GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: ELECTRICAL & ELECTRONICAL ENGINEERING
SUBJECT NAME: Sensor Networks & Instrumentation
SUBJECT CODE: 2170808
B.E. 7th SEMESTER

Type of course: Electrical Engineering

Prerequisite: Fundamental of Electrical Measurement, Analog Electronics, Op-amps

Rationale: The course introduces fundamentals of sensors and provides essential knowledge about design of signal conditioning circuits for the purpose of interfacing with embedded hardware. The course will be useful to gain knowledge of the latest developments in measurement theory and practice, and also helps to learn typical characteristics and capabilities of the range of sensors and instruments that are currently in use.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	Viva (V)	PA (I)	
3	0	2	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs	% Weight
1	**Sensors Fundamental:** Sensor classification, Thermal sensors, Humidity sensors, Capacitive sensors, Electromagnetic sensors, Light sensing technology, Moisture sensing technology, Carbon dioxide (CO2) sensing technology, Sensors parameters, Selection of sensors.	6	15-20%
2	**Interfacing of Sensors and Signal Conditioning:** Change of bios and level of signals, Loading effects on Sensor's output, Potential divider, Low-Pass RC filter, High-Pass RC filter, practical issues of designing passive filters.	6	15-20%
3	**Op-amp based Instrumentation:** Op-Amp Fundamentals, Basic op-amp configurations, Ideal op-amp circuit analysis, Negative feedback, Feedback in op amp circuits, Loop gain, Op amp powering.	6	15-20%
4	**Circuits with Resistive Feedback:** I/V and V/I converters, Current amplifiers, Difference amplifiers, Triple and dual op amp Instrumentation amplifiers, Instrumentation applications, Transducer bridge amplifiers.	4	10-15%
5	**Active Filters**: Transfer function, First order active filters, Standard second order responses, KRC filters, Multiple feedback filters, Sensitivity, Filter approximations, Cascade design, Direct design, Switched capacitor, Switched capacitor filter.	4	10-15%
6	**Wireless sensors and sensors network:** Introduction, Frequency of wireless communication, Development of wireless sensor network based project, Wireless sensor network based on only Zigbee.	6	15-20%

7	**Smart Transducers:** Smart Sensors, Components of Smart Sensors, General Architecture of Smart Sensors, Evolution of Smart Sensors, Advantages, Application area of Smart Sensors,	**6**	15-20%

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**25**	**25**	**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 above table.

Reference Books:

1. Smart Sensors, Measurement and Instrumentation by Subhas Chandra Mukhopadhyay, Springer publication
2. Measurement and Instrumentation: Theory and ApplicationcBy Alan S Morris, Reza Langari, Academic Press, Elsevier, 2015
3. Operational Amplifiers and Analog Integrated Circuits by Franco S. McGraw Hill International Edition, 1988
4. Understanding Smart Sensors by Randy Frank, Artech House sensors library.
5. Analog Circuit Design by John Marcus, PH
6. Data Acquisition and Signal Processing for Smart Sensors by Nikolay Kirianaki, Sergey Yurish, Nestor Shpak, Vadim Deynega, John Wiley & Sons Ltd

Course Outcome:

After learning the course the students should be able to:

- select op amp for the sensor interface.
- design signal conditioning circuit for sensor interface to digital computer.
- design intelligent sensors as per IEEE standard.
- interface wireless sensors with computer network.

List of Experiments:

Student has to simulate/synthesis signal processing circuits based on designed syllabus.

Design based Problems (DP)/Open Ended Problem:

Solutions of the open ended problem(s) and mini project on signal conditioning/interfacing of sensors in guidance of the course instructor is mandatory. Few problems are specified as under.

1. WSN Based Physiological Parameters Monitoring System (Measurement of Human Body Temperature)
2. Intelligent Sensing System for Emotion Recognition
3. WSN Based Smart Power Monitoring System

Major Equipment: Data acquisition hardware to interface between the computer and the sensor signal. National Instruments (NI) promoted Academic Laboratory setup or such DAQ facility should be available to facilitate practical knowledge.

List of Open Source Software/learning website: NPTEL, Multisim, PSpice, Orcade, LabVIEW (NI),

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

GUJARAT TECHNOLOGICAL UNIVERSITY

SUBJECT NAME: Switch Gear and Protection
SUBJECT CODE: 2170908

B.E. 7th SEMESTER

Type of course: Engineering

Prerequisite: Electrical Power Systems II

Rationale: This subject is a core subject and very important for any practicing electrical engineer. The electrical engineer has to deal with many switchgears and protection systems of various elements of power systems. The subject curriculum focuses on the study of fundamentals of power system protection, electromagnetic relays which are important one. It also covers the protection of feeders, transmission lines, transformers, generators and induction motors. The subject deals with the principles of circuit breaking and circuit breaker fundamentals. It also covers the working principle of protective switch gears like CT and PT. The topics covered in the curriculum are chosen in such a way that the students get a very good idea of the underlying principles of switchgear and protection.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	00	02	06	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	%Weightag
1	**Introduction to Protective Relaying and electromagnetic relays** Faults, Causes and Effects, Protective Zones, Primary and Backup Protection, Desirable Qualities and Terms of Protective Relaying, Basic Connection of Trip Circuit, Types of Relay Units, Relay Pick up, Reset or Drop out, Pick up/ Drop off Ratio, Construction and Working of Different Electromagnetic Relays [3]	3	4
2	**Over Current Protection of Transmission line** Introduction, Fuse, Thermal Relays, Over Current Relays, Application of Definite Time & IDMT O.C. Relays for Protection of Feeder, Directional Over Current Relay, Limitations of O.C. Relays [1]	3	5

3	**Differential Protection** Simple Differential Protection, Zone of Protection and Actual Behavior of Simple Differential Protection, Percentage Differential Protection, Earth Leakage Protection[1]	2	4
4	**Transformer Protection** Types of Faults, Over Current Protection, Percentage Differential Protection, Inrush Phenomenon, High Resistance Ground Faults in Transformers, Inter-turn Faults, Incipient Faults, Over-fluxing Phenomenon[1]	4	7
5	**Distance Protection of Transmission line** Drawbacks of O.C. Protection, 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 Reach, Three Step Protection, Trip contact configuration, 3-step protection of double and fed lines. [1]	5	10
6	**Carrier aided protection of transmission lines** Need for carrier aided protection of transmission lines, various options for carrier, Coupling and trapping the carrier into the desired line section, single line to ground coupling, line to line coupling, unit type carrier aided directional comparison relaying, carrier aided distance scheme for acceleration of zone II, transfer trip or inter trip, permissive inter trip, acceleration of zone II, pre-acceleration of zone II, phase comparison relaying (unit scheme) [1]	5	10
7	**Generator protection** Various faults & abnormal operation conditions, stator & rotor faults, transverse differential protection, unbalanced loading, over speeding, loss of excitation, loss of prime mover [1]	5	10
8	**Induction motor protection** Various faults & abnormal operation conditions, starting of induction motor, protection of small & large induction motor. [2]	5	10
9	**Numerical protection** Introduction, block diagram of numerical relay, numerical over current protection, numerical transformer protection, numerical distance protection of transmission line [1]	5	10
10	**Theory of circuit Interruption**	3	5

	Introduction, Physics of arc phenomena, Maintenance of the arc, Losses from plasma, Essential properties of arc, Arc interruption theories. [4]		
11	**Circuit Constant in Relation to Circuit Breaking** Introduction, Circuit breaker rating, Circuit constants & circuit conditions Re-striking voltage transient Characteristics of re-striking voltage, Interaction between the breaker & circuit, Current chopping, duties of switchgear.[4]	4	5
12	**Theory & Practice of Conventional Circuit Breaker and modern circuit breakers** Automatic switch, Air-break circuit breakers, Oil circuit breakers, Single and multi break Construction, Air-blast circuit breaker, Performance of circuit breakers and system requirements, Modification of circuit breaker duty by shunt resistors, Power factor correction by series resistance, Comparative merits of different types of conventional circuit breakers, Modern trends, Vacuum circuit breakers, Sulphur hexafluoride (SF_6) circuit breakers D.C. circuit breaker, auto-reclosing - definitions & features, 3-Phase versus 1-Phase auto-reclosing [4]	8	15
13	**Protective current transformer and potential transformer** Magnetization curve of CT, Difference between measurement & protective CT, CT errors, calculation of CT accuracy, selection of CT, CT requirements for differential protection, specifications of CT, specifications of PT, CVT. **[2]**	4	5

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**25**	**25**	**20**	**5**	**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.

Self Study: Protection using Fuses, MCB, MCCB & ELCB [2]

Reference Books:

1. Fundamentals Of Power System Protection – Y. G. Parithankar & S. R. Bhide, 2nd edition, PHI [2],[3],[4],[5],[6],[7],[9]
2. Power system protection and switchgear by Oza, Nair, Mehta, Makwana :[8],[13],[Self Study]
3. Switchgear And Protection – S. S. Rao, Khanna publication : [1],
4. Power System Protection And Switchgear – B. Ravindranath and M. Chander: [10],[11],[12]
5. Art And Science Of Protective Relaying – Masson
6. A Web Course on Digital protection of power system by Prof. Dr. S.A.Soman, IIT Bombay.
7. Computer relaying for power systems by A.G.Phadke, J.S.Thorp-research studies press ltd. England John Wiley & sons Inc. New York.
8. Protection of power systems by Blackburn.
9. Protection and switchgear ,By Bhavesh Bhalja, R.P.Maheshwari, Nilesh hotani,1st edition,2011, Oxford Publication
10. Power System Protection – B. Ram , TMH Publication
11. Modern Power System Protection – DivyeshOza, TMH Publication

Course Outcome:

After learning the course the students should be able to:

1. Explain the purposes of protection, in relation to major types of apparatus, protection principle, dangers and criteria.
2. Choose and justify a suitable protection system for a specified application.
3. Analyze and compare specified protection systems
4. Compare merits of various principles, relay hardware and interrupting devices.
5. Compare the different type of circuit breakers performance based on which selection of circuit breaker can be made for a given application

Suggested list of Experiments:

1. To study Micro controller based 3-Phase Differential Relay.
2. To study Micro controller based over current Relay.
3. To study 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 study 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 transformer differential protection.
11. To study the protection schemes for different abnormal conditions in an alternator.
12. To study Buchholz relay for transformer protection.
13. To study Generalized block diagram of Numerical Relay

Design based Problems (DP)/Open Ended Problem:

The students can be asked to collect the data of a small power system network. Then the student is asked to design complete protection scheme of the component of 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.

Major Equipment:

Computers and programming software like C C++ or MATLAB SCILAB

List of Open Source Software/learning website:

NPTEL web courses and video courses

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

GUJARAT TECHNOLOGICAL UNIVERSITY

SUBJECT NAME: Digital Signal Processing
SUBJECT CODE: 2171003
B.E. 7th SEMESTER

Type of course:
Compulsory

Prerequisite:
- Higher Engineering Mathematics, Different Transforms (Fourier, Laplace, Z-transforms)
- Signals and systems

Rationale:
The purpose of this course is to provide an understanding of Digital Signal Processing. Topics include: Introduction to digital signal processing and application, discrete time signals and systems; Analysis of LTI systems; Structures of discrete time systems; Filter designing techniques; DFT and FFT; Architecture of DSP Processors, and Multi-rate Signal Processing and applications.

Teaching and Examination Scheme:

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

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE- End Semester Examination; PA- Progressive Assessment; OEP-Open Ended problem; AL-Active learning;

Learning Objectives:

1. To learn digital signal processing fundamentals.
2. To understand the representation of discrete time signals in frequency domain, using z-transform and discrete Fourier transform.
3. To Understand the implementation of the DFT in terms of FFT, as well as some of its applications.
4. To learn the basic forms of FIR & IIR filters, and to design filters.
5. To know the typical applications of digital signal processing.

Contents:

Sr. No.	Contents	Total Hrs	% Weight age
1	**Introduction to DSP:** Overview: Signals, systems and signal processing, classification of signals, elements of digital signal processing system, concept of frequency in continuous and discrete time signals, Periodic Sampling, Frequency	3	05

	domain representation of sampling, Reconstructions of band limited signals from its samples		
2	**Discrete-Time Signals and Systems (Frequency Domain analysis):** Z-transform & Inverse z-transform, Linear convolution and its properties, Linear Constant Coefficient Difference equations, Frequency domain representation of Discrete-Time Signals & Systems, Representation of sequences by discrete time Fourier Transform, (DTFT), Properties of discrete time Fourier Transform, and correlation of signals, Fourier Transform Theorems.	5	10
3	**Analysis of Linear Time Invariant System:** Analysis of LTI systems in time domain and stability considerations. Frequency response of LTI system, System functions for systems with linear constant-coefficient Difference equations, Freq. response of rational system functions relationship between magnitude & phase, All pass systems, inverse systems, Minimum/Maximum phase systems, systems with linear phase.	8	15
4	**Structures for Discrete Time Systems:** Block Diagram and signal flow diagram representations of Linear Constant-Coefficient Difference equations, Basic Structures of IIR Systems, lattice and lattice-ladder structures, Transposed forms, Direct and cascade form Structures for FIR Systems, Linear Phase FIR structure, Effects of Co-efficient quantization.	7	15
5	**Filter Design Techniques:** Design of Discrete-Time IIR filters from Continuous-Time filters Approximation by derivatives, Impulse invariance and Bilinear Transformation methods; Design of FIR filters by windowing techniques.	9	15
6	**Discrete-Fourier Transform & Fast Fourier Transform:** Representation of Periodic sequences: The discrete Fourier Series and its Properties Fourier Transform of Periodic Signals, Sampling the Fourier Transform, The Discrete-Fourier Transform, Properties of DFT, Linear Convolution using DFT. FFT-Efficient Computation of DFT, Goertzel Algorithm, radix2 Decimation-in-Time and Decimation-in-Frequency FFT Algorithms.	9	15
7	**Advance DSP Techniques:** **Multirate Signal Processing:** Decimation, Interpolation, Sampling rate conversion by rational factor **Adaptive filters:** Introduction**,** Basic principles of Forward Linear Predictive filter and applications such as system identification, echo cancellation, equalization of channels, and beam forming using block diagram representation study only.	7	15
8	**Architecture of DSP Processors & applications:** Harward architecture, pipelining, Multiplier-accumulator (MAC) hardware, architectures of fixed and floating point (TMSC6000) DSP processors. Applications	4	10
	Total	52	100

BookS:

1. "Digital Signal Processing: Principles, Algorithm & Application", 4th edition, Proakis, Manolakis, Pearson
2. "Discrete Time Signal Processing":Oppeheim, Schafer, Buck Pearson education publication, 2nd Edition, 2003.
3. Digital Signal Processing fundamentals and Applications,Li Tan , Jean Jiang, Academic Press,2nd edition,2013
4. Digital Signal Processing – A computer based Approach, S.K.Mitra, Tata McGraw Hill,3rd edition,2006
5. Fundamentals of digital Signal Processing –Lonnie c.Ludeman, Wiley
6. Digital Signal processing-A Practical Approach,second edition, Emmanuel I. feacher, and BarrieW..Jervis, Pearson Education
7. Digital Signal Processing, S.Salivahanan, A.Vallavaraj, C.Gnapriya TMH
8. Digital Signal Processors, Architecture, programming and applications by B. Venkatramani, M Bhaskar, Mc-Graw Hill

Suggested specification table with Marks (Theory):

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

Course Outcome:

By the end of this course, the student will be able to:

1. Formulate engineering problems in terms of DSP tasks
2. Analyse digital and analog signals and systems
3. Analyze discrete time signals in frequency domain
4. Design digital filters
5. Change sampling rate of the signal
6. Conceptualize the need of adaptive filters in communication applications.
7. Understand the key Architectural features of Digital Signal Processor
8. Apply digital signal processing algorithms to various areas

Suggested List of Suggested Experiments:

Sr. No.	Experiment Name
1	Write a program for Direct form – I, II form realization of the given IIR system function.
2	Write a program to plot pole-zero of a given FIR filter.
3	(A) Create Blackman Harris, Hamming and Gaussian window and plot them in the same filter design tool. (B) Design an FIR filter with side lobe attenuation of 40 dB using Kaiser Window of 200 points.
4	(A) Design low pass butter worth digital filter with given specification using impulse invariance method. (B) Design a high pass elliptical filter with given specification using impulse invariance method. (C) Design a band pass chebychev-2 filter with given specification using impulse invariance method.
5	Design a second-order digital bandpass Butterworth filter with the following specifications: fu= 2.6 kHz,fL = 2.4 kHz , fs = 8000 Hz. Plot the magnitude and phase response.
6	Write a program to demonstrate the time shifting and frequency shifting property of DTFT.
7	Write a program to perform circular convolution of two sequences using DFT.
8	Write a program to up sample the sinusoidal sequence by an integer factor.
9	Write a program to down sample the sinusoidal sequence by an integer factor.
10	Write a program to convert the sampling by non integer factor of a sinusoidal sequence.

Design based Problems (DP)/Open Ended Problem:

Apply Digital Signal Processing technique to any one specific area like Speech processing, Image processing, Audio processing, Bio-Medical Instrumentation, Encoding of signals, Signal Compression etc. Develop a program for the same using MATLAB/SciLab of equivalent software.

C. List of Software: MATLAB/Code Composer Studio

Learning website: www.nptel,http://ocw.mit.edu, https://cnx.org/content

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

GUJARAT TECHNOLOGICAL UNIVERSITY

SUBJECT NAME: Advanced Power Electronics
SUBJECT CODE: 2170906
B.E. 7th SEMESTER

Type of course: Engineering

Prerequisite: Power Electronics-I (2150903) and Power Electronics-II (2160902)

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
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	Viva	PA (I)	
3	0	2	5	70	30	30	20	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE- End Semester Examination; PA- Progressive Assessment;

Learning Objectives:

The objectives of this course is to make the students conversant with principle, operation, and control of power electronic converters like resonant converters, multi-pulse converter, multi-level converter, FACTS devices, Switching voltage regulators etc. and the applications of these power electronic converters in the areas like HVDC transmission, Reactive Power Compensation, SMPS, Electrical Drives, Solar Photovoltaic Systems etc.

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Switching Voltage Regulators** Introduction; Linear power supply (voltage regulators); Switching voltage regulators; Review of basic dc-dc voltage regulator configurations -Buck, Boost, Buck-Boost converters and their analysis for continuous and discontinuous mode; Other converter configurations like Flyback converter, Forward converter, Half bridge, Full bridge configurations, Push-pull converter, C'uk converter, Sepic Converter; Design criteria for SMPS; Multi-output switch mode regulator	**10**	24
2	**Resonant Converters** Introduction, Need of resonant converters, Classification of resonant	**7**	17

	converters, Load resonant converters, Resonant switch converters, zero-voltage switching dc-dc converters, zero current switching dc-dc converters, clamped voltage topologies		
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 for multi-level converters	**6**	15
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	**5**	11
5	**HVDC Transmission** Introduction, Operation of 12-pulse converter as receiving and sending terminals of HVDC system, Equipment required for HVDC System and their significance, Comparison of AC and DC transmission, Control of HVDC transmission	**4**	9
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**	24

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 Outcome:

After learning the course the students should be able to:

Evaluate different dc-dc voltage regulators
Simulate and analyze resonant converters
Select appropriate phase shifting converter for a multi-pulse converter
Evaluate various multi-level inverter configurations
Compare various FACTS devices for VAR compensation

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. About 10 experiments (from different topics) shall be included to cover the entire course.

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 second order converters like Buck-Boost, Flyback, Forward 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.

Design based Problems (DP)/Open Ended Problem:

Course coordinator can assign the design based problem/open ended problem.

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

BRANCH NAME: ELECTRICAL & ELECTRONICAL ENGINEERING
SUBJECT NAME: Power Quality and Management
SUBJECT CODE: 2170910
B.E. 7th SEMESTER

Type of course: Power Quality and Management, Electrical Engineering

Prerequisite: Fundamentals of Power Systems and Power Electronics

Rationale: Quality of power can have direct impact on many industrial consumers**.** There has recently been a great emphasis on revitalizing industry with more automation and more modern equipment. This usually means electronically controlled, energy-efficient equipment that is often much more sensitive to deviations in the supply voltage. This worsens the quality of power. The electric utility is concerned about power quality issues as well. This course would make the students aware about the various issues affecting the power quality as well as techniques available to improve the quality of power

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	Viva (V)	PA (I)	
3	0	2	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.	% Wtg.
1.	**Introduction to Power Quality:** Definition of power Quality, power quality terminology, power quality issues, Susceptibility Criteria, Responsibility of supplier and users of elect power, Standards	**3**	**8**
2.	**Power Frequency Disturbance:** Common power frequency disturbances, voltage sags, cures of low frequency disturbances, voltage tolerance	**4**	**10**
3.	**Electrical Transients:** Transient system model, Examples of models & response, Types and causes of transients, Examples of transient wave forms	**4**	**10**
4.	**Harmonics:** Definition , number, odd and even harmonics, causes of harmonics, Individual & total distortion, Harmonics signatures, Effect of harmonics, Guide lines for harmonic voltage & current limitation, Harmonic current mitigation	**6**	**12**
5.	**Grounding & Bonding:** Introduction, National electric code grounding requirements, Essentials of grounding system, Ground electrodes, Earth resistance tests, Earth ground grid system, Power Ground system, Signal reference ground, Signal reference ground methods, Single and multi-point grounding, Ground loops	**6**	**12**
6.	**Power Factor:** Introduction, Active and Reactive power, Displacement and true power factor, power factor improvement, correction, penalty, voltage rise due to capacitance, application of synchronous condensers and static VAR compensators	**3**	**8**

7.	**Electromagnetic Interference:** Electric and magnetic fields, Electromagnetic interference terminology, Power frequency fields, High frequency interference, EMI Mitigation, Cable shielding to minimize EMI, Health concerns of EMI	**6**	**14**
8.	**Power Quality Measurement:** Power quality measurement devices, power quality measurements, Number of test locations, Test duration, Instrument set-up, Instrument set up guidelines.	**6**	**14**
9.	**Distributed Generation and Power Quality:** Resurgence of DG, DG technologies, Interface to the utility system, Power quality issues, Operating conflicts,	**6**	**12**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
7	28	21	7	7	-

Reference Books:

1. Power Quality by C.Sankaran, CRC publication
2. Electrical Power Systems Quality by Roger C.Dugan , TMH publication
3. Harmonics and Power Systems by Francisco C. De La Rosa, CRC Publication

Course Outcome:

After learning the course the students should be able to understand the major power quality problems, equipments that are required to measure the quality of power, as well as techniques available to mitigate power quality problems

Suggested list of experiments:

1) Study and calculation of THD and IHD of various types of non-linear loads
2) Power factor improvement using static VAR compensators
3) Measurement of current harmonics using current probe
4) Measurement of high frequency noise with oscilloscopes having high sampling rates
5) Measurement of true RMS value of voltage and current using true RMS meters
6) Measurement of magnetic and electric field using low frequency electromagnetic field meter
7) Study of harmonic distortion limits in agreement with IEEE 519
8) Study of power quality monitoring standards such as IEEE 1159 and IEC 61000-4-30

Design based Problems (DP)/Open Ended Problem

Students can carry out analysis of harmonics generated due to non-linear loads. The analysis of harmonics may be also simulated using MATLAB or PSCAD.

Major Equipments:

1) Current probe for measuring current harmonics
2) True RMS meter
3) Spectrum analyzer
4) Oscilloscope with high sampling rate
5) Data loggers and chart recorders

6) Low frequency electromagnetic field meter
7) MATLAB for simulation of harmonics generated by non-linear loads

List of Open Source Software/learning website:

Learning resource by nptel, http://nptel.ac.in/courses/108106025/ Power quality in power distribution systems, Dr. Mahesh Kumar, IIT Madras

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

GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: ELECTRICAL & ELECTRONICAL ENGINEERING
SUBJECT NAME: Energy Conservation and Audit
SUBJECT CODE: 2170911
B.E. 7th SEMESTER

Type of course: Power Quality and Management, Electrical Engineering

Prerequisite: Fundamentals of Power Systems and Power Electronics

Rationale: The course provides basic understanding of energy audit and management. The consumption of energy is increasing day by day. One way to cope up with the increase in energy demand is to increase the production of energy which demands more investment and the other way is to conserve the energy because energy conserved/saved is energy generated. Energy conservation means reduction in energy consumption but not compromising with the quality or quantity of energy production. Essential theoretical and practical knowledge about the concept of energy conservation, energy management, different approaches of energy conservation in industries, economic aspects of energy conservation project and energy audit and measuring instruments in commercial and industrial sector will be achieved by this course.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	Viva (V)	PA (I)	
3	0	2	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.	% Wtg.
1.	**Energy Audit Methodology and recent trends.** General Philosophy, need of Energy Audit and Management. Definition and Objective of Energy Management, General Principles of Energy Management. Energy Management Skills, Energy Management Strategy. Economics of implementation of energy optimization projects, it's constraints, barriers and limitations, Report-writing, preparations and presentations of energy audit reports, Post monitoring of energy conservation projects, MIS, Case-studies / Report studies of Energy Audits. Guidelines for writing energy audit report, data presentation in report, findings recommendations, impact of renewable energy on energy audit recommendations. Case studies of implemented energy cost optimization projects in electrical utilities as well as thermal utilities. Instruments for Audit and Monitoring Energy and Energy Savings, Types and Accuracy.	**10**	**25-30%**
2.	**Electrical Distribution and Utilization:** Electrical Systems, Transformers loss reductions, parallel operations, T & D losses, P.F. improvements, Demand Side management (DSM), Load Management, Harmonics & its improvements, Energy efficient motors and Soft starters, Automatic power factor Controllers, Variable speed drivers, Electronic Lighting ballasts for Lighting, LED Lighting, Trends and Approaches. Study of 4 to 6 cases of Electrical Energy	**10**	**25-30%**

	audit and management (Power factor improvement, Electric motors, Fans and blowers, Cooling Towers, Industrial/Commercial Lighting system, etc.)		
3.	**Thermal Systems:** Boilers- performance evaluation, Loss analysis, Water treatment and its impact on boiler losses, integration of different systems in boiler operation. Advances in boiler technologies, FBC and PFBC boilers, Heat recovery Boilers- it's limitations and constraints. Furnaces- Types and classifications, applications, economics and quality aspects, heat distributions, draft controls, waste heat recovering options, Furnaces refractory- types and sections. Thermic Fluid heaters, need and applications, Heat recovery and its limitations. Insulators- Hot and Cold applications, Economic thickness of insulation, Heat saving and application criteria. Steam Utilization Properties, steam distribution and losses, steam trapping, Condensate, Flash steam recovery.	**10**	**20-25%**
4.	**System Audit of Mechanical Utilities:** Pumps, types and application, unit's assessment, improvement option, parallel and series operating pump performance. Energy Saving in Pumps & Pumping Systems. Bloomers (Blowers) types & application, its performance assessment, series & parallel operation applications & advantages. Energy Saving in Blowers Compressors, types & applications, specific power consumption, compressed air system,& economic of system changes. Energy Saving in Compressors & Compressed Air Systems Cooling towers, its types and performance assessment & limitations, water loss in cooling tower. Energy Saving in Cooling Towers .Study of 4 to 6 cases of Energy Audit & Management in Industries (Boilers, Steam System, Furnaces, Insulation and Refractory, Refrigeration and Air conditioning, Cogeneration, Waste Heat recovery etc.)Study of Energy Audit reports for various Industries and Organizations	**10**	**20-25%**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
7	28	21	7	7	-

Reference Books:

1. Energy Audit and Management, Volume-I, IECC Press
2. Energy Efficiency in Electrical Systems, Volume-II, IECC Press
3. Energy Management: W.R.Murphy, G.Mckay, Butterworths Scientific
4. Energy Management Principles, C.B.Smith, Pergamon Press
5. Industrial Energy Conservation, D.A. Reay, Pergammon Press
6. Energy Management Handbook, W.C. Turner, John Wiley and Sons, A Wiley Interscience
7. Industrial Energy Management and Utilization, L.C. Witte, P.S. Schmidt, D.R. Brown, Hemisphere Publication, Washington, 1988
8. Hand Book of Energy Audits, Albert Thumann, P.E., C.E.M. William J. Younger, C.E.M., CRC Press

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

1. Understand the basic knowledge of Different terms & principles of energy audit and management.
2. Assess the energy saving & conservation in different electric system

3. Understand about heat utilization, saving and recovery in different thermal system
4. Learn the preparation of energy audit report & Different cases related to industries.

Suggested list of experiments:

1. List various energy management systems prevailing in a particular industry/Organization
2. Identify the energy management skills and strategies in the energy management system
3. Organize a energy management program in a given industry
4. List the various energy conservation methods useful in a particular industry
5. Identify the critical areas where energy conservation is required
6. Select appropriate energy conservation method for the critical area identified
7. List the various energy conservation methods useful in power generation, transmission and distribution
8. Find out the payback period for a given energy conservation equipment
9. Determine depreciation cost of a given energy conservation project/equipment
10. Draw the energy flow diagram for a industry/shop floor division
11. Identify various measuring instruments used for energy audit
12. Use various measuring instruments for carrying out energy audit
13. Prepare a sample energy audit questionnaire
14. Prepare a energy audit report
15. Prepare a technical report on energy conservation act 2003

SUGGESTED LIST OF STUDENT ACTIVITIES:

Following is the list of proposed student activities: Assignments on solving simple numerical, Prepare a report based on a survey of at least two nearby industries on energy conservation measures adopted by them using questionnaire, Carry out a survey on internet and prepare a report on energy conservation act an ECBC. Carry out detailed energy audit of your Institute or any other official building.

Major Equipments:

Anemometer, Lux Meter, Power Analyzer, Thermometer (Contact / Non-contact type), Tachometer (Contact / Non-contact type), Pressure Gauges, Multimeter, Ammeter (AC / DC), Voltmeter (AC / DC) Mandatory, Power Factor meter, Tong Tester, Earth Tester, Energy meter, Tri-vector meter, Stroboscope,

List of Open Source Software/learning website:

https://beeindia.gov.in/
http://nptel.ac.in/
https://lbre.stanford.edu/sem/energy_conservation

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