DR. A.P.J. ABDUL KALAM TECHNICAL UNIVERSITY UTTAR PRADESH, LUCKNOW

EVALUATION SCHEME & SYLLABUS

FOR

B. TECH. 3rd YEAR (EE)

ELECTRICAL ENGINEERING

BASED ON

AICTE MODEL CURRICULUM

[Effective from the Session: 2020-21]

EVALUATION SCHEME - B.TECH 3rd YEAR (ELECTRICAL ENGINEERING)

SEMESTER V

Sl. No.	Subject Codes	Subject	Periods			Evaluation Scheme				End Semester		Total	Credit
			L	T	P	CT	TA	Total	PS	TE	PE		
1	KEE501	Power System - I	3	1	0	30	20	50		100		150	4
2	KEE502	Control System	3	1	0	30	20	50		100		150	4
3	KEE503	Electrical Machines-II	3	1	0	30	20	50		100		150	4
4	KEE051-KEE054	Departmental Elective-I	3	0	0	30	20	50		100		150	3
5	KEE055-KEE058	Departmental Elective-II	3	0	0	30	20	50		100		150	3
6	KEE551	Power System-I Lab	0	0	2				25		25	50	1
7	KEE552	Control System Lab	0	0	2				25		25	50	1
8	KEE553	Electrical Machines - II Lab	0	0	2				25		25	50	1
9	KEE554	Mini Project or Internship Assessment*	0	0	2				50			50	1
10	KNC501/ KNC502	Constitution of India, Law and Engineering / Indian Tradition, Culture and Society	2	0	0	15	10	25		50			
11		MOOCs (Essential for Hons. Degree)											
		Total	**17**	**3**	**8**							**950**	**22**

**The Mini Project or internship (4 weeks) conducted during summer break after IV semester and will be assessed during V semester.*

DEPARTMENT ELECTIVE - I

KEE051 Robotics
KEE052 Sensors and Transducers
KEE053 Industrial Automation and Control
KEE054 Electrical Standards and Engineering Practices

DEPARTMENT ELECTIVE - II

KEE055 Optimization Techniques
KEE056 Neural Networks & Fuzzy System
KEE057 Digital Signal Processing
KEE058 Analog & Digital Communication

SEMESTER VI

Sl. No.	Subject Codes	Subject	Periods			Evaluation Scheme				End Semester		Total	Credit
			L	T	P	CT	TA	Total	PS	TE	PE		
1	KEE601	Power System-II	3	1	0	30	20	50		100		150	4
2	KEE602	Microprocessor and Microcontroller	3	1	0	30	20	50		100		150	4
3	KEE603	Power Electronics	3	1	0	30	20	50		100		150	4
4	KEE06*	Departmental Elective-III	3	0	0	30	20	50		100		150	3
5	KOE06*	Open Elective-I	3	0	0	30	20	50		100		150	3
6	KEE651	Power System-II Lab	0	0	2				25		25	50	1
7	KEE652	Microprocessor and Microcontroller Lab	0	0	2				25		25	50	1
8	KEE653	Power Electronics Lab	0	0	2				25		25	50	1
10	KNC601/ KNC602	Constitution of India, Law and Engineering / Indian Tradition, Culture and Society	2	0	0	15	10	25		50			
11		MOOCs (Essential for Hons. Degree)											
		Total	**17**	**3**	**6**							**900**	**21**

<u>DEPARTMENT ELECTIVE - III</u>

KEE 061 Special Electrical Machines
KEE 062 Electrical Machine Design
KEE 063 Digital Control System
KEE 064 Electrical and Hybrid Vehicles

B.Tech 3rd Year

V Semester

Syllabus

POWER SYSTEM-I

Pre-requisites of the course: Basic Electrical Engineering, Networks Analysis and Synthesis, Electromagnetic Field Theory.

Course Outcome		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO1	Describe the working principle and basic components of conventional power plants as well as the other aspects of power generation.	**K2**
CO2	Recognize elements of power system and their functions, as well as compare the different types of supply systems. Illustrate different types of conductors, transmission lines and various performance parameters of transmission line for short, medium and long transmission line.	**K4**
CO3	Calculate sag and tension in overhead lines with and without wind and ice loading. Classify different type of insulators, determine potential distribution over a string of insulator, string efficiency and its improvement.	**K4**
CO4	Compute the inductance and capacitance of single phase, three phase lines with symmetrical and unsymmetrical spacing, Composite conductors-transposition, bundled conductors, and understand the effect of earth on capacitance of transmission lines.	**K4**
CO5	Elucidate different types of cables and assess the Resistance and capacitance parameters of cables, grading of cables and compare overhead lines and cables.	**K4**

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)
K1 – Remember K2 – Understand K3 – Apply K4 – Analyze K5 – Evaluate K6 – Create

Detailed Syllabus:

UNIT-I (Power Generation):
Introduction: Basic structure of power system, sources of electric energy: conventional and non-conventional; Layout of Hydro-electric, Thermal and Nuclear power plants, Concept of cogeneration, combined heat and power, and captive power plants.
Load curve, load duration curve, Concept of Connected Load, Maximum Demand, Average load, Demand Factor, Load factor, Diversity Factor, Capacity Factor, Utilization factor, Plant use factor, Installed capacity, Reserves, role of load diversity in power system economy. Load Sharing between Base load and Peak Load

UNIT-II (Transmission & Distribution of Electric Power- I):
Single line diagram of Power system, choice of transmission voltage, Different kinds of supply system and their comparison.
Configurations of transmission lines: Types of conductors, Bundled Conductors, resistance of line, skin effect, Kelvin's law, Proximity effect,
Corona Effect, factors affecting the Corona, Corona Power Loss, Advantages and Disadvantages.
Performance of Lines: Representation of lines, short transmission lines, medium length lines, nominal T and л-representations, long transmission lines. The equivalent circuit representation of a long Line, A, B, C, D constants, Ferranti Effect.

UNIT-III (Transmission & Distribution of Electric Power- II):
Mechanical Design of Over Headlines: Catenary curve, calculation of sag & tension, effects of wind and ice loading, sag template, vibration dampers
Overhead line Insulators: Type of insulators and their applications, potential distribution over a string of insulators, methods of equalizing the potential, string efficiency

UNIT-IV (Transmission Line Parameters):
Inductance and Capacitance Calculations of Transmission Lines: Line conductors, inductance and capacitance of single phase and three phase lines with symmetrical and unsymmetrical spacing, Composite conductors-transposition, bundled conductors, and effect of earth on capacitance.

UNIT-V (Insulated Cables):
Insulated Cables: Introduction, insulation, insulating materials, Extra high voltage cables, grading of cables, insulation resistance of a cable, Capacitance of a single core and three core cables, Overhead lines versus underground cables, types of cables

Textbooks:

1. Kothari & Nagrath, “Power System Engineering”, McGraw-Hill Education
2. B.R. Gupta, “Generation of Electrical Energy”, S. Chand Publication.
3. Chakrabarti A., Soni M.L., Gupta P.V., and Bhatnagar U.S., 'A textbook on Power Systems Engg.', Dhanpat Rai and Sons, New Delhi.
4. JB Gupta, ‘A Course in Power Systems’, S.K. Kataria and Sons.
5. C.L. Wadhwa, “Electrical Power System”, New Age International Ltd. Third Edition.
6. Arun Ingole, "Power Transmission and Distribution", Pearson Education, 2018
7. A. J. Wood & B.F. Wollenburg, “Power Generation, Operation and Control “John Wiley & Sons.

Reference Books:

1. Wadhwa, C.L., ‘Generation Distribution and Utilization of Electrical Energy', New Age International publishers.
2. Deshpande M.V, `Elements of Electrical Power systems Design’, Pitman, New Delhi, PHI Learning Private Limited,
3. S.N. Singh, “Electric Power Generation, Transmission & Distribution”, PHI Learning.

CONTROL SYSTEM

Pre-requisites of course: Basic signal systems

Course Outcome		Knowledge Level, KL
Upon the completion of the course, the student will be able to:		
CO 1	Obtain transfer functions to predict the correct operation of open loop and closed loop control systems and identify the basic elements, structures and the characteristics of feedback control systems.	**K3**
CO 2	Measure and evaluate the performance of basic control systems in time domain. Design specification for different control action.	**K4**
CO 3	Analyze the stability of linear time-invariant systems in time domain using Routh-Hurwitz criterion and root locus technique.	**K4**
CO 4	Determine the stability of linear time-invariant systems in frequency domain using Nyquist criterion and Bode plot.	**K4**
CO 5	Design different type of compensators to achieve the desired performance of control System by root locus and Bode plot method. Develop and analyze the intermediate states of the system using state space analysis.	**K5**

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)
K1 – Remember K2 – Understand K3 – Apply K4 – Analyze K5 – Evaluate K6 – Create

Detailed Syllabus:

Unit-I:
Control System Concepts: Elements of control systems, concept of open loop and closed loop systems, Examples and application of open loop and closed loop systems, Mathematical Modelling of Physical Systems (Electro Mechanical), Determination of transfer function by block diagram reduction techniques and signal flow method using Mason's gain formula, Basic Characteristics of negative feedback control systems.
Control System Components: Constructional and working concept of AC & DC servomotor, synchro's, stepper motor and tachometer.

Unit-II:
Time Response Analysis: Standard test signals, time response analysis of first and second order systems, time response specifications of second order system for unit step input, location of roots of characteristics equation and corresponding time response, steady state errors and error constants.
Basic modes of feedback control: Proportional, Derivative, Integral and PID controllers.

Unit-III:
Stability and Algebraic Criteria: Concept of stability and its necessary conditions, Routh-Hurwitz criteria and its limitations.
Root Locus Technique: Salient features of root locus plot, Procedure for plotting root locus, root contours.

Unit-IV:

Frequency Response Analysis: Frequency Response analysis from transfer function model, Construction of polar and inverse polar plots.

Stability in Frequency Domain: Nyquist stability criterion, Determination of gain and phase margin from Bode & Nyquist Plots, Correlation between time and Frequency Responses.

Unit-V

Introduction to Design: The design problems and preliminary considerations of lead, lag and lead-lag compensation networks, design of closed loop systems using compensation techniques in time and frequency domains.

State Space Technique: The concept of state & space, State-space model of physical system, conversion of state-space to transfer function model and vice-versa, State transition matrix, Concept of controllability and observability and their testing.

Text Book:

1. I. J. Nagrath & M. Gopal, "Control System Engineering", 6th Ed. New Age International Publishers, 4th Edition 2018
2. M. Gopla, "Control System Principles and Design", McGraw Hill 4th Edition
3. Ogata, "Modern Control Engineering, 5th Edition", Pearson Education, 2015
4. B.C. Kuo & Farid Golnaraghi, "Automatic Control Systems", 10th Edition, McGraw Hill
5. D. Roy Choudhary, "Modern Control Engineering", Prentice Hall of India.
6. Salivahanan, "Control Systems Engineering", Pearson Education, 2015
7. Ambikapathy, "Control Systems", Khanna Publishers

Reference Books:

1. (Schaums Outlines Series) Joseph J. Distefano III, Allen R. Stubberud, Ivan J. Williams, "Control Systems", 3rd Edition, McGraw Hill, Special Indian Edition, 2010.
2. Norman S. Mise, Control System Engineering, Wiley Publishing Co.
3. Ajit K Mandal, "Introduction to Control Engineering" New Age International.
4. R.T. Stefani, B.Shahian, C.J.Savant and G.H. Hostetter, "Design of Feedback Control Systems" Oxford University Press.
5. Samarjit Ghosh, "Control Systems theory and Applications", Pearson Education.

ELECTRICAL MACHINE-II

Pre-requisites of course: Basic Electrical Engineering, Electrical Machine-I

Course Outcome		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO 1	Demonstrate the constructional details and principle of operation of three phase Induction and Synchronous Machines.	**K3**
CO 2	Analyze the performance of the three phase Induction and Synchronous Machines using the phasor diagrams and equivalent circuits.	**K4**
CO 3	Select appropriate three phase AC machine for any application and appraise its significance.	**K4**
CO 4	Start and observe the various characteristics of three phase Induction & Synchronous Machines	**K4**
CO 5	Explain the principle of operation and performance of Single-Phase Induction Motor & Universal Motor.	**K3**

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)
K1 – Remember K2 – Understand K3 – Apply K4 – Analyze K5 – Evaluate K6 – Create

Detailed Syllabus:

Unit- I: **Synchronous Machine-I**
Constructional features, Armature winding, EMF Equation, Winding coefficients, Equivalent circuit and phasor diagram, Armature reaction, O. C. & S. C. tests, Voltage regulation using Synchronous Impedance method, MMF method, Potier's Triangle method, Voltage and frequency control (Governer system) of alternators , Parallel operation of synchronous generators, Operation on infinite bus, Synchronizing power and torque co-efficient.

UNIT – II: Synchronous Machine II
Two reaction theory, Transient and sub-transient reactance, Power flow equations of cylindrical and salient pole machines, Operating characteristics. Synchronous Motor - Starting methods, Effect of varying field current at different loads, V- curves, Hunting & damping, Synchronous condenser.

UNIT – III: Three phase Induction Machine - I
Constructional features, Rotating magnetic field, Principle of operation, Phasor diagram, Equivalent circuit, Torque and power equations, Torque- slip characteristics, No load & blocked rotor tests, Efficiency.

UNIT – IV: Three phase Induction Machine- II
Starting, Deep bar and double cage rotors, Cogging & Crawling, Speed control (with and without emf injection in rotor circuit).

UNIT – V: Single phase Induction Motor
Double revolving field theory, Equivalent circuit, No load and blocked rotor tests, Starting methods, Repulsion motor, Universal motor.

Text Books:

1. I J Nagrath & D.P. Kothari, "Electrical Machines", McGraw Hill
2. Rajendra Prasad , "Electrical Machines", PHI
3. PS Bimbhra, "Electrical Machinery", Khanna Publisher
4. AE Fitggerald, C. Kingsley Jr and Umans, "Electric Machinery", McGraw Hill, International Student Edition.

Reference Books:

1. H. Cotton, "Electrical Technology", CBS Publication.
2. MG Say, "The Performance and Design of AC machines", Pit man& Sons.
3. PS Bimbhra, "Generalized Theory.
4. Samarjit Ghosh, " Electrical Machines", Pearson Education

POWER SYSTEM LABORATORY - I

Pre-requisites of course: Basic understanding of Scilab/MATLAB/C/C++

Course Outcomes:		Knowledge Level, KL
Upon the completion of the course, the student will be able to:		
CO1	Use programming tools /Software: Scilab, MATLAB or any C, C++ - Compiler and formulate a program/simulation model for calculation of various parameters related to transmission line.	**K6**

Note: Minimum ten experiments are to be performed from the following list, on a software platform preferably on Scilab, MATLAB, or any C, C++ - Compiler

1. Calculate the parameters of single-phase transmission line
2. Calculate the parameters of three phase single circuit transmission line
3. Calculate the parameters of three phase double circuit transmission line
4. Determine the ABCD constant for transmission line.
5. Simulate the Ferranti effect in transmission line
6. Calculate the corona loss of transmission line
7. Calculation of sag & tension of transmission line
8. Calculation of string efficiency of insulator of transmission line
9. Calculation for grading of underground cables
10. Simulate the skin effect in the transmission line
11. Calculation of ground clearance of transmission line
12. Calculate the parameters for underground cable.

Spoken Tutorial (MOOCs):

Spoken Tutorial MOOCs, ' Course on Scilab', IIT Bombay (http://spoken-tutorial.org/)

CONTROL SYSTEM LABORATORY

Pre-requisites of course: Basic understanding of Scilab/MATLAB or any equivalent open source software

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO 1	Determine the characteristics of control system components like ac servo motor, synchro, potentiometer, servo voltage stabilizer and use them in error detector mode.	**K4**
CO2	Compare the performance of control systems by applying different controllers / compensators.	**K5**
CO3	Analyze the behavior of dc motor in open loop and closed loop conditions at various loads & determine the response of 1^{st}& 2^{nd} order systems for various values of constant K.	**K5**
CO4	Apply different stability methods of time & frequency domain in control systems using software & examine their stability.	**K4**
CO5	Convert the transfer function into state space & vice versa & obtain the time domain response of a second order system for step input and their performance parameters using software.	**K5**

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1 – Remember K2 – Understand K_3 – Apply K_4 – Analyze K_5 – Evaluate K_6 – Create

Note: Minimum 10 experiments are to be performed from the following list:

1. To determine speed-torque characteristics of an AC servomotor.
2. To study
   i) Synchro Transmitter characteristics.
   ii) Obtain Synchro Transmitter – Receiver output vs input characteristics.
3. To determine response of first order and second order systems for step input for various values of constant 'K' using linear simulator unit and compare theoretical and practical results.
4. To study characteristics of positional error detector by angular displacement of two servo potentiometers.
5. To simulate and compare the response of 2^{nd} order system with and without lead, lag, Lead- Lag compensator / simulate PID controller for transportation lag.
6. To study P, PI and PID temperature controller for an oven and compare their characteristics.
7. To study performance of servo voltage stabilizer at various loads using load bank.
8. To study behavior of separately excited dc motor in open loop and closed loop conditions at various loads.

Software based experiments (Scilab/MATLAB or any equivalent open source software**)**

9. To determine time domain response of a second order system for step input and obtain performance parameters.
10. To convert transfer function of a system into state space form and vice-versa.
11. To plot root locus diagram of an open loop transfer function and determine range of gain 'k' for stability.
12. To plot a Bode diagram of an open loop transfer function.
13. To draw a Nyquist plot of an open loop transfers functions and examine the stability of the closed loop system.

Spoken Tutorial (MOOCs):

Spoken Tutorial MOOCs, ' Course on Scilab', IIT Bombay (http://spoken-tutorial.org/)

Reference Books:

1. K.Ogata,"Modern Control Engineering" Prentice Hall of India.
2. Norman S.Nise, "Control System Engineering", John Wiley & Sons.
3. M.Gopal, "Control Systems: Principles & Design" Tata McGraw Hill.

ELECTRICAL MACHINE-II LABORATORY

Pre-requisites of course: Basic Electrical engineering Lab, Electrical Machine-I Lab.

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO 1	Perform various tests and demonstrate the various characteristics of three phase induction motor.	**K4**
CO2	Demonstrate the working of three phase synchronous machine under different operating conditions.	**K4**
CO3	Evaluate the performance of single-phase induction motor under different operating conditions.	**K5**
CO4	Develop simulation models for Electrical Machines.	**K6**

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)
K_1 – Remember K2 – Understand K_3 – Apply K_4 – Analyze K_5 – Evaluate K_6 – Create

Note: Minimum 10 experiments are to be performed from the following list:

1. To perform no load and blocked rotor tests on a three phase squirrel cage induction motor and determine equivalent circuit.
2. To perform load test on a three phase induction motor and draw Torque -speed characteristics
3. To perform no load and blocked rotor tests on a single phase induction motor and determine equivalent circuit.
4. To study speed control of three phase induction motor by varying supply voltage and by keeping V/f ratio constant.
5. To perform open circuit and short circuit tests on a three phase alternator.
6. To determine V-curves and inverted V-curves of a three phase synchronous motor.
7. To determine the direct axis reactance (Xd) and quadrature axis reactance (Xq) of synchronous machine.
8. To study synchronization of an alternator with the infinite bus by using: (i) dark lamp method (ii) two bright and one dark lamp method.
9. To determine speed-torque characteristics of three phase slip ring induction motor and study the effect of including resistance, or capacitance in the rotor circuit.
10. To determine speed-torque characteristics of single phase induction motor and study the effect of voltage variation.
11. To determine speed-torque characteristics of a three phase induction motor by (i) keeping v/f ratio constant (ii) increasing frequency at the rated voltage.
12. To draw O.C. and S.C. characteristics of a three phase alternator from the experimental data and determine voltage regulation at full load, and unity, 0.8 lagging and leading power factors.
13. To determine steady state performance of a three phase induction motor using equivalent circuit.
14. Load Test on Three Phase Alternator.

***The available experiments from above list may be performed on virtual lab on following virtual lab link:**http://vlab.co.in/

B.Tech 3rd Year
VI Semester
Syllabus

POWER SYSTEMS-II

Pre-requisites of course: Basic Electrical Engineering, Networks Analysis and Synthesis, Electromagnetic Field Theory, Power System-I, Electrical Machines-II

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO1	Identify power system components on one line diagram of power system and its representation including the behaviour of the constituent components and sub systems and Analyse a network under both balanced and unbalanced fault conditions and design the rating of circuit breakers.	**K4**
CO2	Perform load flow analysis of an electrical power network and interpret the results of the analysis.	**K4**
CO3	Describe the concept of travelling waves in transmission lines and use the travelling wave theory to determine the over voltage caused by surge propagation in transmission networks.	**K4**
CO4	Assess the steady state and transient stability of the power system under various conditions.	**K4**
CO5	Describe Operating Principle of a relay and classify them according to applications. Explain working principle of Circuit breaker and phenomenon of arc production and quenching.	**K3**

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)
K1 – Remember K2 – Understand K3 – Apply K4 – Analyze K5 – Evaluate K6 – Create

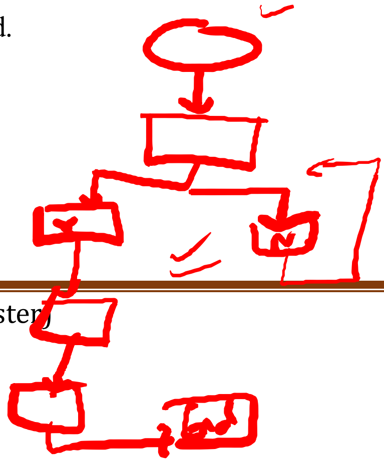
Detailed Syllabus:

UNIT-I (Fault Analysis in Power System):
One-line diagram, Impedance and reactance diagram, per unit system changing the base of per unit quantities, advantages of per unit system.

Symmetrical Components: Significance of positive, negative and zero sequence components, Average 3-phase power in terms of symmetrical components, sequence impedances and sequence networks.

Fault Calculations: Fault calculations, sequence network equations, single line to ground fault, line to line fault, double line to ground fault, three phase faults, faults on power systems, and faults with fault impedance, reactors and their location, short circuit capacity of a bus

UNIT-II (Load Flow Analysis):
Introduction, Formation of Z_{BUS} and Y_{BUS}, development of load flow equations, load flow solution using Gauss Siedel and Newton-Raphson method, Comparison of Gauss Siedel and Newton Raphson Method, approximation to N-R method, fast decoupled method.



UNIT-III (Travelling Waves in Power System):
Travelling Waves on Transmission Lines: Production of travelling waves, open circuited line, short circuited line, line terminated through a resistance, line connected to a cable, reflection and refraction at T-junction line terminated through a capacitance, capacitor connection at a T-junction, Attenuation of travelling waves, Bewley's Lattice diagram.

UNIT-IV (Stability in Power System):
Power flow through a transmission line, Stability and Stability limit, Steady state stability study, derivation of Swing equation, transient stability studies by equal area criterion. Factors affecting steady state and transient stability and methods of improvement.

UNIT-V (Introduction to Power System Protection):
Relays: Operating Principle of a general relay,
Basic Terminology: Relay, Energizing Quantity, setting, Pickup, drop out, Flag, fault clearing time, Relay time, Breaker time, Overreach, Underreach; Classification of Relays according to applications, according to time. Over current Relay, Distance Protection, Differential Protection.
Circuit Breakers: Arc Phenomenon, Arc Extinction and its Methods, Restriking Voltage & Recovery Voltage, Circuit Breaker Rating.

Text Books:

1. D.P. Kothari & I.J. Nagrath, "Modern Power System Analysis" McGraw Hill, 3rd Edition.
2. P.S.R. Murthy, "Operation and control in Power Systems" B.S. Publications.
3. W. D. Stevenson, "Elements of Power System Analysis", McGraw Hill
4. J. Wood & B.F. Wollenburg, "Power Generation, Operation and Control" John Wiley & Sons.
5. S. S. Rao, "Switchgear and Protection", Khanna Publishers.
6. B. Ravindranath and M. Chander, Power system Protection and Switchgear, Wiley Eastern Ltd.
7. Arun Ingole, "Power Transmission and Distribution", Pearson Education, 2018
8. Jegatheesan & Vijaykumar, "Modern Power System Analysis with MATLAB Applications", Pearson Education, 2020

Reference Books:

1. O.I. Elgerd, "Electric Energy System Theory" McGraw Hill.
2. P. Kundur, "Power System Stability and Control McGraw Hill.
3. T. K. Nagsarkar & M.S. Sukhija,' Power System Analysis' Oxford University Press.
4. Hadi Sadat, "Power System Analysis", McGraw Hill.
5. B. Ram and D. N. Vishwakarma, "Power System Protection and Switchgear", McGraw Hill

MICROPROCESSOR AND MICROCONTROLLER

Pre-requisites of course: Digital Electronics, Computer Basics

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO 1	Demonstrate the basic architecture of 8085 & 8086 microprocessors	K2
CO2	Illustrate the programming model of microprocessors & write program using 8085 microprocessor	K3
CO3	Interface different external peripheral devices with 8085 microprocessor	K3
CO4	Comprehend the architecture of 8051 microcontroller	K2
CO5	Compare advance level microprocessor & microcontroller for different applications	K4

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1 – Remember K_2 – Understand K_3 – Apply K_4 – Analyze K_5 – Evaluate K_6 – Create

Detailed Syllabus:

Unit- I:

Introduction to Microprocessor: Microprocessor architecture and its operations, Memory, Input & output devices, The 8085 MPU- architecture, Pins and signals, Timing Diagrams, Logic devices for interfacing, Memory interfacing, Interfacing output displays, Interfacing input devices, Memory mapped I/O.

Basic Programming concepts:, Flow chart symbols, Data Transfer operations, Arithmetic operations, Logic Operations, Branch operation, Writing assembly language programs, Programming techniques: looping, counting and indexing. Additional data transfer and 16 bit arithmetic instruction, Logic operation: rotate, compare, counter and time delays, 8085 Interrupts.

Unit-II:

Intel 8086 microprocessor: Internal architecture (Bus Interface Unit, Execution unit, Pipelining, Register organization), Pin Diagram, Memory addressing, Physical memory organization, Interrupts (hardware & software interrupts)

Unit-III:

Peripheral Devices: 8237 DMA Controller, 8255 programmable peripheral interface, 8253/8254programmable timer/counter, 8259 programmable interrupt controller, 8251 USART and RS232C. Fundamental of Programming: Program structure & programming techniques for microprocessors, 8085 Addressing modes, 8085 Instruction set, Assembly language programming of 8085 microprocessor with examples (arithmetic operations on 8-bit numbers – add, subtract, multiply, divide, square & square root etc, largest/ smallest number; ascending/ descending order).

Unit-IV:

8051 Microcontroller Basics: Inside the Computer, Microcontrollers and Embedded Processors, Block Diagram of 8051, PSW and Flag Bits, 8051 Register Banks and Stack, Internal Memory Organization of 8051, IO Port Usage in 8051, Types of Special Function Registers and their uses in 8051, Pins Of 8051. Memory Address Decoding, 8031/51 Interfacing With External ROM And RAM. 8051 Addressing Modes.

Unit-V:

Assembly programming and instruction of 8051: Introduction to 8051 assembly programming, Assembling and running an 8051 program, Data types and Assembler directives, Arithmetic, logic instructions and programs, Jump, loop and call instructions, IO port programming. Programming 8051 Timers. Serial Port Programming, Interrupts Programming, Comparison of Microprocessor, Microcontroller, PIC and ARM processors and their application areas.

Text Books:

1. Ramesh Gaonkar, “Microprocessor Architecture, Programming, and Applications with the 8085”, 6th Edition, Penram International Publication (India) Pvt. Ltd.,2013
2. Mazidi Ali Muhammad, Mazidi Gillispie Janice, and McKinlay Rolin D., “The 8051 Microcontroller and Embedded Systems using Assembly and C”, Pearson, 2nd Edition,2006
3. Senthil Kumar Saravanan, Jeevanathan, Microprocessor and Microcontrollers, Oxford,2010
4. D. V. Hall : Microprocessors Interfacing, , McGraw 3rd Edition
5. Fundamental of Microprocessor and Microcontrollers, B. RAM, Dhanpat Rai Publication
6. Soumitta Kumar Mandal, Microprocessor and Microcontrollers Architecture Programming and Interfacing using 8085,8086 and 8051, McGraw Hill
7. K. Ayala , 8051 Microcontroller, Cengage learning

Reference Books:

1. Kenneth L. Short, “Microprocessors and programmed Logic”, 2nd Ed, Pearson Education Inc.,2003
2. Barry B. Brey, “The Intel Microprocessors, 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium, Pentium Pro Processor, PentiumII, PentiumIII, Pentium IV, Architecture, Programming & Interfacing”, Eighth Edition, Pearson Prentice Hall, 2009.
3. Shah Satish, “8051 Microcontrollers MCS 51 Family and its variants”, Oxford,2010

POWER ELECTRONICS

Pre-requisites of course: Basic Electrical Engineering, Network Analysis & Synthesis

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO 1	Demonstrate the characteristics as well as the operation of BJT, MOSFET, IGBT, SCR, TRIAC and GTO and identify their use in the power switching applications.	**K4**
CO2	Comprehend the non-isolated DC-DC converters and apply their use in different Power electronics applications.	**K3**
CO3	Analyze the phase controlled rectifiers and evaluate their performance parameters.	**K5**
CO4	Apprehend the working of single-phase ac voltage controllers, cyclo-converters and their various applications.	**K3**
CO5	Explain the single-phase and three phase bridge inverters differentiate between CSI and VSI and apply PWM for harmonic reduction.	**K4**

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1 – Remember K_2 – Understand K_3 – Apply K_4 – Analyze K_5 – Evaluate K_6 – Create

Detailed Syllabus:

Unit-I: Power semiconductor devices:

Introduction: Concept of Power Electronics, scope and applications, desired Characteristics of controllable switches

Power semiconductor switches and their characteristics: Power Diode, Power BJT, Power MOSFET, IGBT, SCR, TRIAC, GTO.

Unit-II:

Thyristor: Rating & protection, Methods of SCR commutation, Gate Drive Circuit, Series and Parallel operation.

DC-DC Converters: Introduction, Control Strategies, Buck converter, Boost Converter, Buck-Boost converter, Analysis of buck converter, Switched Mode power Supply (SMPS).

Unit-III: Phase Controlled Converters:

Single phase half wave controlled rectifier with various loads, Effect of freewheelingdiode, Single phase fully controlled and half controlled bridge converters with various loads. Performance Parameters of single phase uncontrolled and controlled converters, three phase half wave converters, Three phase fully controlled and half controlled bridge converters, Effect of source impedance, Single phase and three phase dual converters

Unit-IV: AC Voltage Controllers:

Principle of On-Off and phase controls, Single phase ac voltage controller with resistive and inductive loads, sequence control, Introduction to Matrix converter.

Cyclo Converters: Basic principle of operation, single phase to single phase, three phase to single phase output voltage equation.

Unit-V: Inverters:
Single phase and Three phase bridge inverters, voltage source inverters, current source inverters, Voltage control of single phase inverters, Pulse width modulation, Introduction to Multi level inverter.

Text Books:

1. M.H. Rashid,"Power Electronics: Circuits, Devices & Applications", Pearson Education.
2. Ned Mohan, T.M.Undeland and W.P.Robbins, "Power Electronics: Converters, Applications and Design", Wiley India Ltd,2008
3. P.C. Sen, "Power Electronics", McGraw Hill Education (India) Pvt. Ltd.
4. P.S. Bhimbra, "Power Electronics", Khanna Publishers.

Reference Books:

1. M.S. Jamil Asghar, "Power Electronics" Prentice Hall of India Ltd., 2004
2. Chakrabarti & Rai, "Fundamentals of Power Electronics & Drives"Dhanpat Rai & Sons.
3. V.R. Moorthy, "Power Electronics: Devices, Circuits and Industrial Applications" Oxford University Press,2007
4. S.N.Singh, "A Text Book of Power Electronics" Dhanpat Rai & Sons

POWER SYSTEM LAB-II

Pre-requisites of course: Power System-I Lab

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO1	Test various relays for different characteristics and compare with the performance characteristics provided by manufacturers.	**K4**
CO2	Select the power system data for load-flow and fault studies and to develop a program to solve power flow problem using NR and GS methods	**K6**
CO3	Analyze various types of short circuit faults	**K4**
CO4	Demonstrate different numerical integration methods and factors influencing transient stability	**K3**
CO5	Determine the effect of load in long transmission line	**K3**

Note: - Minimum 10 experiments are to be performed from the following list:

(A) Hardware Based Experiments:

1. To determine fault current for L-G, L-L, L-L-G and L-L-L faults at the terminals of an alternator at very low excitation.
2. To Study the over-current relay and the effect of PSM and TSM.
3. To study percentage differential relay.
4. To study Impedance, MHO and Reactance type distance relays and zones of protection.
5. To study Ferranti effect of a transmission line/cable.
6. To measure the dielectric Strength of transformer oil.
7. To study the Synchronization of alternator with infinite bus bar.
8. To determine positive sequence, negative sequence and zero sequence reactance of an alternator.
9. To Study the effect of different shape of electrodes on dielectric (air) breakdown.
10. To Study the gas actuated Buchholz relay for oil filled transformer.
11. To determine the sub-transient (xd″), transient (xd′) and steady state reactance (xd) of a synchronous machine.

*** The available Experiments from above list may be performed on virtual lab on following virtual lab link:** http://vlab.co.in/

(B) Simulation Based Experiments (using Scilab/MATLAB or any other equivalent open source software platform)

1. To obtain formation of Y-bus.
2. Perform load flow analysis on a 3- Bus System using G-S Method.
3. Perform load flow analysis on a 3- Bus System using N-R Method.
4. To perform symmetrical fault analysis in a power system.
5. To perform unsymmetrical fault analysis in a power system.
6. Swing Curve by Step-by-Step Method.
7. Determination of the stability of a SMIB system in occurrence of a fault by solving the Swing equation by Euler's Method.

Text Books: -

1. Haadi Sadat, "Power System Analysis" Tata McGraw Hill.
2. T.K. Nagsarskar & M.S. Sukhija, Power System Analysis' Oxford University Press.
3. K. Umarao, "Computer Techniques and Models in Power System", Wiley

MICROPROCESSOR AND MICROCONTROLLER LAB

Pre-requisites of course: Digital Electronics, Computer Basics

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO 1	Study of microprocessor system	K2
CO2	Development of flow chart for understanding the data flow	K3
CO3	Learning assembly language to program microprocessor based system	K3
CO4	Interfacing different peripheral devices with the microprocessor	K4
CO5	Building logic for microprocessor based system	K4

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)
K_1 – Remember K_2 – Understand K_3 – Apply K_4 – Analyze K_5 – Evaluate K_6 – Create

Note: Minimum ten experiments are to be performed from the following list (on 8085 / 8086 microprocessor)

1. To study 8085 / 8086 based microprocessor system
2. To perform mathematical operations (addition & subtraction) on two 8-bit numbers
3. To perform multiplication on two 8-bit numbers
4. To perform division on two 8-bit numbers
5. To develop and run a program for finding out the largest number from given two 8-bit numbers
6. To develop and run a program for finding out the smallest number from given two 8-bit numbers
7. To develop and run a program for arranging in ascending order of a given set of 8-bit numbers
8. To develop and run a program for arranging in descending order of a given set of 8-bit numbers
9. To perform conversion of temperature from degree F to degree C
10. To perform computation of square root of a given number
11. To obtain interfacing of 8255 – PPI with 8085 microprocessor
12. To perform microprocessor based traffic light control
13. To perform microprocessor based stepper motor operation through 8085 / 8086 kit
14. To obtain interfacing of DMA controller with 8085 / 8086 microprocessor

PART B SUGGESTIVE LIST OF EXPERIMENTS (Through Virtual Lab Link):

1. Write a program using 8085 Microprocessor for Decimal, Hexadecimal addition and subtraction of two Numbers. ***(Through Virtual Lab Link)***
2. Write a program using 8085 Microprocessor for addition and subtraction of two BCD numbers. ***(Through Virtual Lab Link)***
3. To perform multiplication and division of two 8 bit numbers using 8085. ***(Through Virtual Lab Link)***
4. To find the largest and smallest number in an array of data using 8085 instruction set.
5. To write a program using 8086 to arrange an array of data in ascending and descending order. ***(Through Virtual Lab Link)***
6. To convert given Hexadecimal number into its equivalent ASCII number and vice versa using 8086 instruction set.
7. To convert given Hexadecimal number into its equivalent BCD number and vice versa using 8086 instruction set.
8. To interface 8253 programmable interval timer and verify the operation of 8253 in six different modes.
9. To write a program to initiate 8251 and to check the transmission and reception of character.
10. Serial communication between two 8085 through RS-232 C port.
11. Write a program of Flashing LED connected to port 1 of the 8051 Micro Controller
12. Write a program to generate 10 kHz square wave using 8051.
13. Write a program to show the use of INT0 and INT1 of 8051.
14. Write a program for temperature & to display on intelligent LCD display.
15. Interfacing of Stepper motor to 8051.
16. Interfacing of ADC to 8051.

Virtual Lab Link: http://vlabs.iitb.ac.in/vlabs-dev/labs_local/microprocessor/labs/explist.php

Available on: http://www.vlab.co.in/broad-area-electronics-and-communications

POWER ELECTRONICS LABORATORY

Pre-requisites of course: Basic Electrical Engineering, Network Analysis & Synthesis

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO 1	Demonstrate the characteristics and triggering of IGBT, MOSFET, Power transistor and SCR.	**K3**
CO2	Analyze the performance of single phase fully controlled bridge rectifiers under different loading conditions.	**K4**
CO3	Develop simulation models of power electronic circuits.	**K5**

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1 – Remember K_2 – Understand K_3 – Apply K_4 – Analyze K_5 – Evaluate K_6 – Create

Note: Minimum 10 experiments are to be performed from the following list:.

1. To study triggering of (i) IGBT (ii) MOSFET (iii) power transistor
2. To study V-I characteristics of SCR and measure latching and holding currents.
3. To compare the R, RC & UJT trigger circuit for SCR.
4. To study the commutation circuit for SCR.
5. To study single phase fully controlled bridge rectifiers with resistiveand inductive loads.
6. To study single phase fully controlled bridge rectifiers with DC motor load.
7. To study three-phase fully controlled bridge rectifier with resistive and inductive loads.
8. To study single-phase ac voltage regulator with resistive and inductive loads.
9. To study single phase cyclo-converter
10. To study the four quadrant operation of chopper circuit
11. To study MOSFET/IGBT based single-phase bridge inverter.

Software based experiments (Scilab/MATLAB or any equivalent open source software)

12. To obtain the simulation of single phase half wave controlled rectifier with R and RL load and plot load voltage and load current waveforms.
13. To obtain simulation of single phase fully controlled bridge rectifier and plot load voltage and load current waveform for inductive load.
14. To obtain simulation of single phase full wave ac voltage controller and draw load voltage and load current waveforms for inductive load.
15. To obtain simulation of step down dc chopper with L-C output filter for inductive load and determine steady-state values of output voltage ripples in output voltage and load current.

Text/Reference Books:

1. M.H. Rashid,"Power Electronics: Circuits, Devices & Applications", Pearson Education
2. D.W. Hart, "Introduction to Power Electronics" Prentice Hall Inc.

DEPARTMENTAL ELECTIVES

DEPARTMENT ELECTIVE-I

ROBOTICS

Pre-requisites of course: Basic Mathematics.

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO1	Learn the basic terminology used in robotics.	**K2**
CO2	Conceptualize 3-D translation & orientation of robot arm kinematics.	**K3**
CO3	Understand different robotic actuators and power transmission systems.	**K3**
CO4	Classify the types of robotic grippers used in automation industries.	**K2**
CO5	Realization of robotic sensoric system and their interfacing with robot controller.	**K3**

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)
K_1 – Remember K_2 – Understand K_3 – Apply K_4 – Analyze K_5 – Evaluate K_6 – Create

Detailed Syllabus:

UNIT I: INTRODUCTION

Classifications of robots, Flexible automation vs. Robotic technology, Robot components and degree of freedom, Robot joints, coordinates and reference frames, characteristics of robots, Robot workspace, role of robots in Industry 4.0; Robot safety and social robotics.

UNIT II: KINEMATICS OF ROBOT

Matrix representation of robot kinematics, Transformation of matrix, Forward and Inverse Kinematics of robots, D-H Representation of Six Degree of Freedom Robot Arm.

UNIT III: ROBOT ACTUATORS AND POWER TRANSMISSION SYSTEMS

Characteristics of actuating systems, comparison of hydraulic, pneumatic and electrical actuating system, Mechanical transmission method (concept only) - Gear transmission, Belt drives, cables, Roller chains, Link-Rod systems, Rotary-to-Rotary motion conversion, Rotary-to-Linear motion conversion, Rack and Pinion drives, Lead screws, Ball Bearing screws.

UNIT IV: ROBOT GRIPPERS

Classification of End effectors, Drive system for grippers - Mechanical adhesive vacuum-magnetic-grippers. Hooks & scoops, Active and passive grippers.

UNIT V: ROBOT SENSORS, CONTROL HARDWARE AND INTERFACING

Sensor: Contact & Proximity, Position, Velocity, Force and Tactile, Introduction to Cameras, Vision applications in robotics; integration of robot controller with sensors, actuators & other supporting components.

TEXT BOOKS:

1. John J.Craig , “Introduction to Robotics”, Pearson, 2009.
2. Saeed B. Niku, “Introduction to Robotics”, Wiley & Sons, 2011.
3. Deb S. R. and Deb S., “Robotics Technology and Flexible Automation”, Tata McGraw Hill Education Pvt. Ltd, 2010.
4. Mikell P. Groover et. al., "Industrial Robots - Technology, Programming and Applications", McGraw Hill, New York, 2008.

REFERENCES:

1. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India Pvt. Ltd., 2006.
2. Fu K S, Gonzalez R C, Lee C.S.G, "Robotics : Control, Sensing, Vision and Intelligence", McGraw Hill, 1987
3. Spong & Vidyasagar, Robot Dynamics and Control, Mc Graw Hill
4. Subir K Saha, Robotics, Mc GrawHill
5. M. P. Groover, Ashish Dutta, Industrial Robotics, McGraw Hill

SENSORS AND TRANSDUCERS

Pre-requisites of course: Basic Electrical Engineering, Basic signals & systems

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO 1	Understand the working of commonly used sensors in industry for measurement of displacement, force and pressure.	**K3**
CO2	Recognize the working of commonly used sensors in industry for measurement of temperature, position, accelerometer, vibration sensor, flow and level.	**K3**
CO3	Identify the application of machine vision.	**K2**
CO4	Conceptualize signal conditioning and data acquisition methods.	**K2**
CO5	Comprehend smart sensors and their applications in automation systems.	**K4**

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)
K_1 – Remember K_2 – Understand K_3 – Apply K_4 – Analyze K_5 – Evaluate K_6 – Create

Detailed Syllabus:

Unit- I:

Sensors & Transducer: Definition, Classification of transducers, Advantages and Disadvantages of Electrical Transducers; Measurement of displacement using Potentiometer, LVDT & Optical Encoder; Measurement of force using strain gauges & load cells; Measurement of pressure using LVDT based diaphragm & piezoelectric sensor.

Unit-II:

Measurement of temperature using Thermistors, Thermocouples & RTD, Concept of thermal imaging; Measurement of position using Hall effect sensors; Proximity sensor: Inductive, Capacitive & Photoelectric, Use of proximity sensor as accelerometer and vibration sensor; Flow Sensor: Ultrasonic & Laser; Level Sensor: Ultrasonic & Capacitive.

Unit -III:

Machine Vision: Introduction to machine vision, Difference between machine vision and computer vision; Imaging Sensors: CCD and CMOS; sensing & digitizing function in machine vision, image processing and analysis, training the vision system in a pick and place robot.

Unit-IV:

Signal Conditioning: Introduction, Functions of signal conditioning equipment, need for amplification of signals, Types of amplifiers.

Data Acquisition Systems and Conversion: Introduction, Objectives & configuration of data acquisition system, Analog & Digital IO, Counters, Timers, need of data conversion.

Unit V:

Smart Sensors: General Structure of smart sensors & its components, Characteristic of smart sensors: Self calibration, Self-testing & self-communicating, Application of smart sensors: Smart city, Industrial robots & electric vehicles.

Text Books:

1. DVS Murthy, Transducers and Instrumentation, PHI 2nd Edition 2013
2. D Patranabis, Sensors and Transducers, PHI 2nd Edition 2013.
3. S. Gupta, J.P. Gupta / PC interfacing for Data Acquisition & Process Control, 2nd ED / Instrument Society of America, 1994.

Reference Books:

1. Arun K. Ghosh, Introduction to measurements and Instrumentation, PHI, 4th Edition 2012.
2. A.D. Helfrick and W.D. cooper, Modern Electronic Instrumentation & Measurement Techniques,PHI – 2001
3. Hermann K.P. Neubert, “Instrument Transducers” 2nd Edition 2012, Oxford University Press.

INDUSTRIAL AUTOMATION & CONTROL

Pre-requisites of course: Digital Electronics

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO1	Understand the concept of automation, its terminology and basic communication protocol.	**K2**
CO2	Apply Relay logic for automation.	**K3**
CO3	Learn about PLC, its operation and application in automation.	**K3**
CO4	Analyze the industrial sensors, its terminology and how one can interface with PLC.	**K3**
CO5	Demonstrate Pneumatic system and its application in industry.	**K3**

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)
K1 – Remember K2 – Understand K3 – Apply K4 – Analyze K5 – Evaluate K6 – Create

Detailed Syllabus:

Unit1: Introduction of Automation system

Introduction to Industrial Automation, Requirement of automation systems, Application areas, Architecture of Industrial Automation system, Introduction of PLC and supervisory control and data acquisition (SCADA). Industrial communication protocols: modbus & profibus

Unit2: Automation using relay logic

Relay Circuits: Construction & Principle of Operation, Types of Relays, Relay as a memory element, Contactor Circuits, Advantages of Contactors over Relay, DOL circuit implementation using contactor, Automation problems based on relays, PLC Introduction: History & Current Trends, Basic Block Diagram of PLC, Classification of PLCs

Unit3: Automation using PLC

Types of PLC I/O: Analog and Digital, Sink and Source concept, PLC programming: Ladder diagram, Sequential flow chart, ladder programming, Timer instructions – On delay, Off delay, Cyclic and Retentive timers, Up /Down Counters, math instructions

Unit4: Industrial sensors and its application

Introduction to Industrial sensors: optical, inductive, capacitive Sensors, PNP and NPN senor concept, interfacing of sensors with PLC, 4-20 ma current loops, HART protocol, modes of HART protocol

Unit5: Basics of Pneumatics and its use in automation

Introduction to Pneumatics, Role in industries, Laws : Boyel's law, Charle's Law Bernoulli Equation, Humidity(Absolute & Relative) , Dew Point (ADP, PDP) Basic, Pneumatic System (Compressor, After coolers, Dryers, Air Tank, Service Unit (FRL), Actuators(single acting, double acting), Valves : 2/2 & 3/2 Valves ,Problems based on valves and actuator

Text Books:

1. Industrial Instrumentation and Control, by Singh, McGraw Hill.
2. Programmable Logic Controllers with Control Logix, by Jon Stenerson, Delmar Publishers, 2009
3. Webb John W. and Reis A. Ronald, “Programmable Logic Controllers Principles and Applications” PHI ,New Delhi, Latest edition
4. Bolton W, “Programmable Logic Controllers” Elsevier India Pvt. Ltd. New Delhi

Reference Books:

1. B. Pneumatic Systems-Principles and Maintenance Mazumdar S. R
2. John R Hackworth, “Programmable Logic Controllers” Pearson Education New Delhi, Latest edition

ELECTRICAL STANDARDS AND ENGINEERING PRACTICES

Pre-requisites of course: Basic Electrical Engineering, Electrical Machines and Power System

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO1	Interpret different National & International Electrical Standards in practice	**K2**
CO2	Understand Indian standards for cables, lighting and motors.	**K3**
CO3	Understand Indian standards of transformers, LV & HV switchgears	**K3**
CO4	Demonstrate the basic guidelines for National codes and design practices	**K3**
CO5	Select the size and type of transformer, cable & switchgear for electrical applications.	**K4**

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)
K1 – Remember K2 – Understand K3 – Apply K4 – Analyze K5 – Evaluate K6 – Create

Detailed Syllabus:

Unit-I (Introduction of Standards and Design practices)

Different Electrical standards & codes, overview of Indian Standards and International Standards (IS, IEC, IEEE, NEMA and Building codes etc.).

General engineering design practices, selection of voltage level, role of electrical studies and design calculations (load flow, fault level calculation, earthing and lightning calculation, voltage drop) in distribution system planning. Feasibility study, thermal and electrical resistivity of soil, Study of electrical drawings/layouts and cost estimation.

Unit-II (Electrical Standards-I)

Overview of IS standards for cables (IS-7098 IS-8130, IS-10810, IS-1554, IS-1255), IS standards for lighting (IS-3646, IS-10322, IS-6665) and IS standards for motors (IS-325, IS-900, IS-2253, IS-4029, IS-15999) - basic terminologies, type test and routine tests.

Efficiency class of motors as per IS/IEC standard.

Unit-III (Electrical Standards-II)

Transformer types, overview of IS standards for transformer (IS-2026, IS-6600 IS-10028, IS-11171), IS standards for LV & HV switchgears (IS-8623, IS/IEC-60898, IS/IEC-62271, IS-3427, IS-9920, IS-12729) - basic terminologies, type test and routine tests.

Instrument transformers (CT & PT), Instrument safety factor, VA burden, knee point voltage and accuracy classes.

Unit-IV (National Codes and Design practices)

Overview of National electrical code, National Building Code of India, Cable types, installation practices, de-rating factors and bonding methods, Earthing and lightning protection system, touch and step potentials, Hazardous area classification, electrical equipments for different hazardous zones.

Unit-V (Equipment Sizing & Selection, CEA Regulations)

Load estimation, sizing and selection of transformers, cables and switchgears, CEA Regulations 2010 and amendments, safety and installation guidelines.

Reference Books:

1. Robert Alonzo, "Electrical Codes, Standards, Recommended Practices and Regulations 1st Edition", Elsevier Inc.
2. Mohamed A El-Sharkawi, "Electric safety: practice and standards", CRC Press.
3. Central Electricity Authority Regulations and Amendments.

DEPARTMENT ELECTIVE-II

OPTIMIZATION TECHNIQUES

Pre-requisites of course: Basic mathematics

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO 1	Understand the importance of optimization techniques in engineering applications	**K2**
CO2	Learn optimization methods for solving linear programming problems	**K3**
CO3	Learn optimization methods for solving nonlinear programming problems	**K3**
CO4	Be aware of the concept of simulation and modern methods of optimization	**K3**
CO5	Apply optimization techniques to electrical engineering problems	**K4**

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)
K_1 – Remember K_2 – Understand K_3 – Apply K_4 – Analyze K_5 – Evaluate K_6 – Create

Detailed syllabus:

Unit I
Introduction to Optimization: Engineering application of Optimization, Statement of an optimization problem, Optimal problem formulation, Classification of optimization problem, Optimum design concepts: Definition of Global and Local optima using basic calculus concepts; Classical Optimization Techniques: Unconstrained Optimization - Single variable optimization, Constrained multivariable optimization with equality constraints - Lagrange multipliers method, Constrained multivariable optimization with inequality constraints - Kuhn-Tucker conditions.

Unit II
Linear Programming: Standard form of linear programming, Graphical solution, Simplex method, Big-M method, Duality theory, Decomposition principle, Transportation problem using North-West Corner rule and Least cost rule.

Unit III
Non-Linear Programming: Standard form of non-linear programming, One–Dimensional Minimization Methods - Unimodal function, Dichotomous search, interval halving method; Unconstrained Optimization Techniques - Univariate method, Steepest descent method; Constrained Optimization Techniques - Interior Penalty function method, Exterior penalty function method.

Unit IV
Simulation: Definition, types of simulation, General process of simulation, advantages & disadvantages of simulation.
Project Management Techniques: PERT and CPM

Modern methods of Optimization: Genetic algorithm, working principle, fitness function, GA operators – crossover & mutation, comparison of GA with traditional methods.

Unit V

Case study (algorithm only): Economic load scheduling of power plant (without considering losses), maintenance scheduling of machines in manufacturing industry, fuzzy logic based speed control of DC machines.

Text Books:

1. S.S.Rao,"Optimization - Theory and Applications", Wiley-Eastern Limited.
2. D.E. Goldberg,"Genetic Algorithm in Search Optimization and Machine Learning ", Addision-Wesley Publication, 1989
3. Kwang Y. Lee, Mohamed A. El-Sharkawi, "Modern heuristic optimization techniques, Theory and applications to power systems", Wiley-Interscience

Reference Books:

1. David G. Luenberger,"Introduction of Linear and Non-Linear Programming ", Wesley Publishing Company.
2. Polak,"Computational methods in Optimization ", Academic Press.
3. Pierre D.A., "Optimization Theory with Applications", Wiley Publications.
4. Kalyanmoydeb,"Optimization for Engineering Design: Algorithms and Examples", PHI Publication
5. L.P. Singh,"Advanced Power System Analysis and Dynamics ", Wiley Eastern Limited.

NEURAL NETWORKS & FUZZY SYSTEMS

Course Outcomes:		Knowledge Level, KL
Upon the completion of the course, the student will be able to:		
CO 1	Apply the concepts of feed forward neural networks and their learning techniques.	**K3**
CO2	Comprehend the architecture, develop algorithms and apply the concepts of back propagation networks.	**K5**
CO3	Differentiate between the fuzzy and the crisp sets, apply the concepts of fuzziness and the fuzzy set theory.	**K4**
CO4	Select the membership functions, write rules and develop the fuzzy controller for Industrial applications.	**K5**
CO5	Demonstrate the working of fuzzy neural networks and identify its applications.	**K3**

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1 – Remember K_2 – Understand K_3 – Apply K_4 – Analyze K_5 – Evaluate K_6 – Create

Detailed syllabus:

Unit-I: Neural Networks-1(Introduction & Architecture):
Neuron, Nerve structure and synapse, Artificial Neuron and its model, activation functions, Neural network architecture: single layer and multilayer feed forward networks, recurrent networks. Various learning techniques; perception and convergence rule, Auto-associative and hetro-associative memory.

Unit-II: Neural Networks-II (Back propogation networks):
Architecture: perceptron model, solution, single layer artificial neural network, multilayer perception model; back propogation learning methods, effect of learning rule co-efficient ;back propagation algorithm, factors affecting back propagation training, applications.

Unit-III: Fuzzy Logic-I (Introduction):
Basic concepts of fuzzy logic, Fuzzy sets and Crisp sets, Fuzzy set theory and operations, Properties of fuzzy sets, Fuzzy and Crisp relations, Fuzzy to Crisp conversion.

Unit-IV: Fuzzy Logic –II (Fuzzy Membership, Rules):
Membership functions, interference in fuzzy logic, fuzzy if-then rules, Fuzzy implications and Fuzzy algorithms, Fuzzyfications & Defuzzificataions, Fuzzy Controller, Industrial applications.

Unit-V: Fuzzy Neural Networks:
L-R Type fuzzy numbers, fuzzy neutron, fuzzy back propogation (BP), architecture, learning in fuzzy BP, inference by fuzzy BP, applications.

Text Books:

1. Kumar Satish, "Neural Networks" Tata Mc Graw Hill
2. S. Rajsekaran & G.A. Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications" Prentice Hall of India.

Reference Books:

1. Siman Haykin, "Neural Netowrks" Prentice Hall of India
2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications" Wiley India

DIGITAL SIGNAL PROCESSING

Pre-requisites of course: Basic Signals & System, Network Analysis & Synthesis.

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO 1	Represent discrete sequence and LTI systems, frequency domain of discrete sequence. Compute Fourier transform. Draw structure of systems based on System type-IIR & FIR Systems.	**K2**
CO2	Describe sampling of signal and its reconstruction, processing of continuous time and discrete time signals. Sampling rate variation and application of multirate signal processing. Sampling effect in A/D and D/A conversion.	**K3**
CO3	Evaluate the response of LTI system and rational system function. Drive linear phase systems. Compute discrete Fourier transform (DFT) and calculate linear and circular convolution.	**K5**
CO4	Design IIR & FIR filters with the desired specification with the help of impulse invariant and bilinear transformation method for IIR, with the help of window techniques for FIR. Design Butterworth and Chebyshev filter response.	**K6**
CO5	Compute DFT using efficient algorithm like FFT in decimation in time and decimation in frequency both, using convolution property and Goertzel algorithm. Comparison between wavelet and Fourier transform. Application of WCT & DCT.	**K5**

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)
K_1 – Remember K_2 – Understand K_3 – Apply K_4 – Analyze K_5 – Evaluate K_6 – Create

Detailed syllabus:

Unit-I:
Discrete-Time Signals and Systems:
Sequences, discrete time systems, LTI systems, frequency domain representation of discrete time signals and systems, discrete time signals and frequency domain representation, Fourier Transform.
Realization of Digital Linear Systems:
IIR Filter Realization: Direct form, cascade realization, parallel form realization, Ladder structures- continued fraction expansion of H(z). FIR Filter Realization: Direct, Cascade, FIR Linear Phase Realization

Unit-II:
Sampling of Continuous Time Signals:
Sampling and reconstruction of signals, frequency domain representation of sampling, discrete time processing of continuous time signals, continuous time processing of discrete time signals, changing the sampling rate using discrete time processing, multi rate signal processing, digital processing of analog signals, over sampling and noise shaping in A/D and D/A conversion.

Unit-III:

Transform Analysis of LTI Systems:

Frequency response of LTI systems, system functions, frequency response for rational system functions, magnitude-phase relationship, all pass systems, minimum phase systems, and linear systems with generalized linear phase

Discrete Fourier Transform:

Concept and relations for DFT/IDFT, Twiddle factors and their properties, computational burden on direct DFT, DFT/IDFT as linear transformations, DFT/IDFT matrices, computation of DFT/IDFT by matrix method, multiplication of DFTs, circular convolution, computation of circular convolution by graphical, DFT/IDFT and matrix methods, linear filtering using DFT, aliasing error, filtering of long data sequences – Overlap-Save and Overlap-Add methods with example

Unit-IV:

Filter Design Techniques:

Design of IIR filters using Impulse Invariant Response method and Bilinear Transformation method. Butterworth filters and Chebyshev Filter's response, Design of FIR filters by windowing, Kaiser Window method, optimum approximations of FIR filters,

Unit-V:

Fast Fourier Transform:

Radix-2 algorithm, decimation-in-time, decimation-in-frequency algorithms, signal flow graphs, Butterflies, computations in one place, bit reversal, examples for DIT & DIF FFT Butterfly computations with examples.

Introduction to wavelet transform:

Wavelet comparison with Fourier transforms, Applications of Wavelet cosine transform, Discrete cosine transform (DCT).

Text Books:

1. S. Salivahanan, "Digital Signal Processing", McGraw Hill Education (India) Private Limited.
2. Oppenheim & Schafer, Digital Signal Processing. Pearson Education 2015
3. S.K. Mitra, 'Digital Signal Processing–A Computer Based Approach, McGraw Hill, 4th Edition

Reference Books:

1. John G Prokias, Dimitris G Manolakis, Digital Signal Processing. Pearson , 4th Edition, 2007
2. Rabiner, L.R. and Gold B., "Theory and applications of DSP", Prentice Hall of India.
3. Oppenheim, Alan V. &Willsky, Alan S. , "Signals and Systems" , Prentice Hall of India, 2nd Edition
4. Johnny R. Johnson, Digital Signal Processing, PHI Learning Pvt Ltd., 2009.

ANALOG & DIGITAL COMMUNICATION

Pre-requisites of course: Basic Signals & Systems.

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO 1	Understand the Amplitude Modulation in communication system.	**K_2**
CO2	Comprehend the Frequency & Phase modulation.	**K_2**
CO3	Realize the Pulse Modulation Techniques.	**K_2**
CO4	Get the Digital Modulation Techniques and their use in communication system.	**K_2**
CO5	Apply the concept of Information Theory in Communication Engineering.	**K_3**

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)
K_1 – Remember K_2 – Understand K_3 – Apply K_4 – Analyze K_5 – Evaluate K_6 – Create

Detailed Syllabus:

UNIT I
Elements of communication system and its limitations, Amplitude modulation and detection, Generation and detection of DSB-SC, SSB and vestigial side band modulation, carrier acquisition AM transmitters and receivers, Superhetrodyne Receiver, IF amplifiers, AGC circuits, Frequency Division multiplexing.

Unit II
Angle Modulation: Basic definition, Narrow-Band and wideband frequency modulation, transmission bandwidth of FM signals, Generation and detection of frequency modulation, Generation and detection of Phase Modulation.
Noise: External noise, internal noise, noise calculations, signal to noise ratio.

Unit III
Pulse Modulation: Introduction, sampling process, Analog Pulse Modulation Systems, Pulse Amplitude Modulation (PAM), Pulse width modulation (PWM) and Pulse Position Modulation (PPM).
Waveform coding Techniques: Discretization in time and amplitude, Quantization process, quantization noise, Pulse code Modulation, Differential Pulse code Modulation, Delta Modulation and Adaptive Delta Modulation.

Unit IV
Digital Modulation Techniques: Types of digital modulation, waveforms for amplitude, frequency and phase shift keying, coherent and non-coherent methods for the generation of ASK, FSK and PSK. Comparisons of above digital modulation techniques.

Unit V
Time Division Multiplexing: Fundamentals, Electronic Commutator, Bit/byte interleaving, TI carrier system, synchronization and signaling of TI, TDM and PCM hierarchy, synchronization techniques.
Introduction to Information Theory: Measure of information, Entropy & Information rate, channel capacity, Hartley Shannan law, Huffman coding, shannan Fano coding.

Text Books:

1. B.P. Lathi, "Modern Digital and Analog Communication Systems", 4th Edition, Oxford University Press.
2. G.Kennedy and B. Davis," Electronic Communication Systems" 4th Edition, McGraw Hill
3. R.P. Singh & S.D. Sapre, "Communication Systems Analog and Digital", 3th Edition, McGraw Hill.
4. John G. Proakis, "Communication Systems Engineering 2nd Edition, Pearson Education, 2015
5. H. Taub, D L Schilling, Gautam Saha, "Principles of Communication", 4th Edition, McGraw Hill.

Reference Books:

1. (Schaum's Outline Series) H P HSU & D Mitra, "Analog and Digital Communications", McGraw Hill 3rd Edition.
2. Simon Haykin, "Communication Systems", 5th Edition, Wiley India.
3. T.L. Singal, "Analog & Digital Communication", McGraw Hill

DEPARTMENT ELECTIVE-III

SPECIAL ELECTRICAL MACHINES

Pre-requisites of course: Electrical Machines-I & Electrical Machines-II.

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO 1	Describe the working principle, Constructional Features of different types of electrical machines including the fractional kilowatt machines.	**K2**
CO2	Analyse torque- speed characteristics of different electrical machines and interpret their performance and identify the suitable machine for an operation.	**K4**
CO3	Study different types of control techniques for a machine and identify the best control strategy based upon different constraints.	**K4**
CO4	Illustrate the use of stepper, BLDCs, SRM, and other special machines in the area of the various industrial and domestic as well as commercial applications of various fractional kilowatt machines.	**K3**

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1 – Remember K_2 – Understand K_3 – Apply K_4 – Analyze K_5 – Evaluate K_6 – Create

Detailed Syllabus:

Unit-I: Induction Machines: Concept of constant torque and constant power controls, SEIG, DFIG: Operating Principle, Equivalent Circuit, Characteristics, Applications, Linear Induction Motors. Construction, principle of operation, Linear force, and applications.

Two Phase AC Servomotors: Construction, torque-speed characteristics, performance and applications.

Unit-II: Stepper Motors: Constructional features, Principle of operation, Variable reluctance motor, Hybrid motor, Single and multistack configurations, Torque equations, Characteristics, Drive circuits, Microprocessor control of stepper motors, Closed loop control, Applications.

Unit-III: Switched Reluctance Motors: Constructional features, Rotary and Linear SRM, Principle of operation, Torque production, performance characteristics, Methods of Rotor position sensing, Sensor less operation, Closed loop control and Applications

UNIT-IV Permanent Magnet Machines: Permanent Magnet synchronous generator Operating Principle, Equivalent Circuit, Characteristics, Permanent magnet DC motors, sinusoidal PMAC motors, their important features and applications, PCB motors,

Permanent Magnet Brushless D.C. Motors: Principle of operation, Types, Magnetic circuit analysis, EMF and torque equations, Commutation, Motor characteristics and control, Applications.

UNIT-V: Single phase synchronous motor; construction, operating principle and characteristics of reluctance and hysteresis motors;

Single Phase Commutator Motors: Construction, principle of operation, characteristics of universal and repulsion motors;

TEXT BOOKS:

1. K.Venkataratnam, 'Special Electrical Machines', Universities Press (India) Private Limited, 2008.
2. T.J.E Miller, 'Brushless Permanent Magnet and Reluctance Motor Drives', Clarendon Press, Oxford, 1989.
3. P.S. Bimbhra "Generalized Theory of Electrical Machines" Khanna Publishers.

Reference Books:

1. T. Kenjo, 'Stepping Motors and Their Microprocessor Controls', Clarendon Press London, 1984.
2. M.G. Say "Alternating current Machines" Pitman & Sons.

ELECTRICAL MACHINE DESIGN

Pre-requisites of course: Electrical Machine-I & Electrical Machine-II.

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO 1	Classify insulating materials for electrical machines and calculate mmf and magnetizing current.	**K5**
CO2	Design the core, yoke, windings and the cooling system of a transformer.	**K6**
CO3	Illustrate the core and armature design of DC and 3-phase synchronous machine. Design design of three phase induction motors, field system of DC machine and synchronous machines.	**K6**
CO4	Analyse computer aided design approaches and apply the concepts of of optimization for the design of transformer, dc machine, three phase induction and synchronous machines.	**K6**

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)
K_1 – Remember K_2 – Understand K_3 – Apply K_4 – Analyze K_5 – Evaluate K_6 – Create

Detailed syllabus:

UNIT-I
Basic Considerations: Basic concept of design, limitation in design, standardization, modern trends in design and manufacturing techniques, Classification of insulating materials. Calculation of total mmf and magnetizing current.

UNIT-II
Transformer Design: Output equation, design of core, yoke and windings, overall dimensions, Computation of no load current to voltage regulation, efficiency and cooling system designs.

UNIT-III:
Design of rotating machines – I: Output equations of rotating machines, specific electric and magnetic loadings, factors affecting size of rotating machines, separation of main dimensions, election of frame size, Core and armature design of dc and 3-phase ac machines

Unit-IV:
Design of rotating machines – II: Rotor design of three phase induction motors, Design of field system of DC machine and synchronous machines. Estimation of performance from design data.

Unit-V:

Computer Aided Design: Philosophy of computer aided design, advantages and limitations.

Computer aided design approaches analysis, synthesis and hybrid methods. Concept of optimization and its general procedure. Flow charts and 'c' based computer programs for the design of transformer, dc machine, three phase induction and synchronous machines

Text Books:

1. K. Sawhney, "A Course in Electrical Machine Design" Dhanpat Rai & Sons.
2. K.G. Upadhyay," Conventional and Computer Aided Design of Electrical Machines" Galgotia Publications.

Reference Books:

3. M.G. Say, "The Performance and Design of AC Machines" Pitman & Sons.
4. A.E. Clayton and N.N. Hancock, "The Performance and Design of D.C.Machines" Pitman & Sons.
5. S.K. Sen, "Principle of Electrical Machine Design with Computer Programming" Oxford and IBM Publications.

DIGITAL CONTROL SYSTEM

Pre-requisites of course: Control System

Course Outcome		Knowledge Level, KL
Upon the completion of the course, the student will be able to:		
CO 1	Represent discrete time systems under the form of z-domain transfer functions and state-space models.	**K3**
CO 2	Obtain the model of discrete-time systems by pulse transfer function.	**K4**
CO 3	Analyze stability, transient response and steady state behaviour of linear discrete-time systems, analytically and numerically using tools such as MATLAB and Simulink	**K4**
CO 4	Design sampled data control systems.	**K5**
CO 5	Describe Discrete state space model and test controllability and observability of systems.	**K5**

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)

K1 – Remember K2 – Understand K3 – Apply K4 – Analyze K5 – Evaluate K6 – Create

Detailed syllabus:

Unit 1: Introduction to digital control

Introduction, Discrete time system representation, Mathematical modelling of sampling process, Data reconstruction.

Unit 2: Modelling discrete-time systems by pulse transfer function

Revisiting Z-transform, Mapping of s-plane to z-plane, Pulse transfer function, Pulse transfer function of closed loop system, Sampled signal flow graph.

Unit 3: Stability analysis of discrete time systems

Jury stability test, Stability analysis using bi-linear transformation. Time response of discrete systems: Transient and steady state responses, Time response parameters of a prototype second order system.

Unit 4: Design of sampled data control systems:

Root locus method, Controller design using root locus, Root locus-based controller design using MATLAB, Nyquist stability criteria, bode plot, Lead compensator design using Bode plot, Lag compensator design using Bode plot, Lag-lead compensator design in frequency domain.

Unit 5: Discrete state space model

Introduction to state variable model, Various canonical forms, Characteristic equation, state transition matrix, Solution to discrete state equation. Controllability, observability and stability of discrete state space models: Controllability and observability, Stability, Lyapunov stability theorem.

References:

1. B. C.Kuo, Digital Control Systems, Oxford University Press, 2nd Edition, 2007.
2. K. Ogata, Discrete Time Control Systems, Prentice Hall, 2nd Edition, 1995.
3. M. Gopal, Digital Control and State Variable Methods, Mcgraw Hill, 2/e, 2003.
4. G. F. Franklin, J. D.Powell and M. L. Workman, Digital Control of Dynamic Systems, Addison Wesley, 1998, Pearson Education,Asia, 3rd Edition, 2000.
5. K. J.Astroms and B. Wittenmark, Computer Controlled Systems - Theory and Design, Prentice Hall, 3rd Edition, 1997.

ELECTRIC AND HYBRID VEHICLES

Pre-requisites of course: Electrical Machines, Power Electronics

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO1	Choose a suitable drive scheme for developing an electric hybrid vehicle depending on resources	**K3**
CO2	Design and develop basic schemes of electric vehicles and hybrid electric vehicles.	**K6**
CO3	Choose proper energy storage systems for vehicle applications	**K5**
CO4	Identify various communication protocols and technologies used in vehicle networks.	**K4**

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)
K1 – Remember K2 – Understand K3 – Apply K4 – Analyze K5 – Evaluate K6 – Create

Detailed Syllabus:

Unit1:

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles.

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance.

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

Unit2: Electric Propulsion unit:

Introduction to electric components used in hybrid and electric vehicles, 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 system efficiency.

Unit3: Energy Storage:

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.

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Unit4: Sizing the drive system:

Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems

Unit5: Energy Management Strategies:

Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

Text Books:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003

Reference Books:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003
2. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004