Power Electronics (3 – 1 - 2)

Evaluation:

	Theory	Practical	Total
Sessional	30	20	50
Final	50	-	50
Total	80	20	100

Course Objectives:
To understand the behavior of power semiconductor devices and their use in power electronic controllers.

Course Contents:

1. Power Semiconductor Diodes and Transistors **10 hrs**

1.1 Power diode : V-I and switching characteristics, types of power diodes
1.2 Power transistor: V-I and switching characteristics
1.3 Power MOSFET: V-I and switching characteristics
1.4 IGBT: V-I and switching characteristics, comparison with MOSFET
1.5 Thyristor: V-I and switching characteristics, turn on-off mechanism, protection schemes
- 1.5.1 Improvement of thyristor characteristics
- 1.5.2 Firing/triggering circuits: Pulse transformer triggering (short pulse, long pulse and train pulse)
- 1.5.3 Series and parallel operation of thyristors
- 1.5.4 Various commutation techniques: self and forced commutation.
- 1.5.5 Members of thyristor family: TRIAC (V-I characteristics and operating modes of triac), Diac (V-I characteristics), Gate turn off thyristor (GTO): Structure, I-V Characteristics, Comparison between GTO and Thyristor.

2. Single Phase AC to DC Conversion **8 hrs**

2.1 Half wave rectification circuit using diodes and thyristors (R load, R-L load, RL load with freewheeling diode)
2.2 Full wave rectification circuit using diodes and thyristor for both resistive and inductive load
2.3 Performance parameters and filtering schemes
2.4 Single phase semi converter and full converter
2.5 Power factor improvement
- 2.5.1 Extinction angle control
- 2.5.2 Symmetrical angle control
- 2.5.3 Pulse width modulation control

2.6 Effect of source impedance on the performance of single phase full converter

3. Three Phase AC to DC Conversion **4 hrs**

3.1 Three phase half wave rectifier and bridge rectifier using diodes
3.2 Three phase semi converter and full converter with R-L load
3.3 Effect of source impedance on the performance of three phase full converter

4. DC to DC Conversion **4 hrs**

4.1 Introduction, principle of step up and step down operation.
4.2 Step up and step down chopper circuit
4.3 Classification of chopper
4.4 Switching regulators (Buck and Boost regulators)

5. Inverter **5 hrs**

5.1 Single phase inverter
5.2 Application of single phase inverter with ac motor load
5.3 Three phase inverter
5.4 Pulse width modulated (PWM) inverters
- 5.4.1 Single pulse modulation
- 5.4.2 Multiple pulse modulations
- 5.4.3 Sinusoidal pulse width modulation

6. AC Voltage Controller **5 hrs**

6.1 Single phase voltage controller with phase control using resistive and inductive load
6.2 Principle of operation of single phase cycloconverter
6.3 Step-up and step down single phase cycloconverter
6.4 Three phase cycloconverter
6.5 AC voltage controllers with PWM control

7. Power Supplies and Circuit Protection **5 hrs**

7.1 Introduction
7.2 Switched mode dc power supplies
7.3 AC power supplies
- 7.3.1 Uninterruptible power supply (UPS)
- 7.3.2 Switched mode power supply

7.4 Protection of Devices and circuits
- 7.4.1 Cooling and heat sinks
- 7.4.2 Snubber circuits
- 7.4.3 Voltage and current protection

8. HVDC Power Transmission **4 hrs**

8.1 HVDC station configuration (Filter, converters and Inverters)
8.2 Comparison of HVDC and HVAC transmission
8.3 AC line commuted converters for reversible power flow and control in dc line, pulse and 12-pulse operation
8.4 Series and parallel operation of converters

Laboratory:

1. Study the characteristics of thyristors (SCRs)
2. Power control using SCR.
3. Study of single phase rectification with diode and thyristor
4. Study of dc conversion using chopper circuit
5. Study of dc to ac conversion with resistive load
6. Study of ac voltage controller with resistive load

Text Books:

1. Muhammad H. Rashid, *Power Electronics: Circuits, Devices and Applications*. New Delhi: Prentice-Hall.
2. P.S. Bimbhra, *Power Electronics*. New Delhi: Khanna Publishers.

Reference:

B. R. Gupta and V. Singhal, *Power Electronics*. New Delhi: S. K. Kataria & Sons.

Power System Analysis (3 – 1 - 2)

Evaluation:

	Theory	Practical	Total
Sessional	30	20	50
Final	50	-	50
Total	80	20	100

Course Objectives:

1. To provide the knowledge of electrical power systems like load flow, fault analysis and steady state and dynamic stability.
2. To give the knowledge of mathematical model and software simulation of power system network.

Course Contents:

1. Power Flow Analysis **10 hrs**

1.1 Power flow in transmission line
1.2 Importance of Load Flow analysis and Classification of Buses
1.3 Bus impedance matrix and bus admittance matrix
1.4 Bus loading equations
1.5 Formulation and analysis of power flow equations: iterative approach – Gauss Siedel, Newton Raphson, fast decoupled approach
1.6 Computer analysis of power flow
1.7 Effect of network configuration and distribution of generation sources and major loads on line
1.8 Voltage profile and VAR compensation, Series and Shunt Compensation and STATCOM

2. Power System Stability **10 hrs**

2.1 Basic power/ frequency problem
2.2 Power flow and power angle equations of single machine connected to infinite bus with losses and without losses
2.3 Two machine system
2.4 Steady-state, dynamic and transient stability
2.5 Swing equation for a multi machine system
2.6 Equal area criterion, application of equal area criterion
2.7 Solution of swing equation by point – by – point (step by step) method
2.8 Digital computer solution of swing equation using Euler method
2.9 Stability enhancement techniques.
2.10 Effect of Excitation on stability

3. Symmetrical Fault Analysis **4 hrs**

3.1 Introduction
3.2 Rated MVA interrupting capacity of a Circuit Breaker
3.3 Current limit reactor
3.4 Short circuit analysis of large system
3.5 Formulation of Z_{bus} and modification of Z_{bus}

4. Unsymmetrical Faults **8 hrs**

4.1 Introduction and types
4.2 Symmetrical components of unbalances three phase system , power invariance Sequence impedance of transmission line and synchronous generators
4.3 Sequence impedance of loaded synchronous generators and transformers
4.4 Unbalance fault analysis
4.4.1 Single line to ground fault
4.4.2 Double line to ground fault
4.4.3 Line to line fault
4.4.4 open conductor fault

5. Automatic Generation Control **5 hrs**

5.1 Introduction and basics generation control loop
5.2 Fundamental of speed governing system and isochronous governor
5.3 Governors with speed droop characteristics
5.4 Load sharing of parallel generating units
5.5 Control of power output of generating units
5.6 Turbine model and generator load model
5.7 Block diagram representation of isolated power system and state space representation

6. Optimal System Operation **4 hrs**

6.1 Introduction and formulation of economic load dispatch model
6.2 Lagrange method for non linear optimization problem, pelanty factor method
6.3 Classical economical load dispatch without losses and with losses
6.4 Economic Dispatch with transmission loss and generator limits
6.5 Hydro–thermal co-ordination

7. Voltage Stability **4 hrs**

7.1 Introduction, Classifications
7.2 Steady–state analysis of voltage–reactive power problem
7.3 Relationship between power flow and voltage drop
7.4 Power limit without specific voltage support at receiving end
7.5 Power transfer at constant sending and receiving end voltage
7.6 Effect of load characteristics
7.7 Effect of reactive support at receiving end by shunt capacitor
7.8 Analysis for large network
7.9 Generation Capability Curve

Laboratory:

Simulation lab

- Load flow analysis
- Fault analysis
- Stability problem
- State space representation of isolated power generating station

Test Book:

Grainger J. J. and Stevenson W.D. "Power System Analysis", McGraw Hill Publication.

References:

1. Stevenson W.D. "Elements of Power System Analysis", Mcgraw Hill Publication
2. Wadhwa, C. L. "Electrical Power System" , New Age International (P) Limited 2005
3. Das. D. "Electrical Power System" , New Age International (P) Limited 2006
4. Hussain. A. "Electrical Power System", Vani Educational Books

Communications System Engineering (3 – 1 - 1)

Evaluation:

	Theory	Practical	Total
Sessional	30	20	50
Final	50	-	50
Total	80	20	100

Course Objectives:
The objective of this course is to introduce the concept and principles of communication systems.

Course Contents:

1 Introduction **2 hrs**

1.1 Communication Process
1.2 Elements of communication system
1.3 Information source
1.4 Communication channels
1.5 Baseband and Pass band signals

2 Analog Communication. **11 hrs**

2.1 Introduction, Modulation types, Need for modulation
2.2 Time domain expression and Spectrum (Frequency domain representation) of AM wave
2.3 Efficiency (Power and Bandwidth), Transmission efficiency of AM signal
2.4 DSB-SC modulation (Generation, Balanced modulator), SSB Modulation, Vestigial Sideband transmission (VSB)
2.5 Frequency Modulation (FM) , Time domain expression and spectrum, Narrowband & Wideband FM , Transmission Bandwidth of FM signal (Carson's rule)
2.6 Noise and Classifications, Signal to Noise ratio, Noise Figure
2.7 Pulse Modulation, Demodulation/Detection

3 Digital Communication **10 hrs**

3.1 Introduction, Block diagram and Elements of digital communication, Advantages (Comparison with Analog Communication)
3.2 Digital Transmission, Generation of PCM signal (Sampling, Quantization and Coding), Shannon Capacity Theorem, Digital radio
3.3 ASK, FSK & PSK Systems, Bandwidth of FSK, PSK, BPSK, DPSK, QPSK, QAM, Bandwidth Efficiency
3.4 Probability of Error and Bit error rate

4 Data Communication **8 hrs**

4.1 Data Communication Circuit (Topologies, Serial and Parallel data transmission)
4.2 Error detection and Correction technique, Data communication hardware
4.3 Serial interface (RS-232), Parallel Interface, Telephone Network, DDD Network
4.4 Dedicated line Service, Data Modems (Asynchronous and Synchronous and Synchronization)

4.5 Data Communication Protocols, Packet Switching network, User-to-Network Interface Protocol, Packet Format. ISDN, Ethernet

5 Mobile Communication **4 hrs**

5.1 Evolution

5.2 Cellular Telephone (Cellular Concept), Frequency Reuse, Interference, Cell splitting, Sectoring, Cell system layout

5.3 Call Processing, Hand-off

5.4 GSM Services

6 Satellite Communications **5 hrs**

6.1 Introduction & History, Kepler's laws, Satellite orbits, Geostationary Satellite (Orbital Velocity, Round trip time delay of GSS, Advantages and Disadvantages)

6.2 Footprint, Transducers, Satellite system Up Link and Downlink

6.3 Satellite system Parameters and Applications

7 Optical Fiber Communication **5 hrs**

7.1 Introduction to Optical fiber communication (Development, applications, Ray theory for optical fiber communication, Numerical aperture, acceptance angle)

7.2 Fiber Types, Properties and Application, Mode propagation in SI and GI multi-mode fibers

7.3 Characteristic properties of optical fiber: attenuation, Dispersion, Bend loss

7.4 Optical Ground Wire (OPGW) System

Laboratory:

1. Study of AM/FM modulation and demodulation circuits and systems.
2. Field Visit to Communication service providers and AM/FM Broadcasting Stations

Text Book:

Wayne Tomasi, Advanced Electronic Communication System, Prentice Hall

References:

1. S. Haykin, An Introduction to Analog and Digital Communication Wiley, New York, 1989.
2. B. P. Lathi, Modern Analog and Digital Communication Systems, Prism Book Pvt. Ltd.
3. L.W. Couch II, Digital and Analog Communication System, 2nd Edition, Macmillan Publishing Company, New York.
4. Dennis Roddy, Satellite Communication System, Tata McGraw Hill 1989
5. Theoder S. Rappaport, Wireless Communications, Prentice Hall
6. U. D. Black, Data Communication and Distributed Network
7. John M. Senior, *Optical Fiber Communications*, Principles and Practice, Second edition, Prentice Hall of India, 1992
8. William B. Jones, Jr *Introduction to Optical Fiber Communication Systems* Holt, Rinheart and Winston, Inc. 1998

Power Plant Equipment (3 – 1 - 0)

Evaluation:

	Theory	Practical	Total
Sessional	50	-	50
Final	50	-	50
Total	100	-	100

Course Objectives:
To provide basic knowledge on the equipment used in power generating plants.

Course Contents:

1. Hydro Plants **12 hrs**

1.1 Civil engineering works for hydro plants
- 1.1.1 Dams, water conduits
- 1.1.2 Control gates, surge chambers and tanks
- 1.1.3 Other hydraulic structures

1.2 Energy conversion from hydraulic to electrical in the hydro plant
- 1.2.1 Steady state operation, water hammer limitations
- 1.2.2 Transients, control of water delivery to turbines
- 1.2.3 Pumped storage plants; turbines for hydro plants
- 1.2.4 Types of Turbines, characteristics and efficiencies

1.3 Generators for hydro plants
- 1.3.1 Hydro-Generator and it's salient features
- 1.3.2 Methods usually adopted for cooling Hydro-Generators
- 1.3.3 Governor dynamic and speed adjustment
- 1.3.4 Heat dissipation from hydro generators and amount of fluid (air/hydrogen) required, ancillaries and auxiliaries of hydro power plants
- 1.3.5 Short-Circuit Ratio (SCR) and its effect on the performance of synchronous generators

2. Diesel Power Plants **4 hrs**

2.1 Principles of operation of diesel power plant
- 2.1.1 Starting of Diesel power plants; Fuel supply and delivery systems
- 2.1.2 Cooling systems for Diesel power plants

2.2 Governing and speed control
- 2.2.1 Electric generators for diesel power plants
- 2.2.2 Excitation system; salient features of synchronous generators in Diesel power plant

3. Combustion Turbine Power Plants **4 hrs**

3.1 Principles of combustion turbine operation

3.2 Single and multi-shaft units, starting of combustion turbine power plant; efficiency improvement, energy recuperation

3.3 Cooling systems, governing and speed control

3.4 Electric generators for combustion turbine power plant: excitation systems

4. Steam Power Plants **12 hrs**

4.1 Fossil fuel and nuclear heat supply systems for steam generation
4.2 Basic Ranking steam cycle analysis, efficiency improvement using superheating, steam reheating and regeneration
4.3 Steam turbines for utility service: single and compound stage units, vibration monitoring
4.4 Speed governing of steam turbines; Governor adjustments
4.5 Electric generators for steams turbine driven units : Turbo-Generators and their characteristics; Cooling systems
4.6 Hydrogen and air cooled turbo-generator, excitation systems

5. Combined Cycle Plants **5 hrs**

5.1 Integrated total energy systems for industrial plants
5.2 Combined combustion turbine and steam turbine plants
5.3 Combined power generation with process steam use
5.4 Use of industrial process waste gases for power production in steam or combustion turbines

6. General Considerations **8 hrs**

6.1 Electrical considerations in central stations
6.1.1 Station service transformers and their types
6.1.2 High pressure oil supplies for lubrication and control system operation; Fire fighting systems
6.1.3 Bus arrangements
6.1.4 Protection system and switchgear; Earthing practices
6.2 Manual and automatic synchronization equipment; Remote monitoring and control

Field Trip to Generating Plant: (A three-day trip)
Visit a full size, operating generating plant; Prepare a formal report on power plant installation describing specific major components.

Text Book:
Fredric T. Morse, *Power Plant Engineering*, East West Press.

Switch Gear and Protection (3-1-2)

Evaluation:

	Theory	Practical	Total
Sessional	30	20	50
Final	50	-	50
Total	80	20	100

Course Objectives:

- To deliver the knowledge of principle of operation of different relays and circuit breakers.
- To provide the knowledge protection schemes of components of electrical power system network.

Course Contents:

1. Introduction to Protection System **3 hrs**

1.1 Introduction
1.2 Functions of Protective relaying , Protective zones and Primary and Back up Protection
1.3 Nature and causes of Fault , Fault current calculation using Symmetrical Components
1.4 Essential Qualities of Protective relaying
1.5 Classification of Protective relays
  1.5.1 Electromagnetic Attraction type
  1.5.2 Induction Type relays
  1.5.3 Directional Type relays
  1.5.4 Differential Type relays
1.6 Terminologies used in relays

2. Relays **4 hrs**

1.7 Introduction , Basic trip circuits and Auxiliary switch
1.8 Tripping schemes in Circuit Breakers
  2.2.1 Relays with Make type contact
  2.2.2 Relays with break type contact
2.3 Electromagnetic Attraction relay, operation and application
2.4 Induction type relay
  2.4.1 Torque Production
  2.4.2 Shaded pole, Watt-hour and Induction cup type
2.5 Design Consideration of Electromagnetic Relays

3. Relay Application and Characteristics **6 hrs**

3.1 Non Directional Induction Type Over current Relay
  3.1.1 Time Current Characteristic
  3.1.2 Operation
3.2 Directional Power Relay
3.3 Directional Induction type Over Current relay, operation and Directional Characteristics
3.4 Differential Relay and types

3.5 Distance relay
3.6 Impedance relay, torque equation and operational diagram in R-X plane
3.7 Reactance relay, mho relay, torque equation and operation characteristics

4. Circuit Breaking and Theory of Arc quenching **6 hrs**

4.1 Introduction, formation of arc, high resistance and low resistance method for Arc extinction, theories of arc interruption
4.2 DC and AC circuit breaking, transient recovery voltage, Recovery voltage, single frequency and double frequency transient
4.3 Rate of rise of TRV and RV, Re-striking Voltage, frequency of oscillation
4.4 interruption of capacitive current and current chopping

5. Circuit Breakers **4 hrs**

5.1 Introduction, requirements and classification of CB
5.2 Air Blast CB, operation and applications
5.3Air Break CB, operation and applications
5.4 SF_6 CB, operation and applications
5.5 Vacuum CB, operation and applications
5.6 Oil CB, operation and applications
5.7 Minimum Oil CB, operation and applications

6. Transformer Protection **4 hrs**

6.1 Introduction, Possible transformer faults
6.2 Percentage differential Protection, Merz-price protection for star –star and star-delta connection
6.3 Problem encountered in differential protection

7. Generator Protection **5 hrs**

7.1 Introduction, stator fault, rotor fault and abnormal running condition
7.2 Basic differential and percentage differential protection scheme
7.3Merz-Price Protection, Unrestricted and Restricted earth fault protection
7.4 Balanced earth fault, 100% earth fault and interturn faults protection
7.5Rotor earth fault and loss of excitation protection
7.6 Negative sequence relays

8. Protection of Bus Bar **3 hrs**

8.1 Busbar faults and frame leakage protection of bus bar
8.2 circulating current and high impedance differential protection of Busbar

9. Feeder and Transmission line Protection **6 hrs**

9.1 Introduction to feeder protection, over current protection of Transmission Line
9.2Non Directional time and current graded protection
9.2.1 Use of inverse time relays
9.2.2 Setting of inverse over current relay
9.2.3Dis advantages
9.3 Directional time and current graded protection
9.3.1 Parallel Feeder and Tee Feeder protection
9.3.2 Ring main and interconnected system protection
9.4 Differential Protection of feeder (Pilot wire protection)
9.5 Distance protection of transmission line, setting of distance relay and High speed

Impedance protection

10. Digital Protection Device and Protection Scheme **4 hrs**

10.1 Static relay, Static time current relay, characteristics, over current and inverse Time-current type static relay

10.2 Static directional, Static differential and Static distance relays

10.3 Microprocessor Based relays

10.4 Carrier aided protection and phase comparison method for Carrier aided protection

Filed Visit:

Local filed visit of distribution and generation substation

Laboratory:

1. Over current based protection scheme
2. Microprocessor based tripping circuit
3. Over voltage protection scheme
4. Study of relay characters tics
5. Study of overlapped protection

Test Book:

Ram Badri & Vishwakarma D. N. "Power System Protection and Switchgear", Tata McGraw

References:

1. Rao S. Sunil " Switchgear Protection and Power System"
2. Johns. A.T. & Salman K. Salman " Digital Protection for Power System " , IET
3. Wadhwa C. L. "Electrical Power System", New Age International (P) Limited 2005

Research Methodology (2 – 1 - 0)

Evaluation:

	Theory	Practical	Total
Sessional	50	-	50
Final	50	-	50
Total	100	-	100

Course Objectives:
The objective of this course is to introduce students the concept and methods of research, with references to engineering. At the end of the course the students will understand the basic concept of research and be familiar with doing research.

Course outline: The course introduces students to fundamentals of research methodology including the elements of research like the research process, theoretical framework, and the research design; the description of research; data and information for research; and writing a research proposal.
Note: *This course is a basic one and it should be treated in the introductory level of research methodology and method of doing practical knowledge.*

Course Contents:

1. **Introduction** **3hrs**
   - 1.1 The meaning of research
   - 1.2 Defining basic and applied research
   - 1.3 Engineering research in outline

2. **Elements of Research: The Research Process** **4hrs**
   - 2.1 The context of research
   - 2.2 Research problems in their scientific settings
   - 2.3 The characteristics of research
   - 2.4 Goals of research

3. **Elements of Research: The Theoretical Framework** **4hrs**
   - 3.1 Measurements
   - 3.2 Variables and their causal relationship
   - 3.3 Theory
   - 3.4 Hypothesis

4. **Elements of Research: The Research Design** **4hrs**
   - 4.1 Research design orientation
   - 4.2 Elements of research design
   - 4.3 Types of research design and their use in basic and applied research

5. **Description of Research** **2hrs**
   - 5.1 Types and purpose
   - 5.2 Objectives and results

5.3 Level of research
5.4 Categories of research

6. Data and Information for Research **6hrs**

6.1 Meaning; nature and types of data; secondary and primary data; observational data; and experimental data
6.2 Sampling concept types and design
6.3 Introduction to data collection methods and techniques
6.4 Introduction to data organization, processing, and analysis

7. Writing a Research Proposal (students will prepare a research proposal reflecting the theoretical part) **7 hrs**

7.1 Selection of a research topic
7.2 Preliminaries (The context, statement of the problem, research rationale, research objectives, hypotheses)
7.3 Literature review
7.4 Research method

Text Books:

1 Action, Q. Ashton (2011). ***Issues in Engineering Research and Application,*** Atlanta, Georgia: Scholarly Edition. (chapter 4, available in web version, free of cost).
2 Marder, Michael P. (2011). ***Research Methods for Science,*** Cambridge: Cambridge University Press.
3 Pant, Prem R. (2012). ***Social Science Research and Thesis Writing,*** Kathmandu: Buddha Academic Publishers and Distributors.

References:

1. Case, Jennifer M. and Light, Andgregory (2011). Emerging methodologies inengineering education research, ***Journal of Engineering Education,***100(1): 186–210.
2. Miller, Delbert C., 2007. ***Handbook of Research Design and Social Measurement,*** New York: Sage Publication.
3. Schutt, Russell K. (2009), ***Investigating the Social World,*** Los Angeles: Sage Publication.
4. Smith, Robert V. (1990). ***Graduate Research: A Guide for Students in the Science,*** New York: Plenum Publishing.
5. Weber, Karl E. and Tiwari, Indra P. (1992). ***Research and Survey Format Design: An Introduction,*** Bangkok: Division of Human Settlements Development, Asian Institute of Technology.