DEPARTMENT OF ELECTRICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY SRINAGAR

HAZRATBAL, SRINAGAR, KASHMIR – 190006

SEMESTER WISE COURSE STRUCTURE
AND
SUBJECT WISE COURSE CONTENT

FOR

M. Tech. PROGRAMME

(POWER ELECTRONICS & ELECTRIC DRIVES)

(1st to 4th Semester)

IN

ELECTRICAL ENGINEERING

w.e.f YEAR 2020 AND ONWARDS

Recommended by the Departmental Post Graduate Committee

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Department of Electrical Engineering
National Institute of Technology Srinagar

Bimal K Bose writes in the research paper titled " Energy, Environment and Advances in Power Electronics", published in the IEEE transactions on Power Electronics in July 2000,

"Power Electronics has now firmly established its importance as indispensable tool in industrial process applications after decades of technological evolution. Fortunately, we are now living in an era of industrial renaissance when not only power electronics but also computers, communications, information, and transportation technologies are advancing rapidly. In the highly automated industrial environment struggling for high quality products with low cost, it appears that two technologies will be most dominating: computers and power electronics with motion control."

Interestingly**,** technologies like computers, communications, information and transportation that are dominating the sphere of research worldwide, are operationally inadequate without power electronics. From ensuring regulated power supplies for industrial, medical and research equipment, to enhancing the quality of power delivered on the consumer end, power electronics has become a truly irreplaceable technology. Equipments ranging from domestic appliances to industrial and commercial tools, are directly or indirectly dependent on power electronics. Moreover, as concerns for cleaner and renewable alternatives of energy are being raised world over, it is again power electronics that has bridged the gap between otherwise unreliable and intermittent renewable sources of energy and their reliable use in the existing electricity network.

Most research activities in the core disciplines of electrical engineering, such as electrical machines and drives, power systems and renewable energy are heavily dependent on power semi-conductor technology, hence making inevitable use of power electronics. Owing to rapid advances in power electronics and the vast scope of this field in almost all disciplines of electrical engineering, almost all leading technical universities in the world offer at least one masters and research programme in this field. The department of electrical engineering at NIT Srinagar, could not start a PG programme in power electronics earlier, owing to shortage of faculty. However, with the appointment of seven new faculty members, the department is now academically well-equipped to start an M.Tech programme in Power Electronics and Electric Drives.

Electrical drive technology converts electrical energy from the power supply system or from a battery into mechanical energy and transmits the resulting force into motion. Many applications that make our daily lives easier – like lifts, escalators, gate drives, washing machines, mixers, electric razors, etc. – would be unthinkable without electric drives. We can find them in both the megawatt sector in applications such as locomotives and in the microwatt sector, in wristwatches, for instance. Electrical drive technology is also crucial in industrial production, where it plays a key role in machines and plants for production and logistics processes. All in all, we can assume that electrical drive technology consumes the predominant share of our overall electrical energy. The technology is closely associated with power electronics in its operation and control, hence serving as one of the primary applications of power electronics. Both disciplines, viz. power electronics and electric drives, are often studied together under the flagship name of power electronics and electric drives, with the former finding its primary application in the latter.

The Department of Electrical Engineering at National Institute of Technology Srinagar, was one of the first departments of the erstwhile Regional Engineering College (REC) Srinagar. It was established in the year 1960 and is among the oldest departments in the institute. The department runs one undergraduate programme leading to a bachelor's of technology (B. Tech) degree in electrical engineering, one post-graduate programme leading to a master's of technology (M. Tech) degree in electrical power and energy systems. The department also runs PhD programmes with specializations in power systems, power electronics and control & automation. The faculty constantly engage in research apart from teaching and regularly publish in top international journals and conferences. There are ten laboratories in the department catering to the needs of the students.

It has been experienced over the years that Post graduate programmes herald institutions into the field of research and development (R&D). The faculty also grows with research and with other related activities. With experienced and distinguished faculty having a sound research background, the department aspires to float a second post-graduate programme in Power Electronics and Electric Drives (PEED). It is pertinent to mention here that the expertise of our highly qualified faculty can be fully utilized through masters and research programmes likes these, which is not possible at the undergraduate level.

Further new technical Institutions are coming up everywhere. There is a great demand for technical teachers. Our Department can supply study stream of well-qualified teaching professionals to cater to the needs of the upcoming Institutions. Moreover, postgraduates are now preferred in the Private and Public sector because of their in-depth and specialized knowledge.

Department of Electrical Engineering
National Institute of Technology Srinagar

Faculty Structure

S. No.	Name of Faculty	Designation	Qualification	Specialization
1.	Prof. M.D. Mufti	Professor	PhD	Power System Control, Dynamics & Stability
2.	Prof. Aijaz Ahmad	Professor	PhD	Power System Operation & Optimization
3.	Prof. S.A Lone	Professor	PhD	Stand-alone Power Systems
4.	Prof. A.H. Bhat	Professor	PhD	Power Electronics, Electric Drives and Power Quality
5.	Dr. S. Javed Iqbal	Associate Professor	PhD	Power System Dynamics & Control
6.	Dr. Obbu Chandra Sekhar	Associate Professor	PhD	Power Electronics and Drives
7.	Dr. M.A Bazaz	Associate Professor	PhD	Control & Automation
8.	Dr. Asadur Rahman	Assistant Professor	PhD	Power System Control & Optimization, Renewable Energy System
9.	Dr. Neeraj Gupta	Assistant Professor	PhD	Probabilistic Power Systems and Renewable Energy Systems
10.	Dr. Farhad Ilahi Bakhsh	Assistant Professor	PhD	Power Electronics and Drives, Renewable Energy Systems
11.	Dr. Kushal M Jagtap	Assistant Professor	PhD	Distributed Generation and Power Systems
12.	Dr. Ravi Bhushan	Assistant Professor	PhD	Power Stability and Control
13.	Dr. Chilaka Ranga	Assistant Professor	PhD	Electrical Machines and Di-Electrics
14.	Ms. Tabish Nazir Mir	Trainee Teacher	B. Tech, Pursuing PhD	Power Converters-Modulation and Control, Electric Drives

Requirements for completion of M. Tech in

Power Electronics and Electric Drives (PEED):

(As per our NIT academic Statutes)

1. A student has to complete a minimum of 60 credits for the award of M. Tech Degree. The credit structure is as follows:

   Core : 29 credits

   Project : 16 credits

   Electives : 15 credits (Minimum)

2. Full time student has to take 12 to 18 credits in each semester.
3. Part time student has to take 9 to 12 credits in each semester.
4. In addition to above a student can audit a total number of 3 courses during his/her entire programme of M. Tech, for which he/she will be awarded an AU grade, subject to following:
   a. In 1st year: 1st semester, full time student is not allowed to audit a course, whereas a part-time student can do so.
   b. A part time or full time student can audit only one course in one semester.

Eligibility criteria admission to M. Tech in Power Electronics and Electric Drives (PEED):

1. Any one of Following from Accredited/Recognized University/Institution B. E. /B. Tech (4 year Programmes) in

   Electrical Engineering

   Electrical and Electronics Engineering

   Electronics & Instrumentation Engineering

   Instrumentation/Control Engineering

   Electrical and Renewable Energy Engineering

   Electrical and Computer Engineering

   Power Plant Engineering

2. A valid GATE score only in EE / EC/ IN
3. Sponsored category students shall be admitted as per institute policy

Seat Matrix

The Category wise seat matrix for July 2020 session will be as follows:

Category	Intake capacity for Existing M. Tech (EP&ES)	Intake capacity for Proposed M. Tech (PEED)
OC	10	10
OC-PWD	1	1
OC-EWS	2	2
OBC	7	7
SC	4	4
ST	2	2
Sponsored	5	5
Total	**31**	**31**

List of Abbreviations

EEM 1XX	**Theory Course**
EEM 2XX	**Practical Course**
EEM 3XX	**Dissertation**
L	**Lecture**
T	**Tutorial**
P	**Practical**
CW	**Class Work**
PR	**Practical Work**
MTE	**Mid Term Examination**
ETE	**End Term Examination**

Department of Electrical Engineering,

National Institute of Technology Srinagar
Course Structure for M. Tech.
Power Electronics & Electric Drives-PEED

Teaching Scheme				Contact Hrs. Per week			Exam. Duration		Relative Weightage (%)			
S.No.	Course Code	Course Title	No. of Credits	L	T	P	Th	Pr	CW	PR	MTE	ETE
1st YEAR				**I SEMESTER (AUTUMN)**								
1	EEM 118	Modeling and Analysis of Electric Machines	3	3	-	-	3	-	10	-	30	60
2	EEM 119	Applied Power Electronics	4	3	1	-	3	-	10	-	30	60
3	EEM 120	Electric Drives	3	3	-	-	3	-	10	-	30	60
4	EEM 121	Power Quality Problems & Solutions	3	3	-	-	3	-	10	-	30	60
5	EEM 203	Power Electronics Simulation Lab	2	-	-	4	--	1	-	25	25	50
6		Elective – 1	3	3	-	-	3	-	10	-	30	60
Sub Total			**18**									

				II SEMESTER (SPRING)								
1	EEM 122	Advanced Electric Drives	3	3	-	-	3	-	10	-	30	60
2	EEM 123	Linear Systems Theory	3	3	-	-	3	-	10	-	30	60
3	EEM 124	Pulse Width Modulation Techniques	3	3	-	-	3	-	10	-	30	60
4	EEM 125	HVDC Systems	3	3	-	-	3	-	10	-	30	60
5	EEM 204	Electric Drives Lab	2	-	-	4	-	1	-	25	25	50
6		Elective – II	3	3	-	-	3	-	10	-	30	60
Sub Total			**17**									

2nd YEAR				**III SEMESTER (AUTUMN)**								
Teaching Scheme				Contact Hrs. Per week			Exam. Duration		Relative Weightage (%) (Hrs.)			
S.No.	Course Code	Course Title	No. of Credits	L	T	P	Th	Pr	CW	PR	MTE	ETE
1		Elective -III	3	3	-	-	3	-	10	-	30	60
2		Elective-IV	3	3	-	-	3	-	10	-	30	60
3		Elective-V	3	3	--	-	3	-	10	-	30	60
4	EEM 301	Pre-Dissertation	4	-	-	-	-	-	-	-	-	-
Sub Total			**13**									

				IV SEMESTER (SPRING)								
1	EEM 302	Dissertation	12									
Sub Total			12									
Total			60									

Electives for M. Tech I, II, III Semesters (Electrical)

Power Electronics and Electric Drives -PEED

w.e.f YEAR 2020 ONWARDS

Electives – I, II, III, IV,V **3 Credits each**

Teaching Scheme				Contact Hrs. Per week			Exam. Duration		Relative Weightage (%) (Hrs.)			
S.No.	Course Code	Course Title	No. of Credits	L	T	P	Th	Pr	CW	PR	MTE	ETE
1	EEM 126	FPGAs and Digital Signal Processors	3	3	-	-	3	-	10	-	30	60
2	EEM 127	Modeling and Simulation of Power Electronic Systems	3	3	-	-	3	-	10	-	30	60
3	EEM 128	Flexible AC Transmission Systems	3	3	-	-	3	-	10	-	30	60
4	EEM 129	Hybrid Electric Vehicles	3	3	-	-	3	-	10	-	30	60
5	EEM 130	Non Linear Systems	3	3	-	-	3	-	10	-	30	60
6	EEM 131	Power Electronics for Renewable Energy Systems	3	3	-	-	3	-	10	-	30	60
7	EEM 132	Smart Grid Technology	3	3	-	-	3	-	10	-	30	60
8	EEM 133	Intelligent Control in Power Electronics	3	3	-	-	3	-	10	-	30	60
9	EEM 134	Modern Power Electronics	3	3	-	-	3	-	10	-	30	60
10	EEM 135	Drive Systems in Electric Traction	3	3	-	-	3	-	10	-	30	60
11	EEM 136	Special Electric Machines	3	3	-	-	3	-	10	-	30	60
12	EEM 137	Optimal Control	3	3	-	-	3	-	10	-	30	60
13	EEM 105	Renewable Sources of Energy	3	3	-	-	3	-	10	-	30	60
14	EEM 107	Modeling and Simulation of Power System Components	3	3	-	-	3	-	10	-	30	60
15	EEM 108	Soft Computing	3	3	-	-	3	-	10	-	30	60
16	EEM 109	SCADA Systems	3	3	-	-	3	-	10	-	30	60
17	EEM 113	Stand Alone Systems	3	3	-	-	3	-	10	-	30	60
18	EEM 117	Advanced Instrumentation Technology	3	3	-	-	3	-	10	-	30	60
19	ECEM 159	Embedded Systems & Real Time Applications	3	3	-	-	3	-	10	-	30	60
20	MTM 101	Optimization Techniques	3	3	-	-	3	-	10	-	30	60

Syllabi of Core Courses for Semester-I

MODELING AND ANALYSIS OF ELECTRIC MACHINES

Credits: 3

	L	T	P
Course code: EEM 118	**3**	**0**	**0**

Module 1:

Basic concepts of Modeling: Basic Two-pole Machine representation of Commutator machines, 3-phase synchronous machine and 3-phase induction machine, Kron's primitive Machine-voltage, current and Torque equations.

Module 2:

Reference frame theory: Linear transformation-Phase transformation - three phase to two phase transformation (abc to αβ0) and two phase to three phase transformation.

DC Machine Modeling: Mathematical model of separately excited D.C motor, Mathematical model of D.C Series motor.

Module 3:

Modeling of three phase Induction Machine: Generalized model in arbitrary reference frame-Electromagnetic torque-Derivation of commonly used Induction machine models- Stator reference frame model-Rotor reference frame model-Synchronously rotating reference frame model

Module 4:

Modeling of Synchronous Machine: Synchronous machine inductances – Mathematical model-transformation to the rotor's dq0 reference frame- Flux linkages in terms of winding currents-referring rotor quantities to the stator- voltage equations in the rotor's dq0 reference frame-electromagnetic torque-currents in terms of flux linkages. Modeling of PM Synchronous motor, BLDC motor and Switched Reluctance motor

Text books

1. R.Krishnan, "Electric Motor Drives - Modeling, Analysis& control" - Pearson Publications-1st edition -2002
2. D.Sudhoff, "Analysis of Electrical Machinery and Drive systems" – P.C.Krause, OlegWasynczuk, Scott – Second Edition-IEEE Press

References

1. Generalized Theory of Electrical Machines – P.S.Bimbra-Khanna publications-5th edition-1995
2. Dynamic simulation of Electric machinery using Matlab / Simulink –Chee Mun Ong-Prentice Hall edition (19 September 1997)
3. Referred Journal/Conference publications

APPLIED POWER ELECTRONICS

Credits: 4

Course Code: EEM 119	**L**	**T**	**P**
	3	**1**	**0**

Module 1

Power Electronic Devices: Power Diode, SCR, GTO, MOSFET, IGBT, IGCT, SiC and GaN devices –Structure and characteristics.

Module 2:

Non-Isolated DC-DC converters- Buck, Boost, Buck-Boost, Cuk, SEPIC and zeta converters, Isolated DC-DC converters- Flyback, Forward, Push-Pull, Half-bridge and Full-bridge converters, Switch Mode Power Supplies.

Module 3

Improved power quality converters- Multi-pulse converters, buck, boost, buck-boost converters in AC-DC topology, PWM rectifiers and their control, Matrix Converters

Module 4

Three phase AC voltage regulators and Cyclo-converters. Voltage Source Converters and their PWM techniques, Current Source Converters

Text Books

1. Power Electronics by Daniel W Hart, Tata Mc Graw Hill
2. Power Electronic Circuits by Issah Batterseh, Wiley.
3. N. Mohan, T.M. Undeland & W.P. Robbins, Power Electronics: Converter, Applications & Design, John Wiley & Sons, 1989

References

1. Power Electronics: Devices, Drivers, Applications, and Passive Components by Barry Williams, McGraw Hill Higher Education; 2nd Revised edition edition
2. Modern Power Electronics and AC motor Drives By Bimal K Bose- Pearson Publishers, Ist Edition.
3. Referred Journal/Conference publications

ELECTRIC DRIVES
Credits: 3

Course Code: EEM 120

L	T	P
3	0	0

Module 1:
Introduction to Electric Drives, Electric Drive Systems versus Mechanical Drive Systems. **Converter Controlled Dc Motor Drives:** Steady state analysis of semi-controlled and fully controlled converter fed series and separately excited D.C motor drives: Continuous and discontinuous conduction mode, open /closed loop control.**Chopper Controlled Dc Motor Drives:** Four quadrant chopper circuit – closed loop control of chopper fed dc drive –Steady state analysis of chopper controlled DC motor drives.

Module 2:
Voltage Source Inverter Fed Induction Motor Drives: Scalar control- Voltage fed Inverter control-Open loop volts/Hz control-Speed control with slip regulation-Speed control with torque and Flux control-Current controlled voltage fed Inverter Drive**.**

Module 3:
Current Source Inverter Fed Induction Motor Drives: Current-Fed Inverter control-Independent current and frequency control-Speed and flux control in Current-Fed Inverter drive-Volts/Hz control of Current-Fed Inverter drive-Efficiency optimization control by flux program.

Module 4:
Rotor Side Control Of Induction Motor: Rotor resistance control- fixed resistance control, variable resistance control-converter controlled rotor resistance control, Slip power recovery schemes- Static Kramer drive-Phasor diagram-Torque expression-Speed control of a Kramer drive-Static scherbius drive-Modes of operation

Text books

1. Power Electronics and Motor Control – Shepherd, Hulley, Liang – II Edition, Cambridge University Press
2. Modern power Electronics and AC drives, B.K.Bose- pearson publications
3. Control of Electric Drives by Werner Leonhard- Springer

References

1. Power Electronic Circuits, Devices and Applications – M. H. Rashid – Pearson Publishers, Fourth Edition
2. Control of Induction Motors - Andrzej M. Trzynadlowski, Academic Press, Ist Edition
3. Dynamics and control of electrical drives - Piotr Wach, Springer, 2011 Edition

4. Electric Motor Drives Modeling, Analysis and Control – R. Krishnan, Prentice Hall India.
5. Fundamentals of Electric Drives – G. K. Dubey – Narosa Publications – 1995.
7. Referred Journal/Conference publications

POWER QUALITY PROBLEMS AND SOLUTIONS

Credits:3

Course Code: EEM 121	**L**	**T**	**P**
	3	**0**	**0**

Module-1

Introduction to Power Quality- Definition, Power Quality Problems, Causes and Consequences, voltage sags, swells, interruptions, flicker, reactive power and harmonics. Load Current Compensation, Reactive power compensation and zero voltage regulation. Compensation through passives, Active load compensation- D-STATCOM- Design, Control and Phasor Analysis.

Module-2

Source Voltage Compensation, Dynamics of sags and swells, Passive Series Compensation, Active Series Compensation- Dynamic Voltage Restorer (DVR) with and without energy support- Design, Control and Phasor Analysis.

Module-3

Combined Compensation- Unified Power Quality Conditioner (UPQC) , Right Shunt and Left Shunt Topologies, Phasor Analysis of UPQC-P,Q and S under various perturbations.

Module-4

Voltage and Current Harmonics- Causes and Consequences. Design of Passive Filters. Active Shunt Filters and Active Series Filters, Hybrid Filters, Improved Power Quality Converters.

Text Books

1. Understanding Power Quality Problems: Voltage Sags and Interruptions by Math H. Bollen, Wiley-IEEE Press.
2. Power Quality Enhancement using Custom Power Devices by Arindham Ghosh, Gerard Ledwich, Springer.
3. Power Quality Problems and Mitigation Techniques by Bhim Singh and Ambrish Chandra, Wiley.

References

1. N. Mohan, T.M. Undeland & W.P. Robbins, Power Electronics: Converter, Applications & Design, John Wiley & Sons, 1989
2. Referred Journal/Conference publications

POWER ELECTRONICS SIMULATION LAB.

Credits: 2

Course Code: EEM 203

L	T	P
0	0	2

Choice of any 8-10 experiments from the following:

1. To develop and analyze the performance of single-phase half wave controlled converter with R, RL & RLE Loads with/without FD.
2. To develop single-phase full wave semi-controlled and fully-controlled converters with R, RL & RLE Loads and analyze its performance.
3. To develop and analyze the performance of three-phase semi-controlled and fully-controlled converters with R, RL & RLE Loads.
4. To develop the dual converter and analyze its performance with motor loads.
5. To develop and analyze the performance of power factor corrective converter.
6. To develop the multi-pulse converter and analyze its performance.
7. To develop and analyze the performance of buck converter with open loop and closed loop operations.
8. To develop the boost converter with open loop and closed loop operations and analyze its operation.
9. To analyze the performance of buck-boost converter with open loop and closed loop operations.
10. To develop the single-phase AC voltage controller with R & RL Loads and analyze its performance.
11. To develop and analyze the three-phase AC voltage controller with R & RL Loads.
12. To develop single-phase to single-phase cyclo-converter and analyze its performance.
13. To develop and analyze the performance of three-phase to single-phase cyclo-converter.
14. To develop 120° conduction scheme based VSI and analyze its performance with R & RL loads.
15. To develop 180° conduction scheme based VSI and analyze its performance with R & RL loads.
16. To develop CSI and analyze its performance with R & RL loads
17. To develop a sinusoidal PWM based VSI and analyze its performance with R and RL loads.

Syllabi of Core Courses for Semester-II

ADVANCED ELECTRIC DRIVES
Credits: 3

Course code: EEM 122

L	T	P
3	0	0

Module-1
Scalar Control versus Vector Control, vector control of induction motor: Principles of vector control, Direct vector control, Indirect vector control, implementation – block diagram; estimation of flux, flux weakening operation. Sensorless vector control of induction motor: Estimation techniques.

Module-2

Direct Torque Control of Induction Motor Drives, Space Phasor representation, Flux and torque control, Switching implementation, Sensorless operation

Module-3

Control of synchronous motor drives**:** Structure-Stator Excitation-techniques of sensor less operation-convertor topologies- Waveforms- drive design factors-Torque controlled synchronous motor drives-Torque Ripple-Instantaneous Torque control -using current controllers-flux controllers.

Module 4:
Control of Special Machines: principle of operation of PMSM and BLDC Machine, Stepper Motors, Switched Reluctance Motors and Synchronous Reluctance motors

Text books

1. Electric Motor Drives Modeling, Analysis & control -R. Krishnan- Pearson Education
2. Modern Power Electronics and AC Drives –B. K. Bose-Pearson Publications
3. Sensorless Vector Direct Torque control –Peter Vas, Oxford University Press

References

1. Modern Power Electronics and AC Drives –B. K. Bose-Pearson Publications-
2. Power Electronics control of AC motors – MD Murphy & FG Turn Bull Pergman Press -1st edition-1998

3. Power Semiconductor drives- G.K. Dubey-Prentice hall
4. Referred Journal/Conference publications

LINEAR SYSTEMS THEORY

Credits: 3 **L T P**
Course code: EEM 123 **3 0 0**

Module 1:
Linear Algebra Fundamentals: Vector Spaces, Basic properties of vector spaces, subspaces and bases, dimensions, linear dependence and linear independence, orthogonal bases and orthogonal projections, basic matrix operations, matrix decompositions, Eigen values and Eigen Vectors.

Module 2:
State Space Modelling: State Variable Modelling of Linear Time-invariant systems, Equivalence between state-space models and transfer function models, Canonical Representations, Solution of state equations, Concept of state transition Matrix, Evaluation of state transition matrix, Numerical Solution of state equations, Concept of controllability and observability, Necessary and Sufficient conditions for controllability and observability, concept of Grammians.

Module 3:
Pole Placement Techniques: State Feedback Controller Design, Necessary and Sufficient conditions for arbitrary pole placement, State Regulator Problem Formulation and State regulator design, State Observer Design, Full Order and Reduced Order Observer, Observer based state feedback control, Separation Principle.

Module 4:
Modelling of Power Electronic Converters: Basic issues involved, Modelling of PE Circuits as linear switched systems, Model Order Reduction based algorithms for modelling, Multi-resolution simulations.

Books Recommended

1. Chi Tsong Chen, "Linear System Theory and design", Oxford University Press
2. Thomas Kailath, "Linear Systems" Prentice Hall
3. Katsuhiko Ogata, "State Space Analysis of Control Systems", Prentice Hall
4. M Gopal, "Digital Control and State Variable Methods", Tata McGraw Hill.

PULSE WIDTH MODULATION TECHNIQUES

Credits: 3

Course Code: EEM 124	**L**	**T**	**P**
	3	**0**	**0**

Module-1

Power semi-conducting devices as switches (single quadrant, two-quadrant and four-quadrant switches). Basic structure and operation of two-level and multi-level converters.

Module-2

Aim and objectives of pulse width modulation: Single phase square wave VSI, fourier analysis of output voltage waveform, Three-phase 6-STEP VSI, CSI, main issues with these converters, phase modulation, introduction to pulse width modulation, selective harmonic elimination and optimum PWM techniques.

Module-3

Sinusoidal PWM technique for single phase and three phase VSIs, Common mode injection techniques, third harmonic injection technique, bus clamping techniques in VSIs, discontinuous PWM, Concept of dead band/ blanking time and its effects on inverter output voltage.

Module-4

Basic concept of space vector pulse width modulation technique (SVPWM), SVPWM for three phase VSIs, Advantages, Over-Modulation with SVPWM, Space vector based bus clamping and advanced bus clamping techniques, PWM techniques applied to multi-level converters, Hysteresis current control technique and delta-sigma modulation.

Text Books

1. Pulse Width Modulation Techniques by Holmes and Lipo- Wiley-IEEE Press
2. Modern Power Electronics and AC motor Drives By Bimal K Bose- Pearson Publishers.
3. **References**
    - N. Mohan, T.M. Undeland & W.P. Robbins, Power Electronics: Converter, Applications & Design, John Wiley & Sons, 1989
    - Referred Journal/Conference Publications.

HIGH VOLTAGE DIRECT CURRENT SYSTEMS (HVDC SYSTEMS)

	Credits: 3	L	T	P
Course code: EEM 125		**3**	**0**	**0**

Module 1

Evolution of HVDC Transmission, Comparison of HVAC and HVDC system, Types of HVDC Transmission system, Components of HVDC Transmission system, Analysis of simple rectifier circuits, Required features of rectification circuits for HVDC Transmission.

Module 2

Analysis of HVDC converter: Different modes of valve operation, output voltage waveforms and DC voltage in rectification operation, output voltage waveforms and DC voltage in inverter operation, valve voltages, Equivalent electrical circuits, converter chart.

Module 3

Converter mal-operation, commutation failure, converter protection, DC reactor and damper circuits, HVDC system control features, Control modes, Control schemes and control comparisons, Energization and De-energization of bridges, Starting and stopping of HVDC link.

Module 4

Harmonic Analysis, Filter design, Grounding and DC lines, Reactive power requirements, Multi-terminal HVDC system (MTDC), HVDC Light, HVDC system in wind power generation.

Text Books

1. Direct Current Transmission by E. Kimbark

References

1. HVDC Power Transmission Systems by K. R. Padiyar
2. High voltage direct current transmission by Dragan Jovcic, Khaled Ahmed
3. NPTEL Lecture series on HVDC Systems.

ELECTRIC DRIVES LAB

Credits: 2

Course Code: EEM 204	**L**	**T**	**P**
	0	**0**	**2**

Choice of any 8-10 experiments from the following:

1. To achieve the open loop and closed loop speed control of Chopper fed DC Motor Drive.
2. To obtain four quadrant operation of Chopper controlled DC Motor Drive.
3. To achieve the open loop and closed loop speed control of 3-phase Induction Motor Using IGBT based Voltage Source Inverter (VSI).
4. To achieve the open loop and closed loop speed control of 3-phase Induction Motor Using MOSFET based VSI and compare it with IGBT based VSI.
5. To achieve the speed control of 3-phase Induction Motor using V/f controller.
6. To achieve the speed control of 3-phase slip ring Induction Motor by static rotor resistance control.
7. To obtain four quadrant operation of Induction Motor Drive.
8. To analyze the speed control of BLDC Motor Using Microcontroller based PWM Controller having open loop and closed loop DC Control Technique.
9. To obtain the open loop and closed loop speed control of Switched Reluctance Motor Using Microcontroller based PWM Controller.
10. To analyze the performance of multi-phase Inverter Drive.
11. To obtain the speed control of Variable Reluctance Stepper Motor.
12. To analyze the performance of Permanent Magnet Stepper Motor.
13. To analyze the performance of PMSM drive.
14. To analyze the performance of vector controlled I/M drive

Semester-III

PRE-DISSERTATION

Credits: 4

Course Code: EEM 301

Students are expected to present/demonstrate a detailed critical literature survey, motivation behind selection of research topic, plan of work and preliminary implementation.

Semester-IV

DISSERTATION

Credits: 12

Course Code: EEM 302

A complete dissertation on the selected research topic needs to be submitted, besides detailed presentation/demonstration of the work done. Students are encouraged to stress on novelty and prospective publication.

Syllabi of Elective Courses

FPGAs AND DIGITAL SIGNAL PROCESSORS

Credits: 3

Course Code: EEM 126	**L**	**T**	**P**
	3	**0**	**0**

Module 1

PROGRAMABLE LOGIC DEVICES - Programming Techniques-Anti fuse-SRAM-EPROM and EEPROM technology Logical blocks, I/O blocks, Interconnects, Xilinx- XC9500,Cool Runner - XC5200, SPARTAN, Virtex - Altera MAX 7000.

Module 2:

ASIC CONSTRUCTION, FLOOR PLANNING, PLACEMENT AND ROUTING - System partition – FPGA partitioning – Partitioning methods- floor planning – placement- physical design flow – global routing – detailed routing – special routing- circuit extraction – DRC.

Module 3

INTRODUCTION TO DSP : Architecture, Assembly language syntax, Addressing modes Assembly language Instructions - Pipeline structure, Operation Block Diagram of DSP starter kit, Application Programs for processing real time signals. Data Addressing modes of TMS320C54XX DSPs, Data Addressing modes of TMS320C54XX Processors, Memory space of TMS320C54XX Processors, Program Control,, On-Chip peripherals, Interrupts of TMS320C54XX processors.

Module 4

I/O & CONTROL REGISTERS: Pin Multiplexing (MUX) and General Purpose I/O Overview, Multiplexing and General Purpose I/O Control Registers .Introduction to Interrupts, Interrupt Hierarchy, Interrupt Control Registers, Initializing and Servicing Interrupts in Software.

Text books

1. Kamran Eshraghian,Douglas A.Pucknell and Shole Eshraghian," Essentials of VLSI circuits and system", Prentice Hall India,2005.
2. Wayne Wolf, " Modern VLSI design", Prentice Hall India,2006.
3. Rahul Dubey, "Introduction to Embedded System Design Using Field Programmable Gate Arrays", 2009 Springer-Verlag London Limited

References

1. Mohamed Ismail,Terri Fiez, "Analog VLSI Signal and information Processing", McGraw Hill International Editions,1994.
2. Samir Palnitkar, "Veri Log HDL, A Design guide to Digital and Synthesis" 2nd Ed, Pearson,2005.
3. Xilinx (2006) Spartan-3E Starter Kit Board User Guide. UG230 (v1.0) March 2006
4. Xilinx (2006) System Generator for DSP performing Hardware-in-the-loop with the SPARTAN-3E Starter Kit, December 2006
5. Hamid.A.Toliyat and Steven G.Campbell " DSP Based Electro Mechanical Motion Control " CRC Press New York , 2004
6. Texas Instrument TI C2xx manual
7. Referreed Journal/Conference Publications

MODELING AND SIMULATION OF POWER ELECTRONIC SYSTEMS
Credits: 3

Course Code: EEM 127	**L**	**T**	**P**
	3	**0**	**0**

Module 1

MODELING OF POWER ELECTRONIC DEVICES: General purpose circuit analysis software – Methods of analysis of power electronic systems - Transients and the time domain analysis with Pspice – Fourier series and harmonic components – Pspice modeling of diode, BJT,MOSFET,IGBT, SCR,TRIAC in simulation. Diode with R, R-L, R-C and R-L-C load with ac supply. Modeling of SCR, TRIAC and IGBT, simulation of driver and snubber circuits.

Module 2:

SIMULATION OF AC-DC and AC-AC CONVETERS USING PSPICE AND MATLAB SIMULINK: Modeling of single phase and three-phase uncontrolled and controlled (SCR) rectifiers- simulation of converter fed DC drives-computation of performance parameters: harmonics, power factor, angle of overlap. AC Voltage Regulator , Cyclo converter .

Module 3:

SIMULATION OF DC-DC CONVERTERS USING PSPICE AND MATLAB SIMULINK
Modeling of Chopper circuits- Simulation of thyristor choppers with voltage, current and load commutation schemes- Simulation of chopper fed dc motor- computation of performance parameters.

Module 4:

SIMULATION OF DC-AC CONVERTERS USING PSPICE AND MATLAB SIMULINK: Modeling of single and three phase inverters circuits – Space vector representation- Pulse-width modulation methods for voltage control- Simulation of inverter fed induction motor drives..

Text books:

1. Rashid, M., "Simulation of Power Electronic Circuits using PSPICE", Prentice Hall Inc., 2006
2. M. B. Patil, V. Ramnarayanan and V. T. Ranganathan., "Simulation of Power Electronic Converters", 1st Edition, Narosa Publishers, 2010.
3. John Keown., "Microsim, Pspice and circuit analysis"-Prentice Hall Inc., third edition, 1998.

References:

4. Robert Ericson, 'Fundamentals of Power Electronics', Chapman & Hall, 1997.
5. Issa Batarseh, 'Power Electronic Circuits', John Wiley, 2004Simulink Reference Manual, Math works, USA.
6. Referred Journal/Conference Publications

Flexible AC Transmission Systems (FACTS)

	Credits: 3	L	T	P
Course code: EEM 128		3	0	0

Module 1

Introduction to FACTS Technology, Types of FACTS controllers, FACTS vs. HVDC, Benefits of FACTS Technology, Performance Equations and Parameters of Transmission Lines, Transfer of Active and Reactive Power over a Transmission Line, Uncompensated Transmission, Need for Compensation, Definition and Functions of compensation.

Module 2

Compensation Techniques: Ideal Shunt compensation, Ideal Series compensation, Phase-Angle control (Regulator), Advantages of Series compensation (voltage support, Transient stability improvement, Power oscillation damping), Advantages of shunt compensation, Thyristor-Controlled Reactor (TCR), Thyristor-Switched Capacitor (TSC).

Module 3

Analysis of various types of Static Var compensators (SVC), Static Synchronous Compensator (STATCOM): Analysis and comparison with SVC, STATCOM convertors (Multi-level VSIs for STATCOM applications), Series compensators: GTO-Controlled Series Capacitor (GCSC), Thyristor-Switched Series Capacitor (TSSC), Thyristor-Controlled Series Capacitor (TCSC), Static Synchronous Series Compensator (SSSC).

Module 4

Voltage & Phase-Angle Regulation, Thyristor-Controlled Voltage Regulator (TCVR), Thyristor-Controlled Phase-Angle Regulator (TCPAR), Series-Shunt compensator: Unified Power Flow Controller (UPFC), Series-Series compensator: Interline Power Flow Controller (IPFC), Thyristor Controlled Braking Resistor (TCBR), Modeling of some FACTS controllers.

Text Books

2. Hingorani & Gyugyi, “Understanding FACTS – Concepts and Technology of Flexible AC Transmission Systems” Wiley publishers.
3. Mathur & Varma, “Thyristor–Based FACTS Controllers for Electrical Transmission Systems” IEEE Press Series on Power Engineering.

References

4. K.R. Padiyar, “FACTS Controllers in Power Transmission and Distribution” New Age International Publishers.
5. Journal & Conference publications.
6. Online NPTEL Lecture series on FACTS.

HYBRID ELECTRIC VEHICLES

Credits: 3

Course Code: EEM 129	**L**	**T**	**P**
	3	**0**	**0**

Module-1

Introduction: Conventional vehicle and its components, propulsion load, drive cycles, Concept of electric vehicles and hybrid electric vehicles (HEVs), architectures of HEVs, series and parallel HEVs, complex HEVs.

Module-2

HEVs Drive-train: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

Module-3

Plug-in Hybrid Electric Vehicles: PHEVs Architectures, equivalent electric range of PHEVs; Fuel economy of PHEVs, power management of PHEVs, PHEVs battery charging, end-of-life battery for electric power grid support, vehicle to grid technology.

Module-4

Power Electronics in HEVs: Rectifiers used in HEVs, Buck converter used in HEVs, non-isolated bidirectional DC-DC converter, regenerative braking, voltage source inverter, current source inverter, isolated bidirectional DC-DC converter, PWM rectifier in HEVs, EV and PHEV battery chargers.

Text Books

1. Chris Mi and M. Abul Masrur, "Hybrid Electric Vehicle: Principles and Applications with Practical Perspectives" John Wiley & Sons.
2. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory and Design" CRC Press.

References

1. Iqbal Husain, "Electric and Hybrid Vehicles: Design Fundamentals" CRC Press.
2. Ronald K. Jurgen, "Electric and Hybrid-electric Vehicles" SAE International.
3. Referred Journals/Conference Publications

NON-LINEAR SYSTEMS

Credits: 3	**L**	**T**	**P**
Course code: EEM 130	**3**	**0**	**0**

Module 1:

Introduction To Non-Linear Systems: Why Non-Linear Control, Non-Linear System Behaviour, Multiple Equilibrium Points, Limit Cycles, Dependence of Non-linear system behaviour on initial conditions, Bifurcations and chaos, Commonly Occurring Non-linearities in Physical Systems: Saturation, On-Off Non-linearity, Dead Band Non-Linearity, Hysteresis/Backlash etc., Phase Plane Analysis of Non-linear systems

Module 2:

Linearization of Non-linear systems: Types of Non-linearities: Hard and Soft, Autonomous and Non-Autonomous Systems, Local Linearization of Non-linear systems with Soft Non-linearities, concept of Jacobian, Applicability of linearized models, and Concept of local stability.

Module 3:

Describing Function Analysis: Describing Function Fundamentals, Application Domain, Basic Assumptions, Computing Describing Functions, Describing Functions of Common Non-linearities, Describing Function Analysis of Non-Linear Systems, and Reliability of Describing Function Analysis.

Module 4:

Fundamentals of Lyapunov theory: Lyapunov's direct method, Positive Definite Functions and Lyapunov functions, Stability Analysis based on Lyapunov's direct method, Controller design based on Lyapunov's direct method, Concept of stability for Non-linear systems, Lyapunov Stability Analysis of Non-linear systems.

Books Recommended

1. Slotine and Li, " Applied Nonlinear Control" - Prentice-Hall Publication
2. H. K. Khalil, " Non-Linear Systems" Prentice Hall, 2001
3. M Vidyasagar, "Non-linear System Analysis", 2nd Edition, Prentice Hall, 1993
4. Alberto Isidori, "Nonlinear Control Systems",Vol I and II, Springer, 1999

POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

Credits: 3

Course Code: EEM 131	**L**	**T**	**P**
	3	**0**	**0**

Module-1

Overview of conventional and renewable energy technologies, World and India's renewable energy scenario, Energy security, Energy growth, Energy demands, Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems.

Module-2

Solar photo voltaic (SPV) system, Array sizing, Battery sizing, MPPT, Power Electronic Interface of SPV system in isolated and grid connected mode.

Module-3

Wind power generation, Wind energy conversion system (WECS), Power Electronic Interface of WECS, Stand alone operation of fixed and variable speed WECS, Grid integrated PMSG and SCIG based WECS.

Module-4

Need for hybrid energy systems, Type and range of hybrid energy systems, Case studies of SPV & Wind energy systems.

Text Books

1. B. H. Khan, "Non Conventional Energy Resources", Tata McGraw-Hill, New Delhi.
2. C. S. Solanki, "Solar Photovoltaics", PHI.
3. S. N. Bhadra, D. Kastha, S. Banerjee, "Wind Electrical Systems", Oxford.
4. Freris L. L., "Wind Energy Conversion Systems", PHI.

References

1. M. S. J. Asghar, "Power Electronics", PHI.
2. MNRE Manual.
3. Referred Journals/Conference Publications

SMART GRID TECHNOLOGY

Credits: 3

Course Code: EEM 132	**L**	**T**	**P**
	3	**0**	**0**

Module 1

Introduction to AC and DC microgrids and their significance in the contemporary power scenario. Renewable integration, Standalone systems, grid interface, and energy storage in microgrids. Power converters for used in Micro-Grids: AC-DC, DC-DC, DC-AC, AC-AC topologies.

Module 2:

Control of Microgrids: PLL and synchronization,Grid connection issues: leakage current, islanding, harmonics, active/reactive power feedin. Aspects of mechanical control, ratings; Power extraction (MPP) and MPPT schemes.

Module 3

Introduction to smart grid architecture, Advance Metering Infrastructure, Communication technologies, Cost benefit analysis and Business Model of smart grids – case study Data analytics. Forecasting techniques, Demand Response - mathematical formulation and solution.

Module 4

Electric vehicles Cyber security, Vehicle to Grid technology, Smart grid standards, Smart grid regulations, smart Cities, Smart grids and power markets Indian scenario, Pilot projects, and Road map with case studies Smart grid technology for Transmission system

Text books

4. Smart grid handbook, Vol. 1, 2, and 3 - By - Liu, Chen-Ching (Ed.) McArthur, Stephen(Ed.) Lee, Seung-Jae (Ed.) 2015.
5. Smart grid communications and networking by Hossain, Ekram (Ed.) Cambridge University Press 2012.
6. Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, Wiley-IEEE Press, 2011.ix
7. DC distribution systems and micro-grids by Tomislav Dragicevic and Pat Wheeler, IET.

Reference books:

1. Robert Ericson, 'Fundamentals of Power Electronics', Chapman & Hall, 1997.

2. N. Mohan, T.M. Undeland & W.P. Robbins, Power Electronics: Converter, Applications & Design, John Wiley & Sons, 1989
3. Muhammad H. Rashid, Power Electronics: Circuits, Devices, and Applications, Pearson Education India, 2004
4. Referred Journals/Conference Publications

INTELLIGENT CONTROL IN POWER ELECTRONICS

Credits: 3

Course Code: EEM 133	**L**	**T**	**P**
	3	**0**	**0**

Module-1

Introduction to Artificial Intelligence, Basic concept and applications.. Artificial Neural Networks. Typical applications of ANNs : Classification, Clustering, Vector Quantization, Optimization

Module-2

Working of ANN - Training, Learning and Generalization;: Single-layer networks and Multi-layer networks-Architecture, Back Propagation Algorithm (BTA) and other training algorithms**.** **Applications of neural networks in power electronic converter control.**

Module-3

Introduction to Fuzzy Logic Systems. Structure of algebra of fuzzy sets. Fuzzy relations, fuzzy matrices and operations with them. Elements of fuzzy logic, fuzzy negations, fuzzy implications. Fuzzy reasoning, **Application of fuzzy logic in power electronic systems, uncertainity modeling and practical examples.**

Module-4

Introduction to model predictive control and finite control set model predictive control in power electronic converters, multi-objective predictive control, weight assignment and optimization, Sensor elimination using load predictive models, practical cases.

Text Books

2. K. Mehrotra, C.K. Mohan and Sanjay Ranka, Elements of Artificial Neural Networks, MIT Press, 1997 - [Indian Reprint Penram International Publishing (India), 1997].
3. Simon Haykin, Neural Networks - A Comprehensive Foundation, Macmillan Publishing Co., New York, 1994
4. PID and predictive control of Electrical Drives and power converters using Matlab/Simulink by Liuping Wang, Shan Chai et al.- Wiley

Reference Books

1. Modern Power Electronics and AC motor Drives By Bimal K Bose- Pearson Publishers.
2. Referred Journal/Conference Publications.

MODERN POWER ELECTRONICS

Credits: 3

Course Code: EEM 134

L	T	P
3	0	0

Module-1 Three phase rectifier circuits- a review. Power quality problems associated with conventional rectifier circuits, conventional power factor corrective converters.

Module-2

Design of passives for power electronic converters, Resonant Converters, Soft switching techniques, Zero Voltage Switching and Zero Current switching.

Module-3

High Power Converters- Diode Clamped Multi-level converter, Flying capacitor type multi-level converter, Cascaded H-bridge multi-level converter, Capacitor voltage unbalancing in multi-level converters

Module-4

Matrix Converters, Modulation techniques of matrix converters, applications, Z-Source Converters.

Text Books

1. Robert Ericson, 'Fundamentals of Power Electronics', Chapman & Hall, 1997.

2. N. Mohan, T.M. Undeland & W.P. Robbins, Power Electronics: Converter, Applications & Design, John Wiley & Sons, 1989

3. High Power Converters and AC Drives by Bin Wu, Wiley.

References

1. Modern Power Electronics and AC motor Drives By Bimal K Bose- Pearson Publishers.
2. Three-phase AC-AC Power Converters Based on Matrix Converter Topology by Pawel Szczesniak, Springer.
3. Referred Journal/Conference publications.

DRIVE SYSTEM IN ELECTRIC TRACTION

Credits: 3

Course Code: EEM 135	**L**	**T**	**P**
	3	**0**	**0**

Module-1

General features of electric traction, mainline and suburban trains, nature of load and motor for traction, mechanism of train movement, duty cycle, torque sharing between motors, driving axle code.

Module-2

Calculation of tractive effort, drive rating and energy consumption, specific energy consumption, electrical motors for traction, starting and speed control of traction motors.

Module-3

Power electronic converters in modern traction practice: phase controlled converters, choppers, VSI, PWM control.

Module-4

Diesel electric traction, characteristics of diesel engine, AC and DC drives in Electric Traction, comparative advantages of AC traction drives over DC traction drives.

Text Books

1. G. K. Dubey, Fundamentals of Electric Drives, Narosa Publications, New Delhi.
2. Shepherd W., Halley L.N., Liang D.T.W., "Power Electronics and Motor Control", Cambridge Printing Press, UK.
3. Andrews H.I., "Railway Traction-The Principles of Mechanical and Electrical Railway Traction", Elsevier, Prentice Hall.

References

1. Bose B.K., "Power Electronics & Variable Frequency Drives – Technology & Applications", IEEE Press, Standard Publisher Distributors, Delhi.
2. Referred Journals/Conference publications

SPECIAL ELECTRIC MACHINES

Credits: 3

Course Code: EEM 136	**L**	**T**	**P**
	3	**0**	**0**

Module-1

Switched Reluctance Motor (SRM): Construction, Principle of Working, Basics of SRM Analysis, Constraints on Pole Arc and Tooth Arc, Torque Equation and Characteristics, Power Converter Circuits, Control of SRM, Rotor Position Sensors, Current Regulators, Microprocessor – Based Control of SRM, Sensorless Control of SRM.

Permanent Magnet DC Motor and Brushless Permanent Magnet DC Motor: Permanent Magnet DC (PMDC) motor, Brushless Permanent Magnet DC (BLDC) Motors.

Module-2

Synchronous Reluctance Motor (SyRM): Constructional of SyRM, Working, Phasor Diagram and Torque Equation, Control of SyRM, Advantages and Applications.

Module-3

Single Phase Special Electrical Machines: AC series Motor, Repulsion Motor, Hysteresis Motor, Single Phase Reluctance Motor, Universal Motor. Double cage induction motor**Servo Motors:** DC Servo Motors, AC Servo Motors.

Module-4

Linear Electric Machines: Linear Induction Motor, Linear Synchronous Motor, DC Linear Motor, Linear Reluctance Motor, Linear Levitation Machines.

Permanent Magnet Axial Flux (PMAF) Machines: Comparison of Permanent Radial and Axial Flux Machines, Construction of PMAF Machines, Armature Windings, torque and EMF Equations of PMAF, Phasor Diagram, Output Equation, Pulsating Torque And its Minimisation, Control and Applications of PMAF.

Text Books

1. Electrical Machines ,Ramamorrthy, , PHI learning private limited, 2017
2. Special electrical Machines, K.Venkata Ratnam, University press, 2009, New Delhi.

References

1. Brushless Permanent magnet and reluctance motor drives, Clarenden press, T.J.E. Miller, 1989, Oxford.
2. Special electrical machines, E.G. Janardhanan, PHI learning private limited, 2014.
3. Referred Journals/Conference publications

OPTIMAL CONTROL
Credits: 3

Course code: EEM 137	**L**	**T**	**P**
	3	**0**	**0**

Module 1:
Introduction: Classical and Modern Control, Concept of Optimization, Statement of the Optimal Control Problem, Performance Index, Constraints, Types of Constraints.

Module 2:
Calculus of Variations and Optimal Control: Basic Concepts: Function and Functional, Increment, Differential and Variation, Optimum of a function and a functional, basic variational problem, Fixed-end time and fixed-end state system, Discussion of Euler-Lagrange equation, Different cases for Euler-Lagrange equation, the second variation, Extrema of functions and functionals with conditions, Variational Approach to Optimal Control Systems, Optimal Control Systems with Hamiltonian formalism (Pontryagin principle), application to minimum time, energy and control effort problem.

Module 3:
Linear Control Optimal Control Systems: Finite Time Linear Quadratic Regulator, LQR System for general performance index, Analytical Solution to the Matrix differential Ricatti equation, Infinite Time Linear Quadratic Regulator, Finite-Time Linear Quadratic Tracking Problem

Module 4:
Dynamic Programming: Bellman's principle of optimality, Multistage decision processes, Optimal Control using Dynamic Programming, The HJB Equation

Books Recommended

1. D.S. Naidu, "Optimal Control Systems", CRC Press, 2003
2. D. E. Kirk, "Optimal Control Theory" Prentice Hall, 1970
3. Anderson and Moore, "Linear Optimal Control", Prentice Hall, 1971
4. Enid R Pinch, "Optimal Control and Calculus of Variations", Oxford University Press

RENEWABLE SOURCES OF ENERGY

	Credits: 3	L	T	P
Course code: EEM 105		3	0	0

Module 1

Introduction: Review of Conventional and Non-conventional energy resources, Energy problem, Energy and environment, Need for renewable, Policy-Technology-Energy conversion systems, Rural Energy.

Module 2

Solar Energy: Basics of solar energy, Solar Geometry, Measurement and calculation of solar radiation, solar policies and capacity, Direct and indirect methods of energy conversion.

Module 3

Solar Energy Technology:

Solar Photovoltaic (PV): solar cell, module, array; Solar PV system – stand alone and grid connected.

Solar Thermal: solar collectors - flat plate and concentrating, solar water heaters, solar thermal power plants.

Module 4

Wind Energy Conversion System: Wind energy – origin and availability, wind sEEM 1XX and power duration curves, site selection, system components, principles of electrical power generation.

Module 5

Ocean Energy: Electric power generation from Tidal energy, Wave energy and OTEC system, Hybrid energy system.

Text Books

1. B.H. Khan, "Non-Conventional Energy Resources", McGraw Hill Education, 3rd Edition.
2. M. R. Patel, Wind and Solar Power Systems: Design, Analysis, and Operation, Second Edition, Taylor & Francis.

References

1. J. K. Kaldellis, "Stand-Alone and Hybrid Wind Energy Systems: Technology, Energy Storage and applications", CRC Press.
2. B. Zohuri, "Hybrid Energy Systems: Driving Reliable Renewable Sources of Energy Storage", Springer.
3. Referred Journals/Conference Publications

MODELING & SIMULATION OF POWER SYSTEM COMPONENTS

Credits: 3

	L	T	P
Course Code: EEM 107	**3**	**0**	**0**

Module 1:

Synchronous Machine Theory and Modeling: Physical description –Mathematical description of a synchronous Machine – dqo transformation – Per Unit representation-Steady state analysis of Synchronous Machine- Equivalent circuit.

Module 2:

Induction Machine Modeling: Mathematical descriptions of Induction machine – dqo transformation - steady state characteristics-equivalent circuit- Torque -slip characteristics – per unit representation.

Module 3:

Excitation System Modeling: Excitation system requirements - Elements of an Excitation system –Types of Excitation systems-DC, AC and Static excitation systems- Self Excited DC exciter – Stabilizing Circuit-Modeling of power System stabilizer (PSS)

Module 4:

Transmission Line and Transformer Modeling: Pie Model of Transmission line- In phase Transformer – Phase shifting Transformer-Three winding transformer-modeling of Tap Changing transformer-Modeling of load-Modeling of power network-Inter phase power controller.

Hydraulic Turbine Modeling: Turbine Modeling-Governor Modeling -Transfer Function – Electrical Analogue – Non Ideal Turbine

Text books

1. Power System Dynamics and Simulation by Abhijit Chakrabarti - PHI Publishers, 2015
2. P.S.Bhimra, “Generalized theory of electrical machinery”, Khanna publications
3. P.kundur , “ Power System Stability and Control”, Mc Graw-Hill Publications
4. S Krishna “ An Introduction to Modeling of power Systems Components-Springer-2013

SOFT COMPUTING

Credits: 3

	L	T	P
Course code: EEM 108	**3**	**0**	**0**

Module 1

Introduction to Soft Computing: Concept of computing systems, soft vs. hard computing, various types of soft computing techniques, Fuzzy Computing, Neural Computing, Genetic Algorithms, Adaptive Resonance Theory, Classification, Some applications of soft computing techniques.

Module 2

Evolutionary Algorithm: Fundamentals of Genetic Algorithms, basic concepts of "Genetics" and "Evolution", working principle, encoding, fitness function, reproduction, genetic modeling. Basic GA framework and different GA architectures, GA operators: Crossover, Selection, Mutation, Solving single-objective optimization problems using GAs.

Module 3

Fuzzy Set Theory & Fuzzy Systems: Fuzzy set theory, Fuzzy set versus crisp set, Crisp relation & fuzzy relations, introduction & features of membership functions, Extension Principle, Fuzzy If-Then Rules, Fuzzy Inference Systems, Sugeno Fuzzy Models, Fuzzification, Defuzzification, Applications.

Module 4

Fundamentals of Artificial Neural Network (ANN): Introduction, model of artificial neuron, Architectures, Learning methods, Deep learning, Taxonomy of ANN Systems, Single layer ANN system, Supervised learning neural networks, Perceptron, Adeline, Back propagation, Multilayer perceptron, Applications of ANN in research.

Text Books

1. Timothy J.Ross, "Fuzzy Logic with Engineering Applications", McGraw-Hill, 1997.
2. Davis E.Goldberg, "Genetic Algorithms: Search, Optimization and Machine Learning", Addison Wesley, N.Y., 1989.

References

1. Dan W. Patterson, "Introduction to AI and Expert System", PHI, 2009.
2. J.S.R.Jang, C.T.Sun and E.Mizutani, "Neuro-Fuzzy and Soft Computing", PHI, 2004, Pearson Education 2004.
3. Online NPTEL Lecture series on Soft Computing.

SCADA SYSTEMS

Credits: 3 | **L T P**

Course code: EEM 108 | **3 0 0**

Module 1:

General Theory: Purpose and necessity, general structure, data acquisition, transmission and monitoring, general power system hierarchical structure, overview of the methods of data acquisition systems, commonly acquired data, transducers, RTUs, data concentrators, various communication channels, cables, telephone lines, power line carrier, microwaves, fiber- optical channels and satellites.

Module 2:

Supervisory and Control Functions: Data acquisitions, status indications, measured values, energy values, monitoring alarm and event application processing. Control function: ON/OFF control of lines, transformers, capacitors and applications in process industry, valve, opening, closing etc. Regulatory functions: set points and feed-back loops, time tagged data, disturbance data collection and analysis, calculation and report preparation.

Module 3:

Man-Machine Communication: Operator consoles and VDUs, displays, operator dialogues, alarm and event loggers, mimic diagrams, report and printing facilities.

Data bases - SCADA, EMS and network data bases: SCADA system structure - local system, communication system and central system, Configuration- non-redundant single processor, redundant dual processor, multi control centers, system configuration. Performance considerations: real time operation system requirements, modularization of software programming languages.

Module 4:

Energy Management Center: Functions performed at a centralized management center, production control and load management, economic dispatch, distributed centers and power pool management.

Text books

1. Torsten Cegrell, Power System Control Technology, Prentice Hall International, 1986.
2. Stuart A. Boyer, SCADA: Supervisory Control and Data Acquisition, The Instrumentation, Systems and Automation Society, 4th edition, 2009.
3. Krishna Kant, Computer-Based Industrial Control, PHI Learning, 2nd edition, 2013.

References

1. Bela G. Liptak, Instrument Engineers Handbook, Volume 3: Process Software and Digital Networks, CRC Press, 4th edition, 2011.
2. Behrouz Forouzan, Data Communications and Networking, McGraw-Hill, 5th edition, 2012.

STAND-ALONE ENERGY SYSTEMS

	Credits: 3	**L**	**T**	**P**
Course code: EEM 113		**3**	**0**	**0**

Module 1

Introduction to Stand-Alone Energy Systems: Solar, Wind, Micro-hydel and Diesel Power Generation Systems, Introduction to various energy storage devices.

Module 2

Solar based Stand-Alone Energy Systems: Connection of PV Module in Series and Parallel, I-V and P-V characteristics, Sizing of the PV array and battery, charge controller, Maximum Power Point Trackers, Power Electronics interface of SPV system with load and existing grid.

Module 3

Wind based Stand-Alone Energy Systems: Directly coupled Stand-Alone Wind System, Stand-Alone wind system with storage, Power Electronics interface of wind system with load and existing grid.

Module 4

Hybrid Stand-Alone Energy Systems: Modeling and Analysis of various combinations like PV-Wind, PV-Diesel and PV-Mains with examples.

Text Books

1. M. R. Patel, Wind and Solar Power Systems: Design, Analysis, and Operation, Second Edition, Taylor & Francis.
2. J. K. Kaldellis, "Stand-Alone and Hybrid Wind Energy Systems: Technology, Energy Storage and applications", CRC Press.
3. B. Zohuri, "Hybrid Energy Systems: Driving Reliable Renewable Sources of Energy Storage", Springer.

References

4. D. Rekioua, "Wind Power Electric Systems: Modeling, Simulation and Control", Springer.
5. Referred Journals/Conference Publications

ADVANCED INSTRUMENTATION TECHNOLOGY

Credits: 3

Course Code: EEM 117	**L**	**T**	**P**
	3	**0**	**0**

Module 1

Chemical Sensors: Blood –Gas and Acid –base physiology Electrochemical sensors, Chemical Fibro sensors, Iron-Selective Field-Effect Transistor (ISFET), Immunologically Sensitive Field Effect Transistor (IMFET) , Integrated flow sensor and Blood Glucose sensors.

Optical Sensors: Fiber optic light propagation, Graded index fibers, Fiber optic communication driver circuits, Laser classifications, Driver circuits for solid–state laser diodes, Radiation sensors and Optical combinations.

Module 2

Biomedical Sensors: Sensors Terminology in human body, Introduction, Cell, Body Fluids Musculoskeletal system, Bioelectric Amplifiers, Bioelectric Amplifiers for Multiple input Circuits, Differentional Amplifiers, Physiological Pressure and other cardiovascular measurements and devices.

Module 3

Electrodes: Electrodes for Biophysical sensing, Electrode model circuits, Microelectrodes, ECG, EEG, electrodes ECG signals, waveforms, Standard lead system, Polarization Polarizable, Non polarizable electrodes and body surface recording electrodes. Ultrasonic Transducers for Measurement and therapy – radiation detectors – NIR spectroscopy.

Module 4

Advanced Sensor Design: Fluoroscopic machines design, Nuclear medical systems, EMI to biomedical sensors, types and sources of EMI, Fields, EMI effects. Computer systems used in X-ray and Nuclear Medical equipments. Calibration, Typical faults, Trouble shooting, Maintenance procedure for medical equipments and Design of 2 & 4 wire transmitters with 4–20 mA output.

Aerospace Sensor: Laser Gyroscope and accelerometers, sensors used in space and environmental applications.

Text Book:

1. Sensors Hand Book Sabaree Soloman - Sensors Hand Book, McGraw Hill, 1998.
2. Principles of Holography, H. M. Smith, John Wiley & Sons, New York, 1975.
3. Medical instrumentation Application and Design, J. G. Webster, Houghton Mifilin Co. 2004.

References

1. Introduction to Medical Equipment Technology, Carr and Brown, Addison Wesley. 1999
2. Optical Fibre Sensors, B. Culshaw and J. Dakin J (Eds), vol. 1 & 2 Artech House, Norwood. (1989).
3. Guided Weapon Control Systems, P. Garnell, Pergamon Press. 1980.

EMBEDDED SYSTEMS AND REAL TIME APPLICATIONS

Credits: 3

Course Code: ECEM 159	**L**	**T**	**P**
	3	**0**	**0**

Module 1

Embedded system concepts, Hardware organization and architecture.

Module 2

Microcontrollers, ADC/DAC, Input/Output devices, Memory devices.

Module 3

Synchronous/Asynchronous data transfer, Serial/parallel communication ports.

Module 4

Programming embedded systems, Embedded board level design concepts, Introduction to MEMS.

Text books:

1. Introduction to Embedded Systems by McGraw Hill Education India Private Limited
2. Embedded System Design: A Unified Hardware / Software Introduction by Wiley

References:

1. Referred Journal/Conference Publications

OPTIMIZATION TECHNIQUES
Credits: 3

Course Code: MTM 101

L	T	P
3	0	0

Module 1

Mathematical formulation of optimization problems and their general methods of solution. Multiobjective and goal programming (solution using graphical methos and simplex based methods).

Module 2

Kuhn Tucker theory, quadratic programming, Direct search and gradient methods, Optimum of a unimodal function, Fibonacci method, Method of steepest descent.

Module 3

Newton-Raphson method, Hooke's and Jeeve's method, Conjugate gradient method. Bellman's principle of optimality and methods of recursive optimization (simple problems involving upto one constant).

Module 4

Introduction to recent optimization techniques for engineering applications (Genetic algorithms and Particle swarm technique).

Text books:

1. Engineering Optimization: Theory and Practice, 4th Edition by Singiresu S. Rao. (Wiley)

References:

1. Essentials of Metaheuristics by Sean Luke