UNIKASSEL VERSITÄT | ELECTRICAL ENGINEERING COMPUTER SCIENCE

Course Catalog
for
Present Challenges in REEE

Master's program in

Renewable Energies and Energy Efficiency for the Middle East and North Africa Region (REMENA)

Status: July 19, 2023

REMENA

Table of Contents

1. Concept of Present Challenges in REEE

Recently, REMENA master program has established a network called REMENA university network (RUN) including three main partner-universities, namely, Cairo university (CU) in Cairo (C), university of Monastir (UM) in Monastir (M) and university of Kassel (UKAS) in Kassel (K).
In this course catalog, different *elective* modules offered by UKAS are presented, from which REMENA students are able to choose a combination of 30 ECTS modules building up a module called "*Present Challenges in REEE*" which is described briefly in the following table. Clearly, the students, based on their study focus, can also combine 30 ECTS credits either from this course catalog or by successfully passing a combination of elective modules, offered by CU, UKAS and/or UM and listed in the REMENA module handbook, to be a sum of 30 ECTS credits.

Two types of elective modules, based on the study focus, are presented in **Sect. 2** and **Sect. 3**, respectively. The first type of elective modules offered during the summer semester (SS), as shown in **Sect. 2**, is related to electric machine drivers, modelling of AC actuators, embedded generating systems as well as power electronic converters.

The second type of elective modules, however, is focusing on different practical aspects of REEE being important for management of REEE projects e.g., legislation, contracts and engineering Ethics, constrained and unconstrained energy optimization problems, different forecasting and regression techniques etc., and being offered during the winter semester (WS) as discussed in **Sect. 3.**

<table>
<tr><td>Module title</td><td colspan="5">Present Challenges in REEE</td></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Combinations of elective modules for focusing on different aspects and challenges in REEE</td></tr>
<tr><td rowspan="2">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Present Challenges in REEE</td><td>lecture, exercise, lab training, seminar, project</td><td>30</td><td>30</td><td>- group presentations
- lab training
- assignments
- written exam</td></tr>
<tr><td>Semester</td><td colspan="5">summer & winter</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Dahlhaus and team</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">450 hours course attendance
300 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">30</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">After the successful participation in the module Present Challenges in REEE being chosen as combinations of some elective modules, the students are able to learn and understand different challenges and aspects related to REEE e.g.,
- develop and understand geothermal resources and applications
- understand different applications and technologies of CCHP
- analyze energy storage technologies and EE measures for RE systems
- analysis and synthesis of integration processes of RE systems
- understand the fundamentals of project management and implement project management skills regarding REEE projects
- define project scheduling and gain professional and practical skills for project planning
- learn about legislation, contracts and engineering Ethics
- analyze the project management work flow for a wind farm
- assess opportunities of efficiency in the energy sector</td></tr>
</table>

	• understand the importance of renewable energies with regards to environmental and economic impact of energy industry and assessing potential alternatives • implement energy management systems, energy transition and sustainable development • deal with constrained and unconstrained general energy optimization problem • implement and compare different linear and non-linear optimization techniques • identify opportunities for practical implementation of RE system • learn how to select solar energy systems according to specific local conditions • understand and implement different electromagnetic modelling of AC actuators • analyze, design and size storage systems, non-conventional AC machines and the oriented machine modelling using the finite element method • implement and control power electronic converter and learn how to design and analyze embedded generating systems • design of experiments and measuring techniques • describe different forecasting, inventory and regression techniques used for REEE
Contents	30 ECTS modules chosen from RUN course catalog and/or from the elective modules offered by CU, UM and/or UKAS.
Media	Black board and beamer, case studies in groups, lab experiments, measurements.

2. Elective Modules Type 1

In this section, all elective modules related to electric machine drivers, modelling of AC actuators, embedded generating systems as well as power electronic converters are listed in **Table 1** and more details are in the tables below.

Control Oriented Modelling of AC Actuators	ECTS	FEA Modelling of AC Actuators (level 1)	ECTS	FEA Modelling of AC Actuators (level 2)	ECTS	Embedded Energy Storage Systems	ECTS
Induction Machine Modelling	2	Electric System Modelling	2	Linear Static Magnetic Analyses	2	Storage Systems: Case Studies	2
Synchronous Machine Modelling	2	Finite Element Modelling	1	Non-Linear Static Magnetic Analyses	2	Sizing of Storage Systems	2
Special AC Actuators	**ECTS**	**Diagnosis, Monitoring and Reconfiguration of Electric Machines Drives**	**ECTS**	**Control Strategies of Electric Drives**	**ECTS**	**Power Electronic Converters**	**ECTS**
Switched Reluctance Machines	1	Faults in Electric Machine Drives	1	Rotor Flux Oriented Control of Three-Phase Induction Motor	1	PWM Control Strategies of Two-Level Inverters	1
Axial Flux Machines	1	Faults Detection and Isolation Techniques and Methods	1	Direct Torque Control of Three-Phase Induction Motor	1	PWM Control Strategies of Three-Level Inverters	1
Transvers Flux Machines	1	Fault-Tolerant Control Strategies	1	Direct Power Control Strategies of Three-Phase PWM Rectifiers	1	Matrix Converters and their Control Strategies	1
Embedded Generating Systems	**ECTS**	**Rules of Writing Research Documents**	**ECTS**				
Generating Systems Embedded on Board of Road Vehicles	1	The Scientific Paper: From Reading to Writing	2				
Modelling of Claw Pole Alternators	1	Writing Process	1				
Design Improvement of the CPA-Based Generating Systems	1						
Avionic Generating Systems	1						

Table 1: Elective modules related to electric machine drivers offered during SS (34 ECTS credits).

Module title	Control Oriented Modeling of AC Actuators
Module type	E
Competency	Electromagnetic modeling of AC actuators

<table>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Induction Machine Modelling</td><td>lecture, exercise</td><td>1</td><td>2</td><td rowspan="2">- exam (70%)
- tutored project defense (30%)</td></tr>
<tr><td>Synchronous Machine Modelling</td><td>lecture, exercise</td><td>1</td><td>2</td></tr>
</table>

Semester	Summer
Responsible	Dahlhaus
Site	Kassel
Lecturer(s)	Ahmed Masmoudi Badii Bouzidi
Language	English
Workload	30 hours course attendance 70 hours tutored project
Credits	4
Recommended Qualifications	-
Learning Outcomes	**Induction Machine Modelling** After the successful participation in the course **induction machine modelling,** the students are able to: - make the synthesis and the implementation of induction machine vector control strategies, - make the synthesis and the implementation of induction machine direct torque control strategies, - make the synthesis and the implementation of induction machine direct power control strategies.
	Synchronous Machine Modelling After the successful participation in the course **synchronous machine modelling** the students are able to: - make the synthesis and the implementation of synchronous machine vector control strategies, - make the synthesis and the implementation of synchronous machine direct torque control strategies, - make the synthesis and the implementation of synchronous machine maximum torque per ampere control strategies
Contents	**Induction Machine Modelling** - Principle of Operation: Induction Phenomenon - Model Simplification Hypothesis - IM A-B-C Model - Park Transform - IM Park Model - Park Model-Based Analysis of the IM Steady-State Operation
	Synchronous Machine Modelling - Salient Pole SM A-B-C model - SM Park Model - Electromagnetic Torque Formulation - Operation at Maximum Torque - Operation at Unity Power Factor - Flux Weakening Operation
Media	Black board and beamer, lectures and presentations, simulation using conventional software packages.
Literature	- Stephen Chapman, *Electric Machinery Fundamentals*, Fourth Edition, McGraw-Hill Series in Electrical and Computer Engineering, 2005. - Paul Krause, Oleg Wasynczuk, Scott Sudhoff, Steven Pekarek, *Analysis of Electric Machinery and Drive Systems,* Third Edition, Wiley Online Library, 2013.

<table>
<tr><td>Module title</td><td colspan="5">FEA Modelling of AC Actuators (level 1)</td></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Design oriented machine modelling using the finite element method</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Electric System Modelling</td><td>lecture, exercise</td><td>1</td><td>2</td><td rowspan="2">exam (100%)</td></tr>
<tr><td>Finite Element Modelling</td><td>lecture, exercise</td><td>1</td><td>1</td></tr>
<tr><td>Semester</td><td colspan="5">Summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Imen Abdennadher</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">30 hours course attendance
45 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">3</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">Electric System Modelling
After the successful participation in the course electric system modelling the students are able to:
- make the synthesis and the analytical resolution of the electrostatic model,
- make the synthesis and the analytical resolution of the magneto-static model,
- make the synthesis and the analytical resolution of the electro-magnetic system model.</td></tr>
<tr><td colspan="5">Finite System Modelling
After the successful participation in the course finite element modelling the students are able to:
- make the synthesis of finite element model,
- make the resolution of finite element mode,
- make the numerical resolution of the finite element method.</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">Electric System Modelling
- Magnetic and electric laws
- Maxwell’s equations
- Electrostatic model
- Magneto-static model
- Electro-magnetic model
- Cases studies</td></tr>
<tr><td colspan="5">Finite System Modelling
- Fundamentals of FEM
- Approximating potentials with shape functional finite elements
- Edge finite elements
- Application of the finite element method</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer, lectures and presentations, simulation using conventional software packages.</td></tr>
<tr><td>Literature</td><td colspan="5">- Miklos Kuczmann, Potential Formulations in Magnetics Applying the Finite Element Method, Lecture notes, Széchenyi István” University Györ, Hungary, 2009.
- Guillaume Legendre, Introduction à l’Analyse Numérique et au Calcul Scientifique, University of Paris, 2017</td></tr>
</table>

Module title	**FEA Modelling of AC Actuators (level 2)**
Module type	**E**
Competency	**Sizing oriented machine modelling using the finite element method**

Courses

Title	Teaching Method	SWS	Credits	Performance requirements/ Examination
Linear Static Magnetic Analyses	lecture, exercise	1	2	- exam (70%) - tutored project defense (30%)
Non-Linear Static Magnetic Analyses	lecture, exercise	1	2	

Semester	Summer
Responsible	Dahlhaus
Site	Kassel
Lecturer(s)	Imen Abdennadher Amal Souissi
Language	English
Workload	30 hours course attendance 70 hours tutored project
Credits	4
Recommended Qualifications	-
Learning Outcomes	**Linear Static Magnetic Analysis** After the successful participation in the course **linear static magnetic analysis** the students are able to: - establish the model and make the numerical resolution of the linear electrostatic model, - establish the model and make the numerical resolution of the linear magneto-static model, - establish the model and make the numerical resolution of the linear electro-magnetic model.
	Non-Linear Static Magnetic Analysis After the successful participation in the course **non-linear static magnetic analysis** the students are able to: - establish the model and make the numerical resolution of the non-linear electrostatic model, - establish the model and make the numerical resolution of the non-linear magnetostatic model, - establish the model and make the numerical resolution of the non-linear electromagnetic model.
Contents	**Linear Static Magnetic Analysis** - Examples description - Linear material definition - Meshing - Boundary conditions - Loads definition - Review results
	Non-Linear Static Magnetic Analysis - Examples description - Non-linear material definition - Meshing - Boundary conditions - Load definition - Review results
Media	Black board and beamer, lectures and presentations, simulation using conventional software packages.
Literature	Conventional software packages tutorials

<table>
<tr><td>Module title</td><td colspan="5">Embedded Energy Storage Systems</td></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Storage systems analysis and sizing</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Storage Systems: Case Studies</td><td>lecture, exercise</td><td>1</td><td>2</td><td rowspan="2">- exam (70%)
- tutored project defense (30%)</td></tr>
<tr><td>Sizing of Storage Systems</td><td>lecture, exercise</td><td>1</td><td>2</td></tr>
<tr><td>Semester</td><td colspan="5">Summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Lotfi Krichen
Achraf Abdelkafi</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">30 hours course attendance
70 hours tutored project</td></tr>
<tr><td>Credits</td><td colspan="5">4</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">Storage Systems: Case Studies
After the successful participation in the course storage systems: case studies the students are able to:
- understand why we must store in an isolated system,
- understand why we should store in a system connected to the network,
- understand at what level we can store,
- understand the main electrical energy storage technologies.</td></tr>
<tr><td colspan="5">Sizing of Storage Systems
After the successful participation in the course sizing of storage systems the students are able to:
- choose the good electric storage system according to the application,
- size the chosen electric storage system taking into account the imposed constraints,
- evaluate the performances of the studied hybrid system,</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">Storage Systems: Case Studies
- General information on storage systems
- Study of a hydrogen storage system
- Super capacitor energy storage system
- Battery electric storage system
- Application 1: Electric power generation based on WECS-SC under load disturbance
- Application 2: BESS for smoothing load power curves in smart grid</td></tr>
<tr><td colspan="5">Sizing of Storage Systems
- Hydrogen storage system
- Super capacitor
- Battery electric storage system</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer, lectures and presentations, simulation using conventional software packages.</td></tr>
<tr><td>Literature</td><td colspan="5">- Sergio Faias, Jorge Sousa and Rui CastroEmbedded Energy Storage Systems in the Power Grid for Renewable Energy Sources Integration, Intech, 2009,
- Bernard MULTON, Stockage de l’énergie électrique pour la production décentralisée d’électricité (connecté au réseau ou en site isolé), 2010.
- Robert Huggins, Energy Storage, Springer 2010.</td></tr>
</table>

<table>
<tr><td>Module title</td><td colspan="5">Special AC Actuators</td></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Analysis and design of non-conventional AC machines</td></tr>
<tr><td rowspan="4">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Switched Reluctance Machines</td><td>lecture</td><td>1</td><td>1</td><td rowspan="3">exam (100%)</td></tr>
<tr><td>Axial Flux Machines</td><td>lecture</td><td>1</td><td>1</td></tr>
<tr><td>Transvers Flux Machines</td><td>lecture, exercise</td><td>1</td><td>1</td></tr>
<tr><td>Semester</td><td colspan="5">Summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Ahmed Masmoudi</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">45 hours course attendance
30 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">3</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="3">Learning Outcomes</td><td colspan="5">Switched Reluctance Machines
After the successful participation in the course switched reluctance machines, the students are able to:
understand the principle of operation of switched reluctance machines,
understand the principle of torque production in switched reluctance machines.</td></tr>
<tr><td colspan="5">Axial Flux Machine
After the successful participation in the course axial flux machines, the students are able to:
understand the principle of operation of axial flux machines,
understand the principle of torque production in axial flux machines.</td></tr>
<tr><td colspan="5">Transverse Flux Machines
After the successful participation in the course transverse flux machines, the students are able to:
understand the principle of operation of transverse flux machines,
understand the principle of torque production of transverse flux machines,
identify the advantages and limitations of different transverse flux machine topologies.</td></tr>
<tr><td rowspan="3">Contents</td><td colspan="5">Switched Reluctance Machines
Switched reluctance machines: current automotive applications
Switched reluctance machine basis
Switched reluctance machines: associated converter
Switched reluctance machines: torque production
Case study: E-supercharger of Valeo</td></tr>
<tr><td colspan="5">Axial Flux Machine
Axial flux machines: applications
Single stator/single rotor topology
Single stator/dual rotor topology
Single stator/dual rotor torus topology
Single stator/dual rotor coreless torus topologies</td></tr>
<tr><td colspan="5">Transverse Flux Machines
Transverse flux machines: topologies
Transverse flux machines: principle of the torque production
Substitution of laminations by soft magnetic composites
Problem of low power factor
Sizing of double-sided transverse flux machines</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer, lectures and presentations, simulation using conventional software packages.</td></tr>
<tr><td>Literature</td><td colspan="5">Stephen Chapman, Electric Machinery Fundamentals, Fourth Edition, McGraw-Hill Series in Electrical and Computer Engineering, 2005.</td></tr>
</table>

	• A. Masmoudi and A. Elantably, *An Approach to Sizing High Power Density TFPM Intended for Hybrid Bus Electric Propulsion*, Electric Machines and Power Systems, vol. 28, no. 4, pp. 341-354, 2000.

<table>
<tr><th>Module title</th><th colspan="5">Diagnosis, Monitoring and Reconfiguration of Electric Machines Drives</th></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Fault detection and isolation and the synthesis of fault-tolerant control strategies</td></tr>
<tr><td rowspan="4">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Faults in Electric Machine Drives</td><td rowspan="3">lecture, exercise</td><td>1</td><td>1</td><td rowspan="3">exam (100%)</td></tr>
<tr><td>Faults Detection and Isolation Techniques and Methods</td><td>1</td><td>1</td></tr>
<tr><td>Fault-Tolerant Control Strategies</td><td>1</td><td>1</td></tr>
<tr><td>Semester</td><td colspan="5">Summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Houda Ben Attia-Sethom</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">45 hours course attendance
30 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">3</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="3">Learning Outcomes</td><td colspan="5">Faults in Electric Machine Drives
After the successful participation in the course Faults in electric machine drives, the students are able to:
have an overview on the most common faults occurring in AC electric drives (induction and synchronous machines),
distinguish the different type of defaults weather they are mechanically- or electrically-caused,
predict faults on the different electric drive components.</td></tr>
<tr><td colspan="5">Faults Detection and Isolation Techniques and Methods
After the successful participation in the course faults detection and isolation techniques and methods, the students are able to:
know the diagnosis procedure when the data acquisition process may reveal abnormal operating conditions,
distinguish between model-based and data-based diagnosis method and their cases of usage,
determine the parameters and variables to diagnose and use the appropriate model to predict it.</td></tr>
<tr><td colspan="5">Fault-Tolerant Control Strategies
After the successful participation in the course Fault-tolerant control strategies, the students are able to:
know the main factors to be considered in any fault-tolerant control system to automatically compensate the faults,
distinguish between passive and active fault tolerant control techniques, acknowledge their characteristics and case of usage.</td></tr>
<tr><td rowspan="3">Contents</td><td colspan="5">Faults in Electric Machine Drives
Defaults in AC drives
Voltage supply inverter defaults
Sensor defaults</td></tr>
<tr><td colspan="5">Faults Detection and Isolation (FDI) Techniques and Methods
Diagnosis: general procedure
FDI methods classification
Defaults detection: model-based method
Defaults detection: signal processing techniques
Defaults detection: motor current signature analysis (MCSA) technique
Defaults detection: Artificial Intelligent Based Methods</td></tr>
<tr><td colspan="5">Fault-Tolerant Control Strategies
Principle of fault tolerant control
Fault tolerant control: passive technique</td></tr>
</table>

	- Fault tolerant control: active technique - Fault tolerant control: hybrid technique
Media	Black board and beamer, lectures and presentations, simulation using conventional software packages.
Literature	- M. Bourogaoui, I. Jlassi, S. Khojet El Khil, and H. Ben Attia Sethom, *An Effective Encoder Fault detection in PMSM Drives at Different Speed Ranges*, 2015 IEEE 10th International Symposium on Diagnostics for Electrical Machines, Power Electronics and Drives (SDEMPED), pp. 90-96, Guarda, Portugal, Sptember 2015. - A. Bennani-Ben Abdelghani, H. Ben Abdelghani, F. Richardeau, J.-M. Blaquière, F. Mosser, and I. Slama-Belkhodja, *Versatile Three-Level FC-NPC Converter With High Fault-Tolerance Capabilities: Switch Fault Detection and Isolation and Safe Postfault Operation,* IEEE Trans. on Industrial Electronics, vol. 64, no. 8, pp. 6453-6464, 2017.

<table>
<tr><th>Module title</th><th colspan="5">Control Strategies of Electric Drives</th></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Synthesis and implementation of control strategies dedicated to electric drives</td></tr>
<tr><td rowspan="4">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Rotor Flux Oriented Control of three-phase Induction Motor</td><td>lecture, exercise</td><td>1</td><td>1</td><td rowspan="3">- exam (70%)
- tutored project defense (30%)</td></tr>
<tr><td>Direct Torque Control of three-phase Induction Motor</td><td>lecture, exercise</td><td>1</td><td>1</td></tr>
<tr><td>Direct Power Control Strategies of Three-Phase PWM Rectifiers</td><td>lecture, exercise</td><td>1</td><td>1</td></tr>
<tr><td>Semester</td><td colspan="5">Summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Bassem El Badsi</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">45 hours course attendance
30 hours tutored project</td></tr>
<tr><td>Credits</td><td colspan="5">3</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="3">Learning Outcomes</td><td colspan="5">Rotor Flux Oriented Control of Three-Phase Induction Motor
After the successful participation in the course rotor flux oriented control (RFOC) of three-phase induction motor (IM), the students are able to make the synthesis and the implementation of the RFOC strategy of the IM.</td></tr>
<tr><td colspan="5">Direct Torque Control of three-phase Induction Motor
After the successful participation in the course direct torque control (DTC) of three-phase Induction Motor, the students are able to make the synthesis and the implementation of the DTC strategy of the IM.</td></tr>
<tr><td colspan="5">Direct Power Control Strategies of Three-Phase PWM Rectifiers
After the successful participation in the course direct power control (DPC) strategies of three-phase PWM rectifiers, the students are able to make the synthesis and the implementation of DPC strategies for the control of the three-phase PWM rectifiers.</td></tr>
<tr><td rowspan="3">Contents</td><td colspan="5">Rotor Flux Oriented Control of Three-Phase Induction Motor
- Principle of Park Transform
- RFOC of IM Using Current-Controlled VSI
- RFOC of IM Using Voltage-Controlled VSI</td></tr>
<tr><td colspan="5">Direct Torque Control of three-phase Induction Motor
- Space Voltage Vectors of B6 Inverter
- Implementation of Classical DTC Strategy
- Bus-Clamping DTC Strategy</td></tr>
<tr><td colspan="5">Direct Power Control Strategies of Three-Phase PWM Rectifiers
- Modelling of Three-Phase PWM Rectifier
- Line Voltage and Virtual Flux Estimation
- Implementation of DPC Strategy</td></tr>
<tr><td>Media</td><td colspan="5">Lectures and presentations, simulation using MATLAB-Simulink.</td></tr>
<tr><td>Literature</td><td colspan="5">- G. Narayanan, D. Zhao, H. K. Krishnamurthy, R. Ayyanar, and V. T. Ranganathan, Space Vector Based Hybrid PWM Techniques for Reduced Current Ripple, IEEE Trans. on Industrial Electronics, vol. 55, no. 4, pp. 1614-1626, 2008.
- A. Jidin, N. R. N. Idris, A. H. M. Yatim, T. Sutikno, and M. E. Elbuluk, Simple Dynamic Over Modulation Strategy for Fast Torque Control in DTC of Induction Machines with Constant-Switching-Frequency Controller, IEEE Trans. on Industry Applications, vol. 47, no. 5, pp. 2283-2291, 2011.
- B. El Badsi, B. Bouzidi, and A. Masmoudi, Bus-Clamping-Based DTC: An Attempt to Reduce Harmonic Distortion and Switching Losses, IEEE Trans. on Industrial Electronics, vol. 60, no. 3, pp. 873-884, 2013.</td></tr>
</table>

<table>
<tr><th>Module title</th><th colspan="5">Power Electronic Converters</th></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Control strategies of three-phase inverters and matrix converters</td></tr>
<tr><td rowspan="4">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>PWM Control Strategies of Two-Level Inverters</td><td>lecture, exercise</td><td>1</td><td>1</td><td rowspan="3">- exam (70%)
- tutored project defense (30%)</td></tr>
<tr><td>PWM Control Strategies of Three-Level Inverters</td><td>lecture, exercise</td><td>1</td><td>1</td></tr>
<tr><td>Matrix Converters and Their Control Strategies</td><td>lecture, exercise</td><td>1</td><td>1</td></tr>
<tr><td>Semester</td><td colspan="5">Summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Bassem El Badsi
Badii Bouzidi</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">45 hours course attendance
30 hours tutored project</td></tr>
<tr><td>Credits</td><td colspan="5">3</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="3">Learning Outcomes</td><td colspan="5">PWM Control Strategies of Two-Level Inverters
After the successful participation in the course PWM control strategies of two-level inverters, the students are able to make the synthesis and the implementation of different pulse-width modulation techniques for the control of three-phase two-level voltage source inverter.</td></tr>
<tr><td colspan="5">PWM Control Strategies of Three-Level Inverters
After the successful participation in the course PWM control strategies of three-level inverters, the students are able to make the synthesis and the implementation of different PWM techniques for the control of three-phase three-level voltage source inverter.</td></tr>
<tr><td colspan="5">Matrix Converters and their Control Strategies
After the successful participation in the course matrix converters and their control strategies, the students are able to make the modelling and the implementation of different modulation techniques for the control of matrix converters.</td></tr>
<tr><td rowspan="3">Contents</td><td colspan="5">PWM Control Strategies of Two-Level Inverters
- Sinusoidal PWM
- Third Harmonic Injection PWM
- Conventional Space Vector PWM
- Bus-Clamping Space Vector PWM</td></tr>
<tr><td colspan="5">PWM Control Strategies of Three-Level Inverters
- Modelling of Three-Level Inverter
- Sinusoidal PWM Technique
- Space Vector PWM Technique</td></tr>
<tr><td colspan="5">Matrix Converters and their Control Strategies
- Modelling of Matrix Converters
- Venturini Modulation Technique
- Venturini’s Optimum Modulation Technique</td></tr>
<tr><td>Media</td><td colspan="5">Lectures and presentations, simulation using MATLAB-Simulink.</td></tr>
<tr><td>Literature</td><td colspan="5">- H. Fang; X. Feng; W. Song; X. Ge; R. Ding, Relationship between Two-Level Space-Vector Pulse-Width Modulation and Carrier-Based Pulse Width Modulation in the Over-Modulation Region, IET Power Electronics, vol. 7, no. 1, pp. 189-199, 2014.
- R. Baranwal; K. Basu; N. Mohan, Carrier-Based Implementation of SVPWM for Dual Two-Level VSI and Dual Matrix Converter with Zero Common-Mode Voltage, IEEE Trans. on Power Electronics, vol. 30, no. 3, pp. 1471-1487, 2015.
- J. H.Seo; C. H. Choi; and D. S. Hyun, A New Simplified SV-PWM Method for Three-Level Inverters, IEEE Trans. on Power Electronics, vol. 16, no. 4, pp. 545-550, 2001.
- K. Gupta and A. M. Khambadkone, A Space Vector PWM Scheme for Multilevel Inverters Based on Two-Level Space Vector PWM, IEEE Trans. on Industrial Electronics, vol. 53, no. 5, pp. 1631-1639, 2006.</td></tr>
</table>

Module title	Embedded Generating Systems
Module type	**E**
Competency	**Design, modelling, and analysis of embedded generating systems**

Courses

Title	Teaching Method	SWS	Credits	Performance requirements/ Examination
Generating Systems Embedded on Board of Road Vehicles	lecture, exercise	1	1	exam (100%)
Modelling of Claw Pole Alternators		1	1	
Design Improvement of the CPA-Based Generating Systems		1	1	
Avionic Generating Systems		1	1	

Semester	Summer
Responsible	Dahlhaus
Site	Kassel
Lecturer(s)	Amina Ibala Rabeb Rebhi
Language	English
Workload	60 hours course attendance 40 hours self-study
Credits	4
Recommended Qualifications	-
Learning Outcomes	**Generating Systems Embedded on Board of Road Vehicles** After the successful participation in the course **generating systems embedded on board of road vehicles,** the students are able to: - identify the components of embedded generating systems, - classify the embedded generating systems.
	Modelling of Claw Pole Alternators After the successful participation in the course f**inite modelling of claw pole alternators** (CPAs), the students are able to: - establish the magnetic equivalent circuit of CPAs, - predict the no- and load features of CPAs.
	Design Improvement of the CPA-Based Generating Systems After the successful participation in the course **design improvement of the CPA-based generating systems,** the students are able to: - rethought the design of CPAs, - design hybrid excited CPAs.
	Avionic Generating Systems After the successful participation in the course **avionic generating systems,** the students are able to: - identify the components of avionic generating systems, - classify the avionic generating systems.
Contents	**Generating Systems Embedded on Board of Road Vehicles** - Claw pole alternator (CPA) topological description, - Flux path through the CPA magnetic circuit, - Road vehicle embedded generating chain.
	Modelling of Claw Pole Alternators - Magnetic equivalent circuit (MEC) modelling, - CMA MEC elaboration and resolution, - Prediction of the CPA no-load characteristic, - Prediction of the CPA load characteristic.
	Design Improvement of the CPA-Based Generating Systems - Attempts to eradicate the CPA major limitations, - Limitation caused by the slip rings-brushes system, - CPA design rethought: hybrid excitation, - Boosting the DC bus current.

	Avionic Generating Systems - Reason behind the use of 400Hz networks in aircrafts, - Case study: the primary three-stage power generator of the Airbus A380.
Media	Black board and beamer, lectures and presentations, simulation using conventional software packages.
Literature	- D. Elloumi, A. Ibala, R. Rebhi, and A. Masmoudi, *Lumped Circuit Accounting for the Rotor Motion Dedicated to the Investigation of the Time-Varying Features of Claw Pole Topologies*, IEEE Trans. on Magnetics, vol. 51, no. 5, pp. 8105108, 2015. - R. Rebhi, A. Ibala, and A. Masmoudi, *MEC-Based Sizing of a Hybrid-Excited Claw Pole Alternator*, IEEE Trans. on Industry Applications, vol. 51, no. 1, pp. 211-223, 2015. - A. Ibala and A. Masmoudi, *Accounting for the Armature Magnetic Reaction and Saturation Effects in the Reluctance Model of a New Concept of Claw-Pole Alternator*, IEEE Trans. on Magnetics, vol. 46, no. 11, pp. 3955-3961, 2010.

<table>
<tr><th>Module title</th><th colspan="5">Rules of Writing Research Documents</th></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Ability of writing different scientific documents (paper, dissertation, report)</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>The Scientific Paper: from Reading to Writing</td><td>lecture, exercise</td><td>1</td><td>2</td><td rowspan="2">exam (100%)</td></tr>
<tr><td>Writing Process</td><td>lecture, exercise</td><td>1</td><td>1</td></tr>
<tr><td>Semester</td><td colspan="5">Summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Abdelmajid Damak</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">30 hours course attendance
45 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">3</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">The Scientific Paper: from Reading to Writing
After the successful participation in the course the scientific paper: from reading to writing, the students are able to:
- learn efficient ways to organize the reading method with some useful hints for successful reading,
- distinguish between the different type of scientific writing,
- learn how to structure scientific writing and elaborate a work plan.</td></tr>
<tr><td colspan="5">Writing Process
After the successful participation in the course the writing process, the students are able to:
- know the different steps in order to write a scientific paper, from the brainstorming to the final version of the document,
- acknowledge the major difficulties in scientific writing and the possible solutions.</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">The Scientific Paper: from Reading to Writing
- The reading process,
- The notion of scientific publication,
- Structuring the writing and respecting the writing plan,
- Elaborating the work plan.</td></tr>
<tr><td colspan="5">Writing Process
- Pre-writing,
- Organizing,
- Drafting,
- Revising and editing,
- The final copy.</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer, lectures and presentations,</td></tr>
<tr><td>Literature</td><td colspan="5">J. Swales, Genre Analysis: English in academic and research settings, Cambridge University Press, 1990.</td></tr>
</table>

3. Elective Modules Type 2

In this section, all elective modules focusing on contracts and REEE project management, design, testing and controlling experiments related to REEE and different regression and forecasting methods are listed in **Table 2** and more details are in the tables below.

Optimization, Regression and Forecasting	ECTS	Power Systems	ECTS	Contracts and Projects Administration	ECTS
Linear and Non-Linear Optimization	5	Power Electronics	4	Legislation, Contracts and Engineering Ethics	2
Production and Operations Management	5	Distributed Power Systems	5	Construction Contracts and Project Administration	2
Design, Testing and Control	**ECTS**	**Project Work**	**ECTS**		
Design of Experiments and Measuring Techniques	5	Project	15		
Heating, Ventilation and Air Conditioning (HVAC) Systems and Control	5				
Quality Control	5				

Table 2: Elective modules type 2 offered during WS (53 ECTS credits).

<table>
<tr><td>Module title</td><td colspan="5">Optimization, Regression and Forecasting</td></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Fundamental theories and computational methodologies used in (computer aided) optimization analysis, productivity analysis, forecasting techniques, regression and correlation analysis, management, scheduling and aggregate planning</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Linear and Non-Linear Optimization</td><td>lecture, exercise</td><td>4</td><td>5</td><td>- midterm (1/3) assignments
- final exam (2/3)</td></tr>
<tr><td>Production and Operations Management</td><td>lecture, exercise</td><td>4</td><td>5</td><td>- midterm (1/3) assignments
- final exam (2/3)</td></tr>
<tr><td>Semester</td><td colspan="5">Winter</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Eberhard Roos</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">120 hours course attendance
130 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">10</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">Linear and Non-Linear Optimization
After the successful participation in the course Linear and Non-Linear Optimization, the students are able to:
a. Knowledge and Understanding
identify the objective function, the holonomic and nonholonomic constrains.
form the Lagrangian function and solve for the optimal variables and Lagrange multipliers.
form the Hessian matrix and analyze the second order sufficiency conditions of the optimization problem.
compare between optimization techniques such as the gradient descent method, Gauss-Newton method and the Levenberg-Marquardt method.
b. Intellectual Skills
formulation of the optimization problem through the ability to distinguish between the objective functions and the constrains
ability to solve the optimization numerically
ability to select the appropriate optimization problem based on the constrains and the dynamics of the process.</td></tr>
<tr><td colspan="5">Production and Operations Management
After the successful participation in the course Production and Operations Management, the students are able to:
a. Knowledge and Understanding
define productivity analysis and its application
describe different forecasting techniques
describe regression techniques
describe inventory techniques
explain aggregate planning
define project scheduling.
b. Professional and Practical skills
predict new demands of the globally competitive business environment emphasize the importance of change, facilitation of learning, cross-functional teamwork, knowledge capture, and analysis in manufacturing organizations
submit a course project, in which the project process of initiating, planning, executing, controlling and closing the project is applied through case studies.
c. Intellectual skills
develop an understanding of the strategic importance of manufacturing systems, production and operations systems</td></tr>
</table>

	• recognize the relationship between manufacturing and related service providers and other business functions, such as human resources, purchasing, marketing, finance, etc., • calculate forecasts using different techniques • apply qualitative and quantitative methods of inventory models • apply proactive and reactive planning strategies • calculating the timing of the use of different resources in an organization. **d. General and Transferrable skills** • employ critical thinking to solve problems in area of quality control • practice independent learning required to build up knowledge base • work in teams.
Contents	**Linear and Non-Linear Optimization** Optimization analysis, Lagrangian function and Hessian matrix, gradient descent method, Gauss-Newton method and the Levenberg-Marquardt method and different non linear optimization methods.
	Production and Operations Management Productivity analysis, forecasting techniques, regression and correlation analysis, inventory, management, aggregate planning, materials requirements planning (MRP), and scheduling. It also allows more emphasis on computer solutions with excel spreadsheets.
Media	Black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises, case studies in groups; formal & interactive.
Literature	• Optimization of Dynamic Systems (Agrawal et al.) • Nonlinear and dynamic optimization (Chachuat) • R.Dan Reid and Nada R. Sanders (2009), Operations Management (4th edition), Wiley. ISBN-10: 0849309247. ISBN-13: 978-0849309243 • Jay Heizer and Barry Render (2010), Principles of Operations Management (8th edition), Prentice Hall. ISBN-10: 0849309247. ISBN-13: 978-0849309243

<table>
<tr><th>Module title</th><th colspan="5">Power Systems</th></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Fundamentals of power electronics switches and their applications and analyzing the operation of traditional and distributed power systems and study power different generation technologies</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Power Electronics</td><td>lecture, exercise</td><td>2</td><td>4</td><td>- midterm 20%
- assignment 15%
- final exam 45%
- quiz 15%
- report 5%</td></tr>
<tr><td>Distributed Power Systems</td><td>lecture, exercise</td><td>4</td><td>5</td><td>- midterm (1/3) assignments
- final exam (2/3)</td></tr>
<tr><td>Semester</td><td colspan="5">Winter</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Frank Gunzer, Mostafa Soliman</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">90 hours course attendance
135 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">9</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">Power Electronics
After the successful participation in the course Power Electronics, the students are able to:
a. Knowledge and Understanding
- name types of power converters
- list different topologies of each power electronic converter
- discuss the operation of different power electronic converters.
b. Intellectual Skills
- analyze different circuit configurations used in different converters
- solve problems related to DC-DC choppers, AC-AC choppers, and AC-DC converters
- operate different power electronic circuits
- propose suitable power converters for different applications.
b. Professional and Practical Skills
- practice their knowledge with power electronics for advanced applications (practical applications) like electric drives and renewable energy.</td></tr>
<tr><td colspan="5">Distributed Power Systems
After the successful participation in the course Distributed Power Systems, the students are able to:

- demonstrate knowledge and understanding of power system analysis under steady state and faulty conditions
- represent the multi-port power system using impedance and admittance matrices
- recognize and calculate the different types of power system faults
- formulate and solve the load flow problem using approximate and numerical techniques
- assess the different generation technologies and be able to select the size and the location of the distributed generators to support the system steady state performance.</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">Power Electronics
Solid-state switches, controlled and uncontrolled single phase rectifiers, controlled single phase full wave rectifiers, three phase uncontrolled half wave & full wave rectifiers, single phase AC voltage controllers, DC-to-DC converters</td></tr>
<tr><td colspan="5">Distributed Power Systems
1. Power system Representation:
- Power system components</td></tr>
</table>

	- Modelling of system components. - The per-unit system. 2. Power flow analysis: - System performance measures; system losses and voltage profile. - Formulation of the Load flow equations. - Approximate solution of Load flow equations. - Numerical solution of Load flow equations. 3. Distributed generation systems: - Terminology of distributed generation systems. - Different distributed generation technologies. - Benefits of distributed generation systems. - Analysis of distributed generation systems.
Media	Black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises, case studies in groups; formal & interactive.
Literature	- Cyril W. Lander (1994). Power Electronics (3rd edition). McGraw Hill. ISBN: 0077077148. - Muhammad. H. Rashid (2001). Power Electronics Handbook. Academic Press. ISBN: 125816502. - R.W. Erickson and D.Maksimovic (2001). Fundamentals of power electronics. KluverAcademic. ISBN: 792372700 - J. Grainger, W. Stevenson, Power System Analysis, McGraw Hill, 1994. - H. Lee Willis, W. Scott, Distributed power generation planning and evaluation, Marcel Dekker Inc 2000.

<table>
<tr><td>Module title</td><td colspan="5">Contracts and Projects Administration</td></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Laws and legislations concerning engineering works, contracts, industrial safety and security, relation between owner and tenant and engineering Ethics</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Legislation, Contracts and Engineering Ethics</td><td>lecture, exercise</td><td>2</td><td>2</td><td>- midterm 20%
- assignment 10%
- final exam 60%
- quiz 10%</td></tr>
<tr><td>Construction Contracts and Project Administration</td><td>lecture, exercise</td><td>2</td><td>2</td><td>- midterm (1/3) assignments
- final exam (2/3)</td></tr>
<tr><td>Semester</td><td colspan="5">Winter</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Yasser Hegazy, Tarik Youssef</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">60 hours course attendance
40 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">10</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">Legislation, Contracts and Engineering Ethics
After the successful participation in the course Legislation, Contracts and Engineering Ethics, the students are able to:
a. Knowledge and Understanding
- define, describe, identify and explain the Engineering profession and what it implies in terms of technicality, legally and ethics-wise.
- undergo proper contract drafting and/or engaging in a contractual relationship with clients/fellow engineers.
- relate to the diversity of ethics’ codes, worldwide, within different venues such as environmental and computer ethics.
b. Intellectual Skills
- differentiate between business organizations.
- use, properly, the laws and regulations within the country of residence to avoid adverse circumstances/conflicts.
- exhibit ethical conduct in light of the made-available ethical codes and guidelines
b. Professional and Practical Skills
- operate as a professional engineer whether in engineering practice or conduct.
- manage to mitigate the course content to junior engineers of the profession, upon reaching a senior stage.</td></tr>
<tr><td colspan="5">Construction Contracts and Project Administration
After the successful participation in the course Construction Contracts and Project Administration, the students are able to:
- be aware of the importance of legal and contractual issues and due administration on and around construction projects and of the consequences if contractual issues are not taken serious.</td></tr>
<tr><td>Contents</td><td colspan="5">Legislation, Contracts and Engineering Ethics
The course includes the following:
- General overview on the legal systems worldwide
- Business Organizations
- Hierarchy of the Syndicate of Engineers
- Fundamentals and development of tort Law
- Contracts and contractual relations
- Tendering Issues
- Breach of Contracts
- Breach of Contracts
- Regulatory Aspects and Ethics
- Ethical Problems in Engineering management and private practice</td></tr>
</table>

	- Environmental Ethics/Computer Ethics
	Construction Contracts and Project Administration - main contractual terms and conditions of standard contract forms - analysing and evaluating real case issues - different areas will be introduced with its basic application tools as well as its cross links to contract administration.
Media	Black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises, case studies in groups; formal & interactive.
Literature	- Sami M. Fereig. Contract Planning: Risk Management, Legal Aspects and Parties' Obligations (3rd edition). Dar Al Rida. ISBN: 977-5365-85-6. - Sami M. Fereig. Document Preparation, Tendering and Bidding: Project Delivery Systems, Payment Methods and Specification-Writing (3rd edition). Dar Al Rida. ISBN: 977-316-206-0. - Sami M. Fereig. Financial and Time Program for Projects: Preparation and Control (3rd edition). Dar Al Rida. ISBN: 977-316-213-3. - Sami M. Fereig. Dispute Resolution in Construction Projects: Amicable Solutions, Arbitration, Damage Assessment and Parties' Entitlements (2nd edition). Dar Al Rida. ISBN: 977-316-247-8.

Module title	**Design, Testing and Control**				
Module type	**E**				
Competency	**Measurement instrumentations and applications, statistical concepts, basic techniques in experimental and randomized block design, full and fractional factorial design, design an HVAC system and get familiar with air conditioning standards, tables and charts and tackle concepts of energy utilization; improve quality, reliability and design in a manufacturing environment and implement effective quality systems.**				
Courses	**Title**	**Teaching Method**	**SWS**	**Credits**	**Performance requirements/ Examination**
	Design of Experiments and Measuring Techniques	lecture, exercise	4	5	- midterm 20% - assignment 15% - final exam 45% - quiz 15% - report 5%
	Heating, Ventilation and Air Conditioning (HVAC) Systems and Control	lecture, exercise	4	5	- midterm 25% - assignment 10% - final exam 40% - quiz 15% - project 10%
	Quality Control		4	5	- midterm assignments (1/3); - final exam (2/3)
Semester	Winter				
Responsible	Dahlhaus				
Site	Kassel				
Lecturer(s)	El Sayed Imam Morgan, Mohammed Salama Abdelhady				
Language	English				
Workload	180 hours course attendance 195 hours self-study				
Credits	15				
Recommended Qualifications	-				
Learning Outcomes	**Design of Experiments and Measuring Techniques** After the successful participation in the course **Design of Experiments and Measuring Techniques,** the students are able to: - analyse significant testing results and learn the concepts and techniques of design of experiments - appreciate the value of variance reduction in process design and control - design full and fractional factorials and acquire a working knowledge of statistical software programs. - measure several physical and mechanical quantities using simple and/or specialized instrumentations - Learn about general characteristics of sensors and measurement systems. measurement of force, torque, motion, speed, strain, temperature, pressure and flow.				
	Heating, Ventilation and Air Conditioning (HVAC) Systems and Control After the successful participation in the course **Heating, Ventilation and Air Conditioning (HVAC) Systems and Control,** the students are able to: **b. Knowledge and Understanding** - define different types of cooling/heating loads - define different types of air conditioning systems and differentiate between them - identify the concepts of refrigerators and heat pumps and how to measure their performance - recall different properties of moist air - identify the psychometric chart and how to deal with it. **b. Intellectual Skills** - calculate the different components of the cooling load for the conditioned space - decrease the cooling/heating load in order to establish most efficient cooling system				

	- choose the machine suitable for the conditioned space - design an efficient and effective air conditioning system - classify modes of heat transfer that affect the conditioned space (conduction, convection or radiation) - calculate the cooling load for any space (their homes, lecture halls, class rooms…etc.) - categorize the cooling load and the construction of the conditioned space into categories according to their materials and their effect on the cooling load - distribute the air and select the proper duct and air distribution system for a defined space. **b. Professional and Practical Skills** - estimate the cooling load for a defined space. - determine the duct sizing and air distribution in a defined space. - select machines (air-conditioning system selection). - select the appropriate control method for the selected air conditioning system.
	Quality Control After the successful participation in the course **Quality Control,** the students are able to: - improve quality, reliability, and design in a manufacturing environment by learning some practical and statistical engineering methods - learn sampling techniques and fundamental test strategies designed to identify controllable factors and their effects on quality measures as well as the foundations of robust design and its application to design, manufacturing and customer service.
Contents	**Design of Experiments and Measuring Techniques** - statistical concepts, basic techniques in experimental design, comparison of - K-variables - randomized block design - Latin squares, matrix theory, full and fractional factorial design, confounding & blocking and response surface methodology - measurement instrumentations and applications - general characteristics of sensors and measurement systems. Measurement of force, torque, motion, speed, strain, temperature, pressure and flow
	Heating, Ventilation and Air Conditioning (HVAC) Systems and Control - Refrigerating machine and the reversed Carnot cycle - Gas, vapor mixture and air - Conditioning - Psycrometric chart - Air conditioning processes - Principles of air conditioning and comfort conditions - Cooling load estimation - Air conditioning systems and control
	Quality Control - basic definitions, concepts and terminology used in quality control systems - analytical, practical and statistical engineering tools to improve quality, reliability and design in a manufacturing environment and implement effective quality systems.
Media	Black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises, case studies in groups; formal & interactive.
Literature	- Design and Analysis of Experiments, Douglas C. Montgomery, J Wiley 5TH edition - Y. Cengel and M. Boles (2008). Thermodynamics: An Engineering Approach (6th edition). McGraw Hill. ISBN: 0073529214. - Arora C.P. (2000). “Refrigeration and Air Conditioning” (2nd edition). McGraw Hill. ISBN: 0-07-463010-5. - R. Haines, M. Myers (2004). HVAC Systems Design Handbook. McGraw Hill. ISBN-10: 0071622977. ISBN-13: 978-0071622974 - Ashrae Handbook 2009, Fundamentals. American Society of Heating, Refrigerating and Air-Conditioning Engineers. ISBN: 1933742542 - Trane Company. Trane Air Conditioning manuals. - J. M. Juran: Juran's Quality Handbook (McGraw-Hill International Editions: Industrial Engineering Series) ISBN-10: 0071165398

<table>
<tr><th>Module title</th><th colspan="5">Project Work</th></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Scientific analysis of the present challenges in REEE</td></tr>
<tr><td rowspan="2">Courses</td><td>Title</td><td>Type</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Project</td><td>project work</td><td>9</td><td>15</td><td>report and presentation</td></tr>
<tr><td>Semester</td><td colspan="5">Winter</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Dahlhaus and team</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">135 hours course attendance
240 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">15</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">Knowledge of fundamentals in REEE</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">Project work
After the successful participation in the course Project work, the students are able to:
- write a scientific report and presentation of the project results
- investigate literature and internet based sources
- work independently and scientifically.</td></tr>
<tr><td>Contents</td><td colspan="5">- Topics in REEE with a specific focus on issues related to the MENA region
- Fundamentals and present challenges in REEE</td></tr>
<tr><td>Competences to be acquired</td><td colspan="5">- Literature and internet based investigation
- Structured approach for solving a problem
- Independent scientific work
- Ability to work in a team and to exchange ideas
- Presentation in the framework of a project.</td></tr>
<tr><td>Media</td><td colspan="5">PC based software development and/or hardware development (project work), beamer (presentation of results), report (electronic form and hard copy).</td></tr>
<tr><td>Literature</td><td colspan="5">Literature depends on the project topic and is to be gathered by the student upon discussion with the supervisor.</td></tr>
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