Year (Semester)	Course Title	Course Code	L-T-P-Credits
3rd Year	Renewable Power Generation		2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Pre-requisites: None. **Program Elective**

Course Outcomes: At the end of the course, the student will be able to:

CO No.	Course Outcome	Bloom's Taxonomy Level
CO1	Assess different energy resources; Understand energy, environment and need for renewables.	3
CO2	Understand, analyze and apply the concepts of wind energy, solar energy: solar thermal & solar PV technology.	5
CO3	Understand and analyze the principle of energy extraction from Ocean energy (Tidal, Wave, OTEC).	5
CO4	Understand energy conservation and future energy sources.	3

Detailed Syllabus:

Module No.	Contents	Hours
Module 1	Classification of Energy Resources, Need for Alternate Source of Energy, Energy problem, Energy & environment, Rural Energy.	**05**
Module 2	Solar Energy Basics - Solar radiation and its measurement – Solar collectors – Energy Balance Equation and Collector Efficiency – Solar Cell Principles – Conversion Efficiency and Power Output – Photovoltaic system and Solar-Thermal system for Power Generation – Solar Cell Modules - Solar Energy Storage - Applications of Solar Energy.	**12**
Module 3	Wind Energy: Basic Principles - Wind Energy Estimation – Conversion System - Basic Components - Collectors - Rotor Types – Wind Turbine Types - Blade Forces – Aerodynamic Force – Braking Systems – Tower - Control and Monitoring System – Performance of Wind Machines.	**10**
Module 4	Electric Power Generation from Tidal, Ocean Thermal, and Geothermal Energy. Simple power plant based on Tidal / OTEC / Geothermal.	**08**
Module 5	Energy conservation in the transport sector. Energy-efficient buildings. Energy audit. Concept of hybrid energy systems and explore new energy sources.	**07**

Text Books

1. B. H. Khan, "Non-Conventional Energy Resources", Tata McGraw-Hill, 2006.
2. John F. Walker & Jenkins. N, "Wind Energy Technology", John Wiley and Sons, 1997.

Reference

1. G.D. Rai, "Non-Conventional Energy Sources", First Edition, Khanna Publishers, Delhi, 1999.
2. Agarwal M.P., "Future Sources of Electrical Power", S. Chand Co. Ltd., New Delhi, 1999.
3. V. Overstraeton & Mertens R.P., "Physics, Technology and Use of Photovoltaics", Adam Hilger, Bristol, 1996.
4. J. Twidell and T. Weir, Renewable Energy Resources, Taylor and Francis Group
5. G.N. Tiwari, M.K. Ghosal, Renewable Energy Resources: Basic Principles and Application, Narosa Publishing House

Year (Semester)	Course Title	Course Code	L-T-P-Credits
3rd Year (5th Semester)	Digital Signal Processing	EET001	2-1-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Pre-requisites: Signals and Systems.

Course Outcomes: At the end of the course, the student will be able to:

CO No.	Course Outcome	Bloom's Taxonomy Level
CO1	Mathematically interpret and analyze discrete-time/digital signals and systems	4
CO2	Demonstrate the effect of sampling of continuous-time signals, and finite word length effects	5
CO3	Implement DSP systems and address practical implementation issues such as computational complexity, hardware imitations and of DSP systems	5
CO4	Analyze and design digital FIR and IIR Filters.	4

Detailed Syllabus:

Module No.	Contents	Hours
Module 1	**Discrete Time Signals & Systems:** Introduction to digital signal processing, Sequences & sequence operations, Discrete-time systems, Linear time-invariant systems, Impulse response, causality and stability, Linear constant-coefficient difference equations, Frequency-domain representation of discrete-time signals and systems, Discrete-time Fourier transform	**8**
Module 2	**Sampling of Continuous-Time Signals:** Periodic sampling, Frequency-domain representation of sampling, Reconstruction of signals, Discrete-time processing of continuous–time signals, Continuous–time processing of discrete-time signals, Changing the sampling rate using discrete-time processing, Multirate signal processing, Quantization errors	**9**
Module 3	**Transform Analysis of Linear Time-Invariant Systems:** Z-transform, Region of convergence, System function and Frequency response, All-pass systems, Minimum-phase systems, Linear-phase systems	**8**
Module 4	**Realization of Discrete-Time Systems:** Block diagram representation of linear constant-coefficient difference equations, Signal flow graph representation, Basic structures for IIR systems–Direct, Canonic, Cascade and Parallel Forms, Transposed forms, Basic network structures for FIR systems, Finite word-length effects: coefficient quantization, round-off noise, limit cycles	**9**
Module 5	**Filter Design Techniques:** Design of discrete-time IIR filters from continuous-time filters, Impulse invariance, Bilinear transformation, Butterworth, Chebyshev and Elliptic approximation, low-pass, high-pass, band-pass and band-stop filters, Design of FIR filters by Frequency-sampling technique, Fourier and Windowing methods, Kaiser, Hamming, Hanning windows	**9**

Books Recommended:

1. Discrete Time Signal Processing, A.V. Oppenheim and R. W. Schafer; Prentice Hall International
2. Digital Signal Processing Principles, Algorithms and Applications, John G. Proakis and D.G. Manolakis; Prentice Hall International
3. Introduction to Digital Signal Processing, J. R. Johnson; Prentice Hall
4. Theory and Application of Digital Signal Processing, L.R. Rabinder and B. Gold; Prentice Hall

Year (Semester)	Course Title	Course Code	L-T-P-Credits
3rd Year (5th Semester)	Fundamentals of SCADA	EET B2 902	3-0-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Pre-requisites: None.

Course Outcomes: At the end of the course, the student will be able to:

CO No.	Course Outcome	Bloom's Taxonomy Level
CO1	Understand and explain the architecture and components of SCADA systems.	3
CO2	Identify various SCADA communication protocols and techniques.	4
CO3	Analyse supervisory control functions and their implementation.	5
CO4	Apply SCADA concepts to real-world industrial applications.	4

Detailed Syllabus:

Module No.	Contents	Hours
Module 1	Introduction to SCADA: Advantages, General Structure, Architecture, Classification of SCADA systems.	**07**
Module 2	Components of SCADA Systems, Remote Terminal Unit (RTU), Communication Subsystem, Protocols, Logic Subsystem, Termination Subsystem, Test and Power Supply Subsystem, Master Station (MTU), Human Machine Interface, Data Concentrators, Intelligent Electronic Devices.	**10**
Module 3	Supervisory and Control Functions: Overview of the methods of data acquisition systems, commonly acquired data, status indications, measured values, energy values, monitoring alarm and event application processing, Functions of SCADA	**10**
Module 4	SCADA Communication and Protocols: SCADA Communication Requirements, SCADA Communication system topologies, Data Communication Techniques: Master Sleeve, Peer to Peer; Broadcast and Multicast.	**09**
Module 5	Energy Management System: Introduction to EMS, Architecture and working of EMS, Applications of SCADA to EMS	**06**

Books Recommended:

1. Stuart A. Boyer, SCADA- Supervisory Control and Data Acquisition, ISA
2. David Bailey and Edwin Wright, Practical SCADA for Industry, Elsevier.
3. Mini S. Thomas and John Douglas McDonald, "Power System SCADA and Smart Grids" CRC Press-2015.

Year (Semester)	Course Title	Course Code	L-T-P-Credits
3rd Year (5th Semester)	Energy Conversion Technologies	EET B1 901	3-0-0-3
Evaluation Policy	**Mid-Term**	**Internal Assessment**	**End-Term**
	26 Marks	24 Marks	50 Marks

Pre-requisites: None.

Course Outcomes: At the end of the course, the student will be able to:

CO No.	Course Outcome	Bloom's Taxonomy Level
CO1	Identify and classify various non-conventional energy resources and describe their significance in modern energy systems.	3
CO2	Understand the working and components of solar thermal systems. Analyse solar photovoltaic (PV) systems, their characteristics, MPPT and applications.	4
CO3	Understand wind energy systems, turbine types, performance characteristics.	5
CO4	Understand the role and components of other alternate sources. Evaluate energy storage methods and their importance in renewable energy applications.	4

Detailed Syllabus:

Module No.	Contents	Hours
Module 1	Classification of Energy Resources, Importance of Alternate Source of Energy, Present Status and Growth of Energy Sector, Various Aspects of Energy Conservation.	**06**
Module 2	Solar Energy Basics: Sun, Earth Radiation Spectrums, Measurements of Solar Radiation, Solar Radiation Data, Solar Geometry. Solar Thermal Systems: Classification. Solar Water Heater, Solar Refrigeration and air-conditioning systems, Solar Cookers, Solar Pond Electric power plant. Solar Photovoltaic (PV) systems: Construction and Working of Solar Cell, Characteristics, Equivalent Circuit, MPPT.	**12**
Module 3	Wind Energy: Origin of winds, nature of winds, wind turbine siting, major applications, estimation of wind energy, wind speed characteristics, Wind Turbines and their classification, Wind Generators, Wind Energy Conversion Systems.	**9**
Module 4	Other alternate sources of energy (Small Hydro resources, biomass, ocean energy, geothermal energy): Introduction, Classification, Essential Components and Principles.	**8**
Module 5	Emerging Technologies: Fuel Cell and Hydrogen Energy, Super-Capacitors, Superconducting Magnetic Energy Storage (SMES), Applications.	**7**

Books Recommended:

4. B.H. Khan, Non-Conventional Energy Sources, McGraw Hill
5. J. Twidell and T. Weir, Renewable Energy Resources, Taylor and Francis Group
6. G.N. Tiwari, M.K. Ghosal, Renewable Energy Resources: Basic Principles and Application, Narosa Publishing House
7. R.K. Singal, Non-Conventional Energy Resources, Dhanpat Rai

8. S. Rao, B.B. Pariekar, Energy Technology, Khanna Publications