DADI INSTITUTE OF ENGINEERING AND TECHNOLOGY

(Approved by A.I.C.T.E., New Delhi & Permanently Affiliated to JNTUK)

NAAC Accredited Institute

An ISO 9001:2008, 14001:2004 & OHSAS 18001:2007 Certified Institute

NH–16, Anakapalle, Visakhapatnam–531002, Andhra Pradesh

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DELIVERY PLAN

Subject: Flexible AC Transmission Systems **Class and Branch : IV EEE**

Department: EEE **Academic Year:** 2017

Prepared by Course Instructor
Name : A Krishna Nag
Designation : Assistant Professor
Signature :
Date :

Reviewed by Course Co-Ordinator
Name : A Krishna Nag
Designation :
Signature :
Date :

Reviewed by Program Co-Ordinator and HOD
Name : A Krishna Nag
Signature :
Date :

Approved by Academic Convenor
Name :
Signature :
Date :

1. Vision and Mission of the Institute and Department

Vision of the Institute:

To evolve into a premier value based technical institution ensuring academic excellence and promoting innovational research.

Mission of the Institute:

- To impart high quality technical and professional education to uplift the living standards of the youth by focusing on employability, higher education and research.
- To bridge the gap between industry and academia by introducing add on courses based on industrial and academic needs.
- To develop responsible citizens through disciplined career and acceptance of ethical values.
- To be a student centric institute imbibing experiential, innovative and lifelong learning skills addressing societal problems.

Vision of the Department:

To emerge as a hub of producing trained graduates in the field of Electrical and Electronics Engineering

Mission of the Department:

M1. To impart technical knowledge in an effective teaching and learning environment by providing good Infrastructural facilities.

M2. To encourage industrial visits, internships, MoUs to promote passion for the industrial needs.

M3. To build a committed framework for promoting collaborative learning to succeed in career.

M4. To encourage co-curricular and extra-curricular activities with an emphasis on enhancing human values and spirited team work.

PROGRAM EDUCATIONAL OBJECTIVES

PEO 1: Strengthen the knowledge in Electrical and Electronics Engineering to enable them work for modern industries by promoting energy conservation and sustainability.

PEO 2: Enrich analytical, creative and critical logical reasoning skills to solve problems faced by emerging domains of electrical and electronics engineering industries worldwide

PEO 3: Develop effective communication and inter-personal skills to work with enhanced team spirit in multidisciplinary projects with a broader ethical, professional, economical and social perspective.

PROGRAM OUTCOMES

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

PO 2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural science and engineering sciences.

PO 3: Design/development of solutions: design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal and environmental considerations.

PO 4: Conduct investigations of complex problems: use research based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5: Modern tool usage: create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO 6: The engineer and society: apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7: Environment sustainability: understand the impact of the professional engineering solutions in the societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8: Ethics: apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9: Individual and team work: function effectively as an individual and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication: communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: Project management and finance: demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Lifelong learning: recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broader context of technological change.

PROGRAM SPECIFIC OUTCOMES

PSO-1: Professional Skills: Apply the knowledge of Mathematics, Science and Engineering to solve real time problems in the field of Power Electronics, Electrical Drives, Power Systems, Control Systems and Instrumentation.

PSO-2: Research and Innovation: Analyze and synthesize circuits by solving complex engineering problems to obtain the Optimal solution using effective software tools and hardware prototypes in the field of robotics and renewable energy systems.

PSO-3: Product development: Develop concepts and products by applying ideas of electrical domain into other Diversified engineering domains.

2. Syllabus of the Course

IV Year B.Tech EEE - II Semester		L	T	P	C
		4	0	0	3
Flexible AC Transmission Systems [FACTS]					

Learning objectives:

- To learn the basics of power flow control in transmission lines using FACTS controllers
- To explain operation and control of voltage source converter.
- To understand compensation methods to improve stability and reduce power oscillations of a power system.
- To learn the method of shunt compensation using static VAR compensators.
- To learn the methods of compensation using series compensators
- To explain operation of Unified Power Flow Controller (UPFC).

Unit–I:
Introduction to FACTS
Power flow in an AC System – Loading capability limits – Dynamic stability considerations – Importance of controllable parameters – Basic types of FACTS controllers – Benefits from FACTS controllers – Requirements and characteristics of high power devices – Voltage and current rating – Losses and speed of switching – Parameter trade–off devices.

Unit–II:
Voltage source and Current source converters
Concept of voltage source converter(VSC) – Single phase bridge converter – Square–wave voltage harmonics for a single–phase bridge converter – Three–phase full wave bridge converter– Three–phase current source converter – Comparison of current source converter with voltage source converter.

Unit–III:
Shunt Compensators–1
Objectives of shunt compensation – Mid–point voltage regulation for line segmentation – End of line voltage support to prevent voltage instability – Improvement of transient stability – Power oscillation damping.

Unit–IV:
Shunt Compensators–2
Thyristor Switched Capacitor (TSC)–Thyristor Switched Capacitor – Thyristor Switched Reactor (TSC–TCR). Static VAR compensator (SVC) and Static Compensator (STATCOM)**:** The regulation and slope transfer function and dynamic performance – Transient stability enhancement and power oscillation damping– Operating point control and summary of compensation control.

Unit V:
Series Compensators
Static series compensators**:** Concept of series capacitive compensation – Improvement of transient stability – Power oscillation damping – Functional requirements. GTO thyristor controlled Series Capacitor (GSC) – Thyristor Switched Series Capacitor (TSSC) and Thyristor Controlled Series Capacitor (TCSC).

Unit–VI:
Combined Controllers
Schematic and basic operating principles of Unified Power Flow Controller (UPFC).– Application on transmission lines.

Learning Outcomes:

The student should be able to
• Understand power flow control in transmission lines using FACTS controllers.
• Explain operation and control of voltage source converter.
• Analyze compensation methods to improve stability & reduce power oscillations in transmission lines.
• Explain the method of shunt compensation using static VAR compensators.
• Understand the methods of compensations using series compensators.
• Explain operation of Unified Power Flow Controller (UPFC).

Text Books:
1. "Understanding FACTS" N.G. Hingorani and L. Guygi, IEEE Press. Indian Edition is available:— Standard Publications, 2001.

Reference Books:
1. "Flexible ac transmission system (FACTS)" Edited by Yong Hue Song and Allan T Johns, Institution of Electrical Engineers, London.
2. Thyristor-based FACTS Controllers for Electrical Transmission Systems, by R. Mohan Mathur and Rajiv K. Varma, Wiley

3. Additional Reference Books, Journals, websites and E-links

1. https://www.researchgate.net/publication/271743876_Flexible_AC_Transmission_System_Controllers_A_Review
2. https://www.slideshare.net/udaywankar/flexible-ac-transmission-system-43062640
3. https://www.slideshare.net/udaywankar/flexible-ac-transmission-system-43062624
4. https://www.slideshare.net/shimireji/flexible-ac-transmission-facts
5. https://slideplayer.com/slide/6028821/
6. https://www.youtube.com/watch?v=ZEbDeDochWk
7. https://www.youtube.com/watch?v=GVxY3nE5mO8&list=PLLy_2iUCG87AVyRAN4QwVQrC8vSg1vWa6
8. https://www.youtube.com/watch?v=aYNQu7ClIh4
9. https://www.scientific.net/MSF.670.399
10. https://ieeexplore.ieee.org/abstract/document/206621

4. Gaps in the Syllabus to Meet Industry Requirements (if any)

- As per the industry requirement, a topic on Basic POWER ELECTRONIC DEVICES is to be included so that the advanced topics would be better understood
- To fill this gap, we are planning to share NPTEL video links on Power Electronics to understand the operational characteristics of various semi conductor devices

5. Course Handout

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE HANDOUT

Part – A
(Course Description, Course Objectives, Course Outcomes, Course Articulation Matrix)

PROGRAM : IV B.Tech., II-Sem., EEE, Section A+B
ACADEMIC YEAR : 2017
COURSE NAME & CODE : Flexible AC Transmission Systems
L-T-P STRUCTURE : 4-0-0
COURSE CREDITS : 3
COURSE INSTRUCTOR : Mr. A Krishna Nag
COURSE COORDINATOR : Mr. A Krishna Nag
PRE-REQUISITE : Power Electronics, Power System Analysis, Power Systems Operation & Control

COURSE DESCRIPTION:

Flexible Alternating Current Transmission System controllers have become a part of modern power system. It is important for the student to understand the principle of operation of series and shunt compensators by using power electronics. As the heart of many power electronic controllers is a voltage source converter (VSC), the student should be acquainted with the operation and control of VSC. Two modern power electronic controllers are also introduced.

COURSE OBJECTIVES

The student will be able

- To learn the basics of power flow control in transmission lines using FACTS controllers
- To explain operation and control of voltage source converter.
- To understand compensation methods to improve stability and reduce power oscillations of a power system.
- To learn the method of shunt compensation using static VAR compensators.
- To learn the methods of compensation using series compensators
- To explain operation of Unified Power Flow Controller (UPFC).

COURSE OUTCOMES (COs)

The student should be able to

- Understand power flow control in transmission lines using FACTS controllers
- Explain operation and control of voltage source converter
- Analyze compensation methods to improve stability and reduce power oscillations in the transmission lines
- Explain the method of shunt compensation using static VAR compensators
- Understand the methods of compensations using series compensators
- Explain operation of Unified Power Flow Controller (UPFC)

COURSE ARTICULATION MATRIX (Correlation between COs & POs, PSOs):

COs	PO 1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO	1	-	-	-	-	-	-	-	-	-	-	1	1	-
CO	2	2	3	1	-	-	2	-	-	-	-	2	2	2
CO	1	1	3	-	-	-	1	-	-	-	-	2	3	1
CO	1	1	3	-	-	-	2	-	-	-	-	2	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) - : None

Course Instructor **Course Coordinator** **Program Co-Ordinator & HOD**

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DELIVERY PLAN

Subject **:** Flexible AC Transmission Systems
Class & Branch **:** IV B.Tech II Sem EEE A + B
Academic Year **:** 2017 **Regulation** **:** R13
Faculty Name **: A Krishna Nag** **Designation** **:** Assistant Professor

SN	Topic	No. of periods required	Teaching Learning Method	Proposed date of completion	Actual date of completion	HOD Review
UNIT – 1 Introduction to FACTS						
1	Power flow in an AC System	1	**TLM1**	16-02-2017		
2	Loading capability limits	1	**TLM1**	17-02-2017		
3	Dynamic stability considerations	1	**TLM1**	18-02-2017		
4	Importance of controllable parameters	1	**TLM1**	19-02-2017		
5	Basic types of FACTS controllers	1	**TLM1**	21-02-2017		
6	Schematic Diagrams of controllers	1	**TLM2**	22-02-2017		
7	Benefits from FACTS controllers	1	**TLM4**	23-02-2017		
8	Requirements and characteristics of high power devices	1	**TLM7**	24-02-2017		
9	Voltage and current rating	1	**TLM4**	25-02-2017		
10	Losses and speed of switching	1	**TLM1**	26-02-2017		
11	Parameter trade–off devices	1	**TLM6**	28-02-2017		

UNIT - 2 Voltage source and Current source converters						
12	Concept of voltage source converter(VSC)	1	**TLM1**	02-03-2017		
13	Working Principle of VSCs	1	**TLM1**	3-03-2017		
14	Single phase bridge converter	1	**TLM1**	4-03-2017		
15	Waveforms, Equations of 1ph BC	1	**TLM3**	5-03-2017		
16	Square–wave voltage harmonics	1	**TLM2**	7-03-2017		
17	Derivation of Harmonic Current Eqn	1	**TLM3**	8-03-2017		
18	Three–phase full wave bridge converter	1	**TLM1**	9-03-2017		
19	Three–phase current source converter	1	**TLM4**	10-03-2017		
20	Working Principle of CSCs	1	**TLM1**	11-03-2017		
21	Comparison of current source converter with voltage source converter	1	**TLM6**	12-03-2017		
UNIT 3 - Shunt Compensators–1						
22	Objectives of shunt compensation	1	**TLM1**	14-03-2017		
23	Concept of Line Segmentation with phasor relations	1	**TLM1**	15-03-2017		
24	Mid–point voltage regulation	1	**TLM1**	16-03-2017		
25	End Line Compensation	1	**TLM1**	17-03-2017		
26	EoL voltage support to prevent voltage instability	1	**TLM2**	19-03-2017		
27	Improvement of transient stability	1	**TLM1**	21-03-2017		
28	Concept of Equal Area Criterion	1	**TLM2**	22-03-2017		
29	Power oscillation damping	1	**TLM1**	23-03-2017		
30	Comparison of Mid Point & EL Compensation	1	**TLM4**	24-03-2017		
31	Summary of compensating Transient, Dynamic & Voltage Instabilities	1	**TLM6**	25-03-2017		

UNIT – 4 Shunt Compensators–2						
32	Thyristor Switched Capacitor (TSC)	1	**TLM1**	26-03-2017		
33	Thyristor Switched Capacitor – Thyristor Switched Reactor (TSC–TCR)	1	**TLM1**	28-03-2017		
34	Static VAR compensator (SVC)	1	**TLM1**	29-03-2017		
35	Static Compensator (STATCOM)	1	**TLM2**	30-03-2017		
36	The regulation Droop characteristics	1	**TLM1**	31-03-2017		
37	Slope transfer function	1	**TLM3**	01-04-2017		
38	Dynamic performance	1	**TLM1**	11-04-2017		
39	Transient stability enhancement	1	**TLM4**	12-04-2017		
40	Power oscillation damping	1	**TLM1**	13-04-2017		
41	Operating point control	1	**TLM1**	16-04-2017		
42	Summary of compensation control	1	**TLM6**	18-04-2017		
UNIT 5 - Series Compensators						
43	Static series compensators	1	**TLM1**	19-04-2017		
44	Concept of series capacitive compensation	1	**TLM2**	20-04-2017		
45	Improvement of transient stability	1	**TLM1**	21-04-2017		
46	Power oscillation damping	1	**TLM1**	22-04-2017		
47	Functional requirements of damping	1	**TLM4**	23-04-2017		
48	GTO thyristor controlled Series Capacitor (GSC)	1	**TLM1**	25-04-2017		
49	Thyristor Switched Series Capacitor (TSSC)	1	**TLM1**	26-04-2017		
50	Thyristor Controlled Series Capacitor (TCSC)	1	**TLM1**	27-04-2017		
51	Comparison of Series & Shunt Compensation	1	**TLM6**	28-04-2017		
52	Summary of Series Compensation techniques	1	**TLM6**	29-04-2017		

UNIT 6 - Combined Controllers						
53	Concept of Combined Controllers	1	**TLM1**	30-04-2017		
54	Classification of Series-Shunt Combined Controllers	1	**TLM2**	02-05-2017		
55	Unified Power Flow Controller Basics	1	**TLM1**	4-05-2017		
56	Schematic diagram of UPFC	1	**TLM2**	5-05-2017		
57	Operating Principle of UPFC	1	**TLM1**	6-05-2017		
58	Control Block diagram of UPFC	1	**TLM1**	7-05-2017		
59	Interline Power Flow Controller Basics	1	**TLM1**	9-05-2017		
60	Schematic diagram of IPFC	1	**TLM2**	10-05-2017		
61	Operating Principle of IPFC	1	**TLM1**	11-05-2017		
62	Control Block diagram of IPFC	1	**TLM4**	12-05-2017		
63	Application on transmission lines	1	**TLM6**	13-05-2017		

Total No. of classes Required to complete the syllabus: **63**

Course Instructor **Course Coordinator** **Program Coordinator & HOD**

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Part – C

Name of the Course: FACTS **Class& Branch:** IV B.Tech I SEM EEE A

Academic Year: 2017 **Regulation** : R13

ACADEMIC CALENDAR:

EVALUATION PROCESS:

Evaluation Task	**COs**	**Marks**
First Mid Examination	1,2,3	M1=15
First Online Examination	1,2,3	OL1=10
First Assignment	1,2,3	A1=5
First Mid Marks Total (X1)=M1+OL1+A1	1,2,3	X1=30
Second Mid Examination	4,5,6	M2=15
Second Online Examination	4,5,6	OL2=10
Second Assignment	4,5,6	A2=5
Second Mid Marks Total (X2) =M2+OL2+A2	4,5,6	X2=30
Cumulative Internal Examination Marks (X): (80% of Highest + 80% of Lo	1,2,3,4,5,6	X=30
Semester End Examinations	1,2,3,4,5,6	Y=70
Total Marks: X+Y	1,2,3,4,5,6	100

Teaching Learning Methods			
TLM1	Chalk and Talk	**TLM5**	Activity based Learning
TLM2	LCD Projector	**TLM6**	Flipped//Blended Learning
TLM3	Tutorial (Problem Solving)	**TLM7**	Experiential Learning
TLM4	Participatory Learning	**TLM8**	Project Based Learning

Course Instructor **Course Coordinator** **Program Co-Ordinator &HOD**

6. PEOs and PO's

Program Educational Objectives of the UG in Electrical and Electronics Engineering are:

PEO 1. Students shall be engaged in ongoing learning and professional development through continuous education in electrical and electronics engineering and also in the fields related to electrical engineering.
PEO 2. Students shall be adapting updated knowledge exhibiting critical thinking skills & problem solving skills in professional engineering practices to tackle the technical challenges for the benefit of the society
PEO 3. Students shall sustain in supportive and leading roles by improving good communication skills and by developing social ethical values.

Program Specific outcomes

PSO 1: Graduates are capable to demonstrate their logical and technical skills in analyzing various electrical systems

PSO 2: Graduates can transform and provide solution ethically and professionally for societal and environmental electrical engineering problems

PROGRAM OUTCOMES (POs):

PO 1:	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2:	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3:	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO 4:	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5:	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations
PO 6:	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice
PO 7:	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8:	**Ethic**s: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9:	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10:	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11:	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12:	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

7. List of the Students of the Class with Roll Numbers – IV EEE A

S.No.	Register Number	Name of the Student
1	14HN1A0213	P.Rajee
2	14U41A0201	A Sri hari
3	14U41A0203	E Ravi Teja
4	14U41A0204	G Rama Krishna
5	14U41A0205	G Manoj Kumar
6	14U41A0206	K V S B Akhil
7	14U41A0207	M Vinod Kumar
8	14U41A0209	M Indravathi
9	14U41A0211	P Likhitha
10	14U41A0212	S Dhati Divya Sri
11	14U41A0213	S Nishant
12	14U41A0214	S Venkat satish
13	14U41A0215	S Uday Kumar
14	14U41A0217	S Sai Raghu
15	14U41A0218	U Lakshman
16	15U45A0201	A Trinadh
17	15U45A0202	A Hanumanth
18	15U45A0203	A Jitendra Prasad
19	15U45A0204	A Narendra
20	15U45A0205	A Naganna
21	15U45A0206	B Murali
22	15U45A0207	B Bhargav
23	15U45A0208	B Jaswanth Kumar
24	15U45A0209	C vamsi krishna
25	15U45A0210	C V S Anirudh
26	15U45A0211	D L V Sai Kiran
27	15U45A0212	D Manikanta
28	15U45A0213	E R Krishna
29	15U45A0214	G Ooha
30	15U45A0215	Harikrishna K
31	15U45A0216	J Ch V Kamaraju
32	15U45A0217	K Aneesha
33	15U45A0218	K S Raj Kumar
34	15U45A0219	K Raj Kumar

35	15U45A0220	L Jai Ram
36	15U45A0221	M kiran Kumar Reddy
37	15U45A0222	M M Satyanarayana
38	15U45A0223	M Sowjanya
39	15U45A0224	M Tarun
40	15U45A0225	M Venkatesh
41	15U45A0226	N surya Kumar Yadav
42	15U45A0227	N Lakshman rao
43	15U45A0228	P Prameela devi
44	15U45A0229	P K Vinay Kumar
45	15U45A0230	P Tulasi rao
46	15U45A0231	Shaikh Ansar
47	15U45A0232	S Anusha
48	15U45A0234	U Nanji
49	15U45A0235	U Madhavi
50	15U45A0236	V S S V Ramadevi
51	15U45A0237	V Naga Bhaskar
52	15U45A0238	V Krishna
53	15U45A0240	D J Brahmaya
54	15U45A0241	I Nageswar Rao
55	15U45A0242	K Santosh Kumar
56	15U45A0243	M Ravi
57	15U45A0244	M Veena
58	15U45A0246	R Surya Narayana
59	15U45A0248	M Srinu
60	15U45A0250	S Satya Sai
61	15U45A0251	A Hari Babu
62	15U45A0252	M Nanji

8. Class Time Table and Individual Time Table

A Krishna Nag Individual TT – 2017-18

w.e.f.- 27/11/2017 Lecture Hall – 32 (IV Floor) Class Teacher - G.Jagadeesh(jagadeesh@diet.edu.in)(M.No.8500263833) Strength -62

Day	9:00 – 10:00	10:00 -10:50	BREAK	11:00 – 11:50	11:50 – 12:40	LUNCH	1:30 - 2:20	2:20 – 3:10	3:10 – 4:00

MON	UNIX	FACTS		DCS	SPM		GATE(RVS)	GATE(AKN)	PROJECT
TUE	UNIX	FACTS		DCS	SPM		GATE(MRP)	GATE(ALD)	PROJECT
WED	FACTS	SPM		PROJECT	UNIX		DCS	GATE(GJ)	PROJECT
THU	FACTS	UNIX		SPM	PROJECT		DCS	GATE(MRR)	PROJECT
FRI	SPM	FACTS		UNIX	DCS		GATE(KVK)	GATE(DRCH)	PROJECT
SAT	E-LIBRARY			LIBRARY			PROJECT WORK		

9. Tutorial Questions (Unit wise)

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

PROGRAM : **IV** B.Tech., II-Sem., EEE., Section-A

ACADEMIC YEAR : 2017

COURSE NAME & CODE : FLEXIBLE AC TRANSMISSION SYSTEMS

COURSE INSTRUCTOR : Mr. A Krishna Nag, Assistant Professor

TUTORIAL –1

Date:

1. Draw the phasor diagrams & justify the statement "Injecting the voltage into transmission line perpendicular to line current mostly changes the active power"
2. (a) Explain the characteristics of high power devices used in FACTS
   (b) Classify different FACTS controllers. Explain them briefly
3. (a) What are the major issues in AC power transmission? Explain how they addressed using FACTS devices
   (b) What is the relative importance of controllable parameters of the transmission system

TUTORIAL –2

Date:

1. Write about the operation of three phase full wave bridge converter with circuit diagram and waveforms.
2. Draw a neat diagram to explain the working principle and operation of a Current Source Converter
3. What are the effects of harmonics? Prove that the fundamental RMS component of a square wave ac voltage for a single-phase bridge converter is 0.9 times the dc voltage

TUTORIAL –3

Date:

1. (a) "For a radial line, the end of the line is the best location for compensator". Justify
   (b) Explain how midpoint voltage regulation helps in increasing the transmittable power of a line

2. (a) List different methods for controllable VAr generation.
   (b) Explain operation of Thyristor-Controlled Reactor (TCR) with necessary waveforms
3. (a) Discuss the improvement of transient stability with midpoint voltage regulation
   (b) Explain the power oscillation damping with shunt compensation

TUTORIAL –4

Date:

1. (a) Describe the transient stability enhancement with SVC and STATCOM with necessary diagrams
   (b) Describe the power oscillation damping with SVC and STATCOM with necessary diagrams
2. (a) With circuit diagram and waveforms, explain the operation of TCR and TSR
   (b) Discuss the methods of controllable Var Generation
3. (a) Draw the block diagram of VAr reserve control
   (b) Briefly discuss the comparison between STATCOM and SVC with their characteristics

TUTORIAL –5

Date:

1. (a) What are the objectives of series Compensation?
   (b) Explain the operation of GTO Thyristor Controlled Series capacitor?
2. (a) How to improve Voltage stability by using series Compensation?
   (b) Explain the operation & working of TSSC
3. (a) Explain Transient stability improvement by series compensation?
   (b) What are the basic control schemes for GCSC, TCSC & TSSC?

TUTORIAL –6

Date:

1. (a) Explain the Control structure of IPFC & UPFC?
   (b) Explain with block diagram for P & Q Control by UPFC?
2. Compare the performance of UPFC with Controlled Phase angle regulators?
3. Explain how the real & reactive power flow control can be done by using UPFC Controller?

Signature of Course Instructor

11. Assignment Questions (Unit wise)

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NH–16, Anakapalle, Visakhapatnam–531002, Andhra Pradesh

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Assignment Questions [Unit Wise]'

Academic Year	:	**2017**
Name of the Faculty	:	A KRISHNA NAG
Designation	:	**Assistant Professor**
Department	:	**Electrical & Electronics Engineering**
Year/Semester	:	**IV YEAR – II SEMESTER (EEE)**
Course	:	**B.Tech.**

UNIT-1

1. (a) Explain how power flow can be controlled in mesh networks
   (b) Discuss the benefits & opportunities of FACTS controllers
2. Draw the phasor diagrams & justify the statement "Injecting the voltage into transmission line perpendicular to line current mostly changes the active power"
3. (a) Write the limitations for loading capability of a transmission line
   (b) Explain dynamic stability considerations of a transmission interconnection with FACTS
4. (a) Explain the characteristics of high power devices used in FACTS
   (c) Classify different FACTS controllers. Explain them briefly
5. (a) What are the major issues in AC power transmission? Explain how they addressed using FACTS devices
   (c) What is the relative importance of controllable parameters of the transmission system
6. (a) Explain the power flow in parallel circuits with FACTS
   (b) What is the need for transmission interconnections? Explain

UNIT-2

1. Write about the operation of three phase full wave bridge converter with circuit diagram and waveforms.
2. Explain the operation of Single phase full wave bridge converter with circuit diagram and waveforms.
3. Evaluate the differences between VSC and CSC

4. Draw a neat diagram to explain the working principle and operation of a Voltage Source Converter
5. Describe about the square wave harmonics for a single phase bridge converter
6. Draw a neat diagram to explain the working principle and operation of a Current Source Converter
7. What are the effects of harmonics? Prove that the fundamental RMS component of a square wave ac voltage for a single-phase bridge converter is 0.9 times the dc voltage

UNIT-3

1. (a) Explain the objective of reactive shunt compensation in transmission lines
   (b) With phasor diagrams & power-angle characteristics, explain two machine power system with ideal midpoint reactive compensation
2. (a) "For a radial line, the end of the line is the best location for compensator". Justify
   (b) Explain how midpoint voltage regulation helps in increasing the transmittable power of a line
3. (a) Illustrate midpoint voltage regulation for line segment by using shunt compensation
   (b) Discuss how to prevent voltage instability at the end of line by using shunt compensation
4. (a) List different methods for controllable VAr generation.
   (b) Explain operation of Thyristor-Controlled Reactor (TCR) with necessary waveforms
5. (a) Discuss the improvement of transient stability with midpoint voltage regulation
   (b) Explain the power oscillation damping with shunt compensation

UNIT-4

1. (a) Describe the transient stability enhancement with SVC and STATCOM with necessary diagrams
   (b) Describe the power oscillation damping with SVC and STATCOM with necessary diagrams
2. (a) With circuit diagram and waveforms, explain the operation of TCR and TSR
   (b) With circuit diagram and waveforms, explain the operation of TCC and TSC
3. (a) Discuss the basic operating principle of switching converter type VAr generator with control scheme
   (b) Discuss the methods of controllable Var Generation
4. (a) Draw the block diagram of VAr reserve control
   (b) Briefly discuss the comparison between STATCOM and SVC with their characteristics
5. (a) Describe the transfer function and dynamic performance of SVC with necessary diagrams
   (b) Describe the transfer function and dynamic performance of STATCOM with necessary diagrams
6. (a) Explain the operating V-I characteristics of SVC and STATCOM
   (b) What is regulation droop? Explain its significance

UNIT-5

1. (a) What are the objectives of series Compensation?
   (b) Explain the operation of GTO Thyristor Controlled Series capacitor?
2. (a) How to improve Voltage stability by using series Compensation?
   (b) Explain the operation & working of TSSC
3. (a) Explain the operation of GTO TCSC
   (b) Explain the operation & working of SSSC
4. (a) Explain Transient stability improvement by series compensation?
   (b) What are the basic control schemes for GCSC, TCSC & TSSC?
5. (a) Write the functional requirements of Static Series Compensators
   (b) How the Power Oscillation damping can be reduced by using series compensation?

UNIT-6

1. (a) Explain the Control structure of IPFC?
   (b) Explain the Control structure of UPFC?
2. Compare the performance of UPFC with Controlled Phase angle regulators?
3. Explain how the real & reactive power flow control can be done by using UPFC Controller?
4. (a) Explain the Basic operating principle of UPFC Controller
   (b) Explain the Basic operating principle of IPFC Controller
5. (a) Explain with block diagram for P & Q Control by UPFC?
   (b) Basic function of shunt Converter?
6. Compare the performance of UPFC with Series compensators?

11. Quiz Questions/Objective type Questions (Unit wise)

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NH–16, Anakapalle, Visakhapatnam–531002, Andhra Pradesh
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

PROGRAM **: IV** B.Tech., II-Sem., EEE., Section – A

ACADEMIC YEAR **:** 2017-18

COURSE NAME & CODE : Flexible AC Transmission Systems

COURSE INSTRUCTOR **:** Mr A Krishna Nag, Assistant Professor

Quiz Questions/Objective type Questions

1. FACTS devices used in
   a) Generation
   b) AC transmission
   c) DC transmission
   d) None

2. Voltage control means
   a) Boosting the feeder voltage
   b) Reducing the line voltage under over voltage conditions
   c) Keeping the voltage level within the allowable limits.
   d) None

3. Line drop compensation corrects for
   a) Line drop lagging P.F b) voltage at leading P.F
   c) Transformer voltage drop d) voltage drop in feeder lines

4. Which are the shunt compensation devices?
   a) TCSC b) SSSC
   c) UPFC d) SVC

5. Characteristics of a loss less line are
    a) Naturally loading with low power factor at sending end
    b) Naturally loading with unity power factor at both ends
    c) Naturally loading with zero power factor at both ends
    d) Naturally loading with zero power factors at receiving end Transposition of lines is done

6. Voltage regulation depends on _____.

7. FACTS devices are generally used for to compensate _____of the transmission line

8. FACTS devices generally deals with_____

9. Main Advantage of DC transmission over AC_____.

10. The power reversal involves reversal of_____

11. Main Advantage of DC transmission over AC
    a) Maintenance of substations is easy
    b) Switches & breakers have no limits
    c) No commutation problems
    d) Reduced corona loss & interference

12. Distortion is found in
    a) Lower frequencies b) Audible frequencies
    c) Medium frequencies d) Radio frequencies

13. In voltage source inverters (VSIs), the amplitude of the output voltage is
    a) Independent of the load
    b) Dependent only on L loads
    c) Dependent on the load
    d) None of the mentioned

14. In a VSI (Voltage source inverter)
    a) The internal impedance of the DC source is negligible
    b) The internal impedance of the DC source is very very high
    c) The internal impedance of the AC source is negligible
    d) The IGBTs are fired at 0 degrees.

15. Disadvantage of constant voltage transmission_____.

16. In a 3-phase VSI operating in square-wave mode, the output line voltage is free from_____

17. _____materials is not used for transmission & distribution

18. Capacitance in equivalent circuit of a transmission line is due to_____.

19. In voltage source inverters (VSIs), the output currents _____

20. Increase in frequency of a transmission line causes
    a) No change in line resistance
    b) Increase in line resistance
    c) Decrease in line resistance
    d) Decrease in line series reactance

21. Transients in a system are caused due to
    a) Resistance b) Inductance c) Capacitance d) both b) & c)

22. When transmission line is terminated through a resistance equal to surge impedance
    a) There is reflection
    b) There is reflection & refraction
    c) There is neither reflection nor refraction
    d) There is refraction.

23. What is the value of transient stability limit?
    a) Higher than steady state stability limit
    b) Lower than steady state stability limit
    c) Depending upon the severity of load
    d) All of these

24. Which among the following methods is used for improving the system stability?
    a) Increasing the system voltage
    b) Reducing the transfer reactance
    c) Using high speed circuit breaker
    d) All of these

25. Harmonic voltages are due to_____.

26. If terminating resistance greater than natural impedance of the line_____.

27. The accurate technique for analyzing transient circuits_____.

28. To eliminate the harmonics_____ used.

29. The stability of the power system is not affected by_____.

30. STATCOM and SSSC will make_____
    a) UPQC b) TCSC c) UPFC d) SVR

31. Losses in FC-TCR will vary in the range of_____.
    a) 0.5-0.9% b) 0.8-0.15% c) 0.5-0.12% d) 0.5-0.7%

32. TSC-TCR will compensate Q in which region_____.
    a) Capacitive-inductive
    b) Capacitive only
    c) Inductive only
    d) None of these

33. Thyristor firing angle should be between_____

34. Transmission efficiency increases as
    a) Voltage and power factor both increase
    b) Voltage and power factor both decrease
    c) Voltage increases but power factor decreases
    d) Voltage decreases but power factor increases

35. Functionality of FACTS devices_____.

36. SVC and STATCOM are_____ devices.

37. SVC stands for_____.

38. STATCOM stands for_____.

39. STATCOM is_____ regulating device.

40. The main Objective of series compensation
    a) It improve the power factor
    b) It reduces the fault currents
    c) Reduce the voltage drop over long distance
    d) None

41. TCSC is a
    a) Shunt compensation device
    b) Series compensation device
    c) Both A
    d) None of the above

42. SSSC is a
    a) Series compensation device
    b) Shunt compensation device
    c) Combined compensator
    d) Loss reduction device

43. Disadvantage with series compensation
    a) Reduce the stability
    b) Increase the voltage drop
    c) Reduce the power factor
    d) Increase in fault current

44. Characteristics of a loss less line are
    a) Naturally loading with low power factor at sending end.
    b) Naturally loading with unity power factor at both ends
    c) Naturally loading with zero power factor at both ends
    d) Naturally loading with zero power factor at receiving end

45. TCSC is _____ device.

46. SSSC stands _____.

47. UPFC strands _____.

48. The location of series capacitor depends on _____ factors.

49. If load is more than surge impedance loading (SIL) _____ will increase in the line.

12. Question Bank (Descriptive Questions with BLOOMS Taxonomy)

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

UNIT-1

CO	LEVEL	Q.NO	QUESTION (5m each except Q2)
1	2	1	a) Explain how power flow can be controlled in mesh networks b) Discuss the benefits & opportunities of FACTS controllers
1	5	2	Draw the phasor diagrams & justify the statement “Injecting

			the voltage into transmission line perpendicular to line current mostly changes the active power" (10m)
1	**2**	**3**	a) Write the limitations for loading capability of a transmission line b) Explain dynamic stability considerations of a transmission interconnection with FACTS
1	**5**	**4**	a) Explain the characteristics of high power devices used in FACTS b) Classify different FACTS controllers. Explain them briefly
1	**3**	**5**	a) What are the major issues in AC power transmission? Explain how they addressed using FACTS devices b) What is the relative importance of controllable parameters of the transmission system
1	3	**6**	4. Explain the power flow in parallel circuits with FACTS 5. What is the need for transmission interconnections? Explain

UNIT-2

CO	LEVEL	Q.NO	QUESTION (5 marks each)
2	**2**	**1**	Write about the operation of three phase full wave bridge converter with circuit diagram and waveforms.
2	**5**	**2**	Explain the operation of Single phase full wave bridge converter with circuit diagram and waveforms.
2	**4**	**3**	Evaluate the differences between VSC and CSC
2	**5**	**4**	Draw a neat diagram to explain the working principle and operation of a Voltage Source Converter
2	**5**	**5**	Describe about the square wave harmonics for a single phase bridge converter
2	**3**	**6**	Draw a neat diagram to explain the working principle and operation of a Current Source Converter
2	**3**	**7**	What are the effects of harmonics? Prove that the fundamental RMS component of a square wave ac voltage for a single-phase bridge converter is 0.9 times the dc voltage

UNIT-3

CO	LEVEL	Q.NO	QUESTION (5 marks each)
2	**2**	**1**	a) Explain the objective of reactive shunt compensation in transmission lines b) With phasor diagrams & power-angle characteristics, explain two machine power system with ideal midpoint reactive compensation
2	**5**	**2**	a) "For a radial line, the end of the line is the best location for compensator". Justify b) Explain how midpoint voltage regulation helps in increasing the transmittable power of a line
2	**5**	**3**	a) Illustrate midpoint voltage regulation for line segment by using shunt compensation b) Discuss how to prevent voltage instability at the end of line by using shunt compensation
2	**3**	**4**	a) List different methods for controllable var generation. b) Explain operation of Thyristor-Controlled Reactor (TCR) with

			necessary waveforms
2	**2**	**5**	a) Discuss the improvement of transient stability with midpoint voltage regulation b) Explain the power oscillation damping with shunt compensation

UNIT-4

CO	LEVEL	Q.NO	QUESTION (5 marks each)
3	2	1	a) Describe the transient stability enhancement with SVC and STATCOM with necessary diagrams b) Describe the power oscillation damping with SVC and STATCOM with necessary diagrams
3	5	2	a) With circuit diagram and waveforms, explain the operation of TCR and TSR b) With circuit diagram and waveforms, explain the operation of TCC and TSC
3	2	3	a) Discuss the basic operating principle of switching converter type VAr generator with control scheme b) Discuss the methods of controllable Var Generation
3	5	4	a) Draw the block diagram of VAr reserve control b) Briefly discuss the comparison between STATCOM and SVC with their characteristics
3	2	5	a) Describe the transfer function and dynamic performance of SVC with necessary diagrams b) Describe the transfer function and dynamic performance of STATCOM with necessary diagrams
3	2	6	a) Explain the operating V-I characteristics of SVC and STATCOM b) What is regulation droop? Explain its significance

UNIT-5

CO	LEVEL	Q.NO	QUESTION (5 marks each)
3	4	1	What are the objectives of series Compensation? Explain the operation of GTO Thyristor Controlled Series capacitor?
3	4	2	A) How to improve Voltage stability by using series Compensation? B) Explain the operation & working of TSSC
3	2	3	A) Explain the operation of GTO TCSC B) Explain the operation & working of SSSC
3	4	4	A) Explain Transient stability improvement by series compensation? B) What are the basic control schemes for GCSC, TCSC & TSSC?
3	4	5	A) Write the functional requirements of Static Series Compensators B) How the Power Oscillation damping can be reduced by using series compensation?

UNIT-6

CO	LEVEL	Q.NO	QUESTION (5 marks each)

4	5	1	A) Explain the Control structure of IPFC? B) Explain the Control structure of UPFC?
4	2	2	Compare the performance of UPFC with Controlled Phase angle regulators?
4	5	3	Explain how the real & reactive power flow control can be done by using UPFC Controller?
4	2	4	A) Explain the Basic operating principle of UPFC Controller B) Explain the Basic operating principle of IPFC Controller
4	4	5	A) Explain with block diagram for P & Q Control by UPFC? B) Basic function of shunt Converter?
4	4	6	Compare the performance of UPFC with Series compensators?

REVISED Bloom's Taxonomy Action Verbs

Definitions	I. Remembering	II. Understanding	III. Applying	IV. Analyzing	V. Evaluating	VI. Creating
Bloom's Definition	Exhibit memory of previously learned material by recalling facts, terms, basic concepts, and answers.	Demonstrate understanding of facts and ideas by organizing, comparing, translating, interpreting, giving descriptions, and stating main ideas.	Solve problems to new situations by applying acquired knowledge, facts, techniques and rules in a different way.	Examine and break information into parts by identifying motives or causes. Make inferences and find evidence to support generalizations.	Present and defend opinions by making judgments about information, validity of ideas, or quality of work based on a set of criteria.	Compile information together in a different way by combining elements in a new pattern or proposing alternative solutions.
Verbs	• Choose • Define • Find • How • Label • List • Match • Name • Omit • Recall • Relate • Select • Show • Spell • Tell • What • When • Where • Which • Who • Why	• Classify • Compare • Contrast • Demonstrate • Explain • Extend • Illustrate • Infer • Interpret • Outline • Relate • Rephrase • Show • Summarize • Translate	• Apply • Build • Choose • Construct • Develop • Experiment with • Identify • Interview • Make use of • Model • Organize • Plan • Select • Solve • Utilize	• Analyze • Assume • Categorize • Classify • Compare • Conclusion • Contrast • Discover • Dissect • Distinguish • Divide • Examine • Function • Inference • Inspect • List • Motive • Relationships • Simplify • Survey • Take part in • Test for • Theme	• Agree • Appraise • Assess • Award • Choose • Compare • Conclude • Criteria • Criticize • Decide • Deduct • Defend • Determine • Disprove • Estimate • Evaluate • Explain • Importance • Influence • Interpret • Judge • Justify • Mark • Measure • Opinion • Perceive • Prioritize • Prove • Rate • Recommend • Rule on • Select • Support • Value	• Adapt • Build • Change • Choose • Combine • Compile • Compose • Construct • Create • Delete • Design • Develop • Discuss • Elaborate • Estimate • Formulate • Happen • Imagine • Improve • Invent • Make up • Maximize • Minimize • Modify • Original • Originate • Plan • Predict • Propose • Solution • Solve • Suppose • Test • Theory

Anderson, L. W., & Krathwohl, D. R. (2001). A taxonomy for learning, teaching, and assessing, Abridged Edition. Boston, MA: Allyn and Bacon.

Course Material

1. https://www.researchgate.net/publication/271743876_Flexible_AC_Transmission_System_Controllers_A_Review
2. https://www.slideshare.net/udaywankar/flexible-ac-transmission-system-43062640
3. https://www.slideshare.net/udaywankar/flexible-ac-transmission-system-43062624
4. https://www.slideshare.net/shimireji/flexible-ac-transmission-facts
5. https://slideplayer.com/slide/6028821/
6. https://www.youtube.com/watch?v=ZEbDeDochWk
7. https://www.youtube.com/watch?v=GVxY3nE5mO8&list=PLLy_2iUCG87AVyRAN4QwVQrC8vSg1vWa6
8. https://www.youtube.com/watch?v=aYNQu7ClIh4
9. https://www.scientific.net/MSF.670.399
10. https://ieeexplore.ieee.org/abstract/document/206621