercial installations.
5. To demonstrate various electrical installation testing procedures.
6. To apply electrical safety procedures.

Course Outcomes

On completion of the course, learner will be able to

CO-1: Classify different types of distribution supply system and determine economics of distribution system

CO-2: Compare and classify various substations, bus-bars and earthing systems based on their function and application

CO-3: Identify and describe the maintenance strategies for transformer, induction motor, and alternator

CO-4: Evaluate the estimation and costing for internal wiring in residential and commercial

installations

CO-5: Demonstrate various electrical installation testing procedures

CO-6: Describe underground cable and apply electrical safety procedures

Course Contents

Unit I: Transmission & Distribution Economics **(07 Hrs)**

Economics of power transmission: Economic choice of conductor (Kelvin's law) (Derivation and Numerical). Classification of supply systems (i) DC, 2-wire system, (ii) Single phase two wire AC system, (iii) Three phase three wire AC supply system, iv) Three phase four wire AC supply system. Comparison between overhead and underground systems (For above mentioned systems) on the basis of volume requirement for conductor, AC Distribution System: Types of primary and secondary distribution systems, calculation of voltage drops in ac distributors (Uniform and Non Uniform Loading) (Numerical), Distribution Feeders: Design considerations of distribution feeders; radial and ring types of primary feeder's voltage levels, Energy losses in feeders.

Unit II: Substation and Earthing Systems **(07 Hrs)**

A) Substation: Classification of substations, Various equipment used in substation with their specifications, Bus bar arrangements in the substation: Simple arrangements like single bus bar, sectionalized single bus bar, main and transfer bus bar system with relevant diagrams.

B) Earthing Systems: Necessity of Earthing, Equipment, Neutral, and Maintenance Free Earthing system, Methods of testing earth resistance, Different electrode configurations (Plate and Pipe electrode), Tolerable step and touch voltages, Steps involved in design of substation Earthing grid as per IEEE standard 80-2013.

Unit III: Maintenance and Condition Monitoring **(07 Hrs)**

A) Maintenance: Importance and necessity of maintenance, different maintenance strategies like breakdown maintenance, planned - preventive, predictive maintenance, Maintenance of transformer, Induction motor and Alternators, Use of AI and IoT in Predictive Maintenance Polarization index, Dielectric absorption ratio. Hot Line Maintenance - Meaning and advantages, special types of non-conducting Materials used for tools for hot line maintenance.

B) Condition Monitoring: Concept of condition monitoring of electrical equipment. Advance tools and techniques of condition monitoring, Thermography, 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 Current Signature Analysis.

Unit IV: Estimation and Costing **(06 Hrs)**

Purpose of estimating and costing, qualities of good estimator, essential elements of estimating and costing, tender, guidelines for inviting tenders, quotation, price catalogue, labor rates, schedule of rates and estimating data (only theory), Introduction cable sizing, Estimation and conductor size calculations of internal wiring for Residential and Commercial (Numerical) installations and estimate for underground LT service lines.

Unit V: Testing of Electrical System **(06 Hrs)**

Understanding CAT Ratings & Using CAT rated Instrument, Electrical Installation Testing Procedures- Insulation resistance test between installation and earth, Insulation resistance test between conductors (use of GUARD Terminal in IR test & Application) (methods used for IR Testing) Testing of polarity, Testing of earth continuity paths (Applications of PAT Tester "Portable Appliance Tester" in commercial like hotels, hospital & Industry also) and Earth resistance test (methods for earth testing 3 Pole, 4 Pole)

Unit VI: Underground Cable and Electrical Safety **(06 Hrs)**

A) Underground Cables: Construction of Cables, Classification of cables, Capacitance of single core and three core cable, Dielectric stresses in single core cable, Grading of cables, Inter sheath grading, Capacitance grading.

B) Electrical Safety: Objectives of safety and security measures, Applications of AI in electrical safety, Approaches to prevent accidents, Various statutory regulations (Electricity supply regulations, Factory acts and Indian electricity rules of Central Electricity Authority (CEA), Electrical safety standards- IEEE 3007.3-2012, India Standardization IS-5216, IS-5571, IS-6665, Classification of hazardous area, Introduction to OSHA

Books & Other Resources:

Text Books:

1. B. R. Gupta- Power System Analysis and Design, 3rd edition, Wheelers publication
2. S. Rao, Testing Commissioning Operation and Maintenance of Electrical Equipment, Khanna publishers.

3. S. L. Uppal - Electrical Power - Khanna Publishers Delhi.
4. Hand book of condition monitoring by B. K. N. Rao, Elsevier Advance Tech., Oxford (UK).
5. S. K. Shastri – Preventive Maintenance of Electrical Apparatus – Katson Publication House.
6. B. V. S. Rao – Operation and Maintenance of Electrical Equipment – Asia Publication.
7. Hand book on Electrical Safety.

Reference Books:

1. P.S. Pabla –Electric Power Distribution, 5th edition, Tata McGraw Hill.
2. S. L. Uppal, Electrical Wiring and Costing Estimation, Khanna Publishers, New Delhi.
3. Surjit Singh, Electrical wiring, Estimation and Costing, Dhanpat Rai and company, New Delhi.
4. Raina K.B. and Bhattacharya S.K., Electrical Design, Estimating and Costing, Tata McGraw Hill, New Delhi
5. B.D. Arora-Electrical Wiring, Estimation and Costing, - New Heights, New Delhi.
6. M.V. Deshpande, Elements of Power Station design and practice, Wheelers Publication.
7. S. Sivanagaraju and S. Satyanarayana, Electric Power Transmission and Distribution, Pearson Publication
8. Power Equipment Maintenance and Testing (Power Engineering Book 32) by Paul Gill

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5. Sample calculations for one/two readings.
6. Result table.

7. Graph and Conclusions.
8. There should be continuous assessment.
9. Assessment must be based on understanding of theory, attentiveness during practical, understanding Session, how efficiently the student is able to make connections and get the results, and timely submission of journals.

LIST OF PRACTICALS (Any 08 to be performed by the student)

1. Measurement of Dielectric Absorption Ratio and Polarization Index of insulation.
2. Study of thermograph images and analysis based on these images.
3. Practice of earthing and Measurement of earth resistance of Campus premises by using 3 Pole/4 Pole method.
4. Draw a single line diagram of 33kV or 132 kV or 220 kV or 400 kV substation by using Electrical AutoCAD software.
5. Design of earthing grid for 132/220 kV substation.
6. Design and estimation of light and power circuit of labs/industry.
7. Measurement of insulation resistance of motors and cables.
8. Precautions from electric shock and method of shock treatment.
9. Design and estimation of light and power circuit of residential wiring.
10. Estimation and costing for 11 kV feeders and substation
11. To conduct a market survey for collecting information related to electrical components, their specifications, and cost required for residential/commercial plan.
12. Trouble shooting of household equipment – Construction, working and troubleshooting of any two household Electrical equipment's (Fan, Mixer, Electric Iron, Washing Machines, Electric Oven, Microwave - Limited to electrical faults)
13. Design, Estimation and costing of earthing pit and earthing connection for computer lab, electrical machines lab.

Industrial Visit (if any): Visit to substation/installation/electrical maintenance site.

Note :

The list of experiments is not limited to the above, but a course coordinator may design a few new experiments based on recent technologies/trends in the relevant Engineering Domain. However the course coordinator needs to get approval by the Program Assessment Committee and Chairman BOS/HOD well in time.

Course Activity (Any one of the following) :

1. Assembly of any household electrical equipment
2. Testing and troubleshooting of any household electrical equipment
3. Awareness about electrical earthing/safety/maintenance

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PAC Member 1	PAC Member 2	PAC Member 3

VPKBIET BARAMATI
Affiliated to S. P. P. U. Pune Id No. /PU/PN/ Engg./152/2000
PUNE (MS.)

EL24314B: Computer Aided Design of Electrical Machine		
Teaching Scheme: **TH: 03 Hrs/Week** **PR: 02 Hrs/Week**	**Credits:04**	**Examination Scheme:** **Course Activity: 10 Marks** **In-Semester Exam: 30 Marks** **End-Semester Exam: 60 Marks** **Oral Exam: 30 Marks**

Prerequisite Courses: Basic electrical engineering, Fundamentals of electrical machines, Modelling of electrical machines.

Course Objectives:

1. To understand various cooling methods, constructional features and auxiliaries of three phase transformers.
2. To design a core and winding of a three phase transformer.
3. To determine performance parameters of a three phase transformer.
4. To design main dimensions of a three phase induction motor.
5. To design the stator and rotor of a three phase induction motor.
6. To determine performance parameters of a three phase induction motor.

Course Outcomes:

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

CO-1: Explain various cooling methods, constructional features and auxiliaries of three phase transformers.

CO-2: Design overall dimensions of the three phase transformer.

CO-3: Evaluate performance parameters of three phase transformers.

CO-4: Design main dimensions of a three phase induction motor.

CO-5: Design stator and rotor of a three phase induction motor.

CO-6: Evaluate the performance parameters of three phase induction motor

Course Contents

Unit I: Transformer Design: Part 1 **(7 Hrs)**

Modes of heat dissipation. Heating and cooling curves. Calculations of heating and cooling time constants. Methods of cooling a transformer. Types and constructional features of core and windings used in transformers. Transformer auxiliaries such as tap changer, pressure release valve, breather and conservator. Specifications of three phase transformers as per IS 2026 (Part I). Introduction to computer aided design.

Unit II: Transformer Design: Part 2 **(7 Hrs)**

Output equation with usual notations, design of main dimensions, core, yoke and windings of transformer. Methods of cooling and tank design with and without cooling tubes. Optimum design of transformer for minimum cost and loss.

Unit III: Performance Parameters of Transformer **(7 Hrs)**

Estimation of resistance and leakage reactance of transformer. Estimation of no-load current, losses, efficiency and regulation of transformers. Calculation of mechanical forces developed under short circuit conditions, measures to overcome this effect. Computer aided design of transformer, generalized flow chart for design of transformer.

Unit IV: Three phase Induction Motor Design: Part 1 **(7 Hrs)**

Specifications and constructional features. Types of ac windings. Specific electrical and magnetic loadings, ranges of specific loadings. Output equation with usual notations. Calculations for main dimensions, turns per phase and number of stator slots.

Unit V: Three phase Induction Motor Design: Part 2 **(7 Hrs)**

Suitable combinations of stator and rotor slots. Selection of length of air gap, factors affecting length of air gap, unbalanced magnetic pull. Design of rotor slots, size of bars and end rings for cage rotor. Conductor size, turns and area of rotor slots for wound rotor. Specifications of Induction motor.

Unit VI: Performance parameters of Three Phase Induction motor **(7 Hrs)**

Leakage flux and leakage reactance: Slot, tooth top, zig - zag, overhang. Leakage reactance calculation for three phase machines. MMF Calculation for air gap, stator teeth, stator core, rotor teeth and rotor core, effect of saturation, effects of ducts on calculations of magnetizing current, calculations of no-load current. Calculations of losses and efficiency. Computer aided design of induction motor, generalized flow chart for design of induction motor.

Books & Other Resources:

Text Books:

1. M. G. Say–Theory and Performance and Design of A.C. Machines,3rd Edition, ELBS London.
2. A.K. Sawhney–A Course in Electrical Machine Design, -Dhanpat Rai and sons New Delhi, 10th Edition.
3. K. G. Upadhyay- Design of Electrical Machines, New age publication,2004.
4. R. K. Agarwal–Principles of Electrical Machine Design, S. K. Kataria and sons,05th Edition,2014.
5. Indrajit Dasgupta –Design of Transformers–TMH.

Reference Books:

1. K. L. Narang, A TextBook of Electrical Engineering Drawings, Reprint Edition:1993/1994, Satya Prakashan, New Delhi.
2. A Shanmuga sundaram, G. Gangadharan, R. Palani, -Electrical Machine Design Data Book,3rd Edition, 3rd Reprint 1988- Wiley Eastern Ltd., - New Delhi
3. Vishnu Murti, "Computer Aided Design for Electrical Machines", B. S. Publications,2008.

4. Bharat Heavy Electricals Limited, Transformers-TMH.Handbook of International Electrical Safety Practices, Princeton Energy Resources International, 2010.

Guidelines for Laboratory Conduction:

1. DO's and DON'TS, along with precautions, are needed to be displayed at prominent locations in the laboratory.
2. Students should be informed about DO'S and DON'T and precautions before performing.

Guidelines for Students Lab Journal:

The Student's Lab Journal should contain following related to every experiment –

1. Brief theory related to the concerned sheet.
2. Apparatus with their detailed specification as per IS code.
3. Design as per problem statement.
4. Reference tables used for design purposes.
5. Design parameters details in tabular form.
6. Few short questions related to design.
7. A3/A4 size sheet to be used for CAD drawing.

List of Practicals (Any 6 to be performed by the student)

Part A: (Compulsory practicals 1,2,3)

1. To explore the toolbar and basic functionalities of AutoCAD electrical software.
2. To draw the assembly of the three phase distribution transformer with a design report of various parts. (Sheet in AutoCAD Software).
3. To draw the layout of transformer windings with its design report. (Sheet in AutoCAD).

Part B: (Any 3 to be performed by the student)

1. To draw the assembly of a three phase induction motor with a design report of various parts. (Sheet in AutoCAD Software)
2. To draw the layout of single layer three phase winding with its design report. (Sheet in AutoCAD Software)
3. To draw the layout of double layer three phase winding with its design report. (Sheet in AutoCAD Software)
4. To draw the layout of three phase mush winding with its design report. (Sheet in AutoCAD Software)
5. To study Finite Element Analysis (FEA) for electrical machines includes:
    a. Schematic diagram (Diagram/FEA model/Layout)
    b. Current/Flux/Force/Heat distribution
    c. Analysis by variation of design parameters.

- Industrial Visit to manufacturing or repairing unit (any one of the following):
    1) Three phase transformer.
    2) Three phase induction motor.

Note: The list of experiments is not limited to the above, but a course coordinator may design a few new experiments based on recent technologies/trends in the relevant Engineering Domain. However, the course coordinator needs to get approval by the Program Assessment Committee and Chairman BOS/HOD well in time.

Course Activity: For the assessment of Course Activity, a student must complete at least ONE activity out of the followings:

1. Poster Preparation (Any ONE of the following)

A. To prepare a poster on different parts of Three phase power transformers of different manufacturing companies with their rating and specifications.

B. To prepare a poster on different parts of Three phase distribution transformers of different manufacturing companies with their rating and specifications.

C. To prepare a poster on different parts of Three phase slip ring induction motors of different manufacturing companies with their rating and specifications.

D. To prepare a poster on different parts of Three phase squirrel cage induction motors of different manufacturing companies with their rating and specifications.

2. Technical Quiz (based on every unit)

Mr. Sandeep. D. Shelar	Mrs. Jyoti. S. Kulkarni	Mrs. V. V. Deokate
Course Coordinator	PAC member 1	PAC member 2

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