VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELAGAVI

Scheme of Teaching and Examination and Syllabus
B.E. ELECTRICAL AND ELECTRONICS ENGINEERING
VI SEMESER

(Effective from Academic year 2015-16)

BOARD OF STUDIES IN ELECTRICAL AND ELECTRONICS ENGINEERING
July 2017

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI

SCHEME OF TEACHING AND EXAMINATION - 2015-16

B.E. ELECTRICAL AND ELECTRONICS ENGINEERING

CHOICE BASED CREDIT SYSTEM (CBCS)

VI SEMESTER

Sl. No	Subject Code	Subject (Course)	Title	Teaching Department	Teaching Hours /Week		Examination				Credits
					Theory	Practical/ Drawing	Duration in hours	Theory/ Practical Marks	I.A. Marks	Total Marks	
1	15EE61	Core Subject	Control Systems	EEE	04	--	03	80	20	100	4
2	15EE62	Core Subject	Power System Analysis – 1	EEE	04	--	03	80	20	100	4
3	15EE63	Core Subject	Digital Signal Processing	EEE	04	--	03	80	20	100	4
4	15EE64	Core Subject	Electrical Machine Design	EEE	04	--	03	80	20	100	4
5	15EE65X	Professional Elective	Professional Elective – II	EEE	03	--	03	80	20	100	3
6	15EE66Y	Open Elective	Open Elective - II	EEE	03	--	03	80	20	100	3
7	15EEL67	Laboratory	Control System Laboratory	EEE	01-Hour Instruction 02-Hour Practical		03	80	20	100	2
8	15EEL68	Laboratory	Digital Signal Processing Laboratory	EEE	01-Hour Instruction 02-Hour Practical		03	80	20	100	2
			TOTAL		**Theory:22 hours Practical: 06 hours**		**24**	**160**	**640**	**800**	**26**

Elective

Professional Elective		**Open Elective*** Offered by the Department of Electrical and Electronics Engineering**	
Courses under Code 15EE65X	**Title**	**Courses under Code 15EE66Y**	**Title**
15EE651	Computer Aided Electrical Drawing	15EE661	Artificial Neural Networks and Fuzzy logic
15EE652	Advanced Power Electronics	15EE662	Sensors and Transducers
15EE653	Energy Audit and Demand side Management	15EE663	Batteries and Fuel Cells for Commercial, Military and Space Applications
15EE654	Solar and Wind Energy	15EE664	Industrial Servo Control Systems

*** Students can select any one of the open electives offered by any Department (Please refer to consolidated list of VTU for open electives). Selection of an open elective is not allowed provided;

- The candidate has pre – requisite knowledge.
- The candidate has not studied during I and II year of the programme.
- The syllabus content of open elective is similar to that of Departmental core courses or professional electives.
- A similar course, under any category, is prescribed in the higher semesters.

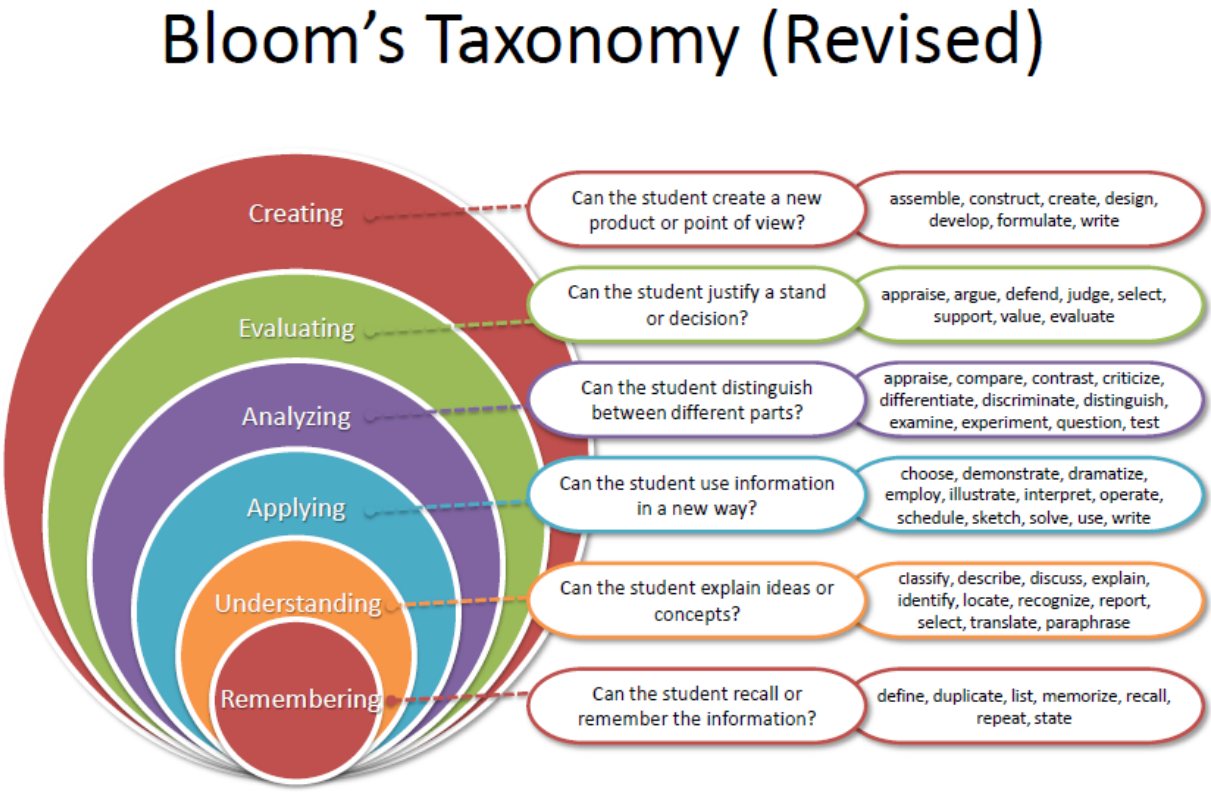
Registration to electives shall be documented under the guidance of Programme Coordinator and Adviser.

1. Core subject: This is the course, which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.

2. Professional Elective: Electives relevant to chosen specialization/ branch.

3. Open Elective: Electives from other technical and/ or emerging subject areas.

CATEGORIZATION FOR THE THINKING PROCESS



Bloom's Revised Taxonomy
Levels, Level Definitions and attributes levels
along with action verbs that can be used when developing learning outcomes.

	Level	Level Definitions and attributes	Verbs(not comprehensive)
Lower order thinking skills (LOTS)	Remembering (Knowledge) $L_1 - Rembr$	Students exhibit memory/rote memorization of previously learnt materials by recognition,recalling facts, terms, basic concepts, and simple answers. Able to remember, but not necessarily fully understanding the material.	Copy, Choose, Define, Discover, Describe, Duplicate, Enumerate, Find, How, Identify, Label, List, Locate, Listen, Memorize, Match, Name, Omit, Quote, Recall, Relate, Reproduce, Recognize, Select, Show, Spell, Tell, Tabulate, Who, When, Where etc.
	Understanding (Comprehension) $L_2 - Undrst$	Students demonstrate understanding of facts and ideas by interpreting, exemplifying, classifying, inferring, summarizing, comparing and explaining main ideas with own words.	Ask, Classify, Compare, Contrast, Demonstrate, Describe, Extend, Differentiate, Distinguish, Discuss, Express, Explain, Group, Illustrate, Infer, Interpret, Outline, Paraphrase, Rephrase, Relate, Show, Summarize, Select, Translate, Restate etc.
	Applying (Application) $L_3 - Apply$	Students solve problems in new situations by applying acquired knowledge, facts, techniques and rules in a different way.	Calculate, Predict, Apply, Solve, Illustrate, Use, Demonstrate, Determine, Model, Build, Construct, Develop, Experiment With, Identify, Make Use Of, Organize, Plan, Select etc.
Higher order thinking skills (HOTS)	Analysing (Analysis) $L_4 - Anlyse$	Students are able to examine and break information into componentparts by identifying motives, causes arrangement, logic and semantics. They can make inferences and find evidence to support generalization.	Analyse, Assume, Break Down, Classify, Categorize, Conclusion, Compare, Contrast, Diagram, Discover, Dissect, Distinguish, Divide, Examine, Function, Illustrate, Inference, Inspect, List,Motive, Outline,Relationships, Simplify, Survey, Take Part In, Test For etc.
	Evaluating (Evaluation) $L_5 - Evlute$	Students are able to present and defend opinions by making judgments about information, validity of ideas, or quality of work based on a set of criteria. They can justify a decision or course of action.	Agree, Appraise, Assess, Award, Build, Create, Compose, Choose, Compare, Conclude, Criteria, Criticize, Design, Derive, Develop, Decide, Deduct, Determine, Disprove, Defend, Estimate, Formulate, Generate, Invent, Modify, Evaluate, Explain, Influence, Judge, Interpret, Justify, Mark, Measure, Perceive, Rate, Prioritize, Recommend, Rule On, Select, Support, Value etc.
	Creating (Synthesis) $L_6 - Create$	Students are able to compile, generate or view information,ideas or products together in a different way by combining elements in a new pattern or by proposing alternative solutions. Also, use information to form a unique product. This requires creativity and originality.	Assemble, Adapt, Anticipate, Build, Change, Choose, Combine, Collaborate, Collect, Create, Compile, Compose, Construct, Delete, Design, Develop, Discuss, Develop, Devise, Elaborate, Estimate, Formulate, Happen, Hypothesize, Imagine, Improve, Invent, Imagine, Intervene, Make Up, Maximize, Modify, Originate, Plan, Predict, Propose, Rearrange, Solve, Suppose, Substitute, Test etc.

Graduate attributes: Graduate attributes are the qualities, skills and understandings a university community agrees its students should develop during their time with the institution. These attributes include but go beyond the disciplinary expertise or technical knowledge that has traditionally formed the core of most university courses. They are qualities that also prepare graduates as agents of social good in an unknown future.

Bowden, Hart, King, Trigwell& Watts (2000)

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER -VI

CONTROL SYSTEMS (Core Subject)

Subject Code	15EE61	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

Credits - 04

Course objectives:

- To define a control system
- To explain the necessity of feedback and types of feedback control systems.
- To introduce the concept of transfer function and its application to the modeling of linear systems.
- To demonstrate mathematical modeling of control systems.
- To obtain transfer function of systems through block diagram manipulation and reduction
- To use Mason's gain formula for finding transfer function of a system
- To discuss transient and steady state time response of a simple control system.
- To discuss the stability of linear time invariant systems and Routh - Hurwitz criterion
- To investigate the trajectories of the roots of the characteristic equation when a system parameter is varied.
- To conduct the control system analysis in the frequency domain.
- To analyze stability of a control system using Nyquist plot.
- To discuss stability analysis using Bode plots.
- To determine the controller or compensator configuration and parameter values relative to how it is connected to the controlled process given the design specifications.■

Module-1		**Teaching Hours**
Introduction to control systems: Introduction, classification of control systems. **Mathematical models of physical systems:** Modelling of mechanical system elements, electrical systems, Analogous systems, Transfer function, Single input single output systems, Procedure for deriving transfer functions, servomotors, synchros, gear trains.■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
Module-2		
Block diagram: Block diagram of a closed loop system, procedure for drawing block diagram and block diagram reduction to find transfer function. **Signal flow graphs:** Construction of signal flow graphs, basic properties of signal flow graph, signal flow graph algebra, construction of signal flow graph for control systems.■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
Module-3		
Time Domain Analysis: Standard test signals, time response of first order systems, time response of second order systems, steady state errors and error constants, types of control systems. **Routh Stability criterion:** BIBO stability, Necessary conditions for stability, Routh stability criterion, difficulties in formulation of Routh table, application of Routh stability criterion to linear feedback systems, relative stability analysis. ■		**10**
Revised Bloom's Taxonomy Level	L_2 – Understanding, L_3 – Applying, L_4 – Analysing, L_5 – Evaluating.	
Module-4		
Root locus technique: Introduction, root locus concepts, construction of root loci, rules for the construction of root locus. **Frequency Response analysis:** Co-relation between time and frequency response – 2^{nd} order systems only. **Bode plots:** Basic factors $G(jw)/H(jw)$, General procedure for constructing bode plots, computation of gain margin and phase margin. Stability analysis with Bode plots. ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - VI

15EE61 CONTROL SYSTEMS (Core Subject)

Module-5	**Teaching Hours**
Nyquist plot: Principle of argument, Nyquist stability criterion, assessment of relative stability using Nyquist criterion. **Design of Control Systems:** Introduction, Design with the PD Controller, Design with the PI Controller, Design with the PID Controller, Design with Phase-Lead Controller, Design with Phase - Lag Controller, Design with Lead-Lag Controller.■	**10**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

Course outcomes:

At the end of the course the student will be able to:

- Discuss the effects of feedback and types of feedback control systems.
- Evaluate the transfer function of a linear time invariant system.
- Evaluate the stability of linear time invariant systems.
- Apply block diagram manipulation and signal flow graph methods to obtain transfer function of systems.
- Demonstrate the knowledge of mathematical modeling of control systems and components
- Determine transient and steady state time response of a simple control system.
- Investigate the performance of a given system in time and frequency domains.
- Discuss stability analysis using Root locus, Bode plots and Nyquist plots.
- Determine the controller or compensator configuration and parameter values relative to how it is connected to the controlled process given the design specifications. ■

Graduate Attributes (As per NBA)

Engineering Knowledge, Problem analysis, Modern Tool Usage, Life-long Learning.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook

1	Control Systems	Anand Kumar	PHI	2nd Edition, 2014
2	Automatic Control Systems	Farid Golnaraghi, Benjamin C. Kuo	Wiley	9th Edition, 2010

ReferenceBooks

1	Control Systems Engineering	Norman S. Nise	Wiley	4th Edition, 2004
2	Modern Control Systems	Richard C Dorf et al	Pearson	11th Edition, 2008
3	Control Systems, Principles and Design	M. Gopal	McGaw Hill	4th Edition, 2012
4	Control Systems Engineering	S. Salivahanan et al	Pearson	1st Edition, 2015

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER -VI

POWER SYSTEM ANALYSIS – 1 (Core Subject)

Subject Code	15EE62	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

Credits - 04

Course objectives:

- To introduce the per unit systemand explain its advantages and computation.
- To explain the concept of one line diagram and its implementation in problems.
- To explain the necessity and conduction of short circuit analysis.
- To explain analysis of three phase symmetrical faults on synchronous machine and simple power systems.
- To discuss selection of circuit breaker.
- To explain symmetrical components, their advantages and the calculation of symmetrical components of voltages and currents in un-balanced three phase circuits.
- To explain the concept of sequence impedance and its analysis in three phase unbalanced circuits.
- To explain the concept of sequence networks and sequence impedances of an unloaded synchronous generator, transformers and transmission lines.
- To explain the analysis of synchronous machine and simple power systems for different unsymmetrical faults using symmetrical components.
- To discuss the dynamics of synchronous machine and derive the power angle equation for a synchronous machine
- Discuss stability and types of stability for a power systemand the equal area criterion for the evaluation of stability of a simple system.■

Module-1		**Teaching Hours**
Representation of Power System Components: Introduction, Single-phase Representation of Balanced Three Phase Networks, One-Line Diagram and Impedance orReactance Diagram, Per Unit (PU) System,Steady State Model of Synchronous Machine, Power Transformer, Transmission of electrical Power, Representation of Loads. ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering,L_2 – Understanding,L_3 – Applying,L_4 – Analysing.	
Module-2		
Symmetrical Fault Analysis: Introduction, Transient on a Transmission Line, Short Circuit of a Synchronous Machine(On No Load), Short Circuit of a Loaded Synchronous Machine, Selection of Circuit Breakers.■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
Module-3		
SymmetricalComponents: Introduction, SymmetricalComponentTransformation, Phase Shift in Star-Delta Transformers, Sequence Impedances of Transmission Lines, Sequence Impedances and Sequence NetworkofPower System, Sequence Impedances and Networks ofSynchronous Machine, Sequence Impedances of Transmission Lines, Sequence Impedances and Networksof Transformers, Construction of Sequence Networks ofa Power System, Measurement of sequence Impedance of Synchronous Generator. ■		**10**
Revised Bloom's Taxonomy Level	L_2 – Understanding,L_3 – Applying,L_4 – Analysing, L_5 – Evaluating.	
Module-4		
Unsymmetrical Fault Analysis: Introduction, Symmetrical Component Analysis ofUnsymmetricalFaults, Single Line-To-Ground (LG) Fault, Line-To-Line (LL) Fault, Double Line-To-Ground (LLG) Fault, Open Conductor Faults.■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER -VI

15EE62 POWER SYSTEM ANALYSIS – 1 (Core Subject)

Module-5		**Teaching Hours**
Power System Stability: Introduction, Dynamics of a Synchronous Machine, Power Angle Equation Salient and Non – Salient pole Synchronous Machines, Simple Systems, Steady State Stability, Transient Stability,Equal Area Criterion,Factors Affecting Transient Stability. ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

Course outcomes:

At the end of the course the student will be able to:

- Show understanding of per unit system, its advantages and computation.
- Show the concept of one line diagram and its implementation in problems
- Perform short circuit analysis on a synchronous machine and simple power system to select a circuit breaker for the system.
- Evaluate symmetrical components of voltages and currents in un-balanced three phase circuits.
- Explain the concept of sequence impedance and sequence networks of power system components and power system.
- Analyze three phase synchronous machine and simple power systems for different unsymmetrical faults using symmetrical components.
- Discuss the dynamics of synchronous machine, stability and types of stability.
- Discuss equal area criterion for the evaluation of stability of a simple systemunder different fault conditions. ■

Graduate Attributes (As per NBA)

Engineering Knowledge, Problem analysis, The Engineer and Society, Ethics

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook

1.	Modern Power System	D. P. Kothari	McGraw Hill	4th Edition,2011

ReferenceBooks

1	Elements of Power System	William D.StevensonJr	McGraw Hill	4th Edition, 1982
2	Power System Analysis and Design	J.Duncan Glover et al	Cengage	4th Edition, 2008
3	Power System Analysis	Hadi Sadat	McGraw Hill	1st Edition, 2002

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER -VI

DIGITAL SIGNAL PROCESSING (Core Subject)

Subject Code	15EE63	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

Credits - 04

Course objectives:

- To define Discrete Fourier transform and its properties.
- To evaluate DFT of various signals using properties of DFT.
- To explain different linear filtering techniques.
- To explain the evaluation of DFT and inverse DFT using fast and efficient algorithms
- To discuss impulse invariant transformation, bilinear transformation techniques and their properties.
- To design infinite impulse response Butterworth digital filters using impulse invariant and bilinear transformation techniques.
- To design infinite impulse response Chebyshev digital filters using impulse invariant and bilinear transformation techniques.
- To discuss direct, cascade, parallel and ladder methods of realizing a digital IIR filter.
- To discuss window functions used for the design of FIR filters.
- To discuss windowing technique of designing FIR filter.
- To discuss frequency sampling technique of designing FIR filter.
- To discuss direct, cascade and linear phase form of realizing a digital FIR filter.■

Module-1		**Teaching Hours**
Discrete Fourier Transforms: Definitions, properties-linearity, shift, symmetry Properties- circular convolution – periodic convolution, use of tabular arrays,circular arrays, Stock ham's method, linear convolution – two finite duration sequence, one finite & one infinite duration, overlap add and save methods.■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering,L_2 – Understanding,L_3 – Applying,L_4 – Analysing. L_5 – Evaluating	
Module-2		
Fast Fourier Transforms Algorithms: Introduction, decimation in time algorithm, first decomposition, number of computations, continuation of decomposition, number of multiplications, computational efficiency, decimation in frequency algorithms, Inverse radix – 2 algorithms.■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing. L_5– Evaluating	
Module-3		
Design of IIR Digital Filters: Introduction, impulse invariant transformation, bilinear transformations, All pole analog filters- Butterworth &Chebyshev filters, design of digital Butterworth filter by impulse invariant transformation and bilinear transformation, Frequency transformations. ■		**10**
Revised Bloom's Taxonomy Level	L1- Remembering, L2 – Understanding, L3 – Applying. L4 – Analysing. L5 – Evaluating	
Module-4		
Design of IIR Digital Filters (Continued): Design of digital Chebyshev –type 1filter by impulse invariant transformation and bilinear transformation, Frequency transformations. **Realization of IIR digital systems:** direct form, cascade form and parallel form, Ladder structures for equal degree polynomial.■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing, L_5– Evaluating	

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER -VI

15EE63 DIGITAL SIGNAL PROCESSING (Core Subject)

Module-5		**Teaching Hours**
Design of FIR Digital Filters: Introduction, windowing, rectangular, modified rectangular. Hamming, Hanning, Blackman window, design of FIR digital filters by use of windows, Design of FIR digital filters-frequency sampling techniques. **Realization of FIR systems:** direct form, cascade form, linear phase form■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing, L_5– Evaluating	

Course outcomes:

At the end of the course the student will be able to:

- Compute the DFT of various signals using its properties and linear filtering of two sequences.
- Apply fast and efficient algorithms for computing DFT and inverse DFT of a given sequence
- Design infinite impulse response Butterworth digital filters using impulse invariant / bilinear transformation technique.
- Design infinite impulse response Chebyshev digital filters using impulse invariant or bilinear transformation technique.
- Realize a digital IIR filter by direct, cascade, parallel and ladder methods of realization.
- Discuss different window functions and frequency sampling method used for design of FIR filters.
- Design FIR filters by use of window function or by frequency sampling method.
- Realize a digital FIR filter by direct, cascade, and linear phase form. ■

Graduate Attributes (As per NBA)

Engineering Knowledge, Problem analysis, Design/ Development of Solutions, Modern Tool Usage, Ethics,

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook

1	Introduction to Digital Signal Processing	Jhonny R. Jhonson	Pearson	1st Edition, 2016

Reference Books

1.	Digital Signal Processing – Principles, Algorithms, and Applications	Jhon G. Proakis Dimitris G. Manolakis	Pearson	4th Edition, 2007.
2.	Digital Signal Processing	A.NagoorKani	McGraw Hill	2nd Edition, 2012
3	Digital Signal Processing	Shaila D. Apte	Wiley	2nd Edition, 2009
4	Digital Signal Processing	Ashok Amberdar	Cengage	1stEdition, 2007
5	Digital Signal Processing	Tarun Kumar Rawat	Oxford	1st Edition, 2015

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER -VI

ELECTRICAL MACHINE DESIGN(Core Course)

Subject Code	15EE64	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

Credits - 04

Course objectives:

- To discuss design factors, limitations in design and modern trends in design and manufacturing of electrical machines.
- To discuss the properties of electrical, magnetic and insulating materials used in the design of electrical machines.
- To derive the output equation of DC machine, single phase, three phase transformers, induction motor and synchronous machines.
- To discuss the selection of specific loadings, for various machines.
- To discuss separation of main dimensions for different electrical machines
- To discuss design of field windings for DC machines and synchronous machines.
- To evaluate the performance parameters of transformer, induction motor.
- To design of cooling tubes for the transformer for a given temperature rise.
- To explain design of rotor of squirrel cage rotor and slip ring rotor.
- To define short circuit ratio and discuss its effect on machine performance.■

Module-1	**Teaching Hours**
Fundamental Aspects of Electrical Machine Design: Design of Machines, Design Factors, Limitations in design, Modern Trends in design, manufacturing Techniques. **Electrical EngineeringMaterials:** Desirabilities of Conducting Materials, Comparison of Aluminium and Copper wires. Ferromagnetic Materials: Soft Magnetic materials – Solid Core Materials, Electrical Sheet and Strip, Cold Rolled Grain Oriented Steel. Insulating Materials: Desirable Properties, Temperature Rise and Insulating Materials, Classification of Insulating materials based on Thermal Consideration.■	**10**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding, L_4 – Analysing.	
Module-2	
Design of DC Machines: Output Equation, Choice of Specific Loadings and Choice of Number of Poles, Main Dimensions of armature, Design of Armature Slot Dimensions, Commutator and Brushes. Estimation of Ampere Turns for the Magnetic Circuit. Dimensions of Yoke, Main Pole and Air Gap. Design of Shunt and Series Field Windings.■	**10**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
Module-3	
Design of Transformers: Output Equationsof Single Phase and Three Phase Transformers, Choice of Specific Loadings, Expression for Volts/Turn, Determination of Main Dimensions of the Core, Estimation of Number of Turns and Conductor Cross Sectional area of Primary and Secondary Windings, No Load Current. Expression for the Leakage Reactance of core type transformer with concentric coils, and calculation of Voltage Regulation. Design of Tank and Cooling (Round and Rectangular) Tubes.■	**10**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
Module-4	
Design of Three Phase Induction Motors: Output Equation, Choice of Specific Loadings, Main Dimensions of Stator. Design of stator slots and Winding, Choice of Length Air Gap, Estimation of Number of Slots for Squirrel Cage Rotor. Design of Rotor Bars and End Ring. Design of Slip Ring rotor. Estimation of No Load Current and Leakage Reactance.■	**10**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER -VI

15EE64 ELECTRICAL MACHINE DESIGN (Core Course)

Module-5

Design of Three PhaseSynchronous Machines: Output Equation, Choice of Specific Loadings, Short Circuit Ratio, Main Dimensions of Stator. Design of stator slots and Winding. Design of Salient and non- salient Pole Rotors. Magnetic Circuit and Field Winding.■	**10**
Revised Bloom's Taxonomy Level L_3 – Applying, L_4 – Analysing. L_2 – Understanding, L_4 – Analysing.	

Course outcomes: At the end of the course the student will be able to:

- Discuss design factors, limitations, modern trends in design, manufacturing of electrical machines and properties of materials used in the electrical machines.
- Derive the output equations of transformer, DC machines and AC machines.
- Discuss selection of specific loadings and magnetic circuits of different electrical machines
- Design the field windings of DC machine and Synchronous machine.
- Design stator and rotor circuits of a DC and AC machines.
- Estimate the number of cooling tubes, no load current and leakage reactance of core type transformer.
- Discuss short circuit ratio and its effects on performance of synchronous machines.
- Design salient pole and non-salient pole alternators for given specifications. ■

Graduate Attributes (As per NBA)

Engineering Knowledge, Problem Analysis, Design/ Development of Solutions, Ethics

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Question paper pattern:

- The question paper will have ten full questions carrying equal marks.Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook

1	A course in Electrical Machine design	A.K.Sawhney	DhanpatRai	6th Edition, 2013

Reference Books

1	Performance and Design of Alternating Current Machines	M.G.Say	CBS Publisher	3rd Edition, 2002
2	Design Data Handbook	A. Sanmugasundaram Et al	New Age International	1st Edition, 2011

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - VI

COMPUTER AIDED ELECTRICAL DRAWING (Professional Elective)

Subject Code	15EE651	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80

Credits - 03

Course objectives:

- To discuss the terminology of DC and AC armature windings.
- To discuss design and procedure to draw armature winding diagrams for DC and AC machines.
- To discuss the substation equipment, their location in a substation and development of a layout for substation.
- To discuss different sectional views of transformers, DC machine, its parts and alternator and its parts.
- To explain development of sectional views of Transformers, DC machine and alternators using the design data, sketches.■

Suitable CAD software can be used for drawings

PART - A

Module-1	**Teaching Hours**
Winding Diagrams: (a) Developed Winding Diagrams of D.C. Machines: Simplex Double Layer Lap and Wave Windings. (b) Developed Winding Diagrams of A.C. Machines: (c)Integral and Fractional Slot Double Layer Three Phase Lap and Wave Windings. (d) Single Layer Windings – Un-Bifurcated 2 and 3 Tier Windings, Mush Windings, Bifurcated 3 Tier Windings. ■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying.	
Module-2	
Single Line Diagrams: Single Line Diagrams of Generating Stations and Substations Covering Incoming Circuits, Outgoing Circuits, Busbar Arrangements (Single, Sectionalised Single, Main and Transfer, Double Bus Double Breaker, Sectionalised Double Bus, One and a Half Circuit Breaker Arrangement, Ring Main),Power Transformers, Circuit Breakers, Isolators,Earthing Switches,Instrument Transformers, Surge or Lightning Arresters, Communication Devices (Power-Line Carrier) and Line Trap.■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

PART - B

Module-3	
Electrical Machine Assembly Drawings Using Design Data, Sketches or Both: Transformers - Sectional Views Of Single And Three Phase Core And Shell Type Transformers. ■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
Module-4	
Electrical Machine Assembly Drawings Using Design Data, Sketches or Both: D.C. Machine - Sectional Views of Yoke with Poles, Armature and Commutator dealt separately.■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
Module-5	
Electrical Machine Assembly Drawings Using Design Data, Sketches or Both: Alternator – Sectional Views of Stator and Rotor dealt separately. ■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - VI

15EE651 COMPUTER AIDED ELECTRICAL DRAWING (Professional Elective)

Course Outcomes: At the end of the course the student will be able to:

- Discuss the terminology and types of DC and AC armature windings.
- Develop armature winding diagram for DC and AC machines
- Develop a layout for substation using the standard symbols for substation equipment..
- Draw sectional views of core and shell types transformersusing the design data
- Draw sectional views of assembled DC machine or its parts using the design data or the sketches.
- Draw sectional views of assembled alternator or its parts using the design data or the sketches. ■

Graduate Attributes (As per NBA)

Engineering Knowledge,Problem Analysis,Modern tool usage,Ethics.

Question paper pattern:

- The question paper will have two parts, PART – Aand PART – B.
- Each part is for 40 marks.
- Part A is for Modules 1 and 2.
- Questions 1 and 2 of PART - A will be only on DC windings or only on AC windings. Students have to answer any one of them. The marks prescribed is 25.
- Question 3 of PART – A covering module 2 is compulsory. The marks prescribed is 15.
- Part B is for Modules 3, 4 and 5.
- Questions 4 and 5 will cover any two modules of modules 3, 4 and 5. Students have to answer any one of them. The marks prescribed is 40.■

Reference Books

1	A course in Electrical Machine design	A.K.Sawhney	DhanpatRai	6th Edition, 2013
2	Electrical Engineering Drawing	K. L. Narang	SatyaPrakashan	2014

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER -VI

ADVANCED POWER ELECTRONICS (Professional Elective)

Subject Code	15EE652	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80

Credits - 03

Course objectives:

- To study switching mode regulators and Boost converters, Resonant Pulse Inverters and multilevel inverters
- To learn the techniques for design and analysis of dc –dc converters, Resonant Pulse Inverters and multilevel inverters
- To explain the operation and frequency characteristics of resonant inverters and thetechniques for zero-voltageand zero-current switching
- To study the performance parameters of resonant inverters
- To explain the techniques for analyzing and design of resonant inverters
- To explain the operation and features of multilevel inverters, their advantages and disadvantages.
- To explain the control strategy to address capacitor voltage unbalancing.
- To discuss potential applications of multilevel inverters.
- To study the types and circuit topologies of power supplies and explain the operation and analysis of power supplies.
- To study the applications of power electronic devices.■

Module-1		**Teaching Hours**
DC–DC Converters: Switching-Mode Regulators, Comparison of Regulators, Multi-output Boost Converter, Diode Rectifier-Fed Boost Converter, Averaging Models of Converters, State–Space Analysis of Regulators, Design Considerations for Input Filter and Converters, Drive IC for Converters.■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_4 – Analysing.	
Module-2		
Resonant Pulse Inverters: Introduction. Series Resonant Inverters, Frequency Response of Series Inverters, Parallel Resonant Inverters, Voltage Controlled Resonant Inverters, Class E Resonant Inverter, Class E Resonant Rectifier, Zero – Current Switching (ZCS) Resonant Converters, Zero Voltage Switching Resonant Converters (ZVS), Comparison between ZCS and ZVS Resonant Converters, Two Quadrant ZVS Resonant Converters, Resonant DC – Link Inverters.■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_4 – Analysing.	
Module-3		
Multilevel Inverters: Introduction, Multilevel Concept, Types of Multilevel Inverters, Diode – Clamped Multilevel Inverter, Flying - Capacitors Multilevel Inverter. Cascaded Multilevel Inverter, Applications, Features of Multilevel Inverters, Comparison of Multilevel Converters.■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_4 – Analysing.	
Module-4		
Power Supplies: Introduction, DC Power Supplies, AC Power Supplies, Multistage Conversions, Control Circuits, Magnetic Design Considerations.■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding. L_4 – Analysing	

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER -VI

15EE652 ADVANCED POWER ELECTRONICS (Professional Elective)

Module-5	**Teaching Hours**
Residential and Industrial Applications: Introduction, Residential Applications, Industrial Applications. **Electrical Utility Applications:**Introduction, High Voltage DC Transmission, Static VAR Compensators, Interconnection of Renewable Energy Sources and Energy Storage systems to the Utility Grid, Active Filters.■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding. L_4 – Analysing	

Course outcomes:

At the end of the course the student will be able to:

- Explain the types of switching – mode regulators, Resonant Pulse Inverters and multilevel inverters
- To discuss the techniques for design and analysis of dc –dc converters, Resonant Pulse Inverters and multilevel inverters
- Evaluate the performance parameters of resonant inverters
- Explain the techniques for zero-voltage and zero-current switching of resonant pulse inverters
- Explain the control strategy to address capacitor voltage unbalancing in multilevel inverters.
- Discuss the types, topologies operation and analysis of power supplies.
- Discuss residential, Industrial and Electrical utility applications of power electronic devices. ■■

Graduate Attributes (As per NBA)

Engineering Knowledge, Problem Analysis Design/ Development of Solutions , Conductinvestigations of complex problems, Ethics

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.■

Textbook

1	Power Electronics: Circuits Devices and Applications,	Mohammad H Rashid	Pearson	4th Edition, 2014
2	Power Electronics Converters, Applications and Design (ForModule 5: Chapters 16 and 17)	Ned Mohan et al	Wiley	3rd Edition, 2014

Reference Books

1	Power Electronics	Daniel W Hart	McGraw Hill	1st Edition, 2011

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER -VI

ENERGY AUDIT AND DEMAND SIDE MANAGEMENT (Professional Elective)

Subject Code	15EE653	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80

Credits - 03

Course objectives:

- To explain the importance of energy audit, its types and energy audit methodology.
- To explain the parameters required for energy audit and the working of the instruments used in the measurement of the parameters.
- To explain the energy audit of different systems and equipment and buildings
- To explain electrical load management techniques, harmonics and their effects, electricity tariffs and power factor improvement.
- To explain the scope of demand side management, its concept and implementation issues and strategies.
- To discuss energy conservation ■

Module-1	**Teaching Hours**
Energy Scenarios: Energy Conservation, Energy Audit, Energy Scenarios, Energy Consumption, Energy Security, Energy Strategy, Clean Development Mechanism. **Types of Energy Audits and Energy-Audit Methodology:** Definition of Energy Audit, Place of Audit, Energy – Audit Methodology, Financial Analysis, Sensitivity Analysis, Project Financing Options, Energy Monitoring and Training. **Survey Instrumentation:** Electrical Measurement, Thermal Measurement, Light Measurement, Speed Measurement, Data Logger and Data – Acquisition System, Thermal Basis.■	**08**
Revised Bloom's Taxonomy Level L_1 - Remembering, L_2 - Understanding, L_3 - Applying, L_4 - Analysing.	
Module-2	
Energy Audit of Boilers: Classification of Boilers, Parts of Boiler, Efficiency of a Boiler, Role of excess Air in Boiler Efficiency, Energy Saving Methods. **Energy Audit of Furnaces:** Parts of a Furnace, classification of Furnaces, Energy saving Measures in Furnaces, Furnace Efficiency.■	**08**
Revised Bloom's Taxonomy Level L_1 - Remembering, L_2 - Understanding, L_3 - Applying, L_4 - Analysing,	
Module-3	
Energy Audit of HVAC Systems: Introduction to HVAC, Components of Air – Conditioning System, Types of Air – Conditioning Systems, Human Comfort Zone and Psychrometry, Vapour – Compression Refrigeration Cycle, Energy Use Indices, Impact of Refrigerants on Environment and Global Warming, Energy – Saving Measures in HVAC, Star Rating and Labelling by BEE. **Electrical-Load Management:** Electrical Basics, Electrical Load Management, Variable- Frequency Drives, Harmonics and its Effects, Electricity Tariff, Power Factor, Transmission and Distribution Losses.■	**08**
Revised Bloom's Taxonomy Level L_1 - Remembering, L_2 - Understanding, L_3 - Applying, L_4 - Analysing	
Module-4	
Energy Audit of Motors: Classification of Motors, Parameters related to Motors, Efficiency of a Motor, Energy Conservation in Motors, BEE Star Rating and Labelling. **Energy Audit of Lighting Systems:** Fundamentals of Lighting, Different Lighting Systems, Ballasts, Fixtures (Luminaries), Reflectors, Lenses and Louvres, Lighting Control Systems, Lighting System Audit, Energy Saving Opportunities. ■	**08**
Revised Bloom's Taxonomy Level L_1 - Remembering, L_2 - Understanding, L_3 - Applying, L_4 - Analysing	

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER -VI

15EE653 ENERGY AUDIT AND DEMAND SIDE MANAGEMENT (Professional Elective)(continued)

Module-5	**Teaching Hours**
Energy Audit Applied to Buildings: Energy – Saving Measures in New Buildings, Water Audit, Method of Audit, General Energy – Savings Tips Applicable to New as well as Existing Buildings. **Demand side Management:** Scope of DSM, Evolution of DSM concept, DSM planning and Implementation, Load management as a DSM strategy, Applications of Load Control, End use energy conservation, Tariff options for DSM, customer acceptance, implementation issues, Implementation strategies, DSM and Environment. **Energy Conservation:** Motivation of energy conservation, Principles of Energy conservation, Energy conservation planning, Energy conservation in industries, EC in SSI, EC in electrical generation, transmission and distribution, EC in household and commercial sectors, EC in transport, EC in agriculture, EC legislation.■	**08**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 - Applying, L_4 - Analysing

Course outcomes:

At the end of the course the student will be able to:

- Understand the need of energy audit and energy audit methodology.
- Explain audit parameters and working principles of measuring instruments used to measure the parameters.
- Conduct energy audit of boilers, furnaces, power plant, steam distribution system and compressed air systems.
- Conduct energy audit HVAC systems, motors, pumps, blowers and cooling towers.
- Explain load management techniques, effects of harmonics, electricity tariff, improvement of power factor and losses in transmission.
- Conduct energy audit of lighting systems and buildings.
- Show an understanding of demand side management and energy conservation. ■

Graduate Attributes (As per NBA)

Engineering Knowledge, Problem Analysis, Conduct investigations of complex Problems, Environment and sustainability, Ethics, Individual and Team work, Communication

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook

1	Handbook on Energy Audit	Sonal Desai	McGraw Hill	1st Edition, 2015
2.	Generation of Electrical Energy	B R Gupta	S. Chand	1stEdition, 1983

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER – V

SOLAR & WIND ENERGY(Professional Elective)

Subject Code	15EE551	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80

Credits – 03

Course objectives:

- To discuss the importance of energy in human life, relationship among economy and environment with energyuse
- Todiscusstheincreasingroleofrenewableenergy,energymanagement,energyaudit,energyefficiency, energyintensity
- To discuss energy consumption status in India, energy saving potential and energy conservationefforts inIndia.
- To explain the concept of energy storage and the principles of energy storagedevices.
- Todiscussthecharacteristicsanddistributionofsolarradiation,measurementofcomponentsofsolar radiation and analysis of collected solar radiationdata.
- To explain availability of solar radiation at a location and the effect of tilting the surface ofcollector with respect to horizontal surface.
- To describe the process of harnessing solar energy in the form of heat and working of solarcollectors.
- To discuss applications of solar energy including heating and cooling.
- To discuss the operation of solar cell and the environmental effects on electrical characteristics ofsolar cell
- To discuss sizing and design of typical solar PV systems and their applications.
- To discuss basic Principles of Wind Energy Conversion and to compute the power available in thewind.
- To discuss forces on the Blades, Wind Energy Conversion, collection of Wind Data, energy estimation and site selection.
- To discuss classification of WEC Systems, its advantages and disadvantages of WECS, and Typesof Wind Machines (Wind Energy Collectors).
- To evaluate the performance of Wind-machines, Generating Systems.
- To discuss energy storage, applications of Wind Energy and Environmental Aspects■

Module-1		**Teaching Hours**
Fundamentals of Energy Science and Technology: Introduction, Energy, Economy and Social Development, Classification of Energy Sources, Importance of Non-conventional Energy Sources, Salient features of Non-conventional Energy Sources, World Energy Status, Energy Status in India. **Energy Conservation and Efficiency:** Introduction, Important Terms and Definitions, Important Aspects of Energy Conservation, Global Efforts, Achievements and Future Planning, Energy Conservation/Efficiency Scenario in India, Energy Audit, Energy Conservation Opportunities. **Energy Storage:** Introduction, Necessity of Energy Storage, Specifications of Energy Storage Devices. **Solar Energy-Basic Concepts:** Introduction, The Sun as Source of Energy, The Earth, Sun, Earth Radiation Spectrum, Extraterrestrial and Terrestrial Radiations, Spectral Power Distribution of Solar Radiation, Depletion of Solar Radiation.■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying.	
Module-2		
Solar Energy-Basic Concepts (continued): Measurement of Solar Radiation, Solar Radiation Data, Solar Time, Solar Radiation Geometry, Solar Day Length, Extraterrestrial Radiation on Horizontal Surface, Empirical Equations for Estimating Terrestrial Solar Radiation on Horizontal Surface, Solar Radiation on Inclined Plane Surface. **Solar Thermal Systems:** Introduction, Solar Collectors, Solar Water Heater, Solar Passive Space Heating and Cooling Systems, Solar Industrial Heating Systems, Solar Refrigeration and Air Conditioning Systems, Solar Cookers.■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analyzing.	

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER – V

15EE551 SOLAR & WIND ENERGY(Professional Elective) (continued)

Module-3		**Teaching Hours**
Solar Photovoltaic Systems: Introduction, Solar Cell Fundamentals, Solar Cell Characteristics, Solar Cell Classification, Solar Cell Technologies, Solar Cell, Module, and Array Construction, Maximizing the Solar PV Output and Load Matching. Maximum Power Point Tracker.Balance of System Components, Solar PV Systems, SolarPV Applications.■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
Module-4		
Wind Energy: Introduction, Basic Principles of Wind Energy Conversion, History of Wind Energy, Wind Energy Scenario – World and India. The Nature of the Wind, The Power in the Wind, Forces on the Blades, Wind Energy Conversion, Wind Data and Energy Estimation, Site Selection Considerations **Wind energy systems:** Environment and Economics Environmental benefits and problems of wind energy, Economics of wind energy, Factors influence the cost of energy generation, machine parameters, Life cycle cost analysis.■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
Module-5		
Basic Components of a Wind Energy Conversion(WEC) System: Classification ofWEC systems, Advantages and Disadvantages ofWECS, Types of Wind Machines (Wind EnergyCollectors), Analysis of Aerodynamic Forces Acting onthe Blade, Performance of Wind-machines, Generating Systems, Energy Storage, Applications of Wind Energy, Environmental Aspects.■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying.	

Course outcomes:
At the end of the course the student will be able to:

- Discusstheimportanceofenergyinhumanlife,relationshipamongeconomyandenvironmentwith energy use and the increasing role of renewableenergy.
- Explain the concept of energy storage and the principles of energy storagedevices.
- To discuss solarradiation on horizontal and tilted surface, its characteristics, measurement and analysis of radiationdata.
- Describe the process of harnessing solar energy and its applications in heating andcooling.
- Discuss fabrication, operation of solar cell, electrical characteristics, sizing and design of solar PV systems and their applications.
- Explain basic Principles of Wind Energy Conversion, collection of wind data, energy estimation and site selection.
- Discuss the performance of Wind-machines, energy storage, applications of Wind Energyand environmentalaspects. ■

Graduate Attributes (As per NBA)

Engineering Knowledge, Design/ Development of Solutions, The Engineer and Society, Environment and Sustainability, Ethics, Project Management and Finance.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under amodule.
- Students will have to answer 5 full questions, selecting one full question from eachmodule. ■

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE) CHOICE BASED CREDIT SYSTEM (CBCS) SEMESTER – V				
15EE551 SOLAR & WIND ENERGY(Professional Elective) (continued)				
Textbook				
1	Non-Conventional Energy Resources	B. H. Khan	McGraw Hill	2nd Edition 2017
2	Non-Conventional Sources of Energy	Rai, G. D	Khanna Publishers	4th Edition, 2009
Reference Books				
1	Non-Conventional Energy Resources	ShobhNath Singh	Pearson	1st Edition, 2015
2	Solar Energy – Principles of Thermal Collections and Storage	S.P. SukhatmeJ.K.Nayak	McGraw Hill	3rd Edition, 2008
3	Wind Turbine Technology	Ahmad Hemami	Cengage	1st Edition, 2012

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER -VI

ARTIFICIAL NEURAL NETWORKS & FUZZY LOGIC(Open Elective)

Subject Code	15EE661	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80

Credits - 03

Course objectives:

- To expose the students to the concepts of feed forward neural networks.
- To provide adequate knowledge about feedback networks.
- To teach about the concept of fuzziness involved in various systems.
- To provide adequate knowledge about fuzzy set theory. ■

Module-1	**Teaching Hours**
Fundamentals of Neural Networks: Basic concepts of Neural networks, Human Brain, Model of an Artificial Neuron, Neural network architectures, Characteristics of Neural Networks, Learning methods, Taxonomy of Neural Network Architectures, Early Neural Network Architectures. **Backpropagation Networks**: Architecture of a Back propagation network, the Perceptron Model, The solution, Single layer Artificial Neural Network, Model for Multilayer Perceptron, Backpropagation Learning, Illustration, Applications.■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying.	
Module-2	
Backpropagation Networks (continued): Effect of Tuning Parameters of the Backpropagation Neural Network, Selection of Various Parameters in BPN, Variations of Standard Backpropagation Algorithm. **Associative Memory:** Autocorrelators, Heterocorrelators: Kosko's Discrete BAM, Wang et al.'s Multiple Training Encoding Strategy, Exponential BAM, Associative Memory for Real-coded Pattern Pairs, Applications, Recent Trends. ■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying.	
Module-3	
Adaptive Resonance Theory: Introduction, ART l, ART 2, Applications, Sensitivities of Ordering of Data.■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying.	
Module-4	
Fuzzy Set Theory: Fuzzy versus Crisp, Crisp sets, Fuzzy Sets, Crisp Relations, FuzzyRelations. ■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding. L_3 – Applying.	
Module-5	
Fuzzy Logic And Inference: Crisp Logic, Predicate Logic, Fuzzy Logic, Fuzzy Rule based System, Defuzzification Methods, Applications. **Type – 2 Fuzzy Sets**: Representation of Type – 2 Fuzzy Sets, Operations on Type – 2 Fuzzy Sets, Interval Type – 2 Fuzzy Sets.■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding. L_3 – Applying.	

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER – VI

15EE661 ARTIFICIAL NEURAL NETWORKS & FUZZY LOGIC(Open Elective)

Course outcomes:

At the end of the course the student will be able to:

- Show an understanding of Organization of the Brain, Biological and Artificial Neuron Models
- Show an understanding of Backpropagation network architecture, Perceptron Model, Single layer Artificial Neural Network, Model for Multilayer Perceptron, Backpropagation Learning,
- Show an understanding of Backpropagation training and summary of Backpropagation Algorithm
- Show an understanding Bidirectional Associative Memory (BAM) Architecture
- Show an understanding adaptive resonance theory architecture and its applications
- Differentiate between crisp logic, predicate logic and fuzzy logic.
- Explain fuzzy rule based system
- Show an understanding of Defuzzification methods. ■

Graduate Attributes (As per NBA)

Engineering Knowledge

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook

1	Neural Networks, Fuzzy Systems and Evolutionary Algorithms: Synthesis and Applications.	S. Rajasekaran, G.A. VijayalakshmiPai	PHI Learning	2nd Edition, 2017

Reference Books

1	Neural Networks – A comprehensive foundation	Simon Haykin	Prentice Hall	3rd Edition, 2004.
2	Fuzzy Logic With Engineering Applications	Timothy J Ross	Wiley	3rd Edition, 2014
3.	Fuzzy sets and Fuzzy Logic: Theory and Applications	Klir, G.J. Yuan Bo	Prentice Hall	2005.
4.	Introduction to Neural Networks using MATLAB 6.0	S.N.Sivanandam, S. Sumathi, S.N. Deepa	Tata McGrow Hills Education India	2005

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER – VI

SENSORS AND TRANSDUCERS(Open Elective)

Subject Code	15EE662	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80

Credits – 03

Course objectives:

- To discuss need of transducers, their classification, advantages and disadvantages.
- To discuss working of different types of transducers and sensors.
- To discuss recent trends in sensor technology and their selection.
- To discuss basics of signal conditioning and signal conditioning equipment.
- To discuss configuration of Data Acquisition System and data conversion.
- To discuss the basics of Data transmission and telemetry.
- To explain measurement of various non-electrical quantities.■

Module-1	**Teaching Hours**
Sensors and Transducers: Introduction, Classification of Transducers**,** Advantages and Disadvantages of Electrical Transducers, Transducers Actuating Mechanisms, Resistance Transducers, Variable Inductance Transducers, Capacitive Transducers, Piezoelectric Transducers, Hall Effect Transducers, Thermoelectric Transducers, Photoelectric Transducers.■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding.	
Module-2	
Sensors and Transducers (continued): Stain Gages, Load Cells, Proximity Sensors, Pneumatic Sensors, Light Sensors, Tactile Sensors, Fiber Optic Transducers, Digital Transducers, Recent Trends – Smart Pressure Transmitters, Selection of Sensors, Rotary – Variable Differential Transformer, Synchros and Resolvers, Induction Potentiometers, Micro Electromechanical Systems.■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding.	
Module-3	
Signal Condition: Introduction, Functions of Signal Conditioning Equipment, Amplification, Types of Amplifiers, Mechanical Amplifiers Fluid Amplifiers, Optical Amplifiers, Electrical and electronic Amplifiers. **Data Acquisition Systems and Conversion:**Introduction, Objectives and Configuration of Data Acquisition System, Data Acquisition Systems, Data Conversion.■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding.	
Module-4	
Data Transmission and Telemetry: Data/Signal Transmission, Telemetry. **Measurement of Non – Electrical Quantities:**Pressure Measurement■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding.	
Module-5	
Measurement of Non – Electrical Quantities (continued): Temperature Measurement, Flow Measurement – Introduction, Electromagnetic Flow meters, Ultrasonic Flow Meters, Thermal Metes, Wire Anemometers. Measurement of Displacement, Measurement of Velocity/ Speed, Measurement of Acceleration, Measurement of Force, Measurement of Torque, Measurement of Shaft Power, Measurement of Liquid Level, Measurement of Viscosity.■	
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding.	

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER – VI

15EE662 SENSORS AND TRANSDUCERS(Open Elective) (continued)

Course outcomes:

At the end of the course the student will be able to:

- Discuss need of transducers, their classification, advantages and disadvantages.
- Show an understanding of working of various transducers and sensors.
- Discuss recent trends in sensor technology and their selection.
- Discuss basics of signal conditioning and signal conditioning equipment.
- Discuss configuration of Data Acquisition System and data conversion.
- Show knowledge of data transmission and telemetry.
- Explain measurement of non-electrical quantities -temperature, flow, speed, force, torque, power and viscosity.■

Graduate Attributes (As per NBA)

Engineering Knowledge

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.■

Textbook

1	Electrical and Electronic Measurements and instrumentation	R.K Rajput	S. Chand	3rd Edition, 2013.

Reference Books

1	A Course in Electronics and Electrical Measurements and Instruments	J.B. Gupta	Katson Books	13th Edition, 2008
2	A Course in Electrical and Electronic Measurements and Instrumentation	A. K. Sawheny	DhanpatRai	2015

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - VI

BATTERIES AND FUEL CELLS FOR COMMERCIAL, MILITARY AND SPACE APPLICATIONS
(Open Elective)

Subject Code	15EE663	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80

Credits - 03

Course objectives:

- To discuss the current status of various rechargeable batteries and fuel cells for various applications.
- To discuss the performance capabilities and limitations of batteries and fuel cells.
- To discuss the performance requirements for next-generation high-power rechargeable lithium-based batteries and sealed nickel-cadmium and lead-acid batteries.
- To discuss fuel cells that are best suited for applications where electrical power requirements vary between several kilowatts (kW) to a few megawatts (MW)
- To describe the high-power batteries currently used by EVs and HEVs and various next-generation rechargeable batteries best suited for all-electric cars, EVs, and HEVs.
- To discuss low-power battery configurations that are best suited for compact commercial, industrial, and medical applications.
- To identify the design aspects and performance characteristics of micro- and nano-batteries best suited for detection, sensing, and monitoring devices.■

Module-1	**Teaching Hours**
Current Status of Rechargeable Batteries and Fuel Cells: Rechargeable Batteries, Fundamental Aspects of a Rechargeable Battery, Rechargeable Batteries Irrespective of Power Capability, Rechargeable Batteries for Commercial and Military Applications, Batteries for Low-Power Applications, Fuel Cells. ■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying.	
Module-2	
Batteries for Aerospace and Communications Satellites: Introduction, On-board Electrical Power System, Battery Power Requirements and Associated Critical Components, Cost-Effective Design Criterion for Battery-Type Power Systems for Spacecraft, Spacecraft Power System Reliability, Ideal Batteries for Aerospace and Communications Satellites, Performance Capabilities and Battery Power Requirements for the Latest Commercial and Military Satellite Systems, Military Satellites for Communications, Surveillance, Reconnaissance, and Target Tracking, Batteries Best Suited to Power Satellite Communications Satellites.■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
Module-3	
Fuel Cell Technology: Introduction, Performance Capabilities of Fuel Cells Based on Electrolytes, Low-Temperature Fuel Cells Using Various Electrolytes, Fuel Cells Using a Combination of Fuels, Fuel Cell Designs for Multiple Applications, Ion-Exchange Membrane Fuel Cells, Potential Applications of Fuel Cells, Fuel Cells for Aircraft Applications, Fuel Cells for Commercial, Military, and Space Applications, Fuel Cells Capable of Operating in Ultra-High-Temperature Environments, Fuel Cell Requirements for Electric Power Plant Applications.■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
Module-4	
Batteries for Electric and Hybrid Vehicles: Introduction, Chronological Development History of Early Electric Vehicles and Their Performance Parameters, Electric and Hybrid Electric Vehicles	**08**

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - VI

15EE663 BATTERIES & FUEL CELLS FOR COMMERCIAL, MILITARY & SPACE APPLICATIONS(Open Elective) (continued)

Module-4	**Teaching Hours**
Batteries for Electric and Hybrid Vehicles (continued): Developed Earlier by Various Companies and Their Performance Specifications, Development History of the Latest Electric and Hybrid Electric Vehicle Types and Their Performance Capabilities and Limitations, Performance Requirements of Various Rechargeable Batteries, Materials for Rechargeable Batteries, Critical Role of Rare Earth Materials in the Development of EVs and HEVs.■	
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding.	

Module-5	
Low-Power Rechargeable Batteries for Commercial, Space, and Medical Applications: Introduction, Low-Power Battery Configurations, Characteristics, Batteries for Miniaturized Electronic System Applications, for Embedded-System Applications, Batteries for Medical Applications, Selection Criteria for Primary and Secondary (Rechargeable) Batteries for Specific Applications. ■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding.	

Course outcomes:

At the end of the course the student will be able to:

- Discuss the current status, the performance capabilities and limitations ofrechargeable batteries and fuel cellsfor various applications.
- To discuss the performance requirements for next-generation high-power rechargeable lithium-based batteries and sealed nickel-cadmium and lead-acid batteries.
- Discuss fuel cells that are best suited for applications where electrical power requirements vary between several kilowatts (kW) to a few megawatts (MW)
- Describe the high-power batteries currently used by EVs and HEVs and various next-generation rechargeable batteries best suited for all-electric cars, EVs, and HEVs.
- Discuss low-power battery configurations that are best suited for compact commercial, industrial, and medical applications.
- Explain the design aspects and performance characteristics of micro- and nano-batteries best suited for detection, sensing, and monitoring devices.■

Graduate Attributes (As per NBA)

Engineering Knowledge

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.■

Textbook

1	Next-Generation Batteries and Fuel Cells for Commercial, Military, and Space Applications	A.R. JHA	CRC Press	1st Edition, 2012

Reference Books

1	Electrochemical Power Sources: Batteries, Fuel Cells, and Supercapacitors.	Vladimir S. Bagotsky	John Wiley	1st Edition,2015
2	Modelling and Control of Fuel Cells: Distributed Generation Applications	M. HashemNehrir Caisheng Wang	Wiley	1st Edition,2009

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - VI

INDUSTRIAL SERVO CONTROL SYSTEMS (Professional Elective)

Subject Code	15EE664	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80

Credits - 03

Course objectives:

- To explain the evolution and classification of servos, with descriptions of servo drive actuators, amplifiers, feedback transducers, performance, and troubleshooting techniques.
- To discuss system analogs and vectors, with a review of differential equations.
- To discuss the concept of transfer functions for the representation of differential equations.
- To discuss mathematical equations for electric servo motors, both DC and brushless DC servo motors.
- To represent servo drive components by their transfer function, to combine the servo drive building blocks into system block diagrams.
- To determine the frequency response techniques for proper servo compensation.
- To explain perform indices and performance criteria for servo systems.
- To discuss the mechanical considerations of servo systems.■

Module-1	**Teaching Hours**
Servos: Introduction, Benefits of Servo Systems, Types of Servos - Evolution of Servo Drives,Classification of Drives, Components of Servos - Hydraulic/Electric Circuit Equations,Actuators—Electric,Actuators—Hydraulic,Amplifiers—Electric,Amplifiers—Hydraulic,Transducers (Feedback).■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying.	
Module-2	
Machine Servo Drives: Types of Drives,Feed Drive Performance. **Troubleshooting Techniques:** Techniques by Drive,Problems: Their Causes and Cures. **Machine Feed Drives:**Advances in Technology, Parameters for making Application Choices. **Application ofIndustrial Servo Drives:** Introduction,Physical System Analogs, Quantities and Vectors,Differential Equations for PhysicalSystems,Electric Servo Motor TransferFunctions and Time Constants, Transport Lag Transfer Function,Hydraulic Servo Motor Characteristics,General Transfer Characteristics.■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
Module-3	
Generalized Control Theory: Servo Block Diagrams,Frequency-Response Characteristics and Construction of Approximate (Bode) Frequency Charts,Nichols Charts, Servo Analysis Techniques,Servo Compensation. **Indexes of Performance:** Definition of Indexes of Performance for Servo Drives,Indexes of Performance for Electric and Hydraulic Drives.■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
Module-4	
Performance Criteria: Percent Regulation,Servo System Responses. **Servo Plant CompensationTechniques:** Dead-Zone Nonlinearity,Change-in-Gain Nonlinearity,Structural Resonances,Frequency Selective Feedback,Feedforward Control. **Machine Considerations:**Machine feed drive Considerations,Ball Screw Mechanical Resonances andReflected Inertias for Machine Drives.■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding.	

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - VI

15EE664 INDUSTRIAL SERVO CONTROL SYSTEMS (Open Elective) (continued)

Module-5		**Teaching Hours**
Machine Considerations: Drive Stiffness, Drive Resolution,Drive Acceleration,Drive Speed Considerations,Drive Ratio Considerations,Drive Thrust/Torque And FrictionConsiderations, Drive Duty Cycles.■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	

Course outcomes:

At the end of the course the student will be able to:

- Explain the evolution and classification of servos, with descriptions of servo drive actuators, amplifiers, feedback transducers, performance, and troubleshooting techniques.
- Discuss systemanalogs and vectors, with a review of differential equations.
- Discuss the concept of transfer functions for the representation of differential equations.
- Discuss mathematical equations for electric servo motors, both DC and brushless DC servo motors.
- Represent servo drive components by their transfer function, to combine the servo drive building blocks into systemblock diagrams.
- Determine the frequency response techniques for proper servo compensation.
- Explain perform indices and performance criteria for servo systems.
- Discuss the mechanical considerations of servo systems.■

Graduate Attributes (As per NBA)

Engineering Knowledge

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.■

Text Book

1	Industrial Servo Control SystemsFundamentals andApplications	George W. Younkin	Marcel Dekker	1st Edition, 2003

Reference Books

1	Servo Motors and Industrial Control Theory	RiazollahFiroozian	Springer	2nd Edition, 2014
2	DC SERVOS Application and Design with MATLAB	Stephen M. Tobin	CRC	1st Edition, 2011

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER -VI

CONTROL SYSTEM LABORATORY

Subject Code	15EEL67	IA Marks	20
Number ofPracticalHours/Week	03	Exam Hours	03
Total Number of PracticalHours	42	Exam Marks	80

Credits - 02

Course objectives:

- To determine the time and frequency domain reposes of a given second order systemusing software package or discrete components.
- To design and analyze Lead, Lag and Lag – Lead compensators for given specifications.
- To draw the performance characteristics of ac and dc servomotors and synchro-transmitter receiver pair.
- To simulate the DC position and feedback control systemto study the effect of P, PI, PD and PID controller and Lead compensator on the step response of the system.
- To write a script files to plot root locus, Bode plot, Nyquist plots to study the stability of the system using a software package.■

Sl. NO	Experiments
1	Experiment to draw the speed torque characteristics of (i) AC servo motor (ii) DC servo motor
2	Experiment to draw synchro pair characteristics
3	Experiment to determine frequency response of a second order system
4	(a)To design a passive RC lead compensating network for the given specifications, viz, the maximum phase lead and the frequency at which it occurs and to obtain the frequency response. (b) To determine experimentally the transfer function of the lead compensating network.
5	(a)To design a passive RC lag compensating network for the given specifications, viz, the maximum phase lag and the frequency at which it occurs and to obtain the frequency response. (b) To determine experimentally the transfer function of the lag compensating network
6	Experiment to draw the frequency response characteristics of the lag – lead compensator network and determination of its transfer function.
	Experiments 7 to 11 must be done using MATLAB/SCILAB only.
7	(a) To simulate a typical second order system and determine step response and evaluate time response specifications. (b) To evaluate the effect of additional poles and zeros on time response of second order system. (c) To evaluate the effect of pole location on stability (d) To evaluate the effect of loop gain of a negative feedback systemon stability.
8	To simulate a second order system and study the effect of (a) P, (b) PI, (c) PD and (d) PID controller on the step response.
9	(a) To simulate a D.C. Position control systemand obtain its step response. (b) To verify the effect of input waveform, loop gain and systemtype on steady state errors. (c) To perform trade-off study for lead compensator. (d) To design PI controller and study its effect on steady state error.
10	(a) To examine the relationship between open-loop frequency response and stability, open-loop frequency and closed loop transient response (b) To study the effect of open loop gain on transient response of closed loop systemusing root locus.
11	(a) To study the effect of open loop poles and zeros on root locus contour (b) To estimate the effect of open loop gain on the transient response of closed loop systemusing root locus. (c) Comparative study of Bode, Nyquist and root locus with respect to stability.

Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding. L_3 – Applying, L_4 – Analysing, L_5 – Evaluating.

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER -VI

15EEL67 CONTROL SYSTEM LABORATORY

Course outcomes: At the end of the course the student will be able to:

- Use software package or discrete components in assessing the time and frequency domain reposes of a given second order system.
- Design and analyze Lead, Lag and Lag – Lead compensators for given specifications.
- Determine the performance characteristics of ac and dc servomotors and synchro-transmitter receiver pair used in control systems.
- Simulate the DC position and feedback control system to study the effect of P, PI, PD and PID controller and Lead compensator on the step response of the system.
- Write a script files to plot root locus, Bode plot, Nyquist plots to study the stability of the system using a software package.
- Work with a small team to carryout experiments and prepare reports that present lab work. ■

Graduate Attributes (As per NBA)

Engineering Knowledge,Problem Analysis, Individual and Team work, Modern tool usage, Communication.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero. ■

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - VI

DIGITAL SIGNAL PROCESSING LABORATORY

Subject Code	15EEL68	IA Marks	20
Number of Practical Hours/Week	03	Exam Hours	03
Total Number of Practical Hours	42	Exam Marks	80

Credits - 02

Course objectives:

- To explain the use of MATLAB software in evaluating the DFT and IDFT of given sequence
- To verify the convolution property of the DFT
- To design and implementation of IIR and FIR filters for given frequency specifications.
- To realize IIR and FIR filters.
- To help the students in developing software skills.■

Sl. No	Experiments
1	Verification of Sampling Theorem both in time and frequency domains
2	Evaluation of impulse response of a system
3	To perform linear convolution of given sequences
4	To perform circular convolution of given sequences using (a) the convolution summation formula (b) the matrix method and (c) Linear convolution from circular convolution with zero padding.
5	Computation of N – point DFT and to plot the magnitude and phase spectrum.
6	Linear and circular convolution by DFT and IDFT method.
7	Solution of a given difference equation.
8	Calculation of DFT and IDFT by FFT
9	Design and implementation of IIR filters to meet given specification (Low pass, high pass, band pass and band reject filters)
10	Design and implementation of FIR filters to meet given specification (Low pass, high pass, band pass and band reject filters) using different window functions
11	Design and implementation of FIR filters to meet given specification (Low pass, high pass, band pass and band reject filters) using frequency sampling technique.
12	Realization of IIR and FIR filters

Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding. L_3 – Applying, L_4 – Analysing, L_5 – Evaluating,

Course outcomes: At the end of the course the student will be able to:

- Give physical interpretation of sampling theorem in time and frequency domains.
- Evaluate the impulse response of a system.
- Perform convolution of given sequences to evaluate the response of a system.
- Compute DFT and IDFT of a given sequence using the basic definition and/or fast methods.
- Provide a solution for a given difference equation.
- Design and implement IIR and FIR filters
- Conduct experiments using software and prepare reports that present lab work■

Graduate Attributes (As per NBA)

Engineering Knowledge, Problem Analysis, Individual and Team work, Communication.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

****** END ******