Master’s Programme in Electric Power Engineering (TELPM)

Patrik Hilber

Programme Director

hilber@kth.se

Agenda

- Presentation
- The programme
- Trodden path
- A few things to think about (objectives, language, emails, etc)
- Courses to read
  - Electromagnetic Engineering (ETK), Hans Edin (14:15-14:25)
  - Electric Power and Energy Systems (EPE), Mikael Amelin (14:30-14:50)
- Registration

Patrik Hilber

-Docent
-Head of the RCAM research group
-Deputy director of the research center SweGRIDS
-Likes hunting

You
-Name
-BSc university
-Something else

School of Electrical Engineering

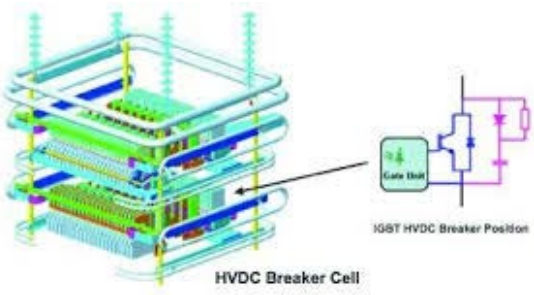
- **One of ten schools at KTH**
- **EE School in numbers**
  - 445 employees:143 teaching staff, 252 doctoral students, 50 tech and admin staff.
  - 200 PhD Students
  - 800 BSc & MSc Students.
- **Focus areas**
  - Power Systems, Power Electronics, Control Systems, Signal Processing, Communication Systems,

QS WORLD UNIVERSITY RANKINGS

#16 - #17 Electrical Engineering

These days, we…

Monitor the Power System using iPad apps



Develop cutting edge HVDC components

Harness Lightning to protect grid components

Build and test Electric roads

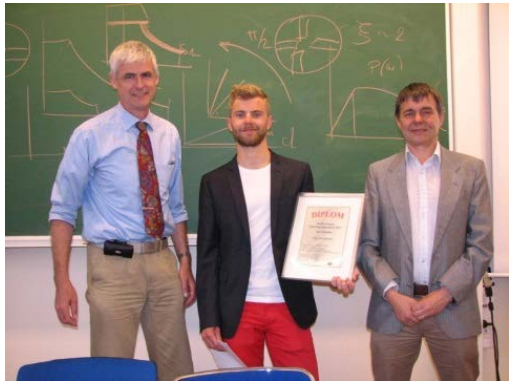
Develop leaders in the IEEE

Develop the Smart Grid on Gotland Island

Our Students….

Build hybrid cars that attract attention

Get a healthy mix of theory and practice



Win Awards

Work hard & Have fun

Get great jobs!

The Program in Brief

Covers all major fields in Electric Power Engineering

Systems and components where electricity is principally used to transfer energy.

Understanding, modelling and analysing individual components as well as power systems

- Design
- Operation
- Control

- > academic research career
- > professional career in industry.

This programme covers the following subject areas:

1. Electric Power Systems (focusing on power system dynamics, stability and control, and on electricity markets)
2. Information and Control Systems (focusing on planning, operation, and control of electric power systems)
3. Electrotechnical Design (focusing on the physical and technical fundamentals for design and maintenance of electrical low and high voltage components, equipment and systems) ,
4. Electrical Drives (focusing on electrical machines and power electronics).

Overview of the Program

Project 9 hp | Project 9 hp | Project 9 hp | Project 9 hp

Completely free
27 ECTS

Advanced Electrical Power Engineering
At least 22,5 ECTS

Mandatory!

Complementary courses
10,5 ECTS

Basic Electric Power Engineering
At least 24 ECTS

Power at EE School

- **Power markets, system performance and regulation**
  Söder, Hesamzadeh, Amelin,
- **Power system stability and control, Hybrid AC/DC system control and operation**
  Ghandhari, Vanfretti, Berggren(ABB)
- **Communication & Control for Power Systems, Cybersecurity, Distributed control**
  Nordström, Ekstedt, Ericsson (SvK),
- **Power System reliability, Reliability centered asset management**
  Bertling, Hilber
- **Power Electronics, Multi-level converter technologies, HVDC applications**
  Nee, Norrga, Harnefors (ABB)
- **Electric drives for hybrid applications, permanent magnet drives, electric traction,**
  Wallmark, Leksell, Östlund
- **Multiphysics modeling, EMC electromagnetic compatibility, lightning**
  Thottapillill, Månsson, Becerra, Norgren
- **Highvoltage, Insulation materials, Electromagnetic modeling,**
  Engdahl, Edin, Wang (ABB)

First set of courses

Conditionally elective 1 - Basic Courses		*24*				
EG2100	Power System Analysis	6	1/1-2	x	x	
EG2200	Power Generation Operation					
	and Planning	6	1/1-2	x	x	
EH2741	Communications and Control					
	in Power Systems	6	1/1-2	x	x	
EI2436	Power Grid Technology					
	and Substation Design	6	1/1-2	x	x	
EJ2301	Power electronics	6	1/1-2	x	x	
EJ2201	Electrical machines and drives	6	1/1-2	x	x	

The complementary courses

Complementary (Mandatory)		*10,5*					
EH2220	The Sustainable Electric Power Engineer	3	1-2 /1-4	x	x	x	x
AK2036!!	Theory and Methodology of Science	7,5!!	1/3			x	

Advanced Electric Power Engineering - I

Conditionally elective 2 - Advanced Courses		*22,5*					
EG2110	Power System Stability and Control	7,5	1/3			x	
EG2120	FACTS and HVDC						
	in Electric Power Systems	7,5	1/4				x
EG2210	Electricity Market Analysis	7,5	1/3			x	
EG2220	Renewable Generation						
	in Electricity Markets	7,5	1/4				x
EG2311	Electric Power Systems						
	Research Project, part 1	7,5	1/4				x
EG2312	Electric Power Systems						
	Research Project, part 2	7,5	2/1-2	x	x		
EG2340	Wind Power Systems	7,5	2/1-2	x	x		
EG2410	Hybrid System Modeling						
	and Simulation	7,5	1/3-4			x	x
EG2420	Monte Carlo Simulation						
	Theory and Project	7,5	2/1-2	x	x		
EH2745	Computer Applications in Power Systems	4,5	1/4				x
EH2770	IT Management						
	with Enterprise Architecture I	7,5	1/4				x
EI2452	Reliability Evaluation						
	of Electrical Power Systems	7,5	1/4				x

Advanced Electric Power Engineering- II

EI2455	Smart Electrical Networks and Systems	7,5	1/2-4		x	x	x
EI2437	Advanced measurements in electrotechnical systems	7,5	2/1-2	x	x		
EI2439	Power System Protection	6	2/1	x			
EI2430	High-voltage Engineering	7,5	1/4				x
EI2433	Electrotechnical Modelling	7,5	1/2		x		
EI2440	Electrotechnical Design	7,5	1/3			x	
EI2490	Seminar course in electrotechnical design and high voltage equipment	1,5	1/3-4 2/1-2	x	x	x	x
EJ2222	Design of Electrical Machines	7,5	2/1	x			
EJ2230	Control in Electrical Energy Conversion	6	1/4				x
EJ2311	Modulation of Power Electronic Converters	6,0	1/3			x	
EJ2420	Seminars in Electrical Machines and Power Electronics	1,5	1/3-4 2/1-2	x	x	x	x
EJ2430	Electric Transportation	6	1/4				x
EL2450	Hybrid and Embedded Control Systems	7,5	1/3				
EP2120	Internetworking	7,5	2/1	x			
EP2500	Networked Systems Security	7,5	2/2		x		

+All courses from the block Basic Courses

Project Courses & Master Thesis

Change in progress…

Conditionally elective 3 - Project Courses		*9*				
EH2751	Distributed Control in Power Systems, project course.	9	2/1-2	x	x	
EI2520	Electromagnetic Engineering, project course	9	2/1-2	x	x	
EJ2120	Electric Energy Conversion, project course	9	2/1-2	x	x	
EG2330	Power System Design, project course	9	2/1-2	x	x	

Mandatory - Master thesis						
E****X	Degree project in ****	30	2/3-4		x	x

Trodden paths

Electrical Energy Conversion (Juliette Soulard)
EJ2201 Electrical Machines and Drives, 6 hp
EJ2301 Power Electronics, 6 hp
EG2100 Power System Analysis, 6 hp

EJ2311 Modulation of Power Electronic Converters, 6 hp
EJ2222 Design of Electrical Machines 7.5 hp
EJ2230 Control in Electrical Energy Conversion 6.0 hp

Power System Design and Maintenance (Hans Edin)
EG2100 Power System Analysis, 6 hp
EI2436 Power Grid Technology and Substation Design, 6 hp
EJ2301 Power Electronics, 6 hp

EI2455 Smart Electrical Networks and Systems, 7.5 hp
EI2440 Electrotechnical Design, 7.5 hp
EI2430 High Voltage Engineering, 7.5 hp
EI2452 Reliability Evaluation of Electrical Power Systems, 7.5 hp

Trodden paths II

Power System Control and Operation (Lars Nordström)
EG2100 Power System Analysis, 6 hp
EG2200 Power System Operation and Planning, 6 hp
EH2741 Communications and Control in Power Systems, 6 hp
EJ2301 Power Electronics, 6 hp

EG2110 Power System Stability and Control, 7,5 hp
EG2120 FACTS and HVDC in Electric Power Systems, 7,5 hp
EL2520 Control Theory and Practice, 7,5 hp

Power system economics (Mikael Amelin)
EG2100 Power System Analysis, 6 hp
EG2200 Power Generation Operation and Planning, 6 hp
EH2741 Communication and Control in Power Systems, 6 hp

EG2210 Electricity Market Analysis, 7.5 hp
EG2220 Power Generation, Environment and Markets, 7.5 hp
EI2452 Reliability Evaluation of Electrical Power Systems, 7.5 hp

A bit of advice and info

General

- Source/reference/collaboration
- Grades
  - P/F
  - A, B, C, D, E, (Fx), F
- Period 1-4
  - HT P1, P2 (Aug-Jan)
  - VT P1, P2 (Jan-Jun)
- Time keeping 08:00 or 08:15

What are your learning objectives?

Power systems? Power components? Control system?
Project management? Computational techniques?

I guess a little bit of all and some of it in particular!

BUT

What is the learning from the program itself?

Some aspects that lack a bit of attention if you read the course/programme syllabus

Being able to focus on one main challenge with many smaller challenges. (MSc, courses)

Delay reward.

Make priorities.

Interact.

Meetings

Is there a clear objective

Are all aware of the objective

Are you prepared

Are the others prepared (have they been given the opportunity to prepare)

Email

Subject: Think from the receivers end.

You are to hand in a report in a reliability course:

Subject: Reliability course

or

Subject: EI2452, report 1.0, group B

?

Language

- Practice your English and Swedish.
- Especially written.
- Intermingle, don’t stick to “your” group, use the opportunity
- Use recommended literature
- Take a course in English and/or Swedish

- It is a bit late to catch all in the MSc thesis

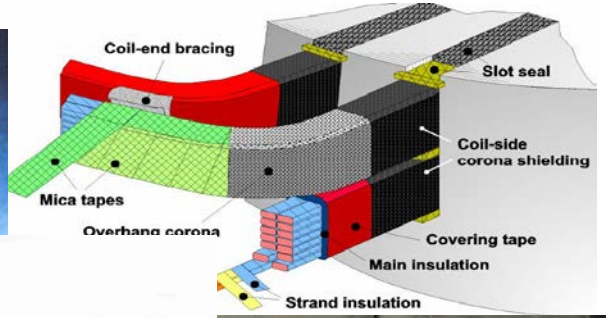
Stick together ;-)

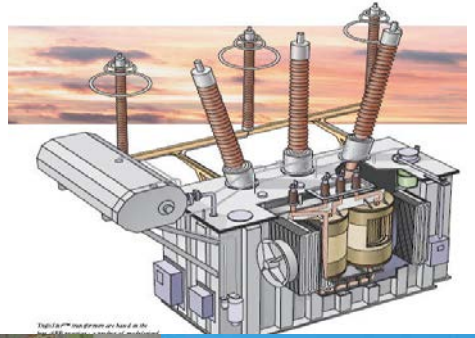
Thank you!

Courses given by Dept. of Electromagnetic Engineering 2016/17 of relevance for TELPM

Hans Edin, KTH, School of Electrical Engineering, Electromagnetic Engineering

It is about the hardware:





Courses suitable for Electric Power Engineering Students or similar

Per 1	Per 2	Per 3	Per 4
EI2436: Electric Power Grid and Substation Design (6 cr)		EI2440: Electrotecnical Design (7,5)	EI2430: High Voltage Engineering (7,5)
EI2439: Electric Power System Protection (6cr)	EI2433: Electrotechnical modelling(6cr)		EI2452 Reliability Evaluation of Electrical Power Systems (7,5)

Electric Power Engineering Courses

Dept. of Electric Power and Energy Systems
Autumn 2016

Dept. of Electric Power and Energy Systems

Research groups

- Management of technology
- Software systems architecture and security
- Power system operation and control
- Power electronics
- Electrical machines and drives
- Integration of renewable energy sources
- Smart transmission systems
- Electricity markets
- Power system operation and planning

EJ2301 Power electronics

Electricity plays a vital role in supplying energy to computers, electronics, industrial processes, trains and many other applications. They all have in common that the electrical energy has to be converted and controlled in a precise manner. This course provides in depth knowledge of power converter topologies, their characteristics and principles for their control. The course also covers the basics of modern power semiconductors.

EJ2301 Power electronics

After completed course the student should be able to

- describe the operating principle for a general power converter by using the basic equations for an inductor and capacitor.
- calculate important measures like average value of output voltage and fundamental content of line current.
- explain different operating conditions.
- outline the control of power converters.
- describe modern power semiconductors, their control and protection.
- dimension and analyze a simple converter both electrically and thermally.

EJ2201 Electrical machines and drives

The course focuses on electrical machines and their important role in modern society, e.g. as traction motors in electric vehicles and generators in hydro power stations.

EJ2201 Electrical machines and drives

After completing the course, the student should be able to:

- describe the fundamental parts of electrical drives including converter, electrical machine and load,
- explain the operating principles of induction machines, synchronous machines and dc machines,
- identify parameters in models of electrical machines,
- use equivalent circuits to analyze electrical machines in steady state,
- construct phasor diagrams for different loads and to use the vector method for analysis of AC machines,
- describe the design of a simple three-phase ac winding and explain the concepts of pole number and winding factor,
- explain the background to voltage harmonics and estimate their influence on e.g. losses in electrical machines,
- use dynamic simulation software to analyze vector control of induction motors.

EG2100 Power system analysis

This course deals with basic models and methods that are used in static analysis of electric power systems. These models and methods are fairly general and can be applied to a power system of any scale ranging from a small-scale distribution grid to a national transmission network.

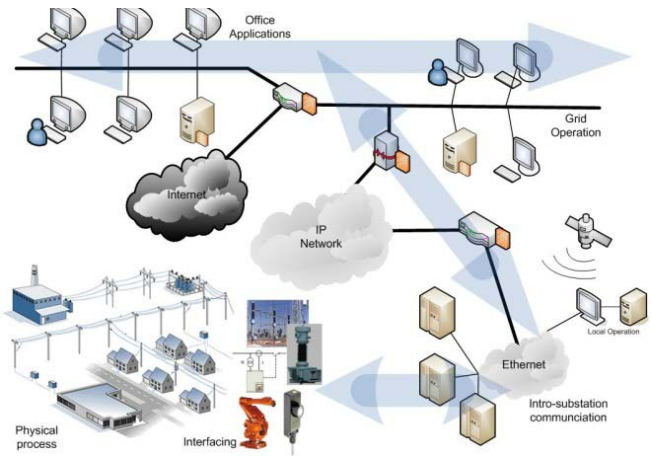
EG2100 Power system analysis

After completing the course, the students should be able to:

- using first principles derive the basic concepts and methods used for power system analysis,
- to construct mathematical models for computing the steady state performance, and basic unbalanced performance of power systems,
- to derive, describe and compare different models of the most common equipment used in power network models.
- using different methods, to compute, analyze, and reflect on the performance of a power system under steady state under symmetrical as well as unsymmetrical conditions.

EH2741 Communication and control in electric power systems

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. The course provides an overview of information and control systems useful to students focusing on other areas of electric power engineering. It also provides an entry point for further studies in communication and control of electric power systems.



EH2741 Communication and control in electric power systems

After the course the student should be able to:

- describe the functions of the primary equipment in the power system that is relevant for protection, automation and control,
- analyze substations and simple power systems in terms of reliability protection, automation and control needs,
- describe the function and architecture of information and control systems used for protection, automation and control of power systems,
- describe the function and architecture of communication systems used for information & control systems for power system control,
- describe the importance of information & control systems for the ability to connect large amounts of renewable power sources,
- analyze and develop basic systems for substation automation and protection,
- analyze and develop basic information & control systems for system-wide control from control rooms, e.g. SCADA systems and EMS applications,
- construct a state estimator for power systems,
- describe relevant interoperability standards in the field, such as IEC 61850 and IEC 61970,
- describe the threats and risks associated with the use of information & control system for controlling the electric power system, known as Cyber Security.

EG2200 Power generation operation and planning

The aim of the course is that the students learn methods and models for operation, planning and analysis of electric power generation. The course comprises background information about possible ways to design an electricity market, computation methods (for example applied optimisation theory and reliability analysis) as well as examples from reality. The course covers five main topics: a basic description of electricity markets, electricity pricing, frequency control, short-term planning of power generation, as well as simulation of electricity markets.

EG2200 Power generation operation and planning

To pass the course, the students should show that they are able to

- describe the principles of how an electricity market can be organised,
- perform rough estimations of electricity prices as well as analyse factors that have a large importance for the electricity pricing, and to indicate how these factors affect for example producers and consumers,
- explain how the balance between production and consumption is maintained in an electric power system, calculate how the frequency is affected by various events in the power system and design the frequency control so that there are sufficient margins in the power system,
- formulate short-term planning problems of hydro-thermal power systems,
- apply probabilistic production cost simulation to calculate the expected operation cost and risk of power deficit in an electricity market, and to use the results of an electricity market simulation to judge the consequences of various actions in the electricity market,
- give a short oral presentation of the solution to a problem within operation and planning of power generation.