# Course description



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|---|---|---|---|---|---|---|
| **Department/Unit /** | KEE / PJS | | | **Academic Year** | 2021/2022 | |
| **Title** | Power system transients | | | **Type of completion** | Exam | |
| **Accredited/Credits** | Yes, 4 Cred. | | | **Type of completion** | Combined | |
| **Number of hours** | Lecture 2 [Hours/Week] Tutorial 2 [Hours/Week] | | | | | |
| **Occ/max** | Status A | Status B | Status C | **Course credit prior to** | YES | |
| **Summer semester** | 0 / - | 0 / - | 0 / - | **Counted into average** | YES | |
| **Winter semester** | 1 / - | 3 / - | 0 / - | **Min. (B+C) students** | 10 | |
| **Timetable** | Yes | | | **Repeated registration** | NO | |
| **Language of instruction** | Czech, English | | | **Semester taught** | Winter semester | |
| **Optional course** | Yes | | | **Internship duration** | 0 | |
| **Evaluation scale** | 1\|2\|3\|4 | | | **Ev. sc. – cred.** | S\|N | |
| **No. of hours of on-premise** | | | | | | |
| **Auto acc. of credit** | Yes in the case of a previous evaluation 4 nebo nic. | | | | | |
| **Periodicity** | | | | | | |
| **Substituted course** | None | | | | | |
| **Preclusive courses** | N/A | | | | | |
| **Prerequisite courses** | N/A | | | | | |
| **Informally recommended courses** | N/A | | | | | |
| **Courses depending on this Course** | KEE/SNPRS | | | | | |

## Course objectives:

To get experience and skills in solving of the influence of non-stationary situations of synchronous machine in symmetrical and asymmetrical transient processes on electric power system, knowledge about transient effects in electric power system.

## Requirements on student

Credit: Demonstration of knowledge from lectured and exercises.
Examination: Written and verbal part.

## Content

Lectures:
1. Transient processes occurring in power and electricity systems according to time constants, character of physical and mathematical description and model substitutions of electrical components. Subtransient, electro-magnetic and electromechanical events with practical examples and possibilities of neglecting some physical components for each case.
2. Description of basic electromagnetic processes in three-phase symmetric systems. Analytical solution and introduction of basic parameters of time process - types of substitute effective values and time constants.
3. Solution of failure conditions in topologically complex systems. Introduction of simplifying assumptions, examination of current conditions by the superposition of active fault-free and passive fault network using the system description by the admittance and impedance matrix. Algorithm for voltage state examining before failure.
4. Introduction of the symmetric component systems method for the solution of asymmetric faults in power systems. Specification of the characteristics and parameters of lines, transformers and rotating machines for both the non-rotating and the reverse sequence systems.
5. Application of the method of interconnected symmetric component systems for unbalanced fault problems. Comparison of sizes and time courses of individual types of unbalanced short-circuit currents with three-phase case and each of them mutually. Software solution of component systems method.
6. Specifics of asymmetric transient ratios in systems with isolated and compensated zero point. Detailed analysis of capacitive transients during intermittent earth connections.
7. Mathematical model and phasor diagram of synchronous alternator during electromagnetic and electromechanical

transient processes. Transient and subtransient reactance parameters and alternator time constants.
8. Alternator short-circuit state equation, its analytical solution using Park's and Laplace transformations and time-course analysis in the d-q and a-b-c coordinate systems. Breakdown of short circuit current components on stator, excitation and alternator damper according to their frequency and time constants.
9. The concept of active and reactive power transmission stability in the power system. Specifying the stability problem to the SMIB situation of the alternator's cooperation with the large power grid. Electromechanical equations of the system and discussion of its static and dynamic stability.
10. Introduction of dynamic stability criteria of produced active power - method of equivalent energy areas. Analysis of system parameters and active operational activities from a point of view to improve system stability.
11. Detailed investigation of stability by modeling the system and its equation of mechanic movement. Principles of dynamic stability criteria in numerical solution. Software applications suitable for solving electromagnetic transients.

Practicum:
1. Basic elements of the power system, their replacement schemes, technical parameters and the possibility of neglecting partial parameters with respect to the character of the investigated transient process.
2. Identification of replacement schemes parameters of overhead lines, cables, transformers and rotating machines based on technical parameters and basic laboratory measurements.
3. Preparation of complex example of electromagnetic transient solution on transformer. Selection of suitable technical parameters and identification of model parameters.
4. Mathematical differential equations and its analytical solution for transient events corresponding to simplified replacement schemes for operation transformer in no-load and short-circuit states. The obtained results are graphically displayed with the MATLAB tool.
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http://home.zcu.cz/~nohac/PJS

## Fields of study

## Guarantors and lecturers

- **Guarantors:** Doc. Ing. Karel Noháč, Ph.D. (100%)
- **Lecturer:** Doc. Ing. Karel Noháč, Ph.D. (90%), Doc. Ing. Lucie Noháčová, Ph.D. (10%)
- **Tutorial lecturer:** Doc. Ing. Karel Noháč, Ph.D. (90%), Doc. Ing. Lucie Noháčová, Ph.D. (10%)

## Literature

- **Extending:** *http://home.zcu.cz/~nohac/PJS*.
- **Extending:** Venikov, V., A. *Transient Processes in Electrical Power Systems*. Mir Publishers - Moscow, 1977.
- **Recommended:** Mühlbacher, Jan. *Metody řešení přechodných jevů v elektrizačních soustavách I.*. 1. vyd. Plzeň : ZČU, 1993. ISBN 80-7082-087-X.
- **Recommended:** Mühlbacher, Jan. *Metody řešení přechodných jevů v elektrizačních soustavách II.*. 1. vyd. Plzeň : ZČU, 1993. ISBN 80-7082-097-7.
- **Recommended:** Kundur, Prabha S. *Power system stability and control*. c 1994. New York : McGraw-Hill, 1993. ISBN 0-07-035958-X.
- **Recommended:** Ametani, Akihiro. *Power system transients : theory and applications*. Boca Raton : CRC Press, 2014. ISBN 978-1-4665-7784-8.
- **Recommended:** Trojánek, Zdeněk; Hájek, Josef; Kvasnica, Pavol. *Přechodné jevy v elektrizačních soustavách*. 1. vyd. Praha : SNTL, 1987.
- **Recommended:** Hájek, Josef. *Přechodné jevy v elektrizačních soustavách*. 1. vyd. Plzeň : VŠSE, 1983.
- **Recommended:** Mühlbacher, Jan; Noháč, Karel. *Přechodné jevy v elektrizačních soustavách : řešené příklady ke cvičení*. 1.vyd. Plzeň : ZČU, 1994. ISBN 80-7082-169-8.
- **Recommended:** Das, J. C. *Transients in electrical systems : analysis, recognition, and mitigation*. New York : McGraw-Hill, 2010. ISBN 978-0-07-162248-6.

## Time requirements

### All forms of study

| Activities | Time requirements for activity [h] |
|---|---|
| Presentation preparation (report) (1-10) | 24 |

| | |
|---|---|
| Preparation for an examination (30-60) | 30 |
| Contact hours | 52 |
| **Total:** | **106** |

## assessment methods

### Knowledge - knowledge achieved by taking this course are verified by the following means:

Combined exam

### Skills - skills achieved by taking this course are verified by the following means:

Combined exam

Skills demonstration during practicum

### Competences - competence achieved by taking this course are verified by the following means:

Combined exam

Skills demonstration during practicum

## prerequisite

### Knowledge - students are expected to possess the following knowledge before the course commences to finish it successfully:

orient in electrical and mechanical diagrams

formulate the no load, on load and short circuit transformer operation

specify adverse effects and types of short circuits

determine produced power of synchronous alternator and the stability of its operation

### Skills - students are expected to possess the following skills before the course commences to finish it successfully:

calculate the basic steady-state parameters of steady state in electromagnetic and mechanical systems

build basic equations and phasor diagram of synchronous generator in steady state

### Competences - students are expected to possess the following competences before the course commences to finish it successfully:

N/A

N/A

## teaching methods

### Knowledge - the following training methods are used to achieve the required knowledge:

Lecture

Practicum

### Skills - the following training methods are used to achieve the required skills:

Lecture

Practicum

### Competences - the following training methods are used to achieve the required competences:

Lecture

## learning outcomes

### Knowledge - knowledge resulting from the course:

define categories of transient events occurring in power systems

describes basic electromechanical processes in simple and also topologically complex systems by characteristic circuit and system of equations

assesses the applicability of the symmetrical component system method for solving fault states and processes

describes parameters of power system basic components for each individual component systems

builds synchronous alternator equations suitable for solving electromagnetic transients and explains the derivation of parameters including time constants in the dq0 and abc coordinate systems

explains analytical and numerical criteria for assessing dynamic stability of active power transfer in a system of single alternator operating into transmission network

**Skills - skills resulting from the course:**

analyze influence of transient processes of electric power system on its stability and reliability

solve time behavior corresponding to transient effects in electric power system

convert analytical differential description of system behavior by equations into a form suitable for numerical solution and implement it in a suitable software tool

**Course is included in study programmes:**

| Study Programme | Type of | Form of | Branch | Stage | St. plan v. | Year | Block | Status | R.year | R. |
|---|---|---|---|---|---|---|---|---|---|---|
| Applied Electrical Engineering | Postgraduate Master | Combined | Applied Electrical Engineering | 1 | 16 | 2021 | Povinné předměty 3. roč. FEL - obor AEk | A | 3 | ZS |
| Applied Electrical Engineering | Postgraduate Master | Combined | Applied Electrical Engineering | 1 | 16 | 2021 | Povinné předměty 3. roč. FEL - obor AEk | A | 3 | ZS |
| Electrical Engineering and Informatics | Postgraduate Master | Full-time | Electrical Power Engineering | 1 | 16 | 2021 | Povinné předměty 2.ročníku oboru EE | A | 2 | ZS |
| Electrical Engineering and Informatics | Postgraduate Master | Full-time | Electrical Power Engineering | 1 | 16 | 2021 | Povinné předměty 2.ročníku oboru EE | A | 2 | ZS |
| Electrical Power Engineering | Postgraduate Master | Full-time | Electrical Power Engineering | 1 | 20 | 2021 | block VSEE-EE1 | B | 2 | ZS |
| Electrical Power Engineering | Postgraduate Master | Full-time | Power Electronics Technology and Drives | 1 | 20 | 2021 | block VSEE-VT2 | B | 2 | ZS |
| Electrical Power Engineering | Postgraduate Master | Full-time | Electrical Power Engineering | 1 | 20 | 2021 | block VSEE-EE1 | B | 2 | ZS |
| Electrical Power Engineering | Postgraduate Master | Full-time | Power Electronics Technology and Drives | 1 | 20 | 2021 | block VSEE-VT2 | B | 2 | ZS |