SMTB5101	ADVANCED MATHEMATICS (Common to all M.E Branches and M.Tech Bio-Medical)	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

Pre requisite: Nil **Co requisite: Nil**

COURSE OBJECTIVES

- The ability to identify, reflect upon, evaluate and apply different types of information and knowledge to form independent judgments.

UNIT 1 MATRIX THEORY 9 Hrs.

QR decomposition – Eigen values using shifted QR algorithm – Singular Value Decomposition – Pseudo inverse – Least square approximations

UNIT 2 CALCULUS OF VARIATIONS 9 Hrs.

Concept of Functionals – Euler's equation – functional dependent on first and higher order derivatives – Functionals on several dependent variables – Iso perimetric problems – Variational problems with moving boundaries

UNIT 3 TRANSFORM METHODS 9 Hrs.

Laplace transform methods for one dimensional wave equation – Displacements in a string – Longitudinal vibration of a elastic bar – Fourier transform methods for one dimensional heat conduction problems in infinite and semi infinite rod.

UNIT 4 ELLIPTIC EQUATIONS 9 Hrs.

Laplace equation – Properties of harmonic functions – Fourier transform methods for Laplace equations – Solution for Poisson equation by Fourier transforms method.

UNIT 5 LINEAR AND NON-LINEAR PROGRAMMING 9 Hrs.

Simplex Algorithm – Two Phase and Big M techniques – Duality theory – Dual Simplex method – Non Linear Programming – Constrained external problems – Lagranges multiplier method – Kuhn – Tucker conditions and solutions.

Max.45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Comprehend the concepts of Matrix theory.
CO2 - Examine the concepts of calculus of variations and its applications.
CO3 - Analyse the concept of transform methods and elliptic equations.
CO4 - Evaluation of the linear and Non-linear programming and its applications.
CO5 - Analyse simplex algorithm methods.
CO6 - Implement transform methods in one dimensional heat conduction problems.

TEXT / REFERENCE BOOKS

1. Richard Bronson, " Schaum's Outline Matrix Operations", McGrawHill, 2011.
2. Venkataraman M K, "Higher Engineering Mathematics", National Pub.Co., 2003.
3. Elsgolts L.," Differential Equations and Calculus of Variations", University Press of the Pacific, 2003.
4. Sneddon I.N., "Elements of Partial differential equations", Dover Publications, 2006.
5. Sankara Rao K., "Introduction to partial differential equations",Prentice Hall of India, 2011.
6. Taha H A., "Operations research - An introduction", McMilan Publishing Co, 2010.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks:100 **Exam Duration: 3 Hrs.**

PART A:5Questions of 6 marks each – No choice **30 Marks**
PART B: 2 Questions from each unit of internal choice, each carrying 14 marks **70 Marks**

SEEB5101	ANALYSIS OF RECTIFIERS AND CHOPPERS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

Pre requisite: Nil **Co requisite: SEEB6101**

COURSE OBJECTIVES

- To have in-depth knowledge on single and three phase rectifiers
- Understand the operation and to analyse AC and DC choppers
- To learn the operation of cycloconverter and special converters

UNIT 1 SINGLE PHASE RECTIFIERS 9 Hrs.

Introduction – Principle of phase controlled converter operation – Single phase full converter with R, RL and RLE loads – Effect of Freewheeling diodes – Effect of source inductance – Single phase semi converter – Single phase dual converter – Single phase series converter.

UNIT 2 THREE PHASE RECTIFIERS 9 Hrs.

Three phase half wave converter – Three phase semi converter – Three phase full converter with R, RL and RLE loads. – Effect of source and load inductance - Three phase dual converter – Power factor improvements

UNIT 3 DC CHOPPERS 9 Hrs.

Introduction – Principles of step-down operation, step-down chopper with RL load – Principle of step-up operation with resistive load – Converter classification – Switching mode regulators – Analysis of buck, boost, buck boost and CUK converter – Comparison of regulators – Multi output boost converter.

UNIT 4 AC CHOPPERS 9 Hrs.

Introduction – Principle of ON-OFF control – Principle of phase control – Single phase bidirectional controllers with resistive loads – Single phase controllers with Inductive loads – Three phase half wave and full wave controllers – Three phase bi-directional delta connected controllers. AC voltage controllers with PWM control.

UNIT 5 CYCLOCONVERTER AND SPECIAL CONVERTERS 9 Hrs.

Cycloconverters – Single phase step up and step down cycloconverter – Single phase to three phase cycloconverter – Three phase to single phase cycloconverter - Study of Harmonics- Introduction to Matrix converter.

Max. 45 Hrs.

COURSE OUTCOMES

On the completion of the course, student will be able to

CO1 - Comprehend single phase rectifiers with various loads
CO2 - Examine three phase rectifiers with various loads
CO3 - Analyze DC chopper for a particular load
CO4 - Design AC voltage controllers
CO5 - Design various power converters
CO6 - Develop new converters to meet industrial requirements

TEXT / REFERENCE BOOKS

1. Rashid M.H., “Power Electronics Circuits, Devices & Applications”, Pearson Education, 4th Edition, 2017.
2. P.S.Bimbra, “Power Electronics”, Khanna Publishers, 5th Edition, 2014.
3. Mohan N., Undeland & Robbins, “Power Electronics Converters, Application & Design”, John Wiley & Sons, Inc, 3rd Edition, Reprint, 2009.
4. P.C.Sen, "Modern Power Electronics”, S.Chand Ltd., 2005.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks:100 **Exam Duration: 3 Hrs.**

PART A: 5 Questions of 6 marks each – No choice **30 Marks**
PART B: 2 Questions from each unit of internal choice, each carrying 14 marks **70 Marks**

SEEB5102	ANALYSIS OF INVERTERS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

Pre requisite: Nil **Co requisite: Nil**

COURSE OBJECTIVES

- Understand the basic inverter circuit operation.
- Understand the three phase inverter types VSI, CSI and Z source inverter.
- Understand the Purpose and need of multilevel inverter.
- Design an inverter for electrical drive, photovoltaic application etc.
- Able to analyze the inverter output using Fourier analysis for harmonics.

UNIT 1 SINGLE PHASE INVERTER **9 Hrs.**

Introduction – Principle of operation – Performance parameters – Single phase half bridge Inverters – Single phase full bridge Inverter – Single phase Series Inverter – Single phase parallel Inverter - Modified McMurray Inverter – McMurray Bedford half bridge and full Inverter Voltage control of single phase Inverters

UNIT 2 VOLTAGE SOURCE AND CURRENT SOURCE INVERTER **9 Hrs.**

Three phase bridge Inverter with 180º and 120º mode of operation – Voltage control of three phase Inverters -Analysis of single phase and three phase auto sequential current source Inverter - Current source bridge Inverter– Harmonic Elimination Techniques.

UNIT 3 Z-SOURCES INVERTER **9 Hrs.**

Single phase and three phase z source inverter -Comparison with VSI and CSI-Equivalent circuit and operation –Circuit analysis and calculation-Introduction to Quasi Z- source inverter-basic topology-Extended boost quasi Z- source inverter topologies.

UNIT 4 RESONANT PULSE INVERTERS **9 Hrs.**

Introduction – Series resonant Inverters with unidirectional and Bidirectional switches – Parallel resonant Inverters– Class E resonant Inverter - Zero current switching resonant converter – Zero voltage switching resonant converter– Two quadrant ZVS resonant converter – Resonant DC link Inverter.

UNIT 5 MULTILEVEL INVERTER **9 Hrs.**

Multilevel concept – Diode clamped – Flying capacitor – Cascade type multilevel Inverters - Comparison of multi-level Inverters - Application of multilevel Inverters.

Max. 45 Hrs.

COURSE OUTCOMES

On the completion of the course, student will be able to

CO1 - Comprehend the Operation of inverter for single phase and three phase circuits
CO2 - Examine how to do the analysis for the inverter for harmonics.
CO3 - Develop controller using modulation techniques to control the inverter output voltage.
CO4 - Design an inverter for a particular application and power level.
CO5 - Examine the need for multi-level inverter and its operation.
CO6 - Evaluate the efficiency by performing the soft switching in the inverter circuit.

TEXT / REFERENCE BOOKS

1. Rashid M.H., "Power Electronics – Circuits, Devices & Applications", Pearson Education, 2013.
2. P.S.Bimbra, "Power Electronics", Khanna Publishers, 5th Edition, 2014.
3. Fang Lin luo, Hong Ye, "Advanced DC/AC Inverters:Applications in Renewable Enegy", CRC Press, Taylor and Francis Group, 2013.
4. Mohan N., Undeland & Robbins, "Power Electronics – Converters, Application & Design", John Wiley & Sons Inc., 2nd Edition,Newyork, 2001.
5. P.C. Sen, "Modern Power Electronics", S.Chand Ltd., 2005.
6. Rashid M.H., "Hand book on Power Electronics", Nihar Kularatna, Newnes, 1998.
7. M.D. Singh & K.B. Khanchandani, "Power Electronics", Tata McGraw Hill Publishing Company Limited, 2nd Edition, 3rd Reprint, 2008.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks:100 **Exam Duration: 3 Hrs.**

PART A: 5 Questions of 6 marks each – No choice **30 Marks**
PART B: 2 Questions from each unit of internal choice, each carrying 14 marks **70 Marks**

SISB9101	RESEARCH METHODOLOGY AND IPR (For AE and Embedded & IoT)	L	T	P	Credits	Total Marks
		3	0	0	3	100

Pre requisite: Nil **Co requisite:** Nil

COURSE OBJECTIVES

- To understand the concepts of research.
- To provide an insight into the techniques of research.
- To learn the requisites of writing a research report.
- To impart knowledge on formulation of research problem, research methodology, ethics involved in doing research and importance of IPR protection

UNIT- I RESEARCH PREPARATION AND PLANNING 9 Hrs

Objectives of research – Understanding research and its goals, Critical thinking, Techniques for generating research topics. Topic selection and justification. Techniques involved in designing a questionnaire – Methods of scientific enquiry – Formulation of hypotheses and testing of the same – Development of a research proposal

UNIT-II RESEARCH RESOURCES 9 Hrs

Sources of information. Literature search. World Wide Web, Online data bases – search tools. Citation in dices – Principles underlying impact factor – Literature review – Case studies, review articles and Meta analysis – Role of the librarian. Ethical and moral issues in Research, Plagiarism, tools to avoid plagiarism

UNIT-III ACADEMIC WRITING AND PRESENTATION 9 Hrs

Proposal submission for funding agencies, Elements of Style. Organization of proposals, Basic knowledge of funding agencies, Research report writing, Communication skills, Tailoring the presentation to the target audience – Oral presentations, Poster preparations, Submission of research articles for Publication in Reputed journal, Thesis writing and Research report writing. Elements of excellent presentation: preparation, visual and delivery, oral communication skills and oral defense.

UNIT-IV DATA COLLECTION, ANALYSIS AND INFERENCE 9 Hrs

Basic statistical distributions and their applications. Sample size determination and sampling techniques. Large sample tests and small sample tests

UNIT-V INTELLECTUAL PROPERTY RIGHTS 9 Hrs

Nature of Intellectual Property: Patents, Designs, Trade Mark and Copyright. Process of Patenting and Development: technological research, innovation, patenting & development. Procedure for grants of patents, Patenting under PCT. Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System.

Total Hrs: 45

COURSE OUTCOMES

On completion of the course, student will be able to

CO 1 Understand the important basics of research and Intellectual Property Rights.

CO 2 Write research problem formulations through various methods of literature survey

CO 3 Analyze research related information and Follow research ethics

CO 4 Correlate the results of any research article with other published results. Write a review article in the field of engineering.

CO5 Differentiate patents, copyrights, trademark and designs.

CO6 Apply the process for IPR protection

TEXT / REFERENCE BOOKS

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
3. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
4. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.
5. James C. Van Horne, Standford University, Financial Management and Policy, Prentice Hall,
6. James R. McGuigan, R. Charles Moyer, Frederick H. deB. Harris, Managerial economics – applications, strategy and Tactics, Cengage learning, India
7. Philip Kotler, Marketing management Pearson Education, India
8. Modern Production / Operations Management, Elwood S. Buffa & Rakesh Sarin, Wiley India
9. Ronald R. Sims, Organizational success through effective human resources Management, Quorum books, London
10. Ganesan R, Research Methodology for Engineers, MJP Publishers, Chennai. 2011.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

PART A	6 Questions of 5 marks each-No choice	**30 Marks**
PART B	2 Questions from each unit of internal choice, each carrying 14 marks	**70 marks**

SEEB6101	POWER ELECTRONICS AND DRIVES LAB	L	T	P	EL	Credits	Total Marks
		0	0	4	0	2	100

Pre requisite: SEEB5101 **Co requisite: Nil**

COURSE OBJECTIVES

- To design and analyze the various DC and AC drives.
- To generate the firing pulses for converters and inverters.
- To design three phase AC voltage regulator.

SUGGESTED LIST OF EXPERIMENTS

1. Single Phase Half and Full converter with R, RL, RLE loads.
2. Three Phase Half and Full converter with R, RL, RLE loads.
3. Three Phase AC voltage regulator.
4. Four quadrant chopper.
5. Modified McMurray - Bedford Inverter.
6. Resonant DC to DC Converter.
7. Speed control of PMDC motor using Voltage Commutated Chopper.
8. Speed control of PMDC motor using Current Commutated Chopper.
9. IGBT based speed control of three phase induction motor using PWM technique.
10. Speed control of BLDC motor.
11. Speed control of SRM motor.
12. Speed control of PMSM
13. Single phase Multi Level Inverter based induction motor drive.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Examine the half and full converter with R,RL and RLE load.
CO2 - Determine the voltage for three phase AC voltage regulator.
CO3 - Analyze speed control of PMDC motor using VCC and CCC.
CO4 - Analyze the performance characteristics of DC-DC converter.
CO5 - Determine performance characteristics of various motor drives.
CO6 - Examine the characteristics of Multilevel Inverter based induction motor drive.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks:100 **Exam Duration: 3 Hrs.**

PART A: 5 Questions of 6 marks each – No choice **30 Marks**
PART B: 2 Questions from each unit of internal choice, each carrying 14 marks **70 Marks**

SEEB5201	SOLID STATE AC DRIVES	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

Pre requisite: Nil **Co requisite: Nil**

COURSE OBJECTIVES

- Ability to understand and analyse the VSI and CSI fed drive.
- Understand the speed control of induction motor by stator and rotor side control.
- Ability to learn synchronous motor drives with fixed and variable frequency.

UNIT 1 STATOR VOLTAGE CONTROL OF INDUCTION MOTOR 9 Hrs.

Torque, Slip characteristics, Equivalent circuit, Speed control – Variable Voltage, Variable Frequency, Constant V/F operation. Operation with different types of loads, Performance, Comparison of different AC power controllers, Speed reversal, Closed loop control.

UNIT 2 STATOR FREQUENCY CONTROL 9 Hrs.

Operation of induction motor with non sinusoidal supply waveforms, Variable frequency operation of 3 phase induction motors, Constant flux operation, Current fed operation, Dynamic and regenerative braking of CSI and VSI fed drives.

UNIT 3 ROTOR RESISTANCE CONTROL 9 Hrs.

Torque, Slip characteristics, Types of rotor choppers, Torque equations, Constant torque operation, TRC strategy, Closed loop speed control.

UNIT 4 SLIP POWER RECOVERY SCHEME 9 Hrs.

Equivalent circuit, Torque equation, Torque - Slip characteristics - Power factor considerations - Sub synchronous operation and closed loop speed control, Vector or Field control - Direct Vector control.

UNIT 5 SYNCHRONOUS MOTOR DRIVES 8 Hrs.

Need for leading PF operation - Open loop VSI fed drive and its characteristics - Self control - Torque angle control - Power factor control - Brush less excitation system - Starting methods - Principles of vector control.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Examine solid state drives for speed control of 3 phase induction motor
CO2 - Analyse different speed control methods in A.C motors using thyristor based control schemes.
CO3 - Examine vector control method for controlling the Induction motor drive.
CO4 - Develop vector control method for controlling the synchronous motor drive5.
CO5 - Design solid state drives for speed control of 3 phase Synchronous motor
C06 - Evaluate the performance and speed control of AC drives.

TEXT / REFERENCE BOOKS

1. Murphy,J.M.D, Turnbull F.G., "Thyristor control of AC motors", Pergamon Press, 2010.
2. B.K.Bose, "Power Electronics & AC drives", Academic Press, 2006.
3. Dubey .G.K., "Power Semiconductor Controlled Drives", Prentice Hall International, Newyork, 2001.
4. Dewan.S.B. Slemon, G.R. Straughen.A., "Power semiconductor drives", John wiley and sons, Newyork, 1984.
5. I.J.Nagrath & D.P.Kothari, "Electrical Machines", Tata McGraw-Hill Publications, 2006.

6. V.R.Moorthi, “Power Electronics Drives, Circuits, and Industrial Applications,” Oxford University press, First published in India 2005, (sixth impression 2008).
7. R. Krishnan, “Electric Motor Drives: Modelling, Analysis, and Control”, Prentice Hall, 2001.
8. Leonhard, Werner, “Control of Electrical Drives”, 3rd edition, 2001, Springer 2001.
9. Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff - “Analysis of Electric Machinery and Drive systems”, IEEE press, 2013.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks:100 **Exam Duration: 3 Hrs.**

PART A: 5 Questions of 6 marks each – No choice **30 Marks**
PART B: 2 Questions from each unit of internal choice, each carrying 14 marks **70 Marks**

SEEB5202	ADVANCED POWER SEMICONDUCTOR DEVICES	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

Pre requisite: Nil **Co requisite: Nil**

COURSE OBJECTIVES

- To study the characteristics of advanced power semiconducting switches.
- To analyse the on-state and switching losses involved in the operation of power semiconducting switches.
- To study the firing and protection circuits of advanced power semiconducting switches.

UNIT 1 INTRODUCTION **9 Hrs.**

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.

UNIT 2 CURRENT CONTROLLED DEVICES **9 Hrs.**

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.

UNIT 3 VOLTAGE CONTROLLED DEVICES **9 Hrs.**

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.

UNIT 4 FIRING AND PROTECTING CIRCUITS **9 Hrs.**

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

UNIT 5 THERMAL PROTECTION **9 Hrs.**

Heat transfer – conduction, convection and radiation; Cooling – Liquid cooling, vapour – Phase cooling; Thermal modelling of power switching devices: Thermal equivalent circuit, Coupling of electrical & thermal components, heat sink types and design – Mounting.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Examine the concept of Power semiconductor devices.
CO2 - Analyse the performance of the current controlled and voltage controlled devices.
CO3 - Explain the working of power semiconductor devices.
CO4 - Evaluate the characteristics of all power semiconductor devices.
CO5 - Examine the applications of power semiconductor devices.
CO6 - Design firing circuits protection circuits and to provide thermal protection for power semiconductor devices.

TEXT / REFERENCE BOOKS

1. Mohan N., Undeland and Robbins, “Power Electronics – Converters, Application & Design”, John Wiley & Sons, Inc, 3rd Edition, Newyork, Reprint, 2009.
2. Simon M.Sze & Kwok K.Ng, “Physics of Semiconductor Devices”, A Wiley Inter Science Publications, John Wiley and Sons, New Jersey, 3rdEdition, 2007.
3. Rashid M.H., “Power Electronics Circuits, Devices and Applications", Pearson Education, 2013.
4. M.D.Singh and K.B. Khanchandani, “Power Electronics”, Tata McGraw Hill Companies, Electrical and Electronics Engineering Series, 2nd Edition, 3rd Reprint, 2008.
5. Jayant Baliga, “Advanced Power Rectifier Concepts”, Springer, 2008.
6. Jayant Baliga, “Advanced High Voltage Power Devices Concepts”, Springer, 2010.
7. Dieter K.Schroder, “Semiconductor Material and Device Characterization”, A John Wiley and Sons Inc, Publication, New Jersey, 2006.
8. Robert F.Pierret, “Semiconductor Device Fundamentals”, Pearson Education, 2ndImpression, 2008.
9. Donald A.Neamen, “Semiconductor Physics and Devices”, McGraw Hill companies, Special Indian Edition, 2007.
10. P.C. Sen, “Power electronics”, S.Chand Ltd., 2007.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks:100 **Exam Duration: 3 Hrs.**

PART A: 5 Questions of 6 marks each – No choice **30 Marks**
PART B: 2 Questions from each unit of internal choice, each carrying 14 marks **70 Marks**

S34BLH21	SOILD STATE DC DRIVES	L	T	P	EL	Credits	Total Marks
		3	0	2	0	4	100

Pre requisite: Nil **Co requisite: Nil**

COURSE OBJECTIVES

- To study and analyze the operation of the converter / chopper fed DC drive, both qualitatively and quantitatively.
- To analyze and design the current and speed controllers for a closed loop solid state DC motor drives.
- To study and design the Siemens drive system for speed control, current and torque measurement.

UNIT 1 REVIEW OF CONVENTIONAL DC DRIVES 9 Hrs.

Different techniques of speed control and methods of braking of series and separately excited DC motor, Ward leonard speed control, Model and transfer function of series and separately excited DC motor.

- Open Loop Control of Separately Excited DC Motor.
- Open Loop Control of DC Series Motor.
- Closed Loop Control of Separately Excited DC Motor.

UNIT 2 CONVERTER CONTROL OF DC MOTORS 9 Hrs.

Analysis of series and separately excited DC motor with single phase and three phase converters operating in different modes and configurations, Problems on DC machines fed by converter supplies, drive employing dual converter.

Simulation of Single Phase Half Converter with different loads.

- Three Phase Full Controlled Rectifier fed DC motor.
- Simulation of Single Phase Semi Converter with motor load.
- Simulation of Three Phase Converter with different loads.

UNIT 3 CHOPPER CONTROL OF DC MOTORS 9 Hrs.

Introduction to time ratio control and frequency modulation; Class A,B,C,D and E chopper controlled DC motor – Performance analysis, multiquadrant control – Chopper based implementation of braking schemes – Multiphase Chopper.

- Simulation of Buck Converter
- Simulation of Boost Converter.
- Simulation of Buck-Boost Converter.
- Chopper fed DC motor drive.

UNIT 4 DESIGN OF CONVERTER AND CHOPPER FOR DC DRIVES 9 Hrs.

Speed loop, P, PI, PID controllers, Current loop, Armature current reversal, Field current reversal – Digital controller and firing circuits, Simulation.

- Closed loop control of dc-dc converter.
- Closed loop control of phase controlled rectifier
- Simulation of different firing circuits

UNIT 5 INDUSTRIAL DC DRIVES 9 Hrs.

Introduction to Siemens drive system - Speed control with emf feedback & tachogenerator – Current measurement & Torque Measurement - Tuning of drive, Phase locked loop control of DC drives.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Comprehend the principle and modelling of DC motor and conventional drives.
CO2 - Examine the operation of single and three phase converter fed DC motor drives.
CO3 - Analyze the operation of chopper fed DC motor drives.
CO4 - Analyse the various methods of closed loop speed control of DC drives.
CO5 - Evaluate the performance of Siemens drive system for speed control of DC drives.
CO6 - Evaluate the performance the phase locked loop for speed control of DC drives.

TEXT / REFERENCE BOOKS

1. Buxbaum.A, Schierau.K and Staughem, “A Design of Control Systems for D.C.Drives”, Springer - Verlag, Berlin, 1990.
2. Dubey .G.K , “Power Semiconductor Controlled Drives”, Prentice Hall International, New jersey, 1989.
3. Sen P.C, “Thyristor D.C Drives”, Krieger Publishing Company,1991.
4. Subrahmanyam .V, “Electric Drives Concept and Applications”, Tata McGraw Hill Publishing Co., LTD., New Delhi, 1st reprint 2010.
5. Siemen’s Course Material
6. R. Krishnan, “Electric Motor Drives: Modelling, Analysis, and Control”, Prentice Hall; 1stedition, 2001.
7. Leonhard, Werner, “Control of Electrical Drives”, 3rd edition, 2001, Springer 2001.

WEB SITES

1. www.automation.siemens.com
2. www.legacypower.net

END SEMESTER EXAMINATION PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A:	MCQ	**20 Marks**
PART B:	Practical	**80 Marks**

SEEB5301	PWM TECHNIQUES IN POWER ELECTRONICS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

Pre requisite: SEEB5102 **Co requisite: Nil**

COURSE OBJECTIVES

- Ability to understand and analyse the PWM techniques.
- Understand the space vector modulation techniques.
- Ability to learn applications of SVM techniques.

UNIT 1 INVERTER CONTROL STRATEGY 9 Hrs.

Introduction - Operation principle – Performance Parameters – PWM with Unipolar and Bipolar voltage switching – Effect of blanking time on voltage in PWM inverter – Voltage control of single phase inverter and three phase inverter.

UNIT 2 ADVANCED PWM TECHNIQUES 9 Hrs.

Different types of advanced modulation techniques - Analysis of third harmonics modulation – Output filter requirement for different PWM techniques - Comparison of PWM techniques – Harmonic reduction

UNIT 3 SPACE VECTOR MODULATION (SVM) 9 Hrs.

Space Vector Modulation – Introduction - Concept of a space vector – Inverter switching states – Modulation Index - dq components for three phase sine wave source / level – Space vector sequence - Minimizing switching losses.

UNIT 4 SVM MODULATION REGIONS 9 Hrs.

Under modulation region – Derivation of Va & Vb – Derivation of formula for Ta and Tb – Calculation of time values for Ta, Tb – Over modulation mode 1 and mode 2 – Modified reference voltage trajectory – Equation of various voltage segments.

UNIT 5 APPLICATIONS 9 Hrs.

SVM implementation of three level diode clamped inverter – Three level inverter switching states, space vector diagram and modulation regions – Flow diagram for SVM implementation of three level inverter – Motor voltage and current waveforms for three level inverter in different regions – Five level diode clamped inverter – Switching states – Five level flying capacitor inverter – Switching states.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Analyse PWM techniques for single and three phase inverters.
CO2 - Examine advanced PWM techniques.
CO3 - Analyse space vector modulation.
CO4 - Analyse space vector modulation regions.
CO5 - Develop SVM for three level inverter.
CO6 - Design five level diode clamped inverter.

TEXT / REFERENCE BOOKS

1. Mohammed H.Rashid, “Power Electronics – Circuits, Devices and Applications”, Prentice Hall, Eastern Economy Edition, Fourth Edition, 2013.
2. Bimal K Bose, “Modern Power Electronics and AC Drives”, Prentice Hall, 1st Edition, 2001.
3. Bimal Bose, “Power electronics and Motor Drives – Advances and Trends” – Academic Press, Elsevier, 2006.

4. Hamid A.Toliyat & Steven G.Campbell, “DSP Based Electro Mechanical Motion Control”, CRC press, 2004.
5. Grahame Holmes .D, Thomas A.Lipo, “Pulse Width Modulation for Power Converters, Principles and Practice” –Wiley IEEE Press – 2003.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks:100 **Exam Duration: 3 Hrs.**

PART A: 5 Questions of 6 marks each – No choice **30 Marks**
PART B: 2 Questions from each unit of internal choice, each carrying 14 marks **70 Marks**

S34BLH31	SPECIAL MACHINES AND THEIR CONTROLLERS	L	T	P	Credits	Total Marks
		3	0	0	3	100

Pre requisite: Nil **Co requisite: Nil**

COURSE OBJECTIVES

- To impart knowledge on working principle, characteristics and applications of special electrical machines.
- To learn various controller circuits of special electrical machines.
- To analyze performance characteristics of universal motor and Linear Electric motors.

UNIT 1 STEPPER MOTORS 9 Hrs.

Introduction to stepper motor - Constructional features and principle of operation - Single phase stepper motors - Modes of excitation - Characteristics - PM stepper motor, Hybrid Stepper motor - Construction and operation of Enhanced PMH stepper motor, Disc Magnet stepper motor, Electro hydraulic stepper motor - Drive circuits for stepper motor – Open loop control and Closed loop control of stepping motor - Single stack variable reluctance stepper motor - Multi-stacks stepper motor– Electromagnetic torque developed in reluctance motor - Effect of saturation - Static and dynamic characteristics - Applications of stepper motor.

- Stepper motor control using digital controller
- Simulation of stepper motor using different control techniques

UNIT 2 SWITCHED RELUCTANCE MOTORS 9 Hrs.

Constructional features - Principle of operation - Torque equation - Power electronic converter circuits - Characteristics and control - Torque-speed Characteristics, Current sensing - Rotor position measurement and estimation- Sensor less rotor position estimation- Incremental inductance measurement and constant flux linkages method – Control of SRM for traction type load.

- SRM control using digital controller
- Simulation of SRM using different control techniques

UNIT 3 PERMANENT MAGNET BRUSHLESS DC MOTORS 9 Hrs.

Commutation in DC motor - Difference between mechanical and electronic commutators - Hall effect sensors -Optical sensors - Multiphase brushless motor - Square wave permanent magnet brushless motor drives - Torque and EMF equation – Torque - speed characteristics – Controllers

- PMBLDC control using digital controller
- Simulation of PMBLDC motor using different control techniques

UNIT 4 PERMANENT MAGNET SYNCHRONOUS MOTORS 9 Hrs.

Construction and operation of permanent magnet synchronous motors-EMF and torque equation-phasor diagram-Locus diagram-torque-speed characteristics- -microprocessor based control of PMSM. Vector control,self-control and -microprocessor based control of permanent magnet synchronous motors.

- PMSM control using digital controller
- Simulation of PMSM using different control techniques

UNIT 5 UNIVERSAL MOTOR AND LINEAR ELECTRIC MOTORS 9 Hrs.

Universal motor- Classification-Design considerations-principle- performance analysis-Equivalent circuit-characteristics- speed control.Linear Electric motors- comparison between linear electric motor and rotary motor- Linear Induction motors-construction, principle, Equivalent circuit ,characteristics and

Design aspects. Linear Synchronous motor- classification, principle, performance equations, LSM control, static power converter.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Comprehend the fundamentals, characteristics and control of stepper motors.
CO2 - Examine the characteristics and control of switched reluctance motors.
CO3 - Analyze the characteristics and commutation circuits of permanent magnet brushless DC motors.
CO4 - Analyse the characteristics and control of permanent magnet Synchronous motors.
CO5 - Evaluaten Design considerations, performance analysis and speed control of Universal motor.
CO6 - Analyze the fundamentals, Equivalent circuit, characteristics and Design aspects of Linear Electric motor.

TEXT / REFERENCE BOOKS

1. Miller. T.J.E. “Brushless Permanent Magnet and Reluctance Motor Drives”, Clarendon Press, Oxford, 1989.
2. Kenjo. T, “Stepping motors and their Microprocessor control”, Clarendon Press, Oxford, 1989.
3. R.Krishnan, “Switched Reluctance Motor Drives – Modelling, Simulation, Analysis, Design and Applications”, CRC Press,2001.
4. J.F.Gieras, “Advancements In Electrical Machines”, Springer Publishers, 2008.
5. Kenjo, T and Nagamori, S, “Permanent Magnet and Brushless DC motors”, Clarendon Press, Oxford, 1989.
6. K.Venkataratnam, “Special Electrical Machines”, University Press Private Limited, 2008.
7. K.Dhayalini, “Special Electrical machines”,Anuradha Publications, Reprint 2015.

END SEMESTER EXAMINATION PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

PART A:	MCQ	**20 Marks**
PART B:	Practical	**80 Marks**

SEEB7001	POWER ELECTRONICS IN POWER SYSTEMS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

Pre requisite: SEEB5202 **Co requisite: Nil**

COURSE OBJECTIVES

- To understand the concepts of Reactive power requirement and load compensation.
- To impart knowledge on FACTS devices and power factor improvement.
- To provide a chance for the students to learn about the different power converter and its methods of commutation.
- To impart more knowledge about Tap changing transformer, UPS, HVDC, etc which helps in energy storage and effective utilization.

UNIT 1 LOAD COMPENSATION **9 Hrs.**

Introduction – Need for Compensation – Objectives in load compensation – Specifications of load compensator – Ferranti Effect - Classification of compensation – Shunt & Series Compensation – Voltage Sag, Swell, Surges - Effects of Voltage Collapse

UNIT 2 INTRODUCTION TO FACTS DEVICES **9 Hrs.**

Thyristor Controlled Reactor (TCR) – Thyristor Switched Capacitor (TSC) – Saturable Reactor – Saturated Reactor Compensator – Static VAR Compensator (SVC) – Thyristor Controlled Series Capacitor (TCSC) – Unified Power Flow Controller (UPFC) - STATCOM – Dynamic Voltage Restorer (DVR)

UNIT 3 HARMONICS CONTROL AND POWER FACTOR IMPROVEMENT **9 Hrs.**

Reactive power variation for fully controlled converter – Half controlled converter – Fully controlled converter with controlled freewheeling – Methods of employing natural commutation – Methods of employing forced commutation – Implementation of forced commutation

UNIT 4 VOLTAGE CONTROL USING STATIC TAP CHANGER **9 Hrs.**

Introduction to voltage regulators – Single Phase voltage controllers – Sequence control of AC voltage controllers – Manually controlled voltage regulator (Conventional Methods) – Static Tap changer using thyristors - Application of Tap-Changing Transformers to Transmission Systems.

UNIT 5 UNINTERRUPTIBLE POWER SUPPLY SYSTEMS **9 Hrs.**

Switched mode power supply (SMPS) – Parallel UPS – Rotating UPS – Static UPS types – UPS using resonant power converters – High voltage DC transmission – Static circuit breakers

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Comprehend reactive power compensation and power factor improvement.
CO2 - Examine the various FACTS devices and its role in compensation.
CO3 - Analyse various methods of commutation for converters.
CO4 - Examine different tap changing transformer and its applications.
CO5 - Analyse the importance of UPS and SMPS.
CO6 - Design and construct HVDC transmission,static circuit breakers.

TEXT / REFERENCE BOOKS

1. Miller.T.J.E, “Reactive Power Control in Electric Systems”, Wiley-Interscience, New York, 1982.
2. G.K.Dubey, “Thyristorised Power Controllers”, New Age International Publishers, 2nd Edition (2012).
3. P.S.Bimbhra, “Power Electronics”, Khanna Publishers, 5th Edition, 2014.
4. R. Mohan Mathur, Rajiv K. Varma, “Thyristor-based Facts Controllers for Electrical Transmission systems”, Wiley-IEEE, 2002.

5. P.C.Sen, “Power Electronics”, Tata Mc Graw Hill, 2008.
6. “Static compensator for AC power systems”, Proc.IEE Vol.128, pt.c, Nov 1981, pp362-406.
7. “A static alternative to the Transformers on Load tap Changing”, IEEE Trans. on PAS, Vol.101, Sep.982, pp3091-3095.
8. K.R. Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International, 2007(Reprint 2013).
9. Narain G.Hingorani and Laszlo Gyugyi, “Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems”, Wiley-IEEE Press, 1999.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks:100 **Exam Duration: 3 Hrs.**

PART A: 5 Questions of 6 marks each – No choice **30 Marks**

PART B: 2 Questions from each unit of internal choice, each carrying 14 marks **70 Marks**

SEEB7002	LINEAR AND NON LINEARSYSTEM THEORY	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

Pre requisite: Nil **Co requisite: Nil**

COURSE OBJECTIVES

- To impart knowledge in State Space Analysis.
- To understand and implement various stability analysis in Non linear systems.
- To gain knowledge in MIMO system analysis.

UNIT 1 PHYSICAL SYSTEMS AND STATE ASSIGNMENTS 9 Hrs.

State space modelling of Electrical, Mechanical, Hydraulic, Pneumatic, Thermal systems – Modelling of some typical systems like DC Machines - Inverted Pendulum.

UNIT 2 STATE SPACE ANALYSIS 9 Hrs.

Realisation of State models: Non-uniqueness - Minimal realization - Balanced realisation – Solution of state equations: – State transition matrix and its properties - Free and forced responses – Properties: Controllability and observability - Stabilizability and detectability – Kalman decomposition.

UNIT 3 MIMO SYSTEMS FREQUENCY DOMAIN DESCRIPTIONS 9 Hrs.

Properties of transfer functions – Impulse response matrices – Poles and zeros of transfer function matrices – Critical frequencies – Resonance – Steady state and dynamic response – Bandwidth - Nyquist plots - Singular value analysis.

UNIT 4 NON-LINEAR SYSTEMS 9 Hrs.

Types of non-linearity – Typical examples – Equivalent linearization - Describing functions - Analysis using Describing functions - Phase plane analysis.

UNIT 5 STABILITY 9 Hrs.

Stability concepts – Equilibrium points – BIBO and asymptotic stability – Direct method of Liapunov – Application to non-linear problems – Frequency domain stability criteria – Popov's method and its extensions.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Analyse Physical Systems in state space analysis.
CO2 - Determine the controllability, observability, stability & detectability of physical systems.
CO3 - Resolve MIMO systems frequency domain specifications.
CO4 - Analyze non-linear systems using conventional Describing functions & Phase plane analysis.
CO5 - Determine the stability condition of non-linear systems using Lipunov's method.

TEXT / REFERENCE BOOKS

1. M.Gopal, "Modern Control System Theory", New Age International, 3rd Edition (Reprint 2014).
2. John S.Bay, "Fundamentals of Linear State Space Systems", McGraw-Hill, 1999.
3. K. Ogata, "Modern Control Engineering", Pearson Education, 2010.
4. John J. D'Azzo, C. H. Houpis and S. N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Taylor Francis, 2003.
5. Z. Bubnicki, "Modern Control Theory", Springer, 2005.
6. Hassan K. Khalil, "Nonlinear Systems", Prentice Hall, 3rdEdition 2002.
7. M. Vidyasagar, "Nonlinear Systems Analysis', Society for Industrial and Applied Mathematics, 2002.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks:100 **Exam Duration: 3 Hrs.**

PART A: 5 Questions of 6 marks each – No choice **30 Marks**
PART B: 2 Questions from each unit of internal choice, each carrying 14 marks **70 Marks**

SEEB7003	ANALYSIS OF ELECTRICAL MACHINES	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

Pre requisite: Nil **Co requisite: Nil**

COURSE OBJECTIVES

- To provide fundamental knowledge in magnetic circuits, energy, force and torque of multi-excited systems.
- To understand the steady state and dynamic state operations of DC machine through mathematical modelling.
- To impart the knowledge on the theory of transformation of three phase variables to two phase variables.
- To analyze the steady state and dynamic state operation of three-phase induction machines using transformation theory based mathematical modelling.
- To analyze the steady state and dynamic state operation of three-phase synchronous machines using transformation theory based mathematical modelling.

UNIT 1 PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION 9 Hrs.

Magnetic circuits, permanent magnet, stored magnetic energy, co-energy - force and torque in singly and doubly excited systems – machine windings and air gap m m f - winding inductances and voltage equations.

UNIT 2 DC MACHINES 9 Hrs.

Elementary DC machine and analysis of steady state operation - Voltage and torque equations – dynamic characteristics of permanent magnet and shunt d.c. motors –Time domain block diagrams - solution of dynamic characteristic by Laplace transformation.

UNIT 3 REFERENCE FRAME THEORY 9 Hrs.

Historical background – phase transformation and commutator transformation – transformation of variables from stationary to arbitrary reference frame - variables observed from several frames of reference.

UNIT 4 INDUCTION MACHINES 9 Hrs.

Three phase induction machine, equivalent circuit and analysis of steady state operation – free acceleration characteristics – voltage and torque equations in machine variables and arbitrary reference frame variables – analysis of dynamic performance for load torque variations.

UNIT 5 SYNCHRONOUS MACHINES 9 Hrs.

Three phase synchronous machine and analysis of steady state operation - voltage and torque equations in machine variables and rotor reference frame variables (Park's equations) – analysis of dynamic performance for load torque variations.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Comprehend the fundamental concepts in magnetic circuits, energy, force and torque of multi-excited systems and winding analysis.

CO2 - Analyze the steady state and dynamic state operations of DC machine through mathematical modelling.

CO3 - Examine the theory of transformation and its importance in design and analysis

CO4 - Analyze the steady state and dynamic state operations of three-phase induction machines and gain knowledge in mathematical modelling.
CO5 - Realize the steady state and dynamic state operation of three-phase synchronous machines using transformation theory based mathematical modelling.
CO6 - Develop mathematical modelling for synchronous machines.

TEXT / REFERENCE BOOKS

1. A Paul C.Krause, Oleg Wasynczuk, Scott D. Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley, Third Edition, 2013.
2. P S Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 5th Edition, 2013.
3. A.Fitzgerald, Charles Kingsley and Stephan D. Umans, " Electric Machinery", Tata McGraw Hill, 6thEdition, 2002.
4. V. Rajini & V.S.Nagarajan, "Electrical Machine Design" Pearson Publishers, 1st Edition, May 2018.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks:100 **Exam Duration: 3 Hrs.**

PART A: 5 Questions of 6 marks each – No choice **30 Marks**
PART B: 2 Questions from each unit of internal choice, each carrying 14 marks **70 Marks**

SEEB7004	INDUSTRIAL MANAGEMENT IN POWER ELECTRONICS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

Pre requisite: SEEB5101,SEEB5102 **Co requisite: Nil**

COURSE OBJECTIVES

- To impart knowledge on operation, modelling and control of industrial management in power electronics.
- To provides an integrated set of control, supervision and management functions for power generation, distribution and supply in industrial plants.
- To gain knowledge about the efficient utilisation of converters by understanding the DC-DC and AC - DC converters architecture.

UNIT 1 POWER MANAGEMENT TECHNOLOGIES 9 Hrs.

Introduction, Integrated Circuits Power Technology - Processing and Packaging – Diodes and Bipolar Transistors- MOS Transistor - DMOS Transistors - CMOS Transistors - Passive Components, Discrete Power Technology -Processing and Packaging - Power MOSFET.

UNIT 2 CIRCUITS 9 Hrs.

Analog Circuits –Transistors – NPN – PNP Trans conductance - Transistor as Transfer Resistor – Transistor Equation, Elementary Circuits - Current Mirror - Current Source – Buffer - Differential Input Stage, Operational Amplifer- Inverting and Non Inverting Amplifier, Voltage Reference, Voltage Regulator, Switching Regulators, Digital Circuits -Logic Function - NAND Gate - Set Reset R Flip Flop.

UNIT 3 CONVERTERS AND DC-DC CONVERSION ARCHITECTURES 9 Hrs.

Buck Converters - Switching Regulator Power Train - Output Capacitor - Electrolytic Capacitor and Transient Response - Ceramic Capacitors - Losses in the Power Train - The Analog Modulator - Driver -Switching Regulator Control Loop, Fly back Converters, DC-DC Conversion - Valley Control Architecture - Monolithic Buck Converter -Battery Charging Techniques.

UNIT 4 AC-DC ARCHITECTURES 9 Hrs.

Power Architecture - PFC Architecture - DC-DC Conversion Down To Low Voltage - Power AC Adapter – DDR Power Management Architecture.

UNIT 5 FUTURE DIRECTIONS AND SPECIAL APPLICATIONS 9 Hrs.

Voltage Regulation with Power Factor Correction, Green Power (Energy Management), Motor Drivers For Portable Electronic Applications - Camera Basics - Motor And Motor Drivers - Drive Implementation, Efficiency - DSC Power consumption.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Examine the processing of different semiconductor devices to manage the power.
CO2 - Design analog and digital circuits.
CO3 - Develop suitable converters architecture for industrial applications.
CO4 - Analyse the various architectural procedures of the power management in industries
CO5 - Implement green power management techniques for obtaining quality power in industries.
CO6 - Select appropriate drive design for real time applications.

TEXT / REFERENCE BOOKS

1. Dr.Nazzareno Rossetti, “Managing Power Electronics: VLSI & DSP Driven Computer Systems”, A John Wiley & Sons, Inc., 2006.
2. Muhammad H.Rashid, “Power Electronics Hand BooK”, Elsevier Inc., 2nd Edition 2007.
3. Steve Doty, Wayne C.Turner, “Energy Management Hand Book”, The Fairmont Press, 7th Edition 2009.
4. Paul R.Gray, Paul J.Hurst, Stephen H.Lewis and Robert G.Meyer “Analysis and Design of Analog Integrated Circuits”, John Wiley & Sons, Inc., 2009.
5. Liv, Kramer, Indiver, Delbruck Douglors, “Analog VLSI: Circuits and Principles”, Massachusetts Institute of Technology, 2002.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks:100 **Exam Duration: 3 Hrs.**

PART A: 5 Questions of 6 marks each – No choice **30 Marks**
PART B: 2 Questions from each unit of internal choice, each carrying 14 marks **70 Marks**

SEEB7005	MODELLING AND SIMULATION IN POWER ELECTRONICS SYSTEM	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

Pre requisite: Nil **Co requisite: Nil**

COURSE OBJECTIVES

- Understand the challenges in simulation process and issues in modelling power electronic systems.
- To provide knowledge on modelling and simulation of machines and power simulation circuits and systems.
- Able to design and develop digital controllers.

UNIT 1 INTRODUCTION AND MODELLING OF POWER ELECTRONICS ELEMENT 9 Hrs.

Challenges in computer simulation, simulation process, Types of analysis, mechanics of simulation, circuit-oriented simulators, equation solvers, Analog hybrid model for thyristor – Modelling of firing circuits for thyristor.

UNIT 2 SYSTEMATIC METHOD OF FORMULATION AND SOLVING STATE EQUATION 9 Hrs.

Network topology – Incidence matrix – Fundamental cutest & loop matrices – Proper tree algorithm – Algorithm for the formulation of fundamental cutest matrix – Welsh Algorithm – Computer solution of state equation – Explicit & Implicit integration method.

UNIT 3 MACHINE MODELING 9 Hrs.

DC machine modelling – Equivalent circuit & electromagnetic torque – Electromechanical modelling – State space modelling – AC machine modelling for three phase induction motors – Squirrel cage type.

UNIT 4 DC MOTOR DRIVES AND VECTOR CONTROLLED INDUCTION MOTOR DRIVES 9 Hrs.

Introduction to phase controlled converters – Single phase & three phase controlled converters – Control circuited– Control modelling – Steady state analysis of three phase converter controlled DC motor drive – Transfer function.

UNIT 5 DIGITAL CONTROLLER DESIGN AND TRANSIENT SIMULATION 9 Hrs.

Controller design techniques, Bode diagram method, PID controller, design, root locus method, state space method. Tracker, controller design, controlling voltage, controlling current. Numerical methods for solving ODEs, Stability of numerical methods. Stiff equations, Adaptive step size, Transient analysis in circuit simulation, Equivalent circuit approach, and practical aspects.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Derive a mathematical model of Power Electronic Devices and computer simulation techniques widely used for Power electronic Converters.
CO2 - Analyze performance parameters of various circuits.
CO3 - Derive a mathematical model for AC and DC machine.
CO4 - Analyse the various simulation methods of power electronic systems.
CO5 - Design closed loop systems.
CO6 - Develop steady state and transient studies on converters and Drives.

TEXT / REFERENCE BOOKS

1. Rajagoplan .V, “Computer aided analysis of power electronics systems”, Marcel Dekker Inc, USA 1987.
2. Krishnan .R, “Electric motor drives modelling analysis & control”, Prentice Hall of India Pvt Ltd, 2nd Edition 2007.
3. Van Valkenburg M.E, “Network Analysis”, 3rd Edition, Prentice Hall of India Pvt Ltd, New Delhi, 1990.
4. Simulink Reference Manual, Math Works, USA.
5. L.Umanand,"Power Electronics Essentials and Applications",1stEdition, John Wiley & Sons, 2009,
6. M.B.Patil, V.Ramanarayanan, V.T.Ranganathan, “Simulation of Power Electronic Circuits”, Narosa Publishing House, 2013, ISBN: 978-81-7319-989-9

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks:100 **Exam Duration: 3 Hrs.**

PART A: 5 Questions of 6 marks each – No choice **30 Marks**
PART B: 2 Questions from each unit of internal choice, each carrying 14 marks **70 Marks**

SEEB7006	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

Pre requisite: Nil **Co requisite: Nil**

COURSE OBJECTIVES

- To provide the knowledge of photo voltaic system and wind energy system.
- To analyse the knowledge for standalone PV systems.
- To obtain the analysis of power control through PV inverters for hybrid and grid connected PV systems.
- To design control and gate driver circuitry for wind energy converter.
- To develop a prototype of wind energy converter with recent control technique.

UNIT 1 INTRODUCTION **9 Hrs.**

Overview of Indian energy scenario – Energy sources and availability – Energy crisis – Need to develop new energy technologies – Solar energy availability in India – Wind survey in India – Emerging trends in electrical energy utility – Energy and environment.

UNIT 2 POWER ELECTRONICS FOR PHOTOVOLTIC SYSTEMS **9 Hrs.**

Solar cell fundamentals – Conversion of sunlight to electricity – Cell performance – Basics of photovoltaic – Types of PV power systems – Standalone PV systems – Battery charging – PV charge controllers – Maximum Power Point Tracking (MPPT) – Inverters for stand alone PV systems – Solar water pumping – Power conditioning unit for PV water pumping.

UNIT 3 HYBRID AND GRID CONNECTED PV SYSTEMS **9 Hrs.**

PV Diesel hybrid systems – Control of PV – Diesel hybrid system – Grid connected PV systems – Inverters for grid connected applications – Inverter – Inverter types – Power control through PV inverters – System configuration – Grid inverter characteristics.

UNIT 4 POWER ELECTRONICS FOR WIND POWER SYSTEM **9 Hrs.**

Basics of wind power – Types of wind turbines – Types of wind generators – Types of wind power systems – Stand alone wind diesel hybrid systems – Grid connected wind energy systems.

UNIT 5 SYSTEM MANAGEMENT OF WIND ENERGY CONVERTER **9 Hrs.**

Prototype development – Control circuitry – Microcontroller – Complex programmable logic device – Gate driver circuitry for wind energy applications.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Comprehend the concepts of photovoltaic system and wind energy system.
CO2 - Examine power electronics for standalone photovoltaic systems.
CO3 - Design a hybrid grid connected PV systems.
CO4 - Develop a power electronics based grid connected wind energy system.
CO5 - Analyse gate driver circuitry for wind energy applications.
CO6 - Develop prototype for energy applications.

TEXT / REFERENCE BOOKS

1. Rashid. M. H, "Power Electronics Handbook", Academic press, 4th edition,September 29th,2017.
2. Erickson. R., Angkrtitrakul. S, Al – Nasean. O and Lujan. G, "Novel power electronics systems for wind energy applications" – Final report, National Renewable Energy Laboratory, Colorado, US. – Aug 24, 1999 – Nov 30, 2002.

3. Rai. G. D, “Non-conventional energy sources”, Khanna Publishers, 6thEdition 2015.
4. B.H.Khan, “Non-conventional Energy Resources”, Tata McGrawHill, 2ndEdition 2009.
5. J.K.Manwell, J.G.McGowan, A.L.Rogers, “Wind energy explained – Theory Design and applications”, John Wiley & Sons, 2ndEdition 2009.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks:100 **Exam Duration: 3 Hrs.**

PART A: 5 Questions of 6 marks each – No choice **30 Marks**
PART B: 2 Questions from each unit of internal choice, each carrying 14 marks **70 Marks**

SEEB7007	INTELLIGENT CONTROL	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

Pre requisite: Nil **Co requisite: Nil**

COURSE OBJECTIVES

- To impart knowledge on intelligent control techniques and implementation in electric drives using power converters.
- To apply artificial neural networks and fuzzy methods in various electrical and electronics engineering applications.
- To discriminate the importance of exploration and exploitation swarm intelligent system to attain near global optimal solution.

UNIT 1 INTRODUCTION **9 Hrs.**

Approaches to intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule – based systems, the AI approach. Knowledge representation. Expert systems.

UNIT 2 ARTIFICIAL NEURAL NETWORKS **9 Hrs.**

Networks and its basic mathematical model, McCulloch - Pitts neuron model, simple Perceptron, Adaline and Madaline, Feed-forward Multilayer Perceptron. Learning and Training the neural network. Hopfield network, Self organizing network and Recurrent network- Back propagation networks. Principal Component analysis and wavelet transformations related to power electronics.

UNIT 3 OPTIMIZATION TECHNIQUES **9 Hrs.**

Objective function-Uni modal-Multi model Constraints-Fitness Function-Operators Genetic Algorithm, Tabu search, ant-colony search.

UNIT 4 FUZZY LOGIC SYSTEM **9 Hrs.**

Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modelling and control. Fuzzification, inferencing, defuzzification. Fuzzy knowledge and rule bases. Fuzzy modelling and control schemes for nonlinear systems. Self-organizing fuzzy logic control - Neuro fuzzy controllers.

UNIT 5 APPLICATION (QUANTITATIVE APPROACH ONLY) **9 Hrs.**

GA application to power electronics for the harmonic reduction in inverter.Case studies: Harmonic elimination method using Neural Network – V/F Speed control of an Induction Motor with Neural network based SVM modulator for inverter. Neuro Fuzzy Based efficiency optimized control-Stability analysis of fuzzy control systems.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Comprehend architecture of intelligent control system.
CO2 - Examine the artificial neural networks by using different learning rule.
CO3 - Analyze the optimization techniques by applying genetic algorithm.
CO4 - Describe fuzzy methods of analyzing problems which involve incomplete or vague criteria rather crispValues.
CO5 - Evaluate the harmonics elimination by implementing the application of genetic algorithm and neural Networks.
CO6 - Develop Neuro fuzzy based system for any desired applications.

TEXT / REFERENCE BOOKS

1. S.N.Sivanandam, S.Sumathi and S.N.Deepa, “Introduction to Neural Networks using MATLAB 6.0”, McGraw Hill Publishing companies Limited, 4th Edition, July 2017.
2. Lawrence V.Fansett, “Fundamentals of Neural Networks: Architectures, Algorithms & Applications”, Prentice Hall, 2010.
3. Simopn S.Haykin, “Neural Networks: A Comprehensive Foundation”, Macmillan, 2008.
4. S.Rajasekaran, G.A.Vijayalakashmi Pai, “Neural Networks, Fuzzy Logic & Genetic Algorithms: Synthesis & Applications”, PHI, 4th Edition 2011.
5. S.N.Sivanandam & S.N.Deepa, “Introduction to genetic Algorithms”, Spinger Publications, 2ndEdition, 2010.
6. Timothy Ross, “Fuzzy Logic with Engineering Application”, McGraw Hill, Edition 1997
7. James A. Freeman & Skapura, “Neural Networks”, Pearson Education, 2011.
8. B.Yegnanarayana, “Artificial Neural Networks” Prentice Hall, September 2013.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks:100 **Exam Duration: 3 Hrs.**

PART A: 5 Questions of 6 marks each – No choice **30 Marks**
PART B: 2 Questions from each unit of internal choice, each carrying 14 marks **70 Marks**

SEEB7008	FLEXIBLE AC TRANSMISSION SYSTEMS	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

Pre requisite: SEEB5202 **Co requisite: Nil**

COURSE OBJECTIVES

- To emphasize the necessity for FACTS controllers.
- To learn the characteristics and applications of Static Var Compensator.
- To impart the knowledge on Thyristor Controlled Series Capacitor.
- To be familiar with the operation and control of Static Synchronous Compensator.
- To analyze the concept of Sub Synchronous Resonance.

UNIT 1 INTRODUCTION **9 Hrs.**

Concepts of reactive power – Load compensation – System compensation – Midpoint conditions of a symmetrical line – Passive shunt and series compensation – Synchronous condenser – Saturated reactor – Phase shifting transformer – Concept of FACTS devices.

UNIT 2 STATIC VAR COMPENSATOR (SVC) **9 Hrs.**

Thyristor Controlled Reactor (TCR) - Thyristor Switched Reactor (TSR) - Thyristor Switched Capacitor (TSC) - Fixed Capacitor - Thyristor Controlled Reactor (FC-TCR) - Thyristor Switched Capacitor - Thyristor Controlled Reactor (TSC -TCR) – V-I Characteristics of Static Var Compensator (SVC) - Advantages of slope in dynamic Characteristic – Voltage control by SVC – Design of SCV voltage regulator. Applications: Increase in power transfer capacity – Enhancement of transient stability – Prevention of voltage instability.

UNIT 3 THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) **9 Hrs.**

Concept of series compensation - Thyristor Controlled Series Capacitor (TCSC) controller: Basic principle – Modes of Operation – Advantages - Analysis – Capability Characteristic, Modelling of TCSC, Applications: Open loop and closed loop control – Improvement of the system stability limit – Enhancement of system damping- Concept of Advanced Series Capacitor (ASC).

UNIT 4 EMERGING FACTS CONTROLLER **9 Hrs.**

Static Synchronous Compensator (STATCOM): Principle of Operation – V-I Characteristic – Harmonic performance – Steady state model. SSSC: principle of operation – Control system. Unified Power Flow Controller (UPFC) : Principle of Operation – Injection model. Interline Power Flow Controller (IPFC): Principle of Operation – Control structure - Hybrid Power Flow Controller (HPFC) - Evaluation of different FACTS controllers.

UNIT 5 SUB SYNCHRONOUS RESONANCE (SSR) **9 Hrs.**

NGH-SSR damping scheme – Thyristor controlled braking resistor (TCBR) – Coordination of Multiple Controllers using Linear Control Techniques – Approximate multimodal decomposition method for the design of FACTS controllers.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Examine reactive power compensation.
CO2 - Analyse the operation and control of static var compensator.
CO3 - Develop model for Thyristor controlled series capacitor.
CO4 - Design emerging FACTS controller.
CO5 - Analyse coordination of multiple controllers.
CO6 - Design FACTS controllers.

TEXT / REFERENCE BOOKS

1. R. Mohan Mathur, Rajiv K. Varma, “Thyristor-based facts controllers for electrical transmission systems”, Wiley-IEEE, 2002.
2. K.R.Padiyar, “Facts Controllers in Power Transmission & Distribution”, New Age International Publishers (P) Ltd., 2016.
3. Enrique Acha, Claudio R. Fuerte-Esquivel, Hugo Ambriz-Perez, Cesar Angeles-Camacho, “FACTS: Modelling and Simulation in Power Networks”, John Wiley & Sons Ltd., 2004.
4. S. Sivanagaraju, S.Sathyabarayana, “Electric Power Transmission and Distribution”, Pearson Education, 2009.
5. Kalyan K. Sen & Mey Ling Sen, “Introduction to FACTS Controllers:Theory, Modelling, and Applications”, Wiley-IEEE, 2009.
6. Narain G. Hingorani, Laszlo Gyugyi, “Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems”, IEEE Press Standard Publishers Distributors, 2000.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks:100 **Exam Duration: 3 Hrs.**

PART A: 5 Questions of 6 marks each – No choice **30 Marks**
PART B: 2 Questions from each unit of internal choice, each carrying 14 marks **70 Marks**

SEEB7009	HIGH VOLTAGE DIRECT CURRENT TRANSMISSION	L	T	P	EL	Credits	Total Marks
		3	0	0	0	3	100

Pre requisite: Nil **Co requisite: Nil**

COURSE OBJECTIVES

- To impart knowledge on operation, modelling and control of HVDC link.
- To impart knowledge on HVDC Converter.
- To convey knowledge on HVDC system control.
- To analyze performance converter model.

UNIT 1 DC POWER TRANSMISSION TECHNOLOGY 9 Hrs.

Introduction - Comparison of AC and DC transmission - Application of DC transmission – Description of DC transmission system - Planning for HVDC transmission - Modern trends in DC transmission.

UNIT 2 ANALYSIS OF HVDC CONVERTERS 9 Hrs.

Pulse number, choice of converter configuration - Simplified analysis of Graetz Circuit - Converter bridge characteristics – Characteristics of a twelve pulse converter - Detailed analysis of converters.

UNIT 3 CONVERTER AND HVDC SYSTEM CONTROL 9 Hrs.

General principles of DC link control - Converter control characteristics - System control hierarchy - Firing angle control - Current and extinction angle control - Starting and stopping of DC link - Power control - Higher level controllers - Telecommunication requirements.

UNIT 4 MULTITERMINAL DC SYSTEM 9 Hrs.

Multiterminal DC systems: Introduction – Potential application of MTDC systems – Types of MTDC systems – Control and protection of MTDC systems - Operation of HVDC breaker.

UNIT 5 HARMONICS AND CONVERTER COMPONENT MODEL 9 Hrs.

Introduction - Generation of harmonics - Design of AC filters - DC filters - Carrier frequency and RI noise. Converter model - Continuous time model - Discrete time converter model - Detailed model of the converter.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Examine need of DC transmission, and various plans to transmit HVDC.
CO2 - Analysis of various converter and identification of suitable converter for HVDC transmission.
CO3 - Select better control system of the converter for HVDC system.
CO4 - Examine the different types of DC system and protection methods of MTDC system.
CO5 - Analysis of various converter model components performance.
CO6 - Analysis of harmonic generation and effect of filters.

TEXT / REFERENCE BOOKS

1. Padiyar K.R., “HVDC Power Transmission Systems”, New Age International (P) Limited,Publishers,2015.
2. Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, 3rdEdition, New Age International(P) Limited,Publishers.,2009
3. Chakrabarti A., M.L.Soni,P.V.Gupta,U.S.Bhatnagar, “Power System Engineering”, Dhanpat Rai & Co., 2010.
4. Sunil S.Rao, “Switchgear Protection and Power Systems”,Khanna Publishers,2008.

5. Vlijay K. Sood, “HVDC & FACTS Controllers – Application of static converters in power system”,Kluwer Academic Publishers,2004.
6. Jos Arillaga, Y.H.Liu, N.R. Watson, “Flexible Power Transmission”, The HVDC option, John Wiley &Sons Ltd., 2007.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks:100 **Exam Duration: 3 Hrs.**

PART A: 5 Questions of 6 marks each – No choice **30 Marks**
PART B: 2 Questions from each unit of internal choice, each carrying 14 marks **70 Marks**