

Scheme & Syllabus
for
M.TECH. COURSE
in
POWER ELECTRONICS & DRIVES
(w.e.f. session 2019-20)



DEPARTMENT OF ELECTRICAL ENGINEERING
J.C. BOSE UNIVERSITY OF SCIENCE AND TECHNOLOGY,
YMCA FARIDABAD



J. C. Bose University of Science and Technology, YMCA, Faridabad
(formerly *YMCA University of Science and Technology*)
A State Govt. University established wide State Legislative Act. No. 21 of 2009

VISION

YMCA University of Science and Technology aspires to be a nationally and internationally acclaimed leader in technical and higher education in all spheres which transforms the life of students through integration of teaching, research and character building.

MISSION

To contribute to the development of science and technology by synthesizing teaching, research and creative activities.

To provide an enviable research environment and state-of-the-art technological exposure to its scholars.

To develop human potential to its fullest extent and make them emerge as world class leaders in their professions and enthuse them towards their social responsibilities.



Department of Electrical Engineering

VISION

Electrical Engineering Department congregates the challenges of new technological advancements to provide comprehensively trained, career focused ,morally strong accomplished graduates, cutting edge researchers by experimental learning which contribute to ever changing global society and serve as competent engineers.

MISSION

- To commit excellence in imparting knowledge through incubation and execution of high quality innovative educational programs.
- To develop the Research oriented culture to build national capabilities for excellent power management.
- To inculcate and harvest the moral values and ethical behavior in the students through exposure of self -discipline and personal integrity.
- To develop a Centre of research and education generating knowledge and technologies which lay ground work in shaping the future in the field of electrical engineering.

J.C. BOSE UNIVERSITY OF SCIENCE & TECHNOLOGY, YMCA FARIDABAD
SCHEME OF STUDIES AND EXAMINATION-2019-20

M-TECH 1st YEAR (POWER ELECTRONICS & DRIVES) SEMESTER-I

Sr. No.	Course Code	Course Title	Hours Per Week			Sessional Marks	Final Marks	Total	Credits
			L	T	P				
1	MPED101	Electric Drives System	3	-	-	25	75	100	3
2	MPED102	Modeling and Analysis of Electrical Machines	3	-	-	25	75	100	3
3		Program Elective-I	3	-	-	25	75	100	3
4		Program Elective-II	3	-	-	25	75	100	3
5	RM101	Research Methodology and IPR	3	-	-	25	75	100	3
6	MPED151	Electrical Drives Laboratory	-	-	4	15	35	50	2
7	MPED152	Electrical Machines Laboratory/Power Quality Lab	-	-	4	15	35	50	2
8	AUD01	Audit-I	2	-	-	25	75	100	0
		TOTAL				180	520	700	19

	Course Code	Course Title
Program Elective-I	MPED103	Advanced Power Electronic Circuits
	MPS107A	Power Quality (Common with M.Tech PS Sem 1)
	MPS106A	Dynamics of Electrical Machine (Common with M.Tech PS Sem 1)

	Course Code	Course Title
Program Elective-II	MPS112A	Static VAR Controllers and Harmonic Filtering (Common with M.Tech PS Sem 1)
	MPED107	Optimal and Adaptive Control
	MPED109A	Advance Microcontroller based Systems (Common with M.Tech PS Sem1)

AUD-1	Course Code	Course Title
	AUD01A	English for Research Paper Writing
	AUD02A	Disaster Management
	AUD03A	Sanskrit for Technical Knowledge
	AUD04A	Value Education
	AUD05A	Constitution of India
	AUD06A	Pedagogy Studies
	AUD07A	Stress Management by Yoga
	AUD08A	Personality Development through Life Enlightenment Skills

Program Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PO4: An ability to design and analysis of various controllers for improvement of performance of Power System & Drives.

PO5: An ability to develop and apply artificial intelligence based techniques for the analysis of problems related to Power System.

Course Objectives: Students will be able to: 1. Understand Basic electrical drives and their analysis. 2. Learn Design of controller for drives. 3. Understand Scalar control of electrical drives.	
Syllabus	
Units	Content
1	• Dynamics of Electric Drives: Fundamentals of torque equation, Speed torque convention and multi-quadrant operation, components of load torques.
2	• Classification of load torques steady state stability. • Load equation, Speed control and drive classification and close loop control of drives.
3	• DC motor Drives-Modeling of DC machines. • Steady state characteristics with armature and speed control, Phase controlled DC motor drives, Chopper controlled DC motor drives.
4	• Poly-phase induction machines- Dynamic modeling of induction machines. • Small signal equations, control characteristics of induction machines. • Phase-controlled induction machines, Stator voltage control, Slip energy recovery scheme, frequency control and vector control of induction motor drives.
5	• Traction motor: Starting, Speed-Time characteristics, Braking, Traction motors used in practice.
6	• Industrial Drives-Digital Control of Electric Drives, Stepper motor, Servo motor, Solar drive, BLDC drive, PMSM drive, SRM drive and their specific applications.

Suggested reading

1. G.K. Dubey, "Power semiconductor controlled Drives", Prentice Hall international, New Jersey, 1989.
2. R.Krishnam, "Electric motor drives modeling, analysis and control", PHI-India-2009.
3. G. K. Dubey, "Fundamentals of electric Drives, Narosa Publishing House", 2nd edition, 2011.
4. W. Leonhard, "Control of Electrical drives", Springer, 3rd edition, 2001.
5. P.C. Krause –, "Analysis of Electric Machine", Wiley-IEEE press 3rd edition.
6. K. Bose, "Modern Power Electronics and AC Drives", Prentice Hall publication, 1st edition, 2001.

Course Outcomes:

Students will be able to:

1. Model and simulate electric drive systems
2. Design modulation strategies of power electronics converters, for drives application
3. Design appropriate current/voltage regulators for electric drives
4. Select and implement the drives for Industrial Process
5. Implement various variable speed drives in Electrical Energy Conversion System

Course Objectives: Students will be able to: 1. To understand the operation of an electrical machine mathematically. 2. To understand how a machine can be represented as its mathematical equivalent. 3. To develop mathematical model of AC & DC machines and perform transient analysis on them.	
Syllabus	
Units	Content
1	• Principles of Electromagnetic Energy Conversion. • General expression of stored magnetic energy. • Co-energy and force/torque, example using single and doubly excited system.
2	• Basic Concepts of Rotating Machines-Calculation of air gap mmf and per phase machine inductance using physical machine data; Voltage and torque equation of dc machine.
3	• Three phase symmetrical induction machine and salient pole synchronous machines in phase variable form • Application of reference frame theory to three phase symmetrical induction and synchronous machines • Dynamic direct and quadrature axis model in arbitrarily rotating reference frames.
4	• Determination of Synchronous machine dynamic equivalent circuit parameters • Analysis and dynamic modeling of two phase asymmetrical induction machine and single phase induction machine.
5	• Special Machines - Permanent magnet synchronous machine • Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines • Construction and operating principle • Dynamic modelling and self-controlled operation.
6	• Analysis of Switch Reluctance Motors. • Brushless D.C. Motor for space Applications • Recent trends.

Suggested reading

1. Charles Kingsle,Jr., A.E. Fitzgerald, Stephen D.Umans, “Electric Machinery”, Tata Mcgraw Hill
2. R. Krishnan, “Electric Motor & Drives: Modeling, Analysis and Control”, Prentice Hall of India
3. Miller, T.J.E., “Brushless Permanent Magnet and Reluctance Motor Drives”, Clarendon Press
4. P.C.Krause “Analysis of Electric Machine” Wiley IEEE Press 3rd Edition

Course Outcomes:

Students will be able to:

1. Knowledge about the dynamic behavior rotating machines.
2. Able to understand equivalent circuit of synchronous machines.
3. To understand various practical issues of different machines.

MPED103	ADVANCED POWER ELECTRONIC CIRCUITS	3L:0T:0P	3 Credits
----------------	---	-----------------	------------------

Course Outcomes:

Students will be able to:

1. Analyse the operation of advanced power electronic circuit topologies.
2. Distinguish among various topologies of DC to Dc converter
3. Examine and analyse the concept of switched mode power supplies
4. Analyse the working of Resonant converter topologies
5. Design and understand the multilevel inverters and their applications
6. Apply the concept of Advanced power Electronic converters in various applications

	Syllabus
Unit	content
1	• Review of basic power electronic converter • Boost type APFC and control.
2	• DC to DC converter : Buck, Boost, Buck-Boost Topologies. Cuck converter
3	• SMPS: Modes of operation –Push-Pull and Forward Converter Topologies , Voltage Mode Control. • Half and Full Bridge Converters
4	• Introduction to Resonant Converters. • Load Resonant Converter. Zero Voltage Switching and zero current switching converter Topologies. • Resonant DC Link Inverters
5	• Multi-level inverters, advantages, configurations: Diode clamped, flying capacitor and cascade multi-level inverters, applications.
6	• Applications of power electronic converter: UPS, Induction heating, ,HVDC Transmission system • Few power electronic circuits used in practice for controlling electric drives. DC-DC Converters for various renewable energy conversion.

Suggested reading

- Rashid “Power Electronics” Prentice Hall India 2007.
- G.K.Dubey et.al “Thyristorised Power Controllers” Wiley Eastern Ltd., 2005, 06.
- Dewan&Straughen “Power Semiconductor Circuits” John Wiley &Sons., 1975.
- B. K Bose “Modern Power Electronics and AC Drives” Pearson Education (Asia)., 2007
- Abraham I Pressman “Switching Power Supply Design” McGraw Hill Publishing Company.
- Mohan, Undeland and Robbins, “Power Electronics: Converters, Applications and Design”, John’s Wiley and Sons

Course Objectives: Students will be able to: 1. Understand the different power quality issues to be addressed 2. Understand the recommended practices by various standard bodies like IEEE, IEC, etc. on voltage & frequency, harmonics 3. Understanding STATIC VAR Compensators		
Syllabus		
Units	Content	Hours
1	• Introduction-power quality-voltage quality-overview of power • Quality phenomena classification of power quality issues. • Power quality measures and standards-THD-TIF-DIN-C-message weights. • Flicker factor transient phenomena-occurrence of power quality problems • Power acceptability curves-IEEE guides • Standards and recommended practices.	5
2	• Harmonics-individual and total harmonic distortion • RMS value of a harmonic waveform • Triplex harmonics. Important harmonic introducing devices.SMPS • Three phase power converters-arcing devices saturable devices • Harmonic distortion of fluorescent lamps-effect of power system harmonics on power system equipment and loads.	8
3	• Modeling of networks and components under non-sinusoidal conditions • Transmission and distribution systems • Shunt capacitors-transformers.Electric machines. • Ground systems loads that cause power quality problems. • Power quality problems created by drives and its impact on drive.	6
4	• Power factor improvement- Passive Compensation. • Passive Filtering.Harmonic Resonance.Impedance Scan Analysis • Active Power Factor Corrected Single Phase Front End • Control Methods for Single Phase APFC. • Three Phase APFC and Control Techniques • PFC based on Bilateral Single Phase and Three Phase Converter.	6
5	• Hamilton-Jacobi-Bellman equation - model reference adaptive systems (MRAS) - Design hypothesis.	8
6	• Introduction to design method based on the use of Liapunov function. • Design and simulation of variable structure adaptive model following control.	8

Suggested reading

1. G.T. Heydt, "Electric power quality", McGraw-Hill Professional, 2007
2. Math H. Bollen, "Understanding Power Quality Problems", IEEE Press, 2000
3. J. Arrillaga, "Power System Quality Assessment", John wiley, 2000
4. J. Arrillaga, B.C. Smith, N.R. Watson & A. R. Wood, "Power system Harmonic Analysis", Wiley, 1997

Course Outcomes:

Students will be able to:

1. Acquire knowledge about the harmonics, harmonic introducing devices and effect of harmonicson system equipment and loads
2. develop analytical modeling skills needed for modeling and analysis of harmonics innetworks and components
3. To introduce the student to active power factor correction based on static VAR compensators andits control techniques
4. To introduce the student to series and shunt active power filtering techniques for harmonics.

Course Objectives: Students will be able to: 1. Learn Performance characteristics of machine. 2. To understand the dynamics of the machine. 3. To understand how to determine stability of machine. 4. Learn the synchronous machine analysis.		
Syllabus		
Units	Content	Hours
1	• Stability. • Primitive 4 Winding Commutator Machine. Commutator Primitive Machine. • Complete Voltage Equation of Primitive 4 Winding Commutator Machine.	6
2	• Torque Equation. Analysis of Simple DC Machines using the Primitive Machine Equations. • The Three Phase Induction Motor. Transformed Equations. • Different Reference Frames for Induction Motor Analysis Transfer Function Formulation.	10
3	• Three Phase Salient Pole Synchronous Machine. • Parks Transformation- Steady State Analysis.	6
4	• Large Signal Transient. Small Oscillation Equations in State Variable form • Dynamical Analysis of Interconnected Machines.	6
5	• Large Signal Transient Analysis using Transformed Equations. • DC Generator /DC Motor System.	8
6	• Alternator /Synchronous Motor System.	4

Suggested reading

1. D.P. Sengupta & J.B. Lynn, "Electrical Machine Dynamics", The Macmillan Press Ltd. 1980
2. R Krishnan "Electric Motor Drives, Modeling, Analysis, and Control", Pearson Education., 2001
3. P.C. Kraus, "Analysis of Electrical Machines", McGraw Hill Book Company, 1987
4. I. Boldia & S.A. Nasar, "Electrical Machine Dynamics", The Macmillan Press Ltd. 1992
5. C.V. Jones, "The Unified Theory of Electrical Machines", Butterworth, London. 1967

Course Outcomes

Students will be able to:

1. Formulation of electrodynamic equations of all electric machines and analyze the performance characteristics
2. Knowledge of transformations for the dynamic analysis of machines
3. Knowledge of determination of stability of the machines under small signal and transient conditions
4. Study about synchronous machine

Course Objectives: Students will be able to: 1. Understand the various static converters 2. Understand the static converter control strategies 3. Understand the active and reactive power compensation and their control 4. Understand harmonic filtering and its control design.		
Syllabus		
Units	Content	Hours
1	• Fundamentals of Load Compensation. • Steady-State Reactive Power Control in Electric Transmission Systems. • Reactive Power Compensation and • Dynamic Performance of Transmission Systems.	6
2	• Power Quality Issues: Sags, Swells, Unbalance, Flicker, Distortion. • Current Harmonics.Sources of Harmonics in Distribution Systems and Ill Effects .	6
3	• Static Reactive Power Compensators and their control.Shunt Compensators. • SVCs of Thyristor Switched and Thyristor Controlled types and their control, • STATCOMs and their control. • Series Compensators of thyristor Switched and Controlled Type and their Control. • SSSC and its Control, Sub-Synchronous Resonance and damping. • Use of STATCOMs and SSSCs for Transient and Dynamic Stability Improvement in Power System.	10
4	• Converters for Static Compensation. • Single Phase and Three Phase Converters and Standard Modulation Strategies (Programmed Harmonic Elimination and SPWM). • GTO Inverters. Multi-Pulse Converters and Interface Magnetics. • Multi-Level Inverters of Diode Clamped Type and Flying Capacitor Type and suitable modulation strategies (includes SVM). • Multi-level inverters of Cascade Type and their modulation. Current Control of Inverters.	8
5	• Passive Harmonic Filtering. • Single Phase Shunt Current Injection Type Filter and its Control. • Three Phase Three-wire Shunt Active Filtering and their control using p-q theory and d-q modeling. • Three phase four wire shunt active filters. • Hybrid Filtering using Shunt Active Filters. • Dynamic Voltage Restorer and its control. • Power Quality Conditioner	8
6	• Series Active Filtering in Harmonic Cancellation Mode. • Series Active Filtering in Harmonic Isolation Mode.	4

Suggested reading

1. Ned Mohan et.al, "Power Electronics", John Wiley and Sons, 2006.
2. G. Massobrio, P. Antognet, "Semiconductor Device Modeling with Spice", McGraw-Hill, Inc., 1988.
3. B. J. Baliga, "Power Semiconductor Devices", Thomson, 2004
4. V. Benda, J. Gower, D. A. Grant, "Power Semiconductor Devices. Theory and Applications", John Wiley & Sons 1994.

Course Outcomes

Students will be able to:

1. Acquire knowledge about the fundamental principles of Passive and Active Reactive Power Compensation Schemes at Transmission and Distribution level in Power Systems.
2. To introduce the student to various single phase and three-phase Static VAR Compensation schemes and their controls
3. To develop analytical modeling skills needed for modeling and analysis of such Static VAR

Course Objectives: Students will be able to: 1. To know the operation of closed and open loop optimal control. 2. Understand the adaptive control strategies. 3. Learn dynamic programming method.		
Syllabus		
Units	Content	Hours
1	Optimal control problem – fundamental concepts and theorems of calculus of variations–Euler - Lagrange equation and extremal of functional.	5
2	- Variational approach to solving optimal control problems. - Hamiltonian and different boundary conditions for optimal control problem.	8
3	Linear regulator problem - Pontryagin's minimum principle.	6
4	Dynamic programming - Principle of optimality and its application to optimal control problem.	6
5	Hamilton-Jacobi-Bellman equation - model reference adaptive systems (MRAS) - Design hypothesis.	8
6	- Introduction to design method based on the use of Liapunov function. - Design and simulation of variable structure adaptive model following control.	8

Suggested reading

1. Donald E. Kirk, "Optimal Control Theory, An introduction", Prentice Hall Inc., 2004
2. A.P. Sage, "Optimum Systems Control", Prentice Hall, 1977
3. HSU and Meyer, "Modern Control, Principles and Applications", McGraw Hill, 1968
4. Yoan D. Landu, "Adaptive Control (Model Reference Approach)", Marcel Dekker. 1981
5. K.K.D.Young, "Design of Variable Structure Model Following Control Systems", IEEE Transactions on Automatic Control, Vol. 23, pp 1079-1085, 1978.

Course Outcomes:

Students will be able to:

1. Knowledge in the mathematical area of calculus of variation so as to apply the same for solving optimal control problems.
2. Problem formulation, performance measure and mathematical treatment of optimal control problems.
3. Acquire knowledge on solving optimal control design problems by taking into consideration the physical constraints on practical control systems.
4. To obtain optimal solutions to controller design problems taking into consideration the limitation on control energy in the real practical world.

Course Objectives: Students will be able to: 1. To understand the architecture of advance microcontrollers 2. To understand the applications of these controllers 3. To get some introduction to FPGA.		
Syllabus		
Units	Content	Hours
1	• Basic Computer Organization. • Accumulator based processes-Architecture-Memory • Organization-I/O Organization	6
2	• Micro-Controllers-Intel 8051, Intel 8056- Registers, Memories. • I/O Ports, Serial Communication. Timers, Interrupts, Programming.	8
3	• Intel 8051 – Assembly language programming-Addressing-Operations-Stack & Subroutines,Interrupts-DMA.	6
4	• PIC 16F877- Architecture Programming. • Interfacing Memory/ I/O Devices, Serial I/Oand data communication	8
5	• Digital Signal Processor (DSP) - Architecture – Programming, Introduction to FPGA	8
6	• Microcontroller development for motor control applications. • Stepper motor control using micro controller.	8

Suggested reading

1. John.F.Wakerly: “Microcomputer Architecture and Programming”, John Wiley and Sons 1981.
2. Ramesh S.Gaonker: “Microprocessor Architecture, Programming and Applications with the 8085”, Penram International Publishing (India), 1994.
3. Raj Kamal: “The Concepts and Features of Microcontrollers”, Wheeler Publishing, 2005.
4. Kenneth J. Ayala, “The 8051 microcontroller”, Cengage Learning, 2004.
5. John Morton,” The PIC microcontroller: your personal introductory course”, Elsevier, 2005.
6. Dogan Ibrahim,” Advanced PIC microcontroller projects in C: from USB to RTOS with the PIC18F Series”, Elsevier, 2008.
7. Microchip datasheets for PIC16F877.

Course Outcomes

Students will be able to:

1. To learn how to program a processor in assembly language and develop an advanced processor based system
2. To learn configuring and using different peripherals in a digital system
3. To compile and debug a Program
4. To generate an executable file and use it

Teaching Scheme Lectures: 1hrs/week	
Course Outcomes: At the end of this course, students will be able to • Understand research problem formulation. • Analyze research related information • Follow research ethics • Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity. • Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular. • Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.	
Syllabus Contents: Unit 1: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations Unit 2: Effective literature studies approaches, analysis Plagiarism, Research ethics, Unit 3: Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee Unit 4: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT. Unit 5: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. Unit 6: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	

References:

- Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students”
- Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
- Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners”
- Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
- Mayall , “Industrial Design”, McGraw Hill, 1992.
- Niebel , “Product Design”, McGraw Hill, 1974.
- Asimov , “Introduction to Design”, Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
- T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

MPED 151- ELECTRICAL DRIVES LABORATORY

List of experiments:

1. Study of Thyristor controlled D.C Drive.
2. Study of Chopper Fed DC Motor.
3. Study of A.C single phase motor speed control using TRIAC.
4. PWM inverter fed three phase induction motor control using PSPICE/MATLAB/PSIM software.
5. VSI/CSI fed induction motor drive analysis using MATLAB/PSPICE/PSIM software.
6. Study of V/f control operation of three phase induction motor.
7. Study of permanent magnet synchronous motor drive fed by PWM inverter using software.
8. Regenerative/ Dynamic breaking operation for DC motor study using software.
9. Regenerative/ Dynamic breaking operation for AC motor study using software.
10. PC/PLC based AC/DC motor control operation.

MPED152- ELECTRICAL MACHINES LABORATORY/POWER QUALITY LABORATORY

Electrical Machines lab

List of experiments:

1. Load test on dc shunt motor to draw speed – torque and horse power – efficiency characteristics.
2. Field Test on dc series machines.
3. Speed control of dc shunt motor by armature and field control.
4. Swinburne's Test on dc motor.
5. Retardation test on dc shunt motor.
6. Regenerative test on dc shunt machines.
7. Load test on three phase induction motor.
8. No load and Blocked rotor test on three phase induction motor to draw (i) equivalent circuit and (ii) circle diagram. Determination of performance parameters at different load conditions from (i) and (ii).
9. Load test on induction generator.
10. Load test on single phase induction motor to draw output versus torque, current, power and efficiency characteristics.
11. Conduct suitable tests to draw the equivalent circuit of single phase induction motor and determine performance parameters.
12. Conduct an experiment to draw V and curves of synchronous motor at no load and load conditions.

Power Quality Lab

2. To study the effect of non linear loads on power quality.
3. To demonstrate the voltage and current distortions experimentally.
4. To reduce the current harmonics with filters.
5. To study the voltage sag due to starting of large induction motor.
6. To study the capacitor switching transients.
7. To study the effect of balanced non linear load on neutral current , in a three phase circuit
8. To study the effect of ground loop.
9. To study the effect of voltage flicker .
10. To calculate the distortion power factor.
11. Study the effect of harmonics on energy meter reading.
12. To study effect of voltage sag on electrical equipments.
13. To obtain the current harmonics drawn by power electronics interface using PSCAD software

