M.TECH. – POWER AND ENERGY (SMARTGRIDS AND ELECTRIC VEHICLES)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

The restructuring and deregulation of electric utilities together with recent progress in Smart grid and Renewable Energy Technologies introduce unprecedented challenges and wide scope for power and energy systems research and open up new opportunities to young Power Engineers. The advancement in Power & Energy with the vision of redefining the Conventional Power System as an Intelligent Power Grid with a blend of the latest technologies like Smart Sensing, Cyber Physical System and ICT coupled with Renewable Energy Sources, Electric Vehicle, and Energy Storage etc. will be the key factors to a sustainable world for future generations.

M. Tech. program in Power and Energy is intended to explore the above mentioned challenges and also to initiate intense research activities. The structure of lab oriented courses will enable the students to have an insight into the real time scenarios and can build a thorough understanding of the systems as a whole. The Power and Energy courses emphasize on various streams like Smartgrids, Electric Vehicles, Power System, Sustainable and Renewable Energy, Computational and Communication Technology Applications, Power Electronics and Control, and Embedded Systems. This program aims to make students employable in various sectors of Power & Energy, Communication, Smartgrid, Electric Transport, Petroleum Industry, Energy Management and Conservations etc. and to impart interest in carrying out high end research activities in these areas.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Type</th>
<th>Course</th>
<th>L-T-P</th>
<th>Credit</th>
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<tbody>
<tr>
<td>19MA604</td>
<td>FC</td>
<td>Software Based Numerical Computation Methods</td>
<td>2-0-2</td>
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<tr>
<td>19PR611</td>
<td>SC</td>
<td>Power System Planning, Operation and Control</td>
<td>3-0-2</td>
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<td>19PR612</td>
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<td>19PR601</td>
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<td>Smartgrid</td>
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* Non-credit course

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<td>19PR616</td>
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Total Credits: 66

LIST OF COURSES

Foundation Core (FC)
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**Subject Core (SC)**

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**ELECTIVES -I**
(Subjects include areas from Power System, Sustainable and Renewable Energy, Computational and Communication Technology, Power Electronics, Control and Smartgrid)

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<td>19PR702</td>
<td>ICT enabled Power System Protection</td>
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<td>19PR703</td>
<td>Advanced Digital Signal Controllers and Applications</td>
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<td>19PR704</td>
<td>Machine learning and Multi Agent Systems for Power Engineering</td>
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<td>19PR705</td>
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<td>19PR706</td>
<td>Cyber Physical Systems</td>
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<td>19PR707</td>
<td>Energy Conservation and Management</td>
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<td>19PR708</td>
<td>Solar Energy Utilisation</td>
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<td>Wind Energy Conversion Systems</td>
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<td>19PR710</td>
<td>Power Plant Instrumentation</td>
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<td>19PR711</td>
<td>Computational Intelligence for Power Applications</td>
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<tr>
<td>19PR712</td>
<td>Bio- Energy Conversion</td>
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ELECTIVES -II
(Subjects include areas from Automotive applications and Electric Vehicles)

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<td>19PR722</td>
<td>System Engineering and Integration</td>
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<tr>
<td>19PR723</td>
<td>Electric Drives And Control</td>
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<td>19PR724</td>
<td>Control System Design</td>
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<td>19PR725</td>
<td>E-mobility Business and policies</td>
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<td>19PR726</td>
<td>Automotive Electronics</td>
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<td>19PR727</td>
<td>Automotive Control System</td>
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<td>19PR728</td>
<td>Vehicle Dynamics and Control</td>
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*Any of the elective subjects offered in any semester in any department may also be permitted with the concurrence of the department.

Project Work

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<tr>
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<tr>
<td>19PR799</td>
<td>Dissertation II</td>
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</table>

TEXT BOOKS/ REFERENCES:

5. R. Erickson, D. Maksimovic, Fundamentals of Power Electronics, Springer 2001
8. Selected transactions on Electric vehicles and Smartgrids

4. PICmicro™ PIC16F87XA Data Sheet 28/40/44-Pin Enhanced Flash
5. . Microcontrollers, 2003 Microchip Technology Inc., DS39582B.

19PR603 POWER QUALITY AND FACTS 2-0-2-3


TEXTBOOKS/ REFERENCES:


19MA604 SOFTWARE BASED NUMERICAL COMPUTATION METHODS

2-0-2-3

TEXT BOOKS/ REFERENCES:


19PR611 POWER SYSTEM PLANNING, OPERATION AND CONTROL

3-0-2-4
TEXT BOOKS/REFERENCES:


19PR612 SUSTAINABLE AND RENEWABLE ENERGY TECHNOLOGY

2-0-2-3

TEXT BOOKS/ REFERENCES:


19PR613 SMART GRID 3-0-0-3

Smart Grids: Smart grid landscape and its characteristics; smart grid architecture; Smart grid scenario in Indian power sector; Smart grid technologies: Information and Communication Technology: Smart sensors, Wired and wireless communication Technology, Network Structures (HAN, LAN, NAN, WAN); Smart sensors, Smart Metering and advanced metering infrastructure (AMI) ; Monitoring smart grid: Intelligent Electronic Devices (IED), wide-area monitoring system (WAMS), SCADA, Phasor Measurement Units, Geographical Information System; Penetration of Clean Energy Technologies; Storage Technology, Geomagnetic Storms as Generators, Near space power generation, Electric Vehicle Technology; Power electronics and power quality in Smart grid; Block chain Technology in Smart grid; Multi-agent technology in Smart grid; Superconducting Technologies- Superconducting power cables, Wireless Power Transmission technology; Smart grid operation & control, self-healing, Resilience, E-Commerce of Electricity, Case study on substation automation; Micro grid: Integration of distributed energy sources, operation, control and protection of Micro grid, Overview of generation, transmission and distribution automation. IoT in Smart Grid: IoT Architecture and its application; Introduction to cloud computing and edge computing application in smart grid, Standards for Information Exchange - Data Security methods; Embedded web servers, Energy Data Analytics in the Smart Grid-Sources, Characteristics, Need, Tools, and Challenges; Artificial Intelligence, Machine Learning and M2M applications in Smart grid applications.

Case study/Simulation/Hardware experiments.

19PR614 ELECTRIC VEHICLE TECHNOLOGY

Case study/Simulation/Hardware experiments

TEXT BOOKS/ REFERENCES:

19PR615 RESTRUCTURED POWER SYSTEM OPTIMISATION

Review of power system operation in restructured scenario, marginal cost of generation, least-cost operation, and incremental cost of generation. Introduction to Power System Optimization: classical and evolutionary approaches of optimization, Formulation of optimal power flow

TEXT BOOKS / REFERENCES:


19PR616 INTELLIGENCE & COMMUNICATION IN SMARTGRID2-0-2-3

Need of intelligence and communication in Smart Grid, Case Study on Postmortem Analysis of Blackouts Drivers Toward the Smart Grid; NETWORK layered ARCHITECTURE, Protocols and standards for information exchange- Advanced Metering Infrastructure Protocols aiding AMI IEEE 802.15.4, 6LoWPAN, ROLL, and RPL, IEEE 802.11 255, Modbus, DNP3, IEC 61850, Ethernet, Power line carrier communication, CAN Bus, I2C, LIN Bus protocol, Modbus protocol structure; Profibus protocol stack, Profibus communication model, Bluetooth, ZigBee, IEEE 801.11-a,b,g,n, Z-Wave, Cellular networks, WiMAX. Techniques for sensing: Phasor measurement units, Compressive sensing, Decentralized and cooperative sensing; Techniques for sensor communications: Machine-to-machine communications, Cooperative communications, Cognitive radio (CR); Medium access control, routing, and transport protocols for sensor data communications; Networked control systems- Time driven, Event driven feedback schemes. Substation Automation Architecture; Data Analytics: Big Data Collection, sampling and preprocessing; Smart Grid Data Analytics : Event Analytics, State Analytics, Customer Analytics, data analytics platform and Operational Analytics ; Big Data Architecture and Platforms ; Application of Big Data in Smart Grids - Intelligent Sensing : missing sensor restoration (MSR) , Monitoring and Identification : PMU for system Identification and state estimation, Power System Operation Support : Forecasting - time series analysis, regression analysis and other statistical methods; ANN short-term load forecaster, Physics-based numerical weather prediction (NWP) , Scheduling : deterministic optimization methods , Security

Case study/Simulation/Hardware experiments

TEXT BOOK/REFERENCES:

5. Bart Baesens"Analytics in a Big data world” Wiley Publications, 2004

19PR617 VEHICULAR NETWORKS AND COMMUNICATIONS  2-0-2-3


Lab Experiments Based On Various Vehicular Communication/Network Protocols/Standards

TEXT BOOKS/REFERENCES:


19PR618APPLICATION DEVELOPMENT LAB  1-0-2-2

The student in consultation with the faculty advisor has to select a topic related to Power and
Energy area, write a paper and present it. Lab training sessions in commonly used ICs and kits (Microcontrollers, FPGA kits etc) to prepare students for project phase

19RM600 RESEARCH METHODOLOGY 2-0-0-2

Unit I:

Unit II:
Problem Formulation, Understanding Modeling & Simulation, Conducting Literature Review, Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval, Tools for identifying literatures, Indexing and abstracting services, Citation indexes

Unit III:
Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Field Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results

Unit IV:
Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents

Unit V:

TEXT BOOKS/REFERENCES:

19PR701 ENERGY STORAGE TECHNOLOGY 3-0-0-3

Introduction to energy storage for power systems: Need and role of energy storage systems in power system, General considerations, Energy and power balance in a storage unit, Mathematical model of storage, Econometric model of storage.

Overview on Energy storage technologies: Potential energy (Pumped hydro, Compressed Air) - Kinetic energy (Mechanical- Flywheel) - Thermal energy without phase change passive (adobe) and active (water) - Thermal energy with phase change (ice, molten salts, steam) - Chemical energy (hydrogen, methane) - Electrochemical energy (Batteries, Fuel cells) - Electrostatic
energy (Super Capacitors), Electromagnetic energy (Super conducting Magnetic Energy Storage) - Different Types of Energy Storage Systems comparative analysis, Comparison of environmental impacts for different technologies.

Energy storage Applications: Renewable energy generation - Solar energy, Wind Energy, pumped hydro energy, fuel cells, battery Storage - types, charging methodologies, SoC, SoH estimation techniques, Hydrogen production methods and storage.

Smart Grid, Smart Microgrid, Smart House,
Mobile storage system: Electric vehicles - G2V, V2G, Management and control hierarchy of storage systems - Aggregating EES systems and distributed generation (Virtual Power Plant Energy Management with storage systems, Battery SCADA, Hybrid Energy storage systems: configurations and applications

Laboratory experiments: Simulation of energy storage systems and its management, smart park, Electric Vehicle charging facility, HESS in microgrid and smart grid, microbial fuel cell, hydrogen fuel cell and so on.

TEXT BOOKS/ REFERENCES:


19PR702ICT ENABLED POWER SYSTEM PROTECTION3-0-0-3

TEXT BOOKS/ REFERENCES:

5. IEEE standards, Transaction papers on power system protection.

19PR703 ADVANCED DIGITAL SIGNAL CONTROLLERS AND APPLICATIONS 3-0-0-3

Pre-requisite: General background of microprocessors and microcontrollers.

Overview of Digital signal controllers: C2000 modules, Piccolo based controllers, Delfino based controllers, MAC units, hardware divide support, floating point signal processing support. dsPIC30F series DSC-CPU, data memory, program Memory, instruction set. Programming using XC16 compiler and C-Interrupt Structure. Peripherals of dsPIC30F: I/O Ports, timers, input capture, output compare, motor control PWM, 10 bit A/D converter, UART. Applications using dsPIC30F: Generating SPWM, generating PWM’s for power converters, PID based control loops, signal processing based on FIR and IIR filter structures, developing single and multi-point communications with dsPIC and other IC’s. Lab Practice: FIR/IIR Filters, FFT, PID control loops and communication systems using dsPIC30F2010.

TEXT BOOKS/ REFERENCES:

1. dsPIC30F Family Reference manual, Microchip, 2008

19PR704 MACHINE LEARNING AND MULTIAGENT SYSTEMS FOR POWER ENGINEERING 3-0-0-3

Machine Learning: Linear Regression and Feature Selection, Analysis of variance for regression, Linear Classification, Support Vector Machines and Artificial Neural Networks, Bayesian Learning and Decision Trees, Evaluation Measures, Hypothesis Testing, Ensemble Methods, Clustering, Graphical Models, Learning Theory and Expectation Maximization. Introduction to Reinforcement Learning. Introduction to Multi Agent Systems: Intelligent Agents, design of intelligent agents, reasoning agents (eg. AgentO), agents as reative systems (eg. subsumption architecture), hybrid agents (eg. PRS), layered agents (eg. InteRRaP) a contemporary (Java-based) framework for programming agents (eg JADE Java

TEXT BOOKS/ REFERENCES:


19PR705MATHEMATICAL MODELLING OF ENERGY SYSTEMS 3-0-0-3


TEXT BOOKS/ REFERENCES:


19PR706CYBER PHYSICAL SYSTEMS 3-0-0-3

Cyber-Physical Systems (CPS) in the real world, Basic principles of design and validation of

TEXT BOOKS/ REFERENCES:


19PR707 ENERGY CONSERVATION AND MANAGEMENT 3-0-0-3

TEXT BOOKS/REFERENCES:

19PR708SOLAR ENERGY UTILISATION 3-0-0-3


TEXT BOOKS/REFERENCES:

19PR709WIND ENERGY CONVERSION SYSTEMS 3-0-0-3

History of wind turbine development and trends. Review on wind resource assessment: windregime modelling, measurement instruments, Weibull parameters, height dependency, wind resources worldwide and in India, wind energy forecast. Wind turbine: Review on basic aerodynamics, air foils, types and characteristics of wind turbine, turbine design, blade element theory, Betz limit, wake analysis, wind turbine rotor design considerations, number of blades, blade profile, 2/3 blades and teetering, coning, power regulation, wind turbine loads, aerodynamic loads in steady operation, wind turbulence, and tower shadow, wind turbine components, braking, yaw system, tower, others. WTGS: Fixed speed and

TEXT BOOKS/ REFERENCES:
5. Nuclear power plant instrumentation and control, A guidebook, International atomic energy agency Vienna, 1984(online resource).

19PR711  COMPUTATIONAL INTELLIGENCE FOR POWER APPLICATIONS 3-0-0-3


TEXT BOOKS/ REFERENCES:

19PR712  BIO-ENERGY CONVERSION 3-0-0-3

Bio-energy: Renewability and sustainability of biomass, origin of bio-mass (Photosynthetic process) sources, characteristics, Energy farming, biofuel production process,
biomass conversion methods, pyrolysis, gasification, types of biomass gasification, biogas systems and classifications. Anaerobic digestion of wastes, high performance bio-gas systems, cleaning of bio-gas, use of bio-mass for electricity production, bio-gas compression and storage. Micro algae for oil production, Straight Vegetable Oil (SVO) in engines, Microbial Fuel Cell, configurations, organic wastes to electricity, Waste to Energy (WTE) systems for Municipal Solid Wastes (MSW), vegetable, fish and meat processing residues for biodiesel production, bio-energy for stand-alone electrification, hybrid renewable energy systems. Simulation and case studies of above topics

**TEXT BOOKS/ REFERENCES:**


**19PR721 ADVANCED POWER ELECTRONICS FOR AUTOMOTIVE**

**APPLICATIONS 3-0-0-3**


Simulation and Hardware experiments based on converter/ drive topologies relevant to topics.

**TEXT BOOKS/ REFERENCES:**


19PR722 SYSTEM ENGINEERING AND INTEGRATION 3-0-0-3

Overview of the systems engineering domain; definitions key to systems engineering; the system life cycle, and the product development life cycle. Phase gate approach to product development enabled by application of systems engineering principles. Concept Exploration and the four types of systems requirements that must be extracted from the customer’s statement of want and needs. Dual nature of validation, and its differences from verification.

Requirement analysis, requirements development, and how these relate to planning for systems integration, verification and validation. Functional analysis, interface analysis, requirement allocation, traceability, and use of commercial tools to enable effective application of SE principles in an integrated team environment.

Development of a master compliance matrix, a test and evaluation master plan, and use of technical performance measures in defining system performance. Use of trade study methods for system definition. Applying these methods in concept exploration and system definition. Modeling, simulation and systems analysis enable analysis of alternatives in concept exploration. Applying specialty-engineering disciplines by the system engineer throughout the product development life cycle, and the system life cycle.

Gaining practical experience in the use of reliability, system safety and human factors engineering. Examining risk management concepts, techniques, and tools and their utility in the concept exploration phase, as well as carry-over utility into the later phases of the product development life cycle.

Exploring the technical management responsibilities and functions of the systems engineer applicable to the entire system and product development life cycles. Examining the later stages of the product development life cycle after Concept Development and understand how knowledge development continues through the phases: preliminary design, detailed design, integration and test, system validation, full rate production. (Explore the ideas behind concurrent engineering, design for six sigma and total quality development as they apply to the systems engineering roles, responsibilities, and the development of high quality products in any market, industry or sector.

Course should be taught in view of electric vehicle as the system.

TEXT BOOK / REFERENCES:

19PR723 ELECTRIC DRIVES AND CONTROL 3-0-0-3

Fundamentals of electric drives, dynamics of electric drives, multi quadrant operation, closed

**TEXT BOOKS/ REFERENCES:**


**19PR724 CONTROL SYSTEM DESIGN** 3-0-0-3

Control system design by root locus method: lag, lead, lag-lead compensators, control system design by frequency response: lag, lead, lag-lead compensators. PID controller design: Tuning algorithms for PID controllers, optimal PID tuning, anti-reset wind up, derivative kick, modifications to conventional PID controller. Design of control system in state space: Pole placement controller, selection of pole locations for good design, control law design for full state feedback, design of servo systems. Observer design: Reduced order observer, design of regulator systems with observers. Computer aided designs. Simulations and case studies of classical controller design.

**TEXT BOOKS/ REFERENCES:**


**19PR725E-MOBILITY BUSINESS AND POLICIES** 3-0-0-3

Introduction to India’s passenger mobility sector: Current State of India’s Public Transport System, Public Transport: Efficiently and Affordably Mobilizing Cities, Opportunities To Maintain And Ideally Increase The Utilization Of Public Transport In India, Expanding India’s Definition Of Public Transport Through Data And New Business Models, India’s Path Forward In Public Transport, Sharing and Mobility Services: Unlocking Economic Electrification - the

TEXT BOOK/REFERENCES:


19PR726 AUTOMOTIVE ELECTRONICS 3-0-0-3

Introduction to Electronic systems in Automotives – Sensors and Actuators for body electronics, power train and chassis systems. Body electronics domain- Automotive alarms, Lighting, Central locking and electric windows, Climatic Control, Driver information, Parking, etc. Power train and chassis control domain – Engine management, Transmission control, ABS, ESP, Traction Control, Active Suspension, passive safety, Adaptive Cruise Control, etc. Hardware implementation example of simple automotive systems using Sensors, Controller, Actuators etc. Battery- types and maintenance, Alternators in vehicles, Starting motor systems, Electrical circuits and wiring in vehicles, vehicle network and communication buses – Digital engine control systems, Introduction to automotive controllers, On-Board Diagnostics (OBD).

TEXT BOOKS/REFERENCES:


19PR727 AUTOMOTIVE CONTROL SYSTEMS 3-0-0-3


Road And Driver Models: Road Model- Requirements Of The Road Model, Definition Of The Course Path, Road Surface And Wind Strength; PID Driver Model; Hybrid Driver Model – Vehicle Control Tasks, Characteristics Of Human As A Controller, Information Handling, Complete Driver Model.

Simulation/case studies on relevant topics.

TEXT BOOKS/REFERENCES:


19PR728  VEHICLE DYNAMICS AND CONTROL 3-0-0-3


Lab Experiments Based On Simulation Tools.
TEXT BOOKS/REFERENCES: