

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL ENGINEERING (07)

ADVANCED POWER SYSTEM PROTECTION AND SWITCHGEAR

SUBJECT CODE: 2710707

SEMESTER: I

Type of course: Engineering

Prerequisite: Fundamentals of Power System; Basics of Generation, Transmission and Distribution Systems, Operation of various equipments used in Power System

Rationale: The protection of power system is very important for its reliability and stability point of view. It is very important to cut / remove unhealthy part of the system during fault / or abnormal condition without affecting normal functions in remaining part of the system. A fast detection and speedy removal of fault is very important for system stability but at the same unwanted tripping may create unwanted problems and disturbance in system. A new algorithm and advance technology for protection of system is incorporated in the syllabus.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P		Theory Marks		Practical Marks				
			ESE (E)	PA (M)	PA (V)		PA (I)			
					ESE	OEP	PA	RP		
3	2	2	5	70	30	20	10	20	0	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	Introduction to Digital Relays Comparison of digital relays with previous generation relays, Basic Components of Digital Relays with block diagram, Signal Conditioning Subsystems, Surge Protection Circuits, Anti aliasing filter, Conversion Subsystem, The Sampling Theorem, Sample and Hold Circuit, Concept of analog to digital and digital to analog conversion, Idea of sliding window concept, introduction to intelligent electronic device (IED), Different relay algorithms such as algorithms for pure sinusoidal relaying signal, algorithm based on solution of system differential equations, Fourier analysis based half cycle and full cycle algorithm.		
2	Coordination of Inverse Definite Minimum Time (IDMT)/Directional Over Current (DOC) Relays in an Interconnected Power System Network Protection of an interconnected system, Link net structure, Flowchart of Primary/Backup relay pairs, Flowchart of Time Multiplier Setting. Examples based on existing power system network		
3	Wide Area Protection and Measurement Definition of wide-area protection, Architectures of wide-area protection, concept of synchronized sampling, wide area phasor measurement technology, concept of Adaptive relaying, advantageous of adaptive relaying and its application		
4	Auto-reclosing and Synchronizing		

	Introduction, history of auto-reclosing, advantageous of auto-reclosing, classification of auto-reclosing, auto-reclosing based on number of phases, auto-reclosing based on number of attempts, auto-reclosing based on speed, Sequence of events in single-shot auto-reclosing scheme, factors to be considered during reclosing such as choice of zone in case of distance relay, dead time, reclaim time, instantaneous trip lockout, intermediate lockout, breaker supervision function, Synchronism check, phasing voltage method, angular method, automatic synchronization		
5	System Response during Severe Upsets Introduction, Nature of system response to severe upsets such as system response to Islanding conditions, Under generated islands, Over generated islands, Reactive Power Balance, Power Plant Auxiliaries, Power System Restoration, Load Shedding, Factors to be considered for load shedding scheme such as maximum anticipated overload, number of load shedding steps, size of load shed at each step, frequency setting, time delay, rate of frequency decline, frequency relays, Issues with islanding and methods of islanding		
6	Protection of Series Compensated Transmission Line Introduction, The Degree of compensation, basic components of series compensated transmission lines, Voltage Profile of Series Compensated Line, Faults with Unbypassed Series Capacitors, Protection problems such as Voltage Inversion, Current Inversion, Overreaching/Underreaching of distance element		

Reference Books:

1. Bhavesh Bhalja, R. P. Maheshwari and N. G. Chothani, "Protection and Switchgear," Oxford University Press, New Delhi, India, 2011.
2. P. M. Anderson, Power System Protection, IEEE Press, New York, 1999.
3. A. T. Johns and S. K. Salman, "Digital Protection for Power Systems," Peter Peregrinus Ltd, UK, 1995.
4. S. H. Horowitz and A. G. Phadke, "Power System Relaying," John Wiley & Sons, New York, 1996.
5. W. A. Almore, "Protective Relaying Theory and Applications," Marcel Dekker Inc; New York, 1994.
6. J. L. Blackburn, "Applied Protective Relaying," Westinghouse Electric Corporation, New York, 1982.
7. Van C. Warrington A. R. "Protective Relays: Their Theory and Practice," Vol 1, Chapman & Hall Ltd, London, 1962.
8. A. G. Phadke and J. S. Thorp, "Computer Relaying for Power Systems," Research study press Ltd, John Wiley & Sons, Taunton, UK, 1988.

Course Outcome:

After learning the course the students should be able to

1. Analyze the tripping characteristics of various relays and its applications. Design inductors and transformers for power electronic converters
2. To operate various static relays, set their parameters and also to confirm its operations.
3. To operate various Numeric relays, set their parameters and also to confirm its operations.

List of Experiments:

1. Study of digital relays with detailed description of each component of the schematic diagram of digital relay
2. Setting up IDMT relays for a radial feeder
3. Setting up IDMT/DOC relays for a power system using link net structure
4. Study of auto-reclosing with related details
5. Study of system response during severe upset and power system restoration
6. Study of load shedding schemes with all related details
7. Study of protection of transmission line which is compensated by fixed series capacitors.
8. Simulation of fixed series capacitor compensated transmission line for fault at various location to explain the phenomena of current inversion and voltage inversion

Open Ended Problem:**Major Equipments:****List of Open Source Software/learning website:**

http://nptel.iitm.ac.in/coursecontents_elec.php

ocw.mit.edu/courses/electrical.../6-334-power-electronics-spring-2007