HONORS IN ELECTRICAL ENGINEERING

SCHEME OF INSTRUCTION AND EVALUATION w.e.f. 2024-2025

S. No.	Code	Course Title	Scheme of Instruction			Contact Hrs/Wk	Scheme of Evaluation			Credits	Sem.
			L	T	P		Hrs	CIE	SEE		
Theory											
1	HR501EE	Modern Control Theory	3	-	-	3	3	40	60	3	V
2	HR601EE	Energy Storage Systems and Applications	3	-	-	3	3	40	60	3	VI
3	HR602EE	Restructured Power Systems	3	-	-	3	3	40	60	3	VI
4	HR701EE	Control and Integration of Renewable Energy Sources	3	-	-	3	3	40	60	3	VII
5	HR702EE	Real-Time Applications in Power Systems	3	-	-	3	3	40	60	3	VII
6	PW851EE	HR- Project Work	3	-	-	6	6	-	100	3	VIII
Total			**18**	**-**	**-**	**21**	**21**	**200**	**400**	**18**	

Course Code	Course Title						Course Type
HR 501 EE	**MODERN CONTROL THEORY**						Core
Prerequisite	**Contact hours per week**			**Duration of SEE (Hours)**	**Scheme of Evaluation**		**Credits**
	L	**T**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- To provide the fundamentals required to model a control system in state space.
- To understand design of state feedback controllers and state observers.
- To educate the students about non-linear systems behavior and the methods to determine their stability.
- To make then students thorough with Lyapunov stability analysis.
- To familiarize the students with the concept of optimal control and how to determine optimum for functional using calculus of variations.

Course Outcomes:

1. Model any control system in state space.
2. Design state feedback controllers and state observer.
3. Understand the behavior of nonlinear system and methods of determining stability.
4. Determine stability of nonlinear system using Liapunov method.
5. Formulate optimal control problem and determine optimum of functionals.

Articulation matrix of Course Outcomes with POs:

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

UNIT - I

State variable representation of systems - Mechanical and Electrical systems - Controllable, Observable and Jordon canonical forms – State transition Matrix, Cayley Hamilton theorem, Solution of state equation

UNIT - II

Concept of Controllability, Observability - Pole placement using state feedback - necessary and sufficient conditions - state observer design - full order observer - reduced order observer

UNIT-III

Classification of Non-linearities: Phenomenon exhibited by the nonlinearities – Limit cycles – Jump resonance, Sub-harmonic oscillations – Phase plane analysis – Singular points – Construction of phase plane trajectories – Isocline method – Delta method – Measurement of time on phase plane trajectories.

.

UNIT- IV

Concept and definition of stability - Lyapunov stability - Lyapunov's first and second methods - Stability of linear time invariant systems by Lyapunov's second method - Generation of Lyapunov functions- Variable gradient method - Krasooviski's method.

UNIT-V

Formulation of optimal control problems - Calculus of variations – Fundamental concepts – Functionals – Variation of functionals – Fundamental theorem of calculus of variations - Boundary conditions – Constrained minimization – Dynamic programming – Hamilton Principle of optimality, Jacobi Bellman equation – Potryagins minimum principle.

Suggested Reading:

1. I.J Nagarath ,M.Gopal *Control Systems Engineering*, fifth edition , New Age International Publishers, 1984 Wiley Eastern Ltd.
2. Ogata K, *Modern Control Engineering*, Prentice Hall, 1997. Donald E Kirk, optimal control theryAn introduction

Course Code	Course Title						Course Type
HR 601 EE	**ENERGY STORAGE SYSTEMS AND APPLICATIONS**						Core
Prerequisite	**Contact hours per week**			**Duration of SEE (Hours)**	**Scheme of Evaluation**		**Credits**
	L	**T**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**3**	**40**	**60**	**3**

Course Outcomes:

1. Understand various energy storage technologies.
2. Develop an algorithm to estimate the state of charge and state of health of a battery.
3. Develop the energy management control of a storage system in a grid connected system.
4. Develop the control algorithm to a grid-connected storage system to improve the grid reliability.

UNIT I

Development of energy storage technology: Basic concept, history of energy storage technologies, demand functions of energy storage technology in power system, application outlook and challenges of energy storage technology in power system.

UNIT II

Technology of energy storage systems: Electrochemical energy storage: lead-acid battery, lithium-ion battery, vanadium redox battery, zinc-bromine, sodium sulphur; physical energy storage: pumped hydro storage, compressed air energy storage, flywheel energy storage; electromagnetic energy storage: supercapacitor energy storage, superconducting magnetic energy storage; new type energy storage: advanced lead-acid battery, lithium-sulphur battery, sodium-ion battery, heat pump storage, gravity energy storage; comprehensive comparison of energy storage technologies: technical maturity, performance parameters, applications.

UNIT III

Technologies for battery management: Battery management systems typical structures, main functions; state of charge (SoC) estimation method: definition, the methods of SoC estimation; state of health (SoH) estimation technology: definition, methods of SoH estimation: balance management technology: protection technology: overvoltage protection, undervoltage protection, overcurrent protection, short circuit protection, over temperature protection.

UNIT IV

Operation control technology of energy storage systems: Grid connected operation control technology: AC/DC converter control, DC/DC converter control, island detection, low-voltage ride through; off-grid operation control technology: control of switching from on-grid to off-gird, synchronization control of the switching from off-gird to on-grid.

UNIT V

Application of energy storage technology in grid-connected energy power generation: Impact of energy storage system on grid-connected energy storage power generation: smooth power fluctuation, reduce power system's demand for peak regulation capacity, energy schedule, regulate frequency and voltage; design of an energy storage system in grid-connected power generation system: storage energy system's configuration, technical/economical analysis of energy storage system, configuration of energy storage system capacity; control of hybrid integrated energy storage generation: smooth the power fluctuation, schedule output, frequency regulation.

Text Books:

1. Grid-scale Energy Storage Systems and Applications, Fu-Bao Wu, Bo Yang, Ji-Lei Ye, Elsevier- Academic Press, 2019, 1st Edition.
2. Energy Storage Devices for Renewable Energy-Based Systems, Nihal Kularatna Kosala Gunawardane, Elsevier-Academic Press 2019, 2nd Edition.
3. Ultra-Capacitors in Power Conversion Systems: Applications, Analysis and Design from Theory to Practice, Petar J. Grbovic, Wiley-IEEE Press, 2013, 1st Edition.

Reference Books:

1. Energy Storage: A New Approach, Ralph Zito, Haleh Ardebili, Wiley, 2019, 2nd Edition.
2. Energy Storage for Power System Planning and Operation: Zechun Hu, Wiley, 2020, 1st Edition.
3. Fuel Cell Systems Explained, Andrew L. Dicks, David A. J. rand, Wiley, 2018, 3rd Edition.

Course Code	Course Title						Course Type
HR 602 EE	**RESTRUCTURED POWER SYSTEMS**						Core
Prerequisite	**Contact hours per week**			**Duration of SEE (Hours)**	**Scheme of Evaluation**		**Credits**
	L	**T**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- Understand the new dimensions associated with operation of deregulated power systems.
- Introduction to the power sector market, trading and bidding strategies.
- Apply the concept of deregulation and ATC.
- Understand the electricity power business and technical issues in a deregulated power system in both Indian and world scenario.
- To learn different pricing mechanisms and power trading in deregulated power systems.

Course Outcomes:

1. Understand the developments in the process of deregulation worldwide.
2. Identify the roles and responsibilities of different entities in power market.
3. Calculate Available Transmission Capability using various methodologies.
4. Explore issues like congestion management, Transmission pricing, Ancillary Services Management.
5. Apply the concepts and terminologies used in power pools and transaction issues.

UNIT I

Fundamentals of Restructuring: Overview of Key Issues in Electric Utilities – Introduction – Restructuring models – Independent system operator (ISO) – Power Exchange - Market operations – Market Power – Stranded costs – Transmission Pricing – Congestion Pricing.

UNIT II

OASIS: Open Access Same-Time Information System: Structure of OASIS –Posting of Information – Transfer capability on OASIS – Definitions Transfer Capability Issues – ATC – TTC – TRM – CBM calculations – Methodologies to calculate ATC, Bidding strategies.

UNIT III

Electricity Pricing: Introduction – Electricity Price Volatility Electricity Price Indexes – Challenges to Electricity Pricing – Construction of Forward Price Curves –Short-term Price Forecasting.

UNIT IV

Power system operation in a competitive environment: Introduction – Operational Planning Activities of ISO- the ISO in Pool Markets – The ISO in Bilateral Markets – Operational Planning Activities of a Genco, Congestion management.

UNIT V

Ancillary Services Management: Introduction – Reactive Power as an Ancillary Service – a review – Synchronous Generators as Ancillary Service Providers.

References

1. Kankar Bhattacharya, Math H.J. Bollen, Jaap E.Daalder, ‘Operation of Restructured Power System’ Kluwer Academic Publisher – 2001

2. Mohammad Shahidehpour, and Muwaffaq Alomoush, - “Restructured Electrical Power systems” Marcel Dekker, Inc. 2001

3. Loi Lei Lai; “Power system Restructuring and Deregulation”, John Wiley & Sons Ltd., England.