# SPPU B.E./B.Tech EE Sem 7 syllabus

## Power System Operation and Control

### 403141: Power System Operation and Control

### Credits Theory :03 Practical :01

**Unit 01 : Power System Stability**
Introduction to stability, dynamics of synchronous machine, swing equation, power angle equation and curve, types of power system stability (concepts of steady state, transient, stability), equal area criterion, applications of equal area criterion (sudden change in mechanical input, effect of clearing time on stability, critical clearing angle, short circuit at one end of line, short circuit away from line ends and reclosure), solution of swing equation by point by point method, methods to improve steady state and transient stability, numerical based on equal area criteria.

**Unit 02 : Reactive Power management**
Necessity of reactive power control, reactive power generation by a synchronous machine, effect of excitation, loading capability curve of a generator, compensation in power system: series and shunt compensation using capacitors and reactors, Problems with Series Compensation, synchronous condenser.

**Unit 03 : FACTs Technology**
Problems of AC transmission system, evolution of FACTs technology, Working principle, circuit diagram, VI characteristics, applications, advantages and limitations of SVC, TCSC, STATCOM and UPFC.

**Unit 04 : Automatic Generation and Control (AGC)**
Concept of AGC, complete block diagram representation of load-frequency control of an isolated power system, steady state and dynamic response, control area concept, two area load frequency control. Schematic and block diagram of alternator voltage regulator scheme.

**Unit 05 : Economic Load Dispatch and Unit Commitment**

**A. Economic load dispatch:** Introduction, revision of cost curve of thermal and hydropower plant, plant scheduling method, equal incremental cost method, method of Lagrange multiplier (neglecting transmission losses), Bmn coefficient, economic scheduling of thermal plant considering effect of transmission losses, penalty factor, procedure of load dispatch at state level load dispatch center, Regional Load Dispatch Center, numerical on penalty factor, exact coordination equation.

**B. Unit commitment:** Concept of unit commitment, constraints on unit commitment – spinning reserve, thermal and hydro constraints, methods of unit commitment – priority list and dynamic programming, Numerical on priority list method.

**Unit 06 : Energy Control and Planning and Reliability of Power Systems**

**A. Energy Control:** Interchange of power between interconnected utilities, economy interchange evaluation, interchange evaluation with unit commitment, types of interchange, capacity and diversity interchange, energy banking, emergency power interchange, inadvertent power exchange, power pools.

**B. Planning and Reliability of Power Systems:** Need of short term planning and long term planning in generation, transmission, distribution expansion. Definition of reliability of power system, Hierarchical levels for reliability study, Reliability evaluation of generation system, loss of load probability (LOLP), loss of load expectation (LOLE), Expected Energy Not Supplied (EENS), generation model, load model, risk model, composite system reliability evaluation, Distribution system reliability evaluation for radial and parallel system, customer oriented and energy based reliability indices.

**Text Books:**

[T1] I. J. Nagrath, D. P. Kothari, “Modern Power System Analysis”, 4th Edition, Tata McGraw Hill Publishing Co. Ltd. (Edition 2)
[T2] Hadi Saadat, “Power System Analysis”, Tata McGraw Hill
[T3] P. S. R. Murthy, “Power System Operation and Control”, Tata McGraw Hill Publishing Co. Ltd.
[T4] P. S. R. Murthy, “Operation and Control in Power System”, B. S. Publication.
[T5] R. Mohan Mathur, Rajiv K. Varma, “Thyristor based FACTs controller for Electrical
transmission system”, John Wiley and Sons Inc.

[T6] Abhijit Chakrabarti, Sunita Halder, “Power System Analysis Operation and Control”, Prentice Hall of India.
[T7] Narain G. Hingorani and Laszlo Gyugyi, “Understanding FACTS”, IEEE Press.

**Reference Books:**

[R1] Allen J. Wood, Bruce F. Wollenberg, “Power Generation, Operation, and Control”, Wiley India Edition.
[R2] “Electrical Power System Handbook”, IEEE Press.
[R3] Narain G. Hingorani, Laszlo Gyugyi, “Understanding FACTs Concepts and Technology of Flexible AC Transmission Systems,” IEEE Press.
[R4] Olle I. Elgerd, “Electrical Energy System Theory”, 2nd Edition, Tata McGraw Hill. Publishing Co. Ltd.
[R5] Prabha Kundur, “Power System Stability and Control”, Tata McGraw Hill.

# PLC and SCADA Applications

## 403142: PLC and SCADA Applications

**Credits Theory :04 Practical :01**

### Unit 01 : Introduction to PLC

Role of automation in Industries, benefits of automation, Necessity of PLC, History and evolution of PLC, Definition as per NEEMA (National Electrical Engineering Manufacturers’ Association), types – fixed/modular/dedicated, Overall PLC system, PLC Input and output modules (along with Interfaces), CPU, programmers and monitors, power supplies, selection criterion, advantages and disadvantages, specifications, comparison of various PLCs manufactured by Allen Bradley, Siemens, ABB, Mitsubishi, GE, Fanuc and Schneider.

### Unit 02 : Interfacing of PLC with I/O devices

Input ON/OFF switching devices, Input analog devices, Output ON/OFF devices, Output analog devices Sensors-temperature, pressure, flow, level Actuators-Electrical, pneumatic, hydraulic Encoders-Incremental, Absolute Transducers, Limit switches, proximity sensors Control Elements- Mechanical, Electrical, Fluid valves

### Unit 03 : Programming of PLC

Programming languages for PLC, Ladder diagram fundamentals, Rules for proper construction of ladder diagram Timer and counter-

types along with timing diagrams, Reset instruction, latch instruction MCR (master control relay) and control zones Developing ladder logic for Sequencing of motors, ON OFF Tank level control, ON OFF temperature control, elevator, bottle filling plant, car parking, traffic light controller.

**Unit 04 : Advance function and Applications of PLC**
Analog PLC operation and PLC analog signal processing, PID principles, Typical continuous process control curves, simple closed loop systems, closed loop system using Proportional, Integral and Derivative (PID), PID modules, PID tuning, tuning methods including "Adjust and observe" method.
Motors Controls: AC Motor starter, AC motor overload protection, DC motor controller, Variable speed (Variable Frequency) AC motor Drive. PLC Applications in developing systems- Tank level controller using analog signals, temperature controller using RTD, speed control of electric motor.

**Unit 05 : SCADA Systems**
Introduction, definitions and history of Supervisory Control and Data Acquisition, typical SCADA system Architecture, important definitions HMI, MTU, RTU, communication means, Desirable Properties of SCADA system, advantages, disadvantages and applications of SCADA.
SCADA generations (First generation - Monolithic, Second generation - Distributed, Third generation – Networked Architecture), SCADA systems in operation and control of interconnected power system, Functions and features of SCADA systems, Automatic substation control, Energy management systems (EMS), System operating states, SCADA system in critical infrastructure: Petroleum Refining Process, Conventional electric power generation, Water Purification System, Chemical Plant.

**Unit 06 : SCADA Protocols**
Open systems interconnection (OSI) Model, TCP/IP protocol, Modbus model, DNP3 protocol, IEC61850 layered architecture, Control and Information Protocol (CIP), Device Net, Control Net, Ether Net/IP, Flexible Function Block process (FFB), Process Field bus (Profibus).

**Text Books:**
[T1] John W. Webb, Ronald A. Reis, "Programmable Logic Controllers: Principles and Application", PHI Learning, New Delhi, 5th Edition
[T2] John R. Hackworth, Frederick D., Hackworth Jr., "Programmable Logic Controllers Programming Methods and Applications", PHI

Publishers
[T3] Ronald L. Kurtz, “Securing SCADA System”, Wiley Publishing
[T4] Stuart A Boyer, “SCADA supervisory control and data acquisition”, ISA, 4th Revised edition
[T5] Sunil S. Rao, “Switchgear and Protection”, Khanna Publication
[T6] Curtis Johnson, “Process Control Instrumentation Technology”, Prentice Hall of India
[T7] Gary Dunning, “Introduction to Programmable Logic Controllers”, Thomson, 2nd Edition

**Reference Books:**

[R1] Gordan Clark, Deem Reynders, “Practical Modern SCADA Protocols”, ELSEVIER
[R2] Batten G. L., “Programmable Controllers”, McGraw Hill Inc., Second Edition
[R3] Bennett Stuart, “Real Time Computer Control”, Prentice Hall, 1988
[R4] Krishna Kant, “Computer Based Industrial Control”, PHI
[R5] P. K. Srivstava, “Programmable Logic Controllers with Applications”, BPB Publications

# Control System II

### 403145: Control System II

**Credits Theory :03 Practical :01**

**Unit 01 : Digital Control System (06 Hrs)**
Introduction, Configuration of the basic digital control system. Advantages and limitations of digital control; data conversion and quantization, Sampling and Reconstruction processes, Shannon’s Sampling theorem, practical aspects of choice of sampling rate. Zero order hold (ZOH) and it’s transfer function, Basic concepts and transfer function of first order hold.

**Unit 02 : Z-transform and Pulse-transfer-function**
Review of z-transform, Inverse z-transform, difference equations and solution using z transform method. Pulse transfer function and Z-transfer function, General procedure for obtaining Pulse-transfer-function, pulse transfer function of ZOH.

**Unit 03 : Stability Analysis**
Sampled data closed loop systems, characteristic equation, causality and physical realizability of discrete data system, realization of digital

controller by digital programming, direct digital programming, cascade digital programming, parallel digital programming. Mapping between S-plane and Z-plane, stability analysis of closed loop system in z-plane using Jury's test, Bilinear Transformation.

**Unit 04 : Introduction to state space analysis**
Important definitions – state, state variable, state vector, state space, state equation, output equation. State space representation for electrical and mechanical system, nth order differential equation and transfer function. Conversion of transfer function to state model and vice versa. State model of armature control DC motor

**Unit 05 : Solution of state equations**
Concept of diagonalization, eigen values, eigenvectors, diagonalization of system matrices with distinct and repeated eigen values, Vandermonde matrix.
Solution of homogeneous and non-homogeneous state equation in standard form, state transition matrix, its properties, Evaluation of STM using Laplace transform method and infinite series method Cayley Hamilton theorem.

**Unit 06 : Design of Control System Using State Space Technique:**
Concept of controllability and observability, controllability and observability Tests, condition for controllability and observability from the system matrices in Canonical form, Jordan canonical form, effect of pole zero cancellation on the controllability and observability of the system, duality property. Pole placement design by state variable feedback. Necessity of an observer, design of full order observer.

**Text Books:**
[T1] K. Ogata, "Discrete Time Control System", 2nd Edition, PHI Learning Pvt. Ltd. 2009
[T2] Benjamin C. Kuo "Digital Control System", Prentice Hall of India Pvt. Ltd.
[T3] J. Nagrath, M. Gopal "Control System Engineering", 5th Edition. New Age International Publishers
[T4] R.Anandanatarajan and P.Ramesh Babu "Control System Engineering",4th Edition, SCITECH Publications, India Pvt. Ltd.

**Reference Books:**
[R1] K. Ogata, "Modern Control Engineering", Prentice Hall of India Pvt. Ltd.

[R2] M. Gopal, “Digital Control and State Variable Methods”, Tata McGraw-Hill.
[R3] M. N. Bandyopadhyay, “Control Engineering – Theory and Practice”, Prentice Hall of India Ltd. Delhi.