DEPARTMENT OF ELECTRICAL ENGINEERING
Fourth Year B. Tech Structure with effect from Academic Year 2018-19
(For the student taken admission in 2015-2016)

SEMESTER VII							
Sl. No.	**Code**	**Subject**	**Type**	**Teaching Scheme**			**Credit**
				L	**P**	**T**	
S1	EE40114	Power System Analysis and Control	Theory – Core	3	-	1	4
S2	CS41111	Soft computing	Theory – Core	3	-	0	3
S3	EE42117	HVDC Transmission	Elective – I	3	-	1	4
	EE42118	Power system stability & control					
	MA43114	Optimization Engineering					
	EE42119	Optimal control					
	CS43107	JAVA					
S4	EE42121	Advance power electronics	Elective – II	3	-	-	3
	EE42120	FACTS					
	EI43103	Sensor and Actuator					
	EE42123	EHVAC System					
	EC43106	VLSI design					
	CS43109	Operating Systems					
	EC43165	Embedded Systems					
P1	EE40309	Power System Lab	Lab –I	-	2	-	1
P2	EE42363 / EE	Advanced Power Electronics Lab / Soft & Evolutionary Computing Lab	Lab –II	-	2	-	1
P3	IN47404	Industrial Training report and viva-voce	Lab		2		1
P4	HS46323	Ethics for Engineering	Lab		2		1
MP	EE47497	Major Project(stage-II)	Project	-	6	-	3
			Total:	**12**	**14**	**2**	**21**

SEMESTER VIII							
Sl. No.	**Code**	**Subject**	**Type**	**Teaching Scheme**			**Credit**
				L	**P**	**T**	
S1	EE40115	Power system Protection	Theory – Core	3	-	1	4
S2	EE40116	Power Quality	Theory – Core	3	-	0	3
S3	EE42124	High voltage Engineering	Elective – I	3	-	1	4
	EC43163	Satellite communications systems					
	EI43108	Process control					
	CS43105	Data Communication & Computer Networking					
	EE42125	Restructured power system					
	CS43162	Data base management systems					
S4	EE42126	Distribution system Engineering	Elective – II	3	-	-	3
	EC43126	Adaptive signal Processing					
	EE42127	Special machines					
	EC43115	Digital Image Processing					
	EE42128	Smart Grid Technology					
P1	EE40310	Power system Protection Lab	Lab – Core	-	2	-	1
P2	EE42364	Power system simulation Lab	Lab – Elective	-	2	-	1
MP	EE47498	Major Project(stage-3)	Project	-	8	-	5
			TOTAL	**12**	**12**	**2**	**21**

EE42121-ADVANCED POWER ELECTRONICS (3-0-0)

Credits:3 **Teaching Scheme: -** Theory 03Hrs/Week

Prerequisites: Basic knowledge of Power Electronics & Electrical Machine

Course Objectives:

This course includes the advanced topics of power electronicssuch as some of the latest devices their control andapplications. The student will learn about the design and working of solid state power devices, switch mode power supplies and resonant converters. The student will also gain an insight into the various methods of power factor improvement with power electronic devices. The student will study about the working of inverters for applications with three phase supply. Further the student will be exposed to the non-drive applications of the power electronics devices.

Course Details:

Unit1: Solid State Power Devices & SMPS (8 Hrs)

U1.1. Design, Construction & Switching Characteristics of Power MOSFET, Power BJT, IGBT & GTO, Methods of Cooling, Thermal Design & Protection. Operation, Waveforms & Working Isolated & Non-Isolated DC-DC Converters (Buck, Boost, Buck-Boost, Flyback, Forward & Push-Pull)

U1.2. Small Signal Analysis & Closed loop control of DC-DC Converter

Unit2: Resonant Converters & Power Factor Improvement (8 Hrs)

U2.1. Operating Principle, Characteristics & Design Equations, Control Techniques & Applications of Resonant DC-DC Converters (ZCS & ZVS), Shunt Reactive Power Compensators, Static Reactive Compensators

U2.2. Switched Capacitors, Static Reactive VAR Generators using PWM-VSI

Unit3: Inverters (8 Hrs)

U3.1. Basic topology and waveform of Three Phase SPWM Inverters, Current Source Inverters (Load commuted inverters, Forced commutated inverters), Resonant AC link/ DC link Inverters& Soft Switched Inverters, Hard Switching Effects. Three Level Inverter: Basic Topology & Waveform, Improvement in Harmonics and High Voltage Application;

U3.2. Pulse width modulation techniques, Sinusoidal PWM, Space vector PWM, Hysteresis band current control PWM, Sigma delta modulation

Unit4: Control & Estimation of Induction Motor Drives (8 Hrs)

U4.1. Slip Power Recovery drives for Induction Motor: Static Kramer Drive and Static Scherbius Drive.Control & Estimation of Induction Motor Drives: Scalar Control, Field oriented Control, Direct Torque Control

U4.2. Dynamic d-q modelling of 3-Φ Induction Motor Drives, Adaptive Method of control and estimation of Induction Motor Drives

Unit5: Non Drive Application of Power Electronic Converters (8 Hrs)

U5.1. Construction, Operation Characteristics and Working of HVDC, FACTS, STATCOM, UPFC, Active Harmonic Filter

U5.2. UPS, Electronic Ballast, Static VAR Compensator, Induction Heating.

Note: Five assignments to be given to the students, each comprises of one assignment from each unit (U1.1, U2.1, U3.1, U4.1, U5.1) and one from self study (U1.2, U2.2, U3.2, U4.2, U5.2)

Course Outcome:

At the end of the Course, the students will be able to

CO-1. Understand thedesign of power electronic devices and working of SMPS.

CO-2. Analyse the working of Resonant Converters and the methods of improving Power Factor.

CO-3. Understand the Basic Principle of Working of Inverters towards the improvement of harmonics.

CO-4. Gain an intuitive understanding of Vector Control & Scalar Control of Speed & Torque of Induction Machine Drives

CO-5. Learn about the various electrical devices utilising the non- drive application of power electronics.

Text Books:

T1. Power Electronics: Circuits, Devices and Applications by M H Rashid, 3rd Edition,

T2. Power Electronics: Converters , Applications and Design by Mohan, Undeland and Robbin, Wiley India Edition

T3. Modern Power Electronics and AC Drives by Bimal K Bose, Eastern EconomyEdition, PHI.

ReferenceBooks

R1. Switched Mode Power Supplies: Design and Construction by H W Whittington,B.W Flynn and D E Macpherson, 2nd Edition, Universities Press)

R2. Power Electronics, P. S. Bhimbra, Khanna Publishers, 2010

R3. Power Electronics: Principle & Applications, J. Vithyathil, TMH Publication

R4. http://nptel.iitm.ac.in

EE42363- ADVANCED POWER ELECTRONICS LABORATORY (0-0-2)

Credits:01 **Teaching Scheme: -** Laboratory 02Hrs/Week

Prerequisites: Basic knowledge of power electronics and electrical machines

Course Objectives:

This is explicit subject for electrical engineering where the student will acquire higher level of training and skill in power electronics. The student can learn about the gate driver circuits in application to power electronics devices. The student will get a practical exposure towards the performance and working of various devices in their application to high voltage system.Further the student will be introduced to the concept of dual converters and inverters and their working.

Course Details:

Select any 10 experiments from the list of 15 experiments

List ofExperiment:

Experiment-1. Study of SCR based gate driver circuit using 555 timer
Experiment-2. Study of MOSFET based gate driver circuit
Experiment-3. Study of 1-ΦFull wave rectifier with Source Inductance
Experiment-4. Study of 3-ΦFull wave rectifier with Source Inductance
Experiment-5. Study the performance of Cyclo-converter
Experiment-6. Study of 1-Φ dual converter
Experiment-7. Study of 3-Φ dual converter
Experiment-8. Study of 1-ΦCurrent Source Inverter
Experiment-9. Study the performance of 3-Φ AC voltage controller with R and R-L load
Experiment-10. Study the performance of Buck, Boost & Buck-boost converter operation
Experiment-11. Study the performance of Fly-back, Forward & Push-pull converter operation
Experiment-12. Study the performance of four quadrant chopper operation
Experiment-13. Study of series resonant inverter
Experiment-14. Study of ZCS and ZVS resonant converter
Experiment-15. Ramp comparator scheme of regulating AC power (TRIAC & Opto-Isolator)

Course Outcome:

At the end of the Course, the students will be able to

CO-1. Learn about Driver Circuits for SCR and MOSFET.

CO-2. Apply knowledge of 1-Φ& 3-Φ Full wave rectifier with the use of Source Inductance to eliminate harmonics

CO-3. Understand the working of Cyclo-Converter, Dual Converters, CSI and AC voltage controllers.

CO-4. Analyze the working of switch mode regulators and isolated regulators.

CO-5. Learn about the working and performance of resonant converters and inverters.

TextBooks:

T1. Modern Power Electronics and AC Drives by Bimal K Bose, Eastern EconomyEdition, PHI
T2. Power Electronics: Circuits, Devices and Applications by M H Rashid, 3rd Edition

ReferenceBooks

R1. Power Electronics, P. S. Bhimbra, Khanna Publishers, 2010
R2. Advanced Power Electronics Lab Manual, CVRCE

EI30103/EI43103SENSOR AND ACTUATORS (3-0-0)

Credits: 03 Teaching Scheme:- Theory 3Hrs/week

Prerequisites: Basic concepts of instrumentation and devices systems.

Objectives: To expose the students to the different types of sensors and actuators and smart sensors.

Course Details:

UNIT –I (8 hrs)

U1.1: Principles of Sensors, Force, Torque, tactile and Pressure Sensor

Sensor classification, Displacement sensors:Principles of variable resistance, variable inductance, variable reluctance, variable capacitance, Hall effect device, Digital displacement sensors. Tactile sensors using contact closure, magnetic, Piezoelectric, Photoelectric, capacitive and ultrasonic methods, Manometer, elastic elements, Electrical and Piezoelectric pressure transducers.

U1.2: McLeod gage, Pirani gage and lionization gage.**(T1)**

UNIT–II (8 hrs)

U2.1: Flow sensors

Basics of flow measurement; differential pressure flowmeters- Pitot tube, Orifice plate, Venturi tube; Rotameter, turbine type flowmeter, electromagnetic flowmeter,Anemometer,Doppler shift flowmeter.

U2.2 Max Machinery flow meter,Paddlewheel Sensors , Positive Displacement Flow Meters .

UNIT–III (8 hrs)

U3.1: Smart Sensor

Methods of internal compensation, information coding, integrated sensor principles, present trends. Sensors in Robotics - Potentiometers, Synchros and Resolvers, Optical encoders, Tactile and Proximity sensors, Non-contact ranging sensors

U3.2: Gyroscopes,**Magnetic Flow meters for Conductive Liquids, spring and Piston Flow Meters**

UNIT –IV (8 hrs)

U4.1: Final Control Elements

Pneumatic systems: Flapper nozzle amplifier and its characteristics, pneumatic actuators; elements of power electronic devices; Electrical actuators,solenoids, d.c and a.c. servomotors, principle of stepper motors, hydraulic actuators, Control valve characteristics.

U4.2: Bimorph,Jackscrew, SCADA, PLC

UNIT –V (8hrs)

U5.1: Actuators

Pneumatic Hydraulic system: Control valves, cylinder, rotary actuators, Mechanical actuating system: Types of Motion, Kinematics chains, Cams, Gear trains, Belts and chain drives, Electrical actuating systems: Solid-state switches, Solenoids, D.C. motors, AC motors, Stepper motors, piezoelectric actuator, micro-actuators.

U5.2 Micro actuator, Robotics,

Course Outcome: At the end of the Course, the students will be able to know the

CO1: concept of sensor as measuring device.

CO2: concept of Miscellaneous Measurements for flow monitor and control

CO3: concept of smart sensor for real world application

CO4: concept of Pneumatic systems for measurement system

CO5:concept of Actuators for practical application

Text Books:

T1. Principles of Measurement Systems- J.P. Bentley (3/e), Pearson Education, N Delhi,
T2. Introduction to Measurement and Instrumentation- A.K. Ghosh (3/e), PHI Learning.
T3. Process Control Instrumentation Technology- C.D. Johnson (8/e), PHI Learning,
T4.Sensors and Actuators: Control System Instrumentation by Clarence W. De Silva Publisher

Reference Books:

R1. Transducers and Instrumentation- D.V.S. Murthy (2/e), PHI Learning, New Delhi, 2009.
R2. Measurement Systems Application and Design- E.O. Doeblin (4/e), McGraw-Hill, International, NY.
R3. Modern Control Technology Components and Systems- C.T. Kilian (3/e), Clengage Learning, New Delhi, 2006.

EE42123-EHVAC SYSTEM (3-0-0)

Credits: 03 **Teaching Scheme: -** Theory 03 Hrs/Week

Pre-requisites: Electromagnetic theory, Transmission and distribution.

Course Objectives:

This course gives idea about modern trends in HVAC Transmission and its application, Understand about the overvoltage and its effects on power system.

Course details:

Unit1: Introduction to EHV Transmission Systems (8Hrs)

U.1.1: Parameters of EHV Lines, Resistance of conductors, Bundle conductors, Inductance of EHV Line configurations. line capacitance, Sequence Inductance and capacitance.

U.1.2: Line parameters for modes of propagation, resistance and Inductance of Ground returns.

Unit2: Voltage Gradient of conductors (8Hrs)

U2.1: Field of sphere gap, Field of line charges and their properties, Charge – potential relations for multi-conductor lines, Surface voltage gradient and conductors without and with ground wires consideration.

U2.2: Gradient factors, Distribution of voltage gradient on sub-conductors of bundle.

Unit3:Corona effects & Noise (8Hrs)

U.3.1: Power loss and Audible Noise, Corona loss, Charge- Voltage diagram, Attenuation of traveling waves Audible, Noise Generation, Characteristics and its limitation.

U.3.2: Measurement, meters, 1-phase and 3- phase AN levels.

Unit4: Over voltage in EHV systems caused by switching operations (8Hrs)

U.4.1: Origin of over voltage and their types, Short circuit current and circuit breaker, Recovery voltage and the circuit breaker, Over voltage caused by interruption of inductive current.

U.4.2: Interruption of capacitive currents, Ferro resonance over voltage, Calculation of switching surges single phase equivalents.

Unit5: Distributed parameter line energized by source (8Hrs)

U.5.1: Generalized equations for single phase representation, Generalized equation of three phase systems.

U.5.2: Inverse Fourier transform for the general case, Reduction of switching surges on EHV systems.

Note: Five assignments to be given to the students, each comprises of one assignment from each unit (U1.1, U2.1, U3.1, U4.1,U5.1) and one from self study (U1.2, U2.2, U3.2, U4.2,U5.2)

Course Outcome:

At the end of the Course, the students will be able to

CO-1. Understand the basic concepts of EHV AC.

CO-2. To understand the fundamental requirements of HVAC transmission line design .

CO-3. To identify the electrical requirements for EHVAC lines.

CO-4. To understand the operation of EHVAC technology.

CO-5. To identify factors affecting EHVAC transmission.

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Text Books:

T1. Begemudre R.D., "EHVAC Transmission Engineering" New Age International, 2007, ISBN : 8122417922, 9788122417920

T2. Rao S., "EHV AC & HVDC Transmission Systems" - Khanna Publisher.

Reference Books:

R1. High-Voltage Engineering: Theory and practice Second Edition, Revised and Mazen Abdel-Salam limited preview-2000

R2. An introduction to high voltage engineering SUBIR RAY .Limited preview-2000

R3. Open source material: www.delnet.nic.in

HS46323- ETHICS FOR ENGINEERS **(3-0-0)**

Credits: 03 **Teaching Scheme: - Theory 02 Hrs/Week**

Introduction/General Aim

Doing business for profit is good, doing business for profit as well as a social responsibility is better but doing business for profit and social responsibility in conformity with ethical values is the best. The present course on 'Business Ethics' hopes to prepare a pool of business professionals who can make significant contribution to the business world without sacrificing their individual moral values and without compromising the ethical values the company stands for. This will teach them how to strike a balance between individual values and the company values while doing successful business for the company they are in.

The course aims at comparing and contrasting business ethics and social responsibility norms and how they influence local and global business practices. The areas to be focused on will include marketing ethics, environmental responsibilities, discrimination, moral rights in the workplace, social responsibility etc. The lab sessions and discussions will provide a framework for identifying and analysing the range and diversity of ethical perspectives around the globe.

Course Objectives:

The objectives of this course are to:

1. Introduce students inductively to a conceptual framework that will facilitate the examination of a range of ethical and social responsibility issues that arise while conducting business in today's global marketplace.
2. Encourage student thinking, reasoning and decision making from the points of view of various stake holders (customers, employees, suppliers, governments, society, etc) as each of these relationships create ethical challenges and responsibilities; and
3. Help students to consider such ethical issues in terms of the type of life they themselves wish to lead and the type of public policy for governing business that they are willing to support.

Course Details:

Lab 1: Introduction and understanding ethics and business ethics,

Brief theoretical input + discussion

Case 1,2.

Lab 2: Individual ethics v/s organisational ethics.

Brief theoretical input + discussion

Case 3,4.

Lab 3: Corporate Social Responsibility.

Brief theoretical input + discussion; Case 5, 6

Lab 4: Case preparation and presentation on the types of cases already in the 1st three labs.

Lab 5: Corporate ethics v/s government policies.

Cases 7,8

Lab 6: Blowing the whistle.

Cases 9, 10

Lab 7: Ethics across the globe.

Brief theoretical input + discussion

Case 11, 12

Lab 8: Case preparation and presentation on the types of cases already done in labs 5-7.

Lab 9: Doing what is right in a competitive market.

Brief theoretical input + discussion

Case 13, 14

Lab 10: Ethics and Technology

Input + discussion

Cases 15, 16

Lab 11: Corporate Governance.

Input + discussion

Cases 17, 18.

Lab 12: Final presentation o0f individual cases written by individual students during the course.

Method of Evaluation

There will be 4 tests of 15 marks each. In addition, the final case preparation and presentation to be done in the last lab class will carry 40 marks.

Text Books:

T1. Business Ethics Now (2012) by Andrew W. Ghillyer, McGraw-Hill Irwin

Reference Books:

R1. Perspectives in Business Ethics: By Laura Hartman- McGraw-Hill
R2. Business Environment: By Francis Charunilam, Himalaya
R3. Ethics in Management: By S.A Sherlakar, Himalaya

EE42120-FLEXIBLE AC TRANSMISSION SYSTEMS (3-0-0)

Credits: 03 **Teaching Scheme: - Theory 03 Hrs/Week**

Pre-requisites: Power Electronics, Electrical Power Transmission and Stability Control

Course Objectives:

This subject facilitates to develop analytical skill and better understanding of FACTS devices, Optimising networks with FACTS devices & the future for FACTS in Interconnected EHV Systems.

Course Details:

Unit 1: FACTS concept and General System Considerations: (10 Hrs)

U1.3. Transmission Interconnections, Flow of Power in an AC System, What limits the Loading Capability, Basic Types of FACTS Controllers, Basic Description and Definitions of FACTS Controllers.
U1.4. Relative Importance of Controllable Parameters

Unit 2: Static Shunt Compensation (08 Hrs)

U2.1. Objectives of Shunt Compensation, Static VAR Compensators SVC and STATCOM.
U2.2. Methods of Controllable VAR Generation

Unit 3: Static Series Compensators (08 Hrs)

U3.1 Objective of Series Compensation (GCSC, TSSC, TCSC), Variable Impedance Type Series Compensators, Switching Converter Type Series Compensators (SSSC)
U3.2. Applications - improvement of the system stability limit.

Unit 4: Static Voltage and Phase Angle Regulator (07 Hrs)

U4.1. Objectives of Voltage and Phase Angle Regulators,
U4.2. Approaches to Thyristor-Controlled Voltage and Phase Angle Regulators (TCVRs and TCPARs).

Unit 5: Combined Compensators (07 Hrs)

U5.1. Introduction, Unified Power Flow Controller (UPFC), The Interline Power Flow Controller (IPFC).
U5.2. Generalized and Multifunctional FACTS Controllers

Note: Five assignments to be given to the students, each comprises of one assignment from each unit (U1.1, U2.1, U3.1, U4.1, U5.1) and one from self study (U1.2, U2.2, U3.2, U4.2, U5.2)

Course Outcome:

At the end of the Course, the students will be able to

CO-1. Understand the importance of controllable parameters and benefits of FACTS controllers.
CO-2. Know the significance of shunt compensation and principle of operation of SVC and STATCOM.
CO-3. Understand the functional operation and control of GCSC, TSSC and TCSC.
CO-4. Analyze the voltage and phase angle regulators.
CO-5. Describe the principles, operation and control of UPFC and IPFC.

Text Books:

T4. "Understanding FACTS: Concepts & Technology of Flexible AC Transmission Systems" By N.G.Hingorani & L.Gyugyi, IEEE Press, Standard Publishers Distributors, Delhi..
T5. Mohan Mathur, R., Rajiv. K. Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc.

Reference Books:

R5. FACTS Controllers in Power Transmission & Distribution by K.R.Padiyar, New Age International.
R6. Modelling & Simulation in Power Networks, Enrique Acha, Clandio Esquival & H.A.Perez,CA Camcho, John Wiley & Sons

EE42117- HIGH VOLTAGE DC TRANSMISSION (3-0-1)

Credits:04 **Teaching Scheme: -** Theory 03Hrs/Week

Prerequisites:Having knowledgeof DC Transmission and distribution systems, its advantages and disadvantages. Basic knowledge of PowerElectronics, Network analysis, Material science.

Course Objectives:

This is a revolutionary and new concept for transmission of power where the student will learn,

1. The concept and planning HVDC transmission, comparison of HVDC transmission over AC transmission.
2. To understand the concept of HVDC CONVERTERS and their operations.
3. To understand the concept of HVDC control techniques.
4. To analyze the concept of Harmonics present in the HVDC and design of Filters circuits
5. To understand the new technologies oh HVDC converter using SVC system and MTDC system.

Course Details:

Unit1: Evolution of HVDC transmission (8Hrs)

U1.1. Introduction to DC transmission technology, comparison of ac transmission and dc transmission, comparison of HVDC link with EHVAC link, description of HVDC transmission system , types of HVDC transmission system,

U1.2. Limitation of HVDC transmission line, reliability of HVDC system, application of dc transmission. Advances in HVDC transmission system

Unit2: Analysis of HVDC converters (8Hrs)

U2.1. Introduction, pulse number, simplified analysis of Graetz circuit, 6 pulse converter operation and analysis, analysis voltage wave form with overlap angle for 6 pulse converter.

U2.2. Complete Equivalent electrical circuit of HVDC link, complete characteristics of 6 pulse converter as rectifier/inverter.

Unit3: Regulation and control of HVDC Converter system (8Hrs)

U3.1. Power flow in a HVDC link, necessity of control in case of a DC link, rectifier control, power reversal in a dc link, voltage dependent current order limit (VDCOL),Inverter Extinction angle control(EAG),pulse phase control.

U3.2. Starting and stopping of a DC link, constant power control.

Unit 4:Harmonics and Harmonics suspension in HVDC system (8Hrs)

U4.1. Generation of harmonics by converters, characteristics harmonics on the DC side, characteristics current harmonics, characteristic variations of Harmonics Currents with Variation of α and μ.

U4.2. Harmonic model and equivalent circuit, use of Filter, Filter configuration.

Unit 5:HVDC transmission developments and its application (8Hrs)

U5.1.HVDC-VSC Transmission system, working principle and operation components VSC converter, analysis of VSC topologies and firing schemes.
U5.2. Application of MTDC system, control of power of MTDC system.

Note: Five assignments to be given to the students, each comprises of one assignment from each unit (U1.1, U2.1, U2.2, U3.1, U4.1, U5.1,U5.2) and one from self study (U1.2, U3.2, U4.2,)

Course Outcome:

At the end of the Course, the students will be able to

CO-1. Understand the importance of Transmission power through HVDC system and various types of HVDC transmission system.
CO-2. Analyze different characteristics of 6 pulse converter and alsocalculate power conversion from AC to DC &DC to AC.
CO-3. Understand different control techniques applied through HVDC and also able to analyze Equivalent Electrical circuit of HVDC system by following different control technique.
CO-4. Analyze the different types harmonics generated at converter side, ac side and dcside and also understand the suspension techniques for harmonics. Analyze the filter circuits used for harmonics suspension.
CO-5. Understand the advance concept of HVDC-VSC system. Analyze the principle of MTDC systems and their different application.

TextBooks:

T6. "HVDC Transmission", S Kamakshaiah and V Kamaraju,Tata McGraw Hill Education Private Limited, 2nd Edition, reprint 2011.
T7. "HVDC Power Transmission System",K R Padiyar,New Academic Science,2nd Edition2011
T8. "High Voltage Direct Current Transmission,Jos Arrillaga,IEE Power and Energy series,2nd Edition

ReferenceBooks

R7. "EHV-AC,HVDC Transmission and Distribution engineering", By Sanjay kumar Sharma SK Kataria and Sons Edition 2013
R2."Power System Stability and Control", By Kundur P McGraw-Hill, Edition 1993.
R3.Open Source material: www.nptel.ac.in

EE42117- HIGH VOLTAGE DC TRANSMISSION (0-0-1)

Teaching Scheme: - Theory 01Hrs/Week

Prerequisites: Having knowledge of AC Transmission and distribution systems, its advantages and disadvantages. Basic knowledge of Power Electronics, Network analysis, Material science.

Course Objectives: Ability to understand and analyze power system operation, stability, control and protection.

Course Details:

Tutorial No.1.	Description of HVDC transmission system, planning for HVDC transmission, Economic advantages of HVDC transmission system.
Tutorial No.2.	Choice of converter configuration, Line commutated converter.
Tutorial No.3.	Complete analysis of 12 pulse converter and its wave form**.**
Tutorial No.4.	Control systems for HVDC converter inverter operation problem.
Tutorial No.5.	Effect of control modes on Harmonics, Non- characteristic Harmonics present in HVDC system.
Tutorial No.6.	System control hierarchy scheme of HVDC system.
Tutorial No.7.	Protection of filter circuit, design of DC filter.
Tutorial No.8.	Control scheme of VSC based HVDC link.
Tutorial No.9.	Recent application of HVDC-VSC system.
Tutorial No.10.	Multi-terminal HVDC system, different types of MTDC system.

Course Outcome:

At the end of the Course, the students will be able to

CO-1. Know whatthe major advantages of HVDC transmission system are.
CO-2. Know the working principle of 12 pulse converter used in HVDC transmission system.
CO-3. Know the different types of Non characteristics Harmonics present in HVDC converter Station.
CO-4. Analyze the protection scheme of filter circuit.
CO-5. Analyze application of HVDC-VSC system and application of MTDC system.

TextBooks:

T1. "HVDC Transmission", S Kamakshaiah and V Kamaraju, Tata McGraw Hill Education Private Limited, 2nd Edition, reprint 2011.
T2. "HVDC Power Transmission System",K R Padiyar, New Academic Science,2nd Edition 2011
T3. "High Voltage Direct Current Transmission, Jos Arrillaga, IEE Power and Energy series,2nd Edition

ReferenceBooks:

R1. "EHV-AC, HVDC Transmission and Distribution engineering", By Sanjay kumar Sharma SK Kataria and Sons Edition 2013
R2. "Power System Stability and Control", By Kundur P McGraw-Hill, Edition 1993.
R3. Open Source material: www.nptel.ac.in

EE47497-MAJOR PROJECT (stage-II) (0-3-0)

Credits: 03 **Teaching Scheme: -** Laboratory 06 Hrs/Week

Course Objectives:

Major project is by far the most important single piece of work in the degree programme included in final year. The course provides the opportunity for students to demonstrate, plan and organize a large project over a long period and to put into practice some of the techniques which are taught throughout the course. Students will also get idea on design, analyze and implementation of projects which involves students working as a team.

Guidelines:

1. Group should maintain a logbook of activities throughout the project stages.

2. Regular discussions should be carried out with project guide.

3. Both the review reports for this stage should be submitted in the prescribed format after approval from the guide.

4. A report on the work done in Stage-2 in prescribed format should be submitted at the time of stage II evaluation.

The Assessment Scheme will be:

(a) Continuous Assessment 70 marks (*based on regular interaction, circuit development*)

(b) End Semester 30 marks (*based on implementation, testing, results, poster presentation, and demonstration)*

Course Outcome:

At the end of the course, the student will be able to-

CO-6. Implement integrated hardware and software in compliance with design standard and safety rules.

CO-7. Collect the data analyze the results and redesign if required.

CO-8. Endure the responsibility to complete the task cost-effectively with time constraint.

CO-9. Understand the basic needs of present/future world and design project which meets the future demand.

CO-10. Learn working as a team member.

EE42119-OPTIMAL CONTROL (3-0-1)

Credits: 04 **Teaching Scheme: -** Theory 04Hrs/Week

Prerequisites: Control system, advanced control system.

Course Objectives:

This is a course of electrical science where the student will learn about various type of performance indices, LQR model, discrete LQR model. To study Kalman filter and stochastic optimal linear estimation, this can be utilized for further research.

Course Details:

Unit1 (9Hrs)

U1.5. Performance Indices:Selection of Performance Index, Calculus of variations:Variation and its properties, Euler-Lagrange Equation.

U1.6. Euler-Lagrange Equation.

Unit2 (7Hrs)

U2.3. Linear Quadratic Regulator: Formulation of Algebraic Riccati Equation (ARE), Solving the

ARE using the Eigenvector Method, Optimal systems with prescribed poles.

U2.4. Linear Quadratic Regulator for Discrete Systems on an infinite Time Interval.

Unit3 **(9Hrs)**

U3.1. Dynamic Programming: Discrete Time Systems, Discrete Linear Quadratic Regulator Problem, Continous Minimum Time Regulator Problem, The Hamilton Jacobi Belman Equation.

U3.2. Pontryagin's Minimum Principle: Optimal control with constraints on inputs.

Unit4 **(08Hrs)**

U4.1. Optimal Observers-the Kalman filter: The linear Quadratic Gaussian (LQG), Loop Transfer Recovery (LTR). H∞ Control.

U4.2. H∞ Control Solution.

Unit5 **(07Hrs)**

U5.3. Suboptimal linear regulators: Continuous Time Systems, Discrete Time Systems.

U5.4. Introduction to Stochastic Optimal Linear Estimation and Control.

Note: Five assignments to be given to the students, each comprises of one assignment from each unit (U1.1, U2.1, U3.1, U4.1, U5.1) and one from self study (U1.2, U2.2, U3.2, U4.2, U5.2)

Course Outcome:

At the end of the Course, the students will be able to

CO1: To study and various performances indices.
CO2: To study LQR.
CO3: Analyze and implement discrete LQR.
CO4: To study Kalman filter.
CO5: To study stochastic optimal linear estimation.

Text Books:

T9. Systems and control by Stanislaw h.Zak,Oxford University Press, Publication 2003

T10. Design of Feedback Control Systems byRaymond T. Stefani, B.Shahian, Clement J Savant, JrJene H. Hostetter, 4th edition (2002), Oxford university press publication.

T3. Modern control system theory by M Gopal, second edition 2000, New age international (P) Ltd. Publishers.

Reference Books

R8. Linear Optimal control by Jeffrey B.Burl, Prentice hall publication (1999).

R2. Control theory (Multivariable and non linear methods) by Torkel Glad and LennartLjung, Taylor & Francis Publications(2009).

R3. Control systems theory (with engineering application) by Sergey, Edward Lysters (2006).

EE40309- POWER SYSTEM LABORATORY (0-0-2)

Credits: 01 **Teaching Scheme: -** Laboratory 02 Hrs/Week

Prerequisites: Basic knowledge of power system operation control and Electrical machines.

Course Objectives:
This is a Electrical Engineering course where the student will learn about the idea of the power transmission and distribution. The student will get exposed to various methods of Measurement of direct-axis subtransient reactance and quadrature axis subtransient reactance of a salient pole synchronous machine, calculation of A,B,C,D, parameter, hybrid parameter of transmission lines. Student will learn about High voltage testing on insulator and testing of transformer oil. Student will learn the concept of Ferranti effect in a long transmission line. Further they will get exposure to various parts of a outdoor power station.

Course Details:

Select any10 experiments from the list of 15 experiments

List of Experiment:

Experiment-1. Study of power distribution of outdoor power sub-station.
a. Study of various types of Lightning arrestors.
b. Study of layout of outdoor pole mounted & plinth mounted sub-stations.

Experiment-2. To study the single line to ground fault.

Experiment-3. To study line to line fault.

Experiment-4. To find out A, B, C, D, parameter, hybrid parameter of given transmission model.

Experiment-5. To study the Ferranti effect in a long transmission line under no load and under light load condition.

Experiment-6. Finding angle characteristics P=f(δ), Q=f(δ), U=f(δ) of three phase synchronous generator**.**

Experiment-7. Measurement of direct-axis subtransient reactance and quadrature axis subtransient reactance of a salient pole synchronous machine.

Experiment-8. Measurement of direct-axis subtransient reactance and quadrature axis subtransient reactance of a salient pole synchronous machine.

Experiment-9. Determination of negative and zero phase sequence reactance of a 3-ϕ Synchronous generator.

Experiment-10. High voltage testing of transformer oil

Experiment-11. Generation and measurements of high impulse voltage (across sphere gap).

Experiment-12. High voltage testing on insulator, measurement of its withstand voltage and its break down strength.

Experiment-13. Measurement of withstand voltage and break down strength of cable under application of high voltage.

Experiment-14. To measurement of soil resistivity as a function of salinity and time.

Experiment-15. To study radial feeder performance when a) fed at one end b) fed at both ends.

Course Outcome:

At the end of the Course, the students will be able to

CO-11. Learn about various methods of fault calculation in power system, concept of Ferranti effect in long transmission line and various reactance calculations.
CO-12. Learn about high voltage testing of transformer oil, Generation and measurements of high impulse voltage.
CO-13. Understand the concept of measurement of withstand voltage and break down strength of cable.
CO-14. Apply the knowledge of soil resistivity for measurement of soil resistivity.
CO-15. Learn about the various types of Lightning arrestors and sub-stations.

Text Books:

T2. "Power system Engineering" ,D.P Kothari& I.J Nagrath ,The McGraw.Hill companies ,2012
T3. "Electrical power systems", C.L.Wadha, New age Publication, 2010.

Reference Books

R3. " Power system Analysis",John J Grainger William D Stevenson, TMC Companies, 4th edition
R4. "Power System Analysis", Hadi Saadat – TMH Edition, 4th edition.
R5. Power Systems Laboratory Manual, CVRCE.

EE40114-POWER SYSTEM ANALYSIS & CONTROL (3-0-1)

Credits: 04 **Teaching Scheme:-Theory 03Hrs/Week**

Pre-requisites: Transmission and distribution system

Course Objectives:

To gain knowledge on factors involved in the operation and control of power systems, power flow studies and stability analysis.

Unit – 1: Fundamental of Power systems **(8 Hrs)**

U.1.1- Introduction, Single Subscript Notation, Double Subscript Notation, Power in Single Phase AC Circuit, Complex Power, The Power Triangle, Direction of Power Flow, Voltage and Current in Balanced Three Phase Circuits, Power in Balanced Three Phase Circuits, Per-Unit Quantities, Changing the Base in Per- Unit Quantities, Node Equations, The Single Lineor One Line Diagram, Impedance and Reactance Diagrams.Primitive network - construction of Y-bus using inspection and singular transformation methods – z-bus.

U.1.2 - Z-bus building algorithm

Unit – 2: Power Flow Solutions (8 Hrs)

U.2.1 - Importance of power flow analysis in planning and operation of power systems – statement of power flow problem - classification of buses - development of power flow model in complex variables form - iterative solution using Gauss-Seidel method - Q-limit check for voltage controlled buses, Newton-Raphson method, the Fast Decoupled Method,

U.2.2 - Comparison Power-Flow Studies in System Design and Operation, Regulating Transformers

Unit – 3: Economic Operation of Power System (8 Hrs)

U.3.1 - Formulation of economic dispatch problem – I/O cost characterization – incremental cost curve – coordination equations without and with loss (No derivation of loss coefficients) - solution by direct method and λ-iteration method - statement of unit commitment problem – priority-list method

U.3.2– forward dynamic programming.

Unit – 4: Load Frequency Control (8 Hrs)

U.4.1-Basics of speed governing mechanism and modeling - speed-load characteristics – load sharing between two synchronous machines in parallel - control area concept - LFC control of a single-area system - static and dynamic analysis of uncontrolled and controlled cases - two-area system – modeling - static analysis of uncontrolled case - tie line with frequency bias control - state variable model -

.

U.4.2 – integration of economic dispatch control with LFC.

Unit– 5: Stability analysis (8 Hrs)

U.5.1-

Importance of stability analysis in power system planning and operation - classification of power system stability - angle and voltage stability – Single Machine Infinite Bus (SMIB) system: Development of swing equation - equal area criterion - determination of critical clearing angle and time – solution of swing equation by modified Euler method.

U.5.2- Solution of swing equation -Runge-Kutta fourth order method.

Course Outcome:

At the end of the Course, the students will be able to

CO-1. Learn the fundamentals of power system and per unit notation.

CO-2. Formulate and solve the power flow equations.
CO-3. Learn the economic operation of power system.
CO-4. Control the power system frequency and voltage variation.
CO-5. Analyse power system stability by different methods.

Text Books:

T1. 'Modern Power System Analysis', Nagrath I.J. and Kothari D.P., Tata McGraw-Hill, Fourth Edition, 2011.

T2. 'Power System Analysis', John J. Grainger and W.D. Stevenson Jr., Tata McGraw-Hill, Sixth reprint, 2010.

T3. "Power System Analysis", HadiSaadat, TMH, 2002 Edition, Eighth Reprint.

T4. "Electric energy systems theory-An introduction", Olle.I.Elgerd, Tata McGraw Hill publishing Ltd, New Delhi, 2008

Reference Books:

R1. Electrical Power systems, C.L.Wadhwa, New age International Publications, new edition

R2. Power System Analysis Operation and Control- By A. Chakrabarti and S. Haldar, ThirdEdition, PHI Publications, 6th Reprint, 2010.

EE40114- POWER SYSTEM ANALYSIS & CONTROL (0-0-1)

Teaching Scheme: - Theory 01Hrs/Week

Prerequisites: Transmission and distribution systems

Course Objectives:
Ability to understand and analyze power system operation, stability, control.

Course Details:
Tutorial No.1. Problem on per unit system and single line diagram.
Tutorial No.2. Problem on Y-Bus.
Tutorial No.3. Power flow solution by Gauss-seidal method.
Tutorial No.4. Power flow solution by NR method.
Tutorial No.5. Problem on Economic Load Dispatch without loss.
Tutorial No.6. Problem on Economic Load Dispatch with loss and considering penalty factor.
Tutorial No.7. Problem on single area power system.
Tutorial No.8. Problem on two-area power system.
Tutorial No.9. Problem on transient stability analysis.
Tutorial No.10. Solution to swing equation.

Course Outcome:

At the end of the Course, the students will be able to
CO-1. Learn the fundamentals of power system and per unit notation.

CO-2. Formulate and solve the power flow equations.
CO-3. Learn the economic operation of power system.
CO-4. Control the power system frequency and voltage variation.
CO-5. Analyse power system stability by different methods.

Text Books:

T1. 'Modern Power System Analysis', Nagrath I.J. and Kothari D.P., Tata McGraw-Hill, Fourth Edition, 2011.

T2. 'Power System Analysis', John J. Grainger and W.D. Stevenson Jr., Tata McGraw-Hill, Sixth reprint, 2010.

T3. "Power System Analysis", HadiSaadat, TMH, 2002 Edition, Eighth Reprint.

T4. "Electric energy systems theory-An introduction", Olle.I.Elgerd, Tata McGraw Hill publishing Ltd, New Delhi, 2008

Reference Books:

R1. Electrical Power systems, C. L.Wadhwa, New age International Publications, new edition

R2. Power System Analysis Operation and Control- By A. Chakrabarti and S. Haldar, Third Edition, PHI Publications, 6th Reprint, 2010.

EE42118-POWER SYSTEM STABILITY & CONTROL (3-0-1)

Credits:04 **Teaching Scheme:-Theory 03Hrs/Week**

Pre-requisites: Power system, Transmission and distribution system

Course Objectives:

To gain comprehensive knowledge on power system analysis problems.

Unit – 1: Introduction to power system operation: (8 Hrs)

U.1.1. Power flow problems, Power flow solutions, economic dispatch, unit commitment.Optimal System Operation: Generation allocation problem formulation, Loss Coefficients,Optimal load flow solutions, constraints in Unit- commitment,

U.1.2. Hydrothermal Coordination

Unit – 2:Fault analysis – Balanced faults (8 Hrs)

U.2.1. Importance of short circuit analysis - assumptions in fault analysis - analysis using Thevenin's theorem- Z-bus building algorithm - fault analysis using Z-bus – computations of short circuit capacity.

U.2.2. Postfault voltage and currents.

Unit – 3: Fault Analysis – Unbalanced Faults (8 Hrs)

U.3.1. Introduction to symmetrical components – sequence impedances – sequence circuits

of synchronousmachine, transformer and transmission lines - sequence networks analysis of single line to ground,line to line and double line to ground faults using Thevenin's theorem.

U.3.2. Fault analysis using Z-bus matrix

Unit – 4: Single Machine Stability (8 Hrs)

U.4.1. The Stability Problem, types of stability, mathematical concept of stability, transient stability, Equal- Area Criterion for Stability, Further Applications of the Equal-Area Criterion.

U.4.2. Methods of improving Transient Stability.

Unit – 5: Multi Machine Stability: (8 Hrs)

U.5.1. Rotor Dynamics and the Swing Equation,Step-By-Step Solution of the Swing Curve, Further Considerations of the Swing Equations, , The Power-Angle Equation, Synchronizing Power Coefficients,Multi-machine,Synchronous machine,Steady state stability, Transient Stability

U.5.2. Solution of swing equation -Runge-Kutta fourth order method.

Course Outcome:

At the end of the Course, the students will be able to

CO-1. Develop mathematical model of a given power system and to perform power flow Analysis using numerical techniques.

CO-2. Learn fault analysis for balanced condition.

CO-3. Learn fault analysis for unbalanced condition.

CO-4. Study and analyse different types of stability.

CO-5. Learn multi machine stability.

Text Books:

T1. 'Power System Analysis', John J. Grainger and W.D. Stevenson Jr., Tata McGraw-Hill, Sixth reprint, 2010.

T2. "Electric energy systems theory-An introduction", Olle.I.Elgerd, Tata McGraw Hill publishing Ltd, New Delhi, 2008.

T3. "Power System Analysis, T K Nagsarkar and M S Sukhija, Oxford University Press.

Reference Books:

R1. "Power System Analysis", HadiSaadat, TMH, 2002 Edition, Eighth Reprint.

R2. "Power System Analysis Operation and Control"- A. Chakrabarti and S. Haldar, Third Edition, PHI Publications, 6th Reprint, 2010.

R3. "Power system stability and control" – P. Kundur

EE42118-POWER SYSTEM ANALYSIS (0-0-1)

Teaching Scheme: - Theory 01Hrs/Week

Prerequisites: Power system, Transmission and distribution systems

Course Objectives:
Ability to understand and analyze power system operation, stability, control.

Course Details:
Tutorial No.1. Problem on per unit system and single line diagram.
Tutorial No.2. Problem on power flow solution using gauss seidal method
Tutorial No.3. Problem on power flow solution using NR method.
Tutorial No.4. Problem on Economic Load Dispatch with loss and considering penalty factor.
Tutorial No.5. Problem on symmetrical fault analysis.
Tutorial No.6. Problem on Z-bus algorihhms.
Tutorial No.7. Problem on unsymmetrical fault analysis.
Tutorial No.8. Problem on transient stability analysis.
Tutorial No.9. Solution to swing equation.
Tutorial No.10. Analysis of Runge-Kutta fourth order method.

Course Outcome:

At the end of the Course, the students will be able to
CO-6. Develop mathematical model of a given power system and to perform power flow Analysis using numerical techniques.
CO-7. Learn fault analysis for balanced condition.
CO-8. Learn fault analysis for unbalanced condition.
CO-9. Study and analyse different types of stability.
CO-10. Learn multi machine stability.

Text Books:

T4. 'Power System Analysis', John J. Grainger and W.D. Stevenson Jr., Tata McGraw-Hill, Sixth reprint, 2010.

T5. "Electric energy systems theory-An introduction", Olle.I.Elgerd, Tata McGraw Hill publishing Ltd, New Delhi, 2008.

T6. "Power System Analysis, T K Nagsarkar and M S Sukhija, Oxford University Press.

Reference Books:

R4. "Power System Analysis", HadiSaadat, TMH, 2002 Edition, Eighth Reprint.

R5. "Power System Analysis Operation and Control"- A. Chakrabarti and S. Haldar, Third Edition, PHI Publications, 6th Reprint, 2010.

R6. "Power system stability and control" – P. Kundur