Scheme & Syllabus of
UNDERGRADUATE DEGREE COURSE

B.Tech. VII & VIII Semester

Electrical Engineering

Rajasthan Technical University, Kota
Effective from session: 2020-21

Teaching & Examination Scheme
B. Tech.: Electrical Engineering
4th Year - VII Semester

SN	Course Type	Course		Hours per Week			Marks				Cr
		Code	Name	L	T	P	Exm Hrs	IA	ETE	Total	
1	PEC	7EE5-11	Wind and Solar Energy Systems.	3	0	0	3	30	120	**150**	**3**
2		7EE5-12	Power Quality and FACTS								
3		7EE5-13	Control System Design.								
4	OE		Open Elective-I	3	0	0	3	30	120	**150**	**3**
			SUB TOTAL	**6**	**0**	**0**		**60**	**240**	**300**	**6**
PRACTICAL & SESSIONAL											
5	PCC	7EE4-21	Embedded Systems Lab	0	0	4	2	60	40	**100**	**2**
6	PCC	7EE4-22	Advance control system lab	0	0	4	2	60	40	**100**	**2**
7	PSIT	7EE7-30	Industrial Training	1	0	0		75	50	**125**	**2.5**
8		7EE7-40	Seminar	2	0	0		60	40	**100**	**2**
9	SODE-CA	7EE8-00	Social Outreach, Discipline & Extra Curricular Activities	0	0	0		0	25	**25**	**0.5**
			SUB TOTAL	**3**	**0**	**8**		**255**	**195**	**450**	**6**
			TOTAL OF VII SEMESTER	**9**	**0**	**8**		**315**	**435**	**750**	**15**

L: *Lecture,* ***T:*** *Tutorial,* ***P:*** *Practical,* ***Cr:*** *Credits*
ETE: *End Term Exam,* ***IA:*** *Internal Assessment*

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Teaching & Examination Scheme
B. Tech. : Electrical Engineering
4th Year - VIII Semester

THEORY											
SN	**Course Type**	**Course**		**Hours per Week**			**Marks**				**Cr**
		Course Code	**Course Name**	**L**	**T**	**P**	**Exm Hrs**	**IA**	**ETE**	**Total**	
1		8EE4-11	HVDC Transmission System.								
2	PEC	8EE4-12	Line Commutated and active rectifiers.	3	0	0	3	30	120	**150**	**3**
3		8EE4-13	Advanced Electric Drives.								
4	OE		Open Elective-II	3	0	0	3	30	120	**150**	**3**
				6	**0**	**0**		**60**	**240**	**300**	**6**
PRACTICAL & SESSIONAL											
			SUB TOTAL	**6**	**0**	**0**		**60**	**240**	**300**	**6**
5	PCC	8EE4-21	Energy Systems Lab	0	0	4	3	60	40	**100**	**2**
6	PSIT	8EE7-50	Project	3	0	0		210	140	**350**	**7**
7	SODE-CA	8EE8-00	SODECA	0	0	0			25	**25**	**0.5**
			SUB TOTAL	**3**	**0**	**4**		**270**	**205**	**475**	**9.5**
			TOTAL OF VIII SEMESTER	**9**	**0**	**4**		**330**	**445**	**775**	**15.5**

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ETE: *End Term Exam,* ***IA:*** *Internal Assessment*

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List of Open Electives for Electrical Engineering

Subject Code	Title	Subject Code	Title
Open Elective - I		**Open Elective - II**	
7AG6-60.1	Human Engineering and Safety	8AG6-60.1	Energy Management
7AG6-60.2	Environmental Engineering and Disaster Management	8AG6-60.2	Waste and By-product Utilization
7AN6-60.1	Aircraft Avionic System	8AN6-60.1	Finite Element Methods
7AN6-60.2	Non-Destructive Testing	8AN6-60.2	Factor of Human Interactions
7CH6-60.1	Optimization Techniques	8CH6-60.1	Refinery Engineering Design
7CH6-60.2	Sustainable Engineering	8CH6-60.2	Fertilizer Technology
7CR6-60.1	Introduction to Ceramic Science & Technology	8CR6-60.1	Electrical and Electronic Ceramics
7CR6-60.2	Plant, Equipment and Furnace Design	8CR6-60.2	Biomaterials
7CE6-60.1	Environmental Impact Analysis	8CE6-60.1	Composite Materials
7CE6-60.2	Disaster Management	8CE6-60.2	Fire and Safety Engineering
7CS6-60.1	Quality Management/ISO 9000	8CS6-60.1	Big Data Analytics
7CS6-60.2	Cyber Security	8CS6-60.2	IPR, Copyright and Cyber Law of India
7EC6-60.1	Principle of Electronic communication	8EC6-60.1	Industrial and Biomedical applications of RF Energy
7EC6-60.2	Micro and Smart System Technology	8EC6-60.2	Robotics and control
7ME6-60.1	Finite Element Analysis	8ME6-60.1	Operations Research
7ME6-60.2	Quality Management	8ME6-60.2	Simulation Modeling and Analysis
7MI6-60.1	Rock Engineering	8MI6-60.1	Experimental Stress Analysis
7MI6-60.2	Mineral Processing	8MI6-60.2	Maintenance Management
7PE6-60.1	Pipeline Engineering	8PE6-60.1	Unconventional Hydrocarbon Resources
7PE6-60.2	Water Pollution control Engineering	8PE6-60.2	Energy Management & Policy
7TT6-60.1	Technical Textiles	8TT6-60.1	Material and Human Resource Management
7TT6-60.2	Garment Manufacturing Technology	8TT6-60.2	Disaster Management

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7EE5-11: WIND AND SOLAR ENERGY SYSTEM

Credit: 3 **Max. Marks: 150(IA:30, ETE:120)**
3L+0T+0P **End Term Exam: 3 Hours**

SN	CONTENTS	Hours
1	**Introduction:** Objective, scope and outcome of the course.	1
2	**Physics of Wind Power** History of wind power, Indian and Global statistics, Wind physics, Betz limit, Tip speed ratio, stall and pitch control, Wind speed statistics-probability distributions, Wind speed and power-cumulative distribution functions.	5
3	**Wind Generator Topologies** Review of modern wind turbine technologies, Fixed and Variable speed wind turbines, Induction Generators, Doubly-Fed Induction Generators and their characteristics, Permanent Magnet Synchronous Generators, Power electronics converters. Generator-Converter configurations, Converter Control.	11
4	**The Solar Resource** Introduction, solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability.	4
5	**Solar Photovoltaic** Technologies-Amorphous, monocrystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, Power Electronic Converters for Solar Systems, Maximum Power Point Tracking (MPPT) algorithms. Converter Control.	8
6	**Network Integration Issues** Overview of grid code technical requirements. Fault ride-through for wind farms - real and reactive power regulation, voltage and frequency operating limits, solar PV and wind farm behavior during grid disturbances. Power quality issues. Power system interconnection experiences in the world. Hybrid and isolated operations of solar PV and wind systems.	8
7	**Solar Thermal Power Generation** Technologies, Parabolic trough, central receivers, parabolic dish, Fresnel, solar pond, elementary analysis.	4
	TOTAL	

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Text/Reference Books	
1	T. Ackermann, "Wind Power in Power Systems", John Wiley and Sons Ltd., 2005.
2	G. M. Masters, "Renewable and Efficient Electric Power Systems", John Wiley and Sons, 2004.
3	S. P. Sukhatme, "Solar Energy: Principles of Thermal Collection and Storage", McGraw Hill, 1984.
4	H. Siegfried and R. Waddington, "Grid integration of wind energy conversion systems" John Wiley and Sons Ltd., 2006.
5	G. N. Tiwari and M. K. Ghosal, "Renewable Energy Applications", Narosa Publications, 2004.
6	J. A. Duffie and W. A. Beckman, "Solar Engineering of Thermal Processes", John Wiley & Sons, 1991

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7EE4-12: POWER QUALITY AND FACTS

Credit: 3 **Max. Marks: 150(IA:30, ETE:120)**
3L+0T+0P **End Term Exam: 3 Hours**

SN	CONTENTS	Hours
1	**Introduction:** Objective, scope and outcome of the course.	01
2	**Transmission Lines and Series/Shunt Reactive Power Compensation** Basics of AC Transmission. Analysis of uncompensated AC transmission lines. Passive Reactive Power Compensation. Shunt and series compensation at the mid-point of an AC line. Comparison of Series and Shunt Compensation	04
3	**Thyristor-based Flexible AC Transmission Controllers (FACTS)** Description and Characteristics of Thyristor-based FACTS devices: Static VAR Compensator (SVC), Thyristor Controlled Series Capacitor (TCSC), Thyristor Controlled Braking Resistor and Single Pole Single Throw (SPST) Switch. Configurations/Modes of Operation, Harmonics and control of SVC and TCSC. Fault Current Limiter.	06
4	**Voltage Source Converter based (FACTS) controllers** Voltage Source Converters (VSC): Six Pulse VSC, Multi-pulse and Multi-level Converters, Pulse-Width Modulation for VSCs. Selective Harmonic Elimination, Sinusoidal PWM and Space Vector Modulation. STATCOM: Principle of Operation, Reactive Power Control: Type I and Type II controllers, Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC): Principle of Operation and Control. Working principle of Interphase Power Flow Controller. Other Devices: GTO Controlled Series Compensator. Fault Current Limiter	08
5	**Application of FACTS** Application of FACTS devices for power-flow control and stability improvement. Simulation example of power swing damping in a single-machine infinite bus system using a TCSC. Simulation example of voltage regulation of transmission mid-point voltage using a STATCOM.	04
6	**Power Quality Problems in Distribution Systems** Power Quality problems in distribution systems: Transient and Steady state variations in voltage and frequency. Unbalance, Sags, Swells, Interruptions, Waveform Distortions: harmonics, noise, notching, dc-offsets, fluctuations. Flicker and its measurement. Tolerance of Equipment: CBEMA curve..	04
7	**DSTATCOM** Reactive Power Compensation, Harmonics and Unbalance mitigation	07

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	in Distribution Systems using DSTATCOM and Shunt Active Filters. Synchronous Reference Frame Extraction of Reference Currents. Current Control Techniques in for DSTATCOM.	
8	**Dynamic Voltage Restorer and Unified Power Quality Conditioner** Voltage Sag/Swell mitigation: Dynamic Voltage Restorer – Working Principle and Control Strategies. Series Active Filtering. Unified Power Quality Conditioner (UPQC): Working Principle. Capabilities and Control Strategies.	**06**
	TOTAL	

Text/Reference Books	
1	N. G. Hingorani and L. Gyugyi, "Understanding FACTS: Concepts and Technology of FACTS Systems", Wiley-IEEE Press, 1999.
2	K. R. Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International (P) Ltd. 2007.
3	T. J. E. Miller, "Reactive Power Control in Electric Systems", John Wiley and Sons, New York, 1983.
4	R. C. Dugan, "Electrical Power Systems Quality", McGraw Hill Education, 2012.
5	G. T. Heydt, "Electric Power Quality", Stars in a Circle Publications, 1991

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7EE5-13: CONTROL SYSTEM DESIGN

Credit: 3 **Max. Marks: 150(IA:30, ETE:120)**
3L+0T+0P **End Term Exam: 3 Hours**

SN	CONTENTS	Hours
1	**Introduction :** Objective, scope and outcome of the course.	1
2	**Design Specifications** Introduction to design problem and philosophy. Introduction to time domain and frequency domain design specification and its physical relevance. Effect of gain on transient and steady state response. Effect of addition of pole on system performance. Effect of addition of zero on system response..	08
3	**Design of Classical Control System in the time domain** Introduction to compensator. Design of Lag, lead lag-lead compensator in time domain. Feedback and Feed forward compensator design. Feedback compensation. Realization of compensators.	07
4	**Design of Classical Control System in frequency domain** Compensator design in frequency domain to improve steady state and transient response. Feedback and Feed forward compensator design using bode diagram.	08
5	**Design of PID controllers** Design of P, PI, PD and PID controllers in time domain and frequency domain for first, second and third order systems. Control loop with auxiliary feedback – Feed forward control	06
6	**Control System Design in state space** Review of state space representation. Concept of controllability & observability, effect of pole zero cancellation on the controllability & observability of the system, pole placement design through state feedback. Ackerman's Formula for feedback gain design. Design of Observer. Reduced order observer. Separation Principle.	08
7	**Nonlinearities and its effect on system performance** Various types of non-linearities. Effect of various non-linearities on system performance. Singular points. Phase plot analysis	03
	TOTAL	

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Text/Reference Books	
1	N. Nise, "Control system Engineering", John Wiley, 2000.
2	I. J. Nagrath and M. Gopal, "Control system engineering", Wiley, 2000.
3	M. Gopal, "Digital Control Engineering", Wiley Eastern, 1988.
4	K. Ogata, "Modern Control Engineering", Prentice Hall, 2010.
5	B. C. Kuo, "Automatic Control system", Prentice Hall, 1995.
6	J. J. D'Azzo and C. H. Houpis, "Linear control system analysis and design (conventional and modern)", McGraw Hill, 1995.
7	R. T. Stefani and G. H. Hostetter, "Design of feedback Control Systems", Saunders College Pub, 1994

7EE4-21: EMBEDDED SYSTEM LAB

Credit: 2 **Max. Marks: 100(IA:60, ETE:40)**
0L+0T+4P

SN	Contents
1	Introduction to Embedded Systems and their working.
2	Data transfer instructions using different addressing modes and block transfer.
3	Write a program for Arithmetic operations in binary and BCD-addition, subtraction, multiplication and division and display.
4	Interfacing D/A converter & Write a program for generation of simple waveforms such as triangular, ramp, Square etc.
5	Write a program to interfacing IR sensor to realize obstacle detector.
6	Write a program to implement temperature measurement and displaying the same on an LCD display.
7	Write a program for interfacing GAS sensor and perform GAS leakage detection.
8	Write a program to design the Traffic Light System and implement the same using suitable hardware.
9	Write a program for interfacing finger print sensor.
10	Write a program for Master Slave Communication between using suitable hardware and using SPI
11	Write a program for variable frequency square wave generation using with suitable hardware.
12	Write a program to implement a PWM based speed controller for 12 V/24V DC Motor incorporating a suitable potentiometer to provide the set point.

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7EE4-22: Advanced Control System Lab

Credit: 2 **Max. Marks: 100(IA:60, ETE:40)**
0L+0T+4P

SN	Contents
1	Determination of transfer functions of DC servomotor and AC servomotor.
2	Time domain response of rotary servo and Linear servo (first order and second order) systems using MATLAB/Simulink.
3	Simulate Speed and position control of DC Motor
4	Frequency response of small-motion, linearized model of industrial robot (first and second order) system using MATLAB.
5	Characteristics of PID controllers using MATLAB. Design and implementation of P, PI and PID Controllers for temperature and level control systems;
6	Design and implement closed loop control of DC Motor using MATLAB/Simulink and suitable hardware platform.
7	Implementation of digital controller using microcontroller;
8	Design and implementation of controller for practical systems - inverted pendulum system.
9	To design and implement control action for maintaining a pendulum in the upright position (even when subjected to external disturbances) through LQR technique in an Arduino Mega.
10	The fourth order, nonlinear and unstable real-time control system (Pendulum & Cart Control System)
11	Mini project on real life motion control system

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8EE4-11: HVDC TRANSMISSION SYSTEM

Credit: 3 **Max. Marks: 150(IA:30, ETE:120)**
3L+0T+0P **End Term Exam: 3 Hours**

SN	CONTENTS	Hours
1	**Introduction:** Objective, scope and outcome of the course.	**01**
2	**dc Transmission Technology:** Comparison of AC and dc Transmission (Economics, Technical Performance and Reliability). Application of DC Transmission. Types of HVdc Systems. Components of a HVdc system. Line Commutated Converter and Voltage Source Converter based systems.	**04**
3	**Analysis of Line Commutated and Voltage Source Converters:** Line Commutated Converters (LCCs): Six pulse converter, Analysis neglecting commutation overlap, harmonics, Twelve Pulse Converters. Inverter Operation. Effect of Commutation Overlap. Expressions for average dc voltage, AC current and reactive power absorbed by the converters. Effect of Commutation Failure, Misfire and Current Extinction in LCC links. Voltage Source Converters (VSCs): Two and Three-level VSCs. PWM schemes: Selective Harmonic Elimination, Sinusoidal Pulse Width Modulation. Analysis of a six pulse converter. Equations in the rotating frame. Real and Reactive power control using a VSC.	**10**
4	**Control of HVdc Converters:** Principles of Link Control in a LCCHVdc system. Control Hierarchy, Firing Angle Controls – Phase-Locked Loop, Current and Extinction Angle Control, Starting and Stopping of a Link. Higher level Controllers Power control, Frequency Control, Stability Controllers. Reactive Power Control. Principles of Link Control in a VSC HVdc system: Power flow and dc Voltage Control. Reactive Power Control/AC voltage regulation	**10**
5	**Components of HVdc systems:** Smoothing Reactors, Reactive Power Sources and Filters in LCC HVdc systems DC line: Corona Effects. Insulators, Transient Over-voltages. dc line faults in LCC systems. dc line faults in VSC systems. dc breakers. Monopolar Operation. Ground Electrodes	**08**
6	**Stability Enhancement using HVdc Control:** Basic Concepts: Power System Angular, Voltage and Frequency Stability. Power Modulation: basic principles – synchronous and asynchronous links. Voltage Stability Problem in AC/dc systems.	**04**
7	**MTdc Links:** Multi-Terminal and Multi-Infeed Systems. Series and Parallel MTdc systems using LCCs. MTdc systems using VSCs. Modern Trends in HVdcTechnology. Introduction to Modular Multi-level Converters	**04**
	TOTAL	

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Text/Reference Books	
1	K. R. Padiyar, "HVDC Power Transmission Systems", New Age International Publishers, 2011.
2	J. Arrillaga, "High Voltage Direct Current Transmission", Peter Peregrinus Ltd., 1983.
3	E. W. Kimbark, "Direct Current Transmission", Vol.1, Wiley-Interscience, 1971.

8EE4-12: Line-Commutated and Active PWM Rectifiers

Credit: 3 | **Max. Marks: 150(IA:30, ETE:120)**
3L+0T+0P | **End Term Exam: 3 Hours**

SN	CONTENTS	Hours
1	**Introduction:** Objective, scope and outcome of the course.	01
2	**Diode rectifiers with passive filtering** Half-wave diode rectifier with RL and RC loads; 1-phase full-wave diode rectifier with L, C and LC filter; 3-phase diode rectifier with L, C and LC filter; continuous and discontinuous conduction, input current waveshape, effect of source inductance; commutation overlap.	06
3	**Thyristor rectifiers with passive filtering** Half-wave thyristor rectifier with RL and RC loads; 1-phase thyristor rectifier with L and LC filter; 3-phase thyristor rectifier with L and LC filter; continuous and discontinuous conduction, input current waveshape.	06
4	**Multi-Pulse converter** Review of transformer phase shifting, generation of 6-phase ac voltage from 3-phase ac, 6- pulse converter and 12-pulse converters with inductive loads, steady state analysis, commutation overlap, notches during commutation.	06
5	**Single-phase ac-dc single-switch boost converter** Review of dc-dc boost converter, power circuit of single-switch ac-dc converter, steady state analysis, unity power factor operation, closed-loop control structure.	06
6	**Ac-dc bidirectional boost converter** Review of 1-phase inverter and 3-phase inverter, power circuits of 1-phase and 3-phase ac-dc boost converter, steady state analysis, operation at leading, lagging and unity power factors. Rectification and regenerating modes. Phasor diagrams, closed-loop control structure.	06
7	Isolated single-phase ac-dc flyback converter Dc-dc flyback converter, output voltage as a function of duty ratio and transformer turns ratio. Power circuit of ac-dc flyback converter, steady state analysis, unity power factor operation, closed loop control structure.	10
	TOTAL	

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Text/Reference Books	
1	G. De, "Principles of Thyristorised Converters", Oxford & IBH Publishing Co, 1988.
2	J.G. Kassakian, M. F. Schlecht and G. C. Verghese, "Principles of Power Electronics", AddisonWesley, 1991.
3	L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, 2009.
4	N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.
5	R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science & Business Media, 2001.

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8EE4-13: ADVANCED ELECTRIC DRIVES

Credit: 2 **Max. Marks: 100(IA:20, ETE:80)**
2L+0T+0P **End Term Exam: 2 Hours**

SN	CONTENTS	Hours
1	**Introduction:** Objective, scope and outcome of the course.	01
2	**Power Converters for AC drives:** PWM control of inverter, selected harmonic elimination, space vector modulation, current control of VSI, three level inverter, Different topologies, SVM for 3 level inverter, Diode rectifier with boost chopper, PWM converter as line side rectifier, current fed inverters with self-commutated devices. Control of CSI, H bridge as a 4-Q drive.	06
3	**Induction motor drives:** Different transformations and reference frame theory, modeling of induction machines, voltage fed inverter control-v/f control, vector control, direct torque and flux control(DTC).	06
4	**Synchronous motor drives:** Modeling of synchronous machines, open loop v/f control, vector control, direct torque control, CSI fed synchronous motor drives.	04
5	**Permanent magnet motor drives:** Introduction to various PM motors, BLDC and PMSM drive configuration, comparison, block diagrams, Speed and torque control in BLDC and PMSM	04
6	**Switched reluctance motor drives:** Evolution of switched reluctance motors, various topologies for SRM drives, comparison. Closed loop speed and torque control of SRM.	03
7	**DSP based motion control:** Use of DSPs in motion control, various DSPs available, realization of some basic blocks in DSP for implementation of DSP based motion control	04
	TOTAL	

Text/Reference Books	
1	B. K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education, Asia, 2003.
2	P. C. Krause, O. Wasynczuk and S. D. Sudhoff, “Analysis of Electric Machinery and Drive Systems”, John Wiley & Sons, 2013.
3	H. A. Taliyat and S. G. Campbell, “DSP based Electromechanical Motion Control”, CRC press, 2003.
4	R. Krishnan, “Permanent Magnet Synchronous and Brushless DC motor Drives”, CRC Press, 2009.

8EE4-21 Energy Systems Lab

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Credit: 2 **Max. Marks: 100(IA:60, ETE:40)**
0L+0T+3P **End Term Exam: 3 Hours**

SN	Contents
1	V-I characteristics of solar panels at various levels of insolation.
2	Experiment of solar Charge controller, PWM, MPPT with boost converter and algorithms.
3	Experiment on Shadowing effect and diode based solution in1kWpSolar PV System.
4	Study of wind turbine generators with DC generators, DFIG, PMSG etc.
5	Performance Study of Solar Flat Plate Thermal Collector Operation with Variation in Mass Flow Rate and Level of Radiation.
6	Characterization of Various PV Modules Using large area Sun Simulator.
7	Study of micro-hydel pumped storage system.
8	Experiment on Fuel Cell and its operation.
9	Study of 100 kW or higher solar PV plant.
10	Study different components of Micro Grid.
11	To design and simulate hybrid wind-solar power generation system using simulation software.
12	Experiment on Performance Assessment of Hybrid (Solar-Wind- Battery) Power System.
13	Simulation study on Intelligent Controllers for on-grid and off-grid Hybrid Power Systems.

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