Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)



Course Contents (Syllabus) for

First Year M. Tech. Electrical (Power Systems Engineering) Sem - I to II

AY 2020-21

ODD Semester

Professional Core (Theory) Courses

Title of the Course: Research Methodology	L	Т	Р	Cr
Course Code: 4IC501	2			2

Pre-Requisite Courses: None

Textbooks:

- 1. C. R. Kothari, Research Methodology, New Age international
- 2. Deepak Chopra and Neena Sondhi, Research Methodology : Concepts and cases, Vikas Publishing House, New Delhi
- 3. Ranjit Kumar, Research Methodology: A Step by Step Guide for Beginners, 2nd Edition

References:

- 1. E. Philip and Derek Pugh, How to get a Ph. D. a handbook for students and their supervisors, open university press
- 2. Stuart Melville and Wayne Goddard, Research Methodology: An Introduction for Science & Engineering Students
- 3. G. Ramamurthy, Research Methodology, Dream Tech Press, New Delhi

Course Objectives:

- 1. Understand some basic concepts of research and its methodologies
- 2. Identify and formulate the research problems, state the hypothesis,
- 3. Organize and conduct and present research in a more appropriate manner
- 4. Prepare research artifacts to the college and papers to Conferences and Journals

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive		
		level	Descriptor	
CO1	Classify various methods to solve research problem.	3	Applying	
CO2	Construct a research problem in respective engineering domain.	3	Applying	
CO3	Investigate various data analysis techniques for a research problem.	4	Analyzing	
CO4	Author the survey paper based on literature review for research problem.	6	Creating	

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2					
CO2					2	2
CO3				2		
CO4		2				

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
Module 1: Introduction to Research	Hrs.
What is research? Literature survey and review, types of research, the process of research.	4
Module 2: Research Procedures	Hrs.
Formulation of a research problem, Experimental design, Classification. Theoretical research,	
Formulating a problem, verification methods, modeling and simulations, ethical aspects, IPR	4
issues, Copyrights and Patenting etc.	
Module 3: Research Methods	Hrs.
Steps in conducting research, Research Problem identification, Probable solutions, verification	
of the proposed methodology, conclusions. Meaning, Need and Types of research design,	_
Research Design Process, Measurement and scaling techniques, Data Collection – concept,	5
types and methods, Processing and analysis of data, Design of Experiment	
Module 4: Analysis Techniques	Hrs
Quantitative Techniques Sampling fundamentals, Testing of hypothesis using various tests like	
Multivariate analysis, Use of standard statistical software, Data processing, Preliminary data	
analysis and interpretation, Uni-variate and bi-variate analysis of data, testing of hypotheses,	5
techniques such as ANOVA, Chi square test etc., Nonparametric tests. Correlation and	
regression analysis	
Module 5: Research Communications	Hrs.
Writing a conference paper, Journal Paper, Technical report, dissertation/thesis writing.	
Presentation techniques, Patents and other IPRs, software used for report writing such as	4
WORD, Latex etc.	
Module 6: Case Studies	Hrs.
Case studies related to the respective disciplines of Engineering.	4
Vodule wise Measurable Students Learning Outcomes:	
After completion of the course students will be able to:	
Module 1: Understand the process of research.	
Module 2: Formulation of a research problem in respective study domains	
Module 3: Learn the important steps in conducting research	
Module 4: Applying data analytics for research validation.	
Module 5: Learn methods for presenting the research results	
Module 6. Applying RM in respective disciplines of Engineering	

Module 6: Applying RM in respective disciplines of Engineering.

Title of the Course: Digital Protection of Power System	L	Т	Р	Cr
Course Code: 4PS501	3			3

Pre-Requisite Courses: Power system protection

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

Course Objectives :

Modern power system protection systems are extensively using digital techniques for realizing various needs of protection. This course will strengthen the concepts in power system protection and develop the skills necessary to analyze, design and implement digital protective relays.

Course	e Learning Outcomes:			
CO	After the completion of the course the student will be able to	Bloom's Cognitive		
		level	Descriptor	
CO1	Interpret the performance of devices like CT, PT and relays used in	3	Applying	
	digital protection of Power Systems.			
CO2	Analyze the use of digital systems for protection of different parts of	4	Analyzing	
	power system.			
CO3	Estimate and Justify settings of relays for protection of different parts of	5	Evaluating	
	power system.			
CO4	Design analog/digital protection scheme for simple electrical systems	6	Creating	
	Monning .			

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2					
CO2				3		
CO3			2			
CO4		2				1

Assessment:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion. [One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2] MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
Module 1: Review of Relaying Schemes	Hrs.
Protection schemes for alternator, transformer, bus bar and induction motors. Transmission	
line protection using over current- time graded and current graded schemes, drawbacks of	6
these schemes, differential & distance schemes, Electromagnetic CT and PT.	l
Module 2: Comparators	Hrs.
a. Dual Input Comparator: Amplitude comparator, phase comparator, duality between	
amplitude and phase comparators, cosine-type and sine-type phase comparators, coincidence	4
type phase comparator.	4
b. Multi Input Comparator: Amplitude comparator, phase comparator.	1
Module 3: Over Current Relays	Hrs.
Different time-current characteristics of over current relay, Microprocessor/microcontroller	
based over current relay, Directional over current relay and its implementation using	8
microprocessor/microcontroller based scheme.	1
Module 4: Differential Relays	Hrs.
Circulating current differential protection, percentage differential protection of power	
transformers, effect of magnetizing inrush, effect of over voltage inrush, hardware and	8
software used for digital protection of transformer.	1
Module 5: Distance Protection Relays	Hrs.
Microprocessor/microcontroller based impedance, reactance and admittance relays, and	
measurement of R and X. Quadrilateral characteristics. Digital protection scheme based upon	8
fundamental frequency signals, hardware and software design.	1
Module 6: Recent Developments in Digital Protection	Hrs.
Digital Relaying techniques based on modern tools of digital signal processing like DFT, Haar	4
Transform, WT etc.	4
Module wise Measurable Students Learning Outcomes :	
After completion of the course students will be able to:	
1. Interpret performance of components used in protection of electrical power systems	
2. Examine comparator techniques used for protection.	
3. Analyze electronic circuits and software programs for digital over current relays.	

- 4. Use simulation software like Proteus to analyze the electronic circuits.
- 5. Estimate & justify relay settings for proper co-ordination.
- 6. Design microcontroller based over current/ differential/ distance relay.

Title of	f the Course: Application of Power Electronics to Power systems	L	Т	Р	Cr	
Course	Code: 4PS502	3			3	
Pre-Re	Pre-Requisite Courses: Power System Engineering , Power Electronics					
Textbo	oks:					
1.	R. Mohan Mathur, Rajiv. K. Varma, Thyristor – Based Facts Controller	rs for El	lectrica	l		
	Transmission Systems, IEEE press and John Wiley & Sons Inc., 2002					
Refere	nces:					
1.	A.T.John, Flexible AC Transmission System, Institution of Electrical and	d Electr	onic E	ngineers		
	(IEEE), 1999.					
2.	NarainG.Hingorani, Laszio. Gyugyl, Understanding FACTS Concepts a	nd Tech	nology	v of Flex	tible	
-	AC Transmission System, Standard Publishers, Delhi, 2001.					
Course	Objectives:					
The ad	vent of high power electronic devices has led to the development of	of FAC	Гѕ Тес	hnology	7. The	
concept	t of FACTs envisages the use of power electronics to improve system	operatio	on by f	ast & re	eliable	
control.	This course is intended to cover concepts of FACTs including the described and the description of the descri	ription,	princip	ole of wo	orking	
and ana	and analysis of various FACTs controllers, control of FACTs and system interactions.					
Course	Learning Outcomes:					
CO	After the completion of the course the student will be able to	Blo	om's (Cognitiv	e	
		level	D	escriptor	r	
CO1	Explain necessity, operating principals and benefits of FACTs	2	Und	erstandi	ng	
	devices.					
CO2	Choose the suitable FACTs device/controller for particular	3	A	pplying		
	application.					
CO3	Analyze the characteristics of FACTs Controllers and effect of	4	A	nalyzing	g	
	location of the controller on Power System.					

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			1			
CO2				2		
CO3						2

Assessment:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50
ISE 1 and ISE 2 are based on assignment, oral	l, seminar, test (surprise/declared/quiz), and group

discussion. [One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2] MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Module 1: Introduction The concept of flexible AC transmission - reactive power control in electrical power	Hrs.
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
Module 2: Static VAR Compensator (SVC) and Applications	Hrs.
Voltage control by SVC – advantages of slope in dynamic characteristics – influence of SVC on system voltage. Applications - enhancement of transient stability – steady state power transfer – enhancement of power system damping – prevention of voltage instability.	6
Module 3: Thyristor Controlled Series Capacitor(TCSC) and Applications	Hrs.
Operation of the TCSC - different modes of operation – modeling of TCSC – variable reactance model – modeling for stability studies. Applications - improvement of the system stability limit – enhancement of system damping – voltage collapse prevention.	6
Module 4 : Emerging FACTS Controllers I	Hrs.
Static Synchronous Compensator (STATCOM) – operating principle – V-I characteristics	6
Module 5 : Emerging FACTS Controllers II	Hrs.
Unified Power Flow Controller (UPFC) – Principle of operation - modes of operation – applications – modeling of UPFC for power flow studies.	6
Module 6 : Co-Ordination of FACTS Controllers	Hrs.
FACTs Controller interactions – SVC–SVC interaction - co-ordination of multiple controllers	6

- 2. Explain the concept and analyze the effect of application of SVC in power transmission system.
- 2. Application and analysis of TCSC in Power transmission System.
- 3. Analysis of STATCOM for various loading conditions.
- 4. Analysis of UPFC for various loading conditions.
- 5. Explain the co-ordination of FACTs devices.

Professional Core (Lab) Courses

Title o	Citle of the Course: Digital Protection of Power System Lab L T P Cr										
Cours	Course Code: 4PS551 4 2										2
Pre-R	equisite Co	ourses: Digi	tal Protect	ion of Pov	wer Systen	ıs					
Textb	ooks:										
1. Badri Ram, D.N. Vishwakarma, Power System Protection and Switchgear, TMH, 2004.											
References:											
1.	PRDC Rel	ay user mar	nuals								
2.	MiPower u	user manual	S								
3.	A.G. Phad	ke, J.S. Tho	orp, Compi	ıter Relay	ing for Po	ver Systems	s, Wiley In	dia, II Ec	li., 201	2	
Cours	e Objectivo	es :									
This la	This laboratory course will develop analytical skills of the student and help to evaluate modern relaying									elaying	
practic	es. It will e	enable the s	tudent to a	levelop pi	otective re	elaying con	cepts as w	ell as pro	ovide a	n oppo	ortunity
for des	igning rela	ying hardwa	are and sof	tware.							
Cours	e Learning	Outcomes	:								
00	Bloom's Cognitive									ive	
CO	After th	e completio	on of the c	ourse the	student v	vill be able	to	level	Ι	Descrip	tor
CO	Demons	trate the op	peration of	electroma	agnetic & d	ligital relay	s.	3		Applyi	ng
CO	Test dig	ital relays to	o verify the	e operating	g character	ristics.		1 0- 6	A	nalyzin	g &
04								4 & 3) E	Evaluati	ng
CO	Design	hardware a	nd compil	e progran	ns for sim	ple digital	relays, as	a 6		Creatir	וס
000	group ta	sk.						Ű		erean	.9
CO-P	O Mapping	<u>g</u> :									
			PO1	PO2	PO3	PO4	PO5	PO6			
		CO1			3						
	$\mathbf{CO2}$ 2 2										

Assessments :

Lab Assessment:

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.

2

IMP: Lab ESE is a separate head of passing.

CO3

Based on	Conducted by	Conduction and Marks Submission	Marks	
Lab activities,	Lab Course Fegulty	During Week 1 to Week 4	25	
attendance, journal	Lab Course Faculty	Submission at the end of Week 5	23	
Lab activities,	Lab Course Feaulty	During Week 5 to Week 8	25	
attendance, journal	Lab Course Faculty	Submission at the end of Week 9	23	
Lab activities,	Lab Course Feaulty	During Week 10 to Week 14	25	
attendance, journal	Lab Course Faculty	Submission at the end of Week 14	23	
Lab Performance and	Lab Course feaulty	During Week 15 to Week 18	25	
related documentation	Lab Course faculty	Submission at the end of Week 18	23	
	Lab activities, attendance, journal Lab activities, attendance, journal Lab activities, attendance, journal Lab Performance and related documentation	Based onConducted byLab activities, attendance, journalLab Course FacultyLab activities, attendance, journalLab Course FacultyLab activities, attendance, journalLab Course FacultyLab Performance and related documentationLab Course faculty	Based onConducted byConduction and Marks SubmissionLab activities, attendance, journalLab Course FacultyDuring Week 1 to Week 4 Submission at the end of Week 5Lab activities, attendance, journalLab Course FacultyDuring Week 5 to Week 8 Submission at the end of Week 9Lab activities, attendance, journalLab Course FacultyDuring Week 10 to Week 14 Submission at the end of Week 14Lab activities, attendance, journalLab Course FacultyDuring Week 10 to Week 14 Submission at the end of Week 14Lab Performance and related documentationLab Course facultyDuring Week 15 to Week 18 	

2

Week 1 indicates starting week of 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.

Course Contents:

- 1) Perform experiment by assembling a set up to obtain Time-Current characteristics of Electromagnetic O/C and E/F relays.
- 2) Perform experiment by assembling a set up to verify Directional O/C relay operation.
- 3) Perform experiment for Plotting Time-current characteristics of DMT, IDMT, NI3, NI1.3, VI, EI etc. using Digital O/C relay.
- 4) Perform experiment and analyze performance of digital distance relay quadrilateral characteristics.
- 5) Fabricate Hardware to realize and program a microprocessor/microcontroller based over current relay.
- 6) Fabricate Hardware to realize and program a microprocessor/microcontroller based differential relay.
- 7) Fabricate Hardware to realize and program microprocessor/microcontroller based distance relays.
- 8) Perform Relay co-ordination study using MiPower software for simple radial feeder system.
- 9) Demonstrate application of NRDE for development of digital relays.

Title of the Course: Ap	L	Т	Р	Cr					
Lab			Δ	2					
Course Code: 4PS552									
Pre-Requisite Courses: Power System Engineering , Power Electronics									
Textbooks:									
1. R. Mohan Mathur	r, Rajiv. K. V	arma, <i>Th</i> y	yristor – Ba	sed Facts Controlle	rs for E	lectrica	al		
Transmission Sys	<i>tems</i> , IEEE p	press and J	ohn Wiley	& Sons Inc., 2002					
References:									
1. A.T.John, Flexibl	le AC Transn	nission Sys	s <i>tem</i> , Institu	tion of Electrical an	d Electi	onic E	ngineers	S	
(IEEE), 1999.									
2. Narain G.Hingora	ani, Laszio. C	Gyugyl, Ui	nderstandin	g FACTS Concepts	and Tec	hnolog	gy of Fle	xible	
AC Transmission	System, Star	ndard Publ	lishers, Dell	ni, 2001.					
Course Objectives:									
The advent of high pov	ver electroni	c devices	has led to	the development of	of FAC	Ts Tec	chnolog	y. Th	
concept of FACTs envis	ages the use	of power	electronics	to improve system	operati	on by f	fast & r	eliabl	
control. This course is in	tended to cov	ver concep	ots of FACT	s including the desc	ription,	princij	ple of w	orkin	
and analysis of various F	ACTs contro	ollers, cont	trol of FAC	Is and system intera	ctions.				
Course Learning Outco	mes:						<u>a</u>		
CO After the comp	letion of the	course th	e student v	vill be able to	Blo	$\frac{1}{1000}$	Cognitiv	/e	
					level		escripto	or	
modelling.	various FAC	CT's device	es to under	stand principle and	2	Unc	lerstand	ıng	
CO2 Choose the su	itable FAC	CTs devi	ice/controlle	r for particular	3	A	Applying	5	
application.									
CO3 Analyze the cha	racteristics o	of FACTs	Controllers	and effect of	4	A	nalyzing	g	
location of the c	ontroller on l	Power Sys	stem.						
CO-PO Mapping :									
			,	1					
	PO1	PO2	PO3	PO4 PO5	PO)6			
CO1			2						
CO2				2					
CO3					2				
Assessment:									
Lab Assessment:									
There are four compone	ents of lab ass	sessment,	LA1, LA2,	LA3 and Lab ESE.					
IMP: Lab ESE is a sepa	rate head of	passing.							
Assessment Ba	ased on	Con	ducted by	Conduction and M	/larks Su	bmissic	on Ma	arks	
LA1 Lab	activities,	Lab Co	ourse Faculty	During Week	1 to	Week	4	25	
attenda	ince, journal			Submission at the e	end of W	eek 5			
LA2 Lab	activities,	Lab Co	ourse Faculty	During Week	5 to	Week	8 2	25	
I A3 Lab	activities	Lah Co	ourse Faculty	During Week 1	$\frac{1000}{0}$ to	Week	14 7	25	
LAJ Lau	acti v11105,	Lauce	Juise Faculty	During WEEK I	0 10	W CCK	17 4		

	attendance, journal		Submission at t	he end of Week 14	1			
Lab ESE	Lab Performance and	Lah Course faculty	During Week	15 to Week	18	25		
	related documentation	Lab Course faculty	Submission at t	he end of Week 18	3	23		
Week	1 indicates	starting	week	of		Semester.		
Lab activitie	s/Lab performance shal	l include performin	ng experiments	s, mini-project,	pres	entations,		
drawings, pro	gramming and other suita	able activities, as per	the nature and	requirement of th	ne lał	o course.		
The experime	ntal lab shall have typica	lly 8-10 experiments						
Course Content:								
1. Simula	1. Simulation and modelling of application of SVC in power system.							
2. Analyst	2. Analysis of various types of SVCs.							
3. Compa	rison of effectiveness of v	various types of SVC	Cs.					
4. Simula	tion of TCSC,							
5. Simula	5. Simulation of TCSC characteristics.							
6. Simula	6. Simulation of STATCOM.							
7. Simula	7. Simulation of UPFC.							
8. Analysis of STATCOM and UPFC for various loading conditions.								
Computer Usa	age / Lab Tool: MATLA	B SIMULINK.						

Professional Elective (Theory) Courses

Title of the Cou	irse: Power	· Apparat	us Modeli	ing			L	Т	Р	Cr
Course Code: 4PS511							3			3
Pre-Requisite Courses: Power System Engineering A C Machines Power System Analysis and Stability									bility	
Tortheeles	Jour Ses. 10	wei bystei		, mg, A.	C. Machines,	10wei Sys		inary si		
1 D Kundu	r Dower Su	stom Stab	ility and (Tontrol 1	Toto McGrow	LIII Now	Dalhi	1004		
I. F. Kulluu	I, FOwer Sy	siem, siud	iiiy ana C	Joniroi,		niii, New	Denn	, 1994.		
1 V D Dodi	Down	Custom Du	namia Sta	hilin l	Control D C	Dublicatio	n 200	0		
1. K.K.Faul	yal, FOWER	Dai Powa	rumic, Sic	wiiiy a Dynamia	Control, D.S	v Person E	II, 200 ducat	jo.	a 1008	
Course Objecti		1 al, 1 Owe	r System I	Jynumic		<i>y</i> , i cisoli E	uucai	IOII AS	la, 1996.	
1 To provi	de the stud	lents the	ability to	underst	and the prol	olem of st	ability	v of si	ingle m	achine
connected	to infinite	bur and m	ulti machi	ne syster	m.	Jiem of St	uonney	01 51	ingle in	xemme
2. To give the	ne students a	a sound ma	athematica	al approa	ich towards m	odeling of	vario	us appr	oach use	ed in
power sys	stem.			TI		0				
Course Learnin	ng Outcome	es:								
CO After t	he complet	ion of the	course th	e studer	nt will be abl	e to	H	Bloom'	s Cognit	tive
	-						le	evel	Descri	ptor
CO1 Constr	ruct models	of apparat	us in pow	er syster	n.			3	Apply	ing
CO2 Analyz	ze models fo	or stability	of power	systems.				4	Analyz	ving
CO3 Recom	mend solu	tions to th	ne probler	n of po	wer system s	tability an	d	5	Evalua	ting
control			1	1	5	5				0
CO-PO Mappi	ng:									
	8									
		PO1	PO2	PO3	PO4	PO5	PC)6		
	C01			3						
	CO2				3					
	CO3						2			
A ssessment ·	0.00			l						
Teacher Assess	ment:									
Two component	ts of In Ser	nester Eva	luation (I	SE). On	e Mid Semes	ter Examir	ation	(MSE) and on	e End
Semester Exami	nation (ESE	E) having 2	20%, 30%	and 50%	weightage r	espectively		(,	
	Assess	ment			00	Ma	rks			
	ISE	1			10					
	MS	E				3	0			
	ISE		10							
	ESI	E			50					
ISE 1 and IS	E 2 are ba	used on as	ssignment	, oral, s	seminar, test	(surprise/d	eclare	ed/quiz), and g	group
discussion. [One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2]										
MSE: Assessment is based on 50% of course content (Normally first three modules)										
ESE: Assessm	ent is based	l on 100%	course co	ontent wi	th70-80% we	ightage for	cours	se cont	ent (nor	nally
last three modu	iles) covered	d after MS	E.							
Course Conten	ts:									

Module 1: Introduction to Power System Stability Problem					
Classification of stability, resolution of stability problem by classical method, transient	6				

stability of multi-machine system.	
Module 2: Modeling of Synchronous machine	Hrs.
Physical description, mathematical description of synchronous machine, dq0 transformation,	6
per unit representation, equivalent circuits for direct and quadrature axis.	0
Module 3: Excitation System	Hrs.
Elements of excitation system, types of excitation system, necessity of stabilizing circuits	6
IEEE excitation systems.	0
Module 4: Prime Movers and Energy supply Systems	Hrs.
Turbines and governing systems, modeling of steam turbines, steam turbine controls, steam	6
turbine off-frequency capability.	U
Module 5: Dynamic modeling of hydro turbine and governors	Hrs.
Hydraulic turbine transfer function, governors for hydraulic turbines, detailed hydraulic	(
system model, guidelines for modeling hydraulic turbines	0
Module 6: Load modeling for stability studies.	Hrs.
Basic load modeling concepts, static load models, dynamic load models, modeling of	6
induction motor, per unit representation, representation in stability studies.	U

Module wise Measurable Students Learning Outcomes:

After completion of the course students will be able to:

- 1. Interpret power system stability phenomenon.
- 2. Estimate the characteristics of Synchronous machine and develop accurate model.
- 3. Choose required dynamic performance criteria for identification and specification of excitation systems.
- 4. Estimate the characteristics of prime mover and energy supply system.
- 5. Construct model of hydro turbine and governor.
- 6. Apply load modeling concepts, load composition, component characteristics, and acquisition of load model parameters and modeling of introduction motor.

Title of the Course: Digital Signal Processing Application to Power	L	Т	Р	Cr
System	3			3
Course Code: 4PS512				
Dro Dogwisita Courses Signals and Systems				

Pre-Requisite Courses: Signals and Systems

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, Haitao Guo, *Introduction to Wavelets and Wavelet Transforms*, A Primer PH International Editions, 1998.
- 2. Raghuveer M. Rao, Ajit S. Bopardikar, *Wavelet Transforms Introduction to Theory and Applications*, Addison Wesley Pearson Education Asia, 2000
- 3. IEEE Transaction Papers.

Course Objectives:

- 1. This course is intended 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.

CO	After the comple	tion of the	course th	e student	will be abl	e to	Bloo	om's Cognitive
							level	Descriptor
CO1	Explain the basi	c concept	s and terr	ninology 1	that are us	ed in the		
	Fourier Techniqu	ues, wave	elets Tran	sforms a	nd Time	frequency	2	Understanding
	analysis.							
CO2	Calculate filter b	ank coeffi	cients and	Apply th	e concepts	of CWT,	2	Applying
	STFT and DWT f	or signal a	nalysis.				5	Applying
CO3	Construct perfect	t reconstru	ction wav	elet filter b	oanks for a	particular	15	Analyzing
	application and ju	stify why	wavelets p	rovide the	right tool.		4,3	Evaluating
CO-PC) Mapping :							
		PO1	PO2	PO3	PO4	PO5	PO6	
	CO1			2				
	CO2				2			
		+			+	1	-	

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion. [One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2] MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Fundamentals of Linear Algebra:	Hrs.
Vector spaces, Bases, Orthogonality, Orth normality, Projection, Functions and function	4
Spaces, Orthogonal functions, Orthonormal functions, Orthogonal basis functions.	4
Module 2: Signal Representation in Fourier Domain	Hrs.
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	6
signal processing, Review of Nyquist theorem., Review of Z transform, Application of Fourier	
family transforms in power systems.	
Module 3: Discrete Wavelet Transform	Hrs.
Introduction to Wavelet Transform: The origins of wavelets, Wavelets and other wavelet	8
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 transform: 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.	
Module 4: Discrete Wavelet Transform and Relation to Filter Banks	Hrs.
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 coefficients, Concepts of Multi-	8
Resolution Analysis (MRA) and Multi-rate signal processing, Applications of DWT in power	
systems.	
Module 5: Short Time Fourier Transform(STFT) and Continuous Wavelet Transform	Hrs.
(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	6
time-frequency representation of signals, Properties of wavelets used in continuous wavelet	
transform, Continuous versus discrete wavelet transform	
Module 6: Designing Orthogonal Wavelet Systems-A Direct Approach	Hrs.
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:	8
Approximation conditions (Smoothness conditions), Designing Daubechies orthogonal wavelet	
system coefficients, Constraints for Daubechies' 6 tap scaling function.	
Module wise Measurable Students Learning Outcomes:	
After completion of the course students will be able to:	
1. Discuss fundamentals of Vector algebra.	
2. Explain concepts of signal processing.	
3. Construct two channel filter bank for perfect reconstruction.	
4. Calculate time bandwidth product.	
5. Explain and Apply concepts of CWT and STFT for signal analysis.	
6. Design orthogonal wavelets.	

Title of the Course: Neural Network and fuzzy Application to Power	L	Т	Р	Cr
System	3			3
Course Code: 4PS515				

Pre-Requisite Courses: Power system

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 Mc Graw Hill Publication, 1993
- 4. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic, PHI Learning Private Limited, 1995.
- 5. Research Papers.

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 Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	Explain the basic knowledge of Neural Network.	2	Understanding
CO2	Apply the Neural network and fuzzy knowledge about different neural	3	Applying
	networks, their architecture and training algorithm to solve power		
	system problems.		
CO3	Study the different applications of neural networks and fuzzy logic.	4	Analyzing

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1						1
CO2				3		
CO3				2		

Assessment:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion. [One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2] MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
Module 1: Introduction to Neural Networks.	Hrs.
Introduction, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron	
Models, Historical Developments, Neuron Model, McCulloch and Pitts models of neuron,	6
ANN terminologies, weights, sigmoidal functions, Bias.	
Module 2: Essentials of Neural Networks.	Hrs.
Types of Neuron Activation Function, Neural networks architectures, Linearly separable	
and linearly non separable systems and their examples, Learning Strategy (Supervised,	6
Unsupervised, Reinforcement), Learning Rules, Hebbian learning rule, Perceptron learning	0
rule etc.	
Module 3: Feed Forward Neural Networks	Hrs.
Introduction, single layer Perceptron Models, architecture, Limitations of the Perceptron	
Model, Applications, Back Propagation Network, architecture, Multilayer Feed Forward	6
Neural Networks. Use of ANN MATLAB tools for programing.	
Module 4: Fuzzy Systems	Hrs.
Basic Fuzzy logic theory, history, operation of Fuzzy Logic, Fuzzy relation and extension	
principle, Fuzzy membership functions and linguistic variables, mamdani and sugens models.	6
Use of MATLAB tools of fuzzy logic.	
Module 5: Application of Neural Network and fuzzy to power system operation and	Hrs.
control problems.	
Use of MATLAB tools of ANN and fuzzy logic for power system applications. Case studies	6
such as load fore-casting, optimal power flow, control applications in FACTS devices, etc.	U
Module 6: Application of Neural Network and fuzzy to recent power system protection	Hrs.
problems.	
Use of MATLAB tools of ANN and fuzzy logic for protection applications. Case studies such	6
as fault analysis, fault detection, fault classification, fault location, etc.	U
Module wise Measurable Students Learning Outcomes :	
After completion of the course students will be able to:	

- 1. Use comparison between Biological and Artificial Neuron Models.
- 2. Summarize different learning strategy.
- 3. Explain different neural network models.
- 4. Apply different fuzzy logic tools.
- 5. Solve power system operation and control problems by using ANN and Fuzzy.
- 6. Study recent power system protection problems by using ANN and Fuzzy.

Title of the Course: Grid Integration of Renewable Energy	L	Т	Р	Cr
Course Code: 4PS516	3			3
Pre-Requisite Courses: Power Electronics, Renewable Energy				
Textbooks:				

- 1. Amirnaser Yazdani, Reza Iravani Voltage-sourced converters in power systems_ modeling, control, and applications (2010, IEEE Press_John Wiley)
- 2. Remus Teodorescu, Marco Liserre, Pedro Rodriguez Grid Converters for Photovoltaic and Wind Power Systems (2011, John Wiley & Sons, Ltd.)

References:

- 1. [Iet Energy Engineering] Antonio Moreno-Munoz Large Scale Grid Integration of Renewable Energy Sources (2017, The Institution of Engineering and Technology)
- 2. Math J. Bollen, Fainan Hassan 'Integration of Distributed Generation in the Power System', IEEE Press, 2011.

Course Objectives :

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

Course Learning Outcomes:

After the completion of the course the student will be able to		Bloom's Cognitive		
After the completion of the course the student will be able to	level	Descriptor		
Summarize two level voltage source converter in various reference		Understanding		
frame.	Z	Understanding		
Apply various voltage source converters and their control.	3	Applying		
Analyze grid synchronization techniques and DC micro-gird.	4	Analyzing		
	After the completion of the course the student will be able toSummarize two level voltage source converter in various reference frame.Apply various voltage source converters and their control.Analyze grid synchronization techniques and DC micro-gird.	After the completion of the course the student will be able to Block Image:		

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3			
CO2				2		
CO3						2

Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion. [One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2] MSE: Assessment is based on 50% of course content (Normally first three modules) ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally

last three modules) covered after MSE.	
Course Contents:	
Module 1: Overview of Renewable Energy	Hrs.
Status & trends of renewable energy sources, solar fundamentals, electrical characteristics of	
PV, stand-alone grid connected PV configurations, wind energy assessment, fixed & variable	7
speed turbines with reduced & full capacity converters.	
Module 2: Two level, three phase voltage-sourced converter	Hrs.
Introduction. Two level voltage sourced-converter: structure, principle of operation & power	6
loss. Average model of two level VSC, model in $\alpha\beta$ -frame, model & control in dq frame.	0
Module 3: Three level, three phase, Neutral Point Clamped voltage-sourced converter	Hrs.
Introduction, Three level half bridge NPC, PWM sche e for three level half bridge NPC,	
switched model & average model for three level half bridge NPC, three level NPC: circuit	6
structure, principle of operation. Three level NPC with impressed dc side voltage.	
Module 4: Grid Imposed frequency VSC system: control in αβ-frame & <i>dq</i> -frame.	Hrs.
Introduction, structure of grid imposed frequency VSC system, real & reactive-power controller,	
Dynamic model & current mode control for real-/reactive power controller in $\alpha\beta$ -frame & dq	6
frame, Phase locked Loop.	1
Module 5: Grid Synchronization	Hrs.
Grid synchronization techniques for single-phase systems, grid synchronization using the	
Fourier analysis, grid synchronization using A phase-locked loop, PLL Based on a T/4 transport	6
delay, PLL based on the Hilbert transform.	1
Module 6: DC Micro-grid	Hrs.
Introduction, DC micro-grid system overview, Operation and control of DC micro-grids, DC	5
micro-grid system protection, Application of DC micro-grids to future smart grids.	3
Module wise Measurable Students Learning Outcomes :	
1. Grasp fundamentals of renewable energy.	
2. Interpret two level VSC model & control in $\alpha\beta$ -frame & dq frame.	
3. Employ model, operation of three level, three phase neutral point clamped VSC.	
4. Employ grid imposed frequency VSC with real-/reactive power controller.	
5. Examine different synchronization techniques.	

Examine different synchronization techniques.
 Inspect concept of DC micro-grid, its control, protection & application.

Mandatory Life Skill Courses

Value Added Professional Courses \$

Value Added Life-Skill Courses \$

Professional Core (Theory) Courses

Title of the Course: Power Quality in Distribution Systems		Т	Р	Cr
Course Code: 4PS521	3			3
				-

Pre-Requisite Courses: Power Systems, Power Electronics

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

Course Objectives :

This course is intended to provide basic knowledge of causes, consequences and solutions of power quality problems that affect the operation of computerized processes and electronic systems.

It also aims to provide a theoretical background to correctly approach the problem of reactive, harmonic and unbalance compensation, in the context of the applicable power theory.

Course	e Learning Outcomes:			
CO	After the completion of the course the student will be able to	Bloom's Cognitive		
		level	Descriptor	
CO1	State and Explain the basic concepts of Power Quality disturbances,	1,2	Remembering	
	reactive power compensation, voltage regulation, power definitions and		and	
	other figures of merit under distorted, operation and modelling of series		Understanding	
	and shunt compensators.			
CO2	Apply the theory and algorithms to realize reference current generation,	3	Applying	
	reactive power compensation, voltage regulation and harmonic			
	compensation.			
C03	Analyze theories of load compensation, reference generation, figures of	4	Analyzing	
	merits and power definitions, Standards applicable to Power Quality.			

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3			
CO2				2		
CO3						2

Assessment:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion. [One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2] MSE: Assessment is based on 50% of course content (Normally first three modules) ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE. **Course Contents:** Module 1: Introduction to Power quality Hrs. 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. 6 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. Module 2: Power Definitions in Single Phase and Three phase Circuits Hrs. 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, 6 unbalanced and non-sinusoidal conditions. IEEE 1459 power definitions applicable to three phase circuits Module 3: Theories of Load compensation Hrs. 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 6 Compensators, Analysis and Design of Passive Shunt Compensators, Modelling, Simulation, and Performance of Passive Shunt and Series Compensators, Numerical Examples. **Module 4: Active Shunt Compensation** Hrs. Introduction, State of the Art on DSTATCOMs, Classification of DSTATCOMs, Principle of Operation and Control of DSTATCOMs, Analysis and Design of DSTATCOMs, Modelling, 6 Simulation, and Performance of DSTATCOMs, Numerical Examples. **Module 5:** Active Series Compensation Hrs. 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 6 Design of Active Series Compensators, Modelling, Simulation, and Performance of Active Series Compensators, Numerical Examples. **Module 6: Unified Power Quality Compensators** Hrs. Introduction, State of the Art on Unified Power Quality Compensators, Classification of Unified Power Quality Compensators, Principle of Operation and Control of Unified Power 6 Quality Compensators, Analysis and Design of Unified Power Quality Compensators, Modelling, Simulation, and Performance of UPQCs, Numerical Examples.

Module wise Measurable Students Learning Outcomes:

After completion of the course students will be able to:

- 1. Explain Power quality problems, indices and effects.
- 2. Calculate various power components under balanced and unbalanced and sinusoidal and nonsinusoidal conditions in single phase circuits and three phase circuits.
- 3. Investigate theories of load compensation.
- 4. Explain the design operation and modeling of unified power quality compensators

- 5. Apply real time mitigation methods to power quality problems using series and shunt devices.
- 6. Analyze the effect of compensators on the power system.

Page

Title of the Course: PLC and Embedded Systems	L	Т	Р	Cr
Course Code: 4PS522	3			3

Pre-Requisite Courses: Instrumentation Techniques, Electrical Measurements, Microcontroller and Applications

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.

Course Objectives :

- 1. The course intends to exploit the PLC and Embedded Control for industrial automation.
- 2. The course aims at developing programs using ladder logic for industrial automation.
- 3. It intends to analyze the performance of automation systems employing PLC and Embedded Control.

Course	e Learning Outcomes:			
СО	After the completion of the course the student should be able to	Bloom's Cognitive		
		level	Descriptor	
CO1	Interpret features of PLC and Embedded Control Systems used for	3	Applying	
	Industrial Automation.			
CO2	Use ladder logic programming technique for various PLC applications.	3	Applying	
CO3	Evaluate the performance of PLC network configurations, PLC	5	Evaluating	
	functions used for different application			

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2			
CO2			2			
CO3				2		

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
Module 1: Introduction to PLC	Hrs.
Introduction, Advantages, Disadvantages, Parts of PLC, PLC Input module, PLC Output	
Module, PLC Architecture, PLC Operation, PLC as a computer, PLC memory and interfacing,	6
Power Supply for PLC	
Module 2: PLC programming	Hrs.
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	6
diagrams from process control description.	
Module 3: PLC Timer and Counter Functions	Hrs.
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	6
UP, DOWN counters, Case studies related to Industrial Automations	
Module 4: PLC Arithmetic, Comparison and Branch functions	Hrs.
PLC Arithmetic functions, PLC comparison functions, Conversion functions, Master control	
relay functions, PLC jump functions, Jump with return and Jump with No return functions,	6
Programs related to Arithmetic, Comparison and Branch functions	
Module 5: Advanced PLC functions	Hrs.
Data move system, data handling functions, Digital bit functions and applications, sequencer	
functions Analog PLC operations, PID control of continuous process, PID modules & tuning,	6
typical PID functions	
Module 6: PLC Networking	Hrs.
Networking of PLCs, Levels of Industrial Control, Types of Networking, Network	6
Communications, Cell control by PLC Networks, Factors to consider in selecting a PLC	U
Module wise Measurable Students Learning Outcomes :	
After the completion of the course the student should be able to:	
1. Interpret the basic features, advantages & disadvantages of PLC.	
2. Implement programs in PLC by using programming tools like ladder diagrams.	
3. Use PLC timer and counter functions to develop ladder logic programs.	
4. Implement various applications of PLC using PLC arithmetic, comparison and branch func	tions.
5. Employ and evaluate PLC for analog operations and design PID createrol using PLC	

6. Interpret the PLC network configuration and select the PLC to meet given constraints.

Professional Core (Lab) Courses

Title of the Course: Power Quality in Distribution Systems Lab	L	Т	Р	Cr
Course Code: 4PS571			4	2

Pre-Requisite Courses: Power Systems, Power Electronics

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

Course Objectives :

This course is intended to educate the students with the practical aspects of Power Quality issues. It also develops the critical thinking in solving power quality problems with contemporary Power Quality Theories and thereby hone the research skills.

Course	Learning Outcomes:			
CO	After the completion of the course the student will be able to	Bloom's Cognitive		
		level	Descriptor	
CO1	Calculate power components and other figures of merit under distorted	3	Applying	
	conditions.			
CO2	Analyze Power Quality Problems and provide suitable remedy.	4	Analyzing	
C03	Evaluate theories of load compensation, reference generation using	5	Evaluating	
	suitable simulation tool.			

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2			
CO2				2		
CO3						3

Assessment:

Lab Assessment:

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.

IMP: Lab ESE is a separate head of passing.

A	ssessment	Based on	Conducted by	Conduction and Marks Submission	Marks
	ΤΑΙ	Lab activities,	Lab Course Feaulty	During Week 1 to Week 4	25
	LAI	attendance, journal	Lab Course Faculty	Submission at the end of Week 5	23
	1.4.2	Lab activities,	Lab Course Feaulty	During Week 5 to Week 8	25
	LAZ	attendance, journal	Lab Course Faculty	Submission at the end of Week 9	23
	Ι Δ 2	Lab activities,	Lab Course Feaulty	During Week 10 to Week 14	25
	LAJ	attendance, journal	Lab Course Faculty	Submission at the end of Week 14	23
	Lob ESE	Lab Performance and	Lah Course feaulty	During Week 15 to Week 18	25
-	Lau ESE	related documentation	Lab Course faculty	Submission at the end of Week 18	23
Wee	ek	1 indicates	starting	week of	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.

Course Contents:

- 1. Analysis of Power Quality Disturbances. (Harmonics, inrush/sag, Transients etc.)
- 2. Calculation of Power Component definitions in single phase circuits: linear and distorted current condition.
- 3. Calculation of Power Component definitions in single phase circuits: Non Sinusoidal supply and Non- linear load.
- 4. Evaluation of theories for power factor correction and load balancing.
- 5. Evaluation of Theories for harmonic compensation.(part 1: four theories)
- 6. Evaluation of Theories for harmonic compensation.(part 2: four theories)
- 7. Evaluation of theories for series compensation.
- 8. Modelling of unified power quality conditioner.

Computer Usage / Lab Tool: MATLAB SIMULINK

Title	e of the C	ourse: PLC a	and Embed	lded Syst	tems Lab			L	Т	P	Cr
Cou	rse Code	: 4PS 572								4	2
Pre-	Requisit	e Courses:	Instrumenta	tion Teo	chniques, E	lectrical	Measurem	ents,	Microc	control	ler and
App	lications										
Tex	tbooks:										
-	l. John V	V. Webb, Ron	ald A. Rei	s, Progra	ammable log	ic control	lers, princ	iples &	applic	cations	, PHI
	public	ation, Eastern	Economic	Edition,	1994.						
Refe	erences:										
1	. John R 2004.	. Hackworth a	nd Petersor	n, <i>PLC co</i>	ontrollers pr	ogrammin	g methods	and a	pplicat	<i>ions</i> , P	PHI,
2	. Gary d	unning, <i>Introa</i>	luction to P	LC, Thor	nson learnir	g, Edition	n III, 2006.				
3	. Willian	n H. Bolton, <i>F</i>	Programma	ble logic	controllers,	Newnes, I	Edition VI	, 2006.			
Cou	rse Obje	ctives :									
1	. The lab	course is aim	ed to devel	op progra	amming skil	ls using P	LC for Ind	lustrial	Auton	nation	
2	. The co	urse intends to	introduce	the use of	f PLC for so	lving real	world pro	blems.			
3	. It will e	enable student	s to use PL	C for con	trol applicat	tions in ele	ectrical en	gineeri	ng		
Cou	rse Lear	ning Outcom	es:					1			
CO	After	the completi	on of the c	ourse the	e student sh	ould be a	ble to	Bloo	m's Co	ognitiv	e
					, source sh	oura se a		level	D	escript	or
CO	1 Execu	ite experimen	ts based on	PLC and	l SCADA sy	stems.		3		Appl	ying
CO	2 Const	truct basic co	ntrol system	ns using l	PLC and SC	ADA.		4		Analy	zing
CO	3 Desig	n ladder logic	programs f	for variou	us PLC appli	cations.		6		Creat	ting
CO	PO Map	ping :					1	1			
			PO1	PO2	PO3	PO4	PO5	PO	6		
		CO1			2						
		CO2				2					
		CO3				2					
Asse	essments	:									
Lab	Assessm	ent:									
The	re are four	components	of lab asses	sment, L	A1, LA2, L	A3 and La	ıb ESE.				
IMP	: Lab ESI	E is a separate	head of pas	ssing.							
A	ssessment	Base	d on	Con	ducted by	Conduc	tion and M	arks Su	bmissio	on N	/larks
	LA1	Lab act	ivities,	Lab Co	urse Faculty	During	Week 1	to	Week	4	25
		attendance	e, journal			Submissi	ion at the er	nd of W	eek 5		
	LA2	Lab act	ivities,	Lab Co	urse Faculty	During	Week 5	to	Week	8	25
		attendance	e, journal			Submissi	$\frac{100}{100}$ at the ei	nd of W	eek 9	1.4	
	LA3	Lab act	ivities,	Lab Co	urse Faculty	During	Week IU	to to	Week	14	25
		Lab Darfor	e, journal			During	$\frac{1000}{W}$		Week 14	10	
]	Lab ESE	related doci	inalice allu	Lab Co	ourse faculty	Submissi	ion at the er	nd of W	veck 18	10	25
Wee	k	1	indicates		starting		reek			Se	emester
Lah	activitie	s/Lah nerfor	mance cha	11 includ	le performi	ng exner	imente r	nini-nr	oiect	nresen	itations
drav	vings nro	oramming and	1 other suits	hle activ	ities as ner	the nature	and requi	rement	of the	lah co	urse
The	experime	ntal lah chall l	have typica]v 8_10 <i>e</i>	experimente	ine nature	and requi		or the	100 00	MIDU.
	- Aperine	inai iao silali i	in the typical		mporments.						

Course Contents:

- 1. Use different components of Relay and PLC logic.
- 2. Implement ladder diagram for ON/OFF and latching functions.
- 3. Design of PLC program for motor reversal control.
- 4. Illustrate stair case lighting using PLC programming.
- 5. Implement PLC program for building automation.
- 6. Design of PLC program for various arithmetical functions.
- 7. Devise the PLC program for traffic control system.
- 8. Design of ON/ OFF control mechanism using PLC timer functions.
- 9. Design of basic applications employing PLC counter functions.

10. Design of basic applications employing PLC analog inputs.

Computer Usage / Lab Tool: RSMicrologix, RSLinx, RSEmulator, PLC Trainerkit

Professional Elective (Theory) Courses

Title of the Course: Power System Dynamics	L	T P	Cr		
Course Code: 4PS531	3 -		3		
Pre-Requisite Courses: Power Apparatus Modeling and Simulation					
Textbooks:					
1. P. Kundur, <i>Power System, Stability and Control</i> , Tata McGraw Hill, Nev	v Delhi, I	1994.			
	·· • • • • • •	0			
1. K. R. Padiyar, Power System Dynamic, Stability & Control, B.S. Publica	$t_{100}, 200$	8.			
Course Objectives :	C				
1. To introduce the concept of small signal and transient stability analysis of 2. To provide colutions to SSD prohlem and voltage stability prohlem.	f power s	systems.			
2. To provide solutions to SSK problem and voltage stability problem.					
Course Learning Outcomes:	Dla	am'a Car			
CO After the completion of the course the student will be able to		Dom's Cog			
CO1 Distinguish various categories of system stability.	2	Unders	tanding		
CO2 Analyze models, use analytical tools to decide upon the stability of	ot 4	Anal	yzing		
various types.					
CO3 Recommend various methods to improve various type of stabilities of	of 5	Eval	ating		
power system.	power system.				
CO-PO Mapping :	1				
PO1 PO2 PO3 PO4 PO5	PO6				
CO1 3					
CO2 3					
CO3	2				
Assessment:					
Teacher Assessment:					
Two components of In Semester Evaluation (ISE), One Mid Semester Exam	nation (1	MSE) and	one End		
Semester Examination (ESE) having 20%, 30% and 50% weightage respectively	у.				
Assessment M	arks				
ISE 1	10				
MSE	30				
ISE 2	10				
ESE	50	/ · >	1		
ISE I and ISE 2 are based on assignment, oral, seminar, test (surprise,	declared	(quiz), ar	a group		
discussion. [One assessment tool per ISE. The assessment tool used for ISE 1 MSE: A gaagement is based on 50% of course content (Normally first three mo	snall not	be used to	or ISE 2]		
ESE: Assessment is based on 100% course content with 70-80% weightage for	uuies)	content (ormally		
last three modules) covered after MSE		content (iormany		
Course Contents:					
Module 1. Introduction to small signal stability of nower system			Hrs		
Small Signal Stability analysis of single machine connected to infinite bus	ten hv st	en model	111.5.		
development of single machine connected to infinite bus	tep by st		6		
Module 2:Improvement of small signal stability			Hrs.		

Power system stabilizer, Simulation of Power System Dynamic response using postabilizer in the small signal stability model of single machine connected to infinite	ower system 6
Module 3:Large scale power systems	Hrs.
Dynamic equalization of large scale system systems. Step by step reduction of	f large scale
model to a smaller model for analysis purpose.	ð
Module 4:Transient stability analysis	Hrs.
Introduction to Direct method of transient stability analysis by roller ball analogy. I	Development
of model using energy concept, and analysis of model for transient stability.	U
Module 5:Sub synchronous resonance	Hrs.
Introduction to Sub-Synchronous oscillation & sub- synchronous resonance. Effe	ect of series
compensation of transmission line. Induction generator effect, stability of hydro turb	bines.
Module 6:Voltage stability	Hrs.
Reactive power compensation and Voltage stability. Development of model of po	ower system
for voltage stability. Sensitivity analysis and QV modal analysis for voltage stabili	ity. Methods 6
of improving stability.	
	· · · · · · · · · · · · · · · · · · ·

Module wise Measurable Students Learning Outcomes:

After completion of the course students will be able to:

- 1. Describe a model of SMIB and solve it analytically.
- 2. Investigate power system stabilizer and simulate the dynamic response of power system.
- 3. Estimate equivalent small dimension model of the given large scale system.
- 4. Assess stability of the system by energy based method.
- 5. Describe the characteristics and modeling of T.G shaft system and discuses problem related and sub synchronous torsional oscillation for design consideration of power system.
- 6. Assess the voltage instability problem by dynamic and static models.

Computer Usage / Lab Tool: MATLAB, ETAP, Mi POWER etc.

Title of the	Course: EHVA	С				L	Т	Р	Cr
Course Cod	e: 4PS532					3			3
Pre-Requisi	te Courses: Pow	ver system							
Textbook:									
1. Rakos	sh Das Begamue	dre, "EHV	AC Tran	smission E	Engineering'	', Wiley	Eastern I	Limited, 3	rd Edition
2008.									
References:									
1. Twiar	n Gonen, "EHVA	AC and H	VDC Tra	nsmission	System Eng	gineering	– Analys	is and Do	esign John
Wiley	and Sons 1988.								
2. EHV	-AC and HVDC	Transmiss	sion Engir	neering &P	ractice : S.V	7. Rao			
3. Twiar	n Gonen, "Electr	ic Power	Transmiss	sion System	n Engineeri	ng-Analys	sis and D	Design", J	ohn Wiley
and S	ons 1988.								
Course Obj	ectives :								
1. Stude	nt will understan	d paramete	ers of EHV	VAC line					
2. Stude	nt will develop a	skill to de	sign and a	nalyze EH	VAC line				
3. Stude	nt will develop a	skill to un	derstand j	power frequ	uency over v	voltages d	eveloped	in EHVA	C line
4. Stude	nt will develop a	skill to un	derstand i	nsulation c	oordination	based on	lightenin	g	
Course Le	arning Outcome	es:							
CO Aft	or the completie	n of the a	ourse the	student ch	ould be ab	la ta	Bloc	om's Cog	nitive
	er the completio	on of the c	ourse me	student si	ioulu de ad	ie to	level	Desci	riptor
CO1 Out	tline parameters	of EHVA	C line ar	nd develop	skills to d	esign and	2	Undere	tonding
ana	lyze EHVAC line	e.					2	Unders	landing
CO2 Exa	mine power free	quency ove	er voltages	s developed	l in EHVAC	Cline.	3	Appl	ying
CO3 Exp	olain insulation c	oordinatio	n based of	n lightenin	g.		4	Anal	yzing
CO-PO Ma	pping :								
		PO1	PO2	PO3	PO4	PO5	PO6		
	CO1	3							
	CO2				3				

Assessments:

Teacher Assessment:

CO3

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

2

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test / quize/ seminar etc.: 10 Marks to be submitted before MSE marks. It is open to students.

MSE: Assessment based on 50% of course content (Normally on module 1-3)

ESE: Assessment based on 100% of course content with 70-80% weightage for course content (Normally last three module) covered after MSE.

Course Contents:

Module 1: Introduction, Calculation of Line and Ground Parameters, Voltage Gradients of
Conductor and Corona EffectsHrs.

- **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.

8

Hrs.

Hrs.

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.

Module 2: Theory of Traveling Waves and Standing Waves	Hrs.
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	6
excitation, line energization with trapped charge voltage, reflection and refraction of traveling	U
waves.	
Module 3: Lightning and Lightning Protection	Hrs.

 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.
 6

Module 4: Over Voltage in EHV Systems Covered by Switching OperationsHrs.Over voltages their types, recovery voltage and circuit breaker, Ferro resonance over voltages
calculation of switching surges single phase equivalents.6

Module 5: 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.

Module 6: Insulation Coordination

Insulation coordination, Insulation levels, voltage withstand levels of protected equipment's and insulation coordination based on lightning, Design of EHVAC lines. 5

Module wise Measurable Students Learning Outcomes

- 1. Student will be able to understand the need and advantages of EHVAC Transmission, they will be able to calculate line and ground parameters, they will understand voltage gradients of the conductor and the phenomenon of corona.
- 2. Student will be able to understand the concepts of travelling waves and standing waves as well as their mathematical representations.
- 3. Student will be able to understand the phenomenon of lightening and associated protection.

- 4. Student will be able to understand different causes of over voltages.
- 5. Student will be able to understand the power circle diagram and SSR phenomenon.
- 6. Student will be able to understand the importance of insulation coordination.

Title of the Course: Deregulated Power System	L	Т	Р	Cr
Course Code: 4PS 533	3			3

Pre-Requisite Courses: Power System Engineering

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.

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.

0	Course	Learning Outcomes:		
	CO	After the completion of the course the student will be able to	Bloo	m's Cognitive
			level	Descriptor
	CO1	Recognize recent changes occurring in the structure of power supply	1	Remembering
		utilities and electric supply market.		
	CO2	Explain the problems associated with deregulation.	2	Understanding
	CO3	Solve some problem associated with deregulate power system.	3	Applying
(Monning		

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2					
CO2		3				
CO3			3			

Assessment:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30

ESE50ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion. [One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2] MSE: Assessment is based on 50% of course content (Normally first three modules) ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.Course Contents:Module 1: Introduction to Basic ConceptsBasic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system.Module 2: Power System RestructuringAn overview of the restructured power system, Difference between integrated power system and restructured power system, Explanation with suitable practical examples
ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion. [One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2] MSE: Assessment is based on 50% of course content (Normally first three modules) ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE. Course Contents: Module 1: Introduction to Basic Concepts Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system. Module 2: Power System Restructuring An overview of the restructured power system, Difference between integrated power system and restructured power system. 6
discussion. [One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2] MSE: Assessment is based on 50% of course content (Normally first three modules) ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE. Course Contents: Module 1: Introduction to Basic Concepts Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system. Module 2: Power System Restructuring An overview of the restructured power system, Difference between integrated power system An overview of the restructured power system, Explanation with suitable practical examples
MSE: Assessment is based on 50% of course content (Normally first three modules) ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE. Course Contents: Module 1: Introduction to Basic Concepts Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system. Module 2: Power System Restructuring An overview of the restructured power system, Difference between integrated power system and restructured power system Explanation with suitable practical examples
ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE. Course Contents: Module 1: Introduction to Basic Concepts Hrs. Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system. Module 2: Power System Restructuring Hrs. An overview of the restructured power system, Difference between integrated power system and restructured power system Explanation with suitable practical examples
last three modules) covered after MSE.Course Contents:Module 1: Introduction to Basic ConceptsHrs.Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system.6Module 2: Power System RestructuringHrs.An overview of the restructured power system, Difference between integrated power system and restructured power system Explanation with suitable practical examples6
Course Contents:Module 1: Introduction to Basic ConceptsHrs.Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system.6Module 2: Power System RestructuringHrs.An overview of the restructured power system, Difference between integrated power system6and restructured power system6
Module 1: Introduction to Basic ConceptsHrs.Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system.6Module 2: Power System RestructuringHrs.An overview of the restructured power system, Difference between integrated power system6and restructured power system, Explanation with suitable practical examples6
Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system.6Module 2: Power System RestructuringHrs.An overview of the restructured power system, Difference between integrated power system6and restructured power system, Explanation with suitable practical examples6
Module 2: Power System RestructuringHrs.An overview of the restructured power system, Difference between integrated power system6and restructured power system, Explanation with suitable practical examples6
An overview of the restructured power system, Difference between integrated power system 6
and restructured power system. Explanation with suitable practical examples
and restructured power system. Explanation with suitable practical examples.
Module 3: Deregulation of Power SectorHrs.
Separation of ownership and operation, Deregulated models, pool model, pool and bilateral
trade model, multilateral trade model.
Module 4: Competitive Electricity MarketHrs.
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.
Module 5: Transmission Pricing Hrs.
Marginal pricing of electricity, nodal pricing, zonal pricing, embedded cost, Postage stamp
method, Contract path method, Boundary flow method, MW-mile method, MVA – mile 6
Medule (a Comparison of different methods.
Module o: Congestion Management In normal operation availantian with suitable avample. Total
Transfer Canability (TTC) Available Transfer Canability (ATC)
Madula wise Measurable Students Learning Outcomes :
After completion of the course students will be able to:
1 State the components and advantages of competitive system
2. Paraphrase integrated and restructured power system.
3. Summarize various trading models and use them as per requirements
4 Explain problems related to market operations
5 Apply different methods of pricing as per the system model
6 Solve congestion management problems in normal condition

Title of the Course: Computer Aided Power System Analysis	L	Т	Р	Cr
Course Code: 4PS535	3			3

Pre-Requisite Courses: Power system

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, 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.

Course Objectives :

- 1. This course make the students conversant with different power system analysis methods.
- 2. This course is intended to provide basic knowledge of formation of Ybus methods. .

3. It also aimed to provide different power system computer analysis methods using computer.

Course	Learning	Outcomes:
--------	----------	-----------

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	Explain various methods of analyzing shunt and series faults.	2	Understanding
CO2	Apply the Network Topology knowledge for power system analysis.	3	Applying
CO3	Study Power flow analysis and economic dispatch of generation.	4	Analyzing

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1				2		
CO2						3
CO3				1		

Assessment:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion. [One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2] MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Analytical Simplifications.	Hrs.
Three Component method, Two-Component method, sequence network connections for	
different faults, Analysis of unsymmetrical shunt and series faults using three-component	6
(symmetrical component method) and two-Component method.	
Module 2: Network Topology.	Hrs.
Introduction, Elementary graph theory, Connected graph, tree, co-tree, basic cutsets, basic	
loops, Incidence matrices, Element-node, Bus incidence, Tree-branch path, Basic cutset,	6
augmented cut-set, Basic loop and Augmented loop, Primitive network, Impedance form and	U
Admittance form.	
Module 3: Network Matrices.	Hrs.
Introduction, formation of Y _{bus} by method of Inspection, method of Singular Transformation,	
Step by Step building algorithm for formation of Y _{bus} . Formation of Bus Impedance Matrix,	6
Modification of Zbus for addition of a branch, addition of link, removal of an element.	
Module 4: Network Fault and Contingency Calculations.	Hrs.
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	6
Unsymmetrical faults using Bus Impedance Matrix.	
Module 5: Power flow analysis	Hrs.
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	6
- frame of reference such as Gauss, Gauss - Seidel, Newton - Raphson methods, Decoupled	U
load flow methods etc.	
Module 6: Optimal Dispatch of generation	Hrs.
Performance Curves, economic dispatch of generation without and with transmission-line	
losses, Iterative technique, approximate penalty factor, Derivation of transmission loss	6
formula, Calculation of loss- coefficient using Ybus and sparse matrix techniques.	
Module wise Measurable Students Learning Outcomes:	
After completion of the course students will be able to:	
1. Explain different analysis methods of shunt and series faults.	
2. Study Impedance and Admittance form of Primitive network.	
3. Compare different methods of Ybus formation.	
4. Solve different methods of fault analyze using the admittance and impedance matrices.	
5. Compare different methods of load flow analysis.	
6. Study different planning methods for economic dispatch of generation.	

		1	1		1
Title	of the Course: Smart Grid	L	Т	Р	Cr
Cour	rse Code: 4PS536	3			3
Pre-I	Requisite Courses: Power System, Power Electronics				
Text	books:				
1.	Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, A	Akihiko	Yoko	yama, '	'Smart
	Grid: Technology and Applications", Wiley				
2.	G. M. Masters, Renewable and Efficient Electric Power Systems, John W	/iley &	Sons In	nc., 2004	4.
Refe	rences:				
1.	Gilbert N. Sorebo, Michael C. Echols, Smart grid security: An end to	end vie	w of se	curity i	in new
	Electrical grid, CRC press, Taylor & Fancis group, 2011.				
2.	S. P. Chowdhary, P. Crosley and S. Chowdhary, Micro-grids and activ	e distri	bution i	network	s, The
	institution of engineering and technology, London, 2009.				
3.	J. S. Thorp, A.G. Phadke, Synchronized Phasor Measurement and	Their A	pplicat	ions Sp	oringer
	2008.				

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 Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	Explain various concepts associated with smart grid.	2	Understanding
CO2	Apply smart grid concept to power system monitoring,	3	Applying
	communication and protection.		
CO3	Analyze tools for smart grid's performance, stability and	4	Analyzing
	computational analysis.		

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3			2
CO2				2		
CO3						2

Assessment:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks		
ISE 1	10		
MSE	30		
ISE 2	10		
ESE	50		
ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and gro			
discussion. [One assessment tool per ISE. The asses	sment tool used for ISE 1 shall not be used for ISE 2]		
MSE: Assessment is based on 50% of course conter	nt (Normally first three modules)		

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally	
last three modules) covered after MSE.	

Course Contents:

Module 1: Smart grid architecture	Hrs.
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	6
components.	
Module 2: Smart grid technologies	Hrs.
Introduction to Smart Meters, Automatic Meter Reading(AMR), Outage Management	
System(OMS), Plug in Hybrid Electric Vehicles(PHEV) & more, Substation Automation,	6
Feeder Automation, Geographic Information System (GIS), Intelligent Electronic	U
Devices(IED) & their application for monitoring & protection	
Module 3: Transmission aspects	Hrs.
Wide area Monitoring Systems (WAMS), PMU and PDCs, PMU placement, linear state	
estimation, System security under smart grid environment, Concept of Resilient & Self-	6
Healing Grid, adaptive relaying using PMUs	
Module 4: Communication aspects	Hrs.
Elements of communication and networking: architectures, standards and adaptation of power	
line communication (PLCC), zigbee, GSM, and more; machine to machine communication	6
models for the smart grid; Home area networks (HAN) and neighborhood area networks	0
(NAN); reliability, redundancy and security aspects.	
Module 5: Performance analysis tool for smart grid design	Hrs.
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	6
to smart grid. Static security assessment and contingencies study for the smart grid.	
Module 6: Stability analysis tools and computational tools for smart grid	Hrs.
Voltage stability assessment and its techniques, angle stability assessment and state	
estimation, optimization techniques, classical optimization methods, Heuristic optimization,	6
evolutionary computational Techniques, Hybrid optimization techniques and application to	0
smart grid.	
Module wise Measurable Students Learning Outcomes :	
After completion of the course students will be able to:	
1. Explain the smart grid architecture.	
2. Explain different smart grid technologies	
3. Application to power system monitoring, state estimation& protection	
4. Application of various communication & networking element for smart grid.	
5. Design and performance analysis of smart grid using computational tools.	

6. Analyze stability of smart grid using computational tools.

Mandatory Life Skill Courses

Value Added Professional Courses \$

Value Added Life-Skill Courses \$

This is Last Page