EE3601	PROTECTION AND SWITCHGEAR	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the significance of protection, protection schemes and role of earthing.
- To study the characteristics, functions and application areas of various relays.
- To acquire practical knowledge about common faults in power system apparatus and applying suitable protective schemes.
- To understand the functioning of static relays and Numerical protection concepts.
- To understand the problems associated with circuit breaking and to discuss about various circuit breakers.

UNIT I PROTECTION SCHEMES 9

Significance and need for protective schemes – nature and causes of faults – types of faults Effects of faults - Zones of protection and essential qualities of protection – Types of Protection schemes - Power system Grounding and Methods of Grounding.

UNIT II BASICS OF RELAYS 9

Operating principles of relays –Universal torque equation - R-X diagram –Electromagnetic Relays – Over current, Directional and non-directional, Distance, Differential, Negative sequence and Under frequency relays.

UNIT III OVERVIEW OF EQUIPMENT PROTECTION 9

Current transformers and Potential transformers and their applications in protection schemes - Protection of transformer, generator, motor, bus bars and transmission line.

UNIT IV STATIC RELAYS AND NUMERICAL PROTECTION 9

Static relays – Phase, Amplitude Comparators – Synthesis of various relays using Static comparators – Block diagram of Numerical relays – Over current protection, transformer differential protection, and distantce protection of transmission lines.

UNIT V CIRCUIT BREAKERS 9

Physics of arcing phenomenon and arc interruption – DC and AC circuit breaking – re-striking voltage and recovery voltage - rate of rise of recovery voltage - current chopping - interruption of capacitive current - resistance switching - Types of circuit breakers – air blast, oil, SF6 and vacuum circuit breakers – comparison of different circuit breakers – HVDC Breaker.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will have theability to:

CO1: Understand and select proper protective scheme and type of earthing.
CO2: Explain the operating principles of various relays.
CO3: Suggest suitable protective scheme for the protection of various power system apparatus.
CO4: Analyze the importance of static relays and numerical relays in power system protection.
CO5: Summarize the merits and demerits and application areas of various circuit breakers.

TEXT BOOKS:

1. Sunil S.Rao, 'Switchgear and Protection', Khanna Publishers, New Delhi, Four Edition, 2010.
2. Badri Ram ,B.H. Vishwakarma, 'Power System Protection and Switchgear', New Age International Pvt Ltd Publishers, Second Edition 2011.
3. B.Rabindranath and N.Chander, 'Power System Protection and Switchgear', New Age International (P) Ltd., Second Edition, 2018.
4. Arun Ingole, 'Switch Gear and Protection' Pearson Education, 2018.

REFERENCES

1. Y.G.Paithankar and S.R.Bhide, 'Fundamentals of power system protection', Second Edition,Prentice Hall of India Pvt. Ltd., New Delhi, 2013.
2. C.L.Wadhwa, 'Electrical Power Systems', 6th Edition, New Age International (P) Ltd., 2018
3. VK Metha," Principles of Power Systems", S. Chand, Reprint, 2013
4. Bhavesh Bhalja, R.P. Maheshwari, Nilesh G. Chotani,'Protection and Switchgear' Oxford University Press, 2nd Edition 2018.

MAPPING OF COs WITH POs AND PSOs

COs	POs												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	2	1	2	1	1	1	1	2	-	3	1	-
CO2	3	1	1	2	1	2	1	1	1	1	2	-	3	1	-
CO3	3	1	1	2	1	2	1	1	1	1	2	-	3	2	-
CO4	3	1	1	2	1	2	1	1	1	1	2	-	3	2	1
CO5	3	1	1	2	2	2	1	1	1	1	2	-	3	1	1
Avg.	3	1	1	2	1.2	2	1	1	1	1	2	-	3	1.4	1

EE3602	POWER SYSTEM OPERATION AND CONTROL	L T P C 3 0 0 3

COURSE OBJECTIVES:

To impart knowledge on,

- The significance of power system operation and control.
- Real power– frequency interaction and design of power– frequency controller.
- Reactive power– voltage interaction and the compensators for maintaining the voltage profile.
- The generation scheduling and economic operation of power system.
- SCADA and its application for real time operation and control of power systems.

UNIT I INTRODUCTION 9

Power scenario in Indian grid – National and Regional load dispatching centres – Requirements of good power system – Necessity of voltage and frequency regulation – real power vs frequency and reactive power vs voltage control loops - System load variation, load curves – Load forecasting – Computational methods in load forecasting – Load shedding and Islanding – deregulation - Basics of electrical energy tariff.

UNIT II REAL POWER FREQUENCY CONTROL 9

Basics of speed governing mechanisms and modelling – Speed regulation of two generators in parallel Load Frequency Control (LFC) of single area system – Static and dynamic analysis – LFC of two area system –Tie line modelling – Block diagram representation of two area system – Static and dynamic analysis – Tie line with frequency bias control – State variable model – Integration of economic dispatch control with LFC.

UNIT III REACTIVE POWER – VOLTAGE CONTROL 9

Generation and absorption of reactive power – Basics of reactive power control – Automatic Voltage Regulator (AVR) – Brushless AC excitation system – Block diagram representation of AVR loop static and dynamic analysis – Stability compensation – Voltage drop in transmission line – Methods of reactive power injection – Tap changing transformer, SVC and STATCOM for voltage control.

UNIT IV ECONOMIC OPERATION OF POWER SYSTEM 9

Statement of economic dispatch problem – Input and output characteristics of thermal plant incremental cost curve – Optimal operation of thermal units without and with transmission losses (no derivation of transmission loss coefficients) – Lambda–iteration method – Base point and participation factors method. Statement of Unit Commitment (UC) problem – Constraints on UC problem – Solution of UC problem using priority list – Special aspects of short term and long-term hydrothermal scheduling problems.

UNIT V COMPUTER AIDED CONTROL OF POWER SYSTEM 9

Need of computer control of power system – Concept of energy control centers and functions – PMU system monitoring, Data acquisition and controls – System hardware configurations – SCADA and EMS functions – State estimation – Measurements and errors – Weighted least square estimation – Various operating states – State transition diagram.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On the successful completion of the course, students will be able to:

CO1: Understand the day – to – day operation of power system.
CO2: Model and analyse the control actions that are implemented to meet the minute-to-minute variation of system real power demand.
CO3: Model and analyze the compensators for reactive power control and various devices used for voltage control.
CO4: Prepare day ahead and real time economic generation scheduling.
CO5: Understand the necessity of computer control of power systems.

TEXTBOOKS:

1. Olle. I. Elgerd, 'Electric Energy Systems theory – An introduction', McGraw Hill Education Pvt. Ltd., New Delhi, 2nd edition, 2017.
2. Allen. J. Wood and Bruce F. Wollen berg, 'Power Generation, Operation and Control', John Wiley & Sons, Inc., 3rd edition, 2013.
3. Abhijit Chakrabarti and Sunita Halder, 'Power System Analysis Operation and Control', PHI learning Pvt. Ltd., New Delhi, Fourth Edition, 2018.

REFERENCE BOOKS:

1. Kothari D.P. and Nagrath I.J., 'Power System Engineering', Tata McGraw– Hill Education, Second Edition, Reprint 2018.
2. Hadi Saadat, 'Power System Analysis', McGraw Hill Education Pvt. Ltd., New Delhi, 23rd reprint, 2015.
3. Kundur P., 'Power System Stability and Control, McGraw Hill Education Pvt. Ltd., New Delhi, 12th reprint, 2015.
4. B.M. Weedy, B.J. Cory et al, 'Electric Power systems', Wiley, Fifth Edition, 2012.

MAPPING OF COs WITH POs AND PSOs

COs	POs												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	-	-	-	-	-	1	-	-	-	2	3	3	3
CO2	3	2	1	1	-	1	-	2	-	2	-	2	3	3	3
CO3	3	2	1	1	-	1	-	2	-	2	-	2	3	3	3
CO4	3	2	1	1	-	1	-	2	-	2	-	2	3	1	2.33
CO5	2	1	-	-	-	-	-	1	-	2	-	2	3	3	3
Avg.	2	1.6	1	1	-	1	-	1.6	-	2	-	2	3	2.2	2.86

NCC Credit Course Level 3*

NX3651	(ARMY WING) NCC Credit Course Level - III	L	T	P	C
		3	0	0	3

PERSONALITY DEVELOPMENT		**9**
PD 3	Group Discussion: Team Work	2
PD 4	Career Counselling, SSB Procedure & Interview Skills	3
PD 5	Public Speaking	4
BORDER & COASTAL AREAS		**4**
BCA 2	Security Setup and Border/Coastal management in the area	2
BCA 3	Security Challenges & Role of cadets in Border management	2
ARMED FORCES		**3**
AF 2	Modes of Entry to Army, CAPF, Police	3
COMMUNICATION		**3**
C 1	Introduction to Communication & Latest Trends	3
INFANTRY		**3**
INF 1	Organisation of Infantry Battalion & its weapons	3
MILITARY HISTORY		**23**
MH 1	Biographies of Renowned Generals	4
MH 2	War Heroes - PVC Awardees	4
MH 3	Study of Battles - Indo Pak War 1965, 1971 & Kargil	9
MH 4	War Movies	6

TOTAL: 45 PERIODS

NCC Credit Course Level 3*

NX3652	(NAVAL WING) NCC Credit Course Level - III	L	T	P	C
		3	0	0	3

PERSONALITY DEVELOPMENT		**9**
PD 3	Group Discussion: Team Work	2
PD 4	Career Counselling, SSB Procedure & Interview Skills	3
PD 5	Public Speaking	4
BORDER & COASTAL AREAS		**4**
BCA 2	Security Setup and Border/Coastal management in the area	2
BCA 3	Security Challenges & Role of cadets in Border management	2
NAVAL ORIENTATION		**6**
NO 3	Modes of Entry - IN, ICG, Merchant Navy	3
AF 2	Naval Expeditions & Campaigns	3
NAVAL COMMUNICATION		**2**
NC 1	Introduction to Naval Communications	1
NC 2	Semaphore	1
NAVIGATION		**2**
N 1	Navigation of Ship - Basic Requirements	1
N 2	Chart Work	1
SEAMANSHIP		**15**
MH 1	Introduction to Anchor Work	2
MH 2	Rigging Capsule	6
MH 3	Boatwork - Parts of Boat	2
MH 4	Boat Pulling Instructions	2
MH 5	Whaler Sailing Instructions	3
FIRE FIGHTING FLOODING & DAMAGE CONTROL		**4**
FFDC 1	Fire Fighting	2
FFDC 2	Damage Control	2
SHIP MODELLING		**3**
SM	Ship Modelling Capsule	3

TOTAL : 45 PERIODS

NCC Credit Course Level 3*

NX3653	(AIR FORCE WING) NCC Credit Course Level - III	L	T	P	C
		3	0	0	3
PERSONALITY DEVELOPMENT					**9**
PD 3	Group Discussion: Team Work				2
PD 4	Career Counselling, SSB Procedure & Interview Skills				3
PD 5	Public Speaking				4
BORDER & COASTAL AREAS					**4**
BCA 2	Security Setup and Border/Coastal management in the area				2
BCA 3	Security Challenges & Role of cadets in Border management				2
AIRMANSHIP					**1**
A 1	Airmanship				1
BASIC FLIGHT INSTRUMENTS					**3**
FI 1	Basic Flight Instruments				3
AERO MODELLING					**3**
AM 1	Aero Modelling Capsule				3
GENERAL SERVICE KNOWLEDGE					**2**
GSK 4	Latest Trends & Acquisitions				2
AIR CAMPAIGNS					**6**
AC 1	Air Campaigns				6
PRINCIPLES OF FLIGHT					**6**
PF 1	Principles of Flight				3
PF 2	Forces acting on Aircraft				3
NAVIGATION					**5**
NM 1	Navigation				2
NM 2	Introduction to Met and Atmosphere				3
AERO ENGINES					**6**
E 1	Introduction and types of Aero Engine				3
E 2	Aircraft Controls				3

TOTAL : 45 PERIODS

EE3611	POWER SYSTEM LABORATORY	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

1 To provide a better understanding of modelling of transmission lines in impedance and admittance forms.
2 To apply iterative techniques for power flow analysis and to carry out short circuit and stability studies on power system.
3 To analyze the load – frequency and voltage controls.
4 To analyze optimal dispatch of generators and perform state estimation.
5 To understand the operation of relays, characteristics, and applications.

LIST OF EXPERIMENTS:

1 Computation and modelling of transmission Lines.
2 Formation of Bus Admittance and Impedance Matrices.
3 Power Flow Analysis Using Gauss-Seidel Method.
4 Power Flow Analysis Using Newton Raphson Method.
5 Symmetric and Unsymmetrical Fault Analysis.
6 Transient Stability Analysis of SMIB System.
7 Load – Frequency Dynamics of Single- Area and Two-Area Power Systems.
8 Economic Dispatch in Power Systems.
9 State estimation: Weighted least square estimation.
10 Performance analysis of over current relay.
11 Performance analysis of impedance relay.
12 Testing of CT, PT, and Insulator string.
13 Relay Coordination in Radial Feeder Protection Scheme.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On the successful completion of the laboratory, students will be able to:
CO1: Model and analyze the performance of the transmission lines.
CO2: Perform power flow, short circuit, and stability analysis for any power system network.
CO3: Understand, design, and analyze the load frequency control mechanism.
CO4: Perform optimal scheduling of generators and compute the state of the power system.
CO5: Understand, analyze, and apply the relays for power system protection.

MAPPING OF COs WITH POs AND PSOs

COs	POs												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	3	-	-	2	1	2	-	3	3	3	3
CO2	3	3	2	2	3	-	-	2	1	2	-	3	3	3	3
CO3	3	3	2	2	3	-	-	2	1	2	-	3	3	3	3
CO4	3	3	2	2	3	-	-	2	1	2	-	3	3	3	3
CO5	3	3	2	2	3	-	-	2	1	2	-	3	3	3	3
Avg	3	3	2	2	3	-	-	2	1	2	-	3	3	3	3

EE3701 **HIGH VOLTAGE ENGINEERING** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

- Various types of over voltages in power system and protection methods.
- Generation of over voltages in laboratories.
- Measurement of over voltages.
- Nature of Breakdown mechanism in solid, liquid and gaseous dielectrics.
- Testing of power apparatus and insulation coordination.

UNIT I OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS 9

Causes of over voltages and its effects on power system – Lightning, switching surges and temporary over voltages – Reflection and Refraction of Travelling waves- protection against over voltages_ Insulation Coordination.

UNIT II DIELECTRIC BREAKDOWN 9

Properties of Dielectric materials - Gaseous breakdown in uniform and non-uniform fields –Corona discharges – Vacuum breakdown – Conduction and breakdown in pure and commercial liquids, Maintenance of oil Quality – Breakdown mechanisms in solid and composite dielectrics- Applications of insulating materials in electrical equipment.

UNIT III GENERATION AND MEASUREMENTS OF HIGH VOLTAGES AND HIGH CURRENTS 9

Generation of High DC, AC, impulse voltages and currents - Analysis of DC/AC and Impulse generator circuits - Tripping and control of impulse generators**,** Measurement of High voltages and High currents – High Resistance with series ammeter – Dividers - Resistance, Capacitance and Mixed dividers - Peak Voltmeter, Generating Voltmeters, Electrostatic Voltmeters – Sphere Gaps, High current shunts- Digital techniques in high voltage measurement.

UNIT IV HIGH VOLTAGE TESTING & INSULATION COORDINATION 9

High voltage testing of electrical power apparatus- International and Indian standards – Power