Walchand College of Engineering

(Government Aided Autonomous Institute)

Vishrambag, Sangli. 416415

Course Content for

M. Tech. (Power System Engineering)

2022-24

PG Coordinator

HOD (Electrical Engg.)

Semester- I
Professional Core (Theory) Courses

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2022-23

Course Information	
Programme	M.Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	6PS501
Course Name	Digital Protection of Power System
Desired Requisites:	Power System Protection

Teaching Scheme		Examination Scheme (Marks)			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	-	30	20	50	100
		Credits: 3			

Course Objectives	
1	To make students understand digital techniques for realizing various needs of protection.
2	To strengthen the concepts in power system protection.
3	To develop the skills necessary to analyze, design and implement digital protective relays.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	Course Outcome Statement/s	Bloom's Taxonomy Level	Bloom's Taxonomy Description
CO1	Interpret the performance of devices like CT, PT and relays used in digital protection of Power Systems.	III	Applying
CO2	Analyse the use of digital systems for protection of different parts of power system.	IV	Analyzing
CO3	Estimate and Justify settings of relays for protection of different parts of power system.	V	Evaluating
CO4	Design analog/digital protection scheme for simple electrical systems.	VI	Creating

Module	Module Contents	Hours
I	**Review of Relaying Schemes** Protection schemes for alternator, transformer, bus bar and induction motors. Transmission line protection using over current- time graded and current graded schemes, drawbacks of these schemes, differential & distance schemes, Electromagnetic CT and PT.	6
II	**Comparators** **a. Dual Input Comparator:** Amplitude comparator, phase comparator, duality between amplitude and phase comparators, cosine-type and sine type phase comparators, coincidence type phase comparator. **b. Multi Input Comparator:** Amplitude comparator, phase comparator.	4
III	**Over Current Relays** Different time-current characteristics of over current relay, Microprocessor/microcontroller based over current relay, Directional over current relay and its implementation using microprocessor/microcontroller-based scheme.	8

IV	**Differential Relays** Circulating current differential protection, percentage differential protection of power transformers, effect of magnetizing inrush, effect of over voltage inrush, hardware and software used for digital protection of transformer.	8
V	**Distance Protection Relays** Microprocessor/microcontroller-based impedance, reactance and admittance relays, and measurement of R and X. Quadrilateral characteristics. Digital protection scheme based upon fundamental frequency signals, hardware and software design.	8
VI	**Recent Developments in Digital Protection** Digital Relaying techniques based on modern tools of digital signal processing like DFT, Haar Transform, WT etc.	4

Textbooks	
1	Badri Ram, D.N. Vishwakarma, "Power System Protection and Switchgear", TMH, 2004.
2	Y.G. Paithankar, S.R. Bhide, "Fundamentals of Power System Protection", PHI, 2003.

References	
1	L.P. Singh, "Digital Protection", New Age, Second Edition, 2004.
2	A.G. Phadke, J.S. Thorp, "Computer Relaying for Power Systems", Wiley India, II Edi., 2012.

Useful Links	
1	https://nptel.ac.in/courses/108/107/108107167/
2	https://nptel.ac.in/courses/108/105/108105167/

CO-PO Mapping

Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1	2					
CO2				3		
CO3			2			
CO4		2				1

The strength of mapping is to be written as 1: Low, 2: Medium, 3: High
Each CO of the course must map to at least one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Walchand College of Engineering, Sangli *(Government Aided Autonomous Institute)*					
AY 2022-23					
Course Information					
Programme		M.Tech. (Power System Engineering)			
Class, Semester		First Year M. Tech., Sem I			
Course Code		6PS502			
Course Name		Application of Power Electronics to Power system			
Desired Requisites:		Power System Engineering, Power Electronics			
Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	-	30	20	50	100
		Credits: 3			

Course Objectives	
1	To make students understand concept of FACTs envisages the use of power electronics to improve system operation by fast & reliable control.
2	To cover concepts of FACTs including the description, principle of working and analysis of various FACTs controllers.
3	To strengthen the control of FACTs and system interactions.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	Explain necessity, operating principals and benefits of FACTs devices.	II	Understanding
CO2	Choose the suitable FACTs device/controller for particular application.	III	Applying
CO3	Analyze the characteristics of FACTs Controllers and effect of location of the controller on Power System.	IV	Analyzing

Module	**Module Contents**	**Hours**
I	**Introduction** The concept of flexible AC transmission - reactive power control in electrical power transmission lines -uncompensated transmission line - series and shunt compensation. Overview of FACTS devices - Static Var Compensator (SVC) - Thyristor Switched Series capacitor (TCSC) - Unified Power Flow controller (UPFC) - Integrated Power Flow Controller (IPFC).	6
II	**Static VAR Compensator (SVC) and Applications** Voltage control by SVC - advantages of slope in dynamic characteristics - influence of SVC on system voltage. Applications - enhancement of transient stability - steady state power transfer - enhancement of power system damping - prevention of voltage instability.	6
III	**Thyristor Controlled Series Capacitor (TCSC) and Applications** Operation of the TCSC - different modes of operation - modelling of TCSC - variable reactance model - modelling for stability studies. Applications - improvement of the system stability limit - enhancement of system damping - voltage collapse prevention.	6
IV	**Emerging FACTS Controllers I** Static Synchronous Compensator (STATCOM) - operating principle, V-I characteristics	6

V	**Emerging FACTS Controllers II** Unified Power Flow Controller (UPFC) - Principle of operation - modes of operation -applications - modeling of UPFC for power flow studies	6
VI	**Co-Ordination of FACTS Controllers** FACTs Controller interactions - SVC-SVC interaction - co-ordination of multiple controllers using linear control techniques - Quantitative treatment of control.	6

Textbooks	
1	R. Mohan Mathur, Rajiv. K. Varma, “Thyristor - Based Facts Controllers for Electrical Transmission Systems”, IEEE press and John Wiley & Sons Inc., 2002.

References	
1	Purkait and Bandyopadhyay “*Electrical Machines*”, Oxford University Press, 1st Edition, 2017 A.T. John, “Flexible AC Transmission System”, Institution of Electrical and Electronic Engineers (IEEE), 1999.
2	Narain G.Hingorani, Laszio. Gyugyl,“Understanding FACTS Concepts and Technology of Flexible AC Transmission System”, Standard Publishers, Delhi, 2001.

Useful Links	
1	https://nptel.ac.in/courses/108/107/108107114/

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			1			
CO2				2		
CO3						2

The strength of mapping is to be written as 1: Low, 2: Medium, 3: High
Each CO of the course must map to at least one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher’s assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Professional Core (Lab) Courses

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2022-23

Course Information	
Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M.Tech., Sem I
Course Code	6PS547
Course Name	Research Methodology for Power System Engineers
Desired Requisites:	None

Teaching Scheme		Examination Scheme (Marks)			
Practical		**MSE**	**ISE**	**ESE**	**Total**
Interaction	2 Hrs/week	30	30	40	100
		Credits: 2			

Course Objectives	
1	To develop a research orientation among the students and to acquaint them with fundamentals of research methods.
2	To develop understanding of the basic framework of research process and techniques
3	To identify various sources of information for literature review and data collection.
4	To develop an understanding of the ethical dimensions of conducting applied research.
5	To develop understanding about patent process.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	Course Outcome Statement/s	Bloom's Taxonomy Level	Bloom's Taxonomy Description
CO1	Classify various methods to solve research problem.	III	Applying
CO2	Construct a research problem in respective engineering domain.	III	Applying
CO3	Investigate various data analysis techniques for a research problem.	IV	Analyzing
CO4	Identify various Intellectual Property Rights procedures	III	Applying

Module	Module Contents	Hours
I	**Research Fundamentals** What is research, types of research, the process of research, Literature survey and review, Formulation of a research problem.	4
II	**Research Methods** Research design- Meaning, Need and Types, Research Design Process, Measurement and scaling techniques, Data Collection - concept, types and methods, Processing and analysis of data, Design of Experiment	5
III	**Analysis Techniques** Quantitative Techniques, Sampling fundamentals, Testing of hypothesis using various tests like Multivariate analysis, Use of standard statistical software, Data processing, Preliminary data analysis and interpretation, Uni-variate and bi-variate analysis of data, testing of hypotheses.	5
IV	**Research Communication** Writing a conference paper, Journal Paper, Technical report, dissertation/thesis writing. Presentation techniques, software used for report writing such as WORD, Latex etc. Types of journal/conference papers.	4
V	**Intellectual Property Rights** 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.	5

VI	**Patents and Patenting Procedures** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. 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	4

	Textbooks
1	C. R. Kothari, Research Methodology, New Age international
2	Deepak Chopra and Neena Sondhi, Research Methodology: Concepts and cases, Vikas Publishing House, New Delhi
	References
1	E. Philip and Derek Pugh, How to get a Ph. D. - a handbook for students and their supervisors, open university press
2	Stuart Melville and Wayne Goddard, Research Methodology: An Introduction for Science & Engineering Students
	Useful Links
1	NPTEL Lectures

CO-PO Mapping

Programme Outcomes (PO)

	1	2	3	4	5	6
CO1	2		1			
CO2					2	2
CO3				2		
CO4		2				

The strength of mapping is to be written as 1: Low, 2: Medium, 3: High
Each CO of the course must map to at least one PO.

Assessment

There are three components of lab assessment, LA1, LA2 and Lab ESE.
IMP: Lab ESE is a separate head of passing (min 40 %), LA1+LA2 should be min 40%

Assessment	Based on	Conducted by	Typical Schedule	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 8 Marks Submission at the end of Week 8	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 9 to Week 16 Marks Submission at the end of Week 16	30
Lab ESE	Lab activities, journal/ performance	Lab Course Faculty and External Examiner as applicable	During Week 18 to Week 19 Marks Submission at the end of Week 19	40

Week 1 indicates starting week of a semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming, and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments and related activities if any.

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AY 2022-23

Course Information	
Programme	M.Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	6PS545
Course Name	Digital Protection of Power System Laboratory
Desired Requisites:	Digital Protection of Power System

Teaching Scheme		**Examination Scheme (Marks)**			
Practical	2 Hrs/ Week	**LA1**	**LA2**	**Lab ESE**	**Total**
Interaction	--	30	30	40	100
		Credits: 1			

Course Objectives	
1	To develop analytical skills of the student and help to evaluate modern relaying practices.
2	To enable the student to develop protective relaying concepts as well as provide an opportunity for designing relaying hardware and software.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	Demonstrate the operation of electromagnetic & digital relays.	III	Applying
CO2	Test digital relays to verify the operating characteristics.	IV & V	Analyzing & Evaluating
CO3	Design hardware and compile programs for simple digital relays, as a group task.	VI	Creating

List of Experiments / Lab Activities/Topics

Lab activities/performance shall include mini project, presentations, drawings, case study, report writing, site visit, lab experiment, tutorials, assignments, group discussion, programming, and other suitable activities as per nature and requirement of lab course.

Textbooks	
1	Badri Ram, D.N. Vishwakarma, "Power System Protection and Switchgear", TMH, 2004.

References	
1	PRDC Relay user manuals
2	Mi-Power user manuals
3	A.G. Phadke, J.S. Thorp, *"Computer Relaying for Power Systems",* Wiley India, II Edi., 2012.

Useful Links	
1	https://nptel.ac.in/courses/108/107/108107167/
2	https://nptel.ac.in/courses/108/105/108105167/

CO-PO Mapping						
Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1			3			
CO2				2	2	
CO3		2				2

The strength of mapping is to be written as 1: Low, 2: Medium, 3: High
Each CO of the course must map to at least one PO.

Assessment

There are three components of lab assessment, LA1, LA2 and Lab ESE.
IMP: Lab ESE is a separate head of passing.(min 40 %), LA1+LA2 should be min 40%

Assessment	Based on	Conducted by	Typical Schedule	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 8 Marks Submission at the end of Week 8	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 9 to Week 16 Marks Submission at the end of Week 16	30
Lab ESE	Lab activities, journal/ performance	Lab Course Faculty and External Examiner as applicable	During Week 18 to Week 19 Marks Submission at the end of Week 19	40

Week 1 indicates starting week of a semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming, and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments and related activities if any.

Walchand College of Engineering, Sangli *(Government Aided Autonomous Institute)*					
AY 2022-23					
Course Information					
Programme		M.Tech. (Power System Engineering)			
Class, Semester		First Year M. Tech., Sem I			
Course Code		6PS546			
Course Name		Application of Power Electronics to Power System Laboratory			
Desired Requisites:		Power System Engineering, Power Electronics			
Teaching Scheme		**Examination Scheme (Marks)**			
Practical	2 Hrs/ Week	**LA1**	**LA2**	**Lab ESE**	**Total**
Interaction	--	30	30	40	100
		Credits: 1			

Course Objectives	
1	To make students understand concept of FACTs envisages the use of power electronics to improve system operation by fast & reliable control.
2	To cover concepts of FACTs including the description, principle of working and analysis of various FACTs controllers.
3	To strengthen the control of FACTs and system interactions.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	Simulation of various FACTs devices to understand principle and modelling.	II	Understanding
CO2	Choose the suitable FACTs device/controller for particular application.	III	Applying
CO3	Analyze the characteristics of FACTs Controllers and effect of location of the controller on Power System.	IV	Analyzing

List of Experiments / Lab Activities/Topics

Lab activities/performance shall include mini project, presentations, drawings, case study, report writing, site visit, lab experiment, tutorials, assignments, group discussion, programming, and other suitable activities as per nature and requirement of lab course

Textbooks

1	R. Mohan Mathur, Rajiv. K. Varma, "Thyristor - Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons Inc., 2002

References

1	A. T. John, *"Flexible AC Transmission System"*, Institution of Electrical and Electronic Engineers (IEEE), 1999.
2	Narain G. Hingorani, Laszio. Gyugyl, *"Understanding FACTS Concepts and Technology of Flexible AC Transmission System"*, Standard Publishers, Delhi, 2001.

Useful Links

1	

CO-PO Mapping						
Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1			2			
CO2				2		
CO3						2

The strength of mapping is to be written as 1: Low, 2: Medium, 3: High
Each CO of the course must map to at least one PO.

Assessment

There are three components of lab assessment, LA1, LA2 and Lab ESE.
IMP: Lab ESE is a separate head of passing.(min 40 %), LA1+LA2 should be min 40%

Assessment	Based on	Conducted by	Typical Schedule	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 8 Marks Submission at the end of Week 8	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 9 to Week 16 Marks Submission at the end of Week 16	30
Lab ESE	Lab activities, journal/ performance	Lab Course Faculty and External Examiner as applicable	During Week 18 to Week 19 Marks Submission at the end of Week 19	40

Week 1 indicates starting week of a semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming, and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments and related activities if any.

Walchand College of Engineering, Sangli

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AY 2022-23

Course Information	
Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	6PS551
Course Name	Presentation and Technical Report Writing
Desired Requisites:	None

Teaching Scheme		**Examination Scheme (Marks)**			
Practical		**LA1**	**LA2**	**Lab ESE**	**Total**
Interaction	1 Hrs/ Week	30	30	40	100
		Credits: 1			

Course Objectives

1	To provide an opportunity to student to do work independently on a topic.
2	To encourage creative thinking process in technical report writing
3	To enable student for good technical report writing and effective presentations.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	Demonstrate the characteristics of technical and business writing.	III	Applying
CO2	Produce documents related to technology and writing in the workplace and will have improved their ability to write clearly, concisely, and accurately.	VI	Creating
CO3	Use a variety of materials to produce appropriate visual presentation for documents, such as instructions, descriptions, and research reports.	V	Evaluating

List of Experiments / Lab Activities/Topics

This course introduces students to the discipline of technical communication. Preparation of visuals to supplement text, workplace communication, descriptions of mechanisms, explanations of processes, and writing reports are the major topics included.
This course is designed for students enrolled in technical degree programs for making them industry ready.

Textbooks

1	Suitable books based on the contents of the topic.

References

1	Suitable books based on the contents of the selected topic and research papers from reputed national and international journals and conferences.

Useful Links

1	As per the need of the topic of report and presentation

CO-PO Mapping						
Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1		3				
CO2		2		1		
CO3		1				2
The strength of mapping is to be written as 1: Low, 2: Medium, 3: High Each CO of the course must map to at least one PO.						

Assessment				
There are three components of lab assessment, LA1, LA2 and Lab ESE. IMP: Lab ESE is a separate head of passing.(min 40 %), LA1+LA2 should be min 40%				
Assessment	**Based on**	**Conducted by**	**Typical Schedule**	**Marks**
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 8 Marks Submission at the end of Week 8	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 9 to Week 16 Marks Submission at the end of Week 16	30
Lab ESE	Lab activities, journal/ performance	Lab Course Faculty and External Examiner as applicable	During Week 18 to Week 19 Marks Submission at the end of Week 19	40
Week 1 indicates starting week of a semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming, and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments and related activities if any.				

Walchand College of Engineering, Sangli *(Government Aided Autonomous Institute)*					
AY 2022-23					
Course Information					
Programme		M.Tech. (Power System Engineering)			
Class, Semester		First Year M. Tech., Sem I			
Course Code		6PS552			
Course Name		Professional Skills 1			
Desired Requisites:		None			
Teaching Scheme		**Examination Scheme (Marks)**			
Practical	--	**LA1**	**LA2**	**Lab ESE**	**Total**
Interaction	1 Hr/ Week	30	30	40	100
		Credits: 1			

Course Objectives	
1	To provide a hands-on experience of software in solving complex Electrical Engineering problems.
2	To enhance the employability of Electrical Engineering student.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	Use of the software related to Electrical Engineering effectively.	V	Evaluating
CO2	Develop the solution for Electrical Engineering problem using software.	VI	Creating
CO3	Explain the process of problem-solving using computing tools.	II	Understanding

List of Experiments / Lab Activities/Topics

This course is based on computing as a tool to design and analyze the Electrical Engineering system. In the modern day work environment, the Electrical Engineer should be able to simulate and solve complex problems on computers. The Electrical Engineer must be highly computer literate. The engineer with strong fundamentals and computer software proficiency is highly in demand from industry. Employability of the student can be enhanced by providing software training.

Textbooks

1	Suitable books based on the contents of software selected

References

1	Suitable books based on the contents of software selected

Useful Links

1	As per the need of the software training

CO-PO Mapping						
Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1	2					
CO2			2			
CO3		3				1
The strength of mapping is to be written as 1: Low, 2: Medium, 3: High Each CO of the course must map to at least one PO.						

Assessment				
There are three components of lab assessment, LA1, LA2 and Lab ESE. IMP: Lab ESE is a separate head of passing.(min 40 %), LA1+LA2 should be min 40%				
Assessment	**Based on**	**Conducted by**	**Typical Schedule**	**Marks**
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 8 Marks Submission at the end of Week 8	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 9 to Week 16 Marks Submission at the end of Week 16	30
Lab ESE	Lab activities, journal/ performance	Lab Course Faculty and External Examiner as applicable	During Week 18 to Week 19 Marks Submission at the end of Week 19	40
Week 1 indicates starting week of a semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming, and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments and related activities if any.				

Professional Elective

Walchand College of Engineering, Sangli *(Government Aided Autonomous Institute)*	
AY 2022-23	
Course Information	
Programme	M.Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	6PS511
Course Name	Professional Elective 1: Power Apparatus Modelling
Desired Requisites:	Power System Engineering, A.C. Machines, Power System Analysis and Stability

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	-	30	20	50	100
		Credits: 3			

Course Objectives	
1	To provide the students the ability to understand the problem of stability of single machine connected to infinite bur and multi machine system.
2	To give the students a sound mathematical approach towards modelling of various approach used in power system.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	Construct models of apparatus in power system.	III	Applying
CO2	Analyze models for stability of power systems.	IV	Analyzing
CO3	Recommend solutions to the problem of power system stability and control.	V	Evaluating

Module	**Module Contents**	**Hours**
I	**Introduction to Power System Stability Problem** Classification of stability, resolution of stability problem by classical method, transient stability of multi-machine system.	6
II	**Modeling of Synchronous machine** Physical description, mathematical description of synchronous machine, dq0 transformation, per unit representation, equivalent circuits for direct and quadrature axis.	6
III	**Excitation System** Elements of excitation system, types of excitation system, necessity of stabilizing circuits IEEE excitation systems.	6
IV	**Prime Movers and Energy supply Systems** Turbines and governing systems, modeling of steam turbines, steam turbine controls, steam turbine off-frequency capability.	6
V	**Dynamic modeling of hydro turbine and governors** Hydraulic turbine transfer function, governors for hydraulic turbines, detailed hydraulic system model, guidelines for modeling hydraulic turbines	6
VI	**Load modeling for stability studies** Basic load modeling concepts, static load models, dynamic load models, modeling of induction motor, per unit representation, representation in stability studies	6

Textbooks	
1	P. Kundur, *Power System, Stability and Control*, Tata McGraw Hill, New Delhi, 1994.

References	
1	K. R. Padiyar, "*Power System Dynamic, Stability & Control*", B.S. Publication, 2008.
2	Peter W.Sauer, M.A. Pai, "*Power System Dynamics and Stability*", Person Education Asia, 1998.
Useful Links	

CO-PO Mapping						
Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1			3			
CO2				3		
CO3						2

The strength of mapping is to be written as 1: Low, 2: Medium, 3: High
Each CO of the course must map to at least one PO.

Assessment
The assessment is based on MSE, ISE and ESE. MSE shall be typically on modules 1 to 3. ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO. ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6. For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Walchand College of Engineering, Sangli
(Government Aided Autonomous Institute)

AY 2022-23

Course Information	
Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	6PS512
Course Name	Professional Elective 1: DSP Application to Power System
Desired Requisites:	Signals and Systems

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	-	30	20	50	100
		Credits: 3			

Course Objectives	
1	To provide a mathematical introduction to the theory and applications of orthogonal wavelets and their use in analyzing functions and function spaces.
2	It includes a brief survey of Fourier series representation of functions, Fourier transform and the Fast Fourier Transform (FFT) before proceeding to the Haar wavelet system, multi resolution analysis, decomposition and reconstruction of functions, Daubechies wavelet construction, and other wavelet systems.
3	It aims at imparting skills to develop wavelet-based algorithms for applications in the area of Power Systems.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	Explain the basic concepts and terminology that are used in the Fourier Techniques, wavelets Transforms and Time frequency analysis.	II	Understanding
CO2	Calculate filter bank coefficients and Apply the concepts of CWT, STFT and DWT for signal analysis.	III	Applying
CO3	Construct perfect reconstruction wavelet filter banks for a particular application and justify why wavelets provide the right tool.	IV	Analyzing

Module	**Module Contents**	**Hours**
I	**Fundamentals of Linear Algebra** Vector spaces, Bases, Orthogonality, Orth normality, Projection, Functions and function Spaces, Orthogonal functions, Orthonormal functions, Orthogonal basis functions.	4
II	**Signal Representation in Fourier Domain** Fourier series, Orthogonality, Orth normality and the method of finding the Fourier coefficients Complex Fourier series, Orthogonality of complex exponential bases, Mathematical preliminaries for continuous and discrete Fourier transform, limitations of Fourier domain signal processing, Review of Nyquist theorem., Review of Z transform, Application of Fourier family transforms in power systems.	6

III	**Discrete Wavelet Transform** **Introduction to Wavelet Transform:** The origins of wavelets, Wavelets and other wavelet like transforms, History of wavelet from Morlet to Daubechies via Mallat, Different communities and family of wavelets, Different families of wavelets within wavelet communities **Discrete wavelet transforms:** Introduction, Haar Scaling Functions and Function Spaces, Translation and Scaling, Orthogonality of Translates, Function Space Vo, Finer Haar Scaling Functions, Nested Spaces Haar Wavelet Function, Scaled Haar Wavelet Functions, Orthogonality of φ(t) and ψ(t), Normalization of Haar Bases at Different Scales, Standardizing the Notations, Refinement Relation with Respect to Normalized Bases, Support of a Wavelet System, Triangle Scaling Function, Daubechies Wavelets.	8
IV	**Discrete Wavelet Transform and Relation to Filter Banks** Signal decomposition (Analysis), Relation with filter banks, Frequency response, Signal reconstruction: Synthesis from coarse scale to fine scale, Up sampling and filtering, Perfect reconstruction filters, QMF conditions, Computing initial sj+1 coefficient, Concepts of Multi-Resolution Analysis (MRA) and Multi-rate signal processing, Applications of DWT in power systems.	8
V	**Short Time Fourier Transform (STFT) and Continuous Wavelet Transform (CWT)** **Short Time Fourier Transform:** Signal representation with continuous and discrete STFT, concept of time-frequency resolution, Resolution problem associated with STFT, Heisenberg's Uncertainty principle and time frequency tiling, why wavelet transform? **Continuous Wavelet Transform:** Wavelet transform-A first level introduction, Continuous time-frequency representation of signals, Properties of wavelets used in continuous wavelet transform, Continuous versus discrete wavelet transform.	6
VI	**Designing Orthogonal Wavelet Systems-A Direct Approach** Refinement relation for orthogonal wavelet systems, Restrictions on filter coefficients, Condition-1: Unit area under scaling function, Condition-2: Orth normality of translates of scaling functions, Condition-3: Orth normality of scaling and wavelet functions, Condition-4: Approximation conditions (Smoothness conditions), Designing Daubechies orthogonal wavelet system coefficients, Constraints for Daubechies' 6 tap scaling function.	6

	Textbooks
1	K P Soman, Ramachandran, Resmi, "*Insights into wavelets from theory to practice"*, Prentice Hall, New Delhi,
2	A.N. Akansu and R.A. Haddad, "*Multiresolution signal Decomposition: Transforms, Subbands and Wavelets*", Academic Press, Oranld, Florida, 1992.
3	John G. Proakis, Dimitris G. Manolakis, "*Digital Signal Processing*", Pearson Prentice Hall,2007.
	References
1	C. Sidney Burrus, Ramesh A. Gopinath, HaitaoGuo, "*Introduction to Wavelets and Wavelet Transform"s,* A Primer PH International Editions, 1998.
2	Raghuveer M. Rao, Ajit S. Bopardikar, "Wavelet Transforms - *Introduction to Theory and Application's"*, Addison Wesley Pearson Education Asia, 2000.
3	IEEE Transaction Papers.
	Useful Links
1	https://nptel.ac.in/courses/117/101/117101001/

CO-PO Mapping						
Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1			2			
CO2				2		
CO3						3

The strength of mapping is to be written as 1: Low, 2: Medium, 3: High
Each CO of the course must map to at least one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2022-23

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	6PS513
Course Name	Professional Elective 2: Grid Integration of Renewable Energy
Desired Requisites:	Power Electronics, Renewable Energy

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	-	30	20	50	100
		Credits: 3			

Course Objectives

1	To make the students conversant with configurations of renewable energy grid integration.
2	To provide the advance knowledge about voltage-sourced converters & their control.
3	To make the students aware of research avenues in the field of renewable grid integration along with DC micro-grid concepts.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	Summarize two level voltage source converters in various reference frame.	II	Understanding
CO2	Apply various voltage source converters and their control.	III	Applying
CO3	Analyze grid synchronization techniques and DC micro-gird.	IV	Analyzing

Module	**Module Contents**	**Hours**
I	**Overview of Renewable Energy** Status & trends of renewable energy sources, solar fundamentals, electrical characteristics of PV, stand-alone grid connected PV configurations, wind energy assessment, fixed & variable speed turbines with reduced & full capacity converters.	7
II	**Two level, three phase voltage-sourced converter** Introduction. Two level voltage sourced-converter: structure, principle of operation & power loss. Average model of two level VSC, model in αβ-frame, model & control in dq frame.	6
III	**Three level, three phase, Neutral Point Clamped voltage-sourced converter** Introduction, Three level half bridge NPC, PWM scheme for three level half bridge NPC, switched model & average model for three level half bridge NPC, three level NPC: circuit structure, principle of operation. Three level NPC with impressed dc side voltage.	6
IV	**Grid Imposed frequency VSC system: control in αβ-frame & dq-frame** Introduction, structure of grid-imposed frequency VSC system, real & reactive-power controller, Dynamic model & current mode control for real-/reactive power controller in αβ-frame & dq frame, Phase locked Loop.	6
V	**Grid Synchronization** Grid synchronization techniques for single-phase systems, grid synchronization using the Fourier analysis, grid synchronization using A phase-locked loop, PLL Based on a T/4 transport delay, PLL based on the Hilbert transform.	6

VI	**DC Micro-grid** Introduction, DC micro-grid system overview, Operation and control of DC micro-grids, DC micro-grid system protection, Application of DC micro-grids to future smart grids.	5

Textbooks	
1	Amirnaser Yazdani and Reza Iravani, *"Voltage-sourced converters in power systems_ modeling, control, and applications"* IEEE Press John Wiley, 2010.
2	Remus Teodorescu, Marco Liserre, and Pedro Rodriguez, *"Grid Converters for Photovoltaic and Wind Power Systems",* John Wiley & Sons, Ltd, 2011.
References	
1	Antonio Moreno-Munoz, *"Large Scale Grid Integration of Renewable Energy Sources"*, The Institution of Engineering and Technology, 2017.
2	Math J. Bollen and Fainan Hassan, *"Integration of Distributed Generation in the Power System"*, IEEE Press, 2011.
Useful Links	
1	http://nptel.ac.in/downloads
2	http://www.nptelvideos.in
3	https://ocw.mit.edu/courses/electrical-engineering

CO-PO Mapping

	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			3			
CO2				2		
CO3						2

The strength of mapping is to be written as 1: Low, 2: Medium, 3: High
Each CO of the course must map to at least one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2022-23

Course Information	
Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M.Tech., Sem I
Course Code	6PS514
Course Name	Professional Elective 2: Neural Network and fuzzy Application to Power System
Desired Requisites:	Power System

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	-	30	20	50	100
		Credits: 3			

Course Objectives	
1	To make the student conversant with basic knowledge of Neural Network.
2	To make the student conversant with design and programming knowledge for power system operation and control.
3	To make the student conversant with basic knowledge of fuzzy system and fuzzy applications.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	Explain the basic knowledge of Neural Network	II	Understanding
CO2	Apply the Neural network and fuzzy knowledge about different neural networks, their architecture and training algorithm to solve power system problems.	III	Applying
CO3	Study the different applications of neural networks and fuzzy logic.	IV	Analyzing

Module	**Module Contents**	**Hours**
I	**Introduction to Neural Networks** Introduction, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron Models, Historical Developments, Neuron Model, McCulloch and Pitts models of neuron, ANN terminologies, weights, sigmoidal functions, Bias.	6
II	**Essentials of Neural Networks** Types of Neuron Activation Function, Neural networks architectures, Linearly separable and linearly non separable systems and their examples, Learning Strategy (Supervised, Unsupervised, Reinforcement), Learning Rules, Hebbian learning rule, Perceptron learning rule etc.	6
III	**Feed Forward Neural Networks** Introduction, single layer Perceptron Models, architecture, Limitations of the Perceptron Model, Applications, Back Propagation Network, architecture, Multilayer Feed Forward Neural Networks. Use of ANN MATLAB tools for programming.	6
IV	**Fuzzy Systems** Basic Fuzzy logic theory, history, operation of Fuzzy Logic, Fuzzy relation and extension principle, Fuzzy membership functions and linguistic variables, Mamdani and sugenos models. Use of MATLAB tools of fuzzy logic.	6

V	**Application of Neural Network and fuzzy to power system operation and control problems** Use of MATLAB tools of ANN and fuzzy logic for power system applications. Case studies such as load fore-casting, optimal power flow, control applications in FACTS devices, etc.	6
VI	**Application of Neural Network and fuzzy to recent power system protection problems** Use of MATLAB tools of ANN and fuzzy logic for protection applications. Case studies such as fault analysis, fault detection, fault classification, fault location, etc.	6

Textbooks	
1	S. N. Sivanandam, "*Introduction to Neural Networks using MATLAB 6*", Tata McGraw hill education, 2006.
2	Hagan, Demuth, Mark Beale, "*Neural Network Design"*, Cengage Learing India Private Limited, 2011.

References	
1	Stamatios V. Kartalopoulos, "Understanding neural networks and fuzzy logic basic concepts and applications", Prentice Hall of India (P) Ltd, New Delhi, 2000.
2	J.M. Zurada, "Introduction to artificial neural systems", Jaico Publishers, 1992.
3	Timothy Ross, "Fuzzy Logic with Engineering Applications", Tata McGraw Hill Publication, 1993
4	George J. Klir and Bo Yuan, "Fuzzy Sets and Fuzzy Logic", PHI Learning Private Limited, 1995.
5	Research Papers.

Useful Links	
1	https://onlinecourses.nptel.ac.in/noc21_ge07/preview

CO-PO Mapping

Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1						1
CO2				3		
CO3				2		

The strength of mapping is to be written as 1: Low, 2: Medium, 3: High
Each CO of the course must map to at least one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Semester- II
Professional Core (Theory) Courses

Walchand College of Engineering, Sangli *(Government Aided Autonomous Institute)*	
AY 2022-23	
Course Information	
Programme	M. Tech (Power System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	6PS521
Course Name	Power Quality in Distribution Systems
Desired Requisites:	Power Systems, Power Electronics

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	--	30	20	50	100
		Credits: 3			

Course Objectives	
1	To make the students to understand basic knowledge of causes, consequences and solutions of power quality problems that affect the operation of computerized processes and electronic systems.
2	To provide a theoretical background to correctly approach the problem of reactive, harmonic and unbalance compensation.
3	To understand and apply the power theories for compensation problems.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	State and explain the basic concepts of Power Quality disturbances, reactive power compensation, voltage regulation, power definitions and other figures of merit under distorted, operation and modelling of series and shunt compensators.	I & II	Remembering & Understanding
CO2	Apply the theory and algorithms to realize reference current generation, reactive power compensation, voltage regulation and harmonic compensation.	III	Applying
CO3	Analyze theories of load compensation, reference generation, figures of merits and power definitions, Standards applicable to Power Quality.	IV	Analyzing

Module	**Module Contents**	**Hours**
I	**Introduction to Power quality** **Power Quality**: Introduction, State of the Art on Power Quality, Classification of Power Quality Problems, Causes of Power Quality Problems, Effects of Power Quality Problems on Users, Classification of Mitigation Techniques for Power Quality Problems. **Power Quality Standards and Monitoring**: Introduction, State of the Art on Power Quality Standards and Monitoring, Power Quality Terminologies, Power Quality Definitions, Power Quality Standards, Power Quality Monitoring, Numerical Examples.	6
II	**Power Definitions in Single Phase and Three phase Circuits** Definitions of various powers, power factor and other figures of merit under balanced, unbalanced and non-sinusoidal conditions applicable to single phase circuits. Definitions of various powers, power factor and other figures of merit under balanced, unbalanced and non-sinusoidal conditions. IEEE 1459 power definitions applicable to three phase circuits	6

III	**Theories of Load compensation** Introduction, State of the Art on Passive Shunt and Series Compensators, Classification of Passive Shunt and Series Compensators, Principle of Operation of Passive Shunt and Series Compensators, Analysis and Design of Passive Shunt Compensators, Modelling, Simulation, and Performance of Passive Shunt and Series Compensators, Numerical Examples	6
IV	**Active Shunt Compensation** Introduction, State of the Art on DSTATCOMs, Classification of DSTATCOMs, Principle of Operation and Control of DSTATCOMs, Analysis and Design of DSTATCOMs, Modelling, Simulation, and Performance of DSTATCOMs, Numerical Examples.	6
V	**Active Series Compensation** Introduction, State of the Art on Active Series Compensators, Classification of Active Series Compensators, Principle of Operation and Control of Active Series Compensators, Analysis and Design of Active Series Compensators, Modelling, Simulation, and Performance of Active Series Compensators, Numerical Examples.	6
VI	**Unified Power Quality Compensators** Introduction, State of the Art on Unified Power Quality Compensators, Classification of Unified Power Quality Compensators, Principle of Operation and Control of Unified Power Quality Compensators, Analysis and Design of Unified Power Quality Compensators, Modelling, Simulation, and Performance of UPQCs, Numerical Examples.	6
	Textbooks	
1	Dr. Mahesh Kumar, IIT Chennai, “*Power Quality in Distribution Systems”*.	
2	Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, “*Power Quality Problems and Mitigation Techniques”*, Wiley, 2015.	
	References	
1	Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, H. Wayne Beaty, “*Electrical Power Systems Quality”*, Mc-Graw Hill, Edition II, 1996.	
2	Angelo Baggini, “*Handbook on Power Quality”*, John Wiley & Sons, New Jersey, USA, 2008	
	Useful Links	
1	https://nptel.ac.in/courses/108/106/108106025/	

CO-PO Mapping						
Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1			1			
CO2	2					
CO3				1		2
The strength of mapping is to be written as 1: Low, 2: Medium, 3: High Each CO of the course must map to at least one PO.						

Assessment
The assessment is based on MSE, ISE and ESE. MSE shall be typically on modules 1 to 3. ISE shall be taken throughout the semester in the form of teacher’s assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO. ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6. For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2022-23

Course Information	
Programme	M.Tech. (Power System Engineering)
Class, Semester	First Year M.Tech., Sem II
Course Code	6PS522
Course Name	PLC and Embedded Systems
Desired Requisites:	Instrumentation Techniques, Electrical Measurements, Microcontroller and Applications

Teaching Scheme		Examination Scheme (Marks)			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	--	30	20	50	100
		Credits: 3			

Course Objectives	
1	To exploit the PLC and Embedded Control for industrial automation.
2	To developing programs using ladder logic for industrial automation.
3	To analyze the performance of automation systems employing PLC and Embedded Control.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	Course Outcome Statement/s	Bloom's Taxonomy Level	Bloom's Taxonomy Description
CO1	Interpret features of PLC and Embedded Control Systems used for Industrial Automation.	III	Applying
CO2	Use ladder logic programming technique for various PLC applications.	III	Applying
CO3	Evaluate the performance of PLC network configurations, PLC functions used for different application	V	Evaluating

Module	Module Contents	Hours
I	**Introduction to PLC** Introduction, Advantages, Disadvantages, Parts of PLC, PLC Input module, PLC Output Module, PLC Architecture, PLC Operation, PLC as a computer, PLC memory and interfacing, Power Supply for PLC	6
II	**PLC programming** Ladder Logic Symbols, Latching and Unlatching of PLC, Programming on/ off inputs to produce on/off outputs, relation of digital gate logic to contact / coil logic, creating ladder diagrams from process control description.	6
III	**PLC Timer and Counter Functions** PLC timer functions, Types of PLC timers, Programming of Non-retentive timers for various applications, Programming of ON timers, OFF timers, PLC counter functions, Programming of UP, DOWN counters, Case studies related to Industrial Automations	6
IV	**PLC Arithmetic, Comparison and Branch functions** PLC Arithmetic functions, PLC comparison functions, Conversion functions, Master control relay functions, PLC jump functions, Jump with return and Jump with No return functions, Programs related to Arithmetic, Comparison and Branch functions	6
V	**Advanced PLC functions** Data move system, Data handling functions, Digital bit functions and applications, Sequencer functions, Analog PLC operations, PID control of continuous process, PID modules & tuning, Typical PID functions	6

VI	**PLC Networking** Networking of PLCs, Levels of Industrial Control, Types of Networking, Network Communications, Cell control by PLC Networks, Factors to consider in selecting a PLC	6

Textbooks	
1	John W. Webb, Ronald A. Reis, "Programmable logic controllers, principles & applications", PHI publication, Eastern Economic Edition, 1994.
References	
1	John R. Hackworth and Peterson, "*PLC controllers programming methods and applications*", PHI, 2004.
2	Gary dunning, "*Introduction to PLC*, Thomson learning", Edition III, 2006
3	William H. Bolton*," Programmable logic controllers"*, Newnes, Edition VI, 2006.
Useful Links	

CO-PO Mapping

	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			2			
CO2			2			
CO3				2		

The strength of mapping is to be written as 1: Low, 2: Medium, 3: High
Each CO of the course must map to at least one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Professional Core (Lab) Courses

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2022-23

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	6PS591
Course Name	Power Quality in Distribution Systems Laboratory
Desired Requisites:	Power Systems, Power Electronics

Teaching Scheme		**Examination Scheme (Marks)**			
Practical	2 Hrs/ Week	**LA1**	**LA2**	**Lab ESE**	**Total**
Interaction	--	30	30	40	100
		Credits: 1			

Course Objectives

1	To educate the students with the practical aspects of Power Quality issues.
2	To develops the critical thinking in solving power quality problems with contemporary Power Quality Theories.
3	To enhance research skills of students to Power Quality issues.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	Calculate power components and other figures of merit under distorted conditions.	III	Applying
CO2	Analyze Power Quality Problems and provide suitable remedy.	IV	Analyzing
CO3	Evaluate theories of load compensation, reference generation using suitable simulation tool.	V	Evaluating

List of Experiments / Lab Activities/Topics

Lab activities/Lab performance shall include mini-project, presentations, drawings, case studies, report writing, site visit, lab experiment, tutorials, assignments, group discussion, programming and other suitable activities, as per the nature and requirement of the lab course.

Textbooks

1	Dr. Mahesh Kumar, IIT Chennai, "*Power Quality in Distribution System*".
2	Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, **"***Power Quality Problems and Mitigation Techniques*", Wiley, 2015.

References

1	Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, H. Wayne Beaty, "*Electrical Power Systems Quality*", Mc-Graw Hill, Edition II, 1996.
2	Angelo Baggini, "*Handbook on Power Quality*", John Wiley & Sons, New Jersey, USA, 2008

Useful Links

1	

CO-PO Mapping						
Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1			2			
CO2				2		
CO3						3

The strength of mapping is to be written as 1: Low, 2: Medium, 3: High
Each CO of the course must map to at least one PO.

Assessment

There are three components of lab assessment, LA1, LA2 and Lab ESE.
IMP: Lab ESE is a separate head of passing.(min 40 %), LA1+LA2 should be min 40%

Assessment	Based on	Conducted by	Typical Schedule	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 8 Marks Submission at the end of Week 8	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 9 to Week 16 Marks Submission at the end of Week 16	30
Lab ESE	Lab activities, journal/ performance	Lab Course Faculty and External Examiner as applicable	During Week 18 to Week 19 Marks Submission at the end of Week 19	40

Week 1 indicates starting week of a semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming, and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments and related activities if any.

Walchand College of Engineering, Sangli *(Government Aided Autonomous Institute)*	
AY 2022-23	
Course Information	
Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M.Tech., Sem II
Course Code	6PS592
Course Name	PLC and Embedded Systems Laboratory
Desired Requisites:	Instrumentation Techniques, Electrical Measurements, Microcontroller and Applications

Teaching Scheme		**Examination Scheme (Marks)**			
Practical	2 Hrs/ Week	**LA1**	**LA2**	**Lab ESE**	**Total**
Interaction	--	30	30	40	100
		Credits: 1			

Course Objectives	
1	To develop programming skills using PLC for Industrial Automation
2	To introduce the use of PLC for solving real world problems.
3	To use PLC for control applications in electrical engineering

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	Execute experiments based on PLC and SCADA systems	III	Applying
CO2	Construct basic control systems using PLC and SCADA.	IV	Analyzing
CO3	Design ladder logic programs for various PLC applications.	V	Creating

List of Experiments / Lab Activities/Topics

Lab activities/Lab performance shall include mini-project, presentations, drawings, case studies, report writing, site visit, lab experiment, tutorials, assignments, group discussion, programming and other suitable activities, as per the nature and requirement of the lab course.

Textbooks	
1	John W. Webb, Ronald A. Reis, "Programmable logic controllers, principles & applications", PHI publication, Eastern Economic Edition, 1994.

References	
1	John R. Hackworth and Peterson, "*PLC controllers programming methods and applications*", PHI, 2004.
2	Gary dunning, "*Introduction to PLC*", Thomson learning, Edition III, 2006
3	William H. Bolton, "*Programmable logic controllers*", Newnes, Edition VI, 2006.

Useful Links	
1	Computer Usage / Lab Tool: MATLAB/TLS/Power world/MiPower Simulator

CO-PO Mapping						
Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1			2			
CO2				2		
CO3				2		

The strength of mapping is to be written as 1: Low, 2: Medium, 3: High
Each CO of the course must map to at least one PO.

Assessment

There are three components of lab assessment, LA1, LA2 and Lab ESE.
IMP: Lab ESE is a separate head of passing.(min 40 %), LA1+LA2 should be min 40%

Assessment	Based on	Conducted by	Typical Schedule	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 8 Marks Submission at the end of Week 8	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 9 to Week 16 Marks Submission at the end of Week 16	30
Lab ESE	Lab activities, journal/ performance	Lab Course Faculty and External Examiner as applicable	During Week 18 to Week 19 Marks Submission at the end of Week 19	40

Week 1 indicates starting week of a semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming, and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments and related activities if any.

Walchand College of Engineering, Sangli *(Government Aided Autonomous Institute)*						
AY 2022-23						
Course Information						
Programme		M.Tech. (Power System Engineering)				
Class, Semester		First Year M. Tech., Sem II				
Course Code		6PS593				
Course Name		Pre-dissertation Work and Seminar				
Desired Requisites:		-				
Teaching Scheme		**Examination Scheme (Marks)**				
Practical	4 Hr/ Week	**LA1**	**LA2**	**Lab ESE**	**Total**	
Interaction	--	30	30	40	100	
		Credits: 2				

Course Objectives	
1	To understand industrial problems.
2	To suggest engineering solutions to the defined problem.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	Chose, Formulate a clear problem.	III	Applying
CO2	Select and apply appropriate engineering methods and tools for solving the problem.	VI	Creating
CO3	Develop the project and its results following an established project methodology.	V	Evaluating
CO4	Present the project results.	IV	Analyzing

List of Experiments / Lab Activities/Topics

Pre-Dissertation seminar will involve the selection of appropriate real time industry problem by understanding the working of particular industry application. Formulate the problem, select design and methodology to find the solution. Construct an electrical system by using appropriate hardware software tools. Each student should conceive, design and develop the idea leading to a project/product. The student should submit a soft bound report at the end of the semester. The final product as a result of Industry project should be demonstrated in phases at the time of examination.

This will help student to understand structured management in industry, sustainable development, with consideration to both scientific and ethical aspects and its presentation with technical report.

Textbooks	
1	To be used based on selected project

References	
1	Industry 4.0 : fourth Industrial Revolution guide to Industry 4.0

Useful Links	
1	

CO-PO Mapping						
Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1	3	2				
CO2				2		2
CO3			2			
CO4		2				
The strength of mapping is to be written as 1: Low, 2: Medium, 3: High Each CO of the course must map to at least one PO.						

Assessment				
There are three components of lab assessment, LA1, LA2 and Lab ESE. IMP: Lab ESE is a separate head of passing.(min 40 %), LA1+LA2 should be min 40%				
Assessment	**Based on**	**Conducted by**	**Typical Schedule**	**Marks**
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 8 Marks Submission at the end of Week 8	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 9 to Week 16 Marks Submission at the end of Week 16	30
Lab ESE	Lab activities, journal/ performance	Lab Course Faculty and External Examiner as applicable	During Week 18 to Week 19 Marks Submission at the end of Week 19	40
Week 1 indicates starting week of a semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming, and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments and related activities if any.				

Professional Elective

Walchand College of Engineering, Sangli
(Government Aided Autonomous Institute)

AY 2022-23

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	6PS531
Course Name	Professional Elective 3: Modern Power Electronics
Desired Requisites:	Power Electronics

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	--	30	20	50	100
		Credits: 3			

Course Objectives	
1	It is aimed to impart skills of analysis for different types of advanced converters and shunt active power filters.
2	Make the students acquainted with control strategies of different types of advanced converters and shunt active power filters.
3	To make aware of research avenues in the field of power electronics.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	Interpret configuration and working of various Power Electronic converters.	III	Applying
CO2	Analyze various Power Electronic converters and systems.	IV	Analyzing
CO3	Evaluate various power electronic systems using power electronic converters.	V	Evaluating

Module	**Module Contents**	**Hours**
I	**PWM rectifiers** Advantages & disadvantages of three phase thyristor converter, Single phase and three phase VSI PWM converters working, types, Control of PWM rectifiers, analysis and application. Three phase CSI PWM converter, control and applications.	5
II	**Multilevel inverters** Three phase two level Voltage source inverter, various PWM methods, Multilevel Voltage source inverter, Types: Diode clamp multilevel inverter, flying capacitor multilevel inverter, cascaded multilevel inverter, applications of multilevel inverters, comparison of multilevel inverter. Control method: Multiple carrier PWM for MLI	5
III	**Resonant pulse inverters** Series resonant inverter with unidirectional and bi-directional switches, parallel resonant inverters, voltage control of resonant inverters, zero current and zero voltage switching resonant converters, two-quadrant ZVS resonant converters, resonant DC link inverters and control technique.	5
IV	**Photovoltaic Inverters** Photovoltaic Inverters structures derived from H bridge topology such as H5 inverter, Heric inverter, REFU inverter, full bridge inverter with DC bypass, inverter structures derived from NPC topology such as neutral point clamped half bridge inverter, conergy NPC inverter, three phase PV inverter.	5

V	**Matrix Converters and Z source inverters** Topology, working and control methods of Matrix converters, Various circuit topologies and control of Z source inverter, Application of Z source in induction motor control.	4
VI	**Active power filters** Power Quality Issues due to power Electronics, Introduction to active power filter, types of active power filters overall control of shunt active power filter, control of shunt active filter based on SRF theory. Control of shunt active filter based on instantaneous power theory. harmonic compensation & reactive power compensation.	4

Textbooks	
1	M. H. Rashid, "*Power Electronics: circuits devices and applications*", Pearson Education, Third edition.
References	
1	B. K. Bose, "*Modern Power Electronics and AC drives*", PHIPL, New Delhi.
2	M. B. Patil, V. Ramayanan and V. T. Ranganathan, "*Simulation of Power Electronics circuits*", Narosa publication.
3	Remus Teodorescu, Marco Liserre and Pedro Rodrigues, "*Grid- Converters for Photovoltaic and Wind Power Converters*", A john Wiley and sons Ltd., first edition 2011.
4	IEEE Transaction papers.
Useful Links	
1	NPTEL lectures on Advanced Power Electronics

CO-PO Mapping

	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			1			
CO2				1		
CO3				2		1

The strength of mapping is to be written as 1: Low, 2: Medium, 3: High
Each CO of the course must map to at least one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2022-23

Course Information	
Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	6PS532
Course Name	Professional Elective 3: EHVAC
Desired Requisites:	Power System

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	-	30	20	50	100
		Credits: 3			

Course Objectives	
1	To understand parameters of EHVAC line.
2	To develop a skill to design and analyze EHVAC line.
3	To develop a skill to understand power frequency over voltages developed in EHVAC line.
4	To develop a skill to understand insulation coordination based on lightening.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	Outline parameters of EHVAC line and develop skills to design and analyze EHVAC line.	II	Understanding
CO2	Examine power frequency over voltages developed in EHVAC line.	III	Applying
CO3	Explain insulation coordination based on lightening.	IV	Analyzing

Module	**Module Contents**	**Hours**
I	**Introduction, Calculation of Line and Ground Parameters, Voltage Gradients of Conductor and Corona Effects.** **A.** Introduction: Engineering aspects and growth of EHVAC transmission line trends and preliminaries, power transferability, transient stability limit and surge impedance loading. **B.** Calculation of Line and Ground Parameters: Resistance, power loss, temperature rise, properties of bundled conductors, inductances, and capacitances, calculation of sequence inductance and capacitance line parameters of modes of propagations, resistance and inductance of ground return. **C.** Voltage Gradients of Conductor: Charge potential relations for multi-conductor lines, surface voltage gradients on conductors, distribution of voltage gradient on sub conductors of bundle. **D.** Corona Effects: I2R and corona loss, corona loss formulae, charge voltage diagram with corona. Attenuation of traveling waves due to corona loss Audible noise; corona pulses; their generation and properties, limits for radio interface fields.	6
II	**Theory of Traveling Waves and Standing Waves** Waves at power frequency, differential equations and solutions for general case, standing waves and natural frequencies , open ended line; double exponential response, response to sinusoidal excitation, line energization with trapped charge voltage, reflection and refraction of traveling waves.	6

III	**Lightning and Lightning Protection** Lightning strokes to lines, their mechanism, general principals of lightning protection problem, tower footing resistance, lightning arresters and protective characteristics, different arresters and their characteristics.	4
IV	**Over Voltage in EHV Systems Covered by Switching Operations** Over voltages their types, recovery voltage and circuit breaker, Ferro resonance over voltages calculation of switching surges single phase equivalents.	4
V	**Power Frequency Voltage Control and Over Voltages** Generalized constants, charging current, power circle diagram and its use, voltage control shunt and series compensation, sub synchronous resonance in series capacitor compensated lines and static reactive compensating systems.	4
VI	**Insulation Coordination** Insulation coordination, Insulation levels, voltage withstand levels of protected equipment's and insulation coordination based on lightning, Design of EHVAC lines.	4

Textbooks	
1	Rakosh Das Begamudre, "EHVAC Transmission Engineering", Wiley Eastern Limited, 3rd Edition 2008.

References	
1	Twian Gonen, "*EHVAC and HVDC Transmission System Engineering – Analysis and Design*" John Wiley and Sons 1988.
2	EHVAC and HVDC Transmission Engineering & Practice: S.V. Rao
3	Twian Gonen, *"Electric Power Transmission System Engineering-Analysis and Design*", John Wiley and Sons 1988.

Useful Links	
1	NPTEL Lectures

CO-PO Mapping						
Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1	3					
CO2				3		
CO3						2
The strength of mapping is to be written as 1: Low, 2: Medium, 3: High Each CO of the course must map to at least one PO.						

Assessment
The assessment is based on MSE, ISE and ESE. MSE shall be typically on modules 1 to 3. ISE shall be taken throughout the semester in the form of teacher's assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO. ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6. For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)

Professional Elective (Lab) Courses

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2022-23

Course Information	
Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	6PS571
Course Name	Professional Elective 3: Modern Power Electronics Laboratory
Desired Requisites:	Power Electronics

Teaching Scheme		**Examination Scheme (Marks)**			
Practical	2 Hrs/ Week	**LA1**	**LA2**	**Lab ESE**	**Total**
Interaction	--	30	30	40	100
		Credits: 1			

Course Objectives	
1	It is aimed to impart skills of analysis for different types of advanced converters and shunt active power filters.
2	Make the students acquainted with control strategies of different types of advanced converters and shunt active power filters.
3	To make aware of research avenues in the field of power electronics.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	Interpret configuration and working of various Power Electronic converters.	III	Applying
CO2	Analyze various Power Electronic converters and systems.	IV	Analyzing
CO3	Evaluate various power electronic systems using power electronic converters.	V	Evaluating

List of Experiments / Lab Activities/Topics

Lab activities/Lab performance shall include mini-project, presentations, drawings, case studies, report writing, site visit, lab experiment, tutorials, assignments, group discussion, programming and other suitable activities, as per the nature and requirement of the lab course.

Textbooks	
1	M. H. Rashid, "Power Electronics: circuits devices and applications", Pearson Education, Third edition.

References	
1	B. K. Bose, "*Modern Power Electronics and AC drives*", PHIPL, New Delhi.
2	M. B. Patil, V. Ramayanan and V. T. Ranganathan, "*Simulation of Power Electronics circuits*", Narosa publication.
	Remus Teodorescu, Marco Liserre and Pedro Rodrigues, "*Grid- Converters for Photovoltaic and Wind Power Converters*", A john Wiley and sons Ltd., first edition 2011.
	IEEE Transaction papers.

Useful Links	
1	NPTEL lectures on Advanced Power Electronics

CO-PO Mapping						
Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1			1			
CO2				1		
CO3				2		1
The strength of mapping is to be written as 1: Low, 2: Medium, 3: High Each CO of the course must map to at least one PO.						

Assessment				
There are three components of lab assessment, LA1, LA2 and Lab ESE. IMP: Lab ESE is a separate head of passing.(min 40 %), LA1+LA2 should be min 40%				
Assessment	**Based on**	**Conducted by**	**Typical Schedule**	**Marks**
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 8 Marks Submission at the end of Week 8	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 9 to Week 16 Marks Submission at the end of Week 16	30
Lab ESE	Lab activities, journal/ performance	Lab Course Faculty and External Examiner as applicable	During Week 18 to Week 19 Marks Submission at the end of Week 19	40
Week 1 indicates starting week of a semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming, and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments and related activities if any.				

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2022-23

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M.Tech., Sem II
Course Code	6PS572
Course Name	Professional Elective 3: EHVAC Laboratory
Desired Requisites:	Power System

Teaching Scheme		**Examination Scheme (Marks)**			
Practical	2 Hrs/ Week	**LA1**	**LA2**	**Lab ESE**	**Total**
Interaction	--	30	30	40	100
		Credits: 1			

Course Objectives

1	To understand the breakdown mechanisms in gaseous, liquid and solid insulation.
2	To understand methods of generation and measurement of high voltage, impulse voltage and impulse current.
3	To lay a foundation for higher studies in extra high voltage ac.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	Summarize breakdown mechanisms in gaseous, liquid and solid insulations.	II	Understanding
CO2	Understand the basic generation and measurement of High voltage and High current for testing purposes	II	Understanding
CO3	Analyze the HV generation equipment and their application.	IV	Analyzing

List of Experiments / Lab Activities/Topics

Lab activities/Lab performance shall include mini-project, presentations, drawings, case studies, report writing, site visit, lab experiment, tutorials, assignments, group discussion, programming and other suitable activities, as per the nature and requirement of the lab course.

Textbooks

1	Rakosh Das Begamudre, "EHVAC Transmission Engineering", Wiley Eastern Limited, 3rd Edition 2008.

References

1	Twian Gonen, "*EHVAC and HVDC Transmission System Engineering – Analysis and Design*" John Wiley and Sons 1988.
2	EHVAC and HVDC Transmission Engineering & Practice: S.V. Rao
3	Twian Gonen, "*Electric Power Transmission System Engineering-Analysis and Design*", John Wiley and Sons 1988.

Useful Links

1	Computer Usage / Lab Tool: MATLAB/TLS/Power world/MiPower Simulator

CO-PO Mapping						
Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1			2			
CO2				2		
CO3				2		

The strength of mapping is to be written as 1: Low, 2: Medium, 3: High
Each CO of the course must map to at least one PO.

Assessment

There are three components of lab assessment, LA1, LA2 and Lab ESE.
IMP: Lab ESE is a separate head of passing.(min 40 %), LA1+LA2 should be min 40%

Assessment	Based on	Conducted by	Typical Schedule	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 8 Marks Submission at the end of Week 8	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 9 to Week 16 Marks Submission at the end of Week 16	30
Lab ESE	Lab activities, journal/ performance	Lab Course Faculty and External Examiner as applicable	During Week 18 to Week 19 Marks Submission at the end of Week 19	40

Week 1 indicates starting week of a semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming, and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments and related activities if any.

Open Elective

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2022-23

Course Information

Programme	M.Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	6OE506
Course Name	Open Elective: Control Techniques for Electrical Drives
Desired Requisites:	M.Tech. (Power System Engineering)

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs/week	**MSE**	**ISE**	**ESE**	**Total**
Tutorial	--	30	20	50	100
		Credits: 3			

Course Objectives

1	To provide the latest knowledge in the field of electrical drives.
2	To provide sufficient knowledge in the area of advanced control techniques for induction motor and synchronous machines.
3	To make the student aware of the research in the field of electrical drives.

Course Outcomes (CO) with Bloom's Taxonomy Level

At the end of the course, the students will be able to,

CO	**Course Outcome Statement/s**	**Bloom's Taxonomy Level**	**Bloom's Taxonomy Description**
CO1	Explain various concept used in AC and DC drives.	II	Understanding
CO2	Apply control techniques to AC and DC drives.	III	Applying
CO3	Analyze control techniques for AC and DC drives.	IV	Analyzing
CO4	Evaluate various control schemes of AC and DC drives.	V	Evaluating

Module	**Module Contents**	**Hours**
I	**Basics of drives** Types & parts of the Electrical drives, fundamental torque equation, speed torques characteristics DC motor & Induction motor, multi quadrant operation of the drive, classification of mechanical load torques, steady state stability of the drive, constant torque and constant HP operation of the drive, closed loop speed control.	4
II	**DC motor drives** Methods of speed control, starting and breaking operation, single phase and three phase full controlled and half controlled converter fed DC drives, Multi quadrant operation of separately excited DC shunt motor, dual converter fed DC drives, circulating and non – circulating mode of operation, chopper control of DC shunt motor drives, four quadrant operation of chopper fed DC shunt motor drive.	5
III	**Induction motor drives** Speed control methods for three phase induction motor, VSI fed induction motor drive, constant torque (constant E/F and constant V/F), constant HP operation, closed loop speed control block diagram., CSI fed induction motor drive, speed torque characteristics of CSI fed drive, closed loop speed control block diagram, comparison of CSI fed and VSI fed induction motor drive, Stator voltage control. Chopper controlled resistance in rotor circuit, slip power recovery using converter cascade in rotor circuit, sub synchronous and super synchronous speed control, Kramer speed control.	5

IV	**Modeling of Induction Motor and PWM Techniques** abc – dq transformation, transformation from stationary reference frame to synchronously rotating reference frame and vice versa. Equivalent circuits of induction motor in dynamic dq stationary and synchronously rotating reference frame. Permanent magnet synchronous machine dq equivalent circuits. The three phase six step bridge inverter, three phase PWM inverter, PWM techniques such as sinusoidal PWM, hysteresis band current control PWM.	5
V	**Vector Control and Direct Torque Control of Induction Motor** Vector control of induction motor, DC drive analogy, equivalent circuit, phasor diagram. Direct rotor flux oriented vector control and indirect rotor flux oriented vector control, stator flux oriented vector control. Torque equation of IM in terms of stator and rotor flux, direct torque and flux control method (DTC) and self-commissioning of the drive.	5
VI	**Synchronous motor and SRM Drives** VSI fed synchronous motor drives, true synchronous and self-control mode, open loop and closed loop speed control of Permanent magnet synchronous machine, brushless DC motor drives. Switched reluctance motor drives, torque equation, converter circuits, operating modes and applications. Solar panel VI characteristics, solar powered pump, maximum power point tracking and battery operated vehicles.	4

Textbooks	
1	G. K. Dubey, *“Fundamentals of Electrical Drives*”, Narosa publication, 2nd edition, 2002.
2	B. K. Bose, “*Modern Power Electronics and AC drives*”, Prentice Hall of India Pvt. India, 1986.

References	
1	Peter Vas, “*Vector Control of AC machines*”, Clarendon Press Oxford, 1999.
2	Ned Mohan, “*Advanced Electrical drives – Analysis, control and modeling using Simulink*”, John Wiley and sons, 2001.
3	P. S. Bhimra, “*Power Electronics*”, 2nd edition, Khanna Publishers.

Useful Links	
1	NPTEL video lectures on Electrical Drives

CO-PO Mapping

Programme Outcomes (PO)						
	1	2	3	4	5	6
CO1				1		
CO2				1		
CO3			1	2		
CO4			1	3		

The strength of mapping is to be written as 1: Low, 2: Medium, 3: High
Each CO of the course must map to at least one PO.

Assessment

The assessment is based on MSE, ISE and ESE.
MSE shall be typically on modules 1 to 3.
ISE shall be taken throughout the semester in the form of teacher’s assessment. Mode of assessment can be field visit, assignments etc. and is expected to map at least one higher order PO.
ESE shall be on all modules with around 40% weightage on modules 1 to 3 and 60% weightage on modules 4 to 6.
For passing a theory course, Min. 40% marks in (MSE+ISE+ESE) are needed and Min. 40% marks in ESE are needed. (ESE shall be a separate head of passing)