

UNIT I – PROTECTIVE RELAYS

Basic principles, types, Construction and characteristics of electromagnetic relays, Elements of static relays, Comparators, Basic principle of digital relays, Overcurrent , Earth fault and differential relays.

UNIT II – PROTECTION SCHEMES

Protection of generators, transformers, transmission line, busbar and motors

UNIT III – ARC INTERRUPTION THEORIES

Formation and extinction of arc, properties of the arc, Restriking and recovery voltage, Methods and control devices for arc extinction, Current chopping, Resistance switching

UNIT IV – CIRCUIT BREAKERS

Oil circuit breaker, Air blast circuit breaker, SF₆ circuit breaker, Vacuum circuit breaker, Circuit breaker duties and ratings, Testing and maintenance of circuit breakers, HRC and other types of fuse, Isolators

UNIT V – POWER SYSTEM TRANSIENTS

Overvoltage in the transmission lines, Fault clearance, Lightning and switching surges, Transmission, refraction and attenuation of surges. Ground wire, Sphere gaps, Lightning arrestors, BIL and insulation coordination, Grounding of power system.

Text Books

1. Switchgear and protection Sunil S. Rao, Khanna Publishers
2. Power System Engg. Soni Gupta & Bhatnagar, Dhanpat Rai & Sons
3. A course in Electrical Power, C.L. Wadhawa, New Age International
4. Power system protection and switchgear, B. Ram, Wiley Eastern Ltd.

Reference Books

1. Power system protection & switchgear, Badriram & D.V. Vishwakarma, TMH
2. Switchgear & Protection, M.V. Deshpande, TMH

UNIT-I TRANSDUCER – I

Definition, advantages of electrical transducers, classification, characteristics, factors affecting the choice of transducers, Potentiometers, Strain gauges, Resistance thermometer, Thermistors, Thermocouples, LVDT, RVDT

UNIT-II TRANSDUCER – II

Capacitive, Piezoelectric Hall effect and opto electronic transducers. Measurement of Motion, Force pressure, temperature, flow and liquid level.

UNIT-III TELEMETRY

General telemetry system, land line & radio frequency telemetering system, transmission channels and media, receiver & transmitter. Data Acquisition System: Analog data acquisition system, Digital data acquisition system, Modern digital data acquisition system.

UNIT-IV DISPLAY DEVICES AND RECORDERS

Display devices, storage oscilloscope, spectrum analyzer, strip chart & x-y recorders, magnetic tape & digital tape recorders.

Recent Developments: Computer aided measurements, fibre optic transducers, microprocessors, smart sensors, smart transmitters.

UNIT-V PROCESS CONTROL

Principle, elements of process control system, process characteristics, proportional (P), integral (I), Derivative (D), PI, PD and PID control modes. Electronic, Pneumatic & digital controllers.

Text Books:

1. A.K.Sawhney, "Advanced Measurements & Instrumentation", Dhanpat Rai & Sons
2. B.C. Nakra & K.Chaudhry, "Instrumentation, Measurement and Analysis", Tata Mc Graw Hill 2nd Edition.
3. Curtis Johns, "Process Control Instrumentation Technology", Prentice Hall

Reference Books:

4. E.O. Decblin, "Measurement System – Application & design", Mc Graw Hill.
5. W.D. Cooper and A.P. Beltried, "Electronics Instrumentation and Measurement Techniques" Prentice Hall International
6. Rajendra Prasad, "Electronic Measurement and Instrumentation Khanna Publisher
7. M.M.S. Anand, "Electronic Instruments and Instrumentation Technology" PHI Learning.

UNIT I – INTRODUCTION

Representation of power system components like synchronous machine, transformer, transmission line. One line diagram, Impedance and Reactance diagram, per unit system of calculation, Brief description of power system components like synchronous machine, transformer, busbar, transmission line and isolators.

UNIT II – LOAD FLOW ANALYSIS

Bus classifications, Formation of bus admittance matrix by singular transformation, Formation of load flow problem, Gauss – Siedel and Newton – Raphson method of load flow analysis, Approximation of Newton – Raphson load flow analysis, Fast decoupled method.

UNIT III – FAULT ANALYSIS

Types of fault – shunt and series, Calculation of fault current and voltages for symmetrical short circuit, Symmetrical components, Sequence impedance, Unsymmetrical short circuits, Open conductor fault, Current limiting reactors

UNIT IV – STABILITY ANALYSIS

Introduction to steady state and transient Stability of power systems, Swing equation, Equal area criteria, Solution of swing equation, Methods of improving stability

UNIT V – DISTRIBUTION SYSTEM & SUBSTATIONS

Different types of distribution systems, Distribution from one and both ends, Ring mains, Unbalanced loading, 3 phase 4 wire and 3 phase 5 wire distribution system, Layout of distribution substation, Rural electrification and grounding.

Text Books

6. W.D. Stevenson, "Element of Power System Analysis", McGraw Hill, USA
7. C.L. Wadhwa, "Electrical Power Systems", New Age International Ltd., Third Edition
8. Ashfaq Husain, "Power System", CBS Publishers & Distributors, India
9. B.R. Gupta, "Power System Analysis & Design", S.Chand & Co, Third Edition
10. M.V. Deshpande, " Electrical Power System Design", Tata McGraw Hill

Reference Books

4. Soni, Gupta & Bhatnagar, "A Course in Electrical Power", Dhanpat Rai & Sons, India
5. S.L. Uppal, " Electric Power", Khanna Publishers
6. S.N. Singh, "Electric Power Generation, Transmission & Distribution", PHI, New Delhi

Unit I: Discrete Data Systems: Introduction to discrete time systems, sample and hold circuits, pulse transfer function, representation by differential equations and its solution using z-transform and inverse-z transforms, analysis of LTI systems, unit circle concepts.

Unit II: State Space analysis

State equations for dynamic systems, State equations using phase, physical and canonical variables, realization of transfer matrices, Solution of state equation, concepts of controllability, observability, Controllability and Observability tests.

Unit III: Non-linear System & Linearization: Introduction to non-linear system and their state variable representation. Linearization, describing function of various non-linearities. Stability analysis using describing function.

Unit IV: Stability: Liapunov's method, generation of Liapunov's function, Popov's criteria, design of state observers and controllers, adaptive control systems, model reference.

Unit V: Optimal Control: Introduction , formation of optimal control problems, calculus of variation, minimization of functions, constrained optimization, dynamic programming, performance index , optimality principles, Hamilton – Jacobian equation, linear quadratic problem, Ricatti II equation and its solution, solution of two point boundary value problem

Text Books:

1. K. Ogata, "Modern Control Engineering", Prentice Hall of India.
2. M. Gopal, "Modern Control System", Wiley Eastern.
3. Stefani, Shahain, Savant, Hostetter, "Design of feedback control system", oxford university press.

Reference Books:

1. B.D.O. Anderson and IB. Moore, " Optimal Control System: Linear Quadratic Methods", Prentice Hall International.
2. U. Itkis, "Control System of Variable Structure", John Wiley and Sons.
3. H. Kwakemaok and R. Sivan, "Linear Optimal Control System", Wiley Interscience.

Note: - At least 8 experiments should be performed out of which 3 should be simulation based. The department may add 3 to 4 more experiments in the following list.

(A) Hardware Based:

1. To determine direct axis reactance (x_d) and quadrature axis reactance (x_q) of a salient pole alternator.
2. To determine negative and zero sequence reactances of an alternator.
3. To determine sub transient direct axis reactance (x_d) and sub transient quadrature axis reactance (x_q) of an alternator
4. To determine fault current for L-G, L-L, L-L-G and L-L-L faults at the terminals of an alternator at very low excitation
5. To study the IDMT over current relay and determine the time current characteristics
6. To study percentage differential relay
7. To study Impedance, MHO and Reactance type distance relays
8. To determine location of fault in a cable using cable fault locator
9. To study ferranti effect and voltage distribution in H.V. long transmission line using transmission line model.
10. To study operation of oil testing set.

Simulation Based Experiments (using MATLAB or any other software)

11. To determine transmission line performance.
12. To obtain steady state, transient and sub-transient short circuit currents in an alternator
13. To obtain formation of Y-bus and perform load flow analysis
14. To perform symmetrical fault analysis in a power system
15. To perform unsymmetrical fault analysis in a power system

EA6220: INSTRUMENTATION LAB

Note: Minimum eight experiments are to be performed from the following list. The department may add 3 to 4 more experiments in the following list.

1. Measurement of displacement using LVDT.
2. Measurement of displacement using strain gauge based displacement transducer.
3. Measurement of displacement using magnetic pickup.
4. Measurement of load using strain gauge based load cell.
5. Measurement of water level using strain gauge based water level transducer
6. Measurement of flow rate by anemometer
7. Measurement of temperature by RTD
8. Measurement of temperature by thermocouple
9. Study of P, PI and PID controllers
10. Study of storage oscilloscope and determination of transient response of RLC circuit.
11. Determination of characteristics of a solid state sensor/fibre-optic sensor
12. Design and test a signal conditioning circuit for any transducer
13. Study of data acquisition system using "lab view" software and test all signal points
14. Measurement of sine, triangular, square wave signal of function generator and verify its frequency at 100 Hz tap point using "labview" software.
15. Measurement of voltage and current signal of programmable power supply using Lab view GPIB interface