# EG2120 FACTS and HVDC in Electric Power Systems (7.5 HEC)- VT17

# COURSE SYLLABUS

FACTS (Flexible AC Transmission System) and HVDC (High Voltage Direct Current) transmission are power electronics-based devices whose functions are to enhance the capacity, security and flexibility of power transmission systems. Application of these components in power systems implies an enhancement of transient and voltage stability, increase of power oscillation damping (POD) and improvement of power flow under undisturbed or post-fault conditions. The course starts with a short review of the power system stability challenges, and then discusses the application of the FACTS and HVDC transmission as technical solutions to these challenges. Basic mathematical models and control strategies will be presented to analyze the impact of these devices on power system stability. The software SIMPOW (SIMulation POWer systems) is used in the course. Lectures for the use of the main features of the software are scheduled.

In order to pass this course, the student will need to show, **in a written report and orally**, that he/she is able to

- describe how FACTS and HVDC are designed,
- explain their functions and abilities,
- derive basic mathematical models for these components, and apply these models to load flow, modal analysis and transient stability analysis,
- present and apply different control strategies to these devices,
- present, describe and explain results of simulations about the impact of these devices on power system stability, and power oscillation damping.

Furthermore, the student should critically analyze other student's report and **present his/her analysis in a written report**.

| **Prerequisites** | | **Language** |
|---|---|---|
| EJ2301 | Power electronics | English |
| EG2110 | Power System Stability and Control | |

## Schedule

Please see the course schedule.

## Course structure

The course is given in English, and preliminary includes 12 lectures (24 h), 20 project work hours (40 h) and examination. During the project work hours, the teaching assistants will be available to assist the students with the questions. **Note that teaching assistants will be available only during the project work hours. Participation in the lectures introducing SIMPOW software is mandatory.**

## Course staff

| **Lecturer, Course examiner** | **Lecturer, Course coordinator and Teaching assistant:** |
|---|---|
| Mehrdad Ghandhari | Muhammad Taha Ali |
| mehrdad@kth.se | mtali@kth.se<br>eg2120@ee.kth.se |

| **Lecturer:** |
|---|
| Bertil Berggren |
| bertil.berggren@se.abb.com |

## Course literature

*The Impact of FACTS and HVDC Systems on Transient Stability and Power Oscillation Damping.*

Available online in BILDA.

## Course Registration

To be registered for the course you need to follow the web registration, according to STEX rules. In order to have access to Bilda for this course, the course materials, and to receive a group number (G-number) you need also to send an email to **eg2120@ee.kth.se.** Write G-number in the "subject" of your email, and your name and your email address in the body of your message. **The deadline for requesting a G-number is the day before the first SIMPOW lecture.**

## BILDA – bilda.kth.se

Bilda is an electronic communication platform we use in the course where you find copies of lecture slides, projects, schedule, MATLAB files, etc. Bilda is also the platform where you electronically submit (upload) your report.

## Examination

The examination consists of a project work (home exam) and is divided into three parts: written report, oral presentation and acting as an opponent to assess one of the other project works. Furthermore, there is a compulsory progress presentation (please see the schedule of the course) where the student will show his/her progress in the project work. The students

must do all three parts and the compulsory presentation to get the credits. Table 1 shows how the points are distributed.

| | **Max Points** |
|---|---|
| **Report** | 50 |
| **Presentation** | 30 |
| **Opponent** | 20 |
| **Sum** | **100** |

**Table 1: Distribution of points**

The project work will be done in groups of two people. The course coordinator or teaching assistant **will organize the groups and will assign the respective project work**. Both members of the group must actively work on the project. If the examiner or course staff finds out that one member did not work or did very little **both members will fail the course**. **In case one of the members does not want to work, the other member should inform the case to the examiner or course coordinator.**

**Written Report:** The report should be sufficiently detailed and presented in such a way that a classmate taking the course would be able to follow the line of thoughts and argumentation without difficulties. It is suggested the following structure of the report:

- Abstract
- Introduction
- Theoretical frame
- Simulations and results
- Conclusions
- References

A "Report style format" with guidelines for writing the report is available in the BILDA.

Also available in the BILDA, there is an example paper that can help the students of how the paper should look like.
The report should be submitted via email in **PDF format**. The maximum length of the report is **8 pages** and it should be in **IEEE conference format**.

**Oral Presentation:** The student must orally present his/her report. The presentations are scheduled the day of the examination (see the schedule of the course). It is desirable the student uses a presentation software or transparencies in the presentations. Computer, video beam and overhead projector will be available.
The students have 15-20 minutes maximum to present their project work. Next the opponents have 10 minutes maximum for their questions.

It is suggested that presentations have an outline, an introduction, a body (which can include theoretical frame of the work and simulation results) and conclusions.

A presentation file with guidelines is available for download in the BILDA

**Acting as opponent:** The students will also have the roll as opponent in the presentation of other project work. **Before the final presentation**, the group that has worked in the project

work will receive via email the report for which they will be opponent. The group should then critically analyze the report; evaluate the results; make annotations of errors and incomprehensible or ambiguous text; and prepare the questions for the presentation of the respective project work (it is also reasonable to expect the presentation to generate new questions). **By June 4th , 2017,** the group should submit their review of the report they have been opponent for, their comments about the presentation and finally suggest a grade (**all together maximum 2 pages**).

An "Opponent report" with guidelines for writing the report is the BILDA.

The final grade of the course is given according to Table 2.

| Written Report | Oral Presentation | Role as Opponent | Total points | Grade |
|---|---|---|---|---|
| <25 | <15 | <10 | | F |
| at least25 | at least15 | at least10 | 50-52 | FX |
| at least25 | at least15 | at least10 | 53-59 | E |
| at least25 | at least15 | at least10 | 60-69 | D |
| at least25 | at least15 | at least10 | 70-79 | C |
| at least25 | at least15 | at least10 | 80-89 | B |
| at least25 | at least15 | at least10 | 90-100 | A |

**Table 2: Examination grading table**

Students who have obtained grade **F** or **FX** must contact the course coordinator within the following five days after the examination result is published.

Upon completing the course work and the examination, the students are awarded 7.5 (HEC).