Semester- I
Professional Core (Theory) Courses

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Program	M. Tech. All Branches
Class, Semester	First Year M. Tech., Semester I
Course Code	7IC501
Course Name	Research Methodology and IPR

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

Course Objectives

1	To prepare students for undergoing research, identify and formulate the research problems, state the hypothesis, design a research layout, set a research process and methodology.
2	To enable student interpret the results, propose theories, suggest possible/alternative solutions, solve, and prove the solution adapted–logically and analytically, conclude the research findings.
3	To impart knowledge to analyze critically the literature and publish research in conferences, journals and to expose students to research ethics, IPR and Patents

Course Outcomes (CO) with Bloom's Taxonomy Level

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

CO1	**Demonstrate** a research solution in respective engineering domain using appropriate Engineering research process and research methodology.	Apply
CO2	**Device** feasible solution to a research problem in respective engineering domain based on economic, social and legal aspects using appropriate research procedures and practices.	Analyze
CO3	**Write** research publication, Dissertation, IPR and patent document.	Create

Module	**Module Contents**	**Hours**
I	**Engineering Research Process** Meaning of research problem, Sources of research problem, Criteria and Characteristics of a good research problem, Errors in selecting a research problem, Definition, scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.	6
II	**Research Methodology** Problem statement formulation, resources identification for solution, Experimental and Analytical modelling, Simulations, Numerical and Statistical methods in engineering research. Hypothesis and its testing by different techniques: Z-test etc.,	6
III	**Research Methods** Uni and Multivariate Analysis: ANOVA, Design of Experiments/Taguchi Method, Regression Analysis. Software tools like spreadsheets. Processing and Analysis of Data: Processing Operations, Types of Analysis-Presentation and Interpretation of Data Editing, Classification and Tabulation-	7

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	Interpretation. Analyse your results and draw conclusions.	
IV	**Research Practices** Effective literature studies approaches, critical analysis, Plagiarism, Research ethics, Mendeley - Reference Management Software. Research communication- Effective Technical Writing, Writing a research article for Journal/conference paper, Technical report, Dissertation/ Thesis report writing, Software used for report writing such as WORD, Latex etc. Presentation techniques for paper/report/seminar. Publishing article in Scopus/SCI/Web of science indexed journal or conference.	7
V	**Intellectual Property Rights (IPR)** Nature of Intellectual Property: Patents, Designs, Trade and Copyright, Ownership of copyright, Term of copyright, Technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. New developments in IPR, Traditional knowledge ,Various Case Studies.	7
VI	**Patents** Patent Rights: Scope of Patent Rights. Various Patent databases. Geographical Indications. Procedure for grants of patents, Patenting under PCT. Licensing and transfer of technology. Administration of Patent System. Introduction to International Scenario: WIPO, TRIPs, Patenting under PCT	6

	Textbooks
1	Kothari C. R, "Research Methodology", 2nd Edition, New Age International, 2004
2	Melville Stuart and Goddard Wayne, "Research Methodology: An Introduction for Science & Engineering Students" Juta and Company Ltd, 2000.
3	Kumar Ranjit, "Research Methodology: A Step-by-Step Guide for beginners", SAGE Publications, 4th Ed.-2014.
	References
1	Merges Robert, Menell Peter, Lemley Mark, "Intellectual Property in New Technological Age", ASPEN Publishers, 2016.
2	Ramappa T., "Intellectual Property Rights Under WTO", S. Chand, 2008
3	Mayall, "Industrial Design", McGraw Hill, 1992.
4	Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007
5	Deepak Chopra and Neena Sondhi, Research Methodology : Concepts and cases, Vikas Publishing House, New Delhi
	Useful Links
1	NPTEL :: General - NOC:Introduction to Research
2	Introduction to Research - Course (nptel.ac.in)
3	Qualitative Research Methods And Research Writing - Course (nptel.ac.in)
4	https://onlinecourses.swayam2.ac.in/ntr21_ed23/preview - Academic Research & Report Writing
5	https://www.scopus.com/search/form.uri?display=basic#basic
6	https://onlinecourses.nptel.ac.in/noc21_ge12/preview - Qualitative Research Methods And Research Writing
7	https://onlinecourses.nptel.ac.in/noc21_hs44/preview - Effective Writing
8	https://webofscienceacademy.clarivate.com/learn

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9	https://onlinecourses.swayam2.ac.in/ntr21_ed23/preview - Academic Research & Report Writing
10	https://nptel.ac.in/courses/121/106/121106007/
11	https://www.wipo.int/about-wipo/en/

CO-PO Mapping

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

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)

Solapur
28-8-2023
Dr. S. S. Solapure
Associate Professor (IT) Dept.

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	7PS501
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	Analyze 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.	7
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.	7

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.	7
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.	6
VI	**Recent Developments in Digital Protection** Digital Relaying techniques based on modern tools of digital signal processing like DFT, Haar Transform, WT etc.	6

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)

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AY 2023-24

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	7PS502
Course Name	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.	7
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.	7
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	7
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	
1	https://nptel.ac.in/courses/108104051

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)

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AY 2023-24

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	7PS503
Course Name	Computer Aided Power System Analysis
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 makes the students conversant with different power system analysis methods.
2	To provide basic knowledge of formation of Ybus methods.
3	To provide different power system computer analysis methods using computer.

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 methods of analyzing shunt and series faults.	II	Understanding
CO2	Apply the Network Topology knowledge for power system analysis.	III	Applying
CO3	Study Power flow analysis and economic dispatch of generation.	IV	Analyzing

Module	**Module Contents**	**Hours**
I	**Analytical Simplifications** Three Component method, Two-Component method, sequence network connections for different faults, Analysis of unsymmetrical shunt and series faults using three-component (symmetrical component method) and two-Component method.	6
II	**Network Topology** Introduction, Elementary graph theory, Connected graph, tree, co-tree, basic cutsets, basic loops, Incidence matrices, Element-node, Bus incidence, Tree-branch path, Basic cutset, augmented cut-set, Basic loop and Augmented loop, Primitive network, Impedance form and Admittance form.	7
III	**Network Matrices** Introduction, formation of Ybus by method of Inspection, method of Singular Transformation, Step by Step building algorithm for formation of Ybus. Formation of Bus Impedance Matrix, Modification of Zbus for addition of a branch, addition of link, removal of an element.	7
IV	**Network Fault and Contingency Calculations** Fault calculations using Zbus, fault calculations using the Ybus table of factors, Contingency analysis for Power systems. Using the Ybus table of factors for contingencies. Analysis of Unsymmetrical faults using Bus Impedance Matrix.	7

V	**Power flow analysis** Formulation of the problem and power flow equations. Application of numerical techniques to solve load flow problems using bus admittance matrix and bus impedance matrix in the bus – frame of reference such as Gauss, Gauss – Seidel, Newton – Raphson methods, Decoupled load flow methods etc.	6
VI	**Optimal Dispatch of generation** Performance Curves, economic dispatch of generation without and with transmission-line losses, Iterative technique, approximate penalty factor, Derivation of transmission loss formula, Calculation of loss- coefficient using Ybus and sparse matrix techniques.	6

	Textbooks
1	Pual M. Anderson, "*Analysis of faulted system*", The Iowa state university press/ AMES, 1973.
2	K. Uma Rao, "*Computer Techniques and Models in Power systems*", I. K. International Publishing house Pvt. Ltd. New Delhi, 2007.
	References
1	I. J. Nagrath and D. P. Kothari, "*Power System Engineering*", Tata Mc-Graw Hill Publishing Co., 1994.
2	Hadi Sadat, "*Power system analysis*", 1st edition, Tata Mc-Graw Hill publishing company ltd., 2002.
3	George L. Kusic, "*Computer Aided Power System Analysis*", PHI, 2003.
4	Research Papers.
	Useful Links
1	https://archive.nptel.ac.in/courses/108/107/108107127/

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

Professional Core (Lab) Courses

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	7PS551
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	Analyzing
CO3	Design hardware and compile programs for simple digital relays, as a group task.	V	Evaluating

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 2023-24

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	7PS552
Course Name	Computer Aided Power System Analysis 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 make the students conversant with different recent techniques for power system analysis methods.
2	To provide basic knowledge of formation of Ybus methods using programming languages
3	To provide different computer solution for large interconnected power system networks.

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 different computer analysis methods of power system faults.	II	Understanding
CO2	Apply the Network Topology knowledge for power system analysis.	III	Applying
CO3	Study MATLAB programming for Power flow analysis and economic dispatch of generation.	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	Pual M. Anderson, "*Analysis of faulted system*", The Iowa state university press/ AMES, 1973.
2	K. Uma Rao, "*Computer Techniques and Models in Power systems*", I. K. International Publishing house Pvt. Ltd. New Delhi, 2007.

References

1	I. J. Nagrath and D. P. Kothari, "*Power System Engineering*", Tata Mc-Graw Hill Publishing Co., 1994.
2	Hadi Sadat, "*Power system analysis*", 1st edition, Tata Mc-Graw Hill publishing company ltd., 2002.
3	George L. Kusic, "*Computer Aided Power System Analysis*", PHI, 2003.

Useful Links

1	https://archive.nptel.ac.in/courses/108/107/108107127/

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

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AY 2023-24

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	7PS553
Course Name	Advanced Power System 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 provide extensive knowledge of power system protection measurements, control and relay logic
2	To impart knowledge of designing schemes of protection, relay coordination and numerical relays.
3	To provide basic knowledge of various aspects of power system protection both theoretical and practically as implemented in industry.

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	Implement load flow, contingency analysis etc. in simulation environment.	III	Applying
CO2	Analyze the stability of Power System.	IV	Analyzing
CO3	Evaluate the performance of Power System Network.	V	Evaluating

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	Pual M. Anderson, "*Analysis of faulted system*", The Iowa state university press/ AMES, 1973.
2	K. Uma Rao, "*Computer Techniques and Models in Power systems*", I. K. International Publishing house Pvt. Ltd. New Delhi, 2007.

References

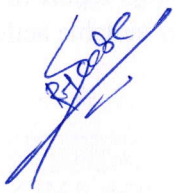
1	I. J. Nagrath and D. P. Kothari, *"Power System Engineering"*, Tata Mc-Graw Hill Publishing Co., 1994.
2	Hadi Sadat, *"Power system analysis"*, 1st edition, Tata Mc-Graw Hill publishing company ltd., 2002.

Useful Links

1	

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



Professional Elective 1

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	7PS511
Course Name	Professional Elective 1: Smart Grid
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 provide the advance knowledge in the field of smart – grid technology
2	To make the students aware of research avenues in the field of smart grid technology
3	To develop the skills of simulation and analysis of smart grid 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 various concepts associated with smart grid.	II	Understanding
CO2	Apply smart grid concept to power system monitoring, communication and protection.	III	Applying
CO3	Analyze tools for smart grid's performance, stability and computational analysis.	IV	Analyzing

Module	Module Contents	Hours
I	**Smart grid architecture** Introduction, smart grid verses today's grid, computational intelligence, power system enhancement, smart grid market drivers, architecture of smart grid, and function of smart grid components.	7
II	**Smart grid technologies** Introduction to Smart Meters, Automatic Meter Reading (AMR), Outage Management System (OMS), Plug in Hybrid Electric Vehicles (PHEV) & more, Substation Automation, Feeder Automation, Geographic Information System (GIS), Intelligent Electronic Devices (IED) & their application for monitoring & protection.	6
III	**Transmission aspects** Wide area Monitoring Systems (WAMS), PMU and PDCs, PMU placement, linear state estimation, System security under smart grid environment, Concept of Resilient & Self-Healing Grid, adaptive relaying using PMUs.	7
IV	**Communication aspects** Elements of communication and networking: architectures, standards and adaptation of power line communication (PLCC), zigbee, GSM, and more; machine to machine communication models for the smart grid; Home area networks (HAN) and neighbourhood area networks (NAN); reliability, redundancy and security aspects.	6

V	**Performance analysis tool for smart grid design** Load flow in smart grid, load flow methods, congestion management flow effect, load flow for smart grid design, dynamic stochastic optimal power flow (DSOPF), DSOPF application to smart grid. Static security assessment and contingencies study for the smart grid.	7
VI	**Stability analysis tools and computational tools for smart grid** Voltage stability assessment and its techniques, angle stability assessment and state estimation, optimization techniques, classical optimization methods, Heuristic optimization, evolutionary computational Techniques, Hybrid optimization techniques and application to smart grid.	6

Textbooks	
1	Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "*Smart Grid: Technology and Applications*".
2	G. M. Masters, "*Renewable and Efficient Electric Power Systems*", John Wiley & Sons Inc., 2004.

References	
1	Gilbert N. Sorebo, Michael C. Echols, *"Smart grid security: An end to end view of security in new Electrical grid"* CRC press, Taylor &Fancis group, 2011.
2	S. P. Chowdhary, P. Crosley and S. Chowdhary, *"Micro-grids and active distribution networks"*, The institution of engineering and technology, London, 2009.
3	J. S. Thorp, A.G. Phadke, *"Synchronized Phasor Measurement and Their Applications"* Springer 2008.

Useful Links	
1	http://nptel.ac.in/downloads/117105077
2	http://www.nptelvideos.in/2012/12/digital-communication.html
3	https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-450-principles-of-digital-communications-i-fall-2006/video-lectures/

CO-PO Mapping

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

DSMore

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	7PS512
Course Name	Professional Elective 1: FACTS
Desired Requisites:	Power System Engineering, Power Electronics

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3Hrs/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

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.	7
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.	7

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IV	**Emerging FACTS Controllers I** Static Synchronous Compensator (STATCOM) - operating Principle, V-I characteristics Static Synchronous Series Compensator (SSSC) - Operating Principle, Control System, Applications	7
V	**Emerging FACTS Controllers II** Unified Power Flow Controller (UPFC) – Principle of operation - modes of operation –applications – modelling 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

	Text Books
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	NarainG.Hingorani, Laszio. Gyugyl,"*Understanding FACTS Concepts and Technology of Flexible AC Transmission System*", Standard Publishers, Delhi, 2001.
	Useful Links
c	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 1,2,3; Where, 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 2023-24

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	7PS513
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.	6
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

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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 $\varphi(t)$ and $\psi(t)$, 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.	7
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.	7
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.	7
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)

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Professional Elective 2

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	7PS514
Course Name	Professional Elective 2: 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.	6
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	7
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.	6

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, co-energy NPC inverter, three phase PV inverter.	7
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.	7
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.	6

	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	https://onlinecourses.nptel.ac.in/noc20_ee28/

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 2023-24

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	7PS515
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.	7
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.	7
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.	7
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)

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem I
Course Code	7PS516
Course Name	Professional Elective 2: Advanced Power System for Grid Resilience
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 explore the fundamental concepts and principles of power system resilience.
2	To study the advanced techniques for modeling, analysis, and simulation of power systems under normal and abnormal operating conditions.
3	To examine the challenges and vulnerabilities of power grids and explore strategies to enhance their resilience.
4	To understand the role of power grid technologies and renewable energy integration with real world applications for grid resilience.

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	Understand Power System Transients: Gain a comprehensive understanding of power system transients, their characteristics, and the factors contributing to their occurrence.	II	Understanding
CO2	Analyze Transient Effects: Analyze the impact of power system transients on various components such as transmission lines, transformers, generators, and protective devices.	IV	Analyzing
CO3	Evaluate Grid Resilience: Evaluate the resilience of power grids against transients and identify vulnerabilities and potential points of failure	V	Evaluating

Module	**Module Contents**	**Hours**
I	**Introduction to Power System Resilience** Definition and importance of power system resilience, Key challenges and vulnerabilities in power grids, Frameworks and metrics for assessing grid resilience.	6
II	**Power System Modeling and Analysis** Power system components and their mathematical representation, Power flow analysis and optimization techniques, Stability analysis: transient, voltage, and frequency stability, Harmonic analysis and mitigation strategies.	7
III	**Power System Oscillations** Overview of Sub synchronous oscillations (SSO) and its classification, Analysis of renewable energy systems, Impact of series compensation on SSO, Damping methods using advanced control system.	6

IV	**Grid Integration of Renewable Energy Sources** Impact of renewable energy sources on grid resilience, Grid codes and standards for renewable energy integration, Power quality issues and solutions, Battery energy storage for grid resilience.	7
V	**Case Studies and Real-World Applications** Analysis of grid resilience in response to natural disasters and cyber-attacks, Case studies of power system oscillations and their impact on grid resilience, Evaluation of resilience-enhancing strategies in power grids, Role of advanced technologies in enhancing grid resilience	7
VI	**Research Trends and Future Directions** Emerging technologies and trends in power system resilience, Research challenges and opportunities in the field, Discussion on ongoing research projects and advancements	6

Textbooks	
1	Power System Analysis and Design" by J. Duncan Glover, Mulukutla S. Sarma, and Thomas Overbye
2	Power System Transients: Parameter Determination" by Juan A. Martinez-Velasco
3	Transient Analysis of Power Systems: A Practical Approach" by Eiichi Haginomori, Tadashi Koshiduka, Junichi Arai, and Hisato Fujisawa
4	Power System Transients: Theory and Applications" by Akihiro Ametani, Naoto Nagaoka, and Teruo Ohno

References	
1	Power System Stability and Control" by Prabha Kundur
2	Power System Transients: Parameter Determination" by Juan A. Martinez-Velasco
3	Power System Dynamics and Stability" by Peter W. Sauer and M. A. Pai
4	Electromagnetic Transients in Power Systems" by Akihiro Ametani, Naoto Nagaoka, and Teruo Ohno

Useful Links	
1	NPTEL Courses: https://nptel.ac.in/
2	Research Papers IEEE : https://ieeexplore.ieee.org/
3	N. Hatziargyriou et al., "Definition and Classification of Power System Stability – Revisited & Extended," in IEEE Transactions on Power Systems, vol. 36, no. 4, pp. 3271-3281, July 2021, doi: 10.1109/TPWRS.2020.3041774.
4	Y. Cheng et al., "Real-World Subsynchronous Oscillation Events in Power Grids With High Penetrations of Inverter-Based Resources," in IEEE Transactions on Power Systems, vol. 38, no. 1, pp. 316-330, Jan. 2023, doi: 10.1109/TPWRS.2022.3161418.

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

Semester- II
Professional Core (Theory) Courses

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7PS521
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.	II	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.	7
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	7
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.	7
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

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AY 2023-24

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7PS522
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.	7
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	7
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	7

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)

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Course Information

Programme	M. Tech (Power System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7PS523
Course Name	Power System Dynamics
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 introduce the concept of small signal and transient stability analysis of power systems.
2	To provide solutions to SSR problem and voltage stability 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	Distinguish various categories of system stability.	II	Understanding
CO2	Analyze models, use analytical tools to decide upon the stability of various types.	IV	Analyzing
CO3	Recommend various methods to improve various type of stabilities of power system.	V	Evaluating

Module	**Module Contents**	**Hours**
I	**Introduction to small signal stability of power system** Small Signal Stability analysis of single machine connected to infinite bus. Step by step model development of single machine connected to infinite bus.	6
II	**Improvement of small signal stability** Power system stabilizer, Simulation of Power System Dynamic response using power system stabilizer in the small signal stability model of single machine connected to infinite bus.	7
III	**Large scale power systems** Dynamic equalization of large scale system systems. Step by step reduction of large scale model to a smaller model for analysis purpose.	7
IV	**Transient stability analysis** Introduction to Direct method of transient stability analysis by roller ball analogy. Development of model using energy concept,and analysis of model for transient stability.	6
V	**Sub synchronous resonance** Introduction to Sub-Synchronous oscillation & sub- synchronous resonance. Effect of series compensation of transmission line. Induction generator effect, stability of hydro turbines.	7
VI	**Voltage stability** Reactive power compensation and Voltage stability. Development of model of power system for voltage stability. Sensitivity analysis and QV modal analysis for voltage stability. Methods of improving stability.	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.
Useful Links	

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

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 canbe 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

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AY 2023-24

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7PS571
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	Nil

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.				

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Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7PS572
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.				

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Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7PS545
Course Name	Seminar
Desired Requisites:	-

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

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	Nil

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 3

Walchand College of Engineering, Sangli

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AY 2023-24

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7PS531
Course Name	Professional Elective 3: Power System Planning and Reliability
Desired Requisites:	Electrical Transmission and Distribution, Power System Analysis

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 the concept of load forecasting.
2	To discuss reliability criteria for generation, transmission, distribution and reliability evaluation and analysis.
3	To understand basic Reliability 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	Understand Load forecasting methodology	II	Understanding
CO2	Predict Generation, Transmission and Distribution planning and reliability.	III	Applying
CO3	Analyze different reliability evaluation techniques	IV	Analyzing

Module	**Module Contents**	**Hours**
I	**System Planning:** Introduction, Objectives & Factors affecting to System Planning, Short Term Planning, Medium Term Planning, Long Term Planning, Reactive Power Planning.	7
II	**Load Forecasting** Introduction, Load Characteristics, Load Driving Parameters, Spatial Load Forecasting, Long Term Load Forecasting Methods, Trend Analysis Econometric Modelling, End-use Analysis, Numerical examples	6
III	**Generation Planning** Generation Sources, Integrated Resource Planning, Generation System Model, Loss of Load (Calculation and Approaches), Outage Rate, Capacity Expansion, Scheduled Outage, Loss of Energy, Evaluation Methods, Interconnected System, Factors Affecting Interconnection under Emergency Assistance.	7
IV	**Transmission Planning** Introduction, Objectives of Transmission Planning, Network Reconfiguration, System and Load Point Indices, Data required for Composite System Reliability.	6
V	**Distribution Planning and Reliability:** Radial Networks, Network Reconfiguration, Evaluation Techniques, Interruption Indices, Effects of Lateral Distribution Protection, Effects of Disconnects, Effects of Protection Failure, Effects of Transferring Loads, Distribution Reliability Indices	7

VI	**Reliability:** Reliability, Failure, Concepts of Probability, Evaluation Techniques (i) Markov Process (ii) Recursive Technique, Stochastic Prediction of Frequency and Duration of Long & Short Interruption, Adequacy of Reliability, Reliability Cost	6

Textbooks	
1	R.L. Sullivan "Power System Planning", Tata McGraw Hill Publishing Company Ltd.
2	Hossein Seifi, Mohammad Sadegh Sepasian, "Electrical power system planning, Issues, algorithms and solution" Springer-Verlag Berlin Heidelberg 2011
References	
1	Roy Billinton & Ronald N. Allan "Reliability Evaluation of Power System", Springer Publication
2	T. W. Berrie "Electricity Economics & Planning", Peter Peregrinus Ltd., London.
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)

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Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7PS532
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.	7

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.	7
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.	6
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.	7
VI	**Insulation Coordination** Insulation coordination, Insulation levels, voltage withstand levels of protected equipment's and insulation coordination based on lightning, Design of EHVAC lines.	6

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	https://archive.nptel.ac.in/courses/108/108/108108099/

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 4

Walchand College of Engineering, Sangli

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Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7PS533
Course Name	Professional Elective 4: Restructured Power System
Desired Requisites:	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 deliver the knowledge of basic concepts and terminologies used in restructuring and deregulation.
2	To explain the difference between integrated and restructured power system.
3	To impart knowledge of various trading models, market architecture and market power.

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	Recognize recent changes occurring in the structure of power supply utilities and electric supply market.	I	Remembering
CO2	Explain the problems associated with deregulation.	II	Understanding
CO3	Solve some problem associated with deregulate power system.	III	Applying

Module	Module Contents	Hours
I	**Introduction to Basic Concepts** Basic Concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system.	6
II	**Power System Restructuring** An overview of the restructured power system, Difference between integrated power system and restructured power system. Explanation with suitable practical examples.	7
III	**Deregulation of Power Sector** Separation of ownership and operation, Deregulated models, pool model, pool and bilateral trade model, multilateral trade model.	6
IV	**Competitive Electricity Market** Independent System Operator activities in pool market, Wholesale electricity market characteristics, central auction, single auction power pool, double auction power pool, market clearing and pricing, Market power and its Mitigation Techniques, Bilateral trading, Ancillary services.	7
V	**Transmission Pricing** Marginal pricing of electricity, nodal pricing, zonal pricing, embedded cost, Postage stamp method, Contract path method, Boundary flow method, MW-mile method, MVA – mile method, Comparison of different methods.	7

VI	**Congestion Management** Congestion management in normal operation, explanation with suitable example, Total Transfer Capability (TTC), Available Transfer Capability (ATC).	6

Textbooks	
1	Loi Lei Lai," *Power System Restructuring and Deregulation: Trading, Performance and Information Technology"*, John Wiley & Sons Ltd., UK, 2001.
2	M. Shahidhpour, M. Alomoush, *"Restructured Electrical power systems: Operating, Trading and Volatility"*, Marcel Dekker Inc., New York, 2001.
3	H. Lee, Willis, W. G. Scott, *"Distributed Power Generation: Planning and Evaluation"*, Marcel Dekker Inc., New York, 2000.
References	
1	Lorrin Philipson, H. Lee Willis, *"Understanding Electric Utilities and Deregulation"*, Marcel Dekker Inc., New York, 1998.
2	K. Bhattacharya, M.H.J. Bollen, J. E. Daalder, *"Operation of Restructured Power Systems"*, Kulwer Academic Publishers, Massachausetts, USA, 2001.
3	M. Shahidhpour, H. Yamin, Z. Li, *"Market of Operations in Electric Power Systems: Forecasting Scheduling, and Risk Management"*, John Wiley & Sons Ltd., New York, 2002.
Useful Links	
1	Nil

CO-PO Mapping

	Programme Outcomes (PO)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2					
CO2		3				
CO3			3			

The strength of mapping is to be written as 1,2,3; Where, 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 2023-24

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7PS534
Course Name	Professional Elective 4: Modern Electric Drives
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	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 & 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	Understand the basics of electrical drives	II	Understanding
CO2	Apply the knowledge for designing the drive system	III	Applying
CO3	Evaluate the performance of Electrical Drives	V	Evaluating

Module	**Module Contents**	**Hours**
I	**Introduction to the Drive** Brief review of DC drives, closed loop speed control, constant HP and constant torque operation. Scalar control of induction motor (frequency control), VSI fed induction motor speed control, CSI fed induction motor speed control, closed loop speed control block diagrams of induction motor.	6
II	**Inverter Fed AC Drives** 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, selected harmonic elimination, space vector PWM hysteresis band current control PWM	7
III	**Vector Control of Induction Motor Drives** Vector control of induction motor, DC drive analogy, equivalent circuit, phasor diagram. Direct vector control and indirect vector control, stator flux-oriented vector control	7
IV	**Sensorless Control of Drives** Sensor-less vector control of induction motor, various speed estimation methods, direct vector control without speed signal, direct torque and flux control method (DTC), adaptive control and self-commissioning of the drive	7

V	**PMDC and BLDC Drives** Permanent magnet synchronous motor drives, sinusoidal surface PM machine drive, self-control and vector control of surface PM machine. Trapezoidal SPM machine drive (BLDC drive)	6
VI	**DSP control of the Drives** Digital Signal Processor for induction motor drive, event manager functional block diagram for PWM waveform generation, quadrature encoder pulse circuit and event manager interrupts	6

	Textbooks
1	B. K. Bose, *"Modern Power Electronics and AC drives"*, Prentice Hall of India Pvt. India
	References
1	Peter Vas, *"Vector Control of AC machines"*, Clarendon Press Oxford, 1999.
2	Hamid Toiyat and Campbell, *"DSP Based Electromechanical Motion Control"* by CPC press, 2004
3	Ned Mohan, *"Advanced Electrical drives – Analysis, control and modeling using Simulink"*, John Wiley and sons, 2001
4	Yasuhiko Dote, *"Servo Motor and Motion Control Using Digital Signal Processor"*, Prentice Hall Eagle ward cliffs, New Jersey,
5	G. K. Dubey *"Fundamentals of Electrical Drives"*, Narosa publication, 2nd edition.
	Useful Links
1	Nil

CO-PO Mapping

	Programme Outcomes (PO)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			3			
CO2				3		
CO3	3					

The strength of mapping is to be written as 1,2,3; Where, 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 2023-24

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7PS535
Course Name	Professional Elective 4: HVDC Transmission
Desired Requisites:	Power Electronics, 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	It is aimed to provide detailed knowledge of controlled converters for HVDC transmission system.
2	It demonstrates use of different control and protection methods in HVDC transmission system.
3	It provides recent trends in HVDC transmission 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	Investigate appropriate control and protection schemes for HVDC transmission System.	III	Applying
CO2	Interpret performance of converter for HVDC transmission systems.	IV	Analyzing
CO3	Appraise recent trends in HVDC transmission systems.	V	Evaluating

Module	**Module Contents**	**Hours**
I	**Introduction to HVDC Transmission Technology** Comparison of EHVAC and HVDC Transmission, types of HVDC transmissionsystems, components of HVDC transmission system	6
II	**Analysis of HVDC converter** Different modes of valve operation, o/p voltage waveforms and D C voltage in rectification, and inverter operation, valve voltages, equivalent electrical circuit,converter charts.	7
III	**HVDCTS control features** Control modes, control schemes and their comparisons, energization and de-energization of bridges, starting and stopping of D C link.	6
IV	**Faults and over-voltages** Converter mal-operations, commutation failure, over-voltages in HVDCTS, protection of converters, D C reactor and damper circuits.	7
V	**Harmonics and their suppression in HVDCTS** Harmonic analysis, filter design, minimum cost tuned A C filters, reactive power requirements.	7
VI	**Multi terminal HVDCTS** Series and parallel MTDCTS, their control, introduction to HVDC light, recenttrends in HVDCTS.	6

Textbooks

1	E.W. Kimbark, *"Direct Current Transmission"*, Win publisher.
2	K.R. Padiyar, *"H.V.D.C. Power Transmission"*, Wiley Eastern New Delhi.
References	
1	J. Arrillaga, *"H.V.D.C. Transmission"*, Peter limited.
2	S.Rao, *"E.H.V.A.C. & H.V.D.C. Transmission"*, Khanna Publishers.
Useful Links	
1	Nil

CO-PO Mapping						
	Programme Outcomes (PO)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				3		
CO2			3			
CO3						2
The strength of mapping is to be written as 1,2,3; Where, 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)

Open Elective

Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2023-24

Course Information

Programme	M. Tech. (Power System Engineering)
Class, Semester	First Year M. Tech., Sem II
Course Code	7OE506
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 make students understand concept of fundamental knowledge in dynamics and control of Electric Drives.
2	To strengthen control principles of various DC and AC motors using solid state converters.
3	To cover principles of selection of Electric Motors and highlights the applications 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 the various concepts used in Electric drives.	II	Understanding
CO2	Apply the control techniques for Electric drives for speed control.	III	Applying
CO3	Analyze the performance of various control techniques used in speed control of electric drives and select a drive for particular application.	IV	Analyzing

Module	**Module Contents**	**Hours**
I	**Fundamentals of Electric Drives** Types & parts of the Electrical drives, Selection criteria of drives, motor rating, selection based on duty cycle, selection of converter rating, 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.	7
II	**DC Motor Drives** Methods of speed control, starting and braking operation, single phase and three phases 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, converter fed DC series motor drive, chopper control of DC shunt and series motor drives, four quadrant operation of chopper fed DC shunt motor drive.	7

III	**Induction Motor Drives** Torque equation, Speed control methods for three phase cage induction motor, braking methods, stator voltage control induction motor drive, VSI fed induction motor drive, constant torque (constant E/F and constant V/F), constant HP operation, closed loop speed control block diagram, Stator current control methods 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.	6
IV	**Slip Ring Induction Motor Drives** 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, cyclo - converter in rotor circuit.	7
V	**Synchronous Motor Drives and Brushless DC Motor 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.	6
VI	**Special Drives** Construction and operating principle of switched reluctance motors, Current / Voltage control, torque equation, converter circuits, operating modes and applications of switched reluctance motors. Solar panel VI characteristics, solar powered pump, maximum power point tracking and battery-operated vehicles.	6

	Textbooks
1	G. K. Dubey, *"Fundamentals of Electrical Drives"*, Narosa publication, 2nd edition, 2002.
	References
1	*"Fundamentals of Electrical Drives"*, NPTEL video lecture series by Prof. Shyama Prasad Das, Department of Electrical Engineering, IIT Kanpur.
2	*"Power Electronics - Converter Application"*, By N. Mohan T.M. Undel and W. P. Robbins, John Wiely and sons.
3	*"Electrical Drives - Concept and application"*, Vedam Subramanyam.
	Useful Links
1	https://nptel.ac.in/courses/108/104/108104140/

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

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