REM master basic syllabus

Title:
ELK10 Quality of supply in electrical power systems

Credit value:
3.75 ECTS

Mandatory/Optional:
Optional

Semester:
3

Lecturer/s:
Adjunct Professor Kjell Sand

University:
NTNU- Norwegian University of Science and Technology

Department:
Department of Electric Power Engineering

Rationale:
For decades, the society's dependency on the availability of electric power and the usability of the power delivered has increased. Quality of the electricity supply is the collective effect of all aspects of performance in the supply of electricity and is a fundamental element in the design and operation of electrical power systems. The quality of the electricity supply includes security of electricity supply as a prerequisite, reliability of the electric power system, power quality (voltage quality) and customer relationships. Over the years, the emission of disturbances have increased (e.g. by REM use of power electronics) and the immunity of equipment has decreased due to REM use of electronics which emphasis the need for good knowledge and training in the quality of supply domain. Distributed generation, EV charging, REM power-demanding appliances are all imposing new challenges, especially for electrical distribution systems, which need to be handled in a socio-economic optimal way to avoid excessive costs to burden the network customers.

Objectives:
The course covers the technical elements of quality of supply i.e., power quality (voltage quality) and power system reliability with the objective to give an overview of the different quality of supply phenomena, their physics, analysis, and mitigation. Legislation and standards that give requirements or limits for various quality of supply phenomena is also covered as well as quality of measurements and problem solving (diagnosis).

Skills: *(according to the list of skills provided)*

Subject skills	**REM Master Skills**						
	L2.1	**L2.2**	**L2.3**	**L2.4**	**L2.5**	**L2.6**	**L2.7**
L3.1. To show a good physical understanding of the different phenomena within power quality including their respective definitions	X						
L3.2. To demonstrate knowledge about voltage quality requirements given in codes and standards	X				X		X
L3.3. To be perform simple power quality analysis based on simplified single line diagram equivalents	X	X	X				
L3.4 To show basic skills in power quality problem diagnosis and mitigation.			X				X
L3.5 To gain understanding of the basic principles of reliability of engineering systems, and be able to apply them to power systems.			X			X	X
L3.6 To compute the various reliability indices of distribution systems.	X		X				

Teaching and learning methods:

The course methodology includes:

1. Lecture format with oral and audiovisual presentations.

2. Exercises.

3. Seminars of invited speakers.

Allocation of student time:

	Attendance (classroom, lab,…)	**Non attendance (lecture preparation, self study…)**
Regular Lectures	20 hours	34 hours
Classroom practice	0 hours	22 hours
Guest lectures	4 hours	4 hours

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Assessment:

Procedures for assessment of the course:

- *There will be a final exam, with 100% weightage.*

Note: The Assessment rules might vary from year to year. The students will be notified at the beginning of the semester of such changes.

Assessment Matrix:

Subject skills	**Assessment method**				
	Exam	**Presentation**	**Paper**	**…**	**…**
L3.1.	100%				
L3.2.	100%				
L3.3.	100%				
L3.4.	100%				
L3.5.	100%				
L3.6.	100%				

Programme:

Topic 1	● Overview of the course ● What is quality of supply Distribution (2 h)
Topic 2	Supply voltage variations ▪ Definition ▪ Physical description ▪ Sources for supply voltage variations ▪ Requirements and mitigation Distribution (2h theory + 2 h exercise)
Topic 3	Voltage dips ▪ Definition ▪ Physical description ▪ Sources for voltage dips ▪ Requirements and mitigation Distribution (2 h theory + 1 h exercises)
Topic 4	Rapid voltage changes – flicker ▪ Definition ▪ Physical description ▪ Sources for rapid voltage changes ▪ Requirements and mitigation Distribution (2 h theory)
Topic 5	Power system harmonics ▪ Definition ▪ Physical description ▪ Sources for power system harmonics ▪ Requirements and mitigation Distribution (3 h theory+ 2h exercises)
Topic 6	Voltage quality unbalance ▪ Physical description ▪ Sources for power system harmonics ▪ Requirements and mitigation Distribution (1 h theory + 1 h exercise)
Topic 7	Voltage quality measurements and customer complaint management ▪ Measurement devices and features ▪ Manage procedure – good practice ▪ Examples from real complaint cases Distribution (4 h theory)
Topic 8	Introduction to Reliability ▪ Reliability block diagrams, Markov models. ▪ Introduction to power system reliability and security of supply ▪ Power system reliability management Distribution (4 h theory)
Topic 9	Distribution System Reliability ▪ RELRAD method of computing reliability indices for distribution systems Distribution (4 h theory + 2h exercises)

Resources:

Classroom, Blackboard, laptop, projector, audio, computer room.

All the material necessary to follow the course is facilitated by the course instructors during the course, through 'eLS' (e-Learning System) platform (known as 'Blackboard).

Bibliography:

The written material used in the course are the following:

- Handouts of power point presentations
- Voltage Characteristics of Electricity Supplied by Public Electricity Networks, CENELEC standard EN 50160.
- A guide to voltage quality planning, SINTEF Technical Report TR A 7290, 2012
- The Norwegian PQ Code
- R. Billinton, Reliability Evaluation of Power Systems, second edition, Plenum Press, New York 1996.

Further comments:

Deviations: Since the teaching and learning processes are adaptive, there may arise minor deviations in the course schedule and content.