

# Syllabus

## "3D Display"

### *Course topic*

3D Display

### *Number of credits*

6 ECTS

### *Course responsible*

National University of Mongolia

Department of Electronics and Communication Engineering

Prof. Dr. Ganbat Baasantseren

### *Course lecturer*

Prof. Dr. Ganbat Baasantseren

Lecture Dr. Nonin-Erdene Dalkhaa

### *Prerequisites*

Physics, Programming, Signal and System, and Mathematics.

### *Learning outcomes*

Upon successful completion of this course students should be able to:

- Understand the principle of 3D displays;
- Compare the advantages and disadvantages of 3D displays;
- Simulate the stereoscopic, integral imaging, and holographic Display;
- Take optic experiments
- Demonstrate those three displays;
- Render 3D object to stereoscopic images and elemental images;

### *Abstract*

We live in the 3D world, however, all most all display is 2D display. In the future, all displays will become a 3D display. Now, many technologies of the displays are developing such as stereoscopic, autostereoscopic displays, integral imaging, holography, and volumetric displays, quickly. This course is known working principle of 3D displays and advantages and disadvantages of the technologies of the 3D display. In the final project, students simulate and demonstrate the Integral Imaging Display and Holographic Display. If who is interesting to improve disadvantages of Imaging Display and Holographic Display, who can study 3D display deeply.

### *Content*

Introduction

Human viewing system and the monocular and binocular viewing human. Disparity and the Depths of Focus and of Field Distance Scaling of Disparity.

1. Stereoscopy: Anaglyph/Color-Encoded, Frame-Sequential/Field-Sequential, Side-By-Side Over-Under/Top-Bottom/Above-Below, Row Interlace/Line Sequential, Multi-view.
2. Projection Technologies: Digital 3D Projection, Digital Micro-Mirror Device, or DLP® Projection, Liquid Crystal on Silicon, LCoS, Single Strip 3D Film Projection, Dual-Strip 3D.

3. Multiplexing Techniques: Time Multiplexing, Wide Band Wavelength Multiplexing, Narrow Band Wavelength Multiplexing, Linear Light Polarization, Circular Light Polarization, Combination of Multiplexing Techniques
4. Filtering Techniques: Active Eye Ware, Wide Band Color Filters, Narrow Band Color Filters, and Polarized Glasses.
5. Autostereoscopic Displays: Lenticular lens, Slanted Lenticular, Switchable Lenslet, Parallax barrier method, Head tracking method
6. Head- and Eye-Tracking: General Eye-Tracking System Design, Camera System, the Eye-Tracking Application, Hardware Design, Comparison with Commercially Available Eye-Tracking Systems.
7. Non-Head Tracked: Multi-view, Light Field Displays, Super Multi-view
8. Volumetric 3D Displays: Translational Motion, Rotational Motion of a Planar Surface, Rotational Motion of a Helical Surface, Static-Volume Techniques, the Ethereal Image Space.
9. Integral imaging: Integral Imaging for Three-Dimensional Display, Computer Generated Integral Imaging, Viewing Characteristics of Integral Imaging, Viewing Angle or Depth Enhancement.
10. Point Light Source Display: Principle Of PLS, Viewing Characteristics Of PLS Display, 3D/2D Convertible Integral Imaging, Viewing Angle or Depth Enhancement.
11. Integral Imaging for Three-Dimensional Information Processing: Geometry of the Pickup System of the Integral Imaging, Extraction of the 3D Information from Elemental Images, Depth Detection.
12. Holographic 3D Displays (1/2): Forming the Holographic Record, Replaying the Holographic Image, Volume Holograms, Phase Holograms, Transfer Holograms, Rainbow Holograms.
13. Holographic 3D Displays (2/2): Focused-Image Holograms, Embossed Holograms, Holographic Stereograms, Pulse Laser Holography, Holography in Color.
14. Floating Image Display (Midair Display): 2D Floating Image Display, Stereo Floating Image Display, Integral Floating Image Display, Holographic Floating Image Display.

#### *Teaching methods*

The theoretical part of the course is presented in lecture room.

The simulation work represents with Python and Matlab.

The practical work represents 3D display laboratory at NUM

In cases on-line support by the tutor is provided.

#### *Assessment*

The course grade consists of these components:

20% – Attendance

40% – Project

40% – Final exam

#### *Recommended reading*

Ernst Lueder, 3D Displays, WILEY, 2012, ISBN: 9781119991519 |Online ISBN: 9781119962762 |DOI:10.1002/9781119962762.

Janglin Chen, Wayne Cranton, and Mark Fihn (ed), Handbook of Visual Display Technology, Springer, 2011, ISBN 978-3-319-14345-3.

# Syllabus

## "Artificial Intelligence and Machine Learning"

### *Course topic*

Artificial Intelligence and Machine Learning

### *Number of credits*

6 ECTS

### *Course responsible*

NUM

Department of Electronics and Communication Engineering

Assoc. Prof. Dr. Lodoiravsal Choimaa

### *Course lecturer*

Assoc. Prof. Dr. Altangerel Chagnaa

### *Prerequisites*

Algorithms, Programming

### *Learning outcomes*

Upon successful completion of this course students should be able to:

- Explain different types of intelligence
- Verify different machine learning techniques, the principles, design, implementation and validation of learning systems
- design and conduct original research in machine learning. Students will also be able to apply machine learning techniques in solving real-life problems.
- be familiar with the use of artificial intelligence and machine learning techniques.

### *Abstract*

Artificial intelligence is the problem of developing computer systems that can carry out complex tasks which people can do easily and almost unconsciously but that have proven extremely difficult to program on a computer. The course will focus on central areas in AI: representation and reasoning, learning, and its applications.

### *Content*

Introduction to artificial intelligence and Machine Learning.

Representation and reasoning:

- Logic and Automated Reasoning
- Reasoning with Uncertainty

Learning:

- Statistical Foundations.
- Decision Tree learning.
- Artificial Neural Networks.
- Support Vector Machines.
- Bayesian Learning.
- Instance based learning.

- Unsupervised learning.
- Reinforcement Learning.

### *Teaching methods*

The theoretical part of the course is presented in the Moodle learning environment in the form of HTML tutorials.

The practical work represents a project for an application AI in some particular topic.

In both cases on-line support by the tutor is provided.

### *Assessment*

The course grade consists of these components:

40% – Knowledge test with a multiple choice questionnaire

60% – Final Project

### *Recommended reading*

Russell, J.S, Norvig, P., Artificial Intelligence- A Modern Approach, Prentice- Hall, Inc., New Jersey, 2nd edition

Mitchell, T., Machine Learning, McGraw Hill, 1997

# Syllabus

## "CMOS VLSI design"

### *Course topic*

CMOS VLSI design

### *Number of credits*

6 ECTS

### *Course responsible*

National University of Mongolia, Ulaanbaatar  
Department of Electronics and Communication Engineering  
Assoc. Prof. Dr. Bolormaa Dalanbayar

### *Course lecturer*

Assoc. Prof. Bolormaa Dalanbayar  
Senior Lect. Battogtokh Jigjidsuren

### *Prerequisites*

Microelectronics technology and design rules, solid state electronics, computer added design in electronics.

### *Learning outcomes*

Upon successful completion of this course students should be able to:

- Understand the fundamentals of CMOS VLSI technologies.
- Demonstrate understanding of static and dynamic behavior of MOSFETs and the secondary effects of the MOS transistor model
- Estimate MOS transistor switching time and its capacitance
- Solve problems in the design of CMOS logic circuits, with particular reference to speed and power consumption.
- Acquire hands-on skills of using CAD tools in VLSI design.
- Appreciate the design process in VLSI through a mini-project on the design of a CMOS sub-system.
- Apply Power reduction techniques possible at circuit , logic level
- Complete a report on laboratory experiments and mini projects
- Assess the relative advantages/disadvantages of new modeling and simulation tools
- Develop abilities to find and locate required information and use information resources

### *Abstract*

This is a graduate level course in VLSI design intended for students with sufficient background in basic VLSI Design. The course will cover advanced aspects of modern circuit design, including: ASIC and FPGA design flow; analysis and design of CMOS circuits; advanced logic synthesis; datapath and arithmetic circuits; memory design; CAD tools, simulation, verification, and testing. Lectures will cover theoretical analysis techniques as well as standard design practices of industry. The assigned labs/projects will help students gain experience with commercial CAD tools. Finally, students will be assigned research papers on selected advanced VLSI topics to present in class for credit

## ***Content***

- Design flow, from behavioral to circuit level
- CMOS technology overview; ASIC and FPGA solutions
- Advanced logic design and synthesis techniques
- Static and dynamic CMOS circuits
- Computer arithmetic, data path designs
- Simulation and formal verification; testing.
- Timing analysis; wiring, layout issues.
- Memory design; SRAM, content addressable memory
- Clocking and advanced latch/flipflop design.
- Transistor level issues: subthreshold operation; gate sizing, stacking.
- Low power design.
- Pipelined designs, parallelism
- Specialized circuits, I/O circuitry
- Special topics: MemRistor, Optical proximity correction (OPC)
- Emerging technologies: FINFET, NanoWires, VISFET, etc.

## ***Teaching methods***

The theoretical part of the course is presented in the Google Classroom environment in the form of pdf tutorials.

The practical work represents a project for design of submicron integrated circuit with a remote access to Nano CMOS tool which run on the <https://nanohub.org/resources/nanocmos> of Purdue University

In both cases on-line support by the tutor is provided.

## ***Assessment***

The course grade consists of these components:

30% – Knowledge test with a multiple choice questionnaire

20% – Design Tool using Project

50% – Final Project

## ***Recommended reading***

- CMOS VLSI Design: A Circuits and Systems Perspective, Weste and Harris, 4th edition, 2011
- Analog VLSI Circuits and Principles, Liu Kramer Indiveri Delbruck, Cambridge 2002.
- Analysis and design of analog integrated circuits, Paul R.Gray,...5<sup>th</sup> edition, 2009
- Design of Analog CMOS Integrated Circuits, Behrad Razave, McGraw-Hill international edition 2001
- Analog VLSI: Circuits Principles, Shin-Chii Liu, .....Cambridge, 2001

# Syllabus

## "Control System"

### *Course topic*

Control System

### *Number of credits*

6 ECTS

### *Course responsible*

NUM

Department of Electronics and Communication Engineering

Assoc. Prof. Dr. Lodoiravsal Choimaa

### *Course lecturer*

Assoc. Prof. Dr. Lodoiravsal Choimaa

Assist. Prof. Dr. Ganbat Baasantseren

### *Prerequisites*

Signals and System

### *Learning outcomes*

Upon successful completion of this course students should be able to:

- Demonstrate an understanding of the fundamentals of (feedback) control systems;
- Determine and use models of physical systems in forms suitable for use in the analysis and design of control systems;
- Express and solve system equations in state-variable form (state variable models);
- Determine the time and frequency-domain responses of first and second-order systems to step and sinusoidal (and to some extent, ramp) inputs;
- Determine the (absolute) stability of a closed-loop control system;
- Apply root-locus technique to analyze and design control systems;
- Analyze existing conditions to identify the true nature of the problem and define critical issues;
- Communicate design results in written reports;
- Design, simulate and implement a control system;
- Work as an effective member or leader of process control project;

### *Abstract*

The course progresses to a detailed discussions on robust control systems and system sensitivity, state variable models, controllability and observability, computer control systems, internal model control, robust PID controllers, and computer-aided design and analysis.

The classical methods of control engineering are thoroughly covered: Laplace transforms and transfer functions; root locus design; Routh-Hurwitz stability analysis; frequency response methods, including Bode, Nyquist, and Nichols; steady-state error for standard test signals; second-order system approximations; and phase and gain margin and bandwidth. In addition, coverage of the state variable method is significant. Fundamental notions of controllability and observability for state variable models are discussed.

## *Content*

### Introduction of Control Systems

1. **Mathematical models of systems**  
Differential Equations of Physical Systems, Linear Approximations of Physical Systems, Laplace Transform, Transfer Function of Linear Systems, Block Diagram Models, Signal-Flow Graph Models, The Simulation of Systems Using Control Design Software
2. **State Variable Models**  
State Variables of a Dynamic System, State Differential Equation, Signal-Flow Graph and Block Diagram Models, Alternative Signal-Flow Graph and Block Diagram Models, Transfer Function from the State Equation, Time Response and the State Transition Matrix, Analysis of State Variable Models Using Control Design Software
3. **Feedback Control System Characteristics**  
Error Signal Analysis, Sensitivity of Control Systems to Parameter Variations, Disturbance Signals in a Feedback Control System, Control of the Transient Response, Steady-State Error, Cost of Feedback, Control System Characteristics Using Control Design Software
4. **The Performance of Feedback Control Systems**  
Test Input Signals, Performance of Second-Order Systems, Effects of a Third Pole and a Zero on the Second-Order System Response, s-Plane Root Location and the Transient Response, The Steady-State Error of Feedback Control Systems, Performance Indices, The Simplification of Linear Systems
5. **The Stability of Linear Feedback Control Systems**  
Concept of Stability, Routh-Hurwitz Stability Criterion, Relative Stability of Feedback Control Systems, Stability of State Variable Systems
6. **The Root Locus Method**  
Root Locus Concept, Root Locus Procedure, Parameter Design by the Root Locus Method, Sensitivity and the Root Locus, Three-Term (PID) Controllers
7. **Frequency Response Methods**  
Frequency Response Plots, Frequency Response Measurements, Performance Specifications in the Frequency Domain, Log Magnitude and Phase Diagrams, Mapping Contours in the s-Plane, The Nyquist Criterion, Relative Stability and the Nyquist Criterion, Time-Domain Performance Criteria in the Frequency Domain, System Bandwidth, The Stability of Control Systems with Time Delays, PID Controllers in the Frequency Domain

### *Teaching methods*

The course organized by flipped classroom. The theoretical part of the course is presented in the OpenedX learning environment. The practical work represents a project for laboratories using NI training tools.

### *Assessment*

The course grade consists of these components:

- 30% – Final exam
- 30% – Project work
- 40% - Lab works

### *Recommended reading*

1. Richard C. Dorf, Robert H Bishop. “Modern Control Systems (11th Edition),” Pearson Prentice Hall
2. Katsuhiko Ogata “Modern Control Engineering (5th Edition),” Pearson Prentice Hall
3. Donald R. Coughanowr, “Process Systems Analysis and Control (2nd edition),” McGraw-Hill

# Syllabus

## "Image Processing and Pattern Recognition"

### *Course topic*

Image Processing and Pattern Recognition

### *Number of credits*

6 ECTS

### *Course responsible*

NUM

Department of Electronics and Communication Engineering

Assoc. Prof. Dr. Lodoiravsal Choimaa

### *Course lecturer*

Assoc. Prof. Dr. Suvdaa Batsuuri

### *Prerequisites*

Probability and statistics, linear algebra, introduction to signal processing and programming skill

### *Learning outcomes*

Upon successful completion of this course students should be able to:

- To understand the fundamentals of image formation.
- To understand the major ideas, methods, and techniques of image processing
- To identify and describe operation of different filters, feature extraction and classification, clustering methods.
- To identify different pattern recognition methods by reading papers
- To analyse the different segmentation techniques
- To apply different de-noising models to recover original image.
- To identify and apply relevant problem-solving methodologies
- To implement and test solutions
- To apply different pattern recognition methods in problem areas.
- To communicate effectively in ways appropriate to the discipline, audience and purpose
- To work as an effective member or leader of diverse teams within a multilevel, multidisciplinary and multicultural setting
- To do research works to use those methods into own thesis.

### *Abstract*

This course will study state-of-the-art techniques for image processing and analysing data. The goal is to apply various image filtering and segmentation methods and to extract meaningful information from feature data. This includes statistical and information theoretic concepts relating to machine learning, data mining and pattern recognition, with applications using Python, C, Java or MATLAB.

This course is intended for computer science and engineering graduate students, but is open to any student with a background in probability and calculus. One additional requirement is some background in programming (preferably including courses on data structures and algorithms) and the willingness and ability to learn Python, C, Java or MATLAB.

## *Content*

Introduction:

### Digital Image Processing and Pattern Recognition

Image Representation and Modelling, Image Enhancement, Image Restoration, Image Analysis, Image Data Compression. Applications of Pattern Recognition, Bayes Theorem, Multiple Features, Conditionality Independent Features, Decision Boundaries, Unequal Costs of Error, Estimation of Error Rates, Kernel and Window Estimator, Nearest Neighbourhood Classification Techniques, Adaptive Decision Boundaries, Adaptive Discriminant Functions. Introduction, Hierarchical Clustering, Partitional Clustering.

#### 1. Digital Image Processing

##### 1.1. Digital Image Fundamentals:

Elements of Visual perception, A simple Image Model, Sampling and Quantization, Some Basic Relationship between Pixels.

##### 1.2. Image Transforms:

Two Dimensional Orthogonal and Unitary Transforms, Properties of Unitary Transforms, One Dimensional DFT, Two Dimensional DFT, Cosine Transforms, Sine transforms, Hadamard Transforms, Haar Transforms, Slant transforms.

##### 1.3. Image Enhancement:

Point Operations, Histogram Modelling, Spatial Operations, Transform Operations.

##### 1.4. Image Restoration and Compression:

Image observation models, Inverse and Wiener Filtering, Pixel Coding, Predictive techniques, Transform Coding of Images.

#### 2. Pattern Recognition

##### 2.1. Feature Selection

Data Preprocessing, Class Separability Measures, Feature Subset Selection, Bayesian Information Criterion, Dimensionality Reduction, Basis Vectors, Singular Value Decomposition, Independent Component Analysis, Kernel PCA,

##### 2.2. Statistical and Non – Parametric Decision Making:

Bayes Decision Theory of Discriminant Functions and Services of the Normal Distribution of Bayesian Classification, Estimating Probability Density Functions, Nearest Neighbour Rules of Bayesian Networks,

##### 2.3. Artificial Neural Networks:

Introduction, Linear Classifiers, the Perceptron Algorithm, Least-Squares Methods, Nonlinear Classifiers, Multilayer Perceptron's, Back Propagation Algorithm

##### 2.4. Tree based methods

Decision Trees, Combinations of Classifiers, Boosting

##### 2.5. Other classification methods

Template Matching, Texture, Shape and Size Characterization, Fractals, Template Matching Using Dynamic Time Warping and Edit Distance

##### 2.6. Clustering

Sequential Algorithms, Hierarchical Algorithms, Functional Optimization-Based Clustering, Graph Clustering, Learning Clustering, Clustering High Dimensional Data, Subspace Clustering, Cluster Validity Measures

## *Teaching methods*

The theoretical part of the course is presented in the course web site as the lecture slides and tutorials in pdf format.

The practical work represents a project for design of object detection, feature extraction and classification/clustering. After completing the project students writes a paper as possible as with new idea.

## *Assessment*

The course grade consists of these components:

30% – Knowledge test with a multiple choices questionnaire and present a reading papers with related topics of own thesis.

70% – Final Project and writing a paper

*Recommended reading*

Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing", Pearson Reprint, 2001.

R. O. Duda, P. E. Hart, D. G. Stork, Pattern Classification, 2nd edition, John Wiley & Sons, Inc., 2000.

Anil K. Jain, "Fundamentals of Digital Image Processing", Prentice-Hall of India, New Delhi, 2001.

S. Theodoridis, K. Koutroumbas, Pattern Recognition, 4th edition, Academic Press, 2009.

*Journal websites:*

1. <https://ieeexplore.ieee.org/Xplore/home.jsp>
2. <https://www.elsevier.com/catalog>
3. <https://www.springer.com>

# Syllabus

## "Solid State Electronics"

### *Course topic*

Solid State Electronics

### *Number of credits*

6 ECTS

### *Course responsible*

National University of Mongolia, Ulaanbaatar  
Department of Electronics and Communication Engineering  
Assoc. Prof. Dr. Bolormaa Dalanbayar

### *Course lecturer*

Assoc. Prof. Bolormaa Dalanbayar  
Lect. Ulziibat Lkhamsuren

### *Prerequisites*

Electronics fundamentals, Microelectronic circuits, computer added design in electronics.

### *Learning outcomes*

Upon successful completion of this course students should be able to:

- Analyse of thermal and electrical properties of solid materials from view of band-structure
- Explain non-equilibrium processes of charge carriers in semiconductors
- Explain processes in basic elements of solid state electronic
- Demonstrate understanding of key concepts involved in semiconductor device operation and their characteristics
- Predict influence of semiconductor properties on device design variations
- Develop analytical approaches to understanding semiconductor devices
- Undertake on-line virtual laboratory experiments
- Application of systematic engineering synthesis and design processes
- Apply appropriate techniques to solve semiconductor device problems
- Complete a report on laboratory experiments and mini projects
- Assess the relative advantages/disadvantages of new modeling and simulation tools
- Develop abilities to find and locate required information and use information resources

### *Abstract*

By studying this course, student will learn semiconductor device physics at the atomic level and learns to use the Schrödinger's equation in band theory of solid state materials theory and electronic transport problems. Also they will learn in some techniques of semiconductor device modeling. And will be able to understand and explain the physical processes used in semiconductor chip design tools.

### *Content*

1. Semiconductors, crystal structure
  - 1.1. Solid-state Materials
  - 1.2. Crystal Lattices
2. Bonding forces and energy bands in solids

- 2.1 Bonding Forces in Solids
- 2.2 Energy Bands
- 2.3 Metals, Semiconductors, and Insulators
- 2.4 Electrons and Holes
- 2.5 Intrinsic Material
- 2.6 Extrinsic Material
- 3.** Distribution functions, Fermi-Dirac statistics, Maxwell-Boltzmann statistics, and carrier concentrations
  - 3.1 The Fermi level
  - 3.2 Electron and Hole Concentrations at Equilibrium
  - 3.3 Temperature Dependence of Carrier Concentrations
  - 3.4 Compensation and Space Charge Neutrality
- 4.** Drift of carriers in electric fields
  - 4.1 Conductivity and Mobility
  - 4.2 Drift and Resistance
  - 4.3 Effects of Temperature and Doping on Mobility
- 5.** Optical absorption and luminescence / Carrier Generation and Recombination
  - 5.1 Optical Absorption
  - 5.2 Direct Recombination of Electrons and Holes
  - 5.3 Indirect Recombination of Electrons and Holes
  - 5.4 Steady State Carrier Generation; Quasi-Fermi Levels
  - 5.5 Steady State Carrier Generation; Quasi-Fermi Levels
  - 5.6 Photoconductive Devices
- 6.** Diffusion of carriers
  - 6.1 Diffusion Processes
  - 6.2 Diffusion and Drift of Carriers
  - 6.3 Diffusion and Drift of Carriers; Built-in Fields
  - 6.4 Diffusion and Recombination
  - 6.5 Steady State Carrier Injection; Diffusion Length
- 7.** p-n junctions in equilibrium, contact potential
  - 7.1 Fabrication of p-n Junctions
  - 7.2 Equilibrium Condition
  - 7.3 The Contact Potential
  - 7.4 Capacitance of p-n Junctions
- 8.** Current flow in a P-N junction
  - 8.1 Forward- and Reverse-Biased Junctions; Steady State Conditions
  - 8.2 Qualitative Description of Current Flow at a Junction
- 9.** Metal semiconductor junctions
  - 9.1 Schottky Barrier
  - 9.2 Rectifying Contacts
  - 9.3 Ohmic Contacts
- 10.** Reverse-bias breakdown
  - 10.1 Reverse-Bias Breakdown
  - 10.2 Zener Breakdown
  - 10.3 Avalanche Breakdown
- 11.** Optoelectronic Devices (Photodiodes)
  - 11.1 Current and Voltage in an Illuminated Junction
  - 11.2 Solar Cells
  - 11.3 Photodetectors

- 11.4 Light-Emitting Diodes
- 12. Metal-insulator-semiconductor FET
  - 12.1 Basic Operation Metal-insulator-semiconductor FET
  - 12.2 The Ideal MOS Capacitor
  - 12.3 Flatband voltage
  - 12.4 Threshold Voltage
  - 12.5 MOS Capacitance-Voltage Analysis
- 13. MOS field-effect transistor
  - 13.1 Output Characteristics
  - 13.2 Transfer Characteristics.
  - 13.3 Small-signal analysis
  - 13.4 Resistive load-NMOSFET-common-source amplifier
- 14. Introduction to bipolar junction transistor BJT specifics
  - 14.1 Introduction to bipolar junction transistor
  - 14.2 Normal mode operation
  - 14.3 Common-emitter amplifier and small-signal current gain

### ***Teaching methods***

The theoretical part of the course is presented in the Google Classroom environment in the form of pdf tutorials.

The practical work represents a project for design of submicron integrated circuit with a remote access to Abacus tool which run on the <https://nanohub.org/resources/nanocmos> of Purdue University

In both cases on-line support by the tutor is provided.

### ***Assessment***

The course grade consists of these components:

- 30% – Knowledge test with a multiple choice questionnaire
- 20% – Design Tool using Project
- 50% – Final Project

### ***Recommended reading***

- Solid state physics for electronics, Andre Moliton, John Wiley & Sons Inc., 2009
- Solid State Electronic Devices, Ben G.Streetman, Sanjay Kumar Banerjee, Pearson, 2009
- Fundamentals of Solid State Engineering, Manijeh Razeghi, Springer Science+Business Media, LLC 2009

<b>Subject</b>	Nanotechnology, Materials Sciences		
<b>Code</b>		<b>Course credit</b>	3
<b>Department</b>	Power energy and Transportation	<b>University</b>	NTU
<b>Previous subject</b>		<b>Courses study with</b>	No
<b>Lecturer</b>	G.Tsermaa	<b>Office</b>	
<b>Email address</b>	<a href="mailto:tsermaa_g@must.edu.mn">tsermaa_g@must.edu.mn</a>	<b>Phone</b>	976-99146855
<b>Assistant</b>			
<b>Courses hours</b>	Total : 144 hours Lecture (32h), Seminar (32 h), Laboratory (0), Self study (80h)		
	<input checked="" type="checkbox"/> Compulsory, <input type="checkbox"/> Elective		
<b>Semester</b>	<input checked="" type="checkbox"/> Any		
<b>Books :</b>			
<ol style="list-style-type: none"> <li>1. В.В. Светухин и др. <i>Введение в нанотехнологий. Модуль Физика</i>, Ульяновск 2008</li> <li>2. Л.К. Каменек и др. <i>Введение в нанотехнологий. Модуль Химия</i>, Ульяновск 2008</li> <li>3. Mongillo, John F. <i>Nanotechnology 101</i>, ISBN-13: 978-0-313-33880-9 Greenwood press, 2007</li> <li>4. Charles P. Poole, Jr.Frank J. Owens, <i>Introduction to Nanotechnology</i>, John Wiley &amp; Sons, ISBN 0-471 -07935-9, 2003</li> <li>5. Gabor L. Hornyak, Joydeep Dutta, H.F. Tibbals, By John J. Moore, <i>Fundamentals of Nanotechnology</i>, CRC Press Inc, 2008</li> <li>6. William D. Callister, Jr.<i>Materials science and Engineering</i>, John Wiley &amp; Sons, ISBN-13: 978-0-471-73696-7, 2007</li> </ol>			
<b>Other materials :</b>			
<ol style="list-style-type: none"> <li>7. Г.Батдэмбэрэл, Н.Ганбямба, Ш.Чадраабал, <i>Нанотехнологийн эхлэл</i>, Улаанбаатар 2011</li> <li>8. Г.Батдэмбэрэл, Н.Ганбямба, Ш.Чадраабал, Г.Цэрмаа, <i>Нанохими ба Наноматериал</i>, ISBN-978-99962-0-735-8, Улаанбаатар 2012</li> <li>9. <i>Нанотехнологи ба наноматериал судлалын үндэс</i>, Г.Цэрмаа, Г.Батдэмбэрэл, Ш.Чадраабал, ISBN999782337-0, Улаанбаатар 2018</li> </ol>			
<b>Course description:</b>			
<p>This course provides introduction of nanostructured materials nanoparticles, fullerene, carbon nanotubes and also methods to obtain them. Besides these introductions, course focuses on characteristics of nanomaterials as well as application. Students obtain a ability to understand achievement of nanoscience. In addition, acquire a deep knowledge in field of nanomaterials science</p>			

Subject plan		
Topics of lecture and seminar	Lecture (hour)	Seminar (hour)
1. Nanaomaterials and their characteristics	2	2
2. Nanopowder	2	2
3. Nanoporous materials, nanoporous carbon, polymer nanocomposite	2	2
4. Smart materials	2	2
5. Electron structure, phase equilibrium, thermodynamics	2	2
6. Properties of conductivity and Optics Characteristics	2	2
7. Mechanics and magnetic properties	2	2
8. Stability, grain growth, diffusion, catalysis	2	2
9. Technology consolidated material	2	2
10. Semiconductor technology	2	2
11. Technology to obtain polymers, porous and biological nanomaterials	2	2
12. Nanoparticles and methods to obtain them	2	2
13. Carbon materials, fullerene, carbon nanotubes	2	2
14. Nanomaterials application	2	2
15. Nanomaterials properties and dimensional effects	2	2
16. Quantum dimensional effects of nanoparticles	2	2
<b>(CLOs)</b>		<b>PLOs</b>
Student will obtain following ability:		
	<i>An ability to apply knowledge of physics chemistry, biology and mathematics science</i>	A1
	An ability to design and contact experiment of determination of nanoparticles and nanomaterials as well as to analyze and interpret data	A2
	An ability to identify formulate and solve nanoscience and engineering problems	B2
	Knowledge of contemporary issues of nanotechnology	C3
	Knowledge of contemporary issues of nanoelectronics, nanobiotechnology, nanophotonics	C3
	An ability to use techniques, skills, modern engineering tools necessary for nanoscience and engineering practice.	D1

Student will obtain following training			
An ability to apply a theoretical knowledge in practice.			A1
An ability to elocutionary and communicate effectively			B4
Management control and strategic planning of nanotechnological techniques process and products in industries of nanomaterilas, nanoengineering and nanoelectronics,			D3
<b>(TLA)</b>			
<b>Courses per week 2:2:0:5 (lecture:seminar:laboratory: self study work)</b>			
Pedagogy	Study course	CLOs	
➤ Training based on problems	✓ Lecture	1,2,3,4,5	
	✓ Seminar	1,2,3,4,5	
Grade			
Type of examination	Examination period	Percent of grade	CLOs
Attendance and participation	Per week	10%	1, 2, 3,4,5
Seminar attendance	Per week	10%	1, 2, 3,4,5
Home work and self study work	Week 8,14	30%	1,2,3,4,5
Test	Week 7,13	20%	1,2,3,4,5
Final exam	Week 17, 18	30%	1,2,3,4,5
<b>Lecurer</b>	G.Tsermaa	<b>Date</b>	<b>2019/03/02</b>
<b>Professor</b>		<b>Date</b>	
<b>Dean</b>	S. Lyankhtsetseg		

COURSE PROGRAMM			
<b>Course Name</b>	<b>ELECTRIC ENERGY QUALITY AND APPLICATION MODE</b>		
<b>Course Code</b>	TD 707	<b>Credit</b>	2
<b>Division</b>	Energy and Transport division	<b>Department</b>	NTI
<b>Code related to previous program</b>	TD 316	1,5:0,5:0:0	
<b>Teacher</b>	B.Unurmaa	<b>Room</b>	303
<b>E-mail</b>		<b>Contact</b>	
<b>Time ratio between primary and auxiliary teacher</b>	Primary teacher (70%) Auxiliary teacher (30%)		
<b>Course duration</b>	Total: 72 hours Lecture (32 hours), seminar (16 hours) Self-learning (24 hours)		
<b>Type of course</b>	<input checked="" type="checkbox"/> Mandatory <input type="checkbox"/> Optional mandatory <input type="checkbox"/> Optional <input type="checkbox"/> Other		
<b>Proposed quarter</b>	<input type="checkbox"/> 1 <sup>st</sup> season <input checked="" type="checkbox"/> 2 <sup>nd</sup> season <input type="checkbox"/> Summer <input type="checkbox"/> Every season		
COURSE DESCRIPTION			
The course allows to study how indicators of electric energy quality influence application mode. Therefore, students are able to learn energy-efficiency methods through this course.			
MATERIALS: (Syllabus , journals, websites and etc., )			
<b>Main syllabus:</b>			
<b>Additional materials:</b>			
COURSE CONTENT AND SCHEDULE			

LECTURE CONTENT	LECTURE HOURS	SEMINAR HOURS
<input type="checkbox"/> Core concept of quality of electric energy	2	2
<input type="checkbox"/> Determine frequency inclination and variation amplitude	2	
<input type="checkbox"/> Determine voltage frequency and amplitude change	2	2
<input type="checkbox"/> Method of estimate non-sinusoidal coefficient of voltage	2	
<input type="checkbox"/> Indicate unequal degree of voltage and calculate coefficient	2	2
<input type="checkbox"/> Determine voltage instability and calculate coefficient	2	
<input type="checkbox"/> Assess capacity coefficient electronic device and its reduction techniques	2	2
<input type="checkbox"/> Capacity coefficient, reduction techniques and its economic consequences	2	2
<input type="checkbox"/> Factors to change capacity coefficient	2	
<input type="checkbox"/> Ways to change capacity coefficient	2	
<input type="checkbox"/> Executing method of reactive power compensation	2	2
<input type="checkbox"/> Compensation device location, selection, adjustment	2	2
<input type="checkbox"/> Voltage adjustment by force distribution of power grasp		
<input type="checkbox"/> Estimate load graphic based on mathematical and statistical method		2
<input type="checkbox"/> Methods to predict, check and prove dynamic growth of load		
<input type="checkbox"/> Consumer factors influencing electric energy quality		
<b>CONTENTS FOR SELF-LEARNING</b>		<b>HOURS</b>
<input type="checkbox"/> Estimate voltage frequency inclination and variation amplitude		4
<input type="checkbox"/> Apply methods to estimate voltage variation and non-sinusoidal coefficient		4
<input type="checkbox"/> Indicate unequal degree of voltage and calculate coefficient		4

<input type="checkbox"/> Power coefficient, decline techniques and its economical consequences	4
<input type="checkbox"/> Estimate power coefficient of electric device and declining reasons	4
Executing method of reactive power compensation, compensation device location, selection and adjustment	4
<b>COURSE LEARNING OUTCOME (CLOs)</b>	
1. Apply estimation methods of voltage inclination and variation in power quality	A1
2. Estimate and perform voltage adjustment of power supply system and explain reduction methods of frequency deviation	A2
3. Methods to improve power coefficient and execute reactive power coefficient	e
4. Analyze load graphic based on mathematical and statistical techniques	k
5. Use writing and speaking skills in assignment, project report and final report	n
<b>LEARNING AND TEACHING</b>	
Weekly schedule 2:1:0:1 lecture hours: 1x2 , Lecture hours: 1x2. Seminar 1x1	
Organize lecture, lab works and assignments based on combination of traditional and active teaching method.	
<b>Pedagogy</b>	<b>Types</b>
1. Problem based training	1. Lecture
2. Project based training	2. Discussion and seminar
3. Test based training	3. Project work-team based
	<b>CLO's</b>
	1,2,4
	2,4,5
	1,3,5

### COMPETENCY MATRITS

Use new power source for power supply		Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10	Subject 11	Subject 12
COURSE LEARNING OUTCOME													
knowle	Study power supply quality and main factors of power techniques and gain knowledge shift to energy efficiency mode.												

	Gain theory knowledge to estimate power coefficient of electric device, its decline techniques and economical consequences																		
skills	Able to apply techniques to increase efficiency indicator and power coefficient of supply system and estimate voltage adjustment. There for gain skills to eliminate bad effects of frequency deviation																		
	Able to ensure sinusoidal of voltage current and to choose compensation devices																		
	Be able to measure and analyze result of test and research works																		
	Able to determine factors of electric energy quality effect on consumption, design optimal solution and engineering abilities to make decisions																		
Attitude	Obtain professional ethical obligations and gain high-level communication skill																		
	Tendency to observe how engineering solution affects electrical software and research and inclination to seek its improvement																		
	Define self knowledge needs and pursue self lifelong learning																		

### COURSE LEARNING OUTCOME

Gain skills to estimate voltage adjustment of power supply system, eliminate bad influence of frequency inclination, calculate and measure voltage sinusoidal, select compensation device and learn mathematical method to analyze research result.

Knowledge	Skills	Attitude
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<input type="checkbox"/> Study main factors of power supply quality and energy techniques and gain knowledge to shift energy efficiency mode.	<input type="checkbox"/> Learn modern techniques to rise coefficient of electric energy efficiency and capacity of supply system, estimate voltage adjustment and able to eliminate bad influence of frequency inclination Gain skill to make decision on result of computer based calculation through problem determined in research which used probability statistic an optimization method	<input type="checkbox"/> Obtain professional ethical obligations and gain high-level communication skills  <input type="checkbox"/>
Gain theory knowledge to estimate power coefficient of electric device, its decline techniques and economical consequences	Able to ensure sinusoidal of voltage current and to choose compensation devices	<input type="checkbox"/> Tendency to observe how engineering solution affects electrical software and research and inclination to seek its improvement
	Be able to use mathematical techniques and analyze result of test and research works	<input type="checkbox"/> Define self knowledge needs and pursue self lifelong learning
	Able to determine factors of electric energy quality effect on consumption, design optimal solution and engineering abilities to make decisions	<input type="checkbox"/>

### STUDENT KNOWLEDGE, SKILLS AND ATTITUDE SCORING

Scoring	Frequency	Minimum performance	Percentage of evaluation	CLOs
 Attendance and activeness	weekly	90%	10%	1,2,3,4,5
 Homework/ assignment	3 times	100%	20%	1,2,3,4,5

 Process test	Twice	75%	20%	1,2,3,4,5
 Present and Report of assignment/ project	Twice	100%	20	1,2,4,5
 Seasonal exam	Once	90%	30%	1,2

### COURSE PRINCIPLES

Students will be eligible for the exam if they has successfully present or report their assignments. If attendance rate is lower than 50%, not eligible to be scored and if total score is lower than 60%, not permitted to take a final exam.

Students are required to give speech and to be discussed his work at least once on home academic conference. Therefore, they are mandatory to publish their writing in international or domestic journals or academic papers at least once.

**Assessment of assignment:** Assessing criteria shall include indicators on executing assignment in time with quality as well as indicator on conducting research or academic work with specific subjects defined by teacher and put survey result on one industrial electrical load and personal consumption on electricity into the program.

COURSE PROGRAMM			
<b>Course Name</b>	<b>CALCULATION OF THE ELECTROENERGES SUPPLY ALGORITHM AND PROGRAMM</b>		
<b>Course Code</b>	TD 703	<b>Credit</b>	2
<b>Department</b>	Energy and Transport division	<b>Department</b>	NTU
<b>Code related to previous program</b>	TD 316	1.5:0.5:0:0	
<b>Teacher</b>	Ch.Zunduisuren	<b>Room</b>	
<b>E-mail</b>	Zunduisuren_e@yahoRo.com	<b>Contact</b>	99133699
<b>Time ratio between primary and auxiliary teacher</b>	Primary teacher (70%) Auxiliary teacher (30%)		
<b>Course duration</b>	Total: 60 hours Lecture (24 hours), seminar (16 hours) Self-learning (20 hours)		
<b>Type of course</b>	<input checked="" type="checkbox"/> Mandatory <input type="checkbox"/> Optional mandatory <input type="checkbox"/> Optional <input type="checkbox"/> Other		
<b>Proposed quarter</b>	<input type="checkbox"/> 1 <sup>st</sup> season <input checked="" type="checkbox"/> 2 <sup>nd</sup> season <input type="checkbox"/> Summer <input type="checkbox"/> Every season		
COURSE DESCRIPTION			
The course allows to study mathematical techniques used in electricity calculation and in writing algorithmic language in advanced level. Through this course, students are able to use object oriented program and conduct research on production, distribution and consumption of electrical energy throughout a creation of simulation of electrical energy supply.			
MATERIALS: (Syllabus , journals, websites and etc., )			
<p><b>Main syllabus:</b></p> <ol style="list-style-type: none"> <li>1. А.А. А.А.Федоров, В.В.Каменева Основы электроснабжения промышленных предприятий. Москва</li> <li>2. А.А.Федеров. Теоретические основы электроснабжения промышленных предприятий. Москва</li> </ol>			

3. И.Л.Акулич Математическое программирование в примерах и задачах Москва. Высшая школа.
4. А.А.Федеров Учебное пособие для курсового и дипломного проектирования. Москва. Энергоатомиздат
5. Kh.Tsagaan, M.Khuyagdorj: Electrical transmission and allocation, Ulaanbaatar 2000's.

**Additional materials:**

1. Справочник по электроснабжению промышленных предприятий. /Промышленные электрические сети/ под ред А.А.Федорова и Г.В.Сербиновского. москва Энергия 1980, 576с.
2. Guide of Delphi-7, Mathcad and Matlab system
3. В.А. Козлов, Н.И.Билик, Д.Л.Файбисович. Справочник по проектированию электроснабжения городов. Л.Энергоатомиздат

### COURSE CONTENT AND SCHEDULE

LECTURE CONTENT	LECTURE HOURS	SEMINAR HOURS
<input type="checkbox"/> Develop software to calculate urban electric supply network method using object oriented program Delphi-7	2	2
<input type="checkbox"/> Develop software for approximation design techniques to describe interception of cross section of wiring economically viable.	2	2
<input type="checkbox"/> Develop software for experimental design techniques in selecting recommended voltage level of power supply	2	2
<input type="checkbox"/> Develop program and algorithm to determine electrical load in industry and personal specific electrify consumption	2	2
<input type="checkbox"/> Determine industrial load of electricity calculation and develop software to build load cartridge	2	2
<input type="checkbox"/> Develop software to determine central zone of power load	2	2
<input type="checkbox"/> Develop software to determine optimal power network through programming	2	2

<input type="checkbox"/> Use potential function to determine power load center, draw level line chart and use Mathcad system	2	2
<input type="checkbox"/> Develop software for estimation of grounding device	2	
<input type="checkbox"/> Develop program in object orientation for open-network estimation	2	
<input type="checkbox"/> Budget of electric installation. Use Delphi-7 system to develop database software	2	
<input type="checkbox"/> Develop simulation in electric transmission and distribution through Mathlab-6 system	2	
<b>CONTENTS FOR SELF-LEARNING</b>		<b>HOURS</b>
<input type="checkbox"/> Survey on industrial electric load, algorithm to determine specific electricity consumption		6
<input type="checkbox"/> Determine industrial load estimation, develop software to build load cartridge		6
<input type="checkbox"/> Develop program for determine dispersal zone of electric load		4
<input type="checkbox"/> Develop software for estimation of grounding device		4
<input type="checkbox"/> Assessment of assignment		
<b>COURSE LEARNING OUTCOME (CLOs)</b>		
Develop software to calculate urban electro network using object oriented program Delphi-7		c
1. Use potential function to determine power load center, draw line chart and use Mathcad system		d
2. Develop program to survey power supply and calculation		e
3. Develop software electrical supply in both Mongolian and English, study on books, syllabus and works about drawing calculation program.		k
4. Use verbal and writing skills in assignment, report project and presentations		n
<b>5. LEARN AND TEACHING</b>		
Weekly schedule 2:1:0:1 lecture hours: 1x2 , Lab hours: 1x1. Organize lecture, lab works and assignments based on combination of traditional and active teaching method.		
<b>Pedagogy</b>	<b>Types</b>	

Problem based training	1. Lecture 2. Discussion and seminar  Project work-team based	<b>CLO's</b>
1. Project based training	3. Lecture 4. Discussion and seminar 5. Project work-team based	1,2,4
2. Test based training		2,4,5
3.		

### COMPETENCY MATRITS

Use new power source for electricity		Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10	Subject 11	Subject 12
COURSE LEARNING OUTCOME		Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10	Subject 11	Subject 12
<b>knowledge</b>	Study mathematical techniques used in electricity calculation, develop software with advanced algorithmic language and earn ability to use object oriented program.												
	Conduct research to determine electric production, distribution and supply with creating electrical supply simulation and earn knowledge to draw graphics.												
<b>skills</b>	Gain skill to make decision on result of computer based calculation through problem determined in research which used probability statistic an optimization method												
	Be able to design regulation for electricity systems production and supply based on software of plan administration												
	Be able to design regulation for electricity systematical production and supply based on software of plan administration												
	Be able to study English which is essential for working international professionals team												
<b>Attit</b>	Be able to planning and executive test and to analyze test result												



	Develop engineering capability to make decision , design potential solution and determine problems on electricity systems production and supply	
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### STUDENT KNOWLEDGE, SKILLS AND ATTITUDE SCORING

Scoring	Frequency	Minimum performance	Percentage of evaluation	CLOs
Attendance and activeness	weekly	90%	10%	1,2,4
Homework/ assignment	3 times	100%	20%	1,2,4
Prances test	Twice	75%	20%	1,2
Present and Report of assignment/ project	Twice	100%	20	1,2,4,5
Seasons exam	Once	90%	30%	1,2

### COURSE PRINCIPLES

Students will be eligible for the exam if they has successfully present or report their assignments. If attendance rate is lower than 50%, not eligible to be scored and if total score is lower than 60%, not permitted to take a final exam.

Students are required to give speech and to be discussed his work at least once on home academic conference. Therefore, they are mandatory to publish their writing in international or domestic journals or academic papers at least once.

**Assessment of assignment:** Assessing criteria shall include indicators on executing assignment in time with quality as well as indicator on conducting research or academic work with specific subjects defined

by teacher and put survey result on one industrial electrical load and personal consumption on electricity into the program.

COURSE PROGRAMM			
<b>Course Name</b>	SPECIFIC COURSE OF ELECTRIC MACHINERY		
<b>Course Code</b>	TD 709	<b>Credit</b>	2
<b>Division</b>	Energy and Transport division	<b>Department</b>	NTI
<b>Code related to previous program</b>	TD 206	1,5:0,5:0:0	
<b>Teacher</b>	S.Lyankhtsetseg	<b>Room</b>	303
<b>E-mail</b>		<b>Contact</b>	
<b>Time ratio between primary and auxiliary teacher</b>	Primary teacher (70%) Auxiliary teacher (30%)		
<b>Course duration</b>	Total: 60 hours Lecture (24 hours), seminar (16 hours) Self-learning (20 hours)		
<b>Type of course</b>	<input checked="" type="checkbox"/> Mandatory <input type="checkbox"/> Optional mandatory <input type="checkbox"/> Optional <input type="checkbox"/> Other		
<b>Proposed quarter</b>	<input type="checkbox"/> 1 <sup>st</sup> season <input checked="" type="checkbox"/> 2 <sup>nd</sup> season <input type="checkbox"/> Summer <input type="checkbox"/> Every season		
COURSE DESCRIPTION			
In this course, students are able to study theory and usage of electric machine which is main subject for the electric mechanisms, determine technique and economical indicators and allowed to conduct survey ad tests in electric mechanisms			
MATERIALS: (Syllabus , journals, websites and etc., )			
<p><b>Main syllabus:</b></p> <ol style="list-style-type: none"> <li>Обобщенная теория и переходные процессы электрических машин Постников И.М. 1975</li> <li>Проверка и испытание электрических машин Каминский М.Л. 1977</li> <li>Electric machines Charles A.Cross</li> </ol> <p><b>Additional materials:</b></p> <ol style="list-style-type: none"> <li>Расчет и конструирование электрических машин. Коцман М.М. 1984</li> <li>www. Amazon. Com</li> </ol>			

www.electricquilt.com		
<b>COURSE CONTENT AND SCHEDULE</b>		
LECTURE CONTENT	LECTURE HOURS	SEMINAR HOURS
<input type="checkbox"/> Types of electric machinery and requirements on the machinery	2	2
<input type="checkbox"/> Electric machine generator	2	2
<input type="checkbox"/> Mini motors of electric current and their usage	2	2
<input type="checkbox"/> Universal motors and their usage	2	2
<input type="checkbox"/> Asynchronous motors and their usage	2	2
<input type="checkbox"/> Induction mini motors and engines. Single phase induction motors	2	2
<input type="checkbox"/> Mini synchronous motors and their types	2	2
<input type="checkbox"/> Synchronous phased mini motor	2	2
<input type="checkbox"/> Tahogenerators	2	
<input type="checkbox"/> Selsyn	2	
<input type="checkbox"/> Wire wound transformer and its types	2	
Wire wound transformer usage	2	
CONTENTS FOR SELF-LEARNING		HOURS
<input type="checkbox"/> Study constant current motor		4
<input type="checkbox"/> Study asynchronous motor with short circuit rotor		4
<input type="checkbox"/> Study management system electric motion		4
<input type="checkbox"/> Study frequency converter		4
<input type="checkbox"/> Calculate continuously using regression and factor analytic method to design parameters of energy system		4

□	
<b>COURSE LEARNING OUTCOME (CLOs)</b>	
1. Purpose of mini electric machinery, its design, physical value of parameters and specification of utility	c
2. Control temperature, pressure and liquid flow without any additional control using sensor adequate for frequency converter of asynchronous mini motor	d
3. Mainly design electric machinery, adjuster of electric mechanic system and converter as mini machinery as well as design them as sensor, differentiator, integration element, comparator and regulator in automatic control system, measuring and computing devices	e
4. Use English and Mongolian books about mini electric machines	k
5. Use oral and writing skills to complete assignment, project report and speech	n
<b>LEARN AND TEACHING</b>	
Weekly schedule 1,5:0:5:1 lecture hours: 1x2 , Lab hours: 1x1. Organize lecture, lab works and assignments based on combination of traditional and active teaching method.	
<b>Pedagogy</b>	<b>Types</b>
1. Problem based learning	1. Lecture
2. Project based learning	2. Discussion and seminar
3. Test based learning	3. Team Project work
	<b>CLOs</b>
	1,2,4
	2,4,5
	1,3,5

### COMPETENCY MATRITS

<b>Use new power source for electricity</b>													
<b>COURSE LEARNING OUTCOME</b>		Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10	Subject 11	Subject 12
<b>knowled</b>	Gain knowledge about different types of mini electric machines, their purpose, design, working principals and physical value of parameters, correlation along with study survey method of												

	technique and economic indicator, specification of utility																				
skills	Gain skill to working on modern automatic system through applying top information technologies rank high in the world in main factors of industrial technology, working scheme and control																				
	Be able to develop program to optimize electric supply in industry																				
	Be able to work with devices of high voltage breakdown, dial devices, prepare for urgent operation, execute lightning protection and grounding and measuring instruments																				
	Be able to work with 1 and 3 phase transformer, different types of electric motors, current converter, rectifier wit semiconductor, controllers and measuring instruments of electric energy parameters																				
	Be able to learn skills to work with techniques used to convert research result, industrial process, rules to electric calculation, automatic control and check-ups																				
	Gain skill to determine problems in energy system industry , design solution and make decision																				
	Gain engineering skills to determine problems in electric supply system, design optimal solutions and make decisions.																				
Attitude	Obtain professional ethical obligations and gain high-level communication																				
	Tendency to observe impact of engineering solution in society, economy, nature and human life and to seek its improvement																				
	Define self knowledge needs and pursue self lifelong learning																				

### COURSE LEARNING OUTCOME

Conduct test using mini electric machines and define their injury and set habit to repair and reconstruct automatic industry program

Knowledge	Skills	Attitude
Gain knowledge about different types of mini electric machines, their purpose, design, working principals and physical value of parameters, correlation along with study survey method of technique and economic indicator, specification of utility	Gain skill to working on modern automatic system through applying top information technologies rank high in the world in main factors of industrial technology, working scheme and control	Obtain professional ethical obligations and gain high-level communication
	Be able to develop program to optimize electric supply in industry	Tendency to observe impact of engineering solution in society, economy, nature and human life and to seek its improvement
	Be able to work with devices of high voltage breakdown, dial devices, prepare for urgent operation, execute lightning protection and grounding and measuring instruments	Define self knowledge needs and pursue self lifelong learning
	Be able to work with 1 and 3 phase transformer, different types of electric motors, current converter, rectifier wit semiconductor, controllers and measuring instruments of electric energy parameters	<input type="checkbox"/>
	Be able to learn skills to work with techniques used to convert research result, industrial process, rules to electric calculation, automatic control and check-ups	<input type="checkbox"/>
	Gain skill to determine problems in energy system industry , design solution and make decision	<input type="checkbox"/>
	Gain engineering skills to determine problems in electric supply system, design optimal solutions and make decisions.	<input type="checkbox"/>

## STUDENT KNOWLEDGE, SKILLS AND ATTITUDE SCORING

Scoring	Frequency	Minimum performance	Percentage of evaluation	CLOs
 Attendance and activeness	weekly	90%	10%	1,2,4
 Homework/ assignment	3 times	100%	20%	1,2,4
 Process test	Twice	75%	20%	1,2
 Present and Report of assignment/ project	Twice	100%	20%	1,2,4,5
 Seasonal exam	Once	90%	30%	1,2

## COURSE PRINCIPLES

Students will be eligible for the exam if they have successfully presented or reported their assignments. If attendance rate is lower than 50%, not eligible to be scored and if total score is lower than 60%, not permitted to take a final exam.

Students are required to give a speech and to discuss their work at least once at a home academic conference during their study period. Therefore, they are mandatory to publish their article in international or domestic journals or academic papers at least once.

**Assessment of assignment:** Assessing criteria shall include indicators on executing assignment in time with quality as well as indicators on developing optimal mathematical programs used for electric supply calculation outlined by the teacher and publishing scientific articles, conducting surveys and techniques and calculation of specific topics.

COURSE PROGRAMM			
<b>Course Name</b>	SPECIFIC COURSE OF ELECTRIC SUPPLY		
<b>Course Code</b>	TD 710	<b>Credit</b>	2
<b>Division</b>	Energy and Transport division	<b>Department</b>	NTI
<b>Code related to previous program</b>	TD 316	2:1:0:0	
<b>Teacher</b>	Ts.Unurmaa	<b>Room</b>	
<b>E-mail</b>		<b>Contact</b>	
<b>Time ratio between primary and auxiliary teacher</b>	Primary teacher (70%) Auxiliary teacher (30%)		
<b>Course duration</b>	Total: 64 hours Lecture (24 hours), seminar (16 hours) Self-learning (24 hours)		
<b>Type of course</b>	<input checked="" type="checkbox"/> Mandatory <input type="checkbox"/> Optional mandatory <input type="checkbox"/> Optional <input type="checkbox"/> Other		
<b>Proposed quarter</b>	<input type="checkbox"/> 1 <sup>st</sup> season <input checked="" type="checkbox"/> 2 <sup>nd</sup> season <input type="checkbox"/> Summer <input type="checkbox"/> Every season		
COURSE DESCRIPTION			
Through the course, students are become able to analyze energy leakage, consumption and energy spending based on probability statistic and optimization method and study a theory of advanced techniques in transferring, supplying and consumption of electric energy			
MATERIALS: (Syllabus , journals, websites and etc., )			
<p><b>Main syllabus:</b></p> <ol style="list-style-type: none"> <li>1. А.А.Федоров, теоретические основы электроснабжения промышленных предприятий. Москва Энергия</li> <li>2. А.С.Овчаренко, Д.И.Розинский. Повышение эффективности электроснабжения промышленных предприятий. Киев. Техника 1989</li> <li>3. Ю.А.Фокин. Вероятности-статические методы в расчетах систем электроснабжения.</li> <li>4. Москва Энергоатомиздат</li> </ol>			

5. Д.А.Арзамасцев, А.В. Липес Снижение технологического расхода энергий в электрических сетях. Москва. Высшая школа.

**Additional materials:**

1. Справочник по электроснабжению промышленных предприятий. /Промышленные электрические сети/ под ред А.А.Федорова и Г.В.Сербиновского. москва Энергия 1980, 570с.
2. Справочник по электроснабжению промышленных предприятий. /Электрооборудование и автоматизация/ А.А.Федорова и Г.В.Сербиновского. москва Энергия 1981, 624с.
3. В.А. Козлов, Н.И.Билик, Д.Л.Файбисович. Справочник по проектированию электроснабжения городов. Л.Энергоатомиздат

### COURSE CONTENT AND SCHEDULE

LECTURE CONTENT	LECTURE HOURS	SEMINAR HOURS
<input type="checkbox"/> Determine energy leakage as electric load probability	2	2
<input type="checkbox"/> Use statistical methods in calculation of electric energy spending and initial data process and calculation formula of energy loss	2	2
<input type="checkbox"/> Statistical methods used in energy spending calculation and regression and factor analyze	2	2
<input type="checkbox"/> Use regression and factor analyze to estimation of energy leakage and design parametric of electric system	2	2
<input type="checkbox"/> Use testing and planning in optimization of electric supply network in industry	2	2
<input type="checkbox"/> Develop software to optimize industrial electric supply	2	2
<input type="checkbox"/> Use gradient method to optimize reactive power allocation and apply algorithm	2	2
<input type="checkbox"/> Develop dynamic program to locate compensation device and configure the device, working principal	2	2

<input type="checkbox"/> System reliability of electric system, number of power transformer and power option	2	2
<input type="checkbox"/> Place general substation that estimate and reduce power system	2	2
<input type="checkbox"/> Define capability of uniformly distributed load and energy loss 0,4kV	2	2
Define capability of parameter of open power network 6.10kV and energy loss	2	2
<b>CONTENTS FOR SELF-LEARNING</b>		<b>HOURS</b>
<input type="checkbox"/> Determine and calculate electric energy loss in power load probability of urban and industry		2
<input type="checkbox"/> Calculate continuously		2
<input type="checkbox"/> Calculate continuously using statistical methods		2
<input type="checkbox"/> Calculate continuously		2
<input type="checkbox"/> Calculate continuously using regression and factor analytic method to design parameters of energy system		4
<input type="checkbox"/> Calculate energy loss		2
<input type="checkbox"/> Calculate continuously		2
<input type="checkbox"/> Assess economic loss due to diminish of power quality of electric supply system		2
<input type="checkbox"/> Calculate continuously		2
<input type="checkbox"/> Assessment of assignment		2
<b>COURSE LEARNING OUTCOME (CLOs)</b>		
1. Determine energy leakage as electric load probability, Use statistical methods in calculation of electric energy spending and initial data process and calculation formula of energy loss, Use regression and factor analyze to estimation of energy leakage and design parametric of electric system		c
2. Develop software to optimize industrial electric supply		d
3. Improve electric supply efficiency through upgrade power quality		e
4. Use English and Mongolian books and articles about power supply		k
5. Use oral and writing skills to complete assignment, project report and speech		n

## LEARN AND TEACHING

Weekly schedule 2:2:0:1 lecture hours: 1x2 , Lab hours: 1x1. Organize lecture, lab works and assignments based on combination of traditional and active teaching method.

Pedagogy	Types	CLOs
1. Problem based learning	1. Lecture	1,2,4
2. Project based learning	2. Discussion and seminar	2,4,5
3. Test based learning	3. Team Project work	1,3,5

## COMPETENCY MATRITS

Use new power source for electricity		Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10	Subject 11	Subject 12
COURSE LEARNING OUTCOME		Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10	Subject 11	Subject 12
knowledge	Gain knowledge on increase efficiency of electric supply through mathematical method for choosing optimal power and improving power quality												
	Gain knowledge on selecting methods to switch on high voltage engine and automatic setting of condensation device												
	Study how to compensate electric current with capability of 6-10kV and improving techniques of electric energy quality. Therefore, gain knowledge of research techniques, development project and technique-economic estimation												
skills	Able to calculate energy loss based on load probability of electric supply system and design parameters of electric system												
	Be able to develop program to optimize electric supply in industry												
	Be able to determine loss of energy, power and electric system parameter and additional loss in												

	electric energy system. Able to estimate and increase efficiency																		
	Be able assess theory studied in the course by on computer and able to solve the result																		
	Be able to use English to work in international professionals team																		
	Plan test and analyze result and data																		
	Gain engineering skills to determine problems in electric supply system, design optimal solutions and make decisions.																		
Attitude	Obtain professional ethical obligations and gain high-level communication																		
	Tendency to observe impact of engineering solution in society, economy, nature and human life and to seek its improvement																		
	Define self knowledge needs and pursue self lifelong learning																		

## COURSE LEARNING OUTCOME

Studying mathematical methods used in calculation of electric supply, students are able to gain skill that making decisions on result of computer calculation on theoretical problems and set habit to develop program

Knowledge	Skills	Attitude
Gain knowledge on increase efficiency of electric supply through mathematical method for choosing optimal power and improving power quality	Able to calculate energy loss based on load probability of electric supply system and design parameters of electric system	Obtain professional ethical obligations and gain high-level communication
Gain knowledge on selecting methods to switch on high voltage engine and automatic setting of condensation device	Be able to develop program to optimize electric supply in industry	Tendency to observe impact of engineering solution in society, economy, nature and human life and to seek its improvement

Study how to compensate electric current with capability of 6-10kV and improving techniques of electric energy quality. Therefore, gain knowledge of research techniques, development project and technique-economic estimation	Be able to determine loss of energy, power and electric system parameter and additional loss in electric energy system. Able to estimate and increase efficiency	Define self knowledge needs and pursue self lifelong learning
	Be able assess theory studied in the course by on computer and able to solve the result	<input type="checkbox"/>
	Be able to use English to work in international professionals team	<input type="checkbox"/>
	Plan test and analyze result and data	<input type="checkbox"/>
	Gain engineering skills to determine problems in electric supply system, design optimal solutions and make decisions.	<input type="checkbox"/>

### STUDENT KNOWLEDGE, SKILLS AND ATTITUDE SCORING

Scoring	Frequency	Minimum performance	Percentage of evaluation	CLOs
 Attendance and activeness	weekly	90%	5%	1,2,4
 Homework/ assignment	3 times	100%	30%	1,2,4
 Process test	Twice	75%	20%	1,2
 Present and Report of assignment/ project	Twice	100%	15%	1,2,4,5
 Seasonal exam	Once	90%	30%	1,2

### COURSE PRINCIPLES

Students will be eligible for the exam if they have successfully presented or reported their assignments. If attendance rate is lower than 50%, not eligible to be scored and if total score is lower than 60%, not permitted to take a final exam.

Students are required to give a speech and to discuss their work at least once at a home academic conference during their study period. Therefore, they are mandatory to publish their article in international or domestic journals or academic papers at least once.

**Assessment of assignment:** Assessing criteria shall include indicators on executing assignment in time with quality as well as indicators on developing optimal mathematical programs used for electric supply calculation outlined by the teacher and publishing scientific articles, conducting surveys and techniques and calculation of specific topics.

COURSE PROGRAMM			
<b>Course Name</b>	<b>TECHNIQUES TO DETERMINE LEAKAGE OF ELECTRIC SUPPLY SYSTEM</b>		
<b>Course Code</b>	TD 713	<b>Credit</b>	2
<b>Division</b>	Energy and Transport division	<b>Department</b>	NTI
<b>Code related to previous program</b>	TD 316	2:1:0:0	
<b>Teacher</b>	Ts.Unurmaa	<b>Room</b>	
<b>E-mail</b>		<b>Contact</b>	
<b>Time ratio between primary and auxiliary teacher</b>	Primary teacher (70%) Auxiliary teacher (30%)		
<b>Course duration</b>	Total: 60 hours Lecture (24 hours), seminar (16 hours) Self-learning (20 hours)		
<b>Type of course</b>	<input checked="" type="checkbox"/> Mandatory <input type="checkbox"/> Optional mandatory <input type="checkbox"/> Optional <input type="checkbox"/> Other		
<b>Proposed quarter</b>	<input type="checkbox"/> 1 <sup>st</sup> season <input checked="" type="checkbox"/> 2 <sup>nd</sup> season <input type="checkbox"/> Summer <input type="checkbox"/> Every season		
COURSE DESCRIPTION			
The course allows to learn techniques to estimate a leakage in new environment of socioeconomic and contemporary methods to decrease the leakage. Through this course, students are able to study energy efficiency policy and common techniques of international practice			
MATERIALS: (Syllabus , journals, websites and etc., )			
<p><b>Main syllabus:</b></p> <ol style="list-style-type: none"> <li>1. А.А. А.А.Федоров, В.В.Каменева Основы электроснабжения промышленных предприятий. Москва</li> <li>2. А.А.Федеров. Теоретические основы электроснабжения промышленных предприятий. Москва</li> </ol>			

3. И.Л.Акулич Матемаическое программирование в примерах и задачах Москва. Высшая школа.
4. А.А.Федеров Учебное пособие для курсового и дипломного проетирования. Москва. Энергоатомиздат
5. Kh.Tsagaan, M.Khuyagdorj: Electrical transmission and allocation, Ulaanbaatar 2000's.

**Additional materials:**

1. Справочник по электроснабжению промышленных предприятий. /Промышленные электрические сети/ под ред А.А.Федорова и Г.В.Сербиновского. москва Энергия 1980, 576с.
2. Guide of Delphi-7, Mathcad and Matlab system
3. В.А. Козлов, Н.И.Билик, Д.Л.Файбисович. Справочник по проектированию электроснабжения городов. Л.Энергоатомиздат

### COURSE CONTENT AND SCHEDULE

LECTURE CONTENT	LECTURE HOURS	SEMINAR HOURS
<input type="checkbox"/> Consumption and criteria of electric energy	2	2
<input type="checkbox"/> Energy and its resource /national and global samples/	2	2
<input type="checkbox"/> TIB is main indicator of system load graph	2	2
<input type="checkbox"/> Accurately determine maximum loss of energy transfer and distribution	2	2
<input type="checkbox"/> Basic method of calculating network genuine and artificial loss of power	2	2
<input type="checkbox"/> An equivalent parametric method to calculate loss, its advantages and disadvantages	2	2
<input type="checkbox"/> Power loss impact on network symmetry	2	2
<input type="checkbox"/> Contemporary methods to calculate energy loss	2	

<input type="checkbox"/> Continuation of topic above	2	
<input type="checkbox"/> Basic methods to reduce power and energy loss	2	
<input type="checkbox"/> Energy loss and energy efficiency are complex problem	2	
Techniques to save energy in industry	2	
Importance of specific energy efficiency and implementation	2	
Methods to save energy in office and public places	2	
<b>CONTENTS FOR SELF-LEARNING</b>		<b>HOURS</b>
<input type="checkbox"/> Skills to use theory in practice		6
<input type="checkbox"/> Gain oral and writing skills used in reporting as team work		6
<input type="checkbox"/> Skills to develop energy saving policy and principal and calculate energy loss. Able to analyze result, to control and planning		4
<input type="checkbox"/> Assessment of assignment		4
<b>COURSE LEARNING OUTCOME (CLOs)</b>		
1. Apply methods of saving electric energy consumption, energy resource and power and reducing energy loss		c
2. Calculate minimum system loss based on electric load graph		d
3. Calculate genuine and artificial loss of network and execute parametric methods		e
4. Use English and Mongolian books about techniques to reduce energy system loss		k
5. Analyze and research ways to save energy and possibilities		n
<b>LEARN AND TEACHING</b>		
Weekly schedule 2:1:0:1 lecture hours: 1x2 , Lab hours: 1x1. Organize lecture, lab works and assignments based on combination of traditional and active teaching method.		
<b>Pedagogy</b>	<b>Types</b>	<b>CLO's</b>
1. Problem based training	1. Lecture 2. Discussion and seminar 3. Project work-team based	1,2,4
2. Project based training		2,4,5
3. Test based training		1,3,5

**COMPETENCY MATRITS**

Use new power source for electricity		Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10	Subject 11	Subject 12
COURSE LEARNING OUTCOME		Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10	Subject 11	Subject 12
knowledge	Gain knowledge about methods to reduce loss on electric transfer and distribution network												
	Gain knowledge about International practical techniques on electric saving policy and principals.												
skills	Able to collect data required to calculate electric energy loss, analyze calculation and implement ways to define loss												
	Be able to estimate genuine and artificial leakage to reduce power loss in electric network and its transfer												
	Be able to implement methods to energy saving in home, office and public places												
	Basic methods to calculate maximum loss of transfer and distribution network and gain skills to estimate impact on power loss												
	Be able to plan and executive test and to analyze test result												
	Develop engineering capability to make decision , design potential solution and determine problems on electric network transfer and supply												
Attitude	Obtain professional ethical obligations and gain high-level communication												
	Tendency to observe how engineering solution affects electrical software and research and to seek its improvement												

Define self knowledge needs and pursue self lifelong learning																			
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### COURSE LEARNING OUTCOME

Learn methods to energy and power loss in electricity transfer and its network and publish research reports, assignments and articles.

Knowledge	Skills	Attitude
Gain knowledge about methods to reduce loss on electric transfer and distribution network	Be able to implement methods to energy saving in home, office and public places	<input type="checkbox"/> Obtain professional ethical obligations and gain high-level communication skills
Gain knowledge about International practical techniques on electric saving policy and principals.	Basic methods to calculate maximum loss of transfer and distribution network and gain skills to estimate impact on power loss	<input type="checkbox"/> Tendency to observe how engineering solution affects electrical software and research and to seek its improvement
	Be able to plan and executive test and to analyze test result	<input type="checkbox"/> Define self knowledge needs and pursue self lifelong learning
	Develop engineering capability to make decision , design potential solution and determine problems on electric network transfer and supply	<input type="checkbox"/>

### STUDENT KNOWLEDGE, SKILLS AND ATTITUDE SCORING

Scoring	Frequency	Minimum performance	Percentage of evaluation	CLOs
Attendance and activeness	weekly	90%	10%	1,2,4
Homework/ assignment	3 times	100%	20%	1,2,4

 Process test	Twice	75%	20%	1,2
 Present and Report of assignment/ project	Twice	100%	20	1,2,4,5
 Seasonal exam	Once	90%	30%	1,2

### COURSE PRINCIPLES

Students will be eligible for the exam if they have successfully presented or reported their assignments. If the attendance rate is lower than 50%, they are not eligible to be scored and if the total score is lower than 60%, they are not permitted to take a final exam.

Students are required to give a speech and to discuss their work at least once at a home academic conference during their study period. Therefore, they are mandatory to publish their article in international or domestic journals or academic papers at least once.

**Assessment of assignment:** Assessing criteria shall include indicators on executing assignments in time with quality as well as indicators on conducting research or academic work with specific subjects defined by the teacher and surveys on international practical techniques of electric energy saving policies and principles.

COURSE PROGRAMM			
<b>Course Name</b>	Use new resource of energy in power supply		
<b>Course Code</b>	TD 709	<b>Credit</b>	2
<b>Division</b>	Energy and Transport division	<b>Department</b>	NTI
<b>Code related to previous program</b>	TD 313	1.5:0:05:01	
<b>Teacher</b>	B.Ayushjav	<b>Room</b>	304
<b>E-mail</b>	Ayush_ba@yahoo.com	<b>Contact</b>	
<b>Time ratio between primary and auxiliary teacher</b>	Primary teacher (70%) Auxiliary teacher (30%)		
<b>Course duration</b>	Total: 64 hours Lecture (24 hours), seminar (16 hours) Self-learning (24 hours)		
<b>Type of course</b>	<input checked="" type="checkbox"/> Mandatory <input type="checkbox"/> Optional mandatory <input type="checkbox"/> Optional <input type="checkbox"/> Other		
<b>Proposed quarter</b>	<input type="checkbox"/> 1 <sup>st</sup> season <input checked="" type="checkbox"/> 2 <sup>nd</sup> season <input type="checkbox"/> Summer <input type="checkbox"/> Every season		
COURSE DESCRIPTION			
<p>Through the course, students learn techniques to apply main renewable resource such as solar, wind, water flow in electric energy, and study storing and reserving techniques and technology more specific as well as study repairing method the techniques. As producing energy using renewable resource is nature friendly ‘green technology’ and different than traditional technology, students are able to analyze and assess result ‘ the green technology’</p>			
MATERIALS: (Syllabus , journals, websites and etc., )			
<p><b>Main syllabus:</b></p> <ol style="list-style-type: none"> <li>1. С.Н.Удалев “Возобновляемые источники энергий” 2007</li> <li>2. Твайделл Д, Уэйр А. “Возобновляемые источники энерги й” 1990</li> <li>3. Девинс Д. “Энергия”</li> <li>4. Берковский Б.М. Кузьминов В.А. “Возобляемые источники энергий на службе человека” 1987</li> </ol>			

5. Patel Bukund R6 Wind and Solar power systems Washigton 1999  
**Additional materials:**
6. Ресурсы и эффективность использования возобновляемых источников энергий в России 2002
  7. Wind energy resourse Atlas of the Mongolia6 D.Elliott, M.Schwartz, G.Scott,S.Haymes, D.Heimillar, R.George “National Renewable Energy Laboratory” 2001
  8. Mongolian wind map 2004
  9. Mongolian atlas
  10. www. Eures.be, [www.shell-renewables.com](http://www.shell-renewables.com) /international/
  11. www. indandsun.co.uk /Great Britain /
  12. [www.fronius.com](http://www.fronius.com) /Austria/

## COURSE CONTENT AND SCHEDULE

LECTURE CONTENT	LECTURE HOURS	SEMINAR HOURS
<input type="checkbox"/> Renewable energy resource: Water, wind and solar	2	
<input type="checkbox"/> Wind flow indicators, wind generators	2	
<input type="checkbox"/> Types of wind farm, select capacity of wind farm	2	
<input type="checkbox"/> Wave and wave energy	2	
<input type="checkbox"/> Solar energy indicators, solar power station	2	Geothermal energy resource in Mongolia
<input type="checkbox"/> Types of solar battery and input scheme	2	
<input type="checkbox"/> Solar power station with stage engine	2	
<input type="checkbox"/> ‘Solar Tower’ station, heating scheme using solar energy and calculation of closed heating system	2	Survey on Mongolian water resource
<input type="checkbox"/> Storing electric energy and charge accumulator battery	2	
Use inductance circuit of transfer	2	Survey on Mongolian water/wind resource
<input type="checkbox"/> Location of wind resource of Mongolia and Mongolian wind farms	2	

Solar energy reserve, possibility to build solar power plant	2	Write assignment
<b>CONTENTS FOR SELF-LEARNING</b>		<b>HOURS</b>
<input type="checkbox"/> Solar energy generator PV system, its types and calculation of number of PV system capacity		4
<input type="checkbox"/> Measuring wind speed, wind direction and indicators of air temperature, use Weibull distribution function in wind speed calculation		4
<input type="checkbox"/> Determine capacity coefficient of wind turbine		4
<input type="checkbox"/> Specific method to charge battery of high voltage and power bank, adjusting scheme		4
<b>COURSE LEARNING OUTCOME (CLOs)</b>		
1. Use calculation program and knowledge of renewable energy technology in accurate selection of device and estimation methods		c
2. Solve issue that proper consumption of renewable energy in electric energy		d
3. Measure indicators of devices and equipment of renewable energy		e
4. Use English and Mongolian books and articles about power supply		k
5. Use oral and writing skills to complete assignment, project report and speech		n
<b>LEARN AND TEACHING</b>		
Weekly schedule 1,5:0:0,5:1 lecture hours: 1x2 , Lab hours: 1x1. Organize lecture, lab works and assignments based on combination of traditional and active teaching method.		
Pedagogy	Types	CLOs
1. Problem based learning	1. Lecture	1,2,4
2. Project based learning	2. Discussion and seminar	2,4,5
3. Test based learning	3. Team Project work	1,3,5

### STUDENT KNOWLEDGE, SKILLS AND ATTITUDE SCORING

Scoring	Frequency	Minimum performance	Percentage of evaluation	CLOs
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 Attendance and activeness	weekly	90%	10%	1,2,4
 Homework/ assignment	3 times	100%	10%	1,2,4
 Reporting lab work	4 times	100%	10%	3,4
 Process test	Twice	75%	20%	1,2
 Present and Report of assignment/ project	Twice	100%	20%	1,2,4,5
 Seasonal exam	Once	90%	30%	1,2

### COURSE PRINCIPLES

Students will be eligible for the exam if they has successfully present or report their assignments. If attendance rate is lower than 50%, not eligible to be scored and if total score is lower than 60%, not permitted to take a final exam.

**Assessment of assignment:** Assessing criteria shall include indicators on executing assignment in time with quality as well as indicators on producing electric energy from solar, water and wind energy, writing project of compact plant and testing equipment as outlined by teacher. Therefore, assessing indicator shall include writing scientific article, research, technical thinking of the students and executive of calculation

**Assessment of lab work:** estimating device and equipment of solar, wind and electric station, setting habits to make measure, to take test, to adjust and repair, following safety rules when using equipment, reporting lab work result

### COMPETENCY MATRITS

<b>Use new power source for electricity</b>	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10	Subject 11	Subject 12
<b>COURSE LEARNING OUTCOME</b>												

<b>knowledge</b>	Gain knowledge about law of energy formation from renewable energy and its accurate consumption in electric energy																	
	Gain knowledge about selecting device which uses renewable energy, measuring, analyzing, calculating and repairing theory																	
<b>skills</b>	Able to assess current situation of renewable energy and use general scheme bind renewable energy to the costumers																	
	Able to adjust new techniques and technologies that applied in solar, wind and water energy resource, estimate accurate capability and repair techniques																	
	Be able to estimate resource reserve identified in Mongolia and able to do engineering calculation																	
	Be able to apply renewable energy in electric industry and able to plan energy system tying up with economy, nature and labor health and safety																	
	Be able to use English to work in international professionals team																	
	Plan test and analyze result and data																	
	Gain engineering skills to determine problems in renewable energy industry, design optimal solutions and make decisions.																	
<b>Attitude</b>	Obtain professional ethical obligations and gain high-level communication																	
	Tendency to observe impact of engineering solution in society, economy, nature and human life and to seek its improvement																	
	Define self knowledge needs and pursue self lifelong learning																	

### COURSE LEARNING OUTCOME

Study methods to conduct survey on renewable energy reverse, select device and equipment used in renewable energy resource, measure and repair device.

Knowledge	Skills	Attitude
Gain knowledge about law of energy formation from renewable energy and its accurate consumption in electric energy	Able to assess current situation of renewable energy and use general scheme bind renewable energy to the costumers	Plan test and analyze result and data
Gain knowledge about selecting device which uses renewable energy, measuring, analyzing, calculating and repairing theory	Able to adjust new techniques and technologies that applied in solar, wind and water energy resource, estimate accurate capability and repair techniques	Gain engineering skills to determine problems in renewable energy industry, design optimal solutions and make decisions.
	Be able to estimate resource reserve identified in Mongolia and able to do engineering calculation	Obtain professional ethical obligations and gain high-level communication
	Be able to apply renewable energy in electric industry and able to plan energy system tying up with economy, nature and labor health and safety	Tendency to observe impact of engineering solution in society, economy, nature and human life and to seek its improvement
	Be able to use English to work in international professionals team	Define self knowledge needs and pursue self lifelong learning

# Syllabus

## " Instrumentation, control and measurement"

### *Course topic*

Fundamental concepts of measurement methods and its theory, instrumentation

### *Number of credits*

3 ECTS

### *Course responsible*

Power Engineering School, Mongolian University of Science and Technology, (MUST)

Department of Electric Technic

Assoc Prof. Dr. Byambasuren Bat-Erdene

### *Course lecturer*

Dr. Damiran Ulemj

### *Prerequisites*

Sensor design and physics

### *Learning outcomes*

Upon successful completion of this course students should be able to:

- Theoretical understanding and application of instrumentation techniques for measurement;
- In-depth understanding and application of key principles for measurement error analysis;
- Critical understanding of sensing techniques for mechanical measurement of temperature, flow, pressure and level;
- Make accuracy statements for various types of measurements;
- Understand how instruments are used for process control;
- Learn how to use a measurement and instrumentation specifications and symbols for drawing automation process diagram

### *Abstract*

Measurements and Instrumentation involves with the measurement of various parameters related to the technological process. Measurements play a very important role in all engineering field. This course aims to provide an insight on recent advances in instrumentation and measurement technology. The goal of the course is approach of modern measuring technology and improving the ability of fundamental concepts of measurement methods and its theory, measurement approach for industrial data acquisition system.

### *Content*

Introduction

Measurement characteristics:

Characteristics of instrumentation, Operational modes of instrumentation, Static and dynamic characteristics of instrumentation, Measurement accuracy and measurement standards etc.

#### 1. The measuring instrumentation specifications and symbols

Getting Started, Understanding of Block Flow Diagram, Process Flow Diagram, Piping and Instrumentation Diagram, Drawing procedure of diagram, ISA 5.1, Measurement and Instrumentation specifications and symbols

#### 2. Temperature measurement

Bimaterials Thermometers, Resistive Thermometers, Thermistor Thermometers, Thermocouple Thermometers, Semiconductor Junction Thermometers, Infrared Thermometers, Pyroelectric

Thermometers, Liquid-in-Glass Thermometers, Manometric Thermometers, Temperature Indicators, Fiber-Optic Thermometers

### 3. Pressure and sound measurement

Basic definitions, Sensing Principles, Silicon, Micro machined Pressure Sensors, Vacuum g  
Conceptual Description of Ultrasound Imaging and Measurements, Single-Element and Array Transducers, Selection Criteria for Ultrasound Frequencies, Basic Parameters in Ultrasound Measurements, Ultrasound Theory and Applications, Review of Common Applications of Ultrasound and Their Instrumentation, Selected Manufacturers of Ultrasound Products, Advanced Topics in Ultrasound ages, Direct reading gages, Indirect reading gages, Definition of basic ultrasound parameters,

### 4. Level measurement

Displacer, Pressure gages, Balance method, Time-of-Flight Measurements, Basic Principle, Ultrasonic, Microwaves, Laser/Light, Level Measurements by Detecting Physical Properties Electrical Properties, Radiation Attenuation, Thermal and Mechanical

### 5. Flow measurement

Differential Pressure Flowmeters, Variable Area Flowmeters, Positive Displacement Flowmeters, Turbine and Vane Flowmeters, Impeller Flowmeters, Electromagnetic Flowmeters, Ultrasonic Flowmeters, Vortex Shedding Flowmeters, Thermal Mass Flow Sensors, Coriolis Effect Mass Flowmeters, Drag Force Flowmeters

### 5. Other measurements

Gas analyser, Radiation measurement, Water quality measurement, pH measurement, Humidity and moisture measurement, Environmental measurement

### *Teaching methods*

The theoretical part of the course is presented in the lecture by the main books.

The practical work represents a laboratory for testing and inspection of various measurement devices.

In both cases on-line support by the tutor is provided.

### *Assessment*

The course grade consists of these components:

30% – Knowledge test with a multiple choice questionnaire, mid-term exam I,II

20% - Laboratory

20% - Project of selected measuring instrumentation

30% – Final exam

### *Recommended reading*

John G. Webster, Halit Eren “The measurement, instrumentation and sensors handbook” CRC press, 2014.

Arun Shukla, James W. Dally “Instrumentation and Sensors for Engineering Measurements and Process Control” College House Enterprises, LLC, 2016, ISBN Number: 1935673068, 9781935673064

Morris, Alan S., and Reza Langari. “Measurement and instrumentation: theory and application” Academic Press, 2012.

# Syllabus

## "Introduction of Research Methodology"

### *Course topic*

Introduction of Research Methodology

### *Number of credits*

1 credit

### *Course responsible*

Mongolian University of Science and Technology

School of Power Engineering

Department of Electric Techniques

Prof. Dr. Bat-Erdene Byambasuren

### *Course lecturer*

Assoc. Prof. Dr. Uuganbayar Tumurkhuu

Assoc. Prof. Dr. Bolormaa Baatar

### *Prerequisites*

There are no prerequisites for this course.

### *Learning outcomes*

Upon successful completion of this course students should be able to:

- Conduct literature review for a given research problem;
- Demonstrate an understanding of how research makes contributions to shared knowledge of science or construction of verified scientific explanations of some aspects of the world;
- Selecting the most appropriate research designs and methods for a given research issue;
- Dealing with uncertainty in research planning;
- Perform data collection, analysis, and interpretation using tools required for creative and meaningful research
- Write research report

### *Abstract*

This course will teach the overview of research methodology including the important concepts of research design, data collection, statistical and interpretative analysis, and final report presentation. The focus of this course is not on mastery of statistics but on the ability to use research in making meaningful innovation in industry.

### *Content*

Introduction

#### 1. Introduction to the Process of Conducting Research

##### 1.1. Definition of research.

Introduction to Academic Research and Contemporary Research in Engineering and Technology, Characteristics of Research, and Types of Research

##### 1.2. Research process and ethics

Identifying a Hypothesis and/or Research Problem, Specifying a Purpose, Creating Research Questions; Reviewing Literature and Ethics of Research

2. Research Identification
  - 2.1. Identification of Topics of Interest  
Collection of Relevant Materials, Group Discussion Reviewing the Literature
  - 2.2. Identifying the Objectives of the Study and Validity of the Conclusions  
Identification of Further Works, Preparation of Research Proposal.
3. Research Design
  - 3.1. Developing Questions and Hypothesis  
The Problem Statement, Different Approaches, Developing and Testing Hypotheses, Use of Theory, Limitation of the Study
  - 3.2. Deductive and Inductive Analysis  
Quantitative and Qualitative methods of research, Selecting Tools, Setting Milestone and Analysing the Achievements
4. Introduction to Qualitative Research
  - 4.1. Essence of Qualitative Data  
Components of Qualitative Research
  - 4.2. Sampling and Collection Techniques  
Biography, Phenomenology, Grounded Theory, Ethnography, and Case Study
5. Interpreting Qualitative Data
  - 5.1. Features of Qualitative Data  
Qualitative Qualitative Research Study Review
  - 5.2. Qualitative Data Analysis Procedures,  
Coding, Thematic Development, Framing the Research Problem as a Qualitative research
6. Introduction to Quantitative Research
  - 6.1. Essence of Quantitative Data  
Making Predictions
  - 6.2. Collection and Analysis Techniques  
Coding, Thematic Development, Framing the Research Problem as a Qualitative research
7. Sampling Concepts
  - 7.1. Defining the Target Population  
Representative Sample, Potential Consequences of Unrepresentative Sampling (Gaming the System), Over Representative Subgroups / Weighting, Design Effect
  - 7.2. Sampling Methods  
Cluster, Stratified, Simple Random and etc
8. Quantitative Data Collection Instruments
  - 8.1. Instruments  
Choosing a Good Instrument, Identifying Poor Data Collection Instruments, Experimental design and analysis; Instrumentation and data acquisition, Interval and Ratio Scales
  - 8.2. Validity and Reliability  
Factor analysis, Principal Components Analysis, Chronbach's alpha (Internal Consistency),
9. Introduction to Applied Statistics
  - 9.1. Identifying the Dependent and Independent Variables  
Dependent variable, independent variable, compound variable, moderating variable, mediation variable, control variable, experimental variable
  - 9.2. Confidence Levels
  - 9.3. Math That Manipulates Data, Results of Time Series Analysis
10. Descriptive Statistics
  - 10.1. Data  
Summarizing and Describing a Collection of Data, Univariate and Bivariate Analysis
  - 10.2. Central Tendency and Dispersion  
Mean, Mode, Ranges, Quartiles, Variance, Standard Deviation, Coefficient of Variation, Percentages and Ratios, Histograms
  - 10.3. Identifying Randomness and Uncertainty in Data

11. Inferential Statistics
  - 11.1. Drawing Inference from Data  
Framing the Research Problem as a Quantitative Study, Modelling Assumptions
  - 11.2. Identifying Patterns  
Regression Analysis, T-Test, Analysis of Variance, Correlations, Chi-Square
12. Introduction to Mixed Methods Research
  - 12.1. Advantages
  - 12.2. Design Components
  - 12.3. Explanatory Mixed Methods Framework
  - 12.4. Exploratory Mixed Methods Framework
13. Writing Quantitative, Qualitative and Mixed Findings
  - 13.1. Writing quantitative findings
  - 13.2. Writing qualitative findings
  - 13.3. Writing mixed findings
14. Writing a Research Report in General  
Research Writing in General, Referencing. Writing a Bibliography, Developing an Outline.  
Writing About a Variable.

#### *Teaching methods*

This is a graduate-level blended-learning course in research methods and statistics for engineering students. The course will consist of readings and presentations, participation in the discussion forum, exercises, and written assignments.

The assigned course readings draw from a variety of resources, such as reports, articles and essays on research methods, and examples of effective and ineffective presentation of statistical information. Students are expected to familiarize themselves with the assigned topic and readings each week and should be prepared to participate in the online discussion forum to discuss the readings critically. The theoretical part of the course is presented in the Moodle learning environment in the form of e-learning tutorials.

#### *Assessment*

The course grade consists of these components:

Class Participation 10%  
 Weekly Assignments 40%  
 Participation in discussion 20%  
 Final Research Project 30%

#### *Recommended reading*

David V. Thiel., *Research Methods for Engineers*, 1st Edition, 2014, Cambridge University Press, ISBN-10: 1107610192

Theodore W., Anderson *An Introduction to Multivariate Analysis*, 3<sup>rd</sup> Edition, 2003, Wiley-Interscience, ISBN: 978-0-471-36091-9

Samir Okasha., *Philosophy of Science – a Very Short Introduction*, Oxford University Press, Oxford, 2002, ISBN-10: 0192802836

Shelton.M. Ross., *Introduction to Probability and Statistics for Engineers and Scientists*, Elsevier Academic Press, 2004, ISBN: 0-12-598057-4.

# Syllabus

## "Modeling for Engineering Science"

### *Course topic*

Modelling for Engineering Science

### *Number of credits*

1 credit

### *Course responsible*

Mongolian University of Science and Technology

School of Power Engineering

Department of Electric Techniques

Prof. Dr. Bat-Erdene Byambasuren

### *Course lecturer*

Assoc. Prof.

Assoc. Prof.

### *Prerequisites*

There are no any prerequisites for this course.

### *Learning outcomes*

Upon successful completion of this course students should be able to:

- use a number of methods and techniques for visualisation of data sets;
- compute probabilities in simple cases;
- give an account of the concept random variable and be able to use some common probability distributions;
- understand the meaning of the central limit theorem;
- use point and interval estimates for some typical statistical problems;
- apply elementary regression for fitting measured data;
- give an account of some typical engineering applications of probability and statistics, e.g. reliability and quality control.

### *Abstract*

This course will teach the role of statistics in engineering. It would cover the probability, discrete random variables and probability distributions, continuous random variables and probability distributions, joint probability distributions, random sampling and data description, point estimation of parameters, statistical intervals for a single sample, and tests of hypotheses for a single sample.

### **Content**

Introduction

#### 1. Introduction

##### 1.1. Role.

The Role of Statistics in the Engineering Problem-Solving Process

#### 2. Descriptive Statistics

##### 2.1. Numerical Methods

Measures of location and variation, frequency tables

##### 2.2. Graphical Methods

Bar diagrams, histograms, other diagrams and tools for visualisation

3. Probability
  - 3.1. Theory  
Introductory combinatorics and probability theory
  - 3.2. Probability distributions  
Binomial, Poisson, normal, exponential.
4. Bayes' Theorem and Random Variables
  - 4.1. Baye's Theorem
  - 4.2. Concept of Random Variables
5. Discrete Random Variable
  - 5.1. Discrete Random Variables and Probability Distributions
  - 5.2. Discrete Random Variables and Probability Distributions, Cont
6. Discrete Probability
  - 6.1. Discrete Probability Distribution, Cont.
  - 6.2. Discrete Probability Distribution, Cont.
7. Continuous Random Variables
  - 7.1. Continuous Random Variables and Probability Distributions
  - 7.2. Continuous Random Variables and Probability Distributions, Cont.
8. Joint Probability
  - 8.1. Joint Probability
  - 8.2. Joint Probability Distribution, Cont.
9. Sampling Distributions
  - 9.1. Sampling Distributions and Point Estimation
  - 9.2. Central Limit Theorem
10. Confidence
  - 10.1. Confidence Interval, Variance Known
  - 10.2. Confidence Interval, Variance Unknown
11. Confidence Interval of a Normal Distribution

### *Teaching methods*

This is a graduate-level conventional-learning course in the modelling for engineering science. This course will be presented by using lectures, in-class exercises, and discussions. Student learning outcomes will be evaluated based on quizzes and exams.

Class handouts, homework problems, and other relevant course materials will be posted on the MUST e-learning website. Students are expected to check the course website before every class for new information.

### *Assessment*

The course grade consists of these components:

Class Participation 10%  
Weekly Assignments 40%  
Participation in discussion 20%  
Final Research Project 30%

### *Recommended reading*

Montgomery, Douglas C. and Runger, George C., Applied Statistics and Probability for Engineers, Fifth Edition, 2011 John Wiley and Sons, Inc., ISBN: 978-0-470-05304-1

Mendenhall, W., and Sincich, T., *Statistics for Engineering and the Sciences*, 6th edition, CRC Press, 2016, ISBN-10: 1498728855

Hogg, R. V., and Tanis, E. A., *Probability and Statistical Inference*, 9<sup>th</sup> edition, Prentice Hall, 2014, ISBN-10: 0321923278

# Syllabus

## "Patent Study"

### *Course topic*

Patent Study

### *Number of credits*

1 credit

### *Course responsible*

Mongolian University of Science and Technology

School of Power Engineering

Department of Electric Techniques

Prof. Dr. Bat-Erdene Byambasuren

### *Course lecturer*

Assoc. Prof. Dr. Uuganbayar Tumurkhuu

Assoc. Prof. Dr. Bolormaa Baatar

### *Prerequisites*

There are no prerequisites for this course.

### *Learning outcomes*

Upon successful completion of this course students should be able to:

- Demonstrate an in-depth understanding of patent law to engineers and scientists.
- Read and interpret patent specifications, analyze patent office procedures and court cases and develop the basic understanding for drafting a patent specification.
- Explain the application of the different patent law concepts, such as e.g. novelty and infringement, in the engineering and technology areas
- Analyse in a qualified way the economic and social effects of patents
- Address practical and strategic patent related problems in the engineering and science fields.

### *Abstract*

This subject is an intensive introduction to the law of intellectual property, with major emphasis on Mongolian patent law. The course also focuses on copyrights, provides a brief look at trademarks and trade secrets, presents comparisons of what can and cannot be protected, and what rights the owner does and does not obtain. Issues relating to information technology, energy, and business methods are highlighted.

Most of the assigned readings are case decisions. Class sessions combine discussion with lecture, and students are expected to read the assigned material carefully prior to each class.

### *Content*

Introduction

#### 1. Introduction

##### 1.1. Overview

Historical and philosophical background of patents and other intellectual property

##### 1.2. Mongolian Patent System

- The Constitution, Parliament, Patent Office (PTO), and courts, Analysing and understanding judicial opinions
2. Comparative overview of patents, copyrights, trade secrets, and trademarks
    - 2.1. Patent Protection
      - Legal fundamentals of patent protection for useful inventions
      - Design and plant patents
    - 2.2. Copyright protection
      - Legal fundamentals of copyright protection
      - Similarity and access
      - Expression vs. ideas and information, merger
    - 2.3. Fair use of copyrighted works (e.g., for classroom use)
      - Contributory copyright infringement
    - 2.4. Difference
      - Critical differences between patent and copyright protection
      - Copyright infringement distinguished from plagiarism
    - 2.5. Trade-secret Protection
      - Legal fundamentals of trade-secret protection
    - 2.6. Trademark
      - Legal fundamentals of trademark protection
  3. Requirements and limitations of patentability
    - 3.1. Novelty
      - New and useful: (A) The legal requirement of novelty, (B) First to invent vs. first inventor to file
    - 3.2. The legal requirement of non-obviousness
    - 3.3. Statutory subject matter and judicial exceptions:
      - (A) Patentability of algorithms, software, and business methods
      - (B) Patentability of medical treatments and human genes
  4. The process of applying for a patent ("patent prosecution")
    - 4.1. Application
      - Anatomy of a patent application
      - Adequate disclosure
    - 4.2. The art of drafting patent claims
    - 4.3. Patent searching:
      - (A) Purposes and techniques
      - (B) On-line tools available to MUST students
  5. Actions for patent infringement
    - 5.1. Infringement
      - Interpretation of claims, Doctrine of equivalents, Product testing as a possibly infringing use, Doctrine of exhaustion
    - 5.2. Remedies
      - Legal and equitable remedies for infringement
    - 5.3. Anatomy of patent litigation
      - Courtroom visit to current patent trial
  6. Other important issues
    - 6.1. Presentations
      - Student presentations of patent-search results
    - 6.2. Licensing and agreements
      - (A) Patent licensing
      - (B) Non-competition agreements
    - 6.3. Rights and Obligations
      - Rights and obligations among co-inventors, co-authors, employers, and licensees

*Teaching methods*

This is a graduate-level active-learning course in patent for engineering students. The course will consist of short patent-search project with a written report and optional class presentation, readings, participation in the discussion forum, exercises, and written assignments. In addition, there will be very short exercises based on the readings throughout the term.

### *Assessment*

The course grade consists of these components:

Class Participation 10%  
Patent-search project 40%  
Participation in discussion 20%  
Final Presentation 30%

### *Recommended reading*

David Pressman, Patent It Yourself, Nolo; 9th edition, 2002, ISBN-10: 0873378016

Michael C. Donaldson,

Р. Санжаасүрэн, Н. Түгжсүрэн, Г. Цог, Шинэ бүтээлийн патент, 2000 он

Ronald D. Slusky, Invention Analysis and Claiming – A Patent Lawyer’s Guide, Second Edition, American Bar Association, 2012.

Feroz Ali, The Touchstone Effect – The Impact of Pre-grant Opposition on Patents, LexisNexis, 2009.

# **Syllabus**

## **" Advanced course of PLC and microprocessor technique"**

### ***Course topic***

Advanced course of PLC and microprocessor technique

### ***Number of credits***

3 credits

### ***Course responsible***

MUST, Ulaanbaatar

Department of Electric Technique

Assoc. Prof. Dr. Bat-Erdene Bayar

### ***Course lecturer***

Prof. Dr. Natsagdorj Chuulan

### ***Prerequisites***

Microprocessor technique, programmable logic controller

### ***Learning outcomes***

Upon successful completion of this course students should be able to:

- Use MP and MP for industrial automation and power system automation
- Getting experience of standard interfaces and protocols M2M, HMI
- Know about ADC for MP and PLC
- Make SCADA used MP and PLC
- Know about Microprocessor registrar REMI

### ***Abstract***

This course will focus the use of modern microcontroller systems for digital relay protection and automation, manufacturing process and technology automation, process measurement, and control/management.

In addition, microprocessor and microcontroller design and its modelling, simulation, some research methods for embedded system will be presented in this course.

### ***Content***

Introduction

1. MP and MCs for automation system

1.1. Modern digital relay protection automatic power system. The current situation of relay protection and automation of Power system. Processing of a RP&A device in microprocessors.

1.2. Relay protection and automated microprocessor systems of power system.

1.3. Using Programmable Logic Controllers in industrial and technological automation.

2. Interrupts

2.1. Interrupt methods in the MP system and programmable controllers, and their organization.

- 2.1.1 Interrupt in microprocessor
  - 2.1.2 Category of interrupts
- 2.2. Mask interrupt
- 3. Standard interfaces
  - 3.1 Methods and standards of information exchange.
  - 3.2 Modern methods and standard system of information exchange used in the industrial automatic
- 4. ADC and DAC
  - 4.1 The principles of analog to digital conversion
  - 4.2 ADC to MP
- 5. Number system and develop a sinusoidal input in MP
  - 5.1 Number Systems and Codes used in MP technique for industrial automation.
  - 5.2 Develop a sinusoidal input in MP
    - 5.2.1 Measuring part of MP protection and automation devices
    - 5.2.2 Algorithms for determining the actual value of sinusoidal values
    - 5.2.3 Methods of sinusoidal input
    - 5.2.4 Algorithms for the identification of symmetric components.
- 6. Control system for industrial automation
  - 6.1 The basic concept of computer monitoring and control systems for the automation of production processes
  - 6.2 Standard computer interfaces and protocols
  - 6.3 Program control, Instructions of PLC
    - 6.3.1 Program Control
    - 6.3.2 Master Control Reset and Jump Instruction
    - 6.3.3 Subroutine Functions
  - 6.4 Data Manipulation, Instructions of PLC
    - 6.4.1 Data Manipulation
    - 6.4.2 Data Transfer Operations and Data Compare Instruction
  - 6.5 Control system of industrial motor used PLC and inverter
- 7. Microprocessor registrar of emergency process of the power system
  - 7.1 Design and purpose of microprocessors registrar (REMI)
  - 7.2 System specifications
  - 7.3 MP operating procedures
  - 7.4 IP connection connections and information networks

### *Teaching methods*

The student studies circuit designing process of microprocessor and microcontroller system, programming approaches and its development procedure. Furthermore, this course will demonstrate knowledge of system collection and how to connect between sensors, actuators and microcontrollers.

The student obtains practical skill that how to use a microcontroller and PLC system, how to develop, update and extend programming code, and ladder circuit.

In both cases on-line support by the tutor is provided.

### *Assessment*

The course grade consists of these components:

30% – Knowledge test with a multiple choice questionnaire

70% – Mid-Term exam 1, 2 and project

*Recommended reading*

Микропроцессорные системы: Учебное пособие для вузов/ Е.К Александров, Р.И Грушвицкий и др. Под общ. ред. Д.В. Пузанкова. –СПб.: Политехника. 2002. -935 с

James W. Coffron, William E. Long, Practical Interfacing techniques for Microprocessor Systems, Prentice-Hall, INC, Englewood Cliffs, New Jersey 07632

# Syllabus

## "Computer based Control System"

### ***Course topic***

Computer based Control System

### ***Number of credits***

3 ECTS

### ***Course responsible***

Power Engineering school of MUST (Mongolian University of Science and Technology)

Department of Electric Technique

Assoc.Prof. Dr. Bat-Erdene Byambasuren

### ***Course lecturer***

Dr. Sarangerel Khayankhyarvaa

### ***Prerequisites***

M.AU203 "Object Oriented Programming (OOP)" and Theory of data transmission.

### ***Learning outcomes***

Upon successful completion of this course students should be able to:

- Understanding the architecture and component of Computer based Control system
- Understanding the fundamentals of serial based data communications.
- Programing, data transmission process a control system of computer
- Select a structure design of control system with optimal
- Explain Modbus and Profibus protocol of data transmission
- Programing and usage of TCP/IP protocol
- Create database
- Obtain usage of HMI (Human interface machine).
- Explain about system, block diagram, architecture and software of SCADA (Supervisory Control and data Acquisition)

### ***Abstract***

Structure and element of Control system, data transmission protocols, software of HMI programing and fundamentals of SCADA system are covered by this course. The goal of course will allow students to demonstrate specific knowledge of computer based control system architecture, programing of control system, create database, topology, and protocols. The main attention is drawn to the theoretical and practical usage of Computer based control system to measurement and control parameter of electric system equipment.

### ***Content***

Introduction

The industrial revolution has contributed largely in the development of machine based control where machines in process industries were took over the work done by human physical power. The early production processes were natural scale-up versions of the traditional manual practices. These were designed as batch process which later was expanded to continuous processes, resulting in economical and technological benefits. The industrial process control has modernized with modernization of industries. Process control is therefore not a discovery of recent past, but is rather as old as the industry itself. The engineers and designers of process industries always tried to automate the processes as much as possible and to do so, brought in measuring instruments.

Thus the need of better instrumentation and automatic control became the dominant reason for better operation of industrial processes.

## 1. Architecture of computer based control system

### 1.1. Architecture of computer based control system.

Introduction, Data acquisition , display and storage equipment, measurement interface, control action data logging and computation, comparing with limits and alarm raising, data accumulation and formatting

### 1.2. RTU (remote terminal unit), DTU(data terminal unit)

Introduction, System concept of the RTU, Monitoring and control function, programing of RTU, difference between RTU and PLC,

## 2. Protocols of data transmission

### 2.1. TCP (Transport Control Protocol)/IP (Internet Protocol) protocol and programing

Introduction, TCP/IP model, File transfer protocol (FTR), Domain Name System, IP Addressing, Collection of network,

### 2.2. Encryption of data transmission and method of encryption

Encryption of data transmission, method of encryption

### 2.3. Modbus, Profibus protocol and programing

Introduction, Difference between Modbus and Profibus, Overview of Modbus gateway facility, principles of operation, using diagnostic table, diagnostic function codes, (redundant) duplex mode

### 2.4. GPRS system

Introduction, Packet control unit (PCU) Serving GPRS support node (SGSN), Gateway GPRS support node, Domain name server, Firewalls, Border Gateway, Charging Gateway, GPRS interface.

## 3. Programing of computer based control system, HMI SCADA software

### 3.1 Programing of computer based control system

### 3.2 Software and usage of HMI

Introduction, Plant mimic diagram of plant/process, Alarm overview presenting information on the alarm status of large areas of the plant, Multiple area displays presenting information on the control system, HMI devices consist

### 3.3 SCADA system

Introduction, SCADA system, Objectives of SCADA, functions of SCADA, SCADA in process control

### *Teaching methods*

The theoretical part of the course is presented by a course tutor, lecture is normally a presentation or demonstration designed to give student an overview of a topic. But the format is normally much more informal and promotes open discussion around specific topics or theories.

The practical work represents a project for design of SCADA, and HMI system and example of Computer based control system. Work independently, in pairs or as part of a small team and for most courses, where a practical element is incorporated, student will be required to submit a piece of work which will count towards your overall result.

### *Assessment*

The course grade consists of these components:

- Attendance 10%
- Mid-Term Exam I 7.5%
- Mid-Term Exam II 7.5%
- Homework/Report 15%
- Laboratory/Report 30%

*Recommended reading*

M.Morris Mano, Computer system architecture

John.P Hayes, Computer architecture and Organization, McGRAW - HILL International Editions

“User Interface Design for Computer Systems” By Tony Rubin, Edition: illustrated, Published by E. Horwood, 1988, Original from the University of Michigan, Digitized Nov, 19, 2007, ISBN 0470211725, 195 pages

“The Windows Serial Port Programming Handbook” By Ying Bai Edition: illustrated

Published by CRC Press, 2004, ISBN 0849322138, 801 pages

# Syllabus

## "Theory of Digital Automation"

### ***Course topic***

Theory of Digital Automat

### ***Number of credits***

3 credits

### ***Course responsible***

MUST, Ulaanbaatar

Department of Electric Technique

Assoc. Prof. Dr. Bat-Erdene Bayar

### ***Course lecturer***

Honorary Prof. Tsevgee Nusgai

### ***Prerequisites***

The calculation of relay protection, digital signal processing, microprocessor, information interface.

### ***Learning outcomes***

Upon successful completion of this course students should be able to:

- Making the knowledge of digital relay protection
- Calculate the thresholds of digital protection
- Put the threshold to relay using the AcSELeator software for SEL relays;
- Solve the problems any type of digital relays malfunction;

### ***Abstract***

The digital relay protection's theory, algorithm and calculation

### ***Content***

Introduction

Introduction of digital relay protection

1. The general principle of the digital protection
  - 1.1. The purpose of digital relay protection, classification of protection for power system
  - 1.2. Main elements of digital protection
  - 1.3. Schematics
  - 1.4. Main parameters of digital signal
  - 1.5. Interfaces for digital protection
2. Measuring parts of digital relay protection
  - 2.1. The structure schema of digital measurement
  - 2.2. Analogue Digital and Digital Analogue Converter
  - 2.3. Measuring element for one measuring
  - 2.4. Digital meter for direction
  - 2.5. Digital meter for distance
3. Dynamic characteristics of digital protection
  - 3.1. The frequency characteristic of digital algorithm for sinusoidal measure
  - 3.2. The power system's procedure influence for dynamic characteristic of relay protection
  - 3.3. Specifications of relay protection's algorithm
4. Overcurrent and direction digital protection

- 4.1. The measuring the voltage, current for relay protection
- 4.2. Overcurrent protection
- 4.3. Zero sequence current in overcurrent
- 5. Over load protection
  - 5.1. Design of measuring temperature
  - 5.2. Controlling and protecting an electrical motor's heat
- 6. Differential protection
  - 6.1. Structure of digital differential protection
  - 6.2. Sensitivity of differential protection

#### *Teaching methods*

The theory, algorithm and calculation of digital relay protection are based on modern protection and the good books are listed.

The practical work is making experience of digital protections based on SEL laboratory of MUST, Mongolia.

#### *Assessment*

The course grade consists of these components:

30% – Knowledge test with a multiple choice questionnaire

70% – Mid-Term exam 1, 2 and homework

#### *Recommended reading*

Шнеерсон Э.М. “Цифровая релейная защита”, М: Энерго атомиздат 2007- 549 с; ил

Г.Циглер “ Цифровая дистанционная защита принципы и применение –Перевод с англв  
Под ред Дьяков А.Ф. –М: Энергоиздат. 2005-322с

# Syllabus

## "Control and data acquisition system, HMI"

### *Course topic*

Fundamental concepts of digital control monitoring system structure and its hardware, software

### *Number of credits*

3 ECTS

### *Course responsible*

Power Engineering School, Mongolian University of Science and Technology, (MUST)

Department of Electric Technic

Assoc Prof. Dr. Byambasuren Bat-Erdene

### *Course lecturer*

Dr. B.Zagdkhorol

### *Prerequisites*

Interfacing technique

### *Learning outcomes*

Upon successful completion of this course students should be able to:

- List and describe the hardware components of a SCADA system.
- Describe the typical communications architectures in a SCADA system.
- Describe the software/communication components of a SCADA system.
- Actuate field devices using interactive elements in an HMI screen.
- Explain the main components and processes of a data acquisition system.
- Describe common SCADA communication protocols and their main characteristics.
- Explain the functions of typical hardware found in a SCADA system installation.
- Specify, deploy, and maintain process historians and associated hardware/software.
- Explain the main characteristics of radio technologies used in SCADA communications.
- Explain the potential security risks inherent in a SCADA system and discuss appropriate remedies.
- Describe common industrial applications of Supervisory Control and Data Acquisition (SCADA) systems.
- Explain the main Remoter Terminal Unit (RTU)

### *Abstract*

This course teaches structure of digital control monitoring system, to learn specific knowledge hardware and software of digital control monitoring system. Communication method with the digital control system, to read and analyze information. Especially, introduce the structure of SCADA system and its hardware, software components.

### *Content*

Introduction

Fundamental principles of modern SCADA systems:

SCADA hardware SCADA software Landlines for SCADA, SCADA and local area networks,  
Modem use in SCADA systems, Computer sites and troubleshooting, System implementation

1. SCADA systems, hardware and firmware

Introduction, Comparison of the terms SCADA, DCS, PLC and smart instrument, SCADA system, Distributed control system (DCS), Programmable logic controller (PLC), Smart instrument, Considerations and benefits of SCADA system

## 2. Remote terminal units

Control processor (or CPU) , Analog input modules, Typical analog input modules  
Analog outputs, Digital inputs, Counter or accumulator digital inputs

### 2.1 Control processor (or CPU) , Analog input modules, Typical analog input modules

Analog outputs, Digital inputs, Counter or accumulator digital inputs, Digital output module, Mixed analog and digital modules, Communication interfaces, Power supply module for RTU, RTU environmental enclosures, Testing and maintenance, Typical requirements for an RTU system

### 2.2 PLCs used as RTUs

PLC software, Basic rules of ladder-logic, The different ladder-logic instructions

### 2.3 The master station.

System SCADA software, Local area networks, Ethernet, System reliability and availability, Communication architectures and philosophies

## 3. SCADA systems software and protocols

The components of a SCADA system, The SCADA software package, Specialized SCADA protocols, Error detection, Distributed network protocol, New technologies in SCADA systems

## 4. Landlines

Background to cables, Definition of interference and noise on cables, Sources of interference and noise on cables, Practical methods of reducing noise and interference on cables, Types of cables, Privately owned cables, Public network provided services, Switched telephone lines, Analog tie lines, Digital data services, Packet switched services, ISDN, ATM

## 5. Local area network systems

Network topologies, Media access methods, IEEE 802.3 Ethernet, MAC frame format, High-speed Ethernet systems, 100Base-T (100Base-TX, T4, FX, T2), Fast Ethernet design considerations, Gigabit Ethernet 1000Base-T, Network interconnection components, TCP/IP protocols, SCADA and the Internet

## 5. Modems, Troubleshooting and maintenance, Specification of systems

Review of the modem, The RS-232/RS-422/RS-485 interface standards, Flow control, Modulation techniques, Error detection/correction and data compression, Data rate versus baud rate, Modem standards, Radio modems, Troubleshooting the system, Selection considerations, Troubleshooting the telemetry system, Maintenance tasks, The maintenance unit system, Common pitfalls, Standards, Performance criteria, Testing, Future trends in technology

### *Teaching methods*

The main part of the course is presented in the lecture by the books.

In both cases on-line support by the tutor is provided.

### *Assessment*

The course grade consists of these components:

30% – Knowledge test with a multiple choice questionnaire, mid-term exam I, II

40% - Project of selected title

30% – Final exam

### *Recommended reading*

Bailey, David, and Edwin Wright. Practical SCADA for industry. Elsevier, 2003. ISBN 07506 58053

Циглер Г. Цифровая дифференциальная защита. Принципы и область применения. – Перевод с англ. / Под ред. Дьякова А.Ф. – М.:Знак. 2008. – 216 с.

Шнеерсон Э.М Ш76 Цифровая релейная защита. – М.: Энергоатомиздат, 2007. 549 с.: ил. ISBN 978-5-283-03256-6

Siprotec Numerical Protection Relays (Siemens). Catalog SIP,2006.

Техническое руководство по применению реле защиты SEPAM-1000 // Фирма Schneider Electric.2002.

Scada: Supervisory Control And Data Acquisition by Stuart A. Boyer (Paperback - Jun 15, 2009)

# Syllabus

## "Digital Filter Design"

### *Course topic*

Digital filter design

### *Number of credits*

3 credits

### *Course responsible*

MUST, Mongolia

Department of Electric Technique

Assoc. Prof. Dr. Bat-Erdene Bayar

### *Course lecturer*

Prof. Dr. Natsagdorj Chuulan

### *Prerequisites*

Fundamental of Digital Signal Processing,

### *Learning outcomes*

Upon successful completion of this course students should be able to:

- Understand the digital filters
- Knowing the Fourier series and FFT
- Knowing the recursive, differentiating and smoothing filters
- Get knowledge about Butterworth filter

### *Abstract*

This course focuses digital filter design, application for industrial automation and power system, the processes of smoothing, predicting, differentiating, integrating, and separating signals, as well as the removal of noise from a signal.

### *Content*

Introduction

#### 1. Digital signal processing and digital filters

1.1. Constraints of digital signal processing, classification, filter response, transfer function, and its application

1.2. Even and odd function, Fourier series, and least square method

1.3. Fourier complex series, updated Fourier series

1.4. Attenuation class of function and fitting speed

#### 2. Recursive filter

2.1. Gibbs effect, Lanczos smoothing, Sigma factor

2.2. Recursive filter, classification, algorithms

2.3. Calculation approach of lowpass digital recursive

#### 3. Differentiating and smoothing filters

3.1. Differentiating filter, check process of differentiating filter based on data processing example

3.2. New filter design from old filter, development and improvement of filter response

3.3. Smoothing filter, and its calculation

3.4. Smoothing filter, specification and characteristic

#### 4. Fourier series and transform

- 4.1. Fourier series: Orthogonal digital filter
- 4.2. Fast Fourier transform: cosinus representation
- 5. Butterworth filter
  - 5.1. Butterworth filter, Z transform
  - 5.2. Simple calculation example of Butterworth filter
  - 5.3. Reduce phasor relationship and two decades filter

#### *Teaching methods*

The student studies advanced knowledge of digital filter design, classification, main constraints, theoretical definition, the use of schematic technical solutions and software tools for electrical system and industrial automation equipment.

The student obtains practical skill to use digital filters for digital technology equipment and automation of electrical energy production and distribution technology, control and management system, technology process, to apply microprocessor and microcontroller systems for the removal process of noise from a signal.

In both cases on-line support by the tutor is provided.

#### *Assessment*

The course grade consists of these components:

30% – Knowledge test with a multiple choice questionnaire

70% – Mid-Term exam 1, 2 and homework project

#### *Recommended reading*

Пухальский Г.И. Проектирование микропроцессорных устройств: Учебное пособие для вузов / –СПб.: Политехника. 2001. -544 с

Willis J., Tompkins John G. Editors, Interfacing sensors to the IBM PC Prentice Hall, Englewood Cliffs, New Jersey

Р.В. Хемминг Цифровые фильтры. Пер. С английского В.И Ермишина. –М., Советское Радиов 1980

Э.М Шнеерсон Цифровая релейная защита. –М.: Энергоатомиздат, 2007. 549 с.: ил. ISBN 978-5-283-03256-6

Гольдеиберг Л. Мвь Левчук Ю.П., Поляк М. Н. Цифровые фильтры. –М.: Связь., 1974

# Syllabus

## "Automatic control for industrial process and modelling"

### *Course topic*

Automatic control for industrial process and modelling

### *Number of credits*

3 ECTS

### *Course responsible*

Power engineering school, Mongolian University of Science and Technology (MUST)

Department of Electric Technique

Assoc. Prof. Dr. Byambasuren Bat-Erdene

### *Course lecturer*

Assoc. Prof. Dr. Byambasuren Bat-Erdene

### *Prerequisites*

M.AU352 "Industrial automation", and Automatic control, basic theory, transfer function of system, traditional control system, which is called PID, and design rules in automatic control systems.

### *Learning outcomes*

Upon successful completion of this course students should be able to:

- Explain approach of modern control systems, improved ability of calculation methods, modelling & simulation for automatic control of manufacture.
- Explain the steps of system analysis in modern control system and some industrial process
- Compare the traditional control and modern control algorithms
- Design the control system for industrial process and perform the simulation
- Solve problems modelling and simulating for control system and plant
- Demonstrate how to find transfer function of plant, development of new modelling, and an understanding of the building blocks of basic and modern control systems by feedback components, basic features and configurations.

### *Abstract*

The goal of the course is to teach the students about approach of modern control systems, improved ability of calculation methods, modelling & simulation for automatic control of manufacture.

This course teaches model analysis tools and modern industrial processing techniques. This course covers calculation approach of modern control system and usage MATLAB for automatic control system. The topics of this course include the modern control systems, mathematical models of systems, transient and steady-state response analysis, control system analysis, the design by the Root-Locus and Frequency-Response methods, PID controllers and control systems analysis in state space.

### *Content*

Introduction: the concept of a control system and its components, comparison of traditional control systems and modern control systems, and modelling for manufacture.

1. Mathematical models of systems and control systems
  - 1.1 Introduction, and demonstration of some practical example

- Understanding mathematical models of systems, some practical example: spring mass damper system, modelling of the DC motor, modelling of a hydraulic actuator, transfer functions, block diagram models, design example
- 1.2 Control system characteristics  
Understanding control system characteristics, its modelling, some example: speed tachometer system, English Channel boring machines
  - 1.3 Control system performance  
Introduction, Time-Domain Specifications, example of mobile robot steering control, example of AC/AC converter, simplification of linear systems
  - 1.4 Control system stability  
Introduction, Routh-Hurwitz Stability, example of tracked vehicle turning control, control system responses
2. Control system analysis and methods
    - 2.1 Root locus methods  
Introduction, basic understanding of root locus method, obtaining a root locus plot, sensitivity and the root locus
    - 2.2 Frequency response methods  
Introduction, Bode diagram, specifications in the frequency domain, example of engraving machine system
    - 2.3 Stability in frequency domain  
Introduction, Nyquist plots, Nichols charts, example of liquid level control system, example of remote controlled battlefield vehicle
    - 2.4 State-space methods  
Introduction, model relationships, stability of systems in the time domain, example of automatic test system, understanding of time response
3. Control system design
    - 3.1 Lead Compensation  
Introduction, lead compensation, examples
    - 3.2 Lag Compensation  
Introduction, lag compensation, example of rotor winder control system
4. Robust control systems
    - 4.1 Robust PID controlled systems  
Introduction, understanding of robust control, robust PID controlled systems, example of robust control of temperature

### *Teaching methods*

The theoretical part of the course is presented in example scripts and Simulink tools for control system in MATLAB.

The practical work represents a project for design of STM32F4discovery board and mini mechatronics training module.

### *Assessment*

5% - Attendance

10% - Mid-Term Exam I

10% - Mid-Term Exam II

15% - Laboratory tasks

30% - Coursework/Report

30% - Final exam

*Recommended reading*

“Modern Control Systems”, Richard C.Dorf, Robert H.Bishop, Pearson, 2008, Eleventh edition, ISBN Number: 0-13-206710-2.

“Modern Control Engineering” (Fifth Edition [International Edition]), Katsuhiko Ogata, Pearson, 2010, ISBN Number: 978-0-13-713337-6.

“Modern Control Systems Analysis and Design Using MATLAB”, Robert H. Bishop, Addison-Wesley Publishing Company, 2008, ISBN Number: 0-201-59657-1.

“Modeling and Simulation for Automatic Control”, Olav Egeland and Jan Tommy Gravdahl, 2002, ISBN Number: 82-92356-00-2.

“Control Theory: Multivariable and Nonlinear Methods”, Torkel Glad and Lennart Ljung, 2000, ISBN Number: 0-7484-0878-9.

“MATLAB Demystified”, David McMahon, McGraw-Hill, 2007, ISBN Number: 0-07-151030-3.

“MATLAB: The language of technical computing”, 2001.

“Using MATLAB to Interface, Industrial Robotic & Automation Equipment”, J.Norberto Pires, Mechanical Engineering Department, 1999.

# Syllabus

## "Digital signal processing"

### ***Course topic***

Digital signal processing

### ***Number of credits***

3 ECTS

### ***Course responsible***

Power engineering school, Mongolian University of Science and Technology (MUST)

Department of Electric Technique

Assoc. Prof. Dr. Byambasuren Bat-Erdene

### ***Course lecturer***

Assoc. Prof. Dr. Byambasuren Bat-Erdene

### ***Prerequisites***

I.ET203 "Fundamental of Digital Signal Processing" and signals and discrete systems, their classifications, some basic operation and properties in digital system.

### ***Learning outcomes***

Upon successful completion of this course students should be able to:

- Explain advanced knowledge of digital signal classification, sampling theorem, representation of digital signal in time and frequency domain, and its analysis.
- Explain the steps of system implementation, and efficient execution
- Compare the traditional implementation methods of digital system and efficient recursive implementation methods
- Design the digital filter for industrial process and perform the simulation
- Solve problems about algorithms and methods of image processing for intelligent industrial process, design for adaptive digital filter, and audio signal processing.
- Demonstrate how to generate basic signals, basic operation, usage and programming of FFT algorithms, development of digital filter, and an understanding of image processing application for industrial automation

### ***Abstract***

Advanced study of digital signal processing domain is very important since modern digital system and its application are popular used in control engineering field. This course will introduce advanced technique and tools of digital signal processing. There focuses analysis of time and frequency domain of signal, spectrum analysis, and comparison of Fast Fourier Transform (FFT) algorithms. In addition, how to use those algorithms and how to implement those tools are demonstrated. Furthermore, usage of intelligent digital filter design, image and audio signal processing approaches for intelligent manufacture, practical applications in industrial automation engineering field will be briefly explained.

### ***Content***

Introduction: Understanding of signals and systems, basic applications, some practical examples.

#### 1. Discrete time signals and systems

##### 1.1 Signals and systems

Understanding of digital signal processing, digital signal, classification of signals and systems, understanding of analysis of spectrum, time domain, frequency domain

##### 1.2 Convolution and correlation

Properties of convolution and the interconnection of LTI system, crosscorrelation, autocorrelation, properties of correlation, their usage, programming of convolution and correlation algorithm using C++ programming language

### 1.3 Digital filter design

Introduction, classification, design process, FIR and IIR discrete-time system and its structure, modelling and simulation FIR and IIR system

### 1.4 Windowing process

Introduction, basic understanding of windowing process, its programming algorithms

## 2. Discrete Fourier Transform and Fast Fourier Transform

### 2.1 Discrete Fourier Transform (DFT)

Introduction, basic understanding of DFT, amplitude and power spectrum, practical applications, its programming in MATLAB

### 2.2 Fast Fourier Transform (FFT)

Introduction, basic understanding and difference, Raddix-2 algorithm, microcontroller based implementation algorithm of FFT, and its programming

## 3. Audio and sound signal processing

### 3.1 Digital signal representation

Introduction, basic understanding of audio and sound signals, representation of audio signals, some practical examples

### 3.2 Sampling process of audio signals

Sampling process of audio signals, sampling process's implementation of audio signal, its analysis, recording and playing audio signal, signal processing for recorded signal, voice recognition

## 4. Image processing

### 4.1 Introduction

Introduction, basic understanding, how to get image signal, classification, some operation in image signals

### 4.2 Practical implementation

Introduction to image processing and its fundamentals, OV7670 camera module, its signal condition, representation image signal on the thin-film-transistor (TFT) liquid crystal display using microcontroller system, and some practical image processing algorithms

### *Teaching methods*

The theoretical part of the course is presented in example scripts and Simulink tools for control system in MATLAB.

The practical work represents a project for design of PsoC 5 (cypruss controller) based training board and STM32F407 training module.

### *Assessment*

10% - Attendance

10% - Mid-Term Exam I

10% - Mid-Term Exam II

20% - Laboratory report

20% - Coursework/Report

30% - Final exam

*Recommended reading*

“Digital Signal Processing: principles, algorithms, and applications”, John G.Proakis, Dimitris G.Manolakis, Prentice-Hall, 2007.

“Digital signal processing: Laboratory manual”, B.Bat-Erdene, 2018, ISBN: 999785723-2

“Digital signal processing in Power System Protection and Control”, Waldemar R, Janusz S, Andrzej W, Springer, 2011.

“Digital Signal Processing using MATLAB”, Vinay K.Ingle, John G.Proakis, International Student Edition, Thomson, 2007.

“Signal Processing of Power Quality Disturbances”, Math H.J. Bollen, Irene Y.H. Gu, IEEE Press Series on Power Engineering, 2006.

“Digital Signal Processing”, Li Tan, Academic Press, 2008, ISBN Number: 9780123740908.

“Digital Signal Processing”, (Second Edition), Emmanuel Ifeachor, Prentice Hall, 2001, ISBN Number: 0201596199.

“DSP First”, McCellan, Prentice-Hall, 1999.

“Signal Processing First”, McClellan, Prentice-Hall, 2003.

“Digital Signal Processing- A hands-on- approach”, Charles Schuler, McGraw-Hill, 2005.

# Syllabus

## "Industrial robots and manipulators"

### *Course topic*

Industrial robots and manipulators

### *Number of credits*

3 ECTS

### *Course responsible*

Power engineering school, Mongolian University of Science and Technology (MUST)

Department of Electric Technique

Assoc. Prof. Dr. Byambasuren Bat-Erdene

### *Course lecturer*

Dr. Baatar Bilguun

### *Prerequisites*

M.AU354 “Advanced course of Industrial automation” and industrial automation, industrial robots, robotics engineering, their classifications, future trends in intelligent manufacture.

### *Learning outcomes*

Upon successful completion of this course students should be able to:

- Explain basic knowledge of industrial robotics and industrial manipulators, and its control system
- Explain the steps of robot system implementation, application software of robot modelling and simulation, kinematics and dynamic constraints of manipulators
- Compare the traditional control methods and modern control methods for robot manipulator
- Design the robot arm, choose degree of freedom, arm type and perform the simulation
- Solve problems of kinematics and dynamic calculation, constraints.
- Demonstrate image processing algorithms of industrial robot, modelling and simulation tools of mobile robot, calculation of kinematics and dynamic for industrial manipulators
- Demonstrate connection methods and installation for industrial manipulators, programming method of control system, communication interfaces, and protocols for industrial robot.

### *Abstract*

This course will demonstrate application of manipulator and mobile robot for factory process and those control system, design process of robot hardware, modelling, and simulation process, image processing of industrial robot, kinematics and dynamic optimization of industrial manipulators.

### *Content*

Introduction: Understanding of industrial robots, manipulators, basic applications, some practical examples.

#### 1. Introduction to the Industrial Robot

##### 1.1 Introduction

Understanding of industrial robot, brief history

##### 1.2 Using robotics to learn

Constitution of the Robot (example of Nicola robot), example software, PLC software, software for on-board PC, feedback from the on-board webcam

##### 1.3 Using robotics to work

Using on offline simulation environment, statistics of robotics workers

2. Robot manipulators and control systems
  - 2.1 Kinematics
 

Direct kinematics, inverse kinematics, Jacobian, singularities, position sensing, actuators, motors, motor drive systems
  - 2.2 Dynamics
 

Inertia tensor and mass distribution, Lagrange-Euler formulation, D'Alembert formulation, Newton-Euler formulation, Dynamic parameters, robot control system, servo control, sensor interface, programming, user interface
3. Software interfaces
  - 3.1 Low level interfaces
 

Introduction, IO digital signals, robot controller software, PLC software, PC software, using fieldbuses: Profibus (Process Fieldbus), CAN (Controller Area Network), DeviceNet
  - 3.2 Data protocols and connections
 

RPC (Remote Procedure Calls), TCP/IP sockets, TCP ports, UDP datagrams, USD datagrams, UDP ports
  - 3.3 Interfacing a CCD camera
 

Robot controller software, webcam software, remote client, using UDP datagrams, industrial example: control panel, data access remote controller, semi-autonomous labelling system
4. Interface devices and systems
  - 4.1 Speech interfaces
 

Introduction, evolution, technology, automatic speech recognition system, strategy, pick-and-place and robotic welding examples, adjusting process variables
  - 4.2 VoiceRobCam
 

Robot manipulator and robot controller, PLC Siemens S7-200 and server, webcam and image processing software, user client application, speech interface, CAD interface, example of speech interface for welding
5. Industrial manufacturing systems
  - 5.1 Helping Wrapping Machines for the Paper Industry
 

Layout of the system, stations, dimensions and weight, roll wrapping and inner header, external header, labelling, example of EmailWare
  - 5.2 Complete Robotic Inspection Line for the Ceramic Industry
 

Motivation and goals, approach and results, basic functioning of the De-palletizing system, functioning of the Palletizing system
  - 5.3 Handling Production Changes Online
 

Robotic Palletizing system, identify empty pallets and measure parameters of an empty pallet, pick a glass from the production line, palletize the glass, system software, on-line monitoring

### *Teaching methods*

The theoretical part of the course is presented in example scripts and Simulink tools for robotics control system in MATLAB.

The practical work represents a project for design of ABB's industrial robot training module.

### *Assessment*

10% - Attendance

10% - Mid-Term Exam I

10% - Mid-Term Exam II

20% - Laboratory report

20% - Coursework/Report

30% - Final exam

*Recommended reading*

“Industrial Robots programming: Building Applications for the Factories of the Future”, J. Norberto Pires, Springer, 2007.

Miltiadis A.Boboulos, “Automation and Robotics”, IDC Technologies, 2010, ISBN: 978-87-7681-696-4.

“iRobot Create: Open Interface: Manual”, [www.irobot.com](http://www.irobot.com)

“Industrial Control Handbook“, Third Edition, Andrew Parr, New York, 1998, ISBN: 0831130857, Industrial press.

“Process Control Instrumentation Technology”, Seventh Edition, Curtis D.Johnson, 2003, Prentice Hall.

# Syllabus

## "Digital electronics design"

### *Course topic*

Digital electronics design

### *Number of credits*

3 credits

### *Course responsible*

MUST, Ulaanbaatar

Department of Electric Technique

Assoc. Prof. Dr. Bat-Erdene Bayar

### *Course lecturer*

Dr. Nyambayar Baatar

### *Prerequisites*

Digital electronics system, computer added design in electronics.

### *Learning outcomes*

Upon successful completion of this course students should be able to:

- Student will be able to understand digital design theory
- Deep understanding of hardware description languages such as VHDL and Verilog.
- Understanding of digital electronics circuit design methods
- Design complex circuits using hardware description language

### *Abstract*

This course provides deep understanding of combinational circuits, memory elements, sequential circuits, structure of logic elements structure on a transistor level, different type of memory, programmable logic devices (ROM, PAL and PLA), a microcontroller, AD, DA conversion, VHDL language, FPGAs, EDA tools.

### *Content*

Introduction

Introduction to digital electronics design, state of art and VHDL

1. Logic elements and type of hardware description language
2. Combinational circuits and their structures
3. Sequential circuits and their structures
4. TTL level logic element
5. ROM, PAL, PLA, design using programmable logic devices
6. VHDL description of digital systems – behavioural modelling
7. VHDL description of digital systems - structural modelling
8. Type of memory circuits and components
9. Memory timing issues
10. VHDL description of state machines
11. Instruction set architecture
12. Microprocessor datapath, data transfer methods
13. Pipeline design

14. Control units of microprocessor
15. Special purpose microprocessors

#### *Teaching methods*

The theoretical part of the course is presented in the different type of EDA tools, behavioural and structural design using VHDL language.

The practical work presents a project for design digital circuit using Xilinx ISE – VHDL tools and complete laboratory assignments and their design on Spartan 3E FPGA kit.

In both cases on-line support by the tutor is provided.

#### *Assessment*

The course grade consists of these components:

70% – Mid-Term exam 1,2 and homework

30% – Knowledge test

#### *Recommended reading*

Enoch O. Hwang “**Digital Logic and Microprocessor Design With VHDL**”,2005

Peter Anshenden “**The Designer’s Guide to VHDL**”, 1996

<http://esd.cs.ucr.edu/labs/tutorial/>

# Syllabus

## "Advanced Course of Power Electronics"

### ***Course topic***

Advanced Course of Power Electronics

### ***Number of credits***

3 ECTS

### ***Course responsible***

Power Engineering school of MUST (Mongolian University of Science and Technology)

Department of Electric Technique

Assoc.Prof. Dr. Bat-Erdene Byambasuren

### ***Course lecturer***

Dr. Nyambayar Baatar

### ***Prerequisites***

M.EC334 "Power electronics" and theory of electronics

### ***Learning outcomes***

Upon successful completion of this course students should be able to:

- Design and analyse power electronics circuits using PSIM software and MATLAB Simulink software
- Understanding advanced technical and theory of the power semiconductor elements applications
- Explain Power factor and measures of distortion
- Explain DC/DC converters and Inverters (DC/AC converters)
- Understanding resonant converters and RF (radio frequency) power circuits
- Demonstrating principle of Pulse-width modulation (PWM) scheme

### ***Abstract***

Power electronics devices are fundamental to the electrical energy transmission, transformation and use of electrical energy. This course provides a theoretical knowledge and operating characteristics of power electronics devices and design, analysis and control of Step-down (Buck), Step-Up (Boost), Buck-Boost and Full bridge topologies, Pulse-width modulation (PWM) scheme, characteristics of controllable switches, continuous and discontinuous current mode. Switch-mode DC-AC converters: single and three phase inverter concepts, Sinusoidal PWM.

### ***Content***

#### **Introduction**

Power electronics has become the fastest development in the last three decades by the rapid development of power semiconductors, power processing needs and requirement in the motion control systems. Applications of power electronics include industrial uses, commercial uses, residential purposes, electric vehicles, aerospace and space technologies. Examines the application of electronics to energy conversion and control. Topics covered include: modelling, analysis, and control techniques; design of power circuits including inverters, rectifiers, and DC-DC converters; analysis and design of magnetic components and filters; and characteristics of power semiconductor devices. Numerous application examples will be presented such as motion control systems, power supplies, and radio-frequency power amplifiers.

#### **1. Introduction and Analysis Methods, Introduction to Rectifiers, Power Factor and Measures of Distortion**

##### **1.1. Introduction and analysis methods**

Switching Power Electronics, Linear Regulator, Analysis Techniques, Methods of Assumed States, Periodic Steady State, Equivalent source replacement

- 1.2. Introduction to rectifiers  
Introduction, Load Regulation, Phase-controlled Rectifier, Thyristor device, Silicon controlled Rectifier (SCR)
- 1.3. Power factor and measures of distortion  
Introduction, Definitions and identities, Power factor, Total Harmonic Distortion (THD), Power factor compensation
2. DC/DC Converters and introduction to magnetics
  - 2.1. Introduction to DC/DC converters  
Analysis techniques, Combine elements, Direct converters, Indirect converter, Isolated DC/DC converters, MOSFET, Ripple components and Filter sizing, Discontinuous conduction mode,
  - 2.2. Introduction magnetics  
Fundamental law of magnetics, Reluctance of electro magnetics, Transformer, Theory of losses on transformer
3. Inverters and switching
  - 3.1 Inverters AC/DC converter  
Introduction, Fourier series review, Inverter structure, Programmed RWM, Magnitudes harmonic and Fundamental, Multilevel converters, Inverter current control technique, current control methods
  - 3.2 Switching losses and snubbers  
Introduction, Semiconductor losses, Snubbers, Buck converter/ MOSFET
  - 3.3 Soft-switching techniques  
Introduction, General method, Zero-Voltage Switching (ZVS), Zero-Current Switching (ZCS), ZVS PWM Buck converter, Full-Wave ZCS Quasi-Resonant Buck Converter, Resonant Pole Inverter and its operation
4. Thermal modelling and heat sinking, EMI (electromagnetic interference) filtering, Three-phase systems, Resonant converters and RF (radio frequency) power circuits
  - 4.1 Thermal Modelling and Heat sinking  
Introduction, Method of heat removal (Convection, Conduction, Radiation), Thermal Capacitance, Transient Thermal Impedance
  - 4.2 EMI filtering  
Introduction, Requirements of EMI, Consider on simple cases, Control considerations of EMI filters
  - 4.3 Three-phase systems  
Basic theory of three-phase system, three-phase rectification, Higher order rectifiers,
  - 4.4 Resonant converters and RF (radio frequency) power circuits  
Resonant power conversion, Resonant circuit review, Resonant gate drives, multi-stage amplifiers, maximum power transfer theorem, matching networks

### *Teaching methods*

The theoretical part of the course is presented by a course tutor, lecture is normally a presentation or demonstration designed to give student an overview of a topic. but the format is normally much more informal and promotes open discussion around specific topics or theories.

The practical work represents a design of electronic circuit examples and Simulink tools for control system and analyse in Matlab. Work independently, in pairs or as part of a small team and for most courses, where a practical element is incorporated, student will be required to submit a piece of work which will count towards your overall result.

### *Assessment*

The course grade consists of these components:

- Attendance 10%
- Mid-Term Exam I 7.5%
- Mid-Term Exam II 7.5%
- Homework/Report 15%
- Laboratory/Report 30%

*Recommended reading*

Kassakian, John G., Martin F. Schlecht, and George C. Verghese. *Principles of Power Electronics*. Reading, MA: Addison-Wesley, 1991

Mohan, Ned, Tore Undeland, and William Robbins. *Power Electronics: Converters, Applications, and Design*. 2nd ed. New York, NY: John Wiley & Sons, 1995

Krein, Philip T. *Elements of Power Electronics*. New York, NY: Oxford University Press, 1998

# Syllabus on Nanomaterials for Electronics

## ***Course topic***

Nanomaterials for Electronics

## ***Number of credits***

5 ECTS

## ***Course responsible***

TUS Sofia

Department of Microelectronics

Prof. Dr. Slavka Tzanova

## ***Course lecturer***

Ass. Prof. Dr. Elitsa Gieva

Assoc. Prof. Dr. Mariya Alexandrova-Pandieva

Ass. Prof. Maria Angelova

## ***Prerequisites***

Microelectronics technology and design rules, solid state physics, computer added design in electronics.

## ***Learning outcomes***

Upon successful completion of this course students should be able to:

- Compare the properties of materials for deep-submicron and nanometre CMOS IC, HEMT, single electron transistors and resonant tunnelling devices;
- Discuss the advantages of devices on carbon nanotubes and graphene;
- Explain the physical principles of spintronic devices and choose appropriate materials for them;
- Select a method and plan the procedures for characterisation of molecular systems;
- Plan the fabrication procedure for deep-submicron and nanometre CMOS IC with the proper technological process for the materials of the substrate, implanted areas, isolation, metallisation.

## ***Abstract***

This course will take an in-depth look at nanomaterials used in nanoelectronics. Theory and concepts of nanomaterials will be covered, including the chemistry and physics of nanomaterials. The course will also focus on major classes of nanomaterials, including carbon nanotubes, nanostructured materials, nanowires, nanoparticles, nanoclays, and other nanomaterials. Applications of nanomaterials to technology areas in nanoelectronics will also be discussed.

## ***Content***

1. Current trends in nanoelectronics

The course will cover the materials for:

- Deep-submicron and nanometre CMOS IC (under 50  $\mu\text{m}$ );
- HEMT ( high electron mobility transistor);
- Devices on carbon nanotubes and graphene;
- Resonant tunnelling devices and circuits;

- Single electron transistors;
  - Spintronics;
  - Quantum electronics;
  - Bioelectronics and molecular electronic devices.
2. Materials for deep-submicron and nanometer CMOS IC:
- Materials for the substrate – tight Si;
  - Alternative materials for the gate insulator: high K gate insulators;
  - Gate electrode materials ( n+ polysilicon, mid-gap, metals);
  - SOI;
  - Double-Gate Transistor Structures and Multi-Gate Transistor Structures.
3. Materials for HEMT:
- Heterostructures on A3B5 (GaAs/ AlGaAs, InGaAs/InAlAs etc.).
4. Materials for devices on carbon nanotubes and graphene:
- CNT – Carbon nanotubes – physical characteristics.
  - CNT devices: CNT Transistor, CNT –Based Field Emission Devices, Junctions, Heterojunctions and Quantum Confined Structures Based on Carbon Nanotubes, Microwave Devices Based on Carbon Nanotubes, CNT Based Electrical Sensors;
  - Graphene.
5. Materials for resonant tunnelling devices:
- Structures of resonant tunnelling devices and circuits: AlAs/GaAs/AlAs, AlSb/InAs/AlSb.
6. Materials for single electron transistors:
- Single Electron Transistors structure and materials: Si, GaAS.
7. Spintronics:
- Physical principles and materials for spintronic devices;
  - Spintronic structures: Spin Valves, Spin Pumps, Spin Diodes, Spin Transistors, Spin Based Optoelectronics Devices, Spintronic Computation.
8. Quantum electronics:
- Quantum electronic devices (QED) – physical principles and materials;
  - Short-Channel MOS Transistor, Split-Gate Transistor, Electron-Wave Transistor, Electron-Spin Transistor, Quantum Cellular Automata (QCA).
9. Materials for bioelectronics and molecular electronic devices:
- Characterisation of molecular systems: electrical properties of molecules;
  - Molecular electronic devices, polymer electronics, self-assembling circuits, optical molecular memories;
  - Molecular processor, DNA analyzer as biochip.

#### *Teaching methods*

The course is presented in the Moodle learning environment in the form of HTML tutorials.

On-line support by the tutor is provided.

There is optional practical work (mandatory of the students at TUS) in the laboratory of vacuum layer deposition of the Dep. of Microelectronics at TU-Sofia.

*Assessment*

Knowledge test with a multiple choice questionnaire

*Recommended Readings*

Vajtai, R. (Ed.), Springer Handbook of Nanomaterials, Springer, 2013, ISBN 978-3642205958

Bhushan, B. (Ed.), Springer Handbook of Nanotechnology, Springer, 2010, ISBN 978-3642025259

Williams A., Semiconductor Nanomaterials for Flexible Technologies, Sun&Rogers, 2012, ISBN: 978-1437778236

Kumar V., Nanosilicon, 2013, Elsevier Science, ISBN: 9780080445281

Baldo M., Introduction to Nanoelectronics, MIT course materials,  
<http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-701-introduction-to-nanoelectronics-spring-2010/download-course-materials/>

# Syllabus

## "Design of VLSI"

### *Course topic*

Design of Nanoscale MOS ICs

### *Number of credits*

5 ECTS

### *Course responsible*

TUS Sofia

Department of Microelectronics

Prof. Dr. Marin Hristov

### *Course lecturer*

Assoc. Prof. Dr. Rossen Radonov

Assist. Prof. Dr. Elitsa Gieva

### *Prerequisites*

Microelectronics technology and design rules, solid state physics, computer added design in electronics.

### *Learning outcomes*

Upon successful completion of this course students should be able to:

- Compare the CMOS technologies for nanotransistors as FDSOI and Tri-Gate;
- Explain the steps in IC design and the different design rules;
- Design the schematics of CMOS integrated circuits and perform the simulations;
- Solve the problems with modelling and simulating short channel transistor circuits;
- Design the layout of CMOS ICs;
- Perform the extraction of the schematics from the layout and verification of the design and analyse the cause for the errors.
- Demonstrate innovation, autonomy, and sustained commitment to the development of new modelling and design rules through performing a full design of nanoscale ICs

### *Abstract*

Problems related to the design and investigation of submicron and nanoscale MOS integrated circuits are covered by this course. Currently there are some nanotechnologies in the means of 14 nm design kits, which are available via the EURORACTICE organization. The main attention is drawn to the theoretical and practical usage of state-of-the-art industrial CAD systems, e.g. CADENCE, SYNOPSIS and others. The designers who use those systems can implement nanoscale elements from the relevant standard cell libraries. The specific parameters, related to the nanoscale effects are represented in the embedded system models of the elements.

### *Content*

Introduction

The design in the 'More than Moore' era:

The effect 'digital becomes analogue' (subthreshold, gate leakage – pure digital circuits to be simulated with consideration of analogue effects), voltage headroom shrinks and makes analogue and RF design complicated, etc.

1. CAD tools for design of analogue and mixed-signal integrated circuits (CADENCE)

1.1. Schematics.

Getting Started, Understanding Connectivity and Naming Conventions, Creating Schematics, Creating a Multisheet Schematic, Creating Symbols, Automatically Creating Cellviews, Editing Objects, Editing Properties, Traversing the Design Hierarchy and Creating a Design Configuration View, Checking Designs, Plotting Designs, Setting Schematic Composer Options, Customizing the Schematic Composer

## 1.2. Simulation

### 1.2.1. Spice

Introduction, Built-In Variables and Arrays, Expressions and Functions, Commands, Circuit Analysis, Components, Command and Model Files, Device Models, Subcircuits, Examples, Analysis, Node Referencing

### 1.2.2. Spectre

Getting Started with Spectre, SPICE Compatibility, Spectre Netlists, Parameter Specification and Modeling Features, Analyses, Control Statements, Specifying Output Options, Running a Simulation, Time-Saving Techniques, Managing Files, Identifying Problems and Troubleshooting, Example Circuits, Dynamic Loading

### 1.2.3. Verilog XL

About the Verilog-XL Integration Environment, Setting Up the Simulation Environment, Working with the Stimulus, Running and Controlling a Interactive Simulation, Viewing Simulation Results Interactively, Debugging Your Design, Running Batch Simulations, Comparing Simulation Results, Netlisting

## 1.3. Layout

### 1.3.1. Envisia Silicon Ensemble

Introduction, The Basics, Timing-Driven Design Flow, Environment Variables, Error Messages

### 1.3.2. IC Chip Assembly

Chip Assembly Overview, Preparing, Translating, and Checking Data, Setting Routing Rules, Analyzing and Preparing the Design for Routing, Routing Your Design, Design File Syntax Example, Questions and Answers, Trouble Shooting, Via Naming Conventions

## 2. CAD tools for design of digital circuits (SYNOPTSYS)

### 2.1. Methodologies

Introduction, The Design Process, Detailed Design, FPGA's and ASIC's, FPGA Design Flow, ASIC Design Flow

### 2.2. Synopsys Environment

CoCentric, Physical Synthesis, Synthesis Tools, DesignWare, Library Compiler, Simulation Tools, Static Timing and Formal Verification

### 2.3. VHDL and Verilog

## 3. Design of deep-submicron devices (subthreshold, gate leakage etc.)

## 4. System design, future trends (multiphysics simulation, error propagation, multi-technology, multi-scale: device (nm) to board (dm), analogue and digital design for deep-submicron technologies).

### *Teaching methods*

The theoretical part of the course is presented in the Moodle learning environment in the form of HTML tutorials.

The practical work represents a project for design of submicron integrated circuit with a remote access to SYNOPTSYS and CADENCE which run on the server of ECAD laboratory at TU-Sofia. In both cases on-line support by the tutor is provided.

### *Assessment*

The course grade consists of these components:

40% – Knowledge test with a multiple choice questionnaire

60% – Final Project

*Recommended reading*

Deleonibus S., *Intelligent Integrated Systems: Devices, Technologies, and Architectures*, Pan Stanford Publishing, 2014, ISBN-13: 978-9814411424.

Collaert N., *CMOS Nanoelectronics: Innovative Devices, Architectures, and Applications*, CRC Press, 2012, ISBN-13: 978-9814364027.

Deleonibus S., *Electronic Device Architectures for the Nano-CMOS Era. From Ultimate CMOS Scaling to Beyond CMOS Devices*, Pan Stanford Publishing, 2008, ISBN-13: 978-9814241281.

Lee P., *Introduction to Place and Route Design in VLSIs*, 2006, ISBN 978-1-4303-0492-0,

Scheffer L., Lavagno L. and Martin G. (ed), *Electronic Design Automation for Integrated Circuits Handbook, Volume 1, EDA for IC System Design, Verification and Testing*, Taylor & Francis, 2006, ISBN 0-8493-7923-7

Scheffer L., Lavagno L. and Martin G. (ed), *Electronic Design Automation for Integrated Circuits Handbook, Volume 2, EDA for IC Implementation, Circuits Design and Process Technology*, Taylor & Francis, 2006, ISBN 0-8493-7924-5

# Syllabus

## “Electrical Machines”

### *Course topic*

Electrical Machines fundamentals

### *Number of credits*

5 ECTS

### *Course responsible*

Politecnico di Torino

Energy Department

Assoc. Prof. Luca Ferraris

### *Course lecturer*

Assoc. Prof. Luca Ferraris

### *Prerequisites*

Basics of Electrical Circuit Analysis

### *Learning outcomes*

Upon successful completion of this course students should be able to:

- know the principles of main electro-mechanical equipment and electrical machinery used in industry.
- know the criteria for use and application fields of the electrical machinery.
- analyze and evaluate the performance of electric machines.
- make the choice of the appropriate electrical equipment to be included in mechanical systems.

### *Abstract*

The course aims to provide the methodological bases for understanding the operating principles and key operational concepts of electromechanical equipment and in general a rational, proper and safe use of electrical equipment.

The operating principles of the main electrical machinery will be introduced, in view of their application in industrial processes, and the tools to evaluate the performance will be detailed by means of numerical exercises.

### *Content*

Introduction

- Ampere law. Magnetic flux. Lenz and Lorentz laws. Fundamental laws.

Materials

- Soft and hard magnetic materials. Iron losses.
- Conductors and insulators.

Magnetic circuits

- Electromagnet. Magnetic reluctance.
- Permanent magnets.
- Circuits with permanent magnets.
- Exercises: numerical evaluation on magnetic circuit examples

Thermal aspects

- Simplified thermal model. Thermal transients.
- Types of services.

- Exercises: numerical evaluation of the temperature in the machines.

#### Transformer

- Realization aspects. Ideal transformer: working principle.
- Real transformer.
- Equivalent circuit
- Equivalent circuit under sinusoidal supply. Vector diagram.
- Equivalent circuit parameters: no load and short circuit tests
- Voltage drop. Efficiency
- Parallel.
- Three phase transformer.
- Exercises: determination of parameters of the equivalent circuit, operation with load connected, three phase transformer

#### Asynchronous machine

- Rotating magnetic field
- Realization aspects. Wounded rotor and cage rotor
- Working principle. Comparison with transformer
- Energetic balance.
- Mechanical characteristic.
- Determination of parameters.
- Losses and efficiency
- Speed regulation.
- Exercises: determination of parameters of the equivalent circuit, Determination of parameters and working conditions

#### DC machine

- Realization aspects. Rotor
- Working principle. Torque and emf generation
- Machine equations
- Equivalent circuit
- Separately excited machine. Mechanical characteristic
- Speed regulation
- Series excited machine. Mechanical characteristic. Commutation.
- Exercises: evaluation of torque and power in separately excited machines and in series excited machines

#### *Teaching methods*

The lectures will be held with the use of powerpoint slides previously transferred to the students. Practice lessons will consist in the solution of numerical exercises.

#### *Assessment*

Written test; compulsory oral exam.

The written exam consists in the solution of two exercises, in approximately 1.5 hours.

Topics of the exercises are: magnetic circuits, evaluation of the working conditions of transformers, asynchronous and DC machines.

#### *Recommended reading*

- Ned Mohan, "Electric machines and drives: a first course", Wiley, 2012
- Fitzgerald, Kingsley, "Electric Machinery", McGraw Hill
- Slides of the course

# Syllabus

## “Electric plant design”

### *Course topic*

Electric plant design fundamentals

### *Number of credits*

8 ECTS

### *Course responsible*

Politecnico di Torino

Energy Department

Prof. Paolo Di Leo

### *Course lecturer*

Prof. Paolo Di Leo

### *Prerequisites*

Basic concepts of Electrotechnics, Electrical machines, Electrical measurement and Electrical systems.

### *Learning outcomes*

Upon successful completion of this course students should be able to:

- Know the professional aspects concerning electrical plant design and multi-disciplinary integrated design.
- Identify the design objectives and to translate the operating choices into specific documents (technical reports, schemes and drawings, economic assessments).
- Interpret and apply legislative documents and standards.
- Know the design solutions for electrical plants in ordinary environments.

### *Abstract*

The course aims to provide the fundamental elements of electric power plant design with professional focus. The course enables the students to acquire specific applicative and professional skills, through the illustration of the main design principles and solutions, the study of the types of application of traditional and advanced components for electric energy and signal systems, and the detailed analysis of the criteria for component selection and plant sizing. The concepts presented are consolidated into a dedicated design activity referred to the design of an electrical plant of the industrial or tertiary sector, with the development of the corresponding textual or graphical documents, and with details on specific aspects.

The course is also aimed at involving the students into a workgroup-based activity, with distinction of the operational tasks, and at giving them the possibility of handling legislative documents and standards, as well as specific software for computer aided design.

### *Content*

- Introduction to electric design.
- Norms and tools.
- Main components.
- Plant protections.
- Load characterization and diagrams.
- Conventional power.
- Normal, emergency and secure supply.

- MV/LV substations and power switchboards.
- Primary, secondary and tertiary distribution.
- Lighting and related software.
- Photovoltaic power systems.
- PV plant schemes.
- Costs of installed power and produced energy.
- Software for electric design.

### *Teaching methods*

In addition to lectures, the course contents includes design activities.

The course will be developed as seminars and design labs, in the informatics laboratory. The students will be organized into groups of 3-4 persons. Each theoretical presentation will be followed by the development of the related design documentation. Each group will develop all the reports and drawings, according with a given plan.

The student should develop ability in using the graphic software, as Autocad, and the design software.

### *Assessment*

At the end of the course, each group must hand out its project, before the examination. Each student will be subject to a written examination, followed by an oral discussion of the project and its criteria.

The duration of the written test is 3 hours. During the written test it is not allowed to keep and consult notebooks, books, sheets with exercises, but only the use of a portable calculator and the Tables, downloadable on the course portal in the folder called "Tables".

The final grade is given in consideration of the results achieved in the written test, the oral test and the project, evaluating the acquisition of expected learning outcomes.

### *Recommended reading*

- V. Cataliotti: Impianti elettrici vol. I, II, III, ed. Flaccovio
- Progettazione degli impianti elettrici (ed.CEI)
- F. Spertino, R. Carelli: Impianti fotovoltaici di piccola taglia (CLUT)

# Syllabus

## “Electrical Systems”

### *Course topic*

Fundamental on Electrical Systems

### *Number of credits*

12 ECTS

### *Course responsible*

Politecnico di Torino

Energy Department

Assoc. Prof. Angela Russo

### *Course lecturer*

To be defined

### *Prerequisites*

Basic knowledge of electrotechnics (circuit analysis and three-phase systems), basic knowledge of electric machines (transformer, synchronous and induction machines)

### *Learning outcomes*

Upon successful completion of this course, students should be able to:

- understand and interpret the structure and operation of electrical installations in High Voltage, Medium Voltage and Low Voltage systems analyze three phase systems, in normal state and after fault
- model the main components to study the operating conditions in normal state and after faults
- select protection systems against overcurrents and overvoltages
- interpret and apply the concepts referred to safety and the related standards and regulatory documents;
- apply the basic concepts of the design of user power plants, with ability to define basic scheme, to size the components in function of operating requirements and of the possible occurrence of anomalous events (short circuits and overvoltages), to identify the protections types and settings applying the relevant standards.

### *Abstract*

The course aims at providing the basic notions concerning the structure and characteristics of the electrical installations for electricity production, delivery and utilization, with due attention to economic and environmental constraints. After considering the main components, the course will present the basic techniques for three phase systems, in normal state and after faults. The problems of protections against overcurrents and overvoltages will be presented next. Part of the course is dedicated to the general safety concepts and their application to electrical plants, including the main references to the most significant legislation and standards for electrical safety and to the prevention techniques.

The last part of the course is devoted to some basic concepts on electrical plants for final users and their preliminary design.

Numerical examples will enrich the preparation of the students.

### *Content*

**Generation, transmission and distribution systems**

Structure of the electric energy systems:

generation, transmission, distribution

Power plant generation from conventional and non conventional sources.

Energy mix and operation in relation to the load diagram and to economic competitive environment

### **Components**

Electric lines (overhead lines and cables; thermal behaviour of cables, definition of ampacity, behaviour of cables in overload conditions and in faulty conditions)

Protection equipment (classification, interruption process of a direct current and of an alternating current, main devices).

Protection relays.

Circuit breaker.

### **Fault analysis of electric systems**

Faults in electric systems

### **Design of protection systems for cable lines**

Overcurrent and short circuit protection.

Standards.

Basic system design of low voltage distribution systems.

### **Quality of supply**

General definitions.

Harmonic distortion.

Voltage sags.

Italian standards.

### **Power factor correction**

Problems.

Modalities.

Technical rules.

Design of a power factor correction system.

### **Secondary Substations**

Classification.

Schemes.

Component sizing.

### **Electrical safety**

Safety and risk concepts.

Legislation and standards.

Effects of electricity on human body.

Grounding.

Protection against direct contacts

Protection against indirect contacts in TT, TN and IT systems.

Extra-low voltage systems.

Particular environments.

Protection against lightning.

*Teaching methods*

The lectures will be held both with the use of powerpoint slides previously transferred to the students and with the use of blackboard.

Practice lessons will consist in the solution of numerical exercises.

### *Assessment*

Exam: written test; compulsory oral exam;

The exam consists of a written test and an oral colloquium.

The written test (2-hour long) consists of numerical exercises, multiple answer questions and open questions on the course contents.

The maximum score for each question/exercise is indicated in the text. The maximum score for the written test is 30/30.

The oral colloquium includes some questions on the course contents, and could include the discussion on material produced during the laboratory experiences.

The final score refers to the knowledge and ability level reached on the different topics of the course programme.

### *Recommended reading*

- Slides of the course
- F. M. Gatta, Impianti elettrici, Esculapio, 2012.
- R. Benato, L. Fellin, Impianti elettrici, Wolters Kluwer Italia, 2014.
- V. Mangoni, G. Carpinelli, P. Varilone, Elementi di impianti elettrici di media e bassa tensione, Editore: Università di Cassino, 2010.
- G. Conte, Manuale di impianti elettrici, Hoepli, 2014.
- V. Carrescia, Fondamenti di sicurezza elettrica, TNE, 2008

# Syllabus

## “Power Generation from Renewable Sources”

### *Course topic*

Photovoltaic and Wind Power Systems

### *Number of credits*

6 ECTS

### *Course responsible*

Politecnico di Torino

Energy Department

Assoc. Prof. Filippo Spertino

### *Course lecturer*

Assoc. Prof. Filippo Spertino

### *Prerequisites*

Basic knowledge about electric circuit analysis and applied mechanics.

### *Learning outcomes*

At the end of the course the students will know the main technologies about the photovoltaic generators and wind turbines (including general aspects of power electronics), and will be able to calculate the productivity and to correctly design the main components of these power systems.

### *Abstract*

The course is devoted to present both the Photovoltaic and Wind power systems starting from their operating principles, in which general aspects of power electronics are included. The knowledge of the solar and wind resources, the methods to correctly design the main components, to evaluate the energy production, with the economic analysis of investment, are the goals of the course.

### *Content*

PHOTOVOLTAIC POWER SYSTEMS (about 40 h)

State of the art in Photovoltaic (PV) sector: advantages, drawbacks and cost of installation. Manufacturing process of silicon solar cells. Structure of the semiconductors: energy bands; doping; p-n junction and electric field; electron – hole pairs; losses in the energy conversion. Spectral response and efficiency of the main technologies: single, multi-crystalline and amorphous silicon, cadmium telluride, copper-indium-diselenide. Surface covering per installed kilowatt. Equivalent circuit of the solar cell; current-voltage characteristic( I-V curve) at variable irradiance and temperature. Focus on an application problem: series/parallel connection of cells; I-V curve mismatch and shading effect; hot spots and breakdown; bypass and blocking diodes. Structure of a PV module; qualification tests to simulate accelerated ageing. Datasheets of the commercial PV modules, thermography and electroluminescence imaging. Unconventional aspects of PV generators: the option to use the blocking diodes in case of reverse current in a shaded string, the designer choice in case of shadowing between the concentrated one and the equally distributed one. The usage of transistors in DC-AC converters for grid connection; Maximum Power Point Tracking (MPPT); active/reactive power control. Optimal coupling PV array/inverter: constraints of power/voltage/current. Grid interface protections; protections against over-current and direct/indirect contacts. Conventional calculation of energy production:

evaluation of solar radiation, loss sources in the productivity. An innovative procedure to assess the energy production: automatic data acquisition system, experimental tests and results on operating PV plants, economic analysis by the Net Present Value (NPV) method. Cost of energy production. Brief summary about the stand alone PV plants equipped with electrochemical batteries.

#### **WIND POWER SYSTEMS (about 20 h)**

Characterization of the wind: speed and direction; power density; surface roughness; statistic distributions. Structure of a wind turbine: blades, hub, gearbox, electric generator, tower. Operating principle of a wind turbine: lift and drag in a blade; pitch and yaw regulations; adjustment towards stall/feather. Equivalent circuits of induction and synchronous machines. A solution for variable speed wind turbines: the doubly-fed induction generator. The power curve vs. wind speed as a function of pitch regulation and electronic regulation of bidirectional converter. Wind farms: interference among wind turbines, wind park effect. Environmental impact of wind turbines: noise. Power size, diffusion of wind installations in the world. Schemes, cost of installation and energy production. Advantages and drawbacks.

#### ***Teaching methods***

The course is organized with 40 h of lectures and 20 h of classwork exercises and laboratories. Classroom exercises for a total of about 14 h, starting from a summary of electric circuits. 1) Calculation of the electrical parameters of the PV modules in conditions different from rated STC by datasheet of the manufacturers. 2) Calculation of reverse currents in PV strings connected in parallel. 3) Optimum coupling between PV array and inverter. 4) Calculation of the energy production in a PV system. 5) Usage of PVGIS software for solar radiation and PV energy estimation. 6) Calculation of mechanical quantities in a wind turbine. 7) Use of simplified equivalent circuit of induction machine: application to the Doubly Fed Induction Generator (DFIG). 8) Calculation of energy production for a wind turbine. Laboratories for a total of about 6 h: 1) Measurement of the I-V curve of a diode. 2) Measurement of the I-V curve of a PV module. 3) Measurement of the output characteristics for a transistor operating as a switch. 4) Measurement of efficiency and power quality for single-phase inverter. Guided tour to one of the PV plants operating inside the Politecnico di Torino headquarter.

Video lectures of the entire course are available on the PoliTO educational portal for the enrolled students.

#### ***Assessment***

Exam: written test; optional oral exam.

Written exam, 2h duration, with theoretical questions for a total of 20 points (short discussions, drawings and formulas) and numerical exercises regarding the classroom exercises for a total of 10 points. During the written exam it is possible to use an electronic calculator, but it is not permitted to use teaching documents regarding the program of the course. The space at disposal for the answers, on the single sheet of the written exam, is limited to test the ability of the student to summarize the concepts. The request of oral exam is possible only above the mark 24/30 in the written exam. The oral exam deals with the whole program of the course. During the oral exam it is not possible to use any document.

#### ***Recommended reading***

Teaching documents (short handbooks on PV/wind power systems and slides on the lectures) on the POLITO portal of the teacher. For deepening, it is suggested the book "M. Patel, Wind and Solar Power Systems, 2006, CRC Press, USA".