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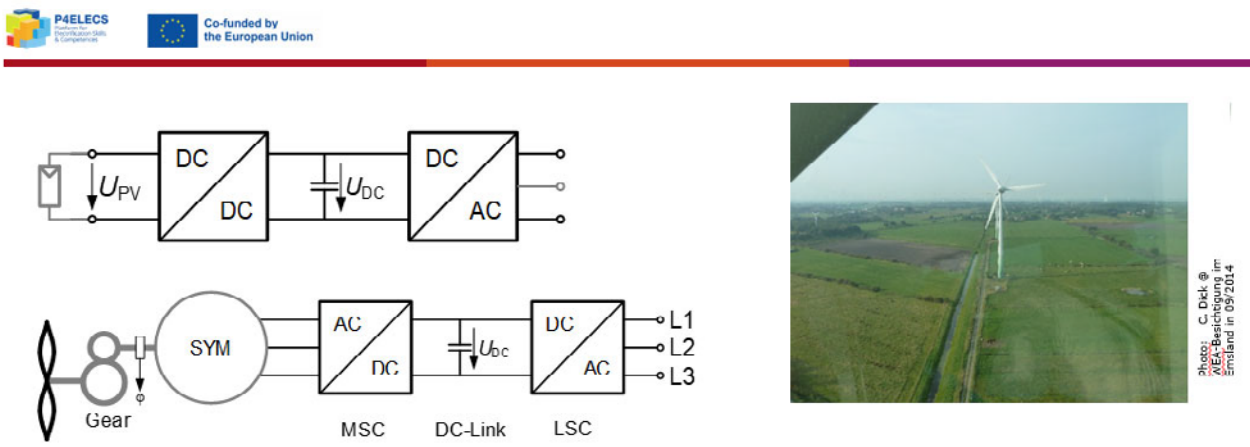
# Power Electronics for Photovoltaic- and Wind Energy Systems

# COURSE DESCRIPTION

## Power Electronics for Photovoltaic- and Wind Energy Systems




### BACKGROUND – RELEVANCE

The rapid advancement of renewable energy technologies has been driven by the global imperative to reduce carbon emissions and transition towards sustainable energy sources. Photovoltaic (PV) and wind energy systems are at the forefront of this transformation, owing to their potential to generate clean, abundant, and renewable electricity. Power electronics is a crucial field of study that deals with the conversion and control of electrical power using solid-state electronics, which is essential for integrating renewable energy sources into the power grid.

The relevance of a course focused on power electronics for PV and wind energy systems is underscored by several key factors:

1. Growing Renewable Energy Sector
2. Technological Innovation
3. Grid Integration Challenges
4. Energy Conversion Efficiency
5. Sustainability Goals

Overall, this course is designed to equip students with the knowledge and practical skills needed to address the challenges and leverage the opportunities presented by the integration of PV and wind systems into the modern energy landscape. It prepares students for careers in renewable energy engineering, system design, and grid management, contributing to the wider adoption and optimization of sustainable energy solutions.

### ABSTRACT

This course provides a comprehensive introduction to power electronics in renewable energy systems, focusing specifically on photovoltaic (PV) and wind energy applications. As the demand for sustainable energy solutions increases, understanding the integration of renewable sources into the electrical grid becomes essential. Power electronics play a critical in ensuring efficient energy conversion, control, and distribution.

The course covers focusses on the power electronic circuits, tailored towards PV and wind energy systems, being motivated by their special specifications coming from e.g. large parasitic capacitances between the PV Geneator to ground. Key topics include, DC-DC converters, grid-tied inverters and maximum power point tracking (MPPT) techniques. Additionally, the course addresses

the challenges of integrating these systems into existing grid infrastructure, including issues related to power quality, grid stability, and energy storage solutions. Grid connection including control implementation is detailed out.
Through a blend of theoretical lectures and practical laboratory exercises, students will gain hands-on experience with simulation tools and hardware setups. This immersive approach equips students with the necessary skills to design, analyze, and implement power electronic solutions for renewable energy projects.
By the end of the course, participants will have a deep understanding of how power electronics facilitate the efficient harvesting and utilization of solar and wind energy, positioning them to contribute effectively to the advancement of sustainable energy technologies.

**KEYWORDS - HASTAGS**
Renewable Energy, Power Electronics, Photovoltaic Systems, Wind Energy, DC-DC Converters, Inverters, Maximum Power Point Tracking (MPPT), Grid Integration, Energy Conversion, Power Quality, Grid Stability, Sustainable Energy, Energy Efficiency, Grid Connection, Converter Control

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Technology
Arts Sciences
TH Köln

| FOCUS ON … | Knowledge | Application | | Implementation | |
|---|---|---|---|---|---|
| CDIO | | Conceive | Design | Implement | Operate |
| DIFFICULTY LEVEL | Basic | Intermediate | | Advanced | |
| EQF LEVEL | 7 (Master) | CREDITS | 5 ECTS CPs (reduced course with 3CP possible) | HOURS Software | 150h PLECS (will be provided) |

## LEARNING OUTCOMES

Students can explain and in some cases also develop power electronic topologies and control processes of various renewable energy (RE) generation systems (photovoltaics & wind)
by

- dividing the entire plant-specific system technology into essential parts (electromechanics, power electronics, control/regulation),
- designing computer models of all parts and of the entire system and simulating them using a simulation tool,
- handle power electronics, drives and classic measuring devices and
- recognize and understand specific control challenges and algorithms

in order to

- design and dimension renewable energy generation systems,
- develop power electronic components for RE and
- design specific control systems for RE.

## PRIOR KNOWLEDGE REQUIRED

1. Bachelor degree in an engineering discipline
2. Course on fundamentals in power electronics is helpful. However, the most relevant aspects on topologies, especially the inverter leg, are repeated.

| | theoretical part/simulations/exercises | Hands on part |
|---|---|---|
| **ORGANISER** | TH Köln, Prof. C. Dick | TH Köln, Prof. C. Dick |
| **ERASMUS: Blended Intensive program (BIP)** | This course is one out of two alternative focal points (besides b. Fundamentals of Wind Power, Rotor Design, and Wind Park Planning) within the Blended Intensive Programme "Grid-Integration of Renewables"<br>Titel of the BIPs: Grid-Integration of Renewables<br>BIP-ID: 2024-1-DE01-KA131-HED-000214080-2 | |
| **WHEN & WHERE** | Online sessions will take place on<br><br>Thursdays, from 08:00h-10:30h<br>Start Sept. 29th 2025 until Feb 7th 2025<br><br>It is intended that the blended phase before the hands on part is more intense compared to the phase afterwards.<br><br>https://th-koeln.zoom-x.de/j/5639476887<br>Meeting-ID: 563 947 6887<br>Meeting-Code: 296433 | Nov 24th-28th 2025<br><br>TH Köln<br>Campus Deutz<br>Betzdorfer Straße 2<br>50679 Köln<br><br>Laboratory for Power Electeronics<br>and Electrical Drives<br>Germany<br><br>(more information to follow) |
| **COURSE MATERIAL** | available end of September in www.Xdemia.com | available end of October in www.Xdemia.com |
| **MAX ATTENDEES** | 10 | 10 |
| **REGISTRATION** | Both following points mut be fulfilled:<br>1. **At the home university** applicants contact both the P4ELECS contact persons and the international office. Formulate your wish to participate in the BIP: "Grid-Integration of Renewables, BIP-ID: 2024-1-DE01-KA131-HED-000214080-2" accordingly and also request support for travel expenses. Follow the instructions of your home university.<br>2. Contact Prof. C. Dick (Christian.dick@th-koeln.de) **at TH Köln** and name the focus topic you would like to complete in Cologne, i.e. :<br>a. Power Electronics for Photovoltaic- and Wind Energy Systems<br>b. Fundamentals of Wind Power, Rotor Design, and Wind Park Planning<br>Stay in close contact and inform Prof. Dick on any changes to plans. Please indicate if you would be ready to change the focus topic. | |
| **EVALUATION** | Oral examination, online | |
| **CONTACT PERSON** | Prof. Dr.-Ing. Christian Dick christian.dick@th-koeln.de | |

| COURSE PROGRAM | | | |
|---|---|---|---|
| | Calendar Week | LOCATION | TOPIC |
| 1 | 40/2025 | Online | Introduction and overview Inverter Leg Operation |
| 2 | 41/2025 | Online | Inverter Leg Operation, Controller Interaction and Protection Features, Three-Phase DC/AC Converter: Topologies & Tasks in PV & Wind Energy Systems, Modulation with Orthogonal Signals |
| 3 | 42/2025 | Online | Filter Inductor Current Control of Three-Phase Converters |
| 4 | 43/2025 | | self-studying and repetition |
| 5 | 44/2025 | Online | Phase Locked Loop (PLL): Identification of the Instantaneous grid angle |
| 6 | 45/2025 | Online | Filter-Capacitor Voltage Control of Three-Phase Converters (Island Mode) |
| 7 | 46/2025 | Online | Grid Current and DC-Link Voltage Control |
| 8 | 47/2025 | TH Köln | Lab experiments – programming the grid connected converter |
| 9 | 48/2025 | Online | Maximum Power Point Tracking (Focus on PV) |
| 10 | 49/2025 | Online | H-Bridge Converter as single-phase, grid-coupled DC/AC Converter |
| 11 | 50/2025 | Online | Photovoltaics: Handling Earth Leakage Currents; H5 and HERIC Topology |
| 12 | 51/2025 | Online | Active Damping of Filter Resonances |
| 13 | 02/2026 | Online | Repetition |
| 14 | 03/2026 | Online | Oral examinations |
| 15 | 04/2026 | Online | Oral examinations |