JEPPIAAR ENGINEERING COLLEGE
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

VISION OF INSTITUTION

To build Jeppiaar Engineering College as an institution of academic excellence in technology and management education, leading to become a world class University.

MISSION OF INSTITUTION

- To excel in teaching and **learning, research and innovation** by promoting the principles of scientific analysis and creative thinking.
- To participate in the production, **development, dissemination of knowledge** and interact with **national and international communities.**
- To equip students with ethical **values, and life skills** that would enrich their lives and enable them to meaningfully contribute to the **progress of the society.**
- To prepare students for **higher studies and lifelong learning,** enrich them with the **practical and entrepreneurial skills** necessary to excel as future professionals and contribute to **Nation's economy.**

PROGRAM OUTCOMES (POs)

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
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.
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
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.
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.
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.
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.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
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.
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.
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.

VISION OF THE DEPARTMENT

The Department of Electrical and Electronics Engineering strives to be a Centre of Excellence in education and technical research, in the endeavour of which the Department will continually update the teaching methodologies, progress in the emerging technologies and continue to play a vital role in the development of the society.

MISSION OF THE DEPARTMENT

M1	To develop the ability to **learn** and work creatively that would enhance the ability of both students and faculty to do **innovative research**.
M2	To **create** and maintain state-of-the art facilities which provide students and faculty with opportunities to analyse, apply and **disseminate knowledge globally**.
M3	To impart the knowledge in essential interdisciplinary fields which will enhance the **interpersonal skills**, team work, professional **ethics** and make them work effectively for their own benefit and the **betterment of the society**.
M4	Prepare students for **lifelong learning** of theoretical and **practical concepts** to face intellectual, **economical** and career challenges.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 01	Strengthen the knowledge in Electrical and Electronics Engineering to enable them **work** for modern industries by promoting energy conservation and sustainability.
PEO 02	Enrich analytical, creative and critical **logical reasoning** skills to solve problems faced by emerging domains of electrical and electronics engineering industries worldwide.
PEO 03	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.
PEO 04	Prepare the students either to establish **start ups** or to pursue **higher education** at reputed institutions.

PROGRAM SPECIFIC OUTCOME (PSOs)

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.

EE6004 FLEXIBLE AC TRANSMISSION SYSTEMS **L T P C**
3 0 0 3

OBJECTIVES:

- To introduce the reactive power control techniques
- To educate on static VAR compensators and their applications
- To provide knowledge on Thyristor controlled series capacitors
- To educate on STATCOM devices
- To provide knowledge on FACTS controllers

UNIT I INTRODUCTION 9

Reactive power control in electrical power transmission lines - Uncompensated transmission line -series compensation – Basic concepts of Static Var Compensator (SVC) –Thyristor Controlled Series capacitor (TCSC) – Unified power flow controller (UPFC).

UNIT II STATIC VAR COMPENSATOR (SVC) AND APPLICATIONS 9

Voltage control by SVC – Advantages of slope in dynamic characteristics – Influence of SVC on system voltage – Design of SVC voltage regulator –Modelling of SVC for power flow and fast transient stability – Applications: Enhancement of transient stability – Steady state power transfer – Enhancement of power system damping.

UNIT III THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) AND APPLICATIONS

9

Operation of the TCSC – Different modes of operation – Modelling of TCSC – Variable reactance model – Modelling for Power Flow and stability studies. Applications: Improvement of the system stability limit – Enhancement of system damping

UNIT IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLER

9

Static Synchronous Compensator (STATCOM) – Principle of operation – V-I Characteristics.Applications: Steady state power transfer-enhancement of transient stability - prevention of voltage instability.SSSC-operation of SSSC and the control of power flow – modelling of SSSC in load flow and transient stability studies.

UNIT V CO-ORDINATION OF FACTS CONTROLLERS

9

Controller interactions – SVC – SVC interaction – Co-ordination of multiple controllers using linear control techniques – Control coordination using genetic algorithms.

TEXT BOOKS:

1. R.Mohan Mathur, Rajiv K.Varma, "Thyristor – Based Facts Controllers for Electrical Transmission
Systems", IEEE press and John Wiley & Sons, Inc, 2002.
2. Narain G. Hingorani, "Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems", Standard Publishers Distributors, Delhi- 110 006, 2011.
3. K.R.Padiyar," FACTS Controllers in Power Transmission and Distribution", New Age International(P) Limited, Publishers, New Delhi, 2008.

REFERENCES:

1. A.T.John, “Flexible A.C. Transmission Systems”, Institution of Electrical and Electronic Engineers (IEEE), 1999.
2. V.K.Sood,HVDC and FACTS controllers – Applications of Static Converters in Power System, APRIL 2004 , Kluwer Academic Publishers, 2004.
3. Xiao – Ping Zang, Christian Rehtanz and Bikash Pal, “Flexible AC Transmission System: Modelling and Control” Springer, 2012.

Course code& Name: **EE6004 & Flexible AC Transmission Systems**
Degree/Programme: **B.E/EEE** Semester: **VII** Section: **A, B**
Duration: **JUNE – DEC 2018** Regulation: **2013/AUC**
Name of the Staff: Ms.K.S.Kavitha Kumari & Mr.Kalanithi.C

AIM: Educate the students about the application of power electronics component in the power system networks and to know about the importance of real and reactive power flow in the network .

OBJECTIVES:

1. To introduce the reactive power control techniques
2. To educate on static VAR compensators and their applications
3. To provide knowledge on Thyristor controlled series capacitors
4. To educate on STATCOM devices
5. To provide knowledge on FACTS controllers

COURSE OUTCOMES:

C	Course Outcomes
C4 5.1	Understand the concept of flexible AC transmission and the associated problems
C4 5.2	Explain the operation of SVC controllers and its application.
C4 5.3	Explain the operation of TCSC controller and its application
C4 5.4	Explain the operation of UPFC and STATCOM and its modeling
C4 5.5	Under the concept of FACTS Co-ordination.

Mapping of Course Outcomes(COs), Course(C),ProgramSpecificOutcomes (PSOs)with Program Outcomes. (POs)– [Levels of correlation:3 (High),2 (Medium), 1(Low)]

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C4 5.1	1	-	2	-	2	3	1	1	-	-	-	1	1	1	1
C4 5.2	1	-	2	-	2	3	2	1	-	-	-	1	1	1	3
C4 5.3	1	-	2	-	2	3	2	1	-	-	-	1	1	1	3
C4 5.4	1	-	2	-	2	3	2	1	-	-	-	1	1	1	3
C4 5.5	1	-	2	-	2	3	2	1	-	-	-	1	1	1	1

UNIT - I	INTRODUCTION					Target Periods: 9
Sl N o	**Contents**	**CO Statement**	**Book Reference & Page No**	**Delivery method**	**Delivery Periods**	**Knowledge Level**
1	Reactive power control in electrical power transmission lines	C4 5.1	TB1:16 -39	Chalk & board / PPT	**1**	R & U
2	Uncompensated transmission line	C4 5.1	TB1:18-22	Chalk & board / PPT	**2**	R & U
3	series compensation	C4 5.1	TB1:34-37	Chalk & board / PPT	**1**	R, U, An
4	Basic concepts of Static Var Compensator	C4 5.1	TB1:276	Chalk & board / PPT	**1**	R, U, An
5	Thyristor Controlled Series capacitor (TCSC)	C4 5.1	TB1:277-280	Chalk & board / PPT	**2**	R, U, An
6	Unified power flow controller (UPFC)	C4 5.1	TB2:444-448	Chalk & board / PPT	**2**	R,U, A

UNIT II	STATIC VAR COMPENSATOR (SVC) AND ALPPICATIONS					Target Periods:9
Sl No	**Contents**	**CO Statement**	**Book Reference & Page No**	**Delivery method**	**Delivery Hrs**	**Knowledge Level**
1	Voltage control by SVC	C4 5.2	TB1:142-145	Chalk & board / PPT	**1**	R, A, An
2	Advantages of slope in dynamic characteristics	C4 5.2	TB1:147-148	Chalk & board / PPT	**1**	R, U, A, An
3	Influence of SVC on system voltage	C4 5.2	TB1:149-152	Chalk & board / PPT	**1**	R, U, A, An
4	Design of SVC voltage regulator	C4 5.2	TB1:154-155	Chalk & board / PPT	**1**	R, U, A, An
5	Modelling of SVC for power flow and fast transient stability	C4 5.2	TB1:134-137	Chalk & board / PPT	**1**	R, U, A, An
6	Applications: Enhancement of transient stability	C4 5.2	TB1:224-229	Chalk & board / PPT	**2**	R, A, An
7	Steady state power transfer	C4 5.2	TB1:221	Chalk & board / PPT	**1**	A, An, E
8	Enhancement of power system damping	C4 5.2	TB1:232-236	Chalk & board / PPT	**1**	R, U

UNIT III	THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) AND APPLICATIONS					Target Periods: 9
Sl No	**Contents**	**CO Statement**	**Book Reference & Page No**	**Delivery method**	**Delivery Hrs**	**Knowledge Level**
1	Operation of the TCSC	C4 5.3	TB1:280-283	Chalk & board / PPT	**1**	R, U, An

2	Different modes of operation	C4 5.3	TB1:281	Chalk & board / PPT	1	R, U, A, An
3	Modelling of TCSC	C4 5.3	TB1:304-311	Chalk & board / PPT	1	R, U, A, An
4	Variable reactance model	C4 5.3	TB1:304	Chalk & board / PPT	1	R, A,
5	Modelling for Power Flow and stability studies	C4 5.3	TB1:315	Chalk & board / PPT	1	R, U, A,
6	Applications: Improvement of the system stability limit	C4 5.3	TB1:315-321	Chalk & board / PPT	2	R, U, A, An
7	Enhancement of system damping	C4 5.3	TB1:322-334	Chalk & board / PPT	2	R, U, A, An

UNIT IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS Target Periods:9

Sl No	Contents	CO Statement	Book Reference & Page No	Delivery method	Delivery Hrs	Knowledge Level
1	Static Synchronous Compensator (STATCOM) -	C4.5.4	TB1:413	Chalk & board / PPT	1	R, U
2	Principle of operation	C4.5.4	TB1:414	Chalk & board / PPT	2	R, U, A, An
3	V-I Characteristics	C4.5.4	TB1:415-417	Chalk & board / PPT	1	R, U, A, An
4	Applications: Steady state power transfer	C4.5.4	TB1:221	Chalk & board / PPT	1	R, U, A, An
5	Enhancement of transient stability	C4.5.4	TB1:224	Chalk & board / PPT	1	R, U, A, An
6	Prevention of voltage instability.	C4.5.4	TB1: 263	Chalk & board / PPT	1	R, U, A, An
7	SSSC-operation of SSSC and the control of power flow	C4.5.4	TB1:437-443	Chalk & board /	1	R, U, A, An
8	Modeling of SSSC in load flow and transient stability studies.	C4.5.4	TB1:437	Chalk & board /	1	R, U, A, An

UNIT V CO-ORDINATION OF FACTS CONTROLLERS Target Periods:9

Sl No	Contents	CO Statement	Book Reference & Page No	Delivery method	Delivery Hrs	Knowledge Level
1	Controller interactions	C4.5.5	TB1:359-364	Chalk & board / PPT	2	R, U, A, An
2	SVC – SVC interaction	C4.5.5	TB1:364-380	Chalk & board / PPT	2	R, U, A, An
3	Co-ordination of multiple controllers using linear control techniques	C4.5.5	TB1:401-408	Chalk & board / PPT	3	R, U, A, An
4	Control coordination using genetic algorithms.	C4.5.5	TB1:408	Chalk & board / PPT	2	R, U, A, An

R- Remember, U- Understand, A- Apply, An- Analyze, E- Evaluate & C- Create.

Books:Text/Reference:

S.No		Title of the Book	Author	Publisher	Year
1	TB1	Based Facts Controllers for Electrical Transmission	R.Mohan Mathur, Rajiv K.Varma	IEEE press and John Wiley & Sons	2002

2	**TB2**	Understanding FACTS -Concepts and Technology of Flexible AC	Narain G. Hingorani	Standard Publishers Distributors	
3	**TB3**	FACTS Controllers in Power Transmission and Distribution	K.R.Padiyar	New Age International(P) Limited, Publishers	2008
4	**RB1**	Flexible A.C. Transmission Systems", Institution of Electrical and Electronic	A.T.John	(IEEE),	1999
5	**RB2**	HVDC and FACTS controllers	V.K.Sood,	Kluwer Academic Publishers	2004.
6	**RB3**	Flexible AC Transmission System: Modelling and Control	Xiao – Ping Zang, Christian Rehtanz	Springer,	2012

Comments Given by the Scrutinizing Committee Members	
Signature of the Scrutinizing	
Signature of the HOD	

JEPPIAAR ENGINEERING COLLEGE
DEPARTMENT OF EEE
EE 6004-FLEXIBLE AC TRANSMISSION SYSTEM (R2013)
UNIT I - INTRODUCTION
PART – A

1. What is the need of the FACTS controller? (MJ-14)(ND-17)

1.Lack of fast controllers

2.Making transmission lines flexible by changing one of the base parameters.

3.Reduction of cost instead of constructing new transmission lines.

2. State the objectives of FACTS controller?(ND-12) (MJ-13) (MJ-17)

The main objectives of FACTS controllers are the following:

1.Regulation of power flows in prescribed transmission routes.

2.Secure loading of transmission lines nearer to their thermal limits.

3.Prevention of cascading outages by contributing to emergency control.

4.Damping of oscillations that can threaten security or limit the usable line capacity.

3. What are the limitations of the AC system?

1.Stressing of transmission line due to loads

2.Stability problems

3.Not able to load the line up to thermal limits.

4. What are the types of FACTS controllers?

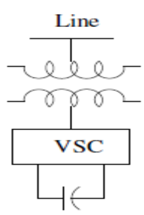
1. Series controller
2. Shunt controller .
3. Series-series controller
4. series-shunt controller

5. What is the difference between load and system compensation. (ND-16)

In load compensation capacitors have to be provided in the load side to compensate the reactive power losses and to maintain the constant voltage. In system compensation power utility companies install compensators to overcome the reactive power losses to maintain voltage constant at the receiving end.

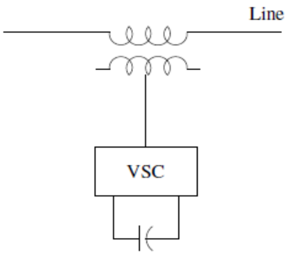
6. Give an example of shunt connected FACTS device

The figure indicates a device of shunt connected FACTS device namely STATCOM



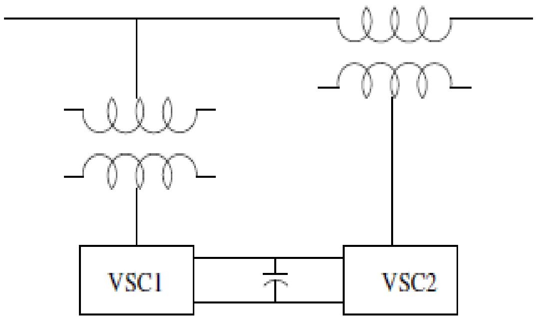
7. Give an example of series connected FACTS device

The figure indicates a device of series connected FACTS device namely SSSC



8. Give an example of shunt – series connected FACTS device

The figure indicates a device of series connected FACTS device namely UPFC



9. Compare the difference between series and shunt compensation.

Series compensation is used to control the real power flow between two buses (reactive power control also possible) and shunt compensation is mainly used to control the reactive power to maintain the voltage constant (real power control also possible).

Series compensation is costlier than the shunt compensation.

($\Delta Q_{se} = 0.072 \Delta Q_{sh}$)

Protection problem is more in series compensation compare to shunt compensation.

10. Compare the difference between compensated and uncompensated power system.

In uncompensated system the control of real power and reactive power is not possible. In Compensated system control both the real power and reactive power is possible. Ordered power is possible in compensated system and it is not possible in case of uncompensated system.

11. What is a ill conditioned power system?

Power system with less stability margin, more reactive power flow in the line and more outages are called ill conditioned power system.

12. What are the factors based on which the FACTS devices are selected?

1. Cost of the device
2. Range of control
3. Speed of operation of the device
4. How good the device is at damping oscillation

13. Why Shunt compensation is attempted always at midpoint? (ND-12) (MJ-17)

The Shunt compensation is attempted always at midpoint because voltage at the midpoint is minimum when compared to the terminal voltage **.**

14. How is SVC modeled for load flow studies?

It is modeled as a PV bus with Q_{min} and $Q_{max.}$

15. Define TCR.

Shunt connected thyrister controlled inductor whose effective reactance is varied in a continuous manner by partial conduction control of the thyrister valve.

16. Define TSC.

Shunt connected thyrister switched capacitor whose effective reactance is varied in a step wise manner by full or zero conduction operation of the thyrister valve.

17. What is the purpose of series compensation?

Series capacitors are used to partially offset the effects of series inductance of lines. Series compensation improves the maximum power transfer capacity of the line.

The net effect is to lower load angle for a given power transmission level and therefore higher stability margin.

18. How is reactive power controlled in an electrical network? (ND-12)

Reactive power control is done by using SVC, STATCOM, UPFC, Synchronous condenser, Static capacitor.

19. Distinguish between reactive power absorber and reactive power supplier?

In transmission applications, the SVC is used to regulate the grid voltage. If the power system's reactive load is capacitive (leading), the SVC will use thyristor controlled reactors to consume VARs from the system, lowering the system voltage. Under inductive (lagging) conditions, the capacitor banks are automatically switched in, supplying reactive power and boost system voltage.

20. What is meant by reactive power control in electric power transmission lines? (MJ-13)

The process of making up or taking away reactive power is called reactive power control in electric power transmission lines.

21. What are the two basic approaches for controllable series compensation? (ND-12)

Thyristor controlled series capacitor (TCSC) is a thyristor based series compensator that connects a **thyristor controlled reactor (TCR)** in parallel with a fixed capacitor. By varying the firing angle of the anti-parallel thyristors that are connected in series with a reactor in the TCR, the fundamental frequency inductive reactance of the TCR can be changed. This effect a change in the reactance of the TCSC and it can be controlled to produce either inductive or capacitive reactance.

Alternatively a **static synchronous series compensator or SSSC** can be used for series compensation. An SSSC is an SVS based all GTO based device which contains a VSC. The VSC is driven by a dc capacitor. The output of the VSC is connected to a three-phase transformer. The other end of the transformer is connected in series with the transmission line. Unlike the TCSC, which changes the impedance of the line, an SSSC injects a voltage in the line in quadrature with the line current. By making the SSSC voltage to lead or lag the line current by 90 °, the SSSC can emulate the behavior of an inductance or capacitance.

22. What is FACTS?

The term FACTS is an acronym for Flexible Alternating Current Transmission Systems In its most general expression, the FACTS concept is based on the incorporation of power electronic devices and methods into the high-voltage side of the network, to make it electronically controllable

FACTS looks at ways of capitalizing on the many breakthroughs taking place in the area of high-voltage and high-current power electronics, aiming at increasing the control of power flows in the high-voltage side of the network during both steady-state and transient conditions

23. Classify FACTS Equipment

Facts Equipment
- Thyristor based
  - Tap changer
  - Phase angle regulator
  - Static VarCompensator
  - Thyristor Controlled Series Compensator
- GTO based
  - Static compensator
  - unified power flow controller
- IGBT based
  - Static compensator
  - HVDC using voltage source converters

24. Write the list of FACTS devices to control the line power flows. (MJ-14)

- **Serial Controllers:** Static Synchronous Series Compensator SSSC, Interline Power Flow Controller

  IPFC, Thyristor Controlled Capacitor TCSC, etc.
- **shunt Controllers:** Static Synchronous Compensator STATCOM, Static Synchronous Generator SSG, Static Var Compensator SVC, etc.
- **Serial - series controllers:** Inter-line power flow controller
- **Series - shunt controllers:** Unified Power Flow Controller UPFC, Unified Controller Phase Shifting Transformer TCPST, Interphase Power Controller IPC, etc.

25. Give some example of special purpose FACTS controllers.

Some of the special purpose FACTS controllers are

(a) Thyristor Controller Braking Resistor (TCBR)

(b) Thyristor Controlled Voltage Limiter (TCVL)

(c) Thyristor Controlled Voltage Regulator (TCVR)

(d) Interphase Power Controller (IPC)

(e) NGH-SSR damping

26. Define FACTS by IEEE

FACTS is defined by the IEEE as " a power electronic based system and other static equipment that provide control of one or more AC transmission system parameters to enhance controllability and increase power transfer capability.

27. Define apparent power?

The product of current and voltage ,regardless of their phase shift ,is called apparent power ,denoted by the symbol S and unit of apparent power is volt ampere.

28. What is the use of shunt compensation?

Regulate the voltage magnitude

Improve the voltage quality

Enhance the system stability

29. What are the characteristics of SVC?

- Based on normal inductive and capacitive elements
- Not based on rotating machines
- Control function is through power electronics

30. Name some disadvantages of shunt capacitors?

The biggest disadvantages of shunt capacitors are that the reactive power output drops with the voltage squared. Thus, during the severe voltage delays these devices are not efficient enough

31. What is the need for a reactor in basic single phase TSC diagram? (ND-16)

To overcome the stress on the thyristor switches a small damping reactor is added in series with the capacitor

32. Define the term TCSC? (ND-16) (AM-14)

Thyristor controlled series capacitor is a series FACTS device which allows rapid and continuous changes of the transmission line impedance.

33. What is meant by passive compensation? (ND-16) (ND-13)

When fixed inductors and /or capacitors are employed to absorb or generate reactive power, they constitute passive control, External devices or subsystems that control reactive power on transmission line are known as compensators. This type of compensation is called as passive compensation

34. What are the two main reasons for incorporating FACTS devices in electric power systems? (AM-15)(AM-14)

To provide reactive power support

To increase the power transfer

State the features of interline power flow controller? (AM-15)

1. Effective power flow management of multi –line transmission systems
2. To provide series compensation on selected transmission line
3. Transfer power from overloaded lines to under loaded lines
4. To effective control of real and reactive power

35. What are the applications of FACTS devices? (ND-14)

- power flow control,
- increase of transmission capability,
- voltage control,
- reactive power compensation,
- stability improvement,
- power quality improvement,
- power conditioning,
- flicker mitigation,
- Interconnection of renewable and distributed generation and storages.

36. Define reactive power (ND-14)

Reactive power is the component of power that oscillates back and forth through the lines being exchanged between electric and magnetic fields and not getting dissipated.

It is denoted by the symbol Q and reactive power is measured in VAR (also written Var),for volt amphere reactive.Its magnitude is given below and the angle ø is the phase difference between voltage and current

37. Define the term IPFC? (ND-13)

The Interline Power Flow Controller (IPFC), with its exclusive capability of series compensation, is a powerful device which can provide the power flow control of multiple transmission lines

38. Distinguish between reactive power absorbers and reactive power supplier (MJ-13)

Sl.No	Absorber	Supplier
1	Inductor act as a absorber	Capacitor act as a supplier
2	Responsible for Lagging power factor	Responsible for Leading power factor

39. What is the necessity of compensation? (AM-18)

Compensation is used to control the real and reactive power between two buses to maintain the voltage constant.

40. Which compensator is used for both active and reactive power control? (AM-18)

Unified power flow controller and Interline power flow controller is used for controlling both active and reactive power control.

Part B Questions

Unit I

1. Explain the various basic types of FACTS controllers in detail.
2. Explain the reactive power compensation at the sending, midpoint and receiving ends of the transmission lines
3. What are FACTS controllers and what is the need for FACTS controllers?
4. What is the need for reactive power compensation?

5. Compare the fixed series compensation and fixed shunt compensation.
6. Explain about various type of shunt controller
7. With neat derivation explain the shunt and series controller in detail?
8. What are the objectives of line compensation? Explain the effect of shunt and series compensation on power transmission capacity of a short symmetrical transmission line**(Nov/Dec-17)**
9. Draw the phasor diagram illustrating the concepts of various power –flow control functions by the use of UPFC. Also explain the modeling procedure of UPFC for power flow studies**(Nov/Dec-17)**
10. Explain the Uncompensated Transmission line**(April/May 2016)**
11. Explain the shunt and series compensation line **(April/May 2016)**
12. Explain how a 3-phase delta connected TCR is used to compensated the reactive power of a transmission line with neat diagrams and waveforms**(April/May 2018)**
13. (i)Discuss how the power transfer capability of a transmission line can be improved by using series compensation**(April/May 2018)**
    (ii)Discuss briefly the power flow model of UPFC **(April/May 2018)**

UNIT II - STATIC VAR COMPENSATOR (SVC)

PART – A

1. What are the various controller parameters

The various controller parameters are

1. control of line impedance
2. control of angle
3. receiving end voltage

2. What is use of SVC in electrical power system networks?

A rapidly operating Static Var Compensator (SVC) can continuously provide the reactive power required to control dynamic voltage swings under various system conditions and thereby improve the power system transmission and distribution performance. Installing an SVC at one or more suitable points in the network can increase transfer capability and reduce losses while maintaining a smooth voltage profile under different network conditions.

3. List the application of SVC regulator (Nov/Dec 2012)

The applications of svc regulator are

1. stabilization of voltage
2. reduction of harmonics
3. minimum flicker disturbance
4. minimum malfunction of protective devices

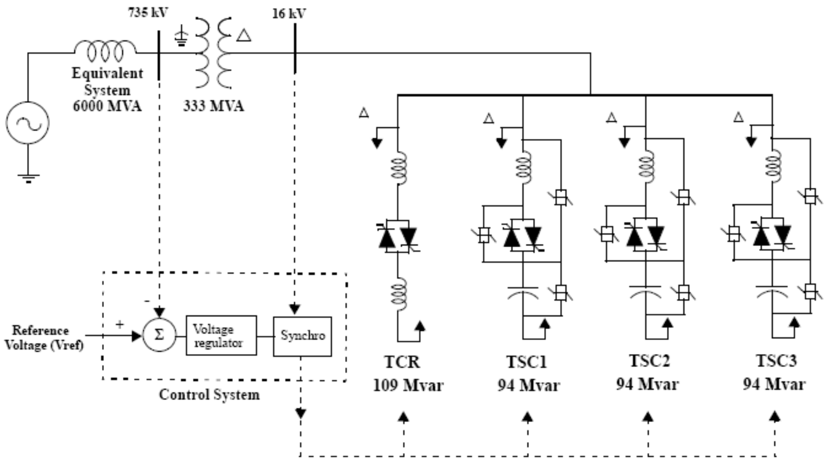
5. What is a SVC

A static var compensator (or SVC) is an electrical device for providing fast-acting reactive power on high-voltage electricity transmission networks. SVCs are part of the Flexible AC transmission system device family, regulating voltage and stabilizing the system. The term "static" refers to the fact that the SVC has no moving parts

6. State the principle of SVC

Typically, a SVC comprises a bank of individually switched capacitors in conjunction with a thyristor-controlled air- or iron-core reactor. By means of phase angle modulation switched by the thyristors, the reactor may be variably switched into the circuit and so provide a continuously variable MVAR injection (or absorption) to the electrical network. In this configuration, coarse voltage control is provided by the capacitors; the thyristor-controlled reactor is to provide smooth control. Smoother control and more flexibility can be provided with thyristor-controlled capacitor switching.

7. **Draw the Single-Line Diagram of the SVC**



8. What is the advantage of SVC?

The main advantage of SVCs over simple mechanically-switched compensation schemes is their near-instantaneous response to changes in the system voltage. For this reason they are often operated at close to their zero-point in order to maximize the reactive power correction they can rapidly provide when required.

They are, in general, cheaper, higher-capacity, faster and more reliable than dynamic compensation schemes such as synchronous condensers.

9. What is the use of SVC?

A Static Var Compensator (SVC) is a device which compensates for the reactive power of the load connected to a power system. Because of its fast response it can stabilize the busbar voltage even during fast changes of the load. An SVC is usually directly connected to a medium voltage power system.

10. What are the economic benefits of SVC?

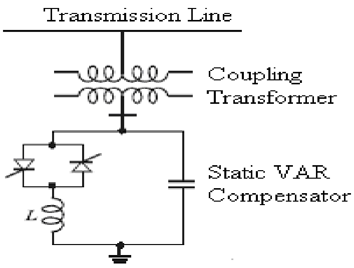
The economic benefits of SVC are

1. Energy savings
2. Increase in productivity
3. Reduction in consumption of electrodes
4. Reduction of heat losses
5. Increase lifetime of furnace inside lining

11. What are the characteristics used in SVC voltage control?

The characteristics used in SVC voltage control are Dynamic characteristics and Steady state characteristics

12. Draw the configuration of SVC (May/June 2014)



13. What are the functional benefits of SVC?

The functional benefits of SVC are

1. Flicker reduction
2. Voltage stabilization
3. Reactive power compensation
4. Reduction of harmonics

14. How the voltage stability is maintained using SVC in power system?

The static var compensator (SVC) is frequently used to regulate the voltage at dynamic loads. But also, it is used to provide a voltage support inside of a power system when it takes place small gradual system changes such as natural increase in system load, or large sudden disturbance such as loss of a generating unit or a heavily loaded line. These events can alter the pattern of the voltage waveform in such a manner that it can damage or lead to mal function of the protection devices. Generally, there are sufficient reserves and the systems settles to stable voltage level. However, it is possible, (because a combination of events and systems conditions), that the additional reactive power demands may lead to voltage collapse, causing a major breakdown of part or all system.

The SVC can improve and increase significantly the maximum power through the lines. This is achieved, if the SVC is operated an instant after of a disturbance providing the necessary flow of power. Therefore, if the approach of maximum transmitted power, is of voltages, it is possible to increase the power flow. In the studied case, it is seen that the transmitted power rise enough according to the used approach, keeping the voltage magnitude within the range of 0.8-1.2 p.u..

15. List the various parameters which depend on the performance of SVC voltage control

The performance of SVC voltage control is critically dependant on

1. Influence of network resonance
2. Transformer saturation
3. Geomagnetic effects
4. Voltage distortion

16. List the advantages of the slope in the SVC dynamic characteristics (MJ 13) (ND-16)(AM-17) (AM-18)

The advantages of the slope in the SVC dynamic characteristics are

Substantially reduces the reactive power rating of the SVC for achieving nearly the same control objective

Prevents the SVC from reaching its reactive power limits too frequently

Facilities the sharing of reactive power among multiple compensators in parallel

17. List the two ways of modeling voltage regulator using SVC

The two ways of modeling voltage regulator using SVC are

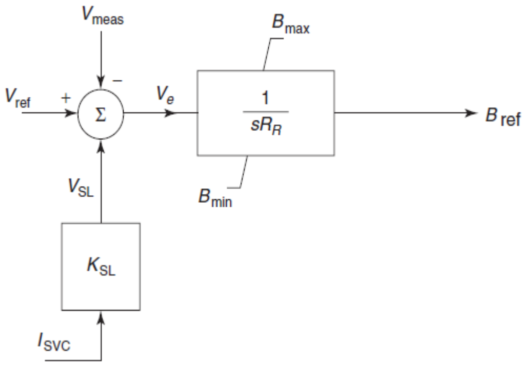
1. Gain time constant representation
2. Integrator current droop model

18. List the various factors which limit the power transfer capability in a transmission line

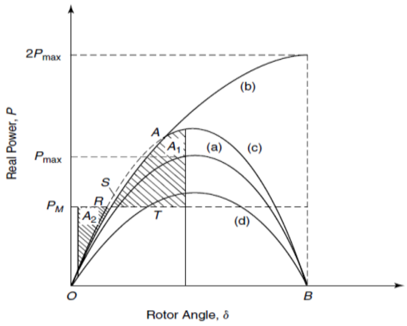
The various factors which limit the power transfer capability in a transmission line are

1. Thermal limit
2. Steady state stability limit
3. Transient stability limit
4. System damping

19. Draw the block diagram of svc voltage regulator in Integrated Current droop form. (May/June 2013)



20. Draw the power angle curve of SMIB system with midpoint SVC.(May/June 2013)



Power angle curve of SMIB system: curve (a) for uncompensated case; curve (b) with an ideal midpoint-connected SVC; curve (c) with a midpoint-connected fixed capacitor; and curve (d) with a midpoint-connected fixed inductor.

21. How is SVC modeled for load flow studies?

It is modeled as a PV bus with Q_{min} and Q_{max}.

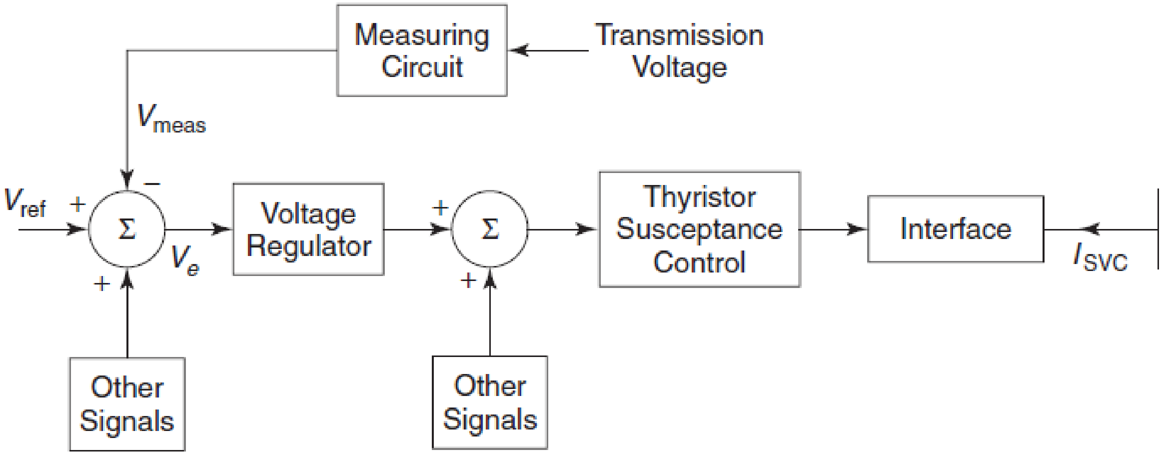
22. What is the effect of mismatched TSC-TCR in SVC operation? (June/July 2013)

The compensator cannot stabilize the system voltage to 1 p.u. Characteristics shows discontinuous system and problems in control.

23. **Write the factors to be considered for designing SVC to regulate mid-point voltage. (May/June 2014) (April/May 2018)**

- Effective Short Circuit Ratio (ESCR)
- Choice of regulator gain
- Slope of Control characteristics
- Steady state change in SVC voltage

24. Draw the IEEE basic model of SVC.



25. Draw the control characteristic of SVC.

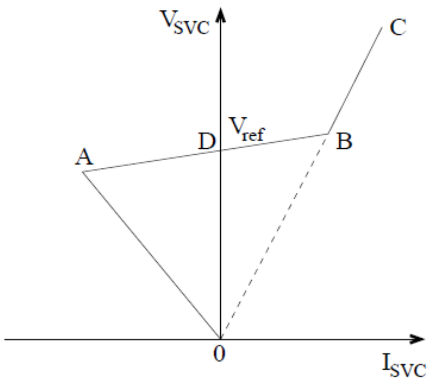


Figure : Control characteristic of SVC

26. What are the main components of SVC?

Coupling transformer

Thyristor valve

Reactors

Capacitors

27. What is the advantage of SVC?

Used to achieve improved transient stability of system

Used to change the susceptance of passive devices to control reactive power

28. How the performance of generator oscillations is characterized in power systems?

Characterized by two torque components

Synchronizing torque

Damping Torque

29.How will you consider influence of SVC on system voltage with considering transformer?

The representation of the SVC including coupling transformer creates a low voltage bus connected to the SVC and the transformer reactance Xt is separated from source side reactance

29. Name the basic SVC schemes?

TSC,TCR, FC-TCR, TSC-TCR

30. What is PSDC?(ND-16)

Power system damping controller for SVC. It is used for securing requisite levels of electrical damping in power system.

31. Define effective short circuit ratio of SVC?(AM-17)

$ESCR=1/ (-\Delta V_{SVC/}\Delta I_{SVC})\backslash$

$=1/X_S= B_S$

Where B_S= The equivalent system susceptance

Part-B Questions

Unit II

1. Compare the performance of SVC with fixed compensation
2. In-detail explains the operation of the SVC (FC+TCR and TSC+TCR) and derive the equations used. Explain how the SVC is able to regulate the
3. Design a voltage regulator of the SVC for a given sample system.
4. Write the various applications of SVC.
5. Compare the difference between current source inverter and voltage source inverter.
6. Explain the influence of the SVC on the system voltage when coupling transformer is ignored.
7. What is the need for variable series compensation compared to fixed series compensation?
8. Show that with SVC transient stability margin can be improved by enhancing synchronizing torque. Derive the necessary equations
9. Draw the IEEE basic model for the SVC control system and explain each block.
10. Describe the working principle of the two types of Static Var Compensators SVC with neat schematic diagrams **(ND-17)**
11. Explain in detail about the role of SVC in enhancing the steady state power limit and power system damping **(ND-17)**

12. Discuss in detail about the static and dynamic V-I characteristics of SVC**(April/May 2016)**
13. Explain how the SVC can be used to enhance the power transfer capacity of the transmission line **(April/May 2016)**
14. Derive the voltage and power expression in SVC**(Nov/Dec 2014)**
15. Explain the prevention of voltage instability**(Nov/Dec 2014)**
16. Describe the working principle of the two types of Static Var Compensators(SVC) with neat Schematic Diagrams.**(April/May 2018)**
17. A 400KV,50 Hz,600 km long symmetrical line is operated at the rated voltage. (i)What is the theoretical maximum power carried by the line ? what is the midpoint voltage corresponding to this condition ? (ii) A series capacitor is connected at the midpoint of the line to double the power transmitted. What is its reactance ? (iii) A shunt capacitor of value 450 ohms is connected at the midpoint of the line. If the midpoint voltage is 0.97, compute the power flow in the line corresponding to this operating point. Data : L=1 mH/Km, C= 11.1 $*10^{-9}$ F/km.(April/May 2018)

UNIT III - THYRISTOR AND GTO THYRISTOR CONTROLLED SERIES CAPACITOR

PART – A

1. Define TCSC

A capacitive reactance compensator which consists of series capacitor banks shunted by a thyristor controlled reactor in order to provide smoothly variable series capacitive reactance.

2. What is thyristor controlled series compensation?

An inductive reactance compensator which consists of a series reactor shunted by a thyristor controlled reactor in order to provide smoothly variable series capacitive reactance.

3. Define TCVL

Thyristor controlled voltage limiter is a thyristor switched metal oxide varistor (MOV) used to limit the voltage across its terminal during transient conditions.

4. What are the advantages of series compensation?

With series capacitor the reactive power increases as the square of line current, whereas in shunt compensation the reactive power is produced square of the line voltage. For achieving the same system benefits the shunt capacitors are three to six times more reactive power rated then series capacitors. Shunt capacitors must be connected at the line midpoint where as no such requirements exist for series capacitors.

5. Write the equation that represents the relationship between the series and shunt capacitor?

$$\frac{Q_{se}}{Q_{sh}} = tan^2\left(\frac{\delta_{max}}{2}\right)$$

6. What is the need for variable series compensation?

1.Enhanced load ability of series compensated line

2.Increased responsiveness of power flow in the series compensated line from outage of the other lines in the system

7. State the advantages of TCSC (April/May 2017) (April/May 2018)

1. Rapid continuous control of the transmission line series compensation level
2. Dynamic control of power flow in selected transmission line
3. Damping of power swings
4. Suppression of sub synchronous resonance (SSR) oscillations
5. Enhanced level of protection of series capacitors.

8. What are the protective devices employed with the TCSC module?

MOV, Circuit Breaker, Current limiting inductor, ultra high speed contact and spark gap

9. Name the different modes of operation of TCSC (Nov/Dec 2012) (ND-16)

1.Bypassed thyristor mode,

2.blocked thyristor mode and

3.partially conducting thyristor mode

10. Differentiate TSSC and TCSC

TSSC permits discrete control of capacitive reactance and TCSC offers continuous control of capacitive reactance

11. What are the losses in a TCSC?

Series capacitor losses, the reactor conduction loss and switching losses

12. What is the TCSC model used for transient and oscillatory stability studies?

Variable reactance model

13. State the different models of TCSC

Variable reactance model, Long term stability model, an advanced transient stability model and a model for SSR studies

14. State the functions of damping control of a TCSC

The functions of damping control of a TCSC are

1. Stabilize both post disturbance oscillations and spontaneously growing oscillations during normal operations
2. Obviate the adverse interaction with high frequency phenomena in power systems, such as network resonances
3. Preclude local instabilities within controller bandwidth
4. Be reliable and robust

15. State the applications of TCSC (ND-17)

Improvement of system stability, damping power oscillations, alleviations of SSR and prevention of voltage collapse.

16. State the different closed loop control techniques to model a TCSC

Constant current control, constant angle control, constant power control and enhanced power control

17. What is BANG-BANG control IN TCSC?(May/June2013) (AM-17)

It is a discrete control in which thyristors are either fully switched on or fully switched off. It's employed to mitigate large disturbance to improve the transient stability.

18. What are local signals employed for modulating TCSC impedance?

The line current, real power flow, bus voltages and local bus frequency

19. What are remote signals employed for modulating TCSC impedance?

The rotor angle and speed deviation of remote generator, the rotor angle difference across the system and real power flow on adjacent lines

20. What does a singular Jacobian matrix indicate?

It indicates the voltage collapse in the system

21. State the criteria for SSR mitigation by the TCSC

TCSC should be able to damp the SSR effects simultaneously on all turbine generators

When it is unable to damp the SSR, it must remove the capacitor from transmission line

22. What is the method of including finite delay associated with firing control in TCSC modeling?(May/June 2013)

Equidistant firing scheme is the most commonly employed in TCSC control. In some special situations in which the damping of the electrical self excitation mode is needed, individual firing control is used.

23. What are the capabilities of GTO Thyristor-Controlled Series Capacitor?

An elementary GTO Thyristor-Controlled Series Capacitor consists of a fixed capacitor with a GTO thyristor valve that has the capability to turn on and off upon command.

24. Compare GCSC and TCSC (May/June 2014)

GCSC utilizes a smaller capacitor, does not need any reactor and, differently from the TCSC, does not have an intrinsic internal resonance. For these reasons, the GCSC may be a better solution in most situations where controlled series compensation is required.

25. State some applications of GCSC

The GCSC could be typically used in applications where a TCSC is used today, mainly in the control of power flow and damping of power oscillations. The GCSC may operate with an open Ioop configuration, where it would simply control its reactance, or in closed loop, controlling power flow or current in the line, or maintaining a constant compensation voltage.

26. What is the firing angle for different modes of TCSC? (June/July 2013)

Bypassed thyristor mode – conduction angle of 180 degrees

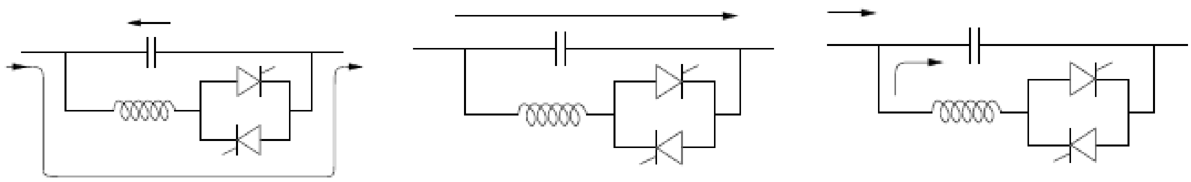
Blocked thyristor mode - no firing pulses

Vernier mode- varied from minimum value to 180 degrees.

27. What is the method of controlling the voltage across the capacitor in TCSC? (June/July 2013)

High voltage across the capacitor is prevented by surge gap and protective devices. The voltage is controlled by varying the firing angle of the thyristor.

28. Draw the equivalent circuit of TCSC for two modes. (May/June 2014)



(a) Bypassed (b)Thyristor blocked (c)Vernier operation

Figure : Operating Modes in a TCSC

29. What are the operational limits in capability curves in TCSC?

Voltage limits

Current limits

Firing angle limits

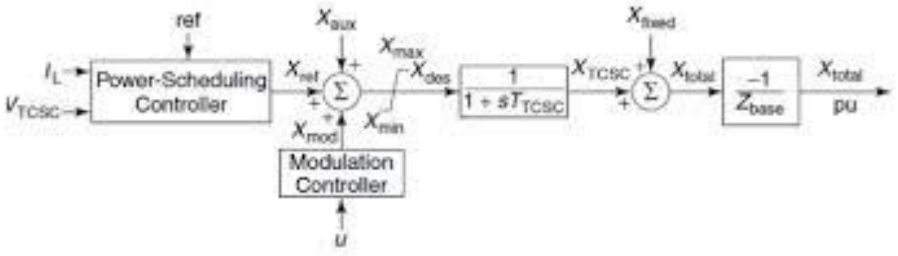
30. What is the role of TCSC in transmission system?

Operation and control of power systems such as enhancing power flow

Limiting fault current

Enhancing transient and dynamic stability

31.Draw the variable reactance model of TCSC? (AM -2018)



Block diagram of the variable reactance model of the TCSC

PART B

1. What are the various modes of TCSC operation**.(April/?May 2016)**
2. Draw and explain the block diagram of the variable reactance model of TCSC and hence derive transient stability and long term stability models**.(ND-17)(April/May 2018)**
3. The particulars of a transmission line are V=220 V,f=60Hz, X = 12Ω and Pp =56 Kw. The particulars of the TCSC are $\delta=80^0$. C=20μF and L= 0.4mH.

   Find:

   i)The degree of compensation r

   ii) The compensating capacitance reactance X_{comp}

   iii) The line current I

   iv) The reactance power Q_c

   v)The delay angle α of the TCSC if the effective capacitive reactance is X_T =-50Ω and

   vi) Plot $X_L(\alpha)$ and $X_T(\alpha)$ against the delay angle α. **(ND-17)**
4. Explain the modelling of TCSC for constant current and constant angle control
5. Applications of TCSC
6. Explain the analysis of TCSC,With a neat block diagram
7. Explain the power flow model of TCSC?
8. With neat diagram explain the analysis of TCSC?
9. Analyze the capability of TCSC in damping the oscillation of power system**(April/May 2016)**
10. Derive the expression of TCSC for the time interval (-β≤wt≤β)

UNIT IV - VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS

PART – A

1. State a few emerging FACTS controllers

STATCOM, DSTATCOM, UPFC, IPFC and Battery Energy Storage System (BESS)

2. Define STATCOM

A SSC is a shunt compensated reactive power compensation device that is capable of generating and/or absorbing reactive power and in which output can be viewed to control the specific parameters of an electric power system

3. Briefly explain the operation of SSSC

It is in general a solid state switching converter capable of generating or absorbing independently controllable real and reactive power at its output terminals when fed from an energy storage device at its input terminal.

4. State the areas in which SSSC can be applied to improve the performance of power system

Dynamic voltage control

Power oscillation damping

Transient stability improvement

Voltage flicker control

Real and reactive power control

5. What are the advantages of STATCOM over synchronous machines?(AM-17)

Small footprint, modular, factory built equipment, less commissioning time and less environmental impacts

6. How is SSC able to control both real and reactive power?

Because it has got the capacity to rapidly change the amplitude as well as the phase angle of the bus voltage to which it's connected.

7. How is a STATCOM modeled?

It's modeled as a adjustable voltage source behind a reactance.

8. What is the difference between the steady state and dynamic state operation of SATCOM?

In steady state the STATCOM operates at fundamental frequency to reduce switching losses and during transient condition caused by line fault a pulse width modulated mode is used to prevent fault current from entering Voltage source converter.

9. What is a VAR compensating system?

A combination of different static and rotating VAR compensators whose outputs are coordinated

10. Define UPFC. State the functions of UPFC (June/July 2013)

A unified power flow controller is a combination of static synchronous compensator and a static synchronous series compensator which are coupled via a common dc link, to allow bidirectional flow of real power between the series output terminals of the S^3C and the shunt output terminal of the STATCOM, and are controlled to provide concurrent real and reactive series line compensation without an external electric energy source.

11. State the advantages of UPFC over other FACTS devices.

It has got all encompassing capabilities of voltage regulation, series compensation and phase shifting. It can independently and very rapidly control both real and reactive power flows in a transmission line.

12. Why UPFC is called the most versatile converter?

Conventional thyristor controlled power controllers employ traditional power system compensation and control schemes in which mechanical switches are replaced by thyristor values. Each scheme is devised to control a particular system parameter affecting power flow. Thus Static Var Compensator are applied for reactive power and voltage control, controllable series compensators for line impedance adjustment and tap changing transformer for phase shift. UPFC can handle practically all power flow control and transmission line compensation problem uniformly, using solid state voltage sources exclusively instead of switched capacitors and reactors or tap changing transformers.

13. State the purpose of series converter in UPFC

Series converter injects a voltage phasor V_{pq} in series with the line, which can be varied from 0 to 360 degree. In this process series controller can exchange both real and reactive power with the transmission line.

14. State the purpose of shunt converter in UPFC

Shunt converter is used to mainly to supply the real power demand of series converter which it derives from the transmission line itself.

15. State the various power flow control of UPFC

The various power flow control of UPFC are

1.Series voltage injections

2.Terminal Voltage regulation

3.Terminal Voltage and line impedance regulation

4.Terminal voltage and phase angle regulation

16. What are the various constraints with which UPFC operates?

1. The series injected voltage magnitude
2. Line current through series converter
3. The shunt converter current
4. The minimum line side voltage of the UPFC
5. The maximum line side voltage of the UPFC

The real power transfer between the series converter and the shunt converter

17. How is UPFC modeled for load flow studies?

UPFC connected in between two buses is modeled as power injections at each of the buses.

18. What are inherent limitations of conventional FACTS devices?

Physical size, relatively high cost which is increasingly dominated by that of non electronic components and labor.

19. Explain the two basic concepts incorporated into UPFC?

One is that all transmission line compensations (shunt or series) can be provided by the same solid state inverter functioning as controllable AC voltage source with internal VAR generation capability and other one is that two of these basic inverters can be combined into a single unit to provide all power flow compensation involving both real and reactive power

20. Explain the hardware design of UPFC

UPFC is a single power electronic hardware building block, the voltage source inverter. This inverter can be constructed from a standard six pulse modules, using GTO values in a flexible harmonic neutralized structure for virtually any desired rating.

21. List some application of STATCOM (May/June 2013)

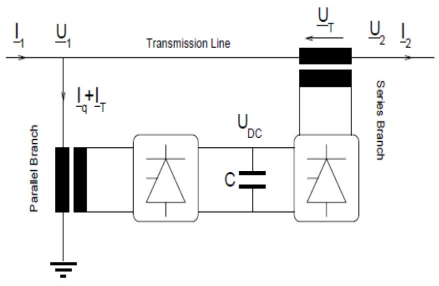
The application of STATCOM are

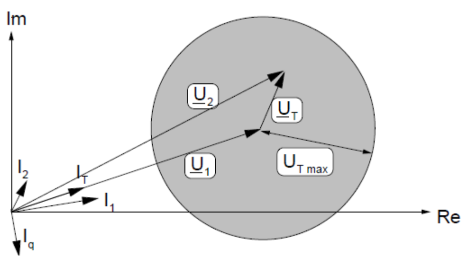
1. Dynamic voltage control in transmission and distribution system;
2. Power-oscillation damping in power transmission systems;
3. The transient stability;
4. The voltage flicker control; and
5. The control of not only reactive power but also active power in the connected line requiring a dc energy source.

22. State the function of converter 1 in UPFC. (May/June 2013).

The shunt connected converter 1 is used mainly to supply real power demand of converter 2 which it derives from transmission line itself. The shunt converter maintains constant voltage of the dc bus. In addition, the shunt converter functions like a STATCOM and independently regulates the terminal voltage of the interconnected bus by generating/absorbing a requisite amount of reactive power

23. Draw the basic scheme of UPFC and its vector diagram





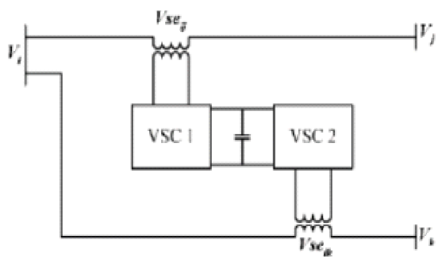
24. What is the role of dc link in UPFC. (Nov/Dec 2012)

The dc voltage for converter 1 and converter 2 in UPFC is provided by dc link. Although the reactive power is internally generated/absorbed by the series converter, the real power generation/absorption is made feasible by the dc energy storage device (dc link-capacitor).

25. Distinguish between UPFC and IPFC (Nov/Dec 2012)

UPFC(Unified Power Flow Controller)	IPFC (Interline Power Flow Controller)
It is a shunt-series FACT device	It is a series-series multiline FACT device
UPFC can perform voltage regulation, series compensation and phase shifting	IPFC address the problem of compensating number of transmission line at a given sub-station

26. Draw the schematic diagram of two converters IPFC



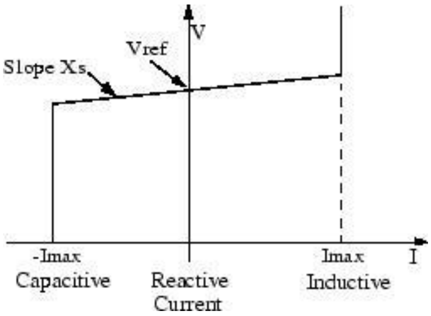
27. Define IPFC

Combination of two or more static synchronous series compensator (SSSC) which are coupled via a common DC link to facilitate bi directional flow of real power between a AC terminal of SSSC and are controlled to provide independent reactive power compensation for the adjustment of real power flow in each line and maintain the desired distribution of reactive power flow among the lines.

28. Define SSSC

A static synchronous generator operated without an external electric energy source as a series compensator whose output voltage is in quadrature with and controllable independently of, the line current for the purpose of increasing or decreasing the overall reactive voltage drop across the line and thereby controlling the transmitted electric power.

29. Draw the VI characteristics of STATCOM (June/July 2013) (ND- 16)



30. Draw the block diagram of SSSC. (ND- 16)

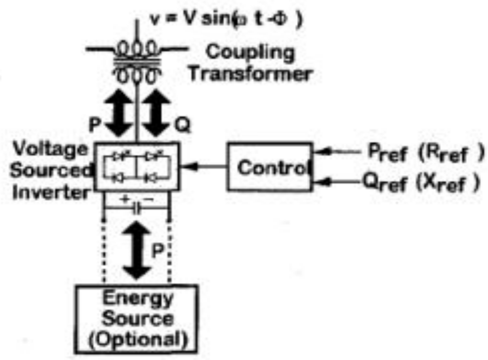


Fig. Block diagram of Stat Synchronous Series Compensator

31. Differentiate STATCOM and SSSC

STATCOM	SSSC
Shunt compensation device of FACTs family	Series compensation device of FACTs family
The STATCOM (or SSC) is a shunt-connected reactive-power compensation device that is capable of generating and/ or absorbing reactive power and in which the output can be varied to control the specific parameters of an electric power system	A series capacitor compensates the transmission line inductance by presenting a lagging quadrature voltage w.r.t voltage appearing across the transmission line inductance, which has the net effect of reducing the line inductance

Used for voltage improvement	Used to enhance the power flow and to provide power oscillation damping

32. What is meant by SSR? (AM-17) (AM-18)

Sub synchronous resonance is an important aspect of SSSC and it assists in the damping of sub synchronous oscillations caused by other series capacitors inserted in the transmission network.

PART-B

1. Compare the performance between STATCOM and SVC.
2. Explain the constant current controller model of TCSC with block diagram.
3. Write the applications of STATCOM in power system.
4. . Explain the operation of UPFC with vector diagrams.
5. Discuss in detail about the modeling of SSSC in load flow and transient stability studies**(ND-17)**
6. Explain the principle of operation and VI characteristics of STATCOM with neat sketch.**(April/May 2016)(April/May 2018)**
7. Explain the basic operating principle and the control capability of UPFC.**(April/May 2016)**
8. With neat sketches ,explain the operating principle and V-I characteristics of Static Synchronous Compensator (STATCOM) **(ND-17)**
9. Explain the basic operating principle and the control capability of UPFC.
10. Show that with Power-angle curve the STATCOM can enhance the transient stability margin..
11. Define UPFC, draw its circuit diagram and explain the working principle.
12. Explain the protection of UPFC and derive the expression of UPFC connected at the mid point **(Nov/Dec 2014)**
13. Explain the application of UPFC for real power control through a transmission line.\
14. Discuss in detail about the modeling of SSSC in load flow and transient stability studies**(April/May 2018)**

UNIT V-CONTROLLERS AND THEIR CO-ORDINATION

PART – A

1. Mention the possible combinations of controller interactions or Classify the FACTS controller interactions. (Nov/Dec 2012,June/July 2013) (ND-16) (AM 17)

The various combinations of controller interactions are

1. Multiple FACTS controllers of a similar kind
2. Multiple FACTS controllers of a dissimilar kind
3. Multiple FACTS controllers and HVDC controllers

2. List the various frequency ranges classification of different control interactions (ND-16)

The various frequency ranges classification of different control interactions are

1. 0 Hz for steady state interactions
2. 0 – 3/5 Hz for electromechanical oscillations
3. 2 – 15 Hz for small signal or control oscillations
4. 10 – 50/60 Hz for sub synchronous resonance interactions
5. >15 Hz for electromagnetic transients

3. List the basic procedure for the controller design

The basic procedure for the controller design is

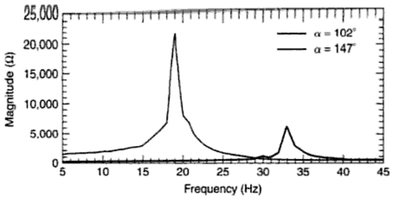
1. Derivation of the system model
2. Enumeration of the system performance specifications
3. Selection of the measurement and control signals
4. Coordination of the controller design
5. Validation of the design and performance evaluation

4. List the broad categories of Coordination techniques of FACTS controllers

Coordination techniques of FACTS controllers are classified in three broad categories as

1. sensitivity based methods,
2. optimization based method, and
3. artificial intelligence based techniques

5. Draw the impedance magnitude of the SVC frequency response



6. List the various Artificial Intelligence based techniques for the coordinated control of FACTS controllers

The coordinated control of FACTS controllers based on various Artificial Intelligence based techniques such as

1. genetic algorithm (GA),
2. expert system (ES), artificial
3. neural network (ANN),
4. tabu search optimization,
5. ant colony optimization algorithm,
6. simulated annealing approach,
7. particle swarm optimization algorithm, and
8. fuzzy logic based approach.

7. What is the major advantage of the AI based optimization methods?

The major advantage of the AI based optimization methods is that they are relatively versatile for handling various qualitative constraints. AI methods can find multiple optimal solutions in single simulation run. So they are quite suitable in solving multi-objective optimization problems for coordination of FACTS controllers in multi-machine power system..

8. State the various FACTS applications to steady state power system problems

The various FACTS applications to steady state power system problems are

1.FACTS Applications to Optimal Power Flow

2.FACTS Applications to Deregulated Electricity Market

9. Compare the various FACTS controller with respect to their performance

	SSSC	STATCOM	TCPST	TCSC	SSC	UPSC
Voltage Control	✓	✓	–	✓	✓	✓
Transient Stability	✓	✓	✓	✓	✓	✓
Damping Power Oscillations	✓	✓	✓	✓	✓	✓
Reactive Power Compensation	✓	✓	–			✓
Power Flow Control	✓	–	✓	✓	✓	✓
SSR Mitigation	✓	–	✓	✓		✓

10. How the UPFC is used in power system?

A unified power flow controller (UPFC) is the most promising device in the FACTS concept. It has the ability to adjust the three control parameters, *i.e.* the bus voltage, transmission line reactance, and phase angle between two buses, either simultaneously or independently. A UPFC performs this through the control of the in-phase voltage, quadrature voltage, and shunt compensation.

11. What is meant by FACTs controller interaction.

Controller interactions can occur in the following combinations:

1. Multiple FACTS controllers of a similar kind.
2. Multiple FACTS controllers of a dissimilar kind.
3. Multiple FACTS controllers and HVDC converter controllers.

Because of the many combinations that are possible, an urgent need arises for power systems to have the controls of their various dynamic devices coordinated.

The term coordinated implies that the controllers have been tuned simultaneously to effect an overall positive improvement of the control scheme

12. Define the term coordination

In an interconnected or coordinated power system, when the controller parameters of a dynamic device are tuned to obtain the best performance

13. State the various issues arises due to FACTS devices installation

The various issues arises due to FACTS devices installation are

1. Location and Feedback Signals
2. Coordination among Different Control Schemes
3. Performance Comparison

14. State the various methods available for the placement of FACTS devices

The various methods available for the placement of FACTS devices are

1. Conventional methods (Local Optima)
2. Heuristic Search methods (near Global Optima)
3. Sensitivity based methods

15. State the various modes of SVC – SVC Interactions

The various modes of SVC – SVC Interactions are

1.Uncoupled SVC buses

2.Coupled SVC buses

16. Who is the pioneer for Sub Synchronous Damping ?

Narain G.Hingorani, is the pioneer for Sub Synchronous Damping

17. What is sub-synchronous resonance interactions? (June/July 2013)(N0v/dec2017)

Sub- synchronous oscillations may be caused by the interaction between the generator torsional system and the series compensator transmission lines , HVDC converter controls, the generator excitation controls. These oscillations are in the frequency range of 10-50 Hz.

18. Why is coordination of FACTS controller required? (AM-18)

The coordination of FACTS controller is required because the different FACTS controllers interact among themselves and also with the power system controllers.

19. What are the disadvantages of using linear control techniques?

Because power system is mathematically modeled as a non linear system, because the linearization of non linear equation is difficult

20. How is coordination of FACTS controller carried out? (Nov/ Dec 2012)

Coordination of FACTS controller carried out by using

1. linear control techniques
2. global coordination using non linear constrained optimization
3. control coordination using genetic algorithm

21. State the use of frequency response curve in the interaction analysis(May/June 2013)

The frequency response curve is used in controller design and coordination. It is also used in validation of the design and performance evaluation.

22. What is electro-mechanical oscillation interactions

Electro-mechanical oscillation interactions between FACTS controllers involves synchronous generators, compensator machines and associated power system stabilizer controls. The oscillation include local mode oscillation in the range of 0.8-2 Hz and inter area mode oscillations in the range of 0.2-0.8 Hz.

23. What is small signal oscillations?

Control interaction between individual FACTS controllers and the network or between the FACTS controllers and HVDC links may lead to the onset of oscillations in the range of 2-15 Hz.

24. Give the mathematical representation of control coordination problem to be solved by GA (June/July 2013)

$$F = \sum_{i=1}^{m}\left[\sum_{j=1}^{n} \xi_i\right]$$

Where n is number of modes to be damped, m is the number of possible operating conditions and the damping ratio of the closed eigen value

25. Write the various control interactions based on frequency ranges.

The frequency ranges of the different control interactions have been classified as follows

26. What is the roll of Fast control associated with FACTS controllers?

Fast control associated with FACTS controllers provide system improvements but they also can interact adversely with one another

27. List the controller design procedure for FACTS POD?

Selection of the proper feedback signal

Design of the controller using the residue method

Test the controller under wide range of operation conditions

28. What is meant by genetic Algorithm(GA)

GA s is search procedures based on the mechanics of natural selection and natural genetics. They are develop to allow computers to evolve solutions to difficult problem such as function, optimization and artificial intelligence

29. Name the two kinds of power oscillation damping controllers in power systems?

- PSS
- FACTS POD Controllers

30. What is the role of Fast controls associated with FACTS controllers?

They provide system improvements but also can interact adversely with one another

31. What is the main problem with multiple SVCs in a power system network?(AM-18)

Interruption in power supply

Unreliability

Voltage Instability

UNIT V

1. What is the need for co-ordination of FACTS controllers.
2. Explain the co-ordinated tuning of FACTS controllers using Genetic Algorithm for damping power system oscillation.**(Nov/Dec 2017)(April/May 2018)**
3. Compare the FACTS controllers
4. Discuss in detail about SVC-SVC interaction**(April/May 2016)**
5. Discuss the coordination procedure of multiple controllers using linear control techniques in detail**(April/May 2016)(April/May 2018)**
6. Discuss Linear quadratic regulator based techniques, Global coordination using nonlinear constrained optimization., Control coordination using genetic algorithms in detail
7. Explain the various control attributes for different FACTS controllers**(nov/Dec 2017)**
8. Explain the Quantitative Treatment in FACTS Controller **(Nov/Dec 2016)**

Question Paper Code : 50461

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2017

Seventh Semester

Electrical and Electronics Engineering

EE6004 – FLEXIBLE AC TRANSMISSION SYSTEMS

(Regulations 2013)

Time : Three Hours | Maximum : 100 Marks

Answer ALL questions

PART – A (10×2=20 Marks)

1. What is the need for FACTS controllers ?
2. How is voltage instability identified in the power system ?
3. What is the function of phase angle regulator ?
4. Write the factors to be considered for designing SVC to regulate mid-point voltage.
5. Draw the basic model of TCSC.
6. Mention the applications of TCSC.
7. What is meant by sub synchronous resonance ?
8. State the salient features of STATCOM.
9. What is the need for coordination of FACTS controllers ?
10. How the voltage profile can be improved by making use of SVC ?

PART – B (5×16=80 Marks)

11. a) What are the objectives of line compensation ? Explain the effect of shunt and series compensation on power transmission capacity of a short symmetrical transmission line. (16)

(OR)

b) Draw the phasor diagrams illustrating the concepts of various power-flow control functions by the use of UPFC. Also explain the modeling procedure of UPFC for power-flow studies. (16)

12. a) Describe the working principle of the two types of Static Var Compensators (SVC) with neat schematic diagrams. **(16)**

(OR)

b) Explain in detail about the role of SVC in enhancing the steady state power limit and power system damping. **(16)**

13. a) Draw and explain the block diagram of the variable reactance model of TCSC and hence derive transient stability and long term stability models. **(16)**

(OR)

b) The particulars of a transmission line are V = 220 V, f = 60 Hz, X = 12 Ω and P_P = 56 kW. The particulars of the TCSC are δ = 80°, C = 20 μF and L = 0.4 mH. Find :

i) The degree of compensation r

ii) The compensating capacitance reactance X_{comp}

iii) The line current I

iv) The reactive power Q_C

v) The delay angle α of the TCSC if the effective capacitive reactance is $X_T = -50\,\Omega$ and

vi) Plot $X_L(\alpha)$ and $X_T(\alpha)$ against the delay angle α. **(16)**

14. a) With neat sketches, explain the operating principle and V-I characteristic of Static Synchronous Compensator (STATCOM). **(16)**

(OR)

b) Discuss in detail about the modeling of SSSC in load flow and transient stability studies. **(16)**

15. a) Describe in detail the power flow control co-ordination of FACTS controllers using Genetic Algorithms. **(16)**

(OR)

b) Explain the various control attributes for different FACTS controllers. **(16)**

Reg. No. [ ]

Question Paper Code : 52606

B.E/B.Tech. DEGREE EXAMINATION, APRIL 2016

Eighth Semester

Electrical and Electronics Engineering

EE 2036/EE 809/10133 EEE 45 – FLEXIBLE AC TRANSMISSION SYSTEMS

(Regulations 2008/2010)

Time : Three Hours **Maximum : 100 Marks**

Answer ALL questions.

PART – A (10 × 2 = 20 Marks)

1. What are the two main reasons for incorporating FACTS devices in electric power systems ?
2. What is meant by Thyristor Switched Series Capacitor (TCSC) ?
3. Define the droop in V-I characteristics of SVC.
4. Write the transfer function of SVC voltage regulator in gain time constant form.
5. What are the methods for protection against over-voltage ?
6. Define Transient stability control.
7. Distinguish between UPFC and IPFC.
8. What is the role of dc link in UPFC ?
9. Mention the possible combinations of FACTS controller interactions.
10. State the use of frequency response curve in the interaction analysis.

PART – B (5 × 16 = 80 Marks)

11. (a) Explain the Uncompensated Transmission Line.

OR

(b) Explain the Shunt and Series Compensation Line.

12. (a) Discuss in detail about the static and dynamic V-I characteristics of SVC.

OR

(b) Explain how SVC can be used to enhance the power transfer capacity of a transmission line.

13. (a) Explain the basic principle and different modes of operation in TCSC. **(16)**

OR

(b) Analyze the capability of TCSC in damping the oscillations of power system. **(16)**

14. (a) Explain the principle of operation and V-I characteristics of STATCOM. **(16)**

OR

(b) (i) Draw the configuration of UPFC implementation using two 'back-to-back' connected voltage sourced converters with a common DC link. **(4)**

(ii) Explain the steady-state UPFC model for power flow studies. **(12)**

15. (a) Investigate the SVC-SVC controller interaction in a large power system. **(16)**

OR

(b) Discuss the co-ordination of multiple FACTS controllers using linear control technique for power flow control applications. **(16)**

Question Paper Code : 71495

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2015.

Eighth Semester

Electrical and Electronics Engineering

EE 2036/EE 809/10133 EEE 45 – FLEXIBLE AC TRANSMISSION SYSTEMS

(Regulation 2008/2010)

(Common to PTEE 2036 – Flexible AC Transmission Systems for B.E. (Part-Time) - Seventh Semester – EEE – Regulation 2009)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What are the two main reasons for incorporating FACTS devices in electric power systems?
2. State the features of Interline Power Flow Controller (IPFC).
3. What are the three basic modes of SVC control?
4. How is voltage instability identified in a power system?
5. State any two advantages of TCSC.
6. What are the functions of damping control of a TCSC?
7. List any two power system performances that can be improved by STATCOM.
8. Write the applications of UPFC.
9. What is the main problem with multiple SVCs in a power system network?
10. What is the significance of 'modal-performance index'?

PART B — (5 × 16 = 80 marks)

11. (a) (i) Explain briefly about load compensation. (4)

(ii) What are the objectives of line compensation? Explain the effect of shunt and series compensation on power transmission capacity of a short symmetrical transmission line. (12)

12. (a) (i) State and explain the advantages of slope in the dynamic characteristics of SVC. (8)

(ii) Explain the influence of SVC on regulating the AC system voltage for the following two cases: (4+4)

(1) Coupling transformer ignored

(2) Coupling transformer considered.

Or

(b) Explain in detail about the role of SVC in enhancing the steady state power limit and power system damping. (6+10)

13. (a) Draw the basic and practical TCSC modules. Explain the basic principle and different modes of operation of TCSC. (2+4+10)

Or

(b) Draw and explain the block diagram of the variable reactance model of TCSC and hence derive transient stability and long term stability models. (8+8)

14. (a) With neat sketches, explain the operating principle and the V-I characteristic of Static Synchronous Compensator (STATCOM). (8+8)

Or

(b) (i) Draw the phasor diagrams illustrating the concepts of various power-flow control functions by use of UPFC. (4)

(ii) Explain the modeling procedure of UPFC for power-flow studies. (12)

15. (a) What is the need for coordination of different FACTS controllers? Explain the different control interactions that are occurring in multiple FACTS controllers. (2+14)

Or

(b) Describe the following linear control techniques used for coordination of multiple FACTS controllers: (4+6+6)

(i) Linear Quadratic Regulator (LQR) based technique

Reg. No. : [| | | | | | | | | | | |]

Question Paper Code : 91432

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2014.

Eighth Semester

Electrical and Electronics Engineering

EE 2036/EE 809/10133 EEE 45 — FLEXIBLE AC TRANSMISSION SYSTEMS

(Regulation 2008/2010)

(Common to PTEE 2036 – Flexible AC Transmission Systems for B.E. (Part-Time) Seventh Semester – EEE – Regulation 2009)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What are the applications of FACTS devices?

2. Define Reactive Power.

3. Compute $\frac{X_{TCSC}}{X_C}$ and $\frac{I_{TCR}}{I_L}$ if

   (a) $X_{TCR} = 1.5 X_C$ and

   (b) $X_{TCR} = 0.75 X_C$.

4. What are the objectives of Static VAR?

5. What are the methods for protection against over voltage?

6. Define Transient stability control.

7. Define Linear Loads.

8. Define UPFC.

9. Draw the control characteristics of SVC.

10. Draw the Power Angle Curve of SVC.

PART B — ($5 \times 16 = 80$ marks)

11. (a) Explain Uncompensated Transmission Line.

Or

(b) Explain Shunt and Series Compensation Line.

12. (a) Derive the Voltage and Power expression in SVC.

Or

(b) Explain prevention of voltage instability.

13. (a) Explain the operation of TCSC.

Or

(b) Derive the expression of TCSC for the time interval $(-\beta \leq wt \leq \beta)$

14. (a) Explain the protection of UPFC.

Or

(b) Derive the expression of UPFC connected at the midpoint.

15. (a) Explain Linear Co-ordination technique.

Or

(b) Explain Quantitative Treatment in FACTS controller.

Reg. No. : [| | | | | | | | | | |]

Question Paper Code : 51429

B.E./B.Tech. DEGREE EXAMINATION, APRIL 2014.

Eighth Semester

Electrical and Electronics Engineering

EE 2036/EE 809/10133 EEE 45 — FLEXIBLE AC TRANSMISSION SYSTEMS

(Regulation 2008)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What are the two main reasons for incorporating FACTS devices in electric power systems?

2. What is meant by Thyristor Switched Series Capacitor (TCSC)?

3. Define 'Effective Short Circuit Ratio (ESCR)' of SVC.

4. What are the factors that limit the power-transfer capacity of a transmission line?

5. Mention the disadvantages of fixed series compensation of transmission lines.

6. What are the functions of damping control of a TCSC?

7. List any two performances of power system that can be improved by STATCOM.

8. State the basic UPFC power flow control functions.

9. What is the need for coordination of different FACTS controllers?

10. Why is it necessary to series-compensate a power system network with multiple SVCs?

PART B — (5 × 16 = 80 marks)

11. (a) (i) Give the complete analysis of lossless distributed parameter transmission lines and derive power equations for symmetrical case. (12)

(ii) Write a brief note on IPFC. (4)

Or

(b) (i) What are the objectives of line compensation? Explain the effect of shunt and series compensation on power transmission capacity of a short symmetrical transmission line. (12)

(ii) List the advantages of SVCs. Pg. No. 40 (4)

12. (a) (i) Write the advantages of the slope in the dynamic characteristics of SVC and comment on the reason for slope. Pg. No 147 (8)

(ii) With a case study, explain how an SVC can be used to prevent voltage instability in a power system. Pg No. 263 (8)

Or

(b) (i) Explain how an SVC can be used to enhance the steady-state power transfer capacity of a transmission line. Pg. No. 221 (8)

(ii) Using power angle curves, explain how SVC enhances transient stability of a power system. Pg. No 224 (8)

13. (a) What are the advantages of TCSC? Explain the different modes of operation of TCSC. Pg. No 278, Pg. No. 281 (6 + 10)

Or

(b) With a neat block diagram, explain the variable reactance model of the TCSC and derive transient stability and long-term stability models. Pg. No 304

14. (a) Explain the principle of operation and V-I characteristics of STATCOM. Pg. No 413 (16)

Or

(b) (i) Draw the configuration of UPFC implementation using two 'back-to-back' connected voltage sourced converters with a common DC link. Pg. No. 446 (4)

(ii) Explain the steady-state UPFC model for power flow studies. (12)

15. (a) Explain the various kinds of control interactions occuring between different FACTS controllers using their frequency response characteristics. 359 (16)

Or

(b) Describe the following linear control techniques used for coordination of control of different FACTS controllers. (4 + 6 +6)

(i) Linear Quadratic Regulator (LQR)-based technique 405

(ii) Global coordination using nonlinear-constrained optimization. 407

(iii) Control coordination using Genetic Algorithms. 408

09/04

Question Paper Code : 21389

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2013

Eighth Semester

Electrical and Electronics Engineering

EE 2036/EE 809 – FLEXIBLE AC TRANSMISSION SYSTEMS

(Regulation 2008)

Time : Three hours | Maximum : 100 marks

Answer ALL questions

PART A – (10 X 2 = 20 marks)

1. Distinguish between reactive power absorbers and reactive power suppliers.
2. State the objectives of FACTS controllers.
3. Draw the block diagram of SVC voltage regulator in Integrated Current droop.
4. Draw the power angle curve of SMIB system with midpoint SVC.
5. What is the method for including finite delay associated with finger control in TCSC modelling?
6. What is Bang-Bang control in TCSC?
7. List some applications of STATCOM.
8. State the function of converter 1 in UPFC.
9. Mention the possible combinations of FACTS controller interactions.
10. State the use of frequency response curve in the interaction analysis.

PART B – (5 X 16 = 80 marks)

11. (a) Explain in detail about shunt and series compensation.

Or

(b) Explain in detail about the classification of different FACTS controllers.

12. (a) Discuss in detail about the static and dynamic VI characteristics of SVC.

Or

(b) Explain how SVC can be used to enhance the power transfer capacity of a transmission line.

13. (a) Explain the working and characteristics of TCSC.

Or

(b) Explain the variable reactance modelling of TCSC.

14. (a) Explain in detail about the implementation of UPFC.

Or

(b) Explain the working of STATCOM. Compare its performance with SVC.

15. (a) Discuss the different classification of controller interactions.

Or

(b) Analyze in detail about SVC-SVC interaction.

Reg. No. : 3 0 6 0 9 1 0 5 3 0 2

Question Paper Code : 31389

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2013.

Eighth Semester

Electrical and Electronics Engineering

EE 2036/ EE 809 — FLEXIBLE AC TRANSMISSION SYSTEMS

(Regulation 2008)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define the term IPFC.

2. What is meant by passive compensation?

3. Define the droop in VI characteristics of SVC.

4. Write the transfer function of SVC voltage regulator in gain time constant form.

5. State the need for variable series compensation.

6. What is blocked Thyristor mode in TCSC operation?

7. State the capabilities of STATCOM.

8. Specify the frequency ranges for electro mechanical oscillation.

9. Draw the UPFC model for power flow studies.

10. State the optimization problem of control coordination.

PART B — (5 × 16 = 80 marks)

11. (a) (i) Explain the concept and need for reactive power. (8)

(ii) Discuss the possible control actions to maintain the voltage at rated value in transmission line. (8)

Or

(b) Explain the effect of shunt and series compensation on power transmission capacity. (16)

12. (a) Draw and discuss in detail about the advantages of slope in dynamic characteristics of SVC. (16)

Or

(b) Explain the role of SVC in the enhancement of stability under sudden changes in the operating conditions of power system. (16)

13. (a) Explain the basic principle and different modes of operation in TCSC. (16)

Or

(b) Analyze the capability of TCSC in damping the oscillations of power system. (16)

14. (a) Explain the operating principle and VI characteristics of shunt switching converter. (16)

Or

(b) With neat phasor diagram analyze the conventional transmission capabilities of UPFC. (16)

15. (a) Discuss the control coordination of multiple controllers using linear control techniques. (16)

Or

(b) Discuss in detail about different factors for SVC-SVC interaction. (16)

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2012.

Eighth Semester

Electrical and Electronics Engineering

EE 2036 — FLEXIBLE AC TRANSMISSION SYSTEMS

(Regulation 2008)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. Define the term 'Facts'.

2. What is the difference between Thyristor Switched series capacitor and TCSC?

3. State the advantages of slope in the SVC dynamic characteristics.

4. What is the contribution of two torque components of generator in improving the system damping?

5. What is meant by bypassed Thyristor mode?

6. What is the indication of voltage collapse points?

7. State the salient features of UPFC.

8. Differentiate between STATCOM and SVC.

9. What is meant by coordination of FACTS controllers?

10. List the possible combination of FACTS controller interactions.

PART B — (5 × 16 = 80 marks)

11. (a) Explain the basic construction, working and characteristic of any one type of SVC.

Or

(b) Explain in detail about series and shunt compensation in transmission lines.

12. (a) Explain the method of voltage control by SVC.

Or

(b) Discuss the method of improving transient stability with SVC.

13. (a) Explain the variable reactance modelling for stability studies.

Or

(b) Discuss the role of TCSC in the enhancement of system damping.

14. (a) Explain the basic construction, principle of operation and VI characteristics of STATCOM.

Or

(b) With phasor diagram explain the different modes of operation of UPFC.

15. (a) Explain in detail about different control interactions.

Or

(b) Discuss about SVC – SVC integration.

———————

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2016.

Seventh Semester

Electrical and Electronics Engineering

EE 6004 — FLEXIBLE AC TRANSMISSION SYSTEMS

(Regulations 2013)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Distinguish between load compensation and system compensation.
2. Write the need for a reactor in basic single phase TSC diagram.
3. List the advantages of slope in dynamic characteristics of SVC.
4. What is PSDC?
5. List the different modes of TCSC operation.
6. Draw the VI capability characteristics for single-module TCSC.
7. Draw the VI characteristics of STATCOM.
8. Define SSSC and list the components in it.
9. List the various possible combinations for the study of controller interactions.
10. What are the frequency ranges for the study of different control interactions?

PART B — (5 × 16 = 80 marks)

11. (a) Draw the single line diagrams of TCSC, STATCOM, SSSC and UPFC. (16)

Or

(b) What is meant by active and passive compensation? Discuss the effect of various types of passive compensation on power transmission capacity with necessary diagrams and expressions. (16)

12. (a) Explain the voltage-control action by the SVC with necessary diagrams. (16)

Or

(b) Explain the role of SVC in increasing the steady state power-transfer capacity with necessary diagrams and expressions. (16)

13. (a) (i) Discuss the advantages of TCSC in detail. (8)

(ii) Describe the variable reactance model of TCSC with block diagram. (8)

Or

(b) Briefly describe the steps to be followed for SSR mitigation by TCSC.

14. (a) (i) Explain the principle of operation and applications of STATCOM. (8)

(ii) Explain the power exchange process between STATCOM and power system. (8)

Or

(b) Explain the principle of operation of SSSC and series-compensation using SSSC with necessary diagrams and expressions. (16)

15. (a) (i) Explain the coordination features of parallel SVCs and electrically close SVCs. (8)

(ii) Explain the controller coordination using Genetic Algorithms. (8)

Or

(b) Describe the basic procedure for controller design for the coordination of multiple controllers using linear control techniques. (16)

Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 71752

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2017.

Seventh Semester

Electrical and Electronics Engineering

EE 6004 — FLEXIBLE AC TRANSMISSION SYSTEMS

(Regulations 2013)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What are the objectives of FACTS controllers?

2. Why shunt compensation is always attempted at midpoint of transmission line?

3. What are the advantages of slope in SVC dynamic characteristics?

4. Define effective short circuit ratio of SVC.

5. What is Bang–Bang control in TCSC?

6. What are the advantages of TCSC?

7. What is meant by SSR?

8. Mention the advantages of STATCOM.

9. What is meant by coordination of FACTS controllers?

10. Classify FACTS controller interactions.

PART B — (5 × 16 = 80 marks)

11. (a) Explain the effect of shunt and series compensation on power transmission capacity. (16)

Or

(b) Discuss the possible control action to maintain the voltage at rated value in transmission line. (16)

12. (a) Explain the influence of SVC on regulating AC system voltage for the following cases:

(i) Coupling transformer ignored

(ii) Coupling transformer considered. (16)

Or

(b) Explain the role of SVC in the enhancement of transient stability under sudden change in the operating condition of power system. (16)

13. (a) What is basic principle of TCSC? What are the different modes of operation in TCSC.? Explain them. (16)

Or

(b) Analyze the capability of TCSC in damping the oscillation of power system and explain the role of TCSC in improvement of system stability limit. (16)

14. (a) Explain the operating characteristics and VI characteristics of STATCOM. (16)

Or

(b) Explain the modeling procedure of SSSC in load flow and transient stability studies. (16)

15. (a) Discuss the control coordination of multiple controllers using linear control techniques for power flow control applications. (16)

Or

(b) Investigate in detail about SVC–SVC controller interactions in a large power system. (16)

Reg. No. :

Question Paper Code : 50461

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2017

Seventh Semester

Electrical and Electronics Engineering

EE6004 – FLEXIBLE AC TRANSMISSION SYSTEMS

(Regulations 2013)

Time : Three Hours | Maximum : 100 Marks

Answer ALL questions

PART – A (10×2=20 Marks)

1. What is the need for FACTS controllers ?
2. How is voltage instability identified in the power system ?
3. What is the function of phase angle regulator ?
4. Write the factors to be considered for designing SVC to regulate mid-point voltage.
5. Draw the basic model of TCSC.
6. Mention the applications of TCSC.
7. What is meant by sub synchronous resonance ?
8. State the salient features of STATCOM.
9. What is the need for coordination of FACTS controllers ?
10. How the voltage profile can be improved by making use of SVC ?

PART – B (5×16=80 Marks)

11. a) What are the objectives of line compensation ? Explain the effect of shunt and series compensation on power transmission capacity of a short symmetrical transmission line. (16)

(OR)

b) Draw the phasor diagrams illustrating the concepts of various power-flow control functions by the use of UPFC. Also explain the modeling procedure of UPFC for power-flow studies. (16)

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12. a) Describe the working principle of the two types of Static Var Compensators (SVC) with neat schematic diagrams. (16)

(OR)

b) Explain in detail about the role of SVC in enhancing the steady state power limit and power system damping. (16)

13. a) Draw and explain the block diagram of the variable reactance model of TCSC and hence derive transient stability and long term stability models. (16)

(OR)

b) The particulars of a transmission line are V = 220 V, f = 60 Hz, X = 12 Ω and P_P= 56 kW. The particulars of the TCSC are δ = 80°, C = 20 μF and L = 0.4 mH. Find :

i) The degree of compensation r

ii) The compensating capacitance reactance X_{comp}

iii) The line current I

iv) The reactive power Q_C

v) The delay angle α of the TCSC if the effective capacitive reactance is $X_T = -50\,\Omega$ and

vi) Plot $X_L(\alpha)$ and $X_T(\alpha)$ against the delay angle α. (16)

14. a) With neat sketches, explain the operating principle and V-I characteristic of Static Synchronous Compensator (STATCOM). (16)

(OR)

b) Discuss in detail about the modeling of SSSC in load flow and transient stability studies. (16)

15. a) Describe in detail the power flow control co-ordination of FACTS controllers using Genetic Algorithms. (16)

(OR)

b) Explain the various control attributes for different FACTS controllers. (16)

Reg. No. : 3 1 0 8 1 4 1 0 5 0 2 8

Question Paper Code : 40979

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2018

Seventh Semester

Electrical and Electronics Engineering

EE 6004 – FLEXIBLE AC TRANSMISSION SYSTEMS

(Regulations 2013)

Time : Three Hours Maximum : 100 Marks

Answer ALL questions

PART – A **(10×2=20 Marks)**

1. What is the necessity of compensation ?
2. Which compensator is used for both active and reactive power control ?
3. Mention the role of SVC in preventing voltage instability.
4. Write the factors to be considered for designing SVC to regulate mid-point voltage.
5. What are the advantages of TCSC ?
6. Draw the variable reactance model of TCSC.
7. Write the significance of sub-synchronous resonance.
8. Name the strategies used for controlling the output voltage of STATCOM.
9. What is the need for coordination of FACTs controllers ?
10. What is the main problem with multiple SVCs in a power system network ?

PART – B **(5×16=80 Marks)**

11. a) Explain how a 3-phase delta connected TCR is used to compensate the reactive power of a transmission line with neat diagrams and waveforms. **(16)**

(OR)

b) i) Discuss how the power transfer capability of a transmission line can be improved by using series compensation. **(8)**

ii) Discuss briefly the power flow model of UPFC. **(8)**

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12. a) Describe the working principle of the two types of Static Var Compensators (SVC) with neat schematic diagrams. (16)

(OR)

b) A 400 kV, 50 Hz, 600 km long symmetrical line is operated at the rated voltage.

i) What is the theoretical maximum power carried by the line ? What is the midpoint voltage corresponding to this condition ? (5)

ii) A series capacitor is connected at the midpoint of the line to double the power transmitted. What is its reactance ? (5)

iii) A shunt capacitor of value 450 ohms is connected at the midpoint of the line. If the midpoint voltage is 0.97, compute the power flow in the line corresponding to this operating point. Data : L = 1 mH/km, $c = 11.1 \times 10^{-9}$ F/km. (6)

13. a) Draw and explain the block diagram of the variable reactance model of TCSC and hence derive transient stability and long term stability models. (16)

(OR)

b) The particulars of a transmission line are V = 220 V, f = 60 Hz, X = 12 Ω and Pp = 56 KW. The particulars of the TCSC are $\delta = 80°$, C = 20 μF and L = 0.4 mH. Find i) the degree of compensation r, ii) the compensating capacitance reactance X_{comp}, iii) the line current I, iv) the reactive power Qc, v) the delay angle of the TCSC if the effective capacitive reactance is $X_T = -50\ \Omega$, and vi) plot $X_L(\alpha)$ and $X_T(\alpha)$ against the delay angle α. (3+3+3+3+2+2)

14. a) Explain the principle of operation and V-I characteristics of STATCOM. (16)

(OR)

b) Discuss in detail about the modeling of SSSC in load flow and transient stability studies. (16)

15. a) Describe in detail the coordinated tuning of FACTS controllers using Genetic algorithm for damping power system oscillations. (16)

(OR)

b) Describe the coordination procedure of multiple controllers using linear-control techniques. (16)