COURSE STRUCTURE FOR M.TECH. ELECTRICAL ENGINEERING(POWER SYSTEMS)
SEMESTER I

w. e. f. 2016-2017

Sr. No	Course Code	Course Name	Teaching Scheme					Exam Scheme					
			L	T	P	C	Hrs/wk	Theory			Practical		Total
								MS	ES	IA	LW	LE/Viva	Marks
1	MA 503T	Advanced Numerical Techniques and Computer Programming	3	1	0	4	4	25	50	25	--	--	100
2	MA 503P	Advanced Numerical Techniques and Computer Programming	0	0	2	1	2	--	--	--	50	50	100
3	EE 501	Advanced Electrical Machines	3	0	0	3	3	25	50	25	--	--	100
4	EE 502	Advanced Power System Protection	4	0	0	4	4	25	50	25	--	--	100
5	EE 503	Modern Processors and Embedded Systems	3	0	0	3	3	25	50	25			100
6	EE 504	Laboratory-I	0	0	4	2	4	--	--	--	50	50	100
7		Open Elective I	3	0	0	3	3	25	50	25	--	--	100
		Total	**16**	**1**	**6**	**20**	**23**	125	250	125	100	100	700

MS = Mid Semester, ES = End Semester; IA = Internal assessment (like Test/quizzes, assignments etc.)
LW = Laboratory work; LE = Laboratory Exam

List of Open Electives (C2) (FOET Level)		
Sr. No.	**Open Elective I (Sem I)**	**Open Elective II (Sem II)**
1	ME 512 Finite Element Method	CE 568 Finite Element Method
2	CE 514 Geographical Information Systems	EN 513 Environmental Impact Assessment
3	EN 502 Air Pollution Modelling, Monitoring and Control	CE 525 Earthquake Engineering
4	NE 511 Introduction to quantum and statistical Mechanics	MA 511 Operation research
5	ME 513 Renewable Energy and Energy Management	ME 516: Solar Thermal Systems
6	SE 505 Renewable Energy and Energy Management (Solar)	EE 513 Control Motors
7	EN 506 Atmospheric Process & Climate Change (Chemical/Science)	
8	EN 504 Environmental Legislation	
9	EE 505 Renewable Energy Systems	

Department Elective

EE 511 Smart Grid Technologies and Applications

EE 512 EHV AC and HVDC Transmission

EE 501 Advanced Electrical Machines										
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	3	3	25	50	25	--	--	100

UNIT I **10**

INDUCTION GENERATORS: self excitation requirements, steady state analysis, voltage regulation, different methods of voltage control, application to mini and micro hydro systems.

DOUBLY FED INDUCTION MACHINES: control via static converter, power flow, voltage/frequency control (generation mode), application to grid connected wind and mini/micro hydro systems.

HIGH PERFORMANCE ENERGY EFFICIENT MACHINES: Technology of energy efficient motors, selection and application of energy efficient motors.

UNIT II **08**

SWITCHED RELUCTANCE MOTOR: Construction, operating performance, control and applications.

UNIT III **12**

BRUSHLESS DC MACHINES: construction operation, performance, control and applications.

LINEAR MACHINES: Linear Induction Machines and Linear Synchronous Machines. Construction, operation, performance, control and applications.

UNIT IV **09**

PERMANENT MAGNET MATERIALS : Properties of different Permanent Magnet materials, B-H loop and demagnetization characteristics, temperature effects, mechanical properties, applications

APPLICATION OF PERMANENT MAGNETS IN ELECTRICAL MACHINE: structure, magnetic materials used, types of motors e.g. PMDC and PM Synchronous Machine, control and applications.

RECENT DEVELOPMENTS IN ELECTRICAL MACHINES

TOTAL HOURS **39**

Texts and References:

1 T. J. E. Miller, "***Brushless PM and Reluctance Motor Drives***", Clarendon Press Oxford

2 R. Krishnan, "***Electric Motor Drives***", PHI

3 JacekGierasewing, "***P. M. motor technology***", Marcel Dekker

4 Denis O'Kelly , "***Performance and Control of Electrical Machines***", McGraw-Hill

5 P. C. Sen, " ***Principles of Electrical Machines and Power Electronics***", Wiley

6 Web-Resources : http://www.beeindia.in/

7 Howard E. Jordan, "***Energy Efficient Electric Motors & Their Applications***", Springer

EE 502 Advanced Power System Protection										
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
4	--	--	4	4	25	50	25	--	--	100

UNIT I **09**

PROTECTIVE RELAYING FUNDAMENTALS: General Background, Zones of Protection, Requirements of Protection System, Unit and Non-unit Protection, Primary and Back-up Protection, Historical Development of protection, Classification of Protective Relays, Electro-mechanical (Electromagnetic) Relays(Thermal relay(Electromagnetic) Relays, Attracted Armature Relay, Induction Relays, Induction Disc Relay, Induction Cup Relay, Balance Beam Relay, Universal Torque Equation), Solid State Relays (Introduction, Comparison between Static and Electromechanical Relays, Classification of Static Relays, Generalized Static Time-Over current Relays), Digital Relaying(Merits and Demerits of Digital Relay, Generalized Block Diagram of Digital Relay, Sampling and Data Window), Tripping Mechanism of Relay, Different Relay Algorithms(Algorithms assuming pure sinusoidal relaying signal, Algorithms based on solution of system differential equations, Algorithms Applicable to Distorted Relaying Signals), Concept of Adaptive Relaying

UNIT II **10**

PROTECTION OF TRANSMISSION LINES: Introduction, Various Types of Transmission Line Faults, Overview of Over Current Protection of Transmission Lines, Over View of directional Protection Relay, Modern Digital/Numerical Over current & Earth Fault Relay, Over Current Relay Coordination in an Interconnected Power System(Introduction, LINKNET Structure, Determination of Primary/Back-Up Relay Pairs)

DISTANCE RELAYING: Introduction, Transmission Line Protection, Distance Protection, Reach of Distance Relay, Selection of Measuring Unit, current and Voltage Connections, Problems & Remedies in Distance Protection(Close-in fault, Fault Resistance, Remote In-feed, Mutual Coupling, Series Compensated Transmission Lines, Power Swing, Overload, Transient Condition), Examples on Setting of Distance Protection, Symmetrical Component Based Distance Relay, Digital Distance Relaying Scheme

PILOT RELAYING SCHEMES FOR TRANSMISSION LINE: Introduction to Pilot Protection System, Circulating Current Based Wire Plot Relaying Scheme, Carrier Current Protection Scheme(Phase Comparison Scheme, Directional Comparison Scheme, Blocking and Unblocking Carrier aided Distance Scheme, Carrier Blocking Scheme, Carrier Unblocking Scheme, Transfer Tripping Carrier aided Distance Scheme, Under Reach Transfer Tripping Scheme, Over Reach Transfer Tripping Scheme)

UNIT III **10**

PROTECTION AGAINST TRANSIENTS AND SURGES: Introduction, Sources of Transients or Surges in EHV Line, Switching of Transmission Line, Switching of Capacitor Bank, Switching of Coupling Capacitor Voltage Transformer (CCVT), Switching of Reactor, Arcing Ground, Lightning Strokes, Overvoltage Phenomenon due to Lightning and Switching, Surges and Travelling Waves, Wave Propagation on Transmission Line, Reflection and Attenuation, Reflection, Attenuation of Transients, Attenuation of

Transients Using Filter, Attenuation of Transients Using Isolation Transformer, Neutral Grounding, effects of Ungrounded Neutral on System Performance Methods of Neutral Grounding, Solid Grounding, Resistance Grounding, Reactance Grounding, Resonant Grounding, Grounding Practices, Protection against Transients and Surges, Protection against Lightning, Earthing Screen (Overhead Shielding), Overhead Ground Wires, Surge Modifier or Absorber, Lightning Arrester (Surge Diverter), Types of Lightning Arresters, Rod Gap Arrester, Horn Gap Arrester, Multi Gap Arrester, Expulsion Type Arrester, Valve Type Arrester, Silicon Carbide (SiC) Lightning Arrester, Metal Oxide (MO) Lightning Arrester, Selection Procedure for Lightning/Surge Arresters, Common Ratings of Lightning/Surge Arresters

UNIT IV **10**

AUTORECLOSING AND SYNCHRONIZING & SYSTEM RESPONSE TO SEVERE UPSETS: Introduction, History of auto reclosing, Advantages of auto reclosing, Classification of auto reclosing Relay, auto reclosing based on number of phases, autoreclosing based on number of attempts, autoreclosing based on speed, Sequence of Events of a Typical Single-shot autoreclosing Scheme, Factors to be considered during Reclosing(Choice of zone in case of distance relay, Dead time/ Deionizing time, Reclaim Time, Instantaneous Lock out, Intermediate Lock Out, Breaker supervision function), Synchronism Check(Phasing Voltage Method, Angular Method, Automatic Synchronizing)

SYSTEM RESPONSE TO SEVERE UPSETS: Introduction, Nature of system response to severe upsets, System Response to Islanding Conditions (Undergenerated Islands, Overgenerated Islands, Reactive Power Balance, Power Plant Auxiliaries, Power System Restoration), Load Shedding, Factors to be considered for Load Shedding Scheme(Maximum Anticipated Overload, Number of Load Shedding Steps, Size of Load Shed at Each Step, Frequency Setting, Time Delay), Rate of Frequency Decline, Frequency Relays, Islanding(Issues with Islanding, Methods of Islanding Detection)

TOTAL HOURS 39

Texts and References:

1 Stanley H. Horowitz and ArunG .Phadke, "***Power System Relaying***", Research Studies Press Ltd, 3rd Edition

2 Bhavesh Bhalja, R. P. Maheshwari, Nilesh G. Chothani, "***Protection and Switchgear***", Oxford Press

3 B. A. Oza, Date, Nair and Makwana, "***Power System Protection and Switchgear***", Tata McGraw Hill

4 Walter A. Elmore, "***Protective Relaying Theory and Application***", Marcel Dexxer INC, New York

5 J. J. Blackburn, "***Protective Relaying Fundamentals***", John Wiley and Sons

EE 503 Modern Processors and Embedded Systems										
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	3	3	25	50	25	--	--	100

UNIT I **10**

Introduction to Embedded Systems: Typical Embedded System, Introductions to architectures of various microcontrollers and microprocessors, Characteristics and Quality Attributes of Embedded Systems.

UNIT II **10**

ARM 9 Processors: Architecture of Arm 9 Embedded Processors, Instruction Set, Thumb Instruction Set Extension, Programming of 32 Bit ARM 9 Processor.

UNIT III **09**

Interfaces: Memory and I/O, Communication Interfaces like I2C BUS, CAN BUS, SPI BUS, UART, 1-Wire etc In Embedded Systems.

UNIT IV **10**

Real-Time Operating Systems: Real-Time Operating System based Embedded System Design. Operating System Basics, Types of OS, Tasks, Process and Threads, Multiprocessing and Multitasking, Task Scheduling, Threads, Processes and Scheduling: Putting them altogether, Task Communication, Task synchronization.

TOTAL HOURS **39**

Text and References:

1 Shibu K V, **"*Introduction to Embedded Systems*",** McGraw-Hill

2 Raj Kamal, **"*Microcontrollers, Architecture, Programming, Interfacing and System Design*",** 2nd Edition, Pearson

3 Lyla B. Das**, "*Embedded Systems-An integrated approach*",** Pearson

4 Raj Kamal**, "*Embedded Systems, Architecture, Programming and Design*",** 2nd Edition**,** McGraw-Hill

5 Arnold S Burger**, "*Embedded system design*",** CMP books

6 David Simon**, "*An embedded software primer*",** PEA

7 ***Internet References***
www.arm.com

Department Elective

EE 512 EHV AC and HVDC Transmission										
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	3	3	25	50	25	--	--	100

UNIT I **08**

INTRODUCTION TO EHV AC TRANSMISSION: Basic requirements of a transmission system, Basic parameters, Need of EHV AC transmission, Configuration of EHV AC transmission link, Special features and technical considerations for EHV AC lines

TRANSMISSION LINE TRENDS AND PRELIMINARIES: Choice of voltage, standard transmission voltages, power handling capacity and line loss calculations, cost of transmission line and equipment, mechanical considerations of line performance.

UNIT II **15**

Conductors used for EHV transmission lines, resistance of conductors, effect of resistance of conductor, temperature rise of conductors and current carrying capacity, conductor configurations used for Bundles, GMR of bundled conductors, Calculation of line and ground parameters, surge impedance loading.

Voltage gradients of conductors, Corona effects including power loss, audible noise and radio interference, calculation of corona loss, Radio Interference, Audible noise.

UNIT III **06**

Shunt and series compensation, Design of EHV AC lines based on steady state limits, Electrostatic and magnetic fields of EHV lines

UNIT IV **10**

HVDC TRANSMISSION: Comparison of AC and DC transmission, applications, types of DC links, components of HVDC transmission, advantages and limitations, thyristor valve, analysis of HVDC converter, HVDC system control, smoothing reactors, transient over voltages in DC lines, protection of DC lines, reactive power control, harmonics and filters, multi terminal HVDC systems.

TOTAL HOURS **39**

Text and References:

1 Rakosh Das Begamudre, ***"Extra high voltage AC transmission engineering"***, New Age International ltd

2 K. R. Padiyar, ***"HVDC power transmission systems technology and system interactions"***, New Age International ltd

Open Elective I

EE505 RENEWABLE ENERGY SYSTEMS										
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	3	3	25	50	25	--	--	100

UNIT I **10**

INTRODUCTION: World energy use, Reserves of energy resources, Environmental aspects of energy utilization, Renewable energy scenario in India, Potentials, Achievements, Applications, Concept of energy conservations.

UNIT II **10**

SOLAR ENERGY: Solar radiation, Solar radiation spectrum, Solar constant, Extra terrestrial radiation, Geometrical parameters – Longitude, Latitude and Altitude angles, Solar angles- solar azimuth angle, surface azimuth angle, air mass, incidence angle, slope. Solar thermal applications, Flat plate and concentrating collectors, Solar heating and cooling techniques, Solar desalination, Solar Pond, Solar cooker, Solar thermal power plant, Solar photo voltaic conversion, Solar cells, PV applications, Blocking diode, Bypass diode

UNIT III **09**

WIND ENERGY: Wind data and energy estimation, Betz limit, Basic components of wind electric system, Types of Wind energy conversion devices (Dutch windmills, Mutli-bladed water pumping windmills, High speed propeller type wind machines), Principle of Lift and Drag force on aerofoil (Basics of Aerodynamics), Design of Wind turbine rotor, Power Speed Characteristics, Power torque characteristics, Concept of Savonius and Darrious rotors, Types of wind energy systems, Performance and calculations, Details of wind turbine generator, Comparison of Wind generators, Wind turbine control system (pitch, stall and yaw controls).

UNIT IV **10**

BIOMASS ENERGY: Biomass direct combustion, Biomass gasifier, Biogas plant, Ethanol production, Bio diesel, Cogeneration, Biomass applications

OTHER RENEWABLE ENERGY SOURCES: Tidal energy, Wave energy, Open and closed OTEC Cycles, Small hydro, Geothermal energy, Fuel cell systems

TOTAL HOURS 39

Text and References:

1 G.D. Rai, "***Non Conventional Energy Sources***", Khanna Publishers, New Delhi, 1999.

2 S.P. Sukhatme, "***Solar Energy***", Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.

3 Godfrey Boyle, "***Renewable Energy, Power for a Sustainable Future***", Oxford University Press, U.K, 1996.

4 Twidell, J.W. & Weir, A., "***Renewable Energy Sources***", EFN Spon Ltd., UK, 1986.

5 G.N. Tiwari, "***Solar Energy, Fundamentals Design, Modelling and applications***", Narosa Publishing House, New Delhi, 2002.

6 L.L. Freris, "***Wind Energy Conversion systems***", Prentice Hall, UK, 1990.

7 Johnson Gary, L., "***Wind Energy Systems***", Prentice Hall, New York, 1985.