



EH2741

Communications & Control in Electric Power Systems



Course Memo

6 ECTS credits

Overview

Communication and control of power systems is a wide and comprehensive topic including many different engineering fields ranging from power system instrumentation to power system modelling and control systems theory. To manage and optimise the control and operation of the power system, information and control systems are used throughout the power system. Actually, the information and control systems are so tightly integrated with the physical power system, that together they constitute a *cyber-physical* system.

This introductory course provides a wide perspective on the field of communication and control of electric power systems, opening for continued studies in specialised subjects. It goes beyond traditional analytical control systems or power system courses, and focuses on the practical implementation of systems for communication and control. The course is focused on design, implementation and use of information and control systems for control and operation of the physical power system.

Course Objectives

The objective of this course is to give an overview of technologies and concepts used for communication and control of power systems in a wide sense, including generation, transmission and distribution of electric power. After completing the course, the participants shall be able to:

- Describe the functions of the primary equipment in the power system that is relevant for protection, automation and control
- Analyse substations and simple power systems in terms of reliability protection, automation and control needs.
- Describe the functions and architecture of information and control systems used for protection, automation and control of power systems.
- Describe the importance of information & control systems for the ability to connect large amounts of renewable power sources.
- Analyse and develop basic systems for substation automation and protection.
- Analyse and develop basic communication systems for system-wide control from control rooms, e.g. SCADA systems and EMS applications.
- Describe relevant interoperability standards in the field, such as the IEC 61850
- Describe the threats and risks associated with the use of information & control system for controlling the electric power system, known as Cyber Security.

Prerequisites

The course has no explicit pre-requisites, but it is assumed that course participants have completed a Bachelors degree in Electrical Engineering, computer science or related a topic and are eligible for studies on the Master level.

Course Structure

The content of the course is focused on practical implementation aspects of communication and control systems. This means that most of the course content is centered on developing solutions to practical problems utilising methods and tools from differens fields. The course is divided into three modules:

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- Power System Control and Protection
 - Substation Automation Systems
 - Power System Communication

Each course module corresponds to 2 ECTS credits, the examination for these three modules is described below.

Lectures and Exercise sessions

The lecture series constitutes 13 Lectures, 6 exercises and 2 lab configuration sessions. Participation in the lecture series is recommended. For each lecture there is recommended reading, either a book chapter excerpt or scientific articles. It is highly recommended that course attendees read these texts before the lectures based on the provided reading guidance. Please note that contents from the reading materials ARE included in the tests.

During the course, voluntary project Q&A sessions are arranged. During these sessions, the students are encouraged to work with their assignments in the classroom and teachers are available to answer questions.

Power System Control Assignment (group)

The power system control assignment is performed using the ARISTO simulator. The questions for the assignment are to be answered according to the instructions in the assignment text and uploaded on the Canvas platform.

The Power System Control Assignment is conducted in groups of three (3) students per group.

Project Assignment (group)

The project assignment involves two parts:

In part 1, students are required to design a substation automation system including selecting measurement devices, designing protection scheme, and communication substation automation. Part 1 is concluded with a practical configuration assignment, in which parts of the designed system is implemented in real controllers.

In part 2, students are required to design an information and communication systems architecture for communication between substations and control centres. Part 2 is also concluded with a practical configuration assignment where the practical communication implementation is studied and analysed.

The project is conducted in groups of three (3) students per group.

Tests (individual)

The course also contains **two** voluntary tests covering the theoretical concepts covered in the lectures, exercises and projects. The tests are individual, and voluntary. Participation in the tests is however a pre-requisite for achieving higher grade than E.

Course Administration

All course materials can be downloaded at Canvas and project assignments must be submitted on Canvas before the corresponding deadlines published therein. Course updates, schedule changes etc. will continually be posted on the KTH canvas, please check regularly.

Literature

The course literature consists of a course book entitled:

“Power System SCADA and Smartgrids” by Mini Thomas & John D McDonald, available in the KTH eLibrary.

This book provides an overview to the field, and in addition to this course book, additional reading will be provided either online or as hand-outs on the lectures. Already now, these include:

Course Schedule

Date, Time		Description	Reading	Teacher
Tuesday 15 January 15-17 U31	Lecture 1	Course Introduction <ul style="list-style-type: none"> • Frequency & Voltage control • Communication & Control Systems 		LN
Wednesday 16 January 10-12 U41	Lecture 2	Primary Equipment <ul style="list-style-type: none"> • Substation topologies • Instrument transformers 		LN
Friday 18 January 15-17 V38	Lecture 3	Power System Protection <ul style="list-style-type: none"> • Measurement setups • Protection Schemes • Protection Principles 		LN
Monday 21 January 15-17 U31	Exercise 1	Power System Protection <ul style="list-style-type: none"> • Protection Settings 		TR
Wednesday 23 January 10-12 L52	Exercise 2	Power System Control <i>Computer exercise using Aristo</i>		MA
Thursday 24 January 08-12 U41	Lecture 4	Control Systems Overview <ul style="list-style-type: none"> • Substation Automation • SCADA/EMS • WAMC 		LN
Tuesday 29 January 10-12 M33	Lecture 5	Substation Automation Systems <ul style="list-style-type: none"> • Introduction to IEC 61850 • System architectures 		LN
Wednesday 30 January	Lecture 6	Substation Automation Systems		LN

10-12 V37		<ul style="list-style-type: none"> Logical Nodes Common Data classes 		
Thursday 31 January 10-12 M33	Exercise 3	Substation Automation Systems <ul style="list-style-type: none"> Building Substation Automation Systems using IEC 61850 		TR
Friday 1 February 23.59		Hand-in Power System Control Assignment		
Monday 4 February 15-17 U31	Lecture 7	Guest Lecture <ul style="list-style-type: none"> IEC 61850 in practice 		Andrea Bonetti
Tuesday 5 February 15-17 U41	Lecture 8	Substation Automation Systems <ul style="list-style-type: none"> IEC 61850 design process 		LN
Thursday 7 February 08-10 L51, L52	<i>Test 1</i>	<i>Voluntary test 1</i>		LN
Lab week Sessions booked separately				
Monday 11 February 15-17 U31	Lecture 9	Communication Systems I <ul style="list-style-type: none"> Communication basics OSI Stack TCP/IP <i>Wireshark Intro</i>		LN
Monday 11 February 23.59		Hand-in Project Assignment 1		
Tuesday 12 February 10-12 Q31	Lecture 10	Communication Systems II <ul style="list-style-type: none"> OSI stack continued TCP/IP networks Topologies <i>Wireshark hands-on</i>		LN

Thursday 14 February 10-12 U51		Cancelled		-
Monday 18 February 15-17 U51	Lecture 11	Substation Communication <ul style="list-style-type: none"> • GOOSE • MMS • SV <i>Wireshark hands-on</i>		LN
Tuesday 19 February 10-12 Q31	Exercise 4	Substation Automation Systems Designing SAS communication systems		TR
Wednesday 20 February 10-12 U41	Lecture 13	Guest lecture Cybersecurity		Pontus Johnson
Monday 25 February 15-17 U31	Lecture 12	Wide Area Communication <ul style="list-style-type: none"> • IEC 60870-5-101/104 • IEEE C37.118 <i>Wireshark hands-on</i>		FH
Tuesday 26 February 15-17 M33	Exercise 5	Wide Area Communication Designing Wide Area Communication Systems		FH
Lab week Sessions booked separately				
Wednesday 27 February 10 – 12 Q34	Lab	Cancelled – used for lab sessions		FH
Monday 4 March 08 – 10 L51,L52	Test 2	<i>Voluntary Test 2</i>		LN
Monday 11 March 23.59		Hand-in Project Assignment 2		

Assessment & Grades

The grading of the course is based on the student achievements in the assignments and on the individual tests.

- The Protection and Control Assignment is graded as Fail or Pass (4 course points). There are no bonus points awarded on the Protection and Control Assignment
- Each of the two parts of the Project Assignment is graded as *Fail*, *Pass* (12 course points) and *Pass with bonus* (13-20 course point).
- There are two individual tests, participation which is on a voluntary basis. Maximum score on each test is 18 course points.

Course grades are only granted to students who pass both parts of the project assignment and the Protection and Control Assignment. Grading of the course is based on the collected course points.

Grade	Course Points
E	28-40
D	41-50
C	51-60
B	61-70
A	71-80

Course Staff

The following persons are active during the course

Lars Nordström	Course Examiner & Lecturer
Fabian Hohn	Course Responsible Project part 2
Tin Rabuzin	Course Assistant Project part 1
Mohamamd Shoaib Almas	Course Assistant Power System Protection & Control exercise