AFFILIATED INSTITUTIONS

ANNA UNIVERSITY, CHENNAI

REGULATIONS - 2009

CURRICULUM AND SYLLABUS I SEMESTER & ELECTIVES

M.E. ELECTRICAL DRIVES AND EMBEDDED CONTROL

SEMESTER I

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	MA9314	Applied Mathematics for Electrical Engineers	3	1	0	4
2	EB9311	Analysis of Power Converters	3	0	0	3
3	EB9312	Dynamic Modelling, Analysis and Design of DC Drives	3	0	0	3
4	ET9311	Design of Embedded System	3	0	0	3
5	CL9312	System Theory	3	0	0	3
6	E1	Elective I	3	0	0	3
		TOTAL	**18**	**1**	**0**	**19**

ELECTIVES FOR ELECTRICAL DRIVES AND EMBEDDED CONTROL

SEMESTER I

SL NO.	COURSE CODE	COURSE TITLE	L	T	P	C
1	HV9311	Electro Magnetic Field Computation and Modelling	3	1	0	4
2	PE9351	Advanced Power Semiconductor Devices	3	0	0	3
3	CL9311	Transducers and Measurements	3	0	0	3

MA 9314 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS L T P C
3 1 0 4

1. ADVANCED MATRIX THEORY: 9

Eigen-values using QR transformations – Generalized eigen vectors – Canonical forms – Singular value decomposition and applications – Pseudo inverse – Least square approximations.

2. LINEAR PROGRAMMING 9

Formulation – Graphical Solution – Simplex Method – Two Phase Method – Transportation and Assignment Problems.

3. ONE DIMENSIONAL RANDOM VARIABLES 9

Random variables - Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a Random Variable.

4. QUEUEING MODELS 9

Poisson Process – Markovian queues – Single and Multi Server Models – Little's formula - Machine Interference Model – Steady State analysis – Self Service queue.

5. COMPUTATIONAL METHODS IN ENGINEERING 9

Boundary value problems for ODE – Finite difference methods – Numerical solution of PDE – Solution of Laplace and Poisson equations – Liebmann's iteration process – Solution of heat conduction equation by Schmidt explicit formula and Crank-Nicolson implicit scheme – Solution of wave equation.

L +T: 45+15 = 60 PERIODS

BOOKS FOR REFERENCE:

1. Bronson, R., Matrix Operation, Schaum's outline series, McGraw Hill, New York, (1989).
2. Taha, H. A., Operations Research: An Introduction, Seventh Edition, Pearson Education Edition, Asia, New Delhi (2002).
3. R. E. Walpole, R. H. Myers, S. L. Myers, and K. Ye, Probability and Statistics for Engineers & Scientists, Asia, 8th Edition, (2007).
4. Donald Gross and Carl M. Harris, Fundamentals of Queueing theory, 2nd edition, John Wiley and Sons, New York (1985).
5. Grewal, B.S., Numerical methods in Engineering and Science, 7th edition, Khanna Publishers, 200

EB 9311	ANALYSIS OF POWER CONVERTERS	L T P C
		3 0 0 3

1. SINGLE PHASE AC-DC CONVERTERS **9**

Uncontrolled, half controlled and fully controlled with R-L, R-L-E loads and free wheeling diode - continuous and discontinuous modes of operation – inverter operation –Dual converter – Sequence control of converters – Performance parameters: harmonics, ripple, distortion, power factor – effect of source impedance and overlap.

2. THREE PHASE AC-DC CONVERTERS **9**

Uncontrolled, half controlled and fully controlled with R-L, R-L-E loads and free wheeling diodes – Inverter operation and its limit – Dual converter – Performance parameter effect of source impedance and overlap.

3. DC – DC CONVERTERS **9**

Principles of step-down and step-up converters – Analysis of buck, boost, buck-boost and Cuk converters – Time ratio and current limit control – Full bridge converter – Resonant and Quasi-resonant converters.

4. DC – AC CONVERTERS **9**

Voltage source inverters - Principle of operation of half and full bridge inverters – 180 degree and 120 degree conduction mode inverters – Voltage control of three phase inverters using various PWM techniques – Harmonics and various harmonic elimination techniques – Analysis with R-L, R-L-E loads – Multi level inverters.

5. AC – AC CONVERTERS **9**

Principle of operation of AC Voltage Controllers, Cycloconverters – Analysis with R-L, R-L-E loads – Introduction to Matrix converters.

TOTAL : 45 PERIODS

TEXT BOOKS

1. Ned Mohan , Undeland and Robbin, “Power Electronics: Converters, Application and Design” A John Wiley and Sons, Inc., Newyork, 1995
2. Rashid M.H . “Power Electronics Circuits, Devices and Applications”, Prentice Hall of India, New Delhi, 1995

REFERENCES

1. P.C Sen .”Modern Power Electronics” Wheeler publishing Co ,First Edition ,New Delhi- 1998.
2. P.S.Bimbra , “Power Electronics”, Khanna Publishers, Eleventh Edition , 2003.
3. Bin Wu, “High Power Converters and AC Drives”, IEEE Press, A John Wiley and Sons, Inc., 2006.

EB 9312 DYNAMIC MODELLING, ANALYSIS AND DESIGN OF DC DRIVES **L T P C**
3 0 0 3

1. SELECTION OF ELECTRIC DRIVES **9**

Equations governing motor load dynamics – Steady state and dynamic state stability – Four quadrant operation – Duty and Rating – Heating and cooling curves – Selection of electric drives for applications: Agricultural pumps, steel mills, paper mills, rolling mills, spinning mills, cement industries, chemical industries, refineries, shipping, power stations and automobiles.

2. PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION **9**

General expression of stored magnetic energy and co-energy, force and torque - Example using singly and doubly excited systems. Calculation of air-gap mmf and per phase machine inductance using physical machine data.

3. DYNAMIC MODELLING OF DC MACHINES **9**

Voltage and torque equations – Dynamic characteristics of permanent magnet and shunt DC motors – State equations – Solution of dynamic characteristic by Laplace transformation - Computer simulation.

4. CONVERTER CONTROL OF DC MOTORS **9**

Analysis of separately excited DC motors fed from single phase and three phase converters operating in different modes and configurations – Dynamic and regenerative braking of DC drives – Design of closed-loop operation of rectifier fed DC drive systems.

5. CHOPPER CONTROL OF DC MOTORS **9**

Analysis of series and separately excited DC motors fed from different Choppers with CLC and TRC strategies – Dynamic and regenerative braking of DC drives – Design of closed-loop operation of DC drive systems.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. Paul C.Krause, OlegWasyzczuk, Scott D.Sudhoff ‘Analysis of Electric Machinery and Drive Systems” IEEE Press, Second Edition, 2002.
2. R.Krishnan, “Electric Motor Drives, Modeling, Analysis and Control” Prentice Hall of India, 2002.
3. Buxbaum, A. Schierau, and K.Staughen, “A design of control systems for DC drives”, Springer-Verlag, Berlin,1990.
4. Dubey,G.K. “Power Semiconductor controlled devices”, Prentice Hall International, New Jersey, 1989.

REFERENCES:

1.Samuel Seely, “Electromechanical Energy Conversion”, Tata McGraw Hill Publishing Company, 2000.
2. A.E.Fitzgerald,Charles Kingsley,Jr. and Stephen D.Umans, “Electric Machinery”, Tata McGraw Hill, Fifth Edition, 1992.
3. Generalized theory of Electrical Machines, P.S.Bimra, Khanna Publishers, 1995.
4. Bin Wu, “High Power Converters and AC Drives”, IEEE Press, A John Wiley and Sons, Inc., 2006.

ET 9311 DESIGN OF EMBEDDED SYSTEMS L T P C
3 0 0 3

1. EMBEDDED DESIGN LIFE CYCLE 9

Product specification – Hardware / Software partitioning – Detailed hardware and software design – Integration – Product testing – Selection Processes – Microprocessor Vs Micro Controller – Performance tools – Bench marking – RTOS Micro Controller – Performance tools – Bench marking – RTOS availability – Tool chain availability – Other issues in selection processes.

2. PARTITIONING DECISION 9

Hardware / Software duality – coding Hardware – ASIC revolution – Managing the Risk – Co-verification – execution environment – memory organization – System startup – Hardware manipulation – memory mapped access – speed and code density.

3. INTERRUPT SERVICE ROUTINES 9

Watch dog timers – Flash Memory basic toolset – Host based debugging – Remote debugging – ROM emulators – Logic analyser – Caches – Computer optimisation – Statistical profiling

4. IN CIRCUIT EMULATORS 9

Buller proof run control – Real time trace – Hardware break points – Overlay memory – Timing constraints – Usage issues – Triggers.

5. TESTING 9

Bug tracking – reduction of risks & costs – Performance – Unit testing – Regression testing – Choosing test cases – Functional tests – Coverage tests – Testing embedded software – Performance testing – Maintenance.

TOTAL : 45 PERIODS

REFERENCE

1. Arnold S. Berger – “Embedded System Design”, CMP books, USA 2002.
2. Sriram Iyer, “Embedded Real time System Programming”
3. ARKIN, R.C., Behaviour-based Robotics, The MIT Press, 1998.

CL 9312	SYSTEM THEORY	L T P C 3 0 0 3

1. STATE VARIABLE REPRESENTATION 9

Introduction-Concept of State-State equation for Dynamic Systems-Time invariance and linearity-No uniqueness of state model-State Diagrams-Physical System and State Assignment.

2. SOLUTION OF STATE EQUATION 9

Existence and uniqueness of solutions to Continuous-time state equations-Solution of Nonlinear and Linear Time Varying State equations-Evaluation of matrix exponential-System modes-Role of Eigenvalues and Eigenvectors.

3. CONTROLLABILITY AND OBSERVABILITY 9

Controllability and Observability-Stabilizability and Detectability-Test for Continuous time Systems- Time varying and Time invariant case-Output Controllability-Reducibility-System Realizations.

4. STABILTY 9

Introduction-Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems-Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and Variable-Gradiant Method.

5. MODAL CONTROL 9

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems-The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

TOTAL: 45 PERIODS

REFERENCES:

1. M. Gopal, “Modern Control System Theory”, New Age International, 2005.
2. K. Ogatta, “Modern Control Engineering”, PHI, 2002.
3. John S. Bay, “Fundamentals of Linear State Space Systems”, McGraw-Hill, 1999.
4. D. Roy Choudhury, “Modern Control Systems”, New Age International, 2005.
5. John J. D’Azzo, C. H. Houpis and S. N. Sheldon, “Linear Control System Analysis and Design with MATLAB”, Taylor Francis, 2003.
6. Z. Bubnicki, ”Modern Control Theory”, Springer, 2005.

HV 9311 ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING L T P C
3 1 0 4

1. INTRODUCTION 9

Review of basic field theory – electric and magnetic fields – Maxwell's equations – Laplace, Poisson and Helmoltz equations – principle of energy conversion – force/torque calculation – Electro thermal formulation.

2. SOLUTION OF FIELD EQUATIONS I 9

Limitations of the conventional design procedure, need for the field analysis based design, problem definition , solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods- Finite Difference Method.

3. SOLUTION OF FIELD EQUATIONS II 9

Finite element method (FEM) – Differential/ integral functions – Variational method – Energy minimization – Discretisation – Shape functions –Stiffness matrix –1D and 2D planar and axial symmetry problem.

4. FIELD COMPUTATION FOR BASIC CONFIGURATIONS 9

Computation of electric and magnetic field intensities– Capacitance and Inductance – Force, Torque, Energy for basic configurations.

5. DESIGN APPLICATIONS 9

Insulators- Bushings – Cylindrical magnetic actuators – Transformers – Rotating machines.

TOTAL : 45 PERIODS

REFERENCES

1. K.J.Binns, P.J.Lawrenson, C.W Trowbridge, "The analytical and numerical solution of Electric and magnetic fields", John Wiley & Sons, 1993.
2. Nathan Ida, Joao P.A.Bastos , "Electromagnetics and calculation of fields", Springer-Verlage, 1992.
3. Nicola Biyanchi , "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005.
4. S.J Salon, "Finite Element Analysis of Electrical Machines." Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, Chennai, India
5. User manuals of MAGNET, MAXWELL & ANSYS software.
6. Silvester and Ferrari, "Finite Elements for Electrical Engineers" Cambridge University press, 1983.

PE 9351 ADVANCED POWER SEMICONDUCTOR DEVICES L T P C
3 0 0 3

1. INTRODUCTION 9

Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – (SOA); Device selection strategy – On-state and switching losses – EMI due to switching - Power diodes - Types, forward and reverse characteristics, switching characteristics – rating.

2. CURRENT CONTROLLED DEVICES 9

BJT's – Construction, static characteristics, switching characteristics; Negative temperature co-efficient and secondary breakdown; Power darlington - Thyristors – Physical and electrical principle underlying operating mode, Two transistor analogy – concept of latching; Gate and switching characteristics; converter grade and inverter grade and other types; series and parallel operation; comparison of BJT and Thyristor – steady state and dynamic models of BJT & Thyristor.

3. VOLTAGE CONTROLLED DEVICES 9

Power MOSFETs and IGBTs – Principle of voltage controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs - Basics of GTO, MCT, FCT, RCT and IGCT.

4. FIRING AND PROTECTING CIRCUITS 9

Necessity of isolation, pulse transformer, optocoupler – Gate drives circuit: SCR, MOSFET, IGBTs and base driving for power BJT. - Over voltage, over current and gate protections; Design of snubbers.

5. THERMAL PROTECTION 9

Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour – phase cooling; Guidance for hear sink selection – Thermal resistance and impedance - Electrical analogy of thermal components, heat sink types and design – Mounting types.

TOTAL : 45 PERIODS

TEXT BOOKS

1. B.W Williams 'Power Electronics Circuit Devices and Applications'.
2. Rashid M.H., " Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.

REFERENCES

1. MD Singh and K.B Khanchandani, "Power Electronics", Tata McGraw Hill, 2001.
2. Mohan, Undcland and Robins, "Power Electronics – Concepts, applications and Design, John Wiley and Sons, Singapore, 2000.

CL 9311 TRANSDUCERS AND MEASUREMENTS L T P C
3 0 0 3

1. RESISTIVE, INDUCTIVE AND CAPACITIVE ELEMENTS 9

Potentiometric, strain-gage and electrode elements – Inductive and Capacitive elements: structures, equivalent circuits and characteristics, single, differential and angle displacement elements, displacement to phase converters, and proximity elements, magnetostrictive elements, temperature instabilities and features.

2. TRANSFORMER, ELECTRODYNAMIC, SERVO AND RESONANT ELEMENTS 9

Transformer elements: Single core, differential, rotating coil and synchro transformers, weak-field sensors - Electrodynamic elements: Moving-coil, variable-reluctance- - Resonant elements: vibrating strings, vibrating beams, vibrating cylinders, piezoelectric resonators, acoustical resonators, microwave cavity resonators.

3. MECHANICAL, ACOUSTICAL AND FLOWMETERING ELEMENTS 9

Stresses state of diaphragm, dynamic characteristics of diaphragm, temperature drifts, sensitivity drifts, sensitivity to acceleration – Inertial mass elements: sensing and transduction elements of flowmeters, electromagnetic flowmeters, nanoelectrode electromagnetic flowmeters -ultrasonic elements – Acoustical elements: acoustical filters.

4. OPTICAL MICROSTRUCTURE SENSORS 9

Photo detectors: Thermal detectors, pneumatic detectors, pyroelectric detectors, photoemissive devices, photo conductive detectors, photo diodes, avalanche photo diodes, schottky photo diodes, photo transistors – Fiber optic sensors: Fibers as light guides, reflection sensors, Intrinsic multimode sensor, temperature sensor, phase modulated sensor, fiber optic gyroscopes and other fiber sensors

5.MISCELLANEOUS MINIATURE SENSORS 9

Magnetic sensors: Hall Effect sensors, magnetoresistors and other sensors – Solid state chemical sensors: Silicon based sensors, metal oxide sensors, solid electrolyte sensors, membranes – Electromechanical micro sensors and basic factors of design

TOTAL : 45 PERIODS

REFERENCES:

1. Alexander D Khazan, “Transducers and their elements – Design and application”, PTR Prentice Hall, 1994.
2. Pavel Ripka and Alois Tipek,“Modern sensors hand book”, Instrumentation and measurement series, ISTE Ltd., 2007
3. David Fraden. , PHI, 2004 “ Hand book of Modern Sensors, Physics,Design and Applications”, Third Edition, Springer India Pvt.Ltd, 2006.