Savitribai Phule Pune University, Pune

Faculty of Science and Technology

Board of Studies

Electrical Engineering

Syllabus

Third Year Electrical Engineering (2019 course)

(w.e.f. 2021-22)

Savitribai Phule Pune University, Pune
Syllabus: Third Year (TE) Electrical Engineering (2019 course)
(w.e.f 2021-22)

SEMESTER-I

Course code	Course Name	Teaching Scheme				Examination Scheme						Credit				
		Th	Pr	Tu	SEM /PW /IN	ISE	ESE	TW	PR	OR	Total	Th	Pr	Tu	SEM /PW /IN	Total
303141	Industrial and Technology Management	3	0	0	0	30	70	0	0	0	100	3	0	0	0	3
303142	Power Electronics	3	4#	0	0	30	70	0	50	0	150	3	2	0	0	5
303143	Electrical Machines-II	3	2	0	0	30	70	25	25	0	150	3	1	0	0	4
303144	Electrical Installation Design and Condition Based Maintenance	3	4#	0	0	30	70	25	0	25	150	3	2	0	0	5
303145	Elective-I	3	0	0	0	30	70	0	0	0	100	3	0	0	0	3
303146	Seminar	0	0	0	1	0	0	50	0	0	50	0	0	0	1	1
303147	Audit course-V	2*	0	0	0	0	0	0	0	0	0	GRADE: PP/NP				0
Total		**15**	**10**	**0**	**1**	**150**	**350**	**100**	**75**	**25**	**700**	**15**	**5**	**0**	**1**	**21**

303145: Elective-I	**303147 : Audit Course-V**
303145A : Advanced Microcontroller and Embedded System	303147A : Energy storage systems
303145B : Digital Signal Processing	303147B : Start-up & Disruptive innovation
303145C : Open Elective	

SEMESTER-II

Course code	Course Name	Teaching Scheme				Examination Scheme						Credit				
		Th	Pr	Tu	SEM /PW /IN	ISE	ESE	TW	PR	OR	Total	Th	Pr	Tu	SEM /PW /IN	Total
303148	Power System-II	3	2	1	0	30	70	25	50	0	175	3	1	1	0	5
303149	Computer Aided Design of Electrical Machines	3	4#	0	0	30	70	50	0	25	175	3	2	0	0	5
303150	Control System Engineering	3	2$	1$	0	30	70	25	0	25	150	3	1	0	0	4
303151	Elective-II	3	0	0	0	30	70	0	0	0	100	3	0	0	0	3
303152	Internship	0	0	0	4	0	0	100	0	0	100	0	0	0	4	4
303153	Audit Course VI	2*	0	0	0	0	0	0	0	0	0	GRADE: PP/NP				0
Total		12	8	2	4	120	280	200	50	50	700	12	4	1	4	21

303151: Elective-II	**303153 : Audit Course-VI**
303151A : IoT and its Applications in Electrical Engineering	303153A: Ethical Practices for Engineers
303151B : Electrical Mobility	303153B :Project Management
303 151C: Cybernetic Engineering	
303151D: Energy Management	

#Practical consists of Part A & part B. PART A; Regular experiments & part B; to bridge the gap between theory & actual industrial practices. For subject 303144; there will be auto cad drawing on Electrical installation, Electrical wiring, cabling etc. For 303149, Part A, Regular drawing by hand & part B same drawing by AutoCAD.
$ tutorial credit merged with Practical.
* Conduct over and above these lectures.

303145A: Elective-I: Advanced Microcontroller and Embedded System

Teaching Scheme			Credits		Examination Scheme	
Theory	03	Hr/Week	**TH**	03	**ISE**	30 Marks
					ESE	70 Marks

Prerequisite:

1. Knowledge of Number system and Basic logic components.
2. Programming basics of C language.
3. Advantage of Microcontroller over Microprocessor.

Course Objectives: The course aims to:

1. Help Students understand Architecture of PIC 18F458 microcontroller.
2. Create and enhance ability to write and Interpret Assembly and C language for PIC 18F458.
3. Make students understand procedure to interface peripherals with PIC 18F458 for various Applications.

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

CO1	Explain architecture of PIC 18F458 microcontroller, its instructions and the addressing modes.
CO2	Use Ports and timers for peripheral interfacing and delay generation.
CO3	Interface special and generate events using CCP module.
CO4	Effectively use interrupt structure in internal and External interrupt mode.
CO5	Effectively use ADC for parameter measurement and also understand LCD interfacing.
CO6	Use Serial Communication and various serial communication protocols.

Unit 01	**PIC Architecture and Embedded C**	**07 hrs**

Comparison of CISC and RISC Architectures, Data and Program memory organization, Program Counters, Stack pointer, Bank Select Register, Status register, Embedded C concepts, Header and source files and pre-processor directives, Data types, data structures, Control loops, functions, bit operations.

Unit 02	**Port and Timer 0 Programming**	**05 hrs**

I/O Ports and related SFRs, I/O port programming in C. PIC 18 Timer 0 Programing in C. Delay programming (with and without Timer0). LED Interfacing and its programming.

Unit 03	**CCP Module and its applications**	**06 hrs**

CCP module in PIC 18 microcontroller, Timers required for CCP Applications, Applications of CCP mode Generation of Square waveform using Compare mode of CCP module. Period measurement of unknown signal using Capture mode in CCP module, Speed control of DC motor using PWM mode of CCP module.

Unit 04	**Interrupt structure and its Programming**	**05 hrs**

Interrupt Programming, Programming of Timer0 interrupts, Programming of External interrupts INT0.

Unit 05	**ADC structure and LCD interfacing**	**07 hrs**

PIC ADC, Programming of ADC using interrupts, Measurement of temperature and Power. Using PIC microcontroller. Interfacing of LCD (16x2) in 4 bit mode.

Unit	**Serial Communication and its protocols**	**06 hrs**

06		
Serial Communication structure and its programming (Data transmit and Receive), Introduction to Communication protocols as SPI and MODE BUS		
Test Books:		
[T1]	PIC Microcontroller and Embedded Systems Using Assembly and C for PIC18 by Muhammad Ali Mazidi, Rolind D. McKinley, Danny Causey, Pearson Education.	
[T2]	Fundamentals of Microcontrollers and Applications in Embedded Systems with PIC by Ramesh Gaonkar, Thomson and Delmar learning, First Edition.	
[T3]	Programming And Customizing the PIC Microcontroller by Myke Predko, TATA McGraw-Hill.	
[T4]	PIC microcontroller: An introduction to software and Hardware interfacing by Han-Way-Huang Thomson Delmar Learning.	
[T5]	Microcontroller Theory and Applications with PIC18F, M. Rafiquzzaman, John Wiley and Sons	
Reference Books:		
[R1]	PIC18F458 datasheet	
[R2]	MPLAB IDE user guides	
[R3]	MICROCHIP Technical Reference Manual of 18F4520 Embedded Design with PIC 18F452 Microcontroller by John B. Peatman, Prentice Hall	

Unit	Text Books	Reference Books
Unit 1	T1,T2,T3,T4	R1
Unit 2	T1, T2,T3,T4,T5	R1,R2
Unit 3	T1,T4,T5	R1
Unit 4	T1,T2,T3,T4	R1
Unit 5	T1,T2,T3,T4	R1
Unit 6	T1,T2,T3,T4	R1,R3

303151B: Elective-II: Electric Mobility

Teaching Scheme			Credits		Examination Scheme	
Theory	03	Hr/Week	**TH**	03	**ISE**	30 Marks
					ESE	70 Marks

Prerequisite:

Basic concept of Batteries, Electrical Motors, Power Electronics

Course Objectives: This course aims to

1. To make students understand the need & importance of Electric & Hybrid Electric vehicles.
2. To differentiate and analyze the various energy storage devices.
3. To impart the knowledge about architecture and performance of Electric and Hybrid Vehicles
4. To classify the different drives and controls used in electric vehicles.

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

CO1	Analyze the concepts of Hybrid and Electric vehicles.
CO2	Describe the different types of energy storage systems
CO3	Comprehend the knowledge of the battery charging and management systems.
CO4	Classify the different mode of operation for hybrid vehicle.
CO5	Apply the different Charging standards used for electric vehicles.
CO6	Differentiate between Vehicle to home & Vehicle to grid concepts.

Unit 01	**Introduction to Hybrid and Electric vehicles**	**06 hrs**

Need and importance of Electric Vehicle and Hybrid Electric Vehicles, Environmental importance of Hybrid and Electric vehicles. Hybrid Electric vehicles: Concept and architecture of HEV drive train (Series, parallel and series-parallel). Micro Hybrid, Mild Hybrid, Full Hybrid, Plug-in Hybrid, Electric vehicles: Components, configuration, performance, tractive effort, Advantages and challenges in EV.

Unit 02	**Energy Storage Systems**	**06 hrs**

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery specifications, Battery based energy storage and its analysis, Classification of lithium-ion batteries, Aluminum Air and Aluminum ion battery. Fuel Cell based energy storage, Super Capacitor based energy storage, Hybridization of Ultra capacitor and Battery. Selection methodology for the energy storage.

Unit 03	**Battery Charging and Management Systems**	**06 hrs**

introduction: Different Charging algorithms and Charging method, Cell Balancing methods.
Battery Management System: Functions of BMS, Block diagram of BMS. SoC Estimation methods, Thermal Management of Battery.

Unit 04	**Hybrid Power Train and mode of operation**	**06 hrs**

Control Strategies and Design of the Major Components: Series and Parallel Hybrid Electric Drive Train. Energy Consumption in Braking, Braking Power and Energy on Front and Rear Wheels, Brake System of EVs and HEVs, Regenerative braking

Unit 05	**Drives and Charging Infrastructure**	**06 hrs**

Selection of drives for Electric vehicle: PMSM drive and BLDC drive, Sizing of motor, Charging Levels: 01,02 and 03, Charging Standards: CCS, CHAdeMO, SAE J1772, IEC 60309, Bharat DC 001, Bharat AC 001, Electric Vehicle Supply Equipment (EVSE).

Unit 06	**Vehicle to Home, Vehicle to Vehicle and Vehicle to Grid**	**06 hrs**

Vehicle to Home: Introduction, applications, V2H with demand response, Case Study of V2H.
Vehicle to Grid: Introduction of V2G, V2G infrastructure in the smart grid, Role of aggregator for V2G, Case study of V2G, Vehicle to Vehicle: Introduction of V2V, Concept & structure.

Test Books:

[T1]	"Electrical Vehicle", James Larminie and John Lowry, John Wiley & Sons, 2012.

[T2]	"Electric and Hybrid-Electric Vehicles", Ronald K. Jurgen, SAE International Publisher.
[T3]	"Energy Systems for Electric and Hybrid Vehicles", K T Chau, The institution of Engineering and Technology Publication
[T4]	"Batteries for Electric Vehicles", D.A.J Rand, R Woods & R M Dell ,Research studies press Ltd, New York, John Willey & Sons
[T5]	Electric & Hybrid Vehicles-Design Fundamentals, CRC press
Reference Books:	
[R1]	"Modern Electrical Hybrid Electric and Fuel Cell Vehicles: Fundamental, Theory and design", Mehrdad Ehsani, Yimin Gao and Ali Emadi. CRC Press, 2009.
[R2]	"Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid", Junwei Lu & Jahangir Hossain et al (eds), IET Digital Library.
[R3]	"Automobile Electrical and Electronic systems", Tom Denton, SAE International publications.
[R4]	"Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", C. Mi, M. A. Masrur and D. W. Gao, John Wiley & Sons, 2011.
[R5]	The Electric Vehicle Conversion handbook –Mark Warner, HP Books, 2011.
Online Resources:	
[O1]	https://www.theiet.org/resources/books/transport/vehicle2grid.cfm?
[O2]	https://www.sae.org/publications/books/content/pt-143.set/
[O3]	http://nptel.ac.in/courses/108103009/

SAVITRIBAI PHULE PUNE UNIVERSITY

SYLLABI OF ALL 4 ELECTIVE SUBJECTS ELECTED BY STUDENTS IS GIVEN IN THIS DOCUMENT

FACULTY OF ENGINEERING

SYLLABUS FOR

B.E. ELECTRICAL ENGINEERING

(2015 course)

WITH EFFECT FROM YEAR 2018-2019

Savitribai Phule Pune University

FACULTY OF ENGINEERING

B.E. Electrical Engineering (2015 Course)
(w.e.f. 2018-2019)

SEMESTER-I													
Sr No	Subject Code	Subject Title	Teaching Scheme (Hrs/Week)			Examination Scheme (Marks)					Total Marks	Credit	
						PP		TW	PR	OR			
			TH	PR	TU	In Sem	End Sem					TH / TU	PR + OR
1	403141	Power System Operation and Control	03	02	--	30	70	25	--	25	150	03	01
2	403142	PLC and SCADA Applications	04	02	--	30	70	25	50	--	175	04	01
3	403143	Elective I	03	02	--	30	70	25	--	--	125	03	01
4	403144	Elective II	03	--	--	30	70	--	--	--	100	03	--
5	403145	Control System II	03	02	--	30	70	25	--	25	150	03	01
6	403146	Project I	--	--	02	--	--	--	--	50	50	02	--
	403152	Audit Course V											
TOTAL			16	08	02	150	350	100	50	100	750	18	04

SEMESTER-II													
Sr No	Subject Code	Subject Title	Teaching Scheme (Hrs/Week)			Examination Scheme (Marks)					Total Marks	Credit	
						PP		TW	PR	OR			
			TH	PR	TU	In Sem	End Sem					TH / TU	PR + OR
1	403147	Switchgear and Protection	03	02	--	30	70	50	--	25	175	03	01
2	403148	Power Electronic Controlled Drives	04	02	--	30	70	25	50	--	175	04	01
3	403149	Elective III	03	02	--	30	70	25	--	25	150	03	01
4	403150	Elective IV	03	--	--	30	70	--	--	--	100	03	--
5	403151	Project II	--	--	06	--	--	50	--	100	150	06	--
	403153	Audit Course VI											
TOTAL			13	06	06	120	280	150	50	150	750	19	03

TH	**Theory lectures hours/week**	**TW**	**Term work**
PR	**Practical hours/week**	**OR**	**Oral**
TU	**Tutorial hours/week**	**PP**	**Paper- In semester and End Semester**

Elective I (403143) **A) Fundamentals of Microcontroller MSP430 and its Applications [Open Elective]** **B) Power Quality** **C) Renewable Energy Systems** **D) Digital Signal Processing**	**Elective II (403144)** **A) Restructuring and Deregulation** **B) Electromagnetic Fields** **C) EHVAC Transmission** **D) Electric and Hybrid Vehicles** **E) Special Purpose Machines**
Elective III (403149) **A) High Voltage Engineering** **B) HVDC and FACTS** **C) Digital Control System** **D) Intelligent Systems and Applications in Electrical Engineering** **E) Analog Electronics and Sensing Technology [Open Elective]**	**Elective IV (403150)** **A) Smart Grid** **B) Robotics and Automation** **C) Illumination Engineering** **D) VLSI Design[Open Elective]**

Audit Course

- Audit Course: Optional for 1st and 2nd term of BE Electrical Engineering
- 'Audit Courses' means a Course in which the student shall be awarded Pass or Fail only. It is left to the discretion of the respective affiliated institute to offer such courses to the students. Evaluation of audit course will be done at institute level itself.
- Teaching-learning process for these subjects is decided by concern faculty/industry experts appointed by the affiliated Engineering College based on the syllabus and guidelines given.
- Marks obtained by student for audit course will not be taken into consideration of SGPA or CGPA.

Audit Course V 403152	**(A) Hydro Energy Systems** **(B) Foreign Language – German**
Audit Course VI 403153	**Energy Storage Systems**

Elective I: 403143 (B) : Power Quality

Teaching Scheme		Credits	Examination Scheme [125 Marks]		
Theory	: 03 Hr/Week	03	In Sem	:	30 Marks
Practical	: 02 Hr/Week	01	End Sem	:	70 Marks
			Term work	:	25 Marks

Prerequisite:
Fundamentals of Power system and Power electronics.

Course Objective: The course aims to:-
- Develop ability to identify various power quality issues, its sources and effects on various equipments.
- Monitor and analyze various power quality problems
- Describe and selection of cost effective power quality mitigation solutions.
- Explain use of power quality standards

Course Outcome: Upon successful completion of this course, the students will be able to:-
1. Identify importance of various power quality issues.
2. Carry out power quality monitoring
3. List and explain various causes and effects of power quality problems
4. Analyze power quality parameters and carry out power quality analysis
5. Select cost effective mitigation technique for various power quality problems
6. Use IEEE 519-2014 power quality standard for harmonic compliance

Unit 01 : Basics of power quality (06 Hrs)
Introduction and importance of power quality, symptoms of poor power quality. Classification of power quality events, power quality definition as per IEEE 1159.Grounding of sensitive electronic equipments and guidelines of IEEE std 1100.Long duration RMS voltage variations, its sources, effects and solutions.

Unit 02 : Voltage Sag (06 Hrs)
Sources of voltage sags, classification of voltage sags, factors governing severity of voltage sag. Area of vulnerability, critical distance. Voltage sag characteristics. Classification of equipments based on its sensitivity to various characteristics of voltage sag. Effect of voltage sag on various equipments. Voltage tolerance curve, ITIC and SEMI F47 curve, investigation of sensitivity of equipments to voltage sags. Voltage sag mitigation techniques at equipment level, LT power entrance and medium voltage. Voltage sag indices. Study of important provisions in IEEE Std 1346.

Unit 03 : Transient Overvoltage and Flicker (06 Hrs)
Sources of transient over voltages, Impulsive and oscillatory transients. Magnification of capacitor switching transients, pre insertion reactors to control capacitor switching transients, ferroresonance, principle of over voltage protection. Devices for over voltage protection. Voltage flicker, its sources. Factors governing severity of flicker. Flicker measurement, Pst and Plt. Flicker mitigation solutions.

Unit 04 : Fundamentals of Harmonics (06 Hrs)
Waveform Distortion, Harmonics, Harmonic phase sequences. Classification of harmonics harmonic, Voltage Verses Current distortion, AC quantities under non-sinusoidal conditions, Voltage and current harmonic indices, Sources of harmonics, General and special Effects of Harmonics on Electrical Equipments, cables, switchgears, Meters and Communications.

Unit 05 : Harmonic Mitigation Techniques (06 Hrs)

System behaviour to harmonics, location of harmonic sources, Series and parallel resonance, Harmonic mitigation, passive tuned and detuned filters, design of tuned filters, Active Filter, Sizing and location of active filters, Advantages of active filters over passive filters, Hybrid filters. IEEE 519-2014 standard.

Unit 06 : Power Quality Monitoring (06 Hrs)

Objectives of Power quality monitoring. Types of power quality monitoring, Power quality monitoring equipments, Power quality analyser specification requirement as per EN50160 Standard. Selection of power quality equipments for cost effective power quality monitoring, selection of voltage and current transducers. Power quality indices. IEEE 1159 standard and important provision related with power quality monitoring. Computer Tools for analysis of power quality.

Guidelines for Instructor's Manual

Instructor's Manual shall have

- Brief relevant theory.
- Equipment with specifications.
- Connection diagram/ methodology.
- Format of observation table and sample results.

Guidelines for Student's Lab Journal

The Student's Lab Journal should contain following related to every experiment –

9. Theory related to the experiment.
10. Apparatus with their detailed specifications.
11. Connection diagram /circuit diagram.
12. Observation table/ simulation waveforms.
13. Sample calculations for one/two reading.
14. Result table.
15. Graph and Conclusions.
16. Few short questions related to the experiment.

Guidelines for Laboratory conduction

- Read and understand power quality analyzer manual completely.
- Make sure that connections of power analyzer are done as per manual.
- Follow safety protocols while doing power quality audit.

List of Experiments

Minimum 8 experiments are to be performed from the following list:

Compulsory experiments:

1. Study of power quality analyzer and measurement of voltage, current, power and power factor using it.
2. Measurement of harmonic distortion of various Equipments such as UPS /AC/DC drive
3. Harmonic compliance of institute as per IEEE 519-2014 standard and sizing of active filter.
4. Power quality audit of institute or department.

Any 4 experiments from following list:

1. Harmonic analysis of transformer for various conditions (no load, inrush, full load etc.)
2. Analysis of performance of induction motor/transformer operated with sinusoidal supply and under distorted supply conditions supplied by 3 phase inverter.
3. Measurement of voltage sag magnitude and duration by using digital storage oscilloscope/ power quality analyzer.
4. Design of 7% detuned Passive Filter
5. Simulation study of transient and/or flicker measurement.
6. Simulation studies of harmonic generation sources such as VFD, SVC, STATCOM and FACTS devices and harmonic measurement (THD) by using professional software like MATLAB.
7. Harmonic load flow analysis by using professional software such as ETAP, PSCAD, ATP etc.

Text Books:

[T1] R. C. Dugan, Mark F. McGranghan, Surya Santoso, H. Wayne Beaty, "Electrical Power System Quality", 2nd Edition, McGraw Hill Publication.

[T2] M. H. J. Bollen, "Understanding Power Quality Problems, Voltage Sag and Interruptions", New York: IEEE Press, 2000, Series on Power Engineering.

[T3] C.Sankaran "Power quality", CRC Press

[T4] Arrillaga, M. R. Watson, S. Chan, "Power System Quality Assessment", John Wiley and Sons.

Reference Books:

[R1] Enriques Acha, Manuel Madrigal, "Power System Harmonics: Computer Modeling and Analysis", John Wiley and Sons Ltd.

[R2] Ewald F. Fuchs, Mohammad A. S. Masoum, "Power Quality in Power Systems and Electrical Machines" Elsevier Publication.

[R3] G. J. Heydt, "Electric Power Quality", Stars in Circle Publications

[R4] EN50160and IEEE 1100, 1346,519 and 1159 standards

[R5] Arrillaga, M. R. Watson, "Power System Harmonics", John Wiley and Sons

Unit	Text Books	Reference Books
1	T1,T2, T3	R3, R4
2	T1,T2,T3	R2, R3, R4
3	T1,T2,T3	R2, R3
4	T1,T3,T4	R1, R4, R5
5	T1,T3,T4	R1, R4, R5
6	T1,T3	R1, R4

Elective II : 403144 (D) : Electric and Hybrid Vehicles

Teaching Scheme	Credits	Examination Scheme [100 Marks]
Theory : 03 Hr/Week	03	In Sem : 30 Marks
		End Sem : 70 Marks

Prerequisite: Basic concept of Batteries, Electrical motors, Power electronic conversion

Course Objective: The course aims:-

- To make students aware the need and importance of Electric, Hybrid Electric Vehicles and Fuel cell vehicle.
- To differentiate and analyze the various energy storage devices and battery charging and management systems.
- To impart knowledge about architecture and performance of Electric and Hybrid Vehicles
- To classify the different drives and controls used in electric vehicles.

Course Outcome: Upon successful completion of this course, the students will be able to:-

1. Review history, Social and environmental importance of Hybrid and Electric vehicles.
2. Describe the performance and selection of energy storage systems and Analyze battery management system.
3. Distinguish between the performance and architecture of various drive trains.
4. Describe the different Instrumentation and Control used for electric vehicles.
5. Differentiate between Vehicle to Home, Vehicle to Vehicle and Vehicle to Grid energy systems concepts.

Unit 01 : Introduction (05 Hrs)

Conventional Vehicle: Basic of Vehicle performance, vehicle power source characterization, transmission characterization. Need and importance of transportation development.
History of Electric Vehicle, Hybrid Electric Vehicle and Fuel cell Vehicle. Social and environmental importance of Hybrid and Electric vehicles. Impact of modern drive-trains on energy supplies.

Unit 02 : Energy Storage Systems (07 Hrs)

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, Ultra capacitor based energy storage and its analysis, flywheel based energy storage and its analysis.
Hybridization of energy sources for Hybrid and Electric vehicle: - Hybridization of drive trains in HEVs, Hybridization of energy storage in EVs.
Selection of energy storage technology.

Unit 03 : Battery charging and Management systems (06 Hrs)

Introduction, charging algorithm, balancing method for battery pack charging.
Battery management system representation: - battery module, measurement unit block, battery equalization balancing unit, MCU estimation unit, display unit, fault warning block.
SoC and SoH, estimation of SoC, battery balancing, Thermal monitoring of Battery unit.

Unit 04 : Hybrid and Electric vehicles (05 Hrs)

Electric vehicles: - Components, configuration, performance, tractive efforts in normal driving, Advantages and challenges in EV design.
Hybrid Electric vehicles: - Concept and architecture of HEV drive train (Series, parallel and series-parallel).Energy consumption of EV and HEV

Unit 05 : Drives and control systems (07 Hrs)

Drives: - Application of BLDC drives and Switched reluctance motor drive for HEV and EV, performance characteristics of drives.

Instrumentation and control system related to Hybrid and Electric vehicles, speed control, acceleration characteristics, Electric steering, motion control, braking mechanism, Vehicle tracking through GPS, over speed indicating systems, Auto-parking systems

Unit 06 : Vehicle to Home, Vehicle to Vehicle and Vehicle to Grid energy systems (06 Hrs)

Vehicle to Home(V2H): PHEV control Strategies to V2H applications, V2H with demand response.

Vehicle to Vehicle(V2V): - Concept and structure of EV aggregator, control method for EV aggregator for dispatching a fleet of EV.

Vehicle to Grid(V2G): - planning of V2G infrastructure in the smart grid, ancillary services provided by V2G, cost emission optimization.

Text Books:

[T1] James Larminie and John Lowry, "Electrical Vehicle", John Wiley and Sons, 2012.

[T2] Ronald K. Jurgen, "Electric and Hybrid-Electric Vehicles", SAE InternationalPublisher**.**

[T3] K T Chau, "Energy Systems for Electric and Hybrid Vehicles", The institution of Engineering and Technology Publication

[T4] D.A.J Rand, R Woods, R M Dell, "Batteries for Electric Vehicles", Research studies press Ltd, New York, John Willey and Sons

[T5] Electric and Hybrid Vehicles-Design Fundamentals, CRC press

[T6] Mark Warner, The Electric Vehicle Conversion handbook –HP Books, 2011.

Reference Books:

[R1] Mehrdad Ehsani, Yimin Gao and Ali Emadi, "Modern Electrical Hybrid Electric and Fuel Cell Vehicles: Fundamental, Theory and design", CRC Press, 2009.

[R2] Junwei Lu, Jahangir Hossain,"Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid", IET Digital Library.

[R3] "Automobile Electrical and Electronic systems", Tom Denton, SAE International publications.

[R4] "Automotive handbook 5th edition", Robert Bosch, SAE international publication.

Unit	Text Books	Reference Books
1	T1,T2,T3, T4, T5	R1
2	T1,T2,T3, T4, T5	R1, R3
3	T2,T3,T4	R1
4	T1,T2,T5	R1
5	T1,T2,T5	R1
6	T3	R2

Elective –III : 403149 (A): High Voltage Engineering

Teaching Scheme	Credits	Examination Scheme [150 Marks]
Theory : 03 Hrs./Week	03	In Sem : 30 Marks
Practical : 02 Hrs./Week	01	End Sem : 70 Marks
		Oral : 25 Marks
		Term work : 25 Marks

Prerequisite: Atomic and molecular structure of gaseous and solid materials, basic properties of conductors and insulators, knowledge of material science.

Course Objective: The course aims to:-

- To enable students to know and compare the various processes of breakdown in solid, liquid and gaseous dielectric materials
- To enable students understand and apply various methods of generation and measurement of DC, AC, impulse voltage and current.
- To enable students to know the charge formation and separation phenomenon in clouds, causes of overvoltage and lightening phenomenon
- To develop ability among learners to execute testing on various high voltage equipments as per standards
- To introduce students to the design, layout, safety precautions, earthing, and shielding of HV laboratory.

Course Outcome: Upon successful completion of this course, the students will be able to

1. Identify, describe and analyze the breakdown theories of solid, liquid and gaseous materials
2. Describe as well as use different methods of generation of high AC, DC, impulse voltage and current.
3. Demonstrate and use different methods of measurement of high AC, DC, impulse voltage and current.
4. Identify the occurrence of overvoltage and to provide remedial solutions
5. Demonstrate an ability to carry out different tests on high voltage equipment and devices as well as ability to design the high voltage laboratory with all safety measures

Unit 01 : Breakdown in Gases (06 Hrs)

Ionization process in gas, Townsend's Theory, current growth equation in presence of primary and secondary ionization processes, Townsend's breakdown criterion, primary and secondary ionization coefficients, limitations of Townsend's theory, Streamer mechanism of breakdown, Paschen's Law and its limitations, Corona discharges for point plane electrode combination with positive and negative pulse application, time lag and factors on which time lag depends. (Numerical on Townsend's theory and Paschen's law).

Unit 02 : (06 Hrs)

1. **Breakdown in Liquid Dielectrics:** Pure and commercial liquids, Different breakdown theories: Breakdown in Pure liquid and breakdown in commercial liquids: Suspended Particle theory, Cavitations and bubble theory, Thermal mechanism of breakdown and Stressed Oil volume theory

2. Breakdown in Solid Dielectrics: Intrinsic breakdown: electronic breakdown, avalanche or streamer breakdown, electro-mechanical breakdown, thermal breakdown, treeing and tracking phenomenon, Chemical and electrochemical breakdown, Partial discharge(Internal discharge),Composite dielectric material, Properties of composite dielectrics, breakdown in composite dielectrics. (Numerical on theories of liquid and solid dielectric materials)

Unit 03 : Generation of High Voltages and Current (06 Hrs)

a)Generation of high ac voltages-Cascading of transformers, series and parallel resonance system, Tesla coil

b)Generation of impulse voltages and current-Impulse voltage definition, wave front and wave tail time, Multistage impulse generator, Modified Marx circuit, Tripping and control of impulse generators, Generation of high impulse current

Unit 04 : Measurement of High Voltage and HighCurrents: (06 Hrs)

Sphere gap voltmeter, electrostatic volt meter, generating voltmeter, peak reading voltmeter, resistive, capacitive and mixed potential divider , capacitance voltage transformer, cathode ray oscilloscope for impulse voltage and current measurement, measurement of dielectric constant and loss factor, partial discharge measurements. Measurement of high power frequency a.c. using current transformer with electro-optical signal converter, Radio interference measurements.

Unit 05 : Lightning and Switching Over Voltages (06 Hrs)

Causes of over voltages, lightning phenomenon, Different types of lightening strokes and mechanisms of lightening strokes, Charge separation theories, Wilson theory, Simpson theory, Reynolds and Mason theory, Over voltage due to switching surges and methods to minimize switching surges. Statistical approach of insulation coordination

Unit 06 : High Voltage Testing of Electrical Apparatus and H V Laboratories: (06 Hrs)

a)Testing of insulators and bushings, Power capacitors and cables testing, testing of surge arresters.

b) Design, planning and layout of High Voltage laboratory:-Classification and layouts, earthing and shielding of H.V. laboratories.

Guidelines for Instructor's Manual

The Instructor's Manual should contain following related to every experiment

- Brief theory related to the experiment.
- Circuit diagram and apparatus with their detail specification as per IS code.
- Students should be encouraged to visit industries/HV laboratories/HV installations.
- Students should be encouraged to use virtual labs.
- Few short questions related to each practical.

Assignments based on use of IS and IEC

Guidelines for Student's Lab Journal

The Students lab journal should contain:

- Brief theory related to the experiment.
- Circuit diagram and apparatus with their detail specification as per IS code.
- Observations, result tables and proper inferences/ conclusion from each experiment conducted.
- Reports on visit to industries/HV laboratories/HV installations.
- Simulations and print outs of use of virtual labs.
- Few short questions and answers related to each practical.
- Assignments based on use of IS and IEC.

Guidelines for Laboratory conduction

- There should be continuous assessment for the TW.
- Assessment must be based on understanding of theory, attentiveness during practical.
- Session, how efficiently the student is able to do connections and get the results.
- Timely submission of journal.

List of Experiments

1. To find the constants of breakdown equation of transformer oil.(Analytical and graphical method)
2. Measurement of unknown high a.c. voltage using sphere gap
3. To obtain breakdown strength of composite insulation system, and observe the effect of parameter like no. of layers, thickness of layer, effect of interfacing.
4. To find out the breakdown of air in uniform and non uniform field and compare it.
5. To study surface flashover on corrugated porcelain/polymeric insulation system.
6. To understand basic principle of corona and obtain audible and visible corona inception and extinction voltage under non uniform field.
7. To perform experiment on horn gap arrestor and understand arc quenching phenomenon.
8. To observe development of tracks and trees on polymeric insulation system.
9. Parametric analysis of Impulse current generator using virtual Laboratory.
10. To perform experiment on rod gap arrestor.
11. To Study effect of barrier on breakdown voltage of air/ transformer oil.
12. Simulation of lightening and switching impulse voltage generator using any simulation software.
13. To perform various HV insulation tests on cables as per IS.
14. Study of layout /earthing/safety of HV installation /lab in any industry by visit /virtual lab
15. Study of any IS for any power apparatus (Power Transformer/Induction Motor/ Alternator etc)

Industrial Visit: Industrial visit to high voltage equipment manufacturing industry/EHV substation/High Voltage Testing Unit.

Text Books:

[T1] M. S. Naidu, V. Kamaraju, "High Voltage Engineering", Tata McGraw Hill Publication Co. Ltd. New Delhi

[T2] C. L. Wadhwa, "High Voltage Engineering", New Age International Publishers Ltd.

Reference Books:

[R1] E. Kuffel, W. S. Zaengl, J. Kuffel, "High Voltage Engineering Fundamentals", Newnes Publication

[R2] Prof. D. V. Razevig Translated from Russian by Dr. M. P. Chourasia, "High Voltage Engineering", Khanna Publishers, New Delhi

[R3] Ravindra Arora, Wolf Gang Mosch, "High Voltage Insulation Engineering", New Age International

[R4] High Voltage Engineering Theory and Practice by M. Khalifa Marcel Dekker Inc. New York and Basel.

[R5] Subir Ray, "An Introduction to High voltage Engineering" PHI Pvt. Ltd. New Delhi

[R6] NPTEL lectures

[R7] IS 731-1971:Porcelain insulator for overhead power lines with nominal voltage > 1000 Volt

[R8] Bushings :IS2099-1986,specification for bushings for A.C. Voltages > 1000 Volts

[R9] Pollution test :IEC 60507-1991 on external and internal insulator

[R10] High voltage test techniques, general definitions and test requirements: IS 2071(part 1) 1993,IEC Pub 60-1(1989)

Unit	Text Books	Reference Books
1	T1,T2	R1,R2,R3,R6
2	T1,T2	R1,R2,R3,R5,R6
3	T1,T2	R1,R2,R3,R5,R6
4	T1,T2	R1,R2,R3,R4,R5,R6
5	T1,T2	R1,R2,R3,R4,R5,R6
6	T1,T2	R1,R2,R3,R7,R8,R9, R10

Elective –IV : 403150 (A): Smart Grid

Teaching Scheme	Credit	Examination Scheme [100 Marks]
Theory : 03 Hrs / Week	03	In Sem : 30 Marks
		End Sem : 70 Marks

Prerequisite: Knowledge of power system and power electronics

Course Objective: The course aims:-

- To explain the concept of Smart Grid, compare with conventional grid, and identify its opportunities and barriers.
- To describe the concept of Smart Meter, Smart Appliances, Automatic Meter Reading, Outage Management System, Plug in Hybrid Electric Vehicles, Vehicle to Grid, Smart Sensors, Home and Building Automation, Phase Shifting Transformers.
- To elaborate the concept of Substation Automation, Feeder Automation. Intelligent Electronic Devices, Smart storage like Battery, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System, Phase Measurement Unit.
- To elaborate the concept of microgrid
- To acquaint Power Quality issues of Grid connected Renewable Energy Sources, Web based Power Quality monitoring, Power Quality Audit.

Course Outcome:

1. Apply the knowledge to differentiate between Conventional and Smart Grid.
2. Identify the need of Smart Grid, Smart metering, Smart storage, Hybrid Vehicles, Home Automation, Smart Communication, and GIS
3. Comprehend the issues of micro grid
4. Solve the Power Quality problems in smart grid
5. Apply the communication technology in smart grid

Unit 01 : Introduction to Smart Grid: (06 Hrs)

Concept of Smart Grid, Need of Smart Grid, Functions of Smart Grid, Opportunities and Barriers of Smart Grid, Drivers of SG in India, Functionalities and key components of smart grid, Difference between conventional and smart grid, Smart Grid Vision and Roadmap for India, Concept of Resilient and Self-Healing Grid, Present development and International policies in Smart Grid, Smart Cities, Pilot projects in India.

Unit 02 : Smart Grid Technologies (06 Hrs)

Remote Terminal Unit (RTU):Block diagram and function of each block, Intelligent Electronic Devices (IED), Phase Measurement Unit (PMU). Smart Substations, Substation and Feeder Automation, application for monitoring, protection and control, Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid(V2G), Grid to vehicles(G2V), Smart storage technologies and applications – Battery(flow and advanced), SMES, Super Capacitors, Compressed Air Energy Storage(CAES) and its comparison, Optimal location of PMUs for complete Observability.

Unit 03 : Smart Meters and Advance Metering Infrastructure: (06 Hrs)

Introduction to Smart Meters, Advanced Metering Infrastructure (AMI), Real Time Prizing, Automatic Meter Reading (AMR), Outage Management System (OMS) Smart Sensors, Smart Appliances, Home and Building Automation, Geographic Information System (GIS).

Unit 04 : Microgrids: (06 Hrs)

Concept of Microgrid, need and applications of Microgrid, Microgrid Architecture, DC Microgrid, Formation of Microgrid, Issues of interconnection, protection and control ofMicrogrid, Integration of renewable energy sources, Smart Microgrid, Microgrid and Smart Grid Comparison, Smart Microgrid Renewable Green Energy System, Cyber Controlled Smart Grid.

Unit 05 : Power Quality Management in Smart Grid (06 Hrs)

Power Quality and EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

Unit 06 : Communication Technology for Smart Grid (06 Hrs)

Communication Architecture of SG, Wide Area Measurement System (WAMS), Home Area Network (HAN), Neighbourhood Area Network (NAN), Wide Area Network (WAN)., ZigBee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Basics of CLOUD Computing and Cyber Security for Smart Grid, Broadband over Power line (BPL).

Text Books:

[T1] Ali Keyhani, Mohammad N. Marwali, Min Dai “Integration of Green and Renewable Energy in Electric Power Systems”, Wiley

[T2] Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”,CRC Press

[T3] Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley Publications.

[T4] Stuart Borlase, “Smart Grids-Infrastructure, Technology and Solutions”, CRC Press, Taylor and Francis group

[T5] James Momoh, “Smart Grid-Fundamentals of design and analysis”, Wiley Publications.

Reference Books:

[R1] Nikos Ziargyriour, “Micro grid, Architecture and Control”, IEEE Press, Wiley Publications.

[R2] Yang Xiao, “Communication and Networking in Smart Grids”, CRC Press, Taylor and Francis group

[R3] Lars T. Berger and Krzysztof Iniewski, “Smart Grid-Applications, Communications and Security”, Wiley Publications.

[R4] Mladen Kezunovic, Mark G. Adamiak, Alexander P. Apostolov, Jeffrey George Gilbert “Substation Automation (Power Electronics and Power Systems)”, Springer Publications.

[R5] Smart grid handbook for regulators and policy makers November 2017,ISGF