ECE 6612: FACTS: Models, Controls and Applications
Term: Fall 2012

Summary of the Course:

The course will present the basic concepts, principles and operation of fast high power electronic controllers known as Flexible AC Transmission Systems (FACTS) that enhance power system stability and effectively increase transmission capacity thus yielding significantly higher flexibility of operation. FACTS controllers are studied in detail from the functional, structural, modeling, control and applications viewpoint. The course concentrates on studying the most common Thyristor Based FACTS controllers, in particular Static Var Compensators (SVC) and Thyristor-Controlled Series Compensators (TCSC), and Voltage-Source Converter (VSC) Based FACTS controllers, specifically the Static Compensator (STATCOM), Static Synchronous Series Compensator (SSSC) and the Unified Power Flow Controller (UPFC). Models for various control strategies and practical applications of these Controllers are discussed.

Objectives:

1. Introduce basic FACTS Controller concepts and applications.
2. Explain the operating principles, modeling and control systems of different FACTS Controllers/Devices
3. Study the influence of measurement systems, network resonances and harmonic interactions on the performance of FACTS control systems
4. Discuss the techniques of practical FACTS controller design for various applications, such as, enhancing power transfer, stability and damping; mitigating sub-synchronous resonance; preventing voltage instability, improvement of HVDC Link Performance, etc.
5. Understand the interactions amongst various FACTS Controllers and techniques for their placement and coordination

Course Outline:

[1] FACTS (8 hours)
  – Need for FACTS in emerging power systems
  – Definitions
  – Types of FACTS
  – FACTS and High Voltage DC (HVDC) Transmission

[2] THYRISTOR-BASED FACTS CONTROLLERS (16 hours)
  ♦ Static Var Compensator (SVC)
      – Functional description and structures
      – Control components and Models
      – Concepts of voltage control
      – Controls and Applications

- ♦ Thyristor Controlled Series Compensator (TCSC)
  - – Functional description and structure
  - – Models
  - – Controls and Applications
- ♦ Thyristor Controlled Phase Angle Regulator (TCPAR)

[3] VOLTAGE SOURCE CONVERTER (VSC) BASED FACTS CONTROLLERS
   (9 hours)
- ♦ Static Synchronous Compensator (STATCOM)
  - – Functional description and structure
  - – Models
  - – Controls and Applications
- ♦ Static Synchronous Series Compensator (SSSC)
  - – Functional description and structure
  - – Models
  - – Controls and Applications
- ♦ Unified Power Flow Controller (UPFC)
  - – Functional description and structure
  - – Models
  - – Controls and Applications
- ♦ FACTS Controllers with Energy Storage

[4] Coordination and placement of FACTS Controllers (3 hours)

TEXTBOOK:

[1] R.M. Mathur and R.K. Varma, "*Thyristor-Based FACTS Controllers for Electrical Transmission Systems*", IEEE Press and John Wiley & Sons, New York, USA, Feb. 2002, ISBN: 978-0-471-20643-9

REFERENCE BOOKS:

[2] N.G. Hingorani and L. Gyugyi, "Understanding FACTS", IEEE Press, New York, USA, 1999.
[3] Y.H. Song and A.T. Johns, eds, "Flexible AC Transmission Systems (FACTS)", IEE Press, U.K., 1999
[4]   "FACTS Applications", IEEE-PES Publication 96TP116-0, 1996.
[5]   "Modeling of Power Electronics Equipment (FACTS) in Load Flow and Stability Programs", CIGRE TF 38.01.08, Technical Brochure 145, August 1999.

Additional Reading Material:
Students will also be provided with a reading list for further information on each topic. This list will be attached at the end of each lecture. The majority of this information will be IEEE Transaction papers which can be accessed from the web through the following uWaterloo online journal website, after login in with your uWaterloo ID number at https://login.proxy.lib.uwaterloo.ca/login:

http://journal-indexes.uwaterloo.ca/results.cfm?resourceType=index&subjectID=171&subjectHeading=Electrical%20%26%20Computer%20Engineering

Marking Scheme

1) Project Report – Study of a FACTS Application: 40%
        The students in the course will be required to do literature search and submit a project report presenting three case studies related to a specific FACTS Controller application assigned to the student.
3) Final examination (Closed Book): 60%

Lecture Delivery Schedule:

There will be 12 lecture sessions in the course, on Thursdays during 1:30-4:30PM. All sessions will be delivered on line.

The date of first lecture will be announced separately.

Final Exam: TBA in December 2012 (2 1/2 hours)

Prerequisites:

Basic understanding of power electronic converters and power systems

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