GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170001
Semester –VII
Subject Name: Summer Internship

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)	
0	0	4	2	0	0	80	20	100

The duration of internship will be two weeks. It will be after completion of 6th Semester and before the commencement of Semester VII.

Following five options can be opted by the students:

1. Offline internship in industry - Internship in industry subjected to permissions from Government and concern Industry subject to the conditions of following the SOP issued by Government and written consent of the student and parents. Student is supposed to produce joining letter and relieving letter once the internship is over in case of Offline internship in any industry.
2. Online internship in industry / other agencies
3. Seminar by student under mentorship of a faculty. The topic shall be as per UG Syllabus topics
4. Preparation of consolidated report on survey of materials used in the respective branch of the student. The work should include the study of catalogues, price list specifications, properties, usage notes and other technical details and drawings etc, Work shall be carried out under the guidance of faculty. A detailed report shall be submitted. It shall be done by only one student. It is to be completed individually.
5. A Mini Project- on some suitable topic related to respective branch. It can be small fabrication / experimental results/ simulations / Programmes/ application development etc depending on the branch of the student. Preferably a single student should do it.

Other guidelines:

- Student has to prepare detailed report and submit to his/her college. A copy of report can be kept in the departments for record.
- Each student must be assigned a faculty as a mentor from the college and an Industry expert as co-mentor.
- The evaluation of the work done by students will be carried out after 2 weeks by the internal and external examiner.
- External examiner will evaluate for 80 marks and internal examiner will evaluate for 20 marks.
- The presentation by student in the presence of all student is desirable.

Student should produce successful completion certificate in case of offline / online internship in industry.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170906
Semester – VII
Subject Name: Advanced Power Electronics

Type of course: Professional Elective Course

Prerequisite: Power Electronics (3140915)

Rationale:

The course is aimed to provide exposure of some power electronic converters that are utilized by the industries and utilities and are not taught in the basic courses on Power Electronics-I and Power Electronics-II.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE Viva (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Switching Voltage Regulators** Review of basic dc-dc voltage regulator configurations -Buck, Boost, Buck-Boost converters, Flyback and Forward Converter (2 -3Hrs); Other converter configurations like Half bridge, Full bridge configurations, Push-pull converter, C'uk converter, Sepic Converter; Design criteria for SMPS; Multi-output switch mode regulator; Design of Inductor and high frequency transformer	**10**
2	**Resonant Converters** Introduction, Need of resonant converters, Classification of resonant converters, Load resonant converters, Resonant switch converters, zero-voltage switching dc-dc converters, zero current switching dc-dc converters, clamped voltage topologies	**7**
3	**Multi-level converters** Need for multi-level inverters, Concept of multi-level, Topologies for multi-level: Diode Clamped, Flying capacitor and Cascaded H-bridge multilevel Converters configurations; Features and relative comparison of these configurations, Applications, Introduction to Carrier based PWM technique and SVPWM for Multilevel converters	**7**
4	**Multipulse Converters** Concept of multi-pulse, Configurations for m-pulse (m=12,18,24 ….) converters, Different phase shifting transformer (Y-Δ1, Y-Δ2, Y-Z1 and Y-Z2) configurations for multi-pulse converters, Applications	**6**
5	**HVDC Transmission** Introduction, Operation of 12-pulse converter as receiving and sending terminals of HVDC system, Equipment required for HVDC System and their	**5**

	significance, Comparison of AC and DC transmission, Control of HVDC transmission	
6	**FACTS devices** Importance of reactive power compensation, Flow of power in AC system and conventional control mechanisms, Definition of Flexible ac Transmission Systems (FACTS) and brief description, possible benefits from FACTS, Thyristor- Controlled Reactor (TCR), Fixed Capacitor-Thyristor-Controlled Reactor (FC-TCR), Thyristor-Switched capacitor and Reactor, Thyristor-Switched capacitor-Thyristor-Controlled Reactor (TSCTCR), STATCOM configuration and operating principle, Static characteristics of SVC and STATCOM Comparison of SVC and STATCOM, Principle of series compensation, Introduction to Static Synchronous Series Compensator, Advantages and limitation of SSSC, Introduction to UPFC and operating principle	**10**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**30**	**30**	**15**	**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. Ned Mohan, Tore M. Undeland and William P. Robbins, "Power Electronics – Converters, Applications and Design", John Willey & sons, Inc., 3rd ed., 2003.
2. Muhammad H. Rashid, "Power Electronics - Circuits, Devices and Applications", Prentice Hall of India, 3rd ed., 2009.
3. Bin Wu, "High Power Converters and AC Drives", John Willey & sons, Inc., 2006.
4. Derek A. Paice "Power Electronic Converter Harmonics – Multipulse Methods for Clean Power", IEEE Press, 1996.
5. Muhammad H. Rashid , "Power Electronics Handbook", Elsevier, 3rd ed., 2011.
6. P.C.Sen, "Modern Power Electronics ", S. Chand and Co. Ltd., New Delhi, 2000.
7. Vijay K. Sood, "HVDC and FACTS Controllers Applications of Static Converters in Power Systems", Kluwer Academic Publishers, Boston, 2004.
8. L. Umanand, "Power Electronics Essentials and Applications", Wiley India Ltd., 2009
9. Recent Literature

Course Outcomes:

After learning the course the students should be able to:

Sr. No.	CO statement	Marks % weig4tage
CO-1	Evaluate different dc-dc voltage regulators	24
CO-2	Simulate and analyze resonant converters	16
CO-3	Evaluate various multi-level inverter configurations and Select appropriate phase shifting converter for a multi-pulse converter	27
CO-4	Describe and simulate HVDC transmission system	09
CO-5	Compare various FACTS devices for VAR compensation	24

List of Experiments:

Lab experiments shall be based on the course content and few experiments shall involve the analyzing and designing skills besides the basic understanding of the subject. A list provided here is to indicate the type of experiments that can be included.

1. Evaluate the performance and operating modes of SLR/PLR dc-dc converter with the change in switching frequency.
2. Simulate/Design a circuit for a Buck Converter with ZVS/ZCS to regulate the output voltage Vo with a given input voltage Vin.
3. Carrier based Sine PWM control of a CHB multilevel inverter and study of harmonic spectrum.
4. Study the operation and performance of half-bridge, full-bridge, push-pull converters etc.
5. Study the operation and performance of fourth order converters like C'uk or Sepic converters
6. Evaluate the performance of STATCOM/SVC as a shunt compensator.
7. Study of harmonic spectrum for 12 and 18 pulse converters.

Major Equipment:

Simulation software like MATLAB, PSIM, Scilab, Power Electronic Converters, CRO/DSO, meters, Current/Voltage Probes, Isolation transformer etc. as demanded by the course.

List of Open Source Software/learning website:

1. MIT OPEN COURSEWARE by Massachusetts Institute of Technology
   - website: ocw.mit.edu
2. Courses available through NPTEL.
   - website : nptel.ac.in

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170908

Semester – VII
Subject Name: Switchgear and Protection

Type of course: Professional Core Course

Prerequisite: Power System – I
Power System – II

Rationale: An electrical power system consists of generators, transformers, and transmission and distribution lines. In the case of an event of a fault, an automatic protective scheme comprising of circuit breakers and protective relays isolate the faulty section protecting the healthy part of the system. The safety of equipment and human beings is the major concern for every protection scheme. Moreover, students must develop skills for operating various controls and switchgear in the power system. They are also required to carry out remedial measures for faults/abnormalities in machines/equipment in the power system using appropriate diagnostic instruments/devices. This course attempts to develop these skills in students and hence it is a core course for all electrical engineers.

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)	
4	0	2	5	70	30	30	20	150

Sr. No.	Content	Total Hrs
1	**Fundamentals of Power System Protection:** Introduction to Protective Relaying, Function of the Protective Relaying, Faults and Abnormal Operating Conditions, Desirable Qualities and Terms of Protective Relaying, System Transducers, Basic Tripping Mechanism of a relay, Types and operating principles of various protective relays, Simple Differential Protection, Zone of Protection and Actual Behavior of Simple Differential Protection, Percentage Differential Protection, Earth Leakage Protection [1, 3, 4].	**06**
2	**Overcurrent Protection of the Transmission Line:** Introduction, Thermal Relays, Over Current Relays, Types of Relay Characteristics, Application of Definite Time & IDMT O.C. Relays for Protection of Feeder, Relay Coordination, Directional Over Current Relay, Limitations of O.C. Relays [1].	**05**
3	**Distance Protection of Transmission Line:** Introduction to Distance Protection, Types of Distance Relay, Impedance, Reactance, MHO Relay, Performance of Distance Relay During Normal Load and Power Swing, Effect of Arc Resistance on Reach of Distance Relays, Comparison of Distance Relays, Distance Protection of Transmission line, Reasons for Inaccuracy of Distance Relay	**07**

	Reach, Three Step Protection, Trip contact configuration, 3-step protection of double end fed lines [1].	
4	**Transformer Protection:** Faults and Abnormal Conditions in Transformer, Non-electrical Protection, Overcurrent Protection, Earth Fault Protection, Inter-turn Protection, Differential Protection [4].	**06**
5	**Bus-zone Protection:** Non-Unit Protection by Back-up Relays, Differential Protection of Busbars, External and Internal Fault, Protection of Three-phase Busbars [1,4]	**05**
6	**Generator Protection:** Various faults & abnormal operation conditions in a Generator, Stator & rotor faults, Transverse differential protection of a Generator, Unbalanced loading, Over speeding, Loss of excitation, Loss of prime mover [1].	**06**
7	**Induction Motor Protection:** Various faults & abnormal operation conditions in an Induction Motor, Starting of induction motor, Protection of small & large induction motor [2].	**06**
8	**Current and Voltage Transformer:** Construction of Current Transformers, Difference Between CT Cores Used for Measurement and those Used for Protective Relays, Calculation of CT Accuracy, Factors to be Considered while Selecting a CT, Construction of Potential Transformer, Specifications of Voltage Transformer, Capacitor Voltage Transformer.	**05**
9	**Circuit Breaker:** Classification of switchgear and fields of application and relative merits. Theories of current interruption, Energy balance and recovery rate theories, Air Circuit Breaker(ACB), Air Blast Circuit Breaker (ABCB), Practical systems of arc quenching in oil circuit breakers, Construction and operation of bulk oil, Minimum Oil Circuit Breakers, Recent trends in H.V. Circuit Breakers, Sulphur Hexafluoride Circuit Breaker (SF6), Vacuum Circuit Breaker (VCB), Rating of Circuit Breakers, Testing of Circuit Breakers, Miniature Circuit Breakers, Earth Leakage Circuit Breakers [3].	**07**
10	**Modern Trends in Power System Protection** Introduction to static and digital relays, Introduction to adaptive relays. [6]	**03**

Suggested Specification table with Marks (Theory): (For PDDC only)

Distribution of Theory Marks

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170908

R Level	U Level	A Level	N Level	E Level	C Level
20	20	30	15	10	5

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 the above table.

Reference Books:

1. Fundamentals of Power System Protection –Y. G. Parithankar & S. R. Bhide, 2nd edition, PHI
2. Power System Protection and Switchgear by Badari Ram , D.N Viswakarma, TMH Publications
3. Power system protection and switchgear by Oza, Nair, Mehta, Makwana
4. Protection and switchgear, by Bhavesh Bhalja, R.P.Maheshwari, Nilesh hotani,1st edition, 2011, Oxford Publication
5. Power System Protection and Switchgear –B. Ravindranath and M. Chander
6. Power System Protection & Switchgear by B. Ram, McGraw Hill
7. Power System Protection- Static Relays by T.S.M. Rao Tata McGraw Hill
8. Art and Science of Protective Relaying –Russel Masson

Course Outcomes:

S. No	CO STATEMENT	Bloom's taxonomy level	Marks % weightage
CO1	Acquire the knowledge of various abnormal conditions that could occur in electrical system and protective relays	**Remember L1 , Understand L2, Evaluate L5,**	**15%**
CO2	Knowledge of various conventional relays, their design and latest developments	**Remember L1 , Understand L2, Evaluate L5,**	**25%**
CO3	Ability to understand and design various protective devices in power system for protecting equipment and personnel.	**Remember L1 , Understand L2, Evaluate L5 Create L6**	**40%**
CO4	Knowledge of various types of instrument transformers, circuit breakers with their design and constructional details.	**Remember L1 , Understand L2, Evaluate L5 Create L6**	**20%**

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

CO' s	Program Outcomes (PO's)

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170908

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	2	2	2	1			1			1	1
CO2	3	1	3	2	2	1						2
CO3	1	3	3	2							1	
CO4	2	2	1	1							1	1

1: Slight (Low) **2: Moderate (Medium)** **3: Substantial (High)** **: None**

Suggestive List of Experiments:

1. To check performance/ study of a 3-Phase Differential Relay.
2. To check performance/ study of an over current Relay.
3. To check performance/ study of the Numerical Protection of induction motor.
4. To obtain the operating characteristics of an IDMT relay.
5. To study the operating characteristics of directional over current relay.
6. To check performance/ study of the operating characteristics of the transformer percentage differential relay.
7. To study the magnetic inrush current in a transformer and its protection.
8. To study radial feeder protection using two overcurrent and one Earth fault relay.
9. To obtain and study the magnetization characteristic of CT.
10. To study the protection schemes for different abnormal conditions in an alternator.
11. To study Buchholz relay for transformer protection.
12. To study generalized block diagram of Numerical Relay

Design based Problems (DP)/ Open Ended Problem:

1. The students can be asked to collect the data of a small power system network. Then the student is asked to design a complete protection scheme of the component of the power system like a feeder, a transmission line, transformer, and a generator. The design should include the selection of circuit breaker rating and the relay settings wherever applicable.

2. Students can study and verify various settings of a generator.

3. Students simulates various system and explore how to source impedance and fault location affect the performance of protective relays.

4. With appropriate simulation explain the selectivity of a protective relay.

5. Study and verify factors that will affect CT accuracy and corrective measures.

Major Equipments:

Electromechanical Relay, Static / Numerical Relay, Testing Panels, CT, PT, Timers, Circuit Breakers.

List of Software/learning website:

- MATLAB
- PSCAD
- EMTP
- NPTEL https://nptel.ac.in/courses/108/101/108101039/
- SWAYAM https://onlinecourses.nptel.ac.in/noc20_ee80/preview

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170909
Semester – VII
Subject Name: AC Machine Design

Type of course: Professional Elective Course

Prerequisite:

Rationale:

Electrical machines serve as the backbone for the electrical power sector. The knowledge of electrical machines design is essential for manufacturing as well as the pre-installation performance analysis. The design is also essential for the practicing engineers in the research and development field. This subject deals with design of electrical machines including basics of computer aided design.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE Viva (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Introduction** Major considerations in electrical machine design, Electrical engineering materials, Space factor, Choice of specific electrical and magnetic loadings, Thermal considerations, Heat flow, Temperature rise, Rating of machines.	05
2	**Design of transformers** Sizing of a transformer, Main dimensions, kVA output for single- and three-phase transformers, Window space factor, Overall dimensions, Operating characteristics, Voltage regulation, No load current, Temperature rise in transformers, Design of cooling tank, Methods for cooling of transformers.	10
3	**Design of induction motors** Sizing of an induction motor, Main dimensions, Length of air gap, Rules for selecting rotor slots of squirrel cage machines, Design of rotor bars & slots, Design of end rings, Design of wound rotor, Magnetic leakage calculations, Leakage reactance of poly phase machines, Magnetizing current, Short circuit current, Circle diagram, Operating characteristics.	10
4	**Design of synchronous machines** Sizing of a synchronous machine, Main dimensions, Design of salient pole machines, Short circuit ratio and its significance, Shape of pole face, Armature design, Armature parameters, Estimation of air gap length, Design of rotor, Design of damper winding, Determination of full load field mmf, Design of field winding, Design of turbo alternators.	10
5	**Computer aided design** Need for CAD analysis, Synthesis and hybrid methods, Design optimization methods, Variables, Constraints and objective function, Problem formulation. Introduction to FEM based machine design. Introduction to **c**omplex structures of modern machines- Permanent Magnet Synchronous Machines, Brushless DC Machines and Switched	10

	Reluctance Machines.	

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	20	30	25	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. A. K. Sawhney, "A Course in Electrical Machine Design", Dhanpat Rai and Sons, 2010
2. R. K. Agarwal, "Principles of Electrical Machine Design", S. K. Kataria and Sons, 2009
3. M.G. Say, "Theory & Performance & Design of A.C. Machines", CBS Publishers, 2005
4. S. K. Sen, "Principles of Electrical Machine Design with computer programmes", Oxford and IBH Publishing, 2006.
5. K. M. V. Murthy, "Computer Aided Design of Electrical Machines", B.S. Publications, 2015.
6. Electrical machines and equipment design exercise examples using Ansoft's Maxwell 2D machine design package.

Course Outcomes:

After completing the course, students will be able to;

Sr. No.	CO statement	Marks % weightage
CO-1	Select appropriate design parameters according to applications and rating of electrical machines	20
CO-2	Design the AC machines as per the given specifications	40
CO-3	Evaluate the performance parameters of electrical machines using design parameters	20
CO-4	Formulate the optimum design problem and solve it with computer aided tools	20

List of Experiments:

This is a suggestive list only:

1. Electrical machine design problems should be given for practice to the students. At least 8-10 design problems with different ratings should be practiced by the students
2. Computer aided design problems 1-2 should be practiced by the students

3. 3D visualization of various electrical machine components should be demonstrated to students during lab sessions using open source softwares.

Major Equipment:

Charts and cut section models of various electrical machines, CAD softwares like ANSYS etc..

List of Open Source Software/learning website:

- E-materials available at the website of NPTEL- http://nptel.ac.in/

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170914
ADVANCED MICROCONTROLLERS
7thSEMESTER

Type of course: Engineering

Prerequisite: Basics of Microprocessors and Microcontrollers

Rationale: Microprocessor and microcontrollers are used to design and develop processor and computer based automatic smart electronics systems for home and industry application. This subject is devoted to the study of Advanced Microcontrollers which are used to develop and design embedded systems having low cost, low energy consumption with limited memory and having real time response. The students would learn the architecture and programming of ARM Controller in 'C' and in Assembly Language. They would also be able to develop simple applications by interfacing various sensor and actuators with the ARM controller.

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)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Basics of ARM Controllers:** The Acorn RISC Machine, Architectural inheritance, The ARM Programmer's model, ARM development tools [1]	02
2	**ARM Architecture & Assembly Language Programming:** The General Purpose Registers in ARM, The ARM Memory Map, Load and Store Instructions in ARM, ARM CPSR, ARM Data Format & Directives, Introduction to ARM Assembly Programming, Assembling an ARM Program, The Program Counter and Program ROM Space in ARM, Some ARM addressing modes, RISC Architecture in ARM, Viewing Registers and Memory with ARM Keil IDE.[2]	06
3	**Arithmetic and Logic Instructions & Program**: Arithmetic Instructions, Logic Instructions, Rotate and Barrel Shifter, Shift and Rotate Instructions in ARM Cortex, BCD and ASCII Conversions.[2]	05
4	**Branch, Call and Looping in ARM:** Looping and Branch Instructions, Calling Subroutine with BL, ARM Time Delay and Instruction Pipeline, Conditional Execution [2]	05
5	**Signed Numbers and IEEE 754 Floating Point :** Signed Numbers Concept, Signed Number Instructions and Operations, IEEE 754 floating point standards[2]	02
6	**ARM Programming Using C:** Overview of C compilers and Optimization, Basic 'C' data types, C looping Structures, Register Allocation.[3]	05

7	**Exception & Interrupt Handling:** ARM Processor Exception and Modes, Vector Table, Exception Priorities, Link Register Offsets, Interrupts, Assigning Interrupts, Interrupt Latency, IRQ and FIQ exceptions, Basic Interrupt Stack Design and Implementation[3]	**05**
8*	**Microcontroller development Boards**: About STM32F401 Nucelo board, PWM and the Interrupt on STM32F401, Mbed C Programming Environment.[4] ,	**03**
9*	**Interfacing of Microcontroller development Boards:** Interfacing of STM32F401 Board, Interfacing LED and LCD, Serial port terminal application, Interfacing of temperature sensor, Interfacing of LDR light sensor, Speaker interfacing, Microphone interfacing, Speed control of DC motor using STM32, Accelerometer and its interfacing with STM32, Bluetooth interfacing, Interfacing of gas sensor with STM32 [4]	**12**

*Students are advised to refer NPTEL course of "Embedded system Design with ARM" by Indranil Sengupta & Kamalika Datta and download course (but not limited to) Lecture Nos: 10, 11, 15, 16, 18, 19, 20, 22, 23, 24, 25, 26, 28, 29, 32, 38, 39, 40, 41 for understanding topics given in Sr. No 8 and Sr. No 9. (Link: https://nptel.ac.in/courses/106/105/106105193/)

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 & Online Course:

1. ARM, System-on-chip architecture by Steve Furber, *Addison Wesley Publications*
2. ARM Assembly Language Programming & Architecture by Muhammad Ali Mazidi, Sarmad Naimi, Sepehr Naimi, Janice Mazidi *E-book available*
3. Arm system Developer's Guide –Designing and Optimizing System Software by Andrew Sloss, Dominic Symes and Chris Wright – *Morgan Kaufman Publishers*
4. NPTEL course entitled "Embedded system Design with ARM" by Indranil Sengupta & Kamalika Datta

Course Outcomes:

After learning the course, the students should be able to:

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Describe the basics of RISC machine and ARM controller	
CO-2	Develop assembly language/ embedded C- language code for a given problem	
CO-3	Use ARM development boards and its exception and interrupt handling functionality	
CO – 4	Evaluate the various unsupervised Learning algorithms using appropriate Dataset.	
CO-5	Interface microcontroller development board with various sensors and display devices for given application/problem	

Suggested List of Experiments:

1. Introduction to ARM architecture
2. Assembly language programming of ARM using data transfer, arithmetic and logical group instructions. (Use of ARM Keil is recommended)
3. Assembly language programming of ARM using branching group (Use of ARM Keil is recommended)
4. LED and LCD interfacing with STM32
5. Interfacing of LM35 temperature sensor with STM32F401 Nucleo board
6. Interfacing of electric bulb with STM32 through SRD-05DC-SL-C relay
7. Interfacing of LDR with STM32 board
8. Speed control of DC motor using STM32
9. Bluetooth interfacing with STM32
10. Accelerometer interfacing with STM32

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170915
POWER SYSTEM DYNAMICS AND CONTROL
B.E. 7th SEMESTER

Type of course: Engineering Science (Electrical)

Prerequisite: Basic understanding of power system.

Rationale: Ultimatum of electrical energy is swelling day by day due to upgrading in the life style of the societies of the countries in broad-spectrum. On the other hand, dynamics of power system and it control is becomes a more and more complicated due to increasing in power system complexity. Under this scenario, this syllabus includes various types of stability issues with its improving techniques. This subject is main source for research point of view as a further studies of electrical engineer. With this context, this subject deals with the fundamentals for dynamics of power system and it control of the power system.

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)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1.	**Basic Concepts and Review of Classical Methods** 1.1 General 1.2 Power System Stability 1.3 States of Operation and System Security - A Review 1.4 System Dynamic Problems - Current Status and Recent Trends 1.5 System Model 1.6 Some Mathematical Preliminaries [3, 4] 1.7 Analysis of Steady State Stability 1.8 Analysis of Transient Stability 1.9 Simplified Representation of Excitation Control	7
2.	**Modelling of Synchronous Machine** 2.1 Introduction 2.2 Synchronous Machine 2.3 Park's Transformation 2.4 Analysis of Steady State Performance 2.5 Per Unit Quantities 2.6 Equivalent Circuits of Synchronous Machine 2.7 Determination of Parameters of Equivalent Circuits 2.8 Measurements for Obtaining Data 2.9 Transient Analysis of a Synchronous Machine	12

3.	**Excitation and Prime Mover Controllers** 3.1 Excitation System 3.2 Excitation System Modelling 3.3 Excitation Systems- Standard Block Diagram 3.4 System Representation by State Equations 3.5 Prime-Mover Control System 3.6 Examples	**9**
4	**Transmission Lines, SVC and Loads** 4.1 Transmission Lines 4.2 D-Q Transformation using α - β Variables 4.3 Loads	**7**
5.	**Dynamics of a Synchronous Generator Connected to Infinite Bus** 6.1 System Model 6.2 Synchronous Machine Model 6.3 Application of Model 1.1 6.4 Calculation of Initial Conditions 6.5 System Simulation 6.6 Consideration of other Machine Models	**10**
	Total	**45**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks (%)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**Total**
20	**25**	**10**	**30**	**15**	**100**

Legends: R: Remembrance; U= Understanding; A= Application; N= Analyze; E= Evaluate

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.R.Padiyar, "Power System Dynamics, Stability & Control", BS Publications, Hyderabad - 500 095 - AP., Second Edition, 2008.
[2] P. Kundur, "Power system stability and control", McGraw Hill Inc, New York, 1995.
[3] P.M. Anderson and A.A.Fouad, "Power System Control and Stability", Galgotia Publications, New Delhi, 2003 or P.M. Anderson and A. A. Fouad, "Power system control and stability", IEEE Press
[4] R. Ramanujam, "Power Systems Dynamics"- PHI Publications.
[5] M.A.Pai and W.Sauer, "Power System Dynamics and Stability", Pearson Education Asia, India, 2002.
[6] I.J. Nagrath, D.P. Kothari, "Modern Power System Analysis", Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1994.

[7] B.R. Gupta, "Power system operation and control", S. Chand & Company, New Delhi. Edition: 1. Year: 2012.
[8] A.Chakrabarti, M.L.Soni , P.V.Gupta, U.S.Bhatnagar, "Power system engineering", Dhanpat Rai & Co., New Delhi, 2009
[9] NPTEL for Power system dynamics and control (https://nptel.ac.in/courses/108/101/108101004/)

Course Outcome:

After learning the course the students should be able to:

- Understand the fundamental dynamic behavior of power systems to perform basic stability issues.
- Acquire fundamental knowledge about modelling of synchronous machines.
- Recognize the dynamic performance of power systems.
- Familiarize with the power system stability and controls.
- Realize about the impact of dynamics in power system.

List of Open Source Software/learning website:

- https://nptel.ac.in/courses/108/101/108101004/
- https://a-lab.ee/projects/dq0-dynamics
- For open MATLAB source on Dynamic studies refer- https://ieeexplore.ieee.org/document/1490569

SOFTWARE:

- MATLAB
- ETAP
- Power world simulator
- PSAT (MATLAB open source)
- SCILAB (http://old.cloud.scilab.in/)

List of the practical:

(1) Study of basic element of power system and its control.

(2) Basic study about stability issues in power system (with any one real problem)

(3) Frequency control
(https://old.cloud.scilab.in/#) (15. Power system operation and control B.R. Gupta) (Ch-5 Frequency control)

(4) Reactive power control
(https://old.cloud.scilab.in/#) (15. Power system operation and control B.R. Gupta) (Ch-6 Reactive power control)

(5) System stability and finding critical load angle
(https://old.cloud.scilab.in/#) (13. Power system analysis and design B.R. Gupta) (Example -13.7) or Ch. 12.7 & 12.9

(6) Voltage stability

(https://old.cloud.scilab.in/#) (12. Modern power system analysis, D. P. Kothari and I.J. Nagrath) (Example -17.1 & 17.2)

(7) Define steady state power limit
(https://old.cloud.scilab.in/#) (12. Modern power system analysis, D. P. Kothari and I.J. Nagrath) (Example -12.2)

(8) Maximum power transfer and stability margin
(https://old.cloud.scilab.in/#) (14. Power system engineering, S. Chakraborty, Gupta and Bhatnagar) (Example -17.4)

(9) Multi-machine stability
(https://old.cloud.scilab.in/#) (5. Element of power system analysis, Stevenson) (ch-14 power system stability) (Example -14.9)

(10) To study mathematical modeling of R-L, R-L-C and complex electrical circuit using MATLAB.

(11) To study mathematical modeling of 3rd order differential equation.

(12) To solve differential equations using Euler's and trapezoidal rule.

(13) To observe variable of rotor angle and to find critical clearing time when fault occurs at:
(a) Sending end of the line (b) Mid-point of the line (c) When the fault at mid-point is cleared by removing the faulty line of SMIB system

(14) To study short circuit analysis of overhead transmission line using MATLAB.

(15) To study and determine fault current for short circuit analysis using ETAP software.

(16) Find the steady state stability limit of delivered power.

(17) Compute the equivalent circuit parameters using (a) exact calculation and (b) approximate method.

(18) Calculate the equivalent circuit parameters for the d-axis using (a) standard method (b) Exact method with the assumption Xc = Xau (c) Exact method

(19) Obtain the response of the excitation system.

(20) Find the initial conditions.

(21) Obtain the hybrid parameters for the two port network.

(22) Simulate the system response for the following conditions (a) Step increase in Vref by 0.1 pu (b) Step increase in Tm by 0.1 pu (c) Step increase in Eb by 0.1 pu.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170916
Semester – VII
Subject Name: Advanced Electric Drives

Type of course: Professional Elective Course

Prerequisite: Power Electronics

Rationale: Electric motor is inevitable part of industries. High precision Control of this electric motors for various industrial applications are needed. Electric drive using power electronic converters with suitable control strategy can control the speed and torque of electric motor precisely. The course is aimed to provide exposure about the commonly used power electronic converters for electric drive applications and various control strategies used for the purpose of motion control.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE Viva (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Power Converters for AC drives** PWM control of inverter, selected harmonic elimination, space vector modulation, current control of VSI, three level inverter, Different topologies, SVM for 3 level inverter, Diode rectifier with boost chopper, PWM converter as line side rectifier, current fed inverters with self-commutated devices. Control of CSI, H bridge as a 4-Q drive.	**10**
2	**Induction motor drives** Different transformations and reference frame theory, modeling of induction machines, voltage fed inverter control-v/f control, vector control, direct torque and flux control (DTC).	**10**
3	**Synchronous motor drives** Modeling of synchronous machines, open loop v/f control, vector control, direct torque control, CSI fed synchronous motor drives.	**07**
4	**Permanent magnet motor drives** Introduction to various PM motors, BLDC and PMSM drive configuration, comparison, block diagrams, Speed and torque control in BLDC and PMSM.	**06**
5	**Switched reluctance motor drives** Evolution of switched reluctance motors, various topologies for SRM drives, comparison, Closed loop speed and torque control of SRM.	**06**
6	**DSP based motion control** Use of DSPs in motion control, various DSPs available, realization of some basic blocks in DSP for implementation of DSP based motion control.	**06**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**30**	**30**	**15**	**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. B. K. Bose, "Modern Power Electronics and AC Drives", Pearson Education, Asia, 2003.
2. P.C. Krause, O. Wasynczuk and S.D. Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley & Sons, 2013.
3. H. A. Taliyat and S. G. Campbell, "DSP based Electromechanical Motion Control", CRC press, 2003.
4. R. Krishnan, "Permanent Magnet Synchronous and Brushless DC motor Drives", CRC Press, 2009.

Course Outcomes:

After completing the course, students will be able to;

Sr. No.	CO statement	Marks % weightage
CO-1	Select appropriate power electronic converters for drive applications.	25
CO-2	Analyze the vector control strategies for ac motor drives.	25
CO-3	Select appropriate control strategies for electric drives.	25
CO-4	Evaluate performance of electric drives under different control strategies.	25

List of Experiments:

This is a suggestive list only:

2. PWM inverter fed three phase induction motor control using PSPICE/MATLAB/PSIM software
3. VSI fed induction motor drive analysis using MATLAB/PSPICE/PSIM software
4. Study of V/f control operation of three phase induction motor
5. Study of vector controlled three phase induction motor drive.
6. Study of permanent magnet synchronous motor drive fed by PWM inverter using simulation software.
7. Study of BLDC motor drive fed by PWM inverter using simulation software.
8. Study of SRM motor drive fed by PWM inverter using simulation software.
9. Regenerative/ Dynamic breaking operation for AC motor using simulation software

10. PC/PLC based AC/DC motor control operation

Major Equipment:

Power semiconductor devices, power electronic converter kits, CRO/DSO, choke coil, load bank, voltage and current probes, Simulation software like Scilab, MATLAB, PSIM etc. along with necessary toolbox.

List of Open Source Software/learning website:

- E-materials available at the website of NPTEL- http://nptel.ac.in/

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3170917

HIGH VOLTAGE ENGINEERING

B.E. 7th SEMESTER

Type of course: Professional Core Course (Electrical)

Prerequisite: Not applicable

Rationale: Electrical power transmission is trending towards higher and higher voltages. Under such scenario, the conceptual understanding related to insulation, testing the HV devices is must for every electrical engineer. The subject deals with HV test generating devices, measurement devices, over voltages including lightning and non-destructive testing as well.

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)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1.	Electrostatic fields and field stress control: Electrical field distribution and breakdown strength of insulating materials - fields in homogeneous, isotropic materials - fields in multi-dielectric, isotropic materials.	02
2.	Numerical analysis of electrical fields in high voltage equipment: numerical methods - Charge simulation method (CSM), Finite Difference Method (FDM), Finite Element Method (FEM), The boundary-element method, Comparative summary, Formulation of the finite-element equations in two and three dimensions - Forming the functional equation, The energy functional illustrated, Numerical representation.	04
3.	Electrical breakdown in gases: Gases as insulating media - ionization and decay processes, Townsend first ionization coefficient, photo ionization, ionization by interaction of metastable with atoms, thermal ionization, deionization by recombination, deionization by attachment–negative ion formation, examples - cathode processes – secondary effects, photoelectric emission, electron emission by positive ion and excited atom impact, thermionic emission, field emission, Townsend second ionization coefficient, secondary electron emission by photon impact, examples - transition from non-self-sustained discharges to breakdown, the Townsend mechanism, examples - the streamer or 'kanal' mechanism of spark, examples - the sparking voltage–Paschen's law, penning effect.	05
4.	Breakdown in liquid and solid dielectrics: Liquid as insulators, breakdown in liquids - electronic breakdown, suspended solid particle mechanism, cavity breakdown, examples - static electrification in power transformers,	07

	transformer oil filtration, transformer oil test, alternative liquid insulations like vegetable oils, esters and silicon oils - breakdown in solids, intrinsic breakdown, streamer breakdown, electromechanical breakdown, edge breakdown and treeing, thermal breakdown, erosion breakdown, tracking - breakdown of solid dielectrics in practice, partial discharges in solid insulation.	
5.	Generation of high voltages: Generation of high direct voltages, half and full wave rectifier circuits, voltage multiplier circuits, Van de Graff generators, electrostatic generators, examples - generation of alternating voltages, testing transformers, cascaded transformers, resonant transformers, examples - impulse voltages, Standard lightning and switching surge and associated parameters and their corrections, design and construction of impulse voltage generator circuits, Marx circuit, operation, examples - impulse current generator.	07
6.	Measurement of high voltages: High direct voltage measurement, peak voltage measurements by spark gaps, sphere gaps, reference measuring systems, uniform field gaps, rod gaps, factors affecting sphere gap measurements, examples - electrostatic voltmeters - ammeter in series with high ohmic resistors and high ohmic resistor voltage dividers - generating voltmeters and field sensors - the measurement of peak voltages, the Chubb–Fortescue method, high- voltage capacitors for measuring circuits - voltage dividing systems and impulse voltage measurements. Numericals	06
7.	Over voltages, and insulation coordination: The lightning mechanism, energy in lightning, nature of danger - examples - insulation coordination, insulation level, statistical approach to insulation coordination, correlation between insulation and protection levels.	04
8.	Non-destructive test techniques: Insulation: Measurement of d.c. resistivity - dielectric loss and capacitance measurements, the Schering bridge, current comparator bridges, Tan Delta measurement, Partial-discharge (PD) measurements - the basic PD test circuit, Dissolved gas analysis - Key gas method, Duval's triangle. Machine winding: Frequency Response Analysis Method (FRA)- Introduction, Sweep Frequency Response Analysis (SFRA), procedure, methods of interpretation of signature.	05
9.	High voltage testing: Testing of insulators and bushings, testing of isolators and circuit breakers Testing of cables, testing of transformers - testing of surge diverters	05

Note:

1. 10%-20% weightage should be given to the Examples and Short/Multiple choice questions.
2. The institutes which does not have proper High Voltage Laboratory are advised to visit nearby High Voltage laboratory

Suggested Specification table with Marks (Theory):

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

Legends:R:Remembrance;U:Understanding;A:Application,N:AnalyzeandE:EvaluateC:Createa ndabove Levels (Revised Bloom'sTaxonomy)

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. Kuffel,E.,ZaenglW.S.,KuffelJ.,"HighVoltageEngineering:Fundamentals"Butterworth-Heinmann (A division of Reed Educational & Profession Publishing Limited), 2nd Edition, 2000.
2. Naidu M. S. and Kamaraju V., "High Voltage Engineering", fourth Edition, Tata McGraw- Hill Publishing Company Limited, New Delhi,2009.
3. Rakosh Das Begamudre, "High Voltage Engineering, Problems and Solutions", New Age International Publishers, New Delhi,2010.
4. Dieter Kind, Kurt Feser, "High Voltage Test Techniques", Reed educational and professional publishing ltd. (Indian edition), NewDelhi-2001
5. M. Khalifa, "High Voltage Engineering-Theory and Practice", Marcel Dekker, Inc. New York and Basel,1990.
6. Hugh M. Ryan, "High Voltage Engineering and Testing", 2nd edition, The Institution of Electrical Engineers, London, United Kingdom,2001.
7. Wadhwa C.L., "High Voltage Engineering", third edition, New Age publishers, New Delhi,2010.
8. A. Haddad, D. Warne, "Advances in High Voltage Engineering", IET Power and Energy, Series 40, 2007.
9. Sivaji Chakravorti, Debangshu Dey, BiswenduChatterjee,"Recent Trends in the Condition Monitoring of Transformers",Springer, 2013.
10. Alston L L, High Voltage Technology, Oxford University Press, 2008.

Course Outcome:

After learning the course, the students should be able to

1. Apply numerical methods for engineering problem. (Applying)
2. Recall breakdown mechanism for dielectric materials in solid, liquid and gaseous state. (Remembering)
3. Classify insulation test techniques. (Understanding)
4. Examine methods for generation of test high voltage and as well for its measurement. (Analyzing).
5. Conclude about correctness of design and manufacturing of high voltage insulations after performing tests.(Evaluate)

List of Experiments:

1. Testing of transformer oil according toIS:6792

2. Testing of solid insulation with tapeelectrodes
3. Generation of High D.C. Voltages and measurement through spheregaps
4. Generation of High A. C. voltages and measurement through spheregaps
5. Generation of High A. C. voltages through cascadedtransformers
6. Impulse voltage generation through Marxgenerator
7. Impulse voltage generation thoughsimulation
8. Trace the field through electrolytictank
9. Generation and visualization of corona in coronacage
10. Capacitance and loss factormeasurement
11. A report on visit to high voltage laboratory

Note: At least eight practicals shall be performed depending on availability of the equipment.

Design based Problems (DP)/Open Ended Problem:

1. Design of impulse generator with various combination of wave shaping resistor andcapacitor
2. Design of CW type voltage multiplier with variousstages
3. Design of teslacoil
4. Design of Generatingvoltmeter

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

Major Equipment:

1. Multi stage Impulse voltagegenerator
2. Multi stage Impulse currentgenerator
3. High voltage AC and DC generating source (Min 100kV)
4. Partial Discharge Measurement setup
5. Coronasetup
6. Electrostaticgenerator
7. Cascadetransformer
8. ResonantTransformer
9. Two to three sets of sphere gap assembly of variousdiameters
10. Faradaycage
11. Oil testkit
12. Solid insulation testkit
13. Scheringbridge
14. DC resistivity measurement testkit
15. Surface resistance measurement testkit
16. Paschen's law testkit

List of Open Source Software/learning website:

Open source software:

1. Finite Element Method Magnetics FEMM
2. LTSpice for circuitsimulation,
3. KiCAD for CADapplication

Web-based tools for design:

1. http://www.fairchildsemi.com/support/design-tools/power-supply-webdesigner/

2. http://www.ti.com/lsds/ti/analog/webench/overview.page

Circuit Lab:

1. https://www.circuitlab.com/editor/

Open source Math Tools:

1. http://maxima.sourceforge.net/
2. http://www.sagemath.org/
3. http://www.scilab.org/
4. http://www.gnu.org/software/octave/

Online Experiment Portal

1.http://vlab-ee1.iitkgp.ernet.in

Learning website

1. http://www.electrical-engineering-portal.com/
2. http://nptel.iitm.ac.in/courses.php

Standards

1. “IEEE Standard Techniques for High-Voltage Testing”, 6th edition, IEEE Std.4-1978.
2. “High-voltagetesttechniques,Part1:Generaldefinitionsandtestrequirements”,IEC60060-1,1989.
3. “High Voltage Test Techniques, Part 2: Measuring Systems”, IEC Publication 60060-2,1994.
4. “High Voltage Test Techniques, Part 3: Measuring Devices”, IEC Publication 60060-3,1976.
5. “High Voltage Test Techniques, Part 4: Application Guide for Measuring Devices”, 1st ed., IEC Publication 60060-4,1977.
6. IndianStandardspecificationsforHighVoltagetesttechniques”,BureauofIndianStandard,IS 2071, New Delhi,1991.
7. "IEEE Standard for High Voltage Switchgear (Above 1000 V) Test Techniques - Partial Discharge Measurements" - IEEE Std. C37.301 - 2009.
8. "IEEE guide for the application and interpretation of Frequency Response Analysis for Oil-Immersed Transformers" - IEEE Std. C57.149 - 2012.
9. "Mechanical Condition Assessment of Transformer Windings Using Frequency Response Analysis (FRA)" - CIGRE report by working group A2.26, April 2008.
10. "Power Transformers - Part 18: Measurement of frequency response" - IEC60076-18, 2012.
11. "Mineral oil-filled electrical equipment in service - Guidance on the interpretation of dissolved and free gases analysis" -IEC 60599 - 2015.
12. "IEEE Guide for the Interpretation of Gases Generated in Mineral Oil-Immersed Transformers" - C57.104-2019.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170918
Semester – VII
Subject Name: Digital Signal Processors

Type of course: Professional Elective Course IV

Prerequisite:

Rationale:

Many Electrical and Power Electronics Applications require complex control schemes and signal processing. Hence, for such applications, embedded processor having very good control capacity and signal processing capacity both are required. So, special processors combining both these capacities are used in such applications. They are Digital Signal Controllers (DSC). They combine the best features of microcontrollers (MCU) and powerful digital signal processing (DSP) capabilities in one single chip Considering this, it becomes necessary for any electrical and power electronics engineer involved in product development to understand the concepts of Digital Signal Processing (Theoretical). Also they should understand Digital Signal Controllers from practical implementation point of view. This subject includes both of these.

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)	
3	0	0	3	70	30	0	0	100

Content:

Sr no.	Topics	Teaching Hrs.
1	Introduction: Signals – Classification – Continuous& Discrete Time Signals – Basic Operations on Signals & Sequences – Elementary Signals - Discrete Time Systems &Properties of System, Impulse response of DT-LTI system, Linear Convolution. Sampling of Continuous Time Signals – Sampling Theorem – Aliasing & it's Effects, Signal reconstruction.	4
2	Discrete Time systems and implementation Concepts of Z transformation, properties of Z transformation etc., Block diagram / signal flow graph representation of DT System, Structures for realization of FIR & IIR Systems – Direct, Cascade, Parallel & Linear phase.	4
3	Fourier series and Fourier Transform of DT signals: Concepts of Discrete Time Fourier series, Discrete Time Fourier Transforms –Properties, Analysis of DT-LTI systems using DTFT etc. DFT- Relationship of DFT & other transforms, Properties, Frequency spectrum using DFT, Analysis of LTI system using DFT, DFT as Linear Transformation. FFT– DIT Radix-2 FFT, DIFRadix-2 FFT, Computation of Inverse DFT using FFT.	8
4	Representation of Numbers in digital system (Floating point, Fixed-point representation), Types of arithmetic in digital system, Quantization effect & Errors therein, Concept of Limit Cycle Oscillations & Scaling	4
5	Architecture of DSP and C2000 family Features of Processors– Types of architecture, Concepts of DMA, MAC, Pipelining etc., introduction to DSP architecture. Peripherals available in DSP IC chips, requirements of on chip hardware for power electronics applications. Introduction to C2000 family of	8

	microcontrollers: Comparison of C2000 real time microcontrollers like PICOLO, DELFINO, 28M3x etc., with reference to on chip peripherals, processing capacity, applications etc.	
6	Code Composer Studio: Introduction to CCS as IDE for TI processors, Basics of CCS, Multiprocessing with CCS, Testing Program, debugging Breakpoints, points, using file I/O, Memory map, Watch window, Integrated editor, project environment	4
7	Software Development and Programming: Overview, description, object module, program loading and running, Assembler, Assembler directives, Macros, Linker, using C language Writing program for some simple objectives like initializing peripheral, timer interrupt and ISR for timer interrupt, PWM generation etc. for C2000 microcontrollers.	5
8	TI 320F28X Digital Signal Controllers: TMS320F28335 Introduction, Functional Overview, Memory map, brief description of available peripherals, register maps, device emulation registers, interrupts, system control, On chip Peripherals of TMS320F28335(or any other C2000 Family processor): Timers, PWM generation, ADC, Serial Communication, GPIO, Flash Memory	8

Suggested Specification Table with Marks (Theory): (for BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**30**	**15**	**15**	**10**	**0**

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

1. **Remembering:** Retrieving - recognizing - and recalling relevant knowledge from long-term memory.
2. **Understanding:** Constructing meaning from oral - written - and graphic messages through interpreting - exemplifying - classifying - summarizing - inferring - comparing - and explaining.
3. **Applying:** Carrying out or using a procedure for executing or implementing.
4. **Analysing:** Breaking material into constituent parts - determining how the parts relate to one another and to an overall structure or purpose through differentiating - organizing - and attributing.
5. **Evaluating:** Making judgments based on criteria and standards through checking and critiquing.
6. **Creating:** Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating - planning - or producing.

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/Material:

1. DSP-Based Electromechanical Motion Control (Power Electronics and Applications Series), Hamid A. Toliyat (Author), Steven G. Campbell, CRC press
2. TI technical documents: Code Composer Studio User's Guide, Document no. SPRU328B (Data Manual 28335), SPRS439M (TI 28335 Data sheet), SPRUI07 (Technical Reference Manual), SPRU513V (Discrete TMS320C28x Assembly Language Tools User's Guide), SPRU514V (TMS320C28x Optimizing C/C++ Compiler v20.12.0.STS) , SPRAC71A (C28x Embedded Application Binary Interface), SPRU566N (C2000 Real-Time Control Peripherals)
3. The DSP Handbook Algorithms, Applications and design techniques, Andrew Bateman, Iain Paterson-Stephens, Pearson Education
4. C the complete reference, Herbert Scheldt
5. Digital Signal Processing: Principles, Algorithms, and Applications, Dimitris Manolakis and John G Proakis, Pearson

Course Outcomes:

Sr. No.	CO statement After studying this subject, student will be able to	Topics Mapped	Marks % weightage
CO-1	understand concepts of Digital Signal Processing implementation requirements of Power Electronics systems	1, 2, 3	30
CO-2	select appropriate Digital Signal Processor / Controller for a given application	5, 8	30
CO-3	apply concepts of Digital Signal Processing to practical application	4, 8	10
CO-4	apply the software development tools in a real time embedded application.	6, 7	30

List of Open-Source Software/learning website:

Learning website:

1. http://nptel.iitm.ac.in/courses.php
2. http://ocw.mit.edu/
3. www.ti.com
4. http://www.electrical-engineering-portal.com
5. www.nxp.com
6. www.microship.com
7. www.st.com
8. https://www.ti.com/microcontrollers-mcus-processors/microcontrollers/c2000-real-time-control-mcus/overview.html#portfolio
9. http://software-dl.ti.com/C2000/docs/software_guide/intro.html
10. https://software-dl.ti.com/C2000/docs/optimization_guide/index.html
11. https://www.ti.com/tool/CCSTUDIO#tech-docs
12. https://www.ti.com/tool/CCSTUDIO
13. https://software-dl.ti.com/ccs/esd/documents/users_guide/index.html

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170919
SUBJECT NAME: Power System Operation and Control
B.E. 7TH SEMESTER

Type of course: Professional Elective Course

Prerequisite: Basic understanding of structure of the power system and power system analysis.

Rationale: Demand of electrical energy is increasing day by day due to improvement in the life style of the people in particular and development of the countries in general. Under this scenario, the power system network operates in a stressed condition. Effective management of generation, transmission and distribution of electrical power is necessary for optimal system operation, for loss minimization and to avoid the unwanted power cuts. After the study of power system analysis, the study of power system operation is required. The understanding of automatic generation and control, reactive power characteristics of transmission lines and voltage control, state estimation, load forecasting and restructuring is desired.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	PA (V)	PA (I)	
3	0	0	3	70	30	00	00	100

Content:

Sr. No.	Content	Total Hrs
1.	**Automatic Generation Control and Voltage Control:** Introduction; Load Frequency Control (Single Area Case); Load Frequency Control and Economic Despatch Control; Two-Area Load Frequency Control; Optimal (Two-Area) Load Frequency Control; Automatic Voltage Control; Load Frequency Control with Generation Rate Constraints (GRCs);	8
2.	**Reactive Power and Voltage Control:** Introduction; Reactive power requirement of an uncompensated line; Implication of surge impedance loading; Reactive loss characteristics of transmission line; Operation of a transmission line at no load condition; Operation of a transmission line under heavy loading condition; Voltage regulation of the transmission line and its relation with reactive power; Maximum power transfer in an uncompensated line; Line loadability. Reactive power-voltage (Q-V) coupling concept; Operational aspects in reactive power and voltage control; Basic principle of system voltage control; Reactive power flow constraints and their implications in loss of voltage; Power System Voltage Stability : Introduction, Difference between angle stability and voltage stability, Causes of voltage instability, types, proximity and mechanism of voltage stability, Practical aspects of reactive power flow problems leading to voltage collapse in EHV lines.	10
3.	**Power System Security:** Introduction; System State Classification; Security Analysis; Contingency Analysis; Sensitivity Factors: generation shift distribution factor, line shift distribution factor	6
4.	**State Estimation:**	8

	Introduction; Least Squares Estimation: The Basic Solution; Static State Estimation of Power Systems; Tracking State Estimation of Power Systems; Some Computational Considerations; External System Equivalency; Treatment of Bad Data; Network Observability and Pseudo-Measurements; Application of Power System State Estimation	
5.	**Load Forecasting:** Introduction; Forecasting Methodology; Estimation of Average and Trend Terms; Estimation of Periodic Components; Estimation of $\mathbf{y_s(k)}$**:** Time Series Approach; Estimation of Stochastic Component: Kalman Filtering Approach; Long-Term Load Predictions Using Econometric Models; Reactive Load Forecasting.	**6**
6.	**Introduction to Power System Deregulation and Restructuring:** Introduction; Motivation for Restructuring of power system; Electricity market entities and model; Benefits of Deregulation; Basic terminologies; Deregulation – International scenario; Milestones of deregulation in the world; **Indian power sector – Past and present status:** Growth of power sector in India – An overview, A time line of the Indian power sector, Players in the Indian power sector, Research and professional bodies.	**4**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**Total**
5	**10**	**10**	**25**	**20**	**70**

Legends: R : Remembrance ; U = Understanding; A = Application; N = Analyze; E = Evaluate (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

(Question paper should have 20 to 35 marks for numerical problems based on design or analysis)

Reference Books:

1. Modern Power System Analysis – D. P. Kothari, I. J. Nagrath, TMH Publication
2. Electrical Power Systems – P. Venkatesh, B.V. Manikandan, S.C. Raja, A. Srinivasan, PHI
3. Power System Analysis – J. J. Grainger, W.D. Stevenson, Mc-GrawHill series publication
4. Power Generation Operation and Control – A. J. Wood, B. F. Woolenberg, John Wiley and Sons
5. Power System Analysis – Hadi Saadat, Mc-GrawHill series publication
6. Advanced Power System Analysis and Dynamics – L. P. Singh, New Age International
7. Operation of Restructured Power Systems – K. Bhattacharya, H. J. Bollen, J. E. Daalder, Kluwer academic publishers
8. http://nptel.ac.in/courses/108101040/ (PSOC webcourse)

Sr No.	Course Outcome Statement	Marks % weightage
CO-1	Apply concepts of frequency control and voltage control in small sample single area power system	25

CO-2	Analyse performance of transmission lines with respect to reactive power requirement for voltage stability	30
CO-3	Estimate the state of small sample power system	25
CO-4	Describe concepts of power system security and load forecasting	20

List of Open Source Software/learning website:

- http://nptel.ac.in/courses/108101040/
- http://www.electrical-engineering-portal.com/
- http://nptel.iitm.ac.in/courses.php
- www.vlab.co.in

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170920
Semester – VII
Subject Name: Industrial Electrical Systems

Type of course: Professional Elective Course

Prerequisite:

Rationale:

Electricity is the major power source for almost all small scale to large scale industries. Per capita consumption of electricity is an indicator of the growth of a country. In view of this, it is important for the electrical engineers to understand the components of residential, commercial and industrial electrical systems. This subject deals with the introduction to components of industrial electrical systems. The subject also includes selection of ratings for various components based on applications and basics of automation of industrial electrical systems.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE Viva (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	**Electrical System Components** LT system wiring components, selection of cables, wires, switches, distribution box, metering system, Tariff structure, Protection components- Fuse, MCB, MCCB, ELCB, Symbols for wiring components, Single line diagram (SLD) of a wiring system, Contactor, Isolator, Relays, MPCB, Electric shock and Electrical safety practices	**06**
2	**Residential and Commercial Electrical Systems** Types of residential and commercial wiring systems, General rules and guidelines for installation, Load calculation and sizing of wire, Rating of main switch, distribution board and protection devices, Earthing system calculations, Requirements of commercial installation, Deciding lighting scheme and number of lamps, Earthing of commercial installation, Selection and sizing of components	**10**
3	**Illumination Systems** Understanding various terms regarding light- lumen, intensity, candle power, lamp efficiency, specific consumption, glare, space to height ratio, waste light factor, depreciation factor, Various illumination schemes, Incandescent lamps and modern luminaries like CFL, LED and their operation, Energy saving in illumination systems, Design of a lighting scheme for a residential and commercial premises, Flood lighting	**08**
4	**Industrial Electrical Systems** HT connection, Industrial substation, Transformer selection, Industrial loads, motors, starting of motors, SLD, Cable and Switchgear selection, Lightning Protection, Earthing design, Power factor correction – kVAR calculations, type	**14**

	of compensation, Introduction to PCC, MCC panels. Specifications of LT Breakers, MCB and other LT panel components DG Systems, UPS System, Electrical Systems for the elevators, Battery banks, Sizing the DG, UPS and Battery Banks, Selection of UPS and Battery Banks	
5	**Industrial Electrical System Automation** Study of basic PLC, Role of automation, Advantages of process automation, PLC based control system design, Panel Metering and Introduction to SCADA system for distribution automation	**07**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**25**	**25**	**20**	**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. S. L. Uppal and G. C. Garg, "Electrical Wiring, Estimating & Costing", Khanna publishers, 2008.
2. K. B. Raina, "Electrical Design, Estimating & Costing", New age International, 2007.
3. S. Singh and R. D. Singh, "Electrical estimating and costing", Dhanpat Rai and Co., 1997.
4. H. Joshi, "Residential Commercial and Industrial Systems", McGraw Hill Education, 2008
5. IS Standards : https://bis.gov.in

Course Outcomes:

After completing the course, students will be able to;

Sr. No.	**CO statement**	**Marks % weightage**
CO-1	Explain electrical wiring systems for residential, commercial and industrial consumers through symbols, drawings and SLD	20
CO-2	Justify the need of industrial electrical system components and industrial automation	20
CO-3	Evaluate the size, rating and cost of electrical installations for residential and commercial applications	20
CO-4	Design appropriate electrical system with protective equipments for industrial applications	40

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170921
Semester – VII
Subject Name: Power Quality and FACTS

Type of course: Professional Elective Course

Prerequisite: Power Electronics, Power systems

Rationale:

Electrical Power systems are heavily loaded because of the increase in the demand and restructured power system operation. The technical solution of utilizing available power system structure to deliver more power is using the power electronics devices in power systems for reactive power compensation and HVDC. The other uses of power electronics devices in the distribution and at consumer levels are also inevitable. The more and more use of power electronics devices in the power systems at every stage increases the problem of power quality. The course is aimed to provide exposure about power quality; the commonly used power electronics based compensating devices, its impact on Power Quality and various power quality mitigation techniques.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE Viva (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	**Power Quality** Introduction, Importance of Power Quality, Common Disturbances in Power Systems, Short-Duration Voltage Variation, Long-Duration Voltage Variations, Transients, Impulsive Transients, Oscillatory Transients, Voltage Imbalance, Harmonics, Interharmonics, DC Offset, Notching, Noise, Voltage Fluctuations, Power Frequency Variations, Solutions to Power Quality Problems, Ambiguous Terms CBEMA and ITI Curves, Features of Voltages in Power Systems, Grounding, Ground Electrodes, Ground Rods, Ground Rings, Plates Signal Reference Ground (SRG), Single-Point and Multipoint Grounding, Ground Loops, Isolated Ground, Electrochemical Reactions Due to Ground Grids, Reactive Power in Power Systems with Harmonic Distortion, Single-Phase Systems, Reliability, Power Quality Data Collection .	**06**
2	**Static Var Compensators** Introduction, Different Static Var Compensators, Increase in Transient Stability Margin, Damping of Power Oscillations, Voltage Support, Static Var Compensator Systems Versus Synchronous Condensers, Capacitors, and Reactors, Shunt and Series Compensation, Fundamentals of Load Compensation, Reactive Power Relationships Between Wye- and Delta-Connected Systems, Static Var Compensators for Transmission Systems, SVC Using a TCR and an FC, SVC Using a TCR and TSC, STATCOM (SVC Using Self-Commutated Inverters), SVC Using	**09**

	a Saturated Reactor (SR), Comparison of Static Var Systems, Specification of SVCs, FACTS Technology, Types of FACTS Controllers, Series Controllers, Shunt Controllers, Combined Series and Shunt Controllers, Case Study, Importance Three-Phase Power Flow Studies for PQ.	
3	**Control of Static Var Compensators** Introduction, Control Systems for SVCs in Transmission System Applications, Voltage Regulation, Gain Supervision, Reactive Power Control and Coordination, Control Signals for System Transient Stability, Power Oscillation Damping, and Subsynchronous Resonance Damping Enhancement, Control Systems for SVCs in Traction Applications, Load Compensation, Voltage Regulation and Balancing, Measurement of Sequence Components, Phase-Locked Oscillator Control System.	**06**
4	**Harmonics** Introduction, Converter Harmonics, Effect of Transformer Connections, Harmonics When There Is Overlap in the Commutation Process, Direct-Voltage Harmonics, Imperfect System Conditions, Single-Phase Power Supplies, DC Drives, AC Drives, Pulse-Width Modulation (PWM), Telecontrol Signals, Cycloconverters, Transformers, Harmonics in No-Load Exciting Current, Harmonics due to Inrush Current, DC Magnetization, Harmonics in Rotating Machines, Harmonics in Arc Furnace Loads, Harmonics in a Thyristor-Controlled Reactor, TheK-Factor.	**06**
5	**Utility Harmonics Regulations and Standards** Introduction, Undesirable Effects of the Harmonics, Specification of the Harmonic Limits, Philosophical Differences between IEEE 519-1992 and IEC 61000-Series Standards, IEEE 519-1992, IEC 61000-Series Standards, Assessment Procedure (Harmonic Limits), Summation Laws for Combining Harmonics, General Comments on the Standards, Allocation of Harmonic Voltage or Current or Both Limits to the Customers, Empirical Nature of the Standards, Legal Responsibility for Damages due to Harmonic Problems, Application of the Standards, Application of Standards—B.C. Hydro's Approach, Examples of the Harmonic Studies.	**06**
6	**Harmonic Filters** Introduction, Undesirable Effects of Harmonics, Harmonic Sources, Types of Filters, Types of Damped Filters, AC Network Impedance, Overhead Lines, Underground Cables, Transformers, Rotating Machines, Passive Loads, Electronic Loads, Norton Equivalents of Residential Loads, Design of Single-Tuned Filters, Filter Performance Evaluation, Design of Damped Filters, Comparison of Tuned and Damped Filters, Filter Component Ratings, Filter Capacitors, Tuning Reactors, Outline of Filter Design.	**06**
7	**Monitoring Power Quality** Introduction, Site Surveys, Spectrum Analyzers, Special-Purpose Power System Harmonic Analyzers, Transient-Disturbance Analyzers, Combination Disturbance and Harmonic Analyzers, Flicker Meters, Transducers, Measurement of the Frequency Response of Instrument Transformers, Description of the Instrument Transformers' Tests, Summary of the Conclusions from the Tests, Voltage Transformers, IEC-Recommended Measurement Techniques for Harmonics, Harmonics, RMS Value of a Harmonic Group, RMS Value of a Harmonic Subgroup, Total Harmonie Distortion (THD), Group Total Harmonic Distortion (THDG), Subgroup Total Harmonic Distortion (THDS), Partial Weighted Harmonic Distortion (PWHD), Interharmonics, RMS Value of an Interharmonic Component, RMS Value of an Interharmonic Group, RMS Value of an Interharmonic-Centered Subgroup, Relative and Absolute Harmonic Phase Angle Measurement, Necessity for the Measurement of Harmonic Voltages and Currents, Harmonic Monitoring System, Continuous Harmonic Analysis in Real Time, Presentation of Harmonic	**06**

	Measurements, Case Study, Flicker, IEC Flicker Meter, Short-Term Flicker Evaluation, Flicker Standards	

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**30**	**30**	**15**	**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. R. Sastry Vedam, Mulukulta S Sarma "Power Quality VAR Compensation in Power Systems" CRC Press Indian Edition Indian reprint 2013
2. C.Sankaran, "Power Quality", First Indian reprint, CRC press
3. T. K. Nagsarkar and M. S. Sukhija "Power System Analysis" Oxford University Press

Course Outcomes:

After completing the course, students will be able to;

Sr. No.	CO statement	Marks % weightage
CO-1	Explain Various Power Quality terms of Electrical Power System	25
CO-2	Analyze the application of Static Var Compensators for reactive power compensation in power systems.	25
CO-3	Analyze the causes of Harmonics, its effect on various equipment and its mitigation techniques.	25
CO-4	Evaluate performance of power systems (in regards to Power Quality Issues) under various power quality polluting devices using appropriate power quality monitoring tools.	25

List of Open Source Software/learning website:

https://nptel.ac.in/courses/108/106/108106025/

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170922
Semester – VII
Subject Name: Smart grids

Type of course: Professional Elective Course

Prerequisite: Power System Analysis, basics of internet

Rationale:

This course mainly focuses on basic fundamentals of smart grid for its implementation in the existing power system network. This course provides overview of smart grid and its applications in potential sectors of Modern power systems. It also provides detailed utility level analysis in terms of energy management, network analysis and operation of smart grids. The course also explores issues in management, control, protection and monitoring of grid with renewable energy source integration as well as in micro grids at remote location.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE Viva (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Co

Sr. No.	Content	Total Hrs
1	Basics of Load and Generation, Grid operation, Concepts of Power Flow Analysis, Economic Dispatch and Unit Commitment. Introduction to Smart Grid, Difference between conventional & smart grid, Architecture of Smart Grid, Smart Grid standards, Policies Applications, Smart Grid control layer and elements, Smart Grid Initiative for Power Distribution Utility in India.	05
2	Power Line Communications, Two-way Digital Communications Paradigm, Network Architectures, IP-based Systems, Advanced Metering Infrastructure, Fiber Optical Networks, Wide Area Network WAN based on Fiber Optical Networks, IP based Real Time data Transmission, Substation communication network, Bluetooth, Zig-Bee, GPS, Geographic Information System (GIS), Broadband over Power line (BPL).	08
3	Distributed generation resources, Advantages and disadvantages of DG, Distributed Generation Utilization Barriers, Distributed Generation integration to power grid Smart Grid components control elements, Smart Grid Technologies	08
4	Micro Grids, Concept of micro grid, need & applications of micro grid, formation of micro grid, Modelling of AC Smart Grid components, Modelling of DC Smart Grid components, Modelling of storage devices, issues of interconnection, Operation, protection & control of micro grid. Simulation and case study of AC micro grid Islanding, need and benefits, different methods of islanding detection.	08
5	Load dispatch centers, Sensor Networks, Phasor Measurement Units, Communications Infrastructure, Fault Detection and Self-Healing Systems, Applications and Challenges, , wide-area monitoring system (WAMS), Phasor	08

	measurement units PMU; Smart sensors/telemetry, advanced metering infrastructure (AMI);smart metering; smart grid system monitoring, Phasor estimation, Dynamic Phasor estimation.	
6	Demand side management of Smart Grid, Demand response analysis of Smart Grid, Pricing and Energy Consumption Scheduling, Controllable Load Models, Dynamics and Challenges, Electric Vehicles and Vehicle-to-Grid Systems, Demand Side Ancillary Services Energy Management, Practical study of Smart Grid.	**08**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**30**	**30**	**15**	**10**	**00**

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. EkanayakeJ.,Jenkins N., Liyanage K., Wu, J., Yokoyama A., Smart Grid: Technology and applications, Wiley Publications.
2. Momoh J., Smart Grid: Fundamentals of design and analysis, John Wiley & Sons.
3. Smart Grid: Technology and Applications by Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama Wiley India
4. Ali K., M.N. Marwali, Min Dai, "Integration of Green and Renewable Energy in Electric Power Systems", Wiley.

Course Outcomes:

After completing the course, students will be able to;

Sr. No.	**CO statement**	**Marks % weightage**
CO-1	Summaries various aspects of the smart grid Technologies, Components, Architectures and Applications	25
CO-2	Study and compare modern communication infrastructure and justify the feasibility of the same for smart grid applications.	25
CO-3	Analyze Micro grid and distributed generation as a part of modern hybrid power system with advantages and challenges in smart gird operations	25
CO-4	Use of load modeling techniques, Demand Side Ancillary Services Energy Management in Pricing and Energy Consumption Scheduling in smart grid operations	25

List of Open Source Software/learning website:

https://nptel.ac.in/courses/108/107/108107113

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170923
Semester – VII
Subject Name: Electrical and Hybrid Vehicle

Type of course: Professional Elective Course

Prerequisite:

Rationale:

Vehicle is an unavoidable machine for the industry, individual and government. The fuel consumptions have led the nations to be dependent on electric vehicles and needs a major change in the operation in context to energy saving. The electric vehicle has drawn attention of the designers, researchers and manufacturers for the skilled persons needed in this era. The energy saving concept has lead to hybrid electric vehicle in all the concepts for the transportation.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE Viva (V)	PA (I)	
3	0	0	3	70	30	00	00	100

Content:

Sr. No.	Content	Total Hrs
1	**Introduction to Electric Vehicle:** History of Electric Vehicles, Development towards 21st Century, Types of Electric Vehicles in use today – Battery Electric Vehicle, Hybrid (ICE & others), Fuel Cell EV, Solar Powered Vehicles. Motion and Dynamic Equations of the Electric Vehicles: various forces acting on the Vehicle in static and dynamic conditions.	4
2	**Induction to Hybrid Electric Vehicle:** Social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. 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.	4
3	**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. 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.	10
4	**Types of Storage Systems:**	10

	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. 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, Calculation for the ratings.	
5	**Modelling of Hybrid Electric Vehicle Range:** Driving Cycles, Types of Driving Cycles, Range modelling for Battery Electric Vehicle, Hybrid (ICE & others), Fuel Cell EV, Solar Powered Vehicles. Case study of 2 wheeler, 3 wheeler and 4 wheeler vehicles.	**10**
6	**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. Introduction to various charging techniques and schematic of charging stations.	**07**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**30**	**30**	**15**	**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. James Larminie, J. Lowry, "Electric Vehicle Technology Explaned", John Wiley & Sons Ltd. 2003.
2. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", CRC Press, 2004.
3. S. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies",Springer, 2015.
4. Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2003.

Course Outcomes:

After completing the course, students will be able to:

Sr. No.	CO statement	Marks % weightage
CO-1	Select appropriate source of energy for the hybrid electric vehicle based on driving cycle.	25
CO-2	Analyze the power and energy need of the various hybrid electric vehicle.	25
CO-3	Measure and Estimate the energy consumption of the Hybrid Vehicles.	25
CO-4	Evaluate energy efficiency of the vehicle for its drive trains.	25

List of Open Source Software/learning website:

- Online course: https://nptel.ac.in/course.html
- Ocw.mit.edu/courses
- https://www.eng.mcmaster.ca/mech/content/electric-and-hybrid-vehicles

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170924
Semester – VII
Subject Name: AI and Machine learning

Type of course: Professional Elective Course

Prerequisite: Linear Algebra, Probability

Rationale:

Artificial Intelligence is now a day used in nontechnical and technical fields. In every branch of engineering the AI has been used and Electrical engineering is also one of them infect, the use of AI technique in Electrical engineering is inevitable. The branches of electrical Engineering like Electrical Power Systems, Power Electronics and Smart grid technologies are some of them. The course is aimed to provide exposure about the fundamentals of AI techniques and use of some basic machine learning algorithms to be used in electrical engineering and in other branches of electrical engineering too; the commonly used AI techniques from the application viewpoints will be covered in the this course.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE Viva (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Contents:

Sr. No.	Content	Total Hrs
1	**Introduction:** Scope of the Course, Introduction to AI, Brief review of History of AI, Related fields	03
2	**Introduction to Artificial Neural Networks:** Biological Neurons and Biological Neural Networks, Artificial Neural Networks, Activation Functions, Perceptron NN, Multilayer Perceptron NN, Back-propagation Neural Networks, Training Methods, Basic definition of supervised and unsupervised Learning.	07
3	**Introduction to Machine Learning:** Introduction (Different Types of Learning) Hypothesis Space, Inductive Bias, Evaluation and Cross Validation	02
4	**Main Algorithms used in Machine Learning:** Linear Regression, Decision Trees, Learning Decision Trees, K-nearest Neighbour, Collaborative Filtering, Overfitting, Dimensionality Reduction Technique :Feature Selection, Feature Extraction	08
5	**Logistic Regression and Support Vector Machine:** Logistic Regression, Introduction to Support Vector Machine, The Dual Formation, Maximum Margin with Noise, Nonlinear SVM and Kernel Function, SVM: Solution to the Dual Problem	06
6	**Advanced Learning methods and Clustering:** Introduction to Clustering, K-means Clustering, Agglomerative Hierarchical Clustering, Basics of Semi-Supervised and Reinforcement Learning, Introduction to Deep Learning	06

7	. **Fuzzy Logic** Introduction , Conventional set vs fuzzy set, Operations of fuzzy set , Membership function, Fuzzy rules, Fuzzy inference, De-fuzzification,, Application for control	**06**
8	**Genetic algorithm** Introduction, Comparison with traditional optimisation Technique, Steps for GA, reproduction, Crossover, Mutation, Termination parameter of GA, Application.	**07**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**25**	**30**	**15**	**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. Machine Learning with Python for Everyone, Mark Fenner, Pearson
2. Machine Learning, Anuradha Srinivasaraghavan, Vincy Joseph, Wiley
3. Machine Learning with Python, U Dinesh Kumar Manaranjan Pradhan, Wiley
4. Neural Networks, Fuzzy Logic, and Genetic Algorithms : Synthesis and Applications By S. Rajshekharan, G. A. Vijayalakshmi Pai, PHI
5. KishanMehrotra, Chilukuri Mohan and Sanjay Ranka, Elements of Artificial Neural Networks, Penram International
6. Tom Mitchell, Machine Learning, TMH
7. AthemEalpaydin, Introduction to Machine Learning, PHI
8. Andries P. Engelbrecht, Computational Intelligence - An Introduction, Wiley Publication

Course Outcomes:

After completing the course, students will be able to;

Sr. No.	**CO statement**	**Marks % weightage**
CO-1	Learn the basic concepts of how to use various AI techniques.	25
CO-2	Learn, realize and implement various basic machine learning algorithms.	25
CO-3	Learn the appropriateness and steps to use fuzzy systems and Genetic algorithm for engineering problem solving	25
CO-4	Comprehend basic concepts of Neural network and use of machine learning for training	25

List of Open Source Software/learning website:

1. **https://nptel.ac.in/**
2. **https://www.coursera.org/**
3. **https://www.geeksforgeeks.org/machine-learning/**
4. **https://www.tutorialspoint.com/machine_learning_with_python/index.htm**

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170925
Semester – VII
Subject Name: Industrial Automation

Type of course: Open Elective Subject

Prerequisite: Knowledge of Basic Electrical Engineering, Basic Electronics, Digital Electronics, Electronics Measurement and Instruments

Rationale: Automation is playing a key role in Industries. Industries rely heavily on automation for economic viability and mass production. It is important for the students to learn basic of automation, how system works and importance of PLC, SCADA and robots in automation. This course will provide opportunity to learn industrial automation techniques.

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)	
2	0	2	3	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Introduction:** Automation overview, Requirement of automation systems, Architecture of Industrial Automation system, Introduction of PLC and supervisory control and data acquisition (SCADA). Industrial bus systems: modbus & profibus. Role of computers in measurement and control.	4
2	**Automation components**: Sensors for temperature, pressure, force, displacement, speed, flow, level, humidity and pH measurement. Actuators, process control valves, power electronics devices DIAC, TRIAC, power MOSFET and IGBT. Introduction of DC and AC servo drives for motion control.	6
3	**Programmable logic controllers:** Programmable controllers, Programmable logic controllers, Analog digital input and output modules, PLC programming, Ladder diagram, Sequential flow chart, PLC Communication and networking, PLC selection, PLC Installation, Advantage of using PLC for Industrial automation, Application of PLC to process control industries.	7
4	**Distributed Control System:** Overview of DCS, DCS software configuration, DCS communication, DCS Supervisory Computer Tasks, DCS integration with PLC and Computers, Features of DCS, Advantages of DCS.	7

5	**Overview of Industrial automation using robots:** Basic construction and configuration of robot**,** Pick and place robot, Welding robot. Internet of things for plant automation and overview of Industry 4.0	**6**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
5	**15**	**25**	**10**	**10**	**5**

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] Industrial Instrumentation and Control By. S.K. Singh The McGraw Hill Companies

[2] Process Control Instrumentation Technology By. C.D. Johnson, PHI

[3] Industrial control handbook, Parr, Newnem

[4] Programmable logic controller, Dunning, Delmar

Course Outcomes:

Sr. No.	**CO statement**	**Marks % weightage**
CO-1	Explain automation components and systems application	25
CO-2	Identify suitable industrial automation hardware for given application	30
CO-3	Measure industrial parameters like temperature, pressure, force, displacement, speed, flow, level, humidity and pH.	25
CO-4	Integrate SCADA with PLC Systems	20

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170925

List of Experiments:

(General guidelines.. Institute may change list of experiments based on laboratory set up available)

- Use industrial grade sensors and transducer introduction and characteristics like proximity detector, linear encoder, rotary encoder, touch sensor, force sensor, accelerometer, RTDs, loadcells and LVDT for measurement
- Use Various actuators such as relay, solenoid valve, process control valve and motors for control applications
- Simulate analog and digital function blocks
- Relay logic diagram and ladder logic diagram
- Understand and perform experiments on timers and counters
- Logic implementation for traffic Control Application
- Logic implementation for Bottle Filling Application
- Tune PID controller for heat exchanger using DCS
- FBD for autoclavable laboratory fermentor
- Develop graphical user interface for the plant visited by you
- Industrial visit report

There may be separate list of experiment where laboratory setup is developed by Siemens under Centre of Excellence.

Major Equipment:

1. ADC, DAC and Controller, Switches, LEDs, Solenoid valves
2. Relay, motor
3. PLC with software
4. MATLAB® or LABView®
5. AC Servo drives and DC Servo drives
6. Zeegbee and Bluetooth based short range automation system.
7. IoT boards.
8. Robot for demonstration

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3171108
Semester – VII
Subject Name: Internet of Things

Type of course: Professional Elective Course (PEC-VI)

Prerequisite: Computer networking, Embedded systems

Rationale: IoT market is growing rapidly from installed base of about 30 billion devices in the year 2020 and expected to grow up to 75 billion devices by 2025. IoT is useful in many sectors like consumer, commercial, infrastructure, health, industry and military. Industry 4.0 is based on IoT. This course will provide opportunity to the students for contribution in IoT applications.

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)	
2	0	2	3	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Introduction to Internet of Things:** IoT Definition, IoT characteristics, M2M and IoT, End to End IoT Architecture, Physical design of IoT, Logical Design of IoT, Overview of IoT protocols, IoT levels and deployment templates, Challenges for IoT, Interdependencies of IoT and cloud computing, Web of things	6
2	**Embedded IoT devices:** Sensors and actuators for IoT applications, IoT components and implementation, Programming of NodeMCU and Raspberry PI, Implementation of IoT with Edge devices, Reading sensor data and transmit to cloud, Controlling devices through cloud using mobile application and web application, Types and configurations of gatways, Specifications of IoT gateways (Practical aspects of this chapter should be covered during lab sessions)	8
3	**IoT Protocols:** Link layer protocols, Network/internet layer protocols, Transport layer protocols, Application layer protocols: Hypertext transfer protocol (HTTP), Systematic HTTP access methodology, Web Socket, Constrained application protocol CoAP), Message Queue Telemetry Transport Protocol (MQTT), XMPP, DDS, AMQP	8
4	**IoT Security and challenges :** IOT Security, Dangers, Assigning values to Information, Security Components, Key Management, Update Management, Challenges in IoT security.	4
5	**IoT Applications and case study** Broad categories of IoT applications: Consumer IoT, Commercial IoT, Industrial IoT, Infrastructure IoT, Military Things (IoMT)	4

	IoT Case studies: Home automation with IoT, River water pollution monitoring, Smart city street light control and monitoring, Health care monitoring, Voice Apps on IoT device	

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**	**5**	**5**	**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] Rahul Dubey, "An Introduction to Internet of Things: Connecting Devices, Edge Gateway, and Cloud with Applications", Cengage India Publication
[2] Raj Kamal, "Internet of Things: Architecture and Design Principles, Mc Graw Hill Education

[3] Hanes et al "IoT Fundamentals", Cisco Press

[4] Vijay Madisetti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", , Paperback, 2015.

[5] A. McEwen, H. Cassimally, "Designing the Internet of Things", Wiley, 2013.

[6] Yashwant Kanetkar, "21 Internet of Things Experiments", Kindle edition

[7] Adeel Javed, "Building Arduino projects for Internet of Things", Apress publication

[8] Donald Noris, "The Internet of Things: Do it yourself Projects with Arduino, Raspberry PI and BeagleBone Black" Mc Graw Hill Publication

[9] Adrian McEwen & Hakim Cassimally, "Designing the Internet of things", Willey publication

Course Outcomes:

Sr. No.	**CO statement**	**Marks % weightage**
CO-1	Understand IoT architecture	20%

CO-2	Program Embedded IoT devices	30%
CO-3	Use IoT protocol to upload sensor data and to control devices	30%
CO-4	Design IoT application	20%

Suggested List of Laboratory Experiments:

1. Getting started with NodeMCU, Arduino with ESP8266 and ESP32 in the Arduino IDE.
2. GPIO Interfacing and programming
3. Digital on/off sensor (PIR and IR) Interfacing programming
4. Analog sensor programming and uploading sensor data on cloud
5. Controlling devices remotely using Bluetooth link, WiFi link
6. Interfacing and programming of actuators, Controlling devices remotely using cloud
7. Web based device control
8. Development of Android applications suitable for IoT
9. Experiments on Agriculture IoT (Soil moisture, PH monitor)
10. IoT based home automation
11. Smart energy experiments
12. Smart city IoT applications
13. IoT based mini project
14. Developing Voice App for IoT device

List of Open Source Software/learning website:

1. NPTEL online course on IoT: https://onlinecourses.nptel.ac.in/noc18_cs08
2. IoT Tutorial point www.tutorialspoint.com
3. https://www.microsoft.com/en-us/internet-of-things/
4. https://www.scnsoft.com/blog/iot-architecture-in-a-nutshell-and-how-it-works
5. https://wso2.com/whitepapers/a-reference-architecture-for-the-internet-of-things/