Version 3.0 30 March 2012

EH2740 Computer Applications in Power Systems
Basic Course

Course Syllabus

7.5 ECTS credits

Overview

Control and operation of power systems is a very large and comprehensive topic including many different fields ranging from power system instrumentation to power system modelling and control systems theory.

This introductory course provides a wide perspective on the field, opening for continued studies in specialised subjects. The course is focused on design, implementation and use of information and control systems for control and operation of restructured power systems. Furthermore the course takes the perspective of an organisation managing parts of, or completely integrated, power systems. This means that the topics presented are based on contemporary best-practices at generating companies, transmission system operators and distribution utilities.

The topics covered include several common aspects to technologies and applications utilised for control and operation of power systems. The course also presents similar challenges from other industries using information and control systems to manage a real-time industrial process. Additionally, the course includes introduction to specific challenges and technologies within the areas of generation, transmission and distribution.

Course Objectives

The objective of this course is to give an overview of control and operation 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:

- Perform basic design and evaluation of SCADA system architectures including local systems, communication infrastructure and central systems.
- Describe basic power system instrumentation technologies and principles
- Describe basic power system protection technologies and schemes
- Perform basic fault location analysis
- Analyse and evaluate current processes and technologies employed for control and operation of transmission grids
- Analyse and evaluate current processes and technologies employed for control and operation of distribution networks
- Identify relevant standards in the area of information and control systems and evaluate their application to different areas of power system control and operation.
- Describe cyber-security threats to information and control systems used for power system control and operation.
- Describe future trends in power system control and operation with a focus on new information and control systems technologies.

Prerequisites

The following courses are pre-requisites for this course.

- EG 2020 Power Systems Basic course (mandatory)

Course Structure

The course includes lectures, project assignments, lab work and field trips.

Lectures and Exercise sessions

The lecture series constitutes 16 lectures covering the entire subject area. There are also 2 guest lectures whose content will NOT be included in the exam. Participation in the lecture series is recommended. For each lecture there is recommended reading, either a book chapter excerpt or and 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 and that will be decided during the course.

During the course, voluntary project hours are arranged. During these sessions, the students could work for their assignments at the classroom and teachers are available at their offices for questions.

Project Assignment (group)

The project assignment involves four parts, Part 1, Part 2 and Part 3 together with a presentation with contents of the entire project assignment. In part 1, students are required to design a substation automation system including selecting measurement devices, designing protection scheme, and communication substation automation. In the part 2, students are trained to design ICT architecture for communication between substations and control centers and perform basic calculations in terms of corresponding data volumes for the projected communication channels. The part 3 involves completing a MATLAB code for a Weighted Least Square state estimation problem solved by Newton Raphson methods. Each assignment part corresponds to 1 ECTs.

The students groups are expected to give a 20 minutes presentation about their entire project project assignment. The presentation groups are also expected to do a 10 minutes opposition afterwards. The presentation corresponds to 1.5 ECTS. The evaluation of the assignment report is based on the criteria listed in Appendix 1. The evaluation of the presentation is based on the criteria listed in Appendix 2.

Substation Automation Systems Configuration Lab (group)

Compared to SCADA, substation automation connected to electrical equipment to monitor, protect and control the process. This lab involves configuring automation devices using the communication services defined in the IEC 61850 standard to implement a high-level protection function where process information, signals and commands are exchanged over an Ethernet link.

This lab is performed in the same groups that the students were assigned for the project assignments and will be held at the department lab on Osquldas väg 12, floor 7 (Q building). This lab work corresponds to 1.5 ECTS.

SCADA Data Engineering Lab (group)

The SCADA Data Engineering Lab involves configuring a SCADA system, including building a substation model and assigning measurements to the model and constructing user images.

This lab is performed in the same groups that the students were assigned for the project assignments and will be held at the department lab on Osquldas väg 12, floor 7 (Q building). This lab work corresponds to 1.5 ECTS.

Study Visits

The study visits to Vattenfall and Svenska Kraftnät (Swedish National Grid) are voluntary and are scheduled as indicated in the course schedule below.

Course Administration

All course materials can be downloaded at KTH social and project assignments must be submitted to zhuk@ics.kth.se before the corresponding due dates. Course updates, schedule changes etc. will continually be posted on the KTH social, please check regularly.

Course Schedule

Date, Time		Description	Paper	
Tue 20 March 10.00 – 12.00	L1	Introduction • Course administrations • Computer applications for power systems		ZK&LN
Wed 21 March 15.00 – 17.00	L2	Power system apparatus • Substation scheme • Apparatus	#1 #2(10.2)	ZK
Tue 27 March 10.00 – 12.00	L3	Power system protection I • Principles	#11	MS
Thu 29 March 15.00 – 17.00	L4	Power system protection II • Fault location • Exercises		MS
Fri 30 March 15.00-17.00	L5	Substation automation systems I • RTU, IED, PMUs • Exercises on substation automation systems	#3	NH
Wed 10 April 10.00 -12.00	L6	Substation automation systems II • Information modelling in general • Information modelling for power industry • Data structure basic	#5	NH
Thu 12 April 15.00-17.00	L7	Substation automation systems III	#4 #10	NH
Book your lab work time with Yiming	Lab 1	Substation automation system configuration		YW
Fri 13 April 8.30-12.00	Study visit 1	Vattenfall substation		NH&ZK
Mon 16 April 09.00-10.00	Test 1	Substation		
Mon 16 April	Hand-in	Project assignment part 1		
Tue 17 April	L8	SCADA	*#3 (2.6)*	ZK&YW

10.00 – 12.00		• Architecture • Alarm handling • Lab 2 demonstration		
Wed 18 April 15.00 – 17.00	L9	Communication network I • Computer communication basics • OSI	*#6*	NH
Tue 24 April 10.00 – 12.00	Lab 2	Session I		YW
Thu 26 April 15.00 – 17.00	L10	Communication network II • Relate to power system operation control • Exercise	*#6*	NH
Fri 27 April 08.00 – 10.00	L11	Communication network III • Assignment tutorial	*#6*	NH
Thu 03 May 15.00 – 17.00	Guest lecture 1	Cyber-security for power industry	#7	HH
Fri 04 May 08.00 – 12.00	Lab 2	Session II		YW
Tue 08 May 10.00 – 12.00	Guest lecture 2	SCADA/DMS		KM
Thur 10 May 23.59	Hand-in	Project assignment part 2		
Wed 09 May 15.00 – 17.00	L12	Power grid operation principles: • Transmission • Distribution	#3 (2.2-2.6)	ZK
Mon 14 May 09.00 – 10.00 L41	Test 2	SCADA and communication network basics		
Mon 14 May 15.00 – 17.00	L13	Power system state estimation I	#8	ZK
Tue 15 May 10.00 – 12.00	L14	Power system state estimation II • Exercise • Assignment tutorial	#8	ZK
Tue 15 May	L15	Common information model	#9	ZK

13.00 – 15.00				
Wed 16 May 13.00 – 17.00	Study visit	SvK		ZK
Tue 22 May 10.00 – 12.00	L16	Course wrap-up		LN
Wed 23 May 15.00-16.00	Test 3	Power system operation, State estimation and Common information model		
Wed 23 May 16.00 – 17.00		Project hours for assignment, teachers and teaching assistance are available for questions.		ZK
Wen May 25 23.59	Hand-in	Project assignment part 3		
TBD		Presentations		ZK
TBD		Presentations		NH

Assessment & Grades

The grading of the course is based on the student achievements in the assignments

- Each part of the project assignment is graded as Fail, Pass (6 course point) and Pass with bonus (7-10 course point)
- There are three tests whose participation is on a voluntary basis. Each test corresponds to 10 course point
- Presentation and opposition is graded as Fail, Pass
- The Substation Automation Systems Configuration Lab is graded as Fail and Pass
- The SCADA Data Engineering Lab is graded as Fail and Pass

Course grades are only granted to students who collect all 7.5 course credits. Grading of the course is based on the collected course points.

Grade	Course Points
E	18-24
D	25-31
C	32-39
B	40-46
A	47-60

Course Staff

The following persons are active during the course

Lars Nordström	Course examiner		larsn@ics.kth.se
Zhu Kun	Course responsible/Lecturer	08 790 6829	zhuk@ics.kth.se
Nicholas Honeth	Lecturer	08 790 6826	nicholash@ics.kth.se
Murari Saha	Lecturer		murari.saha@se.abb.com
Yiming Wu	Lab responsible		yiming.wu@ics.kth.se
Hannes Holm	Guest lecturer	08 790 6826	hannesh@ics.kth.se
Kim Malmberg	Guest lecturer		kim.malmberg@netcontrol.com

Appendix I

Writing instructions

1. The students are expected to perform thorough analysis and make relevant assumptions.
2. The project assignment report are expected to be written following the general structure of scientific articles as:
    - Introduction/Background information
    - Objective definition
    - Experiment Set-up
    - Observations
    - Analysis
    - Conclusion and future works
3. The assignment reports are expected to be written in a detail that the students from the same class are able to follow.

Appendix II

Presentation instructions

1. The presenters are expected to prepare their own slides. All group members must speak.
2. The speakers are expected to show their energy and create an interactive atmosphere with audience during the speech.

   Tips:

   - Eye contact
   - Rhythm/volume/speed of the speech
   - Body language
   - Make pauses for audience to digest your information
3. The presentations are expected to be held with a clear structure that could be followed by audience together with smooth transitions between each part.

   Suggested structure:

   - Presentation agenda
   - Introduction
   - Analysis
   - Conclusion
4. The speakers are expected to show their conceptual understanding of certain abstract terminologies.

   For instance:

   "Eigenvalues" is a mathematical terminology that captures the behaviour of oscillation in power systems.
5. The speakers are expected to demonstrate their capability to describe particular objectives from function and technology perspective. The targeted audience are experts in fields of power industry but not necessary to be electric power engineers.
6. The speakers are expected to do opposition for two assigned groups. During the opposition the opponent are expected to give constructive feedbacks to the speakers in terms of presentation structure and materials and raise at least one question about presented content. Important, please show courtesy to other groups.