GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL ENGINEERING (09)
DESIGN OF DC MACHINES AND TRANSFORMER
SUBJECT CODE:2160912
B.E. 6thSEMESTER

Type of course: Engineering Science (Electrical)

Prerequisite: Elements of Electrical Engineering, DC Machines and Transformer

Rationale:NA.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	GENERAL DESIGN ASPECTS: Specific electric loading and Specific magnetic loading; Output coefficient; Output equations for transformers and rotating machines; Factors affecting size of machines; Criteria for selection of specific loadings; Heating and Cooling of Transformers and rotating machines.	**6**	**20**
2	DESIGN OF THREE PHASE TRANSFORMER: Types of transformers; Position of HV and LV windings and its importance; Relation between core and yoke cross section area and its significance; Different types of transformer windings; Different positions of taping; Window space factor; Factors affecting window space factor; Relation between emf per turn and transformer rating; Stacking factor. MAIN DIMENSIONS: Design of window dimensions, yoke dimensions and overall core dimensions; Numerical examples. DESIGN OF WINDINGS: Design of HVand LV windings (No. of turns and area of cross section); Selection of type of winding. PERFORMANCE PARAMETERS ESTIMATION: Primary and secondary winding resistance and Leakage reactance calculation; Calculation of no load current, losses and temperature rise of transformer; Design of tank with tubes; Calculation of dimension of tank; Numerical examples. Variation of output and losses in transformer with linear dimensions; Basic design aspects of dry transformer and high frequency transformers. Basic design aspects of welding transformers and instrument transformers.	**18**	**40**

3	DESIGN OF DC MACHINES: Introduction; Output equation; MMF calculation; Selection of number of poles; Design of core length and armature diameter; Carter's fringing curves and its significance; Design of length of air gap; Numerical examples. ARMATURE DESIGN: Choice of armature winding; Armature conductor; Number of armature slots; Slot dimensions; Slot loading; Design of armature core; Numerical examples. DESIGN OF FIELD SYSTEMS: Pole design; Design of field winding of shunt, series and compound machines; Design of inter poles; Effects and minimization of armature reaction; Design of commutator and brushes; Numerical examples. Performance parameters evaluation.	**18**	**40**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**25**	**15**	**10**	**10**	**0**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. A course in electrical machine Design – A. K. Sawhney
2. Electrical Machine Design – R. K. Agrawal
3. Design of Electrical Machine- V. N. Mittle

Course Outcome:

After learning the course the students should be able to:

1. Design the DC machine of given specifications.
2. Design the transformers of given specifications.
3. Prepare the detailed sketches of the designed machines.

List of Experiments:

During the laboratory hours, the design problems based on the syllabus should be assigned to the students. After carrying out the detailed design, drawing sketches should be prepared by the students. Minimum five drawing sheets must be prepared and evaluated at the end of the term.

Design based Problems (DP)/Open Ended Problem:

(1) Carry out the detailed design of a 63 kVA, 11 kV/440 V, 50 Hz, Three phase, Delta/Star, core type, oil immersed, natural cooled distribution transformer. Maximum temperature rise should not exceed 45 degree centigrade. Prepare the drawings of designed transformer with appropriate scale. Prepare a list of accessories for this transformer.

(2) Carry out the detailed design of a 10 MVA, 66 kV/11 kV, 50 Hz, Three phase, Delta/Star, core type, oil immersed, Oil natural Air forced cooled power transformer. Maximum temperature rise should not exceed 45 degree centigrade. Prepare the drawings of designed transformer with appropriate scale. Prepare a list of accessories for this transformer.

(3) Carry out the detailed design of a 100 MVA, 132 kV/66 kV, 50 Hz, Three phase, Star/Star, core type, oil immersed, Oil forced Air forced cooled power transformer. Maximum temperature rise should not exceed 45 degree centigrade. Prepare the drawings of designed transformer with appropriate scale. Prepare a list of accessories for this transformer.

(4) Do the survey of latest trends in transformer manufacturing technology and corresponding applications. What is its impact on the power system? Use internet and other resources.

(5) Carry out the detailed design of a 50 kW, 240 Volt, 1500 rpm, DC shunt motor to be used for industrial application. Maximum temperature rise should not exceed 45 degree centigrade. Prepare the drawings of designed machine with appropriate scale.

(6) Carry out the detailed design of a 3.8 kW, 240 Volt, 1500 rpm, DC shunt machine to be used for the laboratory of an academic institution. Maximum temperature rise should not exceed 45 degree centigrade. Prepare the drawings of designed machine with appropriate scale.

Major Equipment:

Lab set ups of following machines

(1) Cut section models of (a) Transformer (b) DC machine
(2) Charts to explain various parts of machines

List of Open Source Software/learning website:

1. http://www.electrical-engineering-portal.com/
2. http://nptel.iitm.ac.in/courses.php
3. Virtual Lab Website www.vlab.co.in

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL ENGINEERING (09)

ELECTRICAL POWER SYSTEM – II

SUBJECT CODE:2160908

B.E. 6th SEMESTER

Type of course: Engineering Science (Electrical)

Prerequisite: Electrical Power System – I

Rationale: NA

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Current and Voltage Relations on a Transmission Line:** Representation of line, The short transmission line, The medium-length line, The long transmission line: Solution of the differential equations, The long transmission line: Interpretation of the equations, The long transmission line: Hyperbolic form of the differential equations, The equivalent circuit of a long line, Power flow through atransmission line (circle diagrams), Reactive compensation of transmission lines.	8	15
2	**Symmetrical Three-Phase Faults:** Transients in RL Series circuits, Short-Circuit currents and the reactances of Synchronous machines, Internal voltages of loaded machines under transient conditions, The bus impedance matrix in fault calculations, A bus impedance matrix equivalent network, The selection of circuit breakers.	8	20
3	**Symmetrical Components:** Synthesis of Unsymmetrical phasors from their symmetrical components, The symmetrical components of unsymmetrical phasors, Phase shift of symmetrical components in Star-Delta Transformer Banks [2], Power in terms of symmetrical components, Sequence circuits of Y and Δ impedances, Sequence circuits of a symmetrical transmission line, Sequence circuits of the synchronous machine, Sequence circuits of a Y- Δ transformer, Unsymmetrical series impedances, Sequence networks	8	15
4	**Unsymmetrical Faults:** Single line to ground fault on an unloaded generator, Line to Line fault on an unloaded generator, Double Line to Ground fault on an unloaded generator, Unsymmetrical faults on power systems, Single line to Ground fault on a power system, Line to Line fault on a power system, Double Line to Ground fault on a power system, Interpretation of the interconnected sequence networks, Analysis of	8	20

	unsymmetrical faults using the bus impedance matrix, Faults through impedance, Computer calculations of fault currents		
5	**Transients in Power Systems:** Transients in Simple Circuits, 3-phase Sudden Short Circuit of an Alternator, The Restriking Voltage after Removal of Short Circuit, Travelling Waves on Transmission Lines, Attenuation of Travelling Waves, Capacitance Switching, Overvoltage due to Arcing Ground.	**6**	**15**
6	**Corona:** Critical Disruptive Voltage, Corona Loss, Line Design based on Corona, Disadvantages of Corona, Radio Interference, Inductive interference between Power and Communicationlines.	**6**	**15**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15%	**25%**	**20%**	**20%**	**20%**	**0%**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Power System Analysis : John J. Grainger, William D. Stevenson Jr., Tata McGraw Hill [1,2,3]
2. Elements of Power Systems Analysis : W. D. Stevenson Jr., 4th Edition, McGraw Hill International. [4]
3. Electrical Power systems: C. L .Wadhwa, 5th Edition, New Age International Publishers.[5, 6]
4. Modern Power system Analysis by I J Nagrath, D P Kothari,4th Edition Tata McGraw Hill.
5. Power System Analysis by Hadi Saadat, Tata McGraw Hill.

Course Outcome:

After learning the course the students should be able to:

1. Analyze the performance of Short and Medium transmission line.
2. Describe the symmetrical components and its applications.
3. Analyze Symmetrical and Unsymmetrical faults in power systems.
4. Describe transients in power systems.
5. Describe corona effect.

List of Experiments:

1. To obtain voltage regulation and efficiency of a short transmission line for different specified set of receiving end quantities (different load at leading, unity and lagging power factor).
2. To write computer program for voltage regulation and efficiency of short transmission line for different specified set of receiving end quantities (different load at leading, unity and lagging power factor).

3. To obtain voltage regulation and efficiency of a medium transmission line for different specified set of receiving end quantities (different load at leading, unity and lagging power factor).
4. To write computer program to calculate voltage regulation and efficiency of a Medium transmission line (using π model& T model) for different specified set of receiving end quantities (different load at leading, unity and lagging power factor).
5. To write computer program to calculate voltage regulation and efficiency of a Long transmission line using equivalent π modelfor different specified set of receiving end quantities (different load at leading, unity and lagging power factor).
6. To plot sending end power circle diagram and receiving end power circle diagram of a transmission line on a graph paper with some suitable scale.
7. To simulate transient in series R-L circuit with special attention to change in DC offset current for application of excitation at different instant.
8. To study phase shifting in star- delta transformer with emphasis on the labeling on HV and LV sides. The study should be for positive sequence and negative sequence both.
9. Dynamic simulation of three phase fault on terminal of unloaded synchronous generator. The simulation should show the waveforms of all three line current for fault at different instant on voltage wave of phase A.
10. To analyze L-G fault of a small system (containing generator, transformer and lines) using interconnection of sequence networks.
11. To analyze L- L-G and L- L fault of a small system (containing generators, transformers and lines) using interconnection of sequence network.
12. Calculation of symmetrical components for three to four different set of unbalanced three phase phasors.
13. To write a computer program for obtaining symmetrical components for a given set of unbalanced phasors.
14. Calculation of fault current for a three phase fault in a small power system.
15. To write a computer program for animation of travelling waves of a long transmission line with different operating conditions.

Design based Problems (DP)/Open Ended Problem:

The list of suggested design based problems is as follows:

1. Design of short transmission line for the specified performance parameters and different given load (with power factor).
2. Design of medium transmission line transmission line for the specified performance parameters and different given load (with power factor).
3. Design of long transmission line for the specified performance parameters and different given load (with power factor).
4. Selection of circuit breaker rating (at various buses) for a given small radial feeder for different fault locations and type of faults. The feeder is fed at one end by a voltage source only.
5. Selection of circuit breaker rating (at various buses) for a given small meshed transmission network for different fault locations and type of faults. The network may be fed by some generators.

These problems may be done on paper by hand and/or using some simulation software.

Major Equipment:

MATLAB, C/C++, SciLab

List of Open Source Software/learning website:

http://nptel.iitm.ac.in/coursecontents_elec.php

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL ENGINEERING (09)
POWER ELECTRONICS – II
SUBJECT CODE: 2160902
B.E. 6th SEMESTER

Type of course: NA

Prerequisite: Power Electronics - I

Rationale: The power electronic converters are now widely used in domestic applications as well as in industrial applications like Electrical Drives, Power Systems, Renewable Energy based power generation, heating applications etc. The course is designed to provide exposure of power electronic converters and their operation and control to obtain variable AC voltage (magnitude and/or frequency).

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	DC TO AC CONVERTERS: INVERTERS Performance parameters of Inverters; Classification of Inverters: Voltage source inverters and Current source inverters; Single phase inverters: series, parallel and bridge type (Half wave and Full wave) inverters; Forced Commutated, Line commutated and Self-Controlled Switches based Inverters; Three phase bridge inverters: 180 degree conduction, 120 degree conduction and their comparison PWM Inverters: Principle of PWM control, PWM techniques classifications, Unipolar and Bipolar PWM, Effect of Switching frequency on Harmonic Spectrum, Sinusoidal PWM, Third harmonic PWM, Selective Harmonic Elimination, Hysteresis band current control PWM, Space vector pulse width modulation technique, Comparison of PWM techniques, Voltage and frequency control of single phase and three-phase inverters, Harmonic Cancellation techniques Gating circuits for switches of inverter, Gate driver ICs having high side and low side reference output for driving switches of legs of inverters (like IR25604) Current Source Inverters: single phase and three phase ASCI and self-controlled switch based inverters; Comparison of Voltage and Current source Inverters.	15	38
2	AC VOLTAGE CONTROLLERS	8	20

	Concept of On-Off or integral cycle control and Phase control; Various single phase full wave ac-ac controllers with R, L and RL load; Analysis for phase control and integral cycle control; Gating requirements; Sequence Control of AC regulators; 3-phase full wave converter configurations with Y and Δ connected loads and their analysis with R load; AC Voltage controller with PWM control; Basic principle of matrix converter		
3	CYCLOCONVERTERS Introduction; Basic Principle; Single to single-phase cycloconverters; Three-phase half-wave cycloconverters; Cycloconverters for three phase output; Output voltage equation; Output harmonics in cycloconverter; Comparison between cycloconverter and DC link Converter; Load Commutated cycloconverter.	6	16
4	Induction Motor Drives Comparison of ac & dc drive; their selection for particular application; Review of Induction Motor fundamentals: Equivalent circuit, Characteristics, Basic Equations and speed control methods; motoring and braking (3 Hrs) Soft starting: Stator voltage control with AC voltage controller; Six-step VSI inverter based drives; PWM-VSI drives; Braking and multi-quadrant operation of VSI drives; Cycloconverter based induction motor drive; Variable frequency control from a current source; Slip power control using Rotor resistance along-with chopper; Closed loop control schemes; Effect of non-sinusoidal wave form on AC machine performance; (6 Hrs)	9	18
5	Synchronous Motor Drives Three phase synchronous motors; variable speed drives; variable frequency control; self-controlled synchronous motor drive employing load commutated thyristor inverter, self controlled synchronous motor drive employing a cycloconverter.	3	8

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. M D Singh and K B Khanchandani, "Power electronics", TMH, New Delhi, 2nd ed., 2007.
2. Muhammad H. Rashid, "Power Electronics - Circuits, Devices and Applications", Prentice Hall of India, 3rd ed., 2003.
3. Vedam Subramanyam, "Power Electronics – Devices, Converters and Applications", New Age International Publishers Pvt. Ltd., Bangalore, 2nd ed. 2006.
4. P.S. Bimbhra, "Power Electronics", Khanna Publishers, New Delhi, 2012..
5. Ned Mohan, Undeland and Robbins, "Power Electronics – Converters, Applications and Design", John Willey & sons, Inc., 3rd ed., 2003.
6. V.R.Moorthi, "Power Electronics", Oxford University press, 2005.

7. G..K. Dubey, S.R. Doradla, A. Joshi, and R.M.K. Sinha, "Thyristorised Power Controllers", New Age International Ltd. Publishers, 1986 (Reprint 2008).
8. P.T. Krein, "Elements of Power Electronics", Oxford University Press, 1998.
9. G..K. Dubey, " Fundamentals of Electrical Drives", Narosa Publishing House, New Delhi, 2nd ed. 2001.

Course Outcome:

After learning the course the students should be able to:

1. Analyze, operate and design dc-to-ac inverters.
2. Analyze, operate and design ac-to-ac converters.
3. Apply the knowledge of power electronic converter for speed control of AC motors.
4. Simulate power electronic converters and their control scheme.

List of Experiments:

1. SCR based 1-phase ac voltage controller
2. SCR based 3-phase ac voltage controllers for (i) star connected load with neutral (ii) SCR based 3-phase ac voltage controller (star connected load without neutral)
3. SCR based 1-phase cycloconverter working on the principle of integral half cycle control.
4. SCR based 3-phase to 1- phase cycloconverter
5. Performance of 1-phase bridge inverter with R and R-L load
6. Harmonic spectrum of output voltage for unipolar and bipolar PWM controlled half-bridge and full bridge converter.
7. Performance of 3-phase bridge inverter operating with 120° and 180° conduction mode.
8. Simulation of SVPWM and its effectiveness over SPWM
9. Performance of V/F controlled induction motor drive
10. Closed loop speed control of Induction Motor using stator voltage control
11. Simulation of 1-phase bridge type cycloconverter in MATLAB
12. Coding for selective harmonic elimination technique

Design based Problems (DP)/Open Ended Problem:
Faculty teaching the subject shall provide an application oriented course project. The students can work in a group to design a power electronic converter and its control scheme to target different applications

Major Equipment:

Power semiconductor devices, power electronic converter kits, CRO/DSO, load bank, voltage and current probes, AC load and motors, simulation tools like MATLAB, PSIM etc.

List of Open Source Software/learning website:

http://nptel.iitm.ac.in/coursecontents_elec.php
ocw.mit.edu/courses/electrical.../6-334-power-electronics-spring-2007

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL & ELECTRONICS ENGINEERING (08)

DIGITAL CONTROL SYSTEM

SUBJECT CODE: 2160807

B.E. 6th SEMESTER

Type of course: Engineering Automation & Modern Electrical Control

Prerequisite: Fundamentals of Control Theory

Rationale: To grasp the significance of modern developments, a strong foundation is necessary in analysis, design and stability procedures applied to continuous-time linear and nonlinear feedback control systems. Simultaneously, knowledge of the corresponding methods in the digital version of control systems is also required because of the use of microprocessors, programmable logic devices and DSP chips as controllers in modern systems. This course provides systematic approach for the vital theories required for appreciating the past and present status of control engineering.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs.	% Wtg.
1.	**Introduction:** Control System Terminology, Computer-Based Control: History and Trends, Control Theory: History and Trends, An Overview of the Classical Approach to Analog Controller Design	**6**	**12**
2.	**Signal Processing in Digital Control:** Configuration of the Basic Digital Control Scheme, Principles of Signal Conversion, Discrete-Time Signals, Time-Domain Models for Discrete-Time Systems, The z-Transform, Transfer Function Models, Frequency Response, Stability on the z-Plane and the Jury Stability Criterion.	**8**	**16**
3.	**Sample-and-Hold Systems:** The Sampling operation, The Hold operation, Practical Sample-and-Hold Circuit, Sampled Spectra and Aliasing, Reconstruction of Analog Signals, Practical Aspects of the Choice of Sampling Rate, Principles of Discretization	**7**	**14**
4.	**Models of Digital Control Devices and Systems:** z-Domain Description of Sampled Continuous-Time Plants, z-Domain Description of Systems with Dead-Time, Implementation of Digital Controllers, Tunable PID Controllers, Digital Temperature Control System, Digital Position Control System, Stepping Motors and Their Control, Programmable Logic Controllers	**12**	**24**
5.	**Design of Digital Control Algorithms:**	**8**	**14**

	z-Plane Specifications of Control System Design, Digital Compensator Design using Frequency Response Plots, Digital Compensator Design using Root Locus Plots, z-Plane Synthesis		
6.	**Control System Analysis using State Variable Methods** Introduction to State Variable Model, relation between transfer function and state space model for a discrete time system and various standard or canonical state variable models, Characteristic Equation, Eigenvalues and Eigen vectors, Controllabilit and Observability, Stability of discrete state space models, Multivariable Systems.	**10**	**20**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
14	**28**	**28**	**-**	**-**	**-**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. M. Gopal, "Digital Control and State Variable Methods 4/E", McGraw Hill Education
2. Hemchandra Madhusudan Shertukde, "Digital Control Applications Illustrated with MATLAB" 2015, CRC Press
3. B. C. Kuo, "Digital Control Systems 2/E", Oxford University Press-New Delhi
4. Landau Landau, Zito Landau, "Digital Control Systems : Design, Identification and Implementation, 1/E", Springer-Verlag
5. V. I. George, C.P. Kurian, " Digital Control Systems 1/E", Cengage Learning
6. Kavita Singh, Rashmi Vashisth, "Digital Control System", Galgotia Publications

Course Outcome: After learning the course the students will be able to:

1. Students will be able to develop mathematical models for controlling system behaviour.
2. Students will be able to digital control the systems with nonlinear behavious.
3. Students will learn fundamentals and applications of digital control for multidisciplinary engineering problems.
4. Students will learn fundamentals of intelligent/smart control systems used for industrial automation.

List of Experiments:

1. Describes the process of digital control, followed by a review of Z-transforms, feedback control concepts, and s-to-z plane conversions, mappings, signal sampling, and data reconstruction
2. Presents mathematical representations of discrete systems affected by the use of advances in computing methodologies and the advent of computers
3. Demonstrates state-space representations and the construction of transfer functions and their corresponding discrete equivalents

4. Explores steady-state and transient response analysis using Root-Locus, as well as frequency response plots and digital controller design using Bode Plots
5. Explains the design approach, related design processes, and how to evaluate performance criteria through simulations and the review of classical designs
6. Studies advances in the design of compensators using the discrete equivalent and elucidates stability tests using transformations
7. Employs test cases, real-life examples, and drill problems to provide students with hands-on experience suitable for entry-level jobs in the industry

Design based Problems (DP)/Open Ended Problem:

Students may carry out analysis of specific application based intelligent control system with its mathematical analysis and feedback control system. Control system analysis may be of a linear, nonlinear or discrete category and can be carried out using any simulation software.

Major Equipments:

1. All these experimental study with Software Tool: MATLAB.
2. MATLAB contains Control Systems Toolbox, Digital Signal Processing Toolbox, Fuzzy Toolbox, Neural Toolbox.
3. Control Experiment Equipment: PID Control, Discrete-time Control Systems, PLC & PLC Simulator.

List of Open Source Software/learning website:

1. Learning Resource by NPTEL, http://nptel.ac.in/courses/108103008/, Contributors: Indrani Kar, Somanath Majhi, Dept. of Electronics and Electrical Engg., IIT, Guwahati
2. Web Supplements provided by Gopal, M.: http://www.mhhe.com/gopal/dc4e

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL ENGINEERING (09)
ADVANCE MICROCONTROLLERS
SUBJECT CODE: 2160909
B.E. 6th SEMESTER

Type of course: Engineering (Elective)

Prerequisite: Analog and Digital Electronics, Basics of microprocessor and microcontroller

Rationale: This subject focuses on the study of advanced microcontroller along with the use of microcontroller. It also briefs the students about interfacing of memory and various I/O devices like A to D converter, D to A converter LED, LCD to advanced microcontrollers. The students learn the Programming language (Embedded C) used for microcontrollers. They will be able to use the advanced fast microcontroller in electrical engineering related fields like Power system protection, instrumentation, power electronics, Electrical Drives and control of Electrical Equipments.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1.	Advanced concepts in 8051 architecture: Review of 8051 architecture, concept of synchronous serial communication, SPI and I2C communication protocols, study of SPI port on 89LP 51RD2, study of SAR ADC/DAC MCP3304 / MCP 33, interfacing concepts for SPI based ADC/DAC, study of watchdog timer, study of PCA timer in different modes like capture mode, PWM generation mode, High speed output toggle mode Embedded 'C' programming for the above peripherals	15	35
2.	Introduction to ARM CORTEX M profile: CORTEX M0 and M4 cores, Harvard and Von Neumann architectures, CPU Registers, CPU Operating Modes, Thumb-2 Instruction Set, Memory Map, Bus Interface, bit bending , interrupt handling ,NVIC(Nested Vectored Interrupt Controller), system tick timer, Debug system	5	15
3.	Introduction to STM32F4xx architecture: Features of STM32F4XXDSC, Memory and bus architecture, Multilevel AHB bus matrix, Memory organization, Memory map, NVIC Operation Exception Entry And Exit , Reset and Clock Circuit	5	15
4.	Advanced concepts in Embedded 'C' programming: Pointers, structures, unions, pointers to structures, pointers to functions, addressing mechanism for memory mapped registers, enumerators, Interrupt Handlers	7	15

	Embedded software architecture: Round robin architecture, Round robin with interrupt architecture		
5.	STM32F4 PERIPHERALS & PROGRAMING GPIO, General Purpose Timers, GPIO :Introduction, Main Features , Function Description, Registers, Basic timers (TIM6&TIM7): introduction, main features, functional description, registers Embedded C Programming for GPIO and Timers	10	20

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**20**	**30**	**10**	**10**	**10**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Datasheet of 89V51RD2 (www.nxp.com, www.atmel.com)
2. Datasheet MCP3304/MCP4822 (www.microchip.com)
3. The 8051 Microcontroller and Embedded Systems Using Assembly and C, By Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin McKinlay
4. David E. Simon. "An Embedded Software Primer" Addision Wesley Pearson Education, 1999.
5. "The Definitive Guide to ARM® CORTEX®-M3 and CORTEX®-M4 Processors (Third Edition)", By *Joseph Yiu,* Newnes, Elsevier
6. "The insider's guide to the STM32 ARM based Microcontroller", (www.hitex.com)
7. Datasheet, programming and user reference manual of STM32F4xx (www.st.com)
8. "The Designer's Guide to the Cortex-M Processor Family: A Tutorial Approach", By Trevor Martin, Newnes, Elsevier

Course Outcome:

After learning the course the students should be able to:

1. Understand how microcontroller and its peripherals function.
2. Interface to external peripherals
3. Program an embedded system in assembly and C
4. Design, implement and test a single-processor embedded systems for real-time applications
5. Optimizing embedded software for speed and size for industrial applications.

List of Experiments: (This is a suggestive list only)

1. Introduction to Integrated Development Environment KEIL Micro Vision IV
2. Programming of PCA Timer for 8-bit PWM Generation
3. Programming of PCA timer for Variable frequency square wave generation
4. Programming of PCA Timer for Frequency measurement and display on LCD using Capture mode.
5. Programming of SPI port for Interfacing with ADC MCP3304
6. Programming of SPI port for interfacing with DAC MCP4822

7. Programming of Watchdog Timer
8. Introduction to KEIL Microvision IV MDK-ARM IDE
9. Programming of GPIO port with LED toggling and key interface
10. Programming of Base timer for accurate delays
11. Introduction to auto code generation for STM32F4 target using MATLAB Toolbox and Simulink

Design based Problems (DP)/Open Ended Problem:

Implementation of embedded system for industrial application (e.g. instrumentation, control, automation but not limited to these) using any of the 16-bit or 32-bit microcontroller available in the market, in guidance of course instructor

Major Equipment: Kit for advanced 8051 controller, and advanced 16bit/32 bit controllers, µVISION2/3/4 IDE,

List of Open Source Software/learning website: NPTEL, www.infineon.com, www.silabs.com

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL ENGINEERING (09)
ELECTRICAL DRIVES
SUBJECT CODE: 2160910
B.E. 6th SEMESTER

Type of course: NA

Prerequisite: Power Electronics - I

Rationale: Today's industrial and domestic loads demands precise and smooth variable speed control. The development of compact thyristor power converters has made this possible by smooth speed control of both AC and DC motors which are employed for several applications such as DC/AC drives, Vehicles and renewable energy. This course enables to develop the basics of electric drives and maintain different types of DC in industries. The competency in this area is highly required in diploma pass outs working in most of the industries since these industries employ large number of motors and drives and their smooth operation and maintenance requires lot of competent man power. Thus this course is must for students who want to work in industries.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1.	**Introduction:** • History Of Dc Drive -Electronic Control -Solid State Control • State Of Art Of Dc Drive • Block Diagram Of Drive - Part Of Electrical Drive	03	7
2.	**Dynamics of Electrical Drives** Types of Load-Quadratal diagram of speed –torque characteristics – Types and Characteristics of load torque – Dynamics of motor- load combination – steady state & transient stability of an electrical drive – Determination of moment of inertia.	04	10
3.	**Converters and control** a. Phase controlled converters b. Four quadrant operation c. Choppers d. AC to DC converters e. Inverters and PWM Techniques.	9	21
4.	**Adaptive control techniques for Electric Drives** a. Self tuning control b. Model Referencing Adaptive Control (MRAC) c. Sliding Mode Control	6	10

5.	**DC motor drives** a. Speed-torque characteristics DC shunt, PMDC and series motors b. Dynamic model c. Speed and position control methods	**8**	**20**
6.	**AC motor drives** a. d-q model of induction motor b. constant flux speed control structure c. vector control model d. vector control structure e. Synchronous motor and BLDC machine drive-Introduction	**08**	**20**
7.	**Applications of Electric Drives** a. Introduction to Solar and battery powered Drives b. Introduction to traction Drives c. Servo motor drive requirement – control and implementation	**04**	**12**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks (%)					
R Level	U Level	A Level	N Level	E Level	C Level
10	**30**	**20**	**20**	**10**	**10**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Bimal K. Bose, "Modern Power Electronics and AC Drives", Pearson Education
2. Vedam Subrahmanyam, "Electric Drives", TMH (I), Second Edition,
3. G.K. Dubey, " Fundamentals of Electrical Drives", Narosa Publishing House, New Delhi, 2nd ed. 2001.
4. Ned Mohan, Undeland and Robbins, "Power Electronics – Converters, Applications and Design", John Willey & sons, Inc., 3rd ed., 2003.
5. R.Krishnan, "Electric Motor Drives–Modeling, Analysis and Control" PHI
6. Theodore Wildi, "Electrical Machines, Drives and Power Systems", sixth edition, Pearson

Course Outcome:

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

After learning the course the students should be able to:

1. Select a drive for a particular application based on power rating.
2. Select a drive based on mechanical characteristics for a particular drive application.
3. Operate and maintain solid state drives for speed control of DC and AC machines.
4. Operate and maintain solid state drives for speed control of various special electrical machines

Laboratory Work:

Directions for Laboratory work:

- The list of experiments is given as a sample.
- Minimum 10 experiments should be carried out.
- At least one experiment should be selected from each group.
- Similar laboratory work fulfilling the objectives can also be considered.
- Each experiment should be simulated before verifying practically.
- As far as possible, **printed manual should be preferred** so that students can concentrate in laboratory experiments and related study.

List of Experiments:

1. To study the fundamental and block diagram of Electric drive.
2. To study different methods of speed control of D.C. Motor.
3. To study and simulate 1- Φ Semi Control of D.C. separately excited Motor.
4. To study and simulate 1- Φ Fully Controlled converter of separately excited Motor.
5. To study the control techniques used in D.C. chopper.
6. To study control of D.C. motor for (a) Current limit control (b) Closed loop torque control(c) Closed loop speed control.
7. To study chopper control of D.C. Motor for motoring and generating control.
8. To study D.C. Motor drive using PLL.
9. To study and simulate AC voltage controller based speed control of AC motor.
10. To study and simulate Inverter based speed control of Induction/Synchronous motor.
11. To study and simulate Cycloconverter based speed control of synchronous motor.
12. To study and simulate AC voltage controller based speed control of AC motor.
13. To study solar and battery powered drives.
14. To study traction drives.

Design based Problems (DP)/Open Ended Problem:

1. Specify the appropriate power circuit configuration amongst the phase controlled rectifiers
2. Choppers for the speed control of DC motor drives for four-quadrant operation with current limit.
3. AC voltage controllers and Inverter for speed control of AC motor drive.
4. Simulate/Implement speed control scheme for DC/AC motor drives.
5. Select an appropriate power semiconductor device and design a power converter for the required application for DC/AC Drive
6. Determine the power circuit configuration needed to fulfill the required power conversion with applicable constraints in view of DC /AC Drive.

Major Equipment:

1. 4 ½ digit Digital Multimeter
2. Digital Tachometer
3. Four channel Digital Oscilloscope
4. Various Trainer boards for DC and AC Drives.
5. Any one simulation software (Open source software preferred) : Scilab/Matlab and Simulink toolbox, CASPOC

List of Open Source Software/learning website:

1. http://www.electrical4u.com/electrical-drives/

2. http://nptel.ac.in/courses/108104011/
3. http://electrical4u.com/types-of-dc-motor-separately-excited-shunt-series-compound-dc-motor/
4. https://www.wisc-online.com/learn/career-clusters/stem/iau13208/fundamentals-of-a-dc-motor
5. http://www.ni.com/white-paper/3656/en/
6. http://www.minarik.com/drupal/content/products/Electrical%3E%3EControl%3E%3EDrives%3E%3EDC%20Drives/0
7. http://electrical-engineering-portal.com/download-center/books-and-guides/siemens-basics-of-energy/basics-of-dc-drives
8. https://www.joliettech.com/products/dc-variable-speed-drives/dc-drive-fundamentals/
9. http://www.eetimes.com/
10. http://www.ohioelectricmotors.com/a-guide-to-electric-drives-and-dc-motor-control-688
11. http://www.slideshare.net/psksiva13/63814075-electricaldrivesandcontrollecturenotes
12. http://metalab.uniten.edu.my

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GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL & ELECTRONICS ENGINEERING (08)

ROBOTICS PROGRAMMING AND APPLICATIONS

SUBJECT CODE: 2160808

B.E. 6th SEMESTER

Type of course: Multidisciplinary Engineering Course of Robotic Systems.

Prerequisite: Advance Engineering Mathematics, Fundamentals of Control Theory

Rationale: Today's industrial assembly line is equipped with robots and man vs. machine interface has been replaced by automation. Many industrial machines and plants are available with variety automatic controls. It is therefore need of the day for students to learn Robotics for working in modern industry. This course therefore attempt to build required skills to understand the basic principles, design, analysis, and synthesis of robotics system.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs.	% Wtg.
1.	**Fundamentals:** What is Robot?, Classification of Robots, What is Robotics?, History of Robotics, Advantage and Disadvantages of Robots, Robot Components, Robot Sensing, Robot Degree of Freedom, Robot Joints, Robot Coordinates, Robot Reference Frames, Programming Modes, Robot Programming Language, Robot Applications	**4**	**12**
2.	**Robot Arm Kinematics:** Robots as Mechanisms, Conventions, Matrix Representation: Representation of a Point in Space; Representation of a Vector in Space, Representation of Rigid Body, The Direct Kinematics Problem, The Inverse Kinematics Solution	**4**	**12**
3.	**Robot Arm Dynamics:** Lagrange-Euler Formulation, Newton-Euler Formation, Effective Moments of Inertia, Generalized D'Alembert Equation of Motion,	**3**	**9**
4.	**Panning of Manipulator Trajectories:** Path versus Trajectory, Basics of Trajectory Planning, General Consideration on Trajectory Planning, Joint-interpolated Trajectories, Planning of Manipulator Cartesian Path Trajectories	**4**	**12**
5.	**Control of Robot Manipulators:** Characteristics of Actuating Systems, Comparison of Actuating Systems, Hydraulic Actuators, Pneumatic Devices, Electric Motors: AC Motors; DC Motors; Servomotors; Stepper Motors, Microprocessor Control of Electric	**8**	**20**

	Motors, Magnetostrictive Actuators, Speed Reduction, Other Systems		
6.	**Sensors:** Sensor Characteristics, Sensor Utilization, Position Sensors: Potentiometers; Encoders; LVDT; Resolves; LMDT; Hall-effect Sensors, Velocity Sensors: Encoders; Tachometers; Differentiation of Position Signals, Acceleration Sensors, Force and Pressure Sensors: Piezoelectric; Force Sensing Resistor; Strain Gauge, Torque Sensors, Microswitches, Visible Light and Infrared Sensors, Touch Sensors, Proximity Sensors, Range Finder, Sniff Sensors, Vision System, Voice Recognition Devices, Voice Synthesizers.	**8**	**20**
7.	**Robot Programming Languages:** Characteristics of Robot Level Languages, A brief about AL and AML robot programming languages, Position Specification, Motion Specification, Sensing and Flow of Control, Programming Support, Characteristics of Task Level Languages, World Modeling, Task Specification, Robot Program Synthesis, Concluding Remarks	**5**	**15**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
14	**28**	**28**	**-**	**-**	**-**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, "Robotics: Control, Sensing, Vision and Intelligence", McGraw Hill Education (India Ed.)
2. Saeed B. Niku, "Introduction to Robotics: Analysis, Control, Application 2/E", Wiley India Edition
3. S.K. Saha, "Introduction to Robotics 2/E", McGraw Hill Education (India Ed.)
4. R.K. Mittle, I.J. Nagrath, " Robotics and Control", McGraw Hill Education (India Ed.)
5. Thomas R. Kurfess, " Robotics and Automation Handbook", CRC Press
6. Ashitava Ghosal, "Robotics: Fundamental Concepts and Analysis 1/E", Oxford University Press

Course Outcome: After learning the course the students will be able to:

1. Students will be able to learn fundamental mathematical concepts and analytical tools required to develops the relevant theory and algorithms.
2. Students will be able to understand fair amount of mechanics and kinematics of robots.
3. Students will learn microprocessor applications, control systems, vision systems, sensors and actuators.
4. Students will learn fundamentals of intelligent/smart control systems and programming of robotics.

List of Experiments:

1. Configure the working of robots
2. Demonstrate the different types of sensor in robotics
3. Interface sensors using Microprocessor or Microcontroller
4. Measure various parameters of Electro-Mechanical Instruments Pressure, Flow, Speed and Moisture
5. Interface Actuators using Microprocessor or Microcontroller
6. Interface Drives using Microprocessor or Microcontroller
7. Interface Stepper Motor using Microprocessor or Microcontroller
8. Use robot trainer to perform different tasks
9. Develop a Program for Line Follower Configuration.
10. Develop a Program for coffee maker configuration

Design based Problems (DP)/Open Ended Problem:

Following is the list of proposed student activities:

1. Prepare journals based on practical performed in laboratory.
2. Do assignments on modeling robotics.
3. List various Robot controlling parameters and find how they affect the performance of Robots
4. List two different types of Robots and their application.
5. Download free simulation software and check program on it.
6. Visit Industries having robots and prepare specification list, understand operational and maintenance practices.
7. Download videos of robotic applications

Major Equipments:

1. Experimental study with Software Tool: MATLAB.
2. Programmable Robot trainer [Minimum 3 linkages, Minimum 4 degree of freedom, mechanical end effect or with servo control Interfacing card (RC servo output, sensors input)].

List of Open Source Software/learning website:

1. Learning Resource by NPTEL, http://www.nptel.ac.in/courses/112101099/, Contributors: Prof. P. Seshu, Prof. P.S. Gandhi, Prof. K. Kurien Issac, Prof. B. Seth, and Prof. C. Amarnath, Dept. of Mechanical Engg., IIT, Bombay
2. Learning Resource by NPTEL, http://www.nptel.ac.in/courses/112108093/, Contributors: Prof. Ashitava Ghosal, Dept. of Mechanical Engg., IISc, Bangalore
3. https://www.youtube.com/watch?v=fH4VwTgfyrQ, "ABB Robotics - 10 most popular applications for robots", ABB Robotics, You Tube - Channel.
4. http://www.robotics.org/, Online Resource for Industrial Robotics.

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