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Design and reverse engineering of power electronic

COURSE DESCRIPTION



**P4ELECS**
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Design and reverse engineering of power electronic converters

22 September 2025

Wilmar Martínez – Simon Ravvits
KU Leuven – Power Electronics Group
Spider - **DC-DC converters**



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BACKGROUND – RELEVANCE

Power electronics lies at the heart of modern energy conversion systems, enabling efficient control of electrical power in a wide range of applications. From renewable energy integration and electric vehicles to consumer electronics and industrial drives, power converters are key components that ensure optimal performance, reliability, and energy savings. This course equips students with the theoretical foundation and practical skills to design, analyse, and simulate power electronic circuits. Emphasis is placed on understanding semiconductor switching behaviour, converter topologies, capacitors, inductors, transformers, and thermal management. Real-world case studies provide insight into challenges faced by engineers in the field. The course bridges the gap between circuit-level design and system-level integration with real world applications. A strong focus on hands-on projects prepares students for industry or research careers. By the end, learners will be capable of developing robust, efficient, and application-specific power electronic systems.

ABSTRACT

This course on Power Electronics Design provides a comprehensive introduction to the essential components and techniques used in the development of modern power electronic systems. Students will gain a solid understanding of the main transistor and diode types, with an emphasis on calculating conduction and switching losses for reliable and efficient circuit operation. Capacitor selection criteria will be addressed in the context of voltage ripple, current handling, and lifetime. Learners will acquire the skills to perform basic inductor and transformer designs, considering core materials, magnetic flux, and winding parameters. Thermal management is also covered through practical methods for selecting appropriate heat sinks based on thermal resistance and power dissipation. The course explores the critical role of gate drivers, focusing on their timing, protection, and voltage requirements. Simulation plays a central role, and students will learn to model and analyse power converter circuits in PLECS, a leading tool in the field. Furthermore, during the physical part in EnergyVille, reverse engineering of a real converter is carried out. By combining theoretical foundations with practical tools, this course prepares participants to design, evaluate, and optimize key elements of power electronic systems. Emphasis is placed on real-world engineering constraints and design trade-offs, equipping students with industry-relevant skills.

KEYWORDS - HASTAGS

Power electronics, converters, component selection, hands-on, design and simulation



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| FOCUS ON ... | Knowledge | Application | | Implementation | |
|------------------|-----------|--------------|----------|----------------|---------|
| CDIO | | Conceive | Design | Implement | Operate |
| DIFFICULTY LEVEL | Basic | Intermediate | | Advanced | |
| EQF LEVEL | 6 | CREDITS | 4 (120h) | LANGUAGE | English |


LEARNING OUTCOMES

1. How to characterize power converter components?
2. What are the main transistor and diode types and how to calculate their losses?
3. How to select a capacitor in a given application?
4. How to make a basic inductor or transformer design?
5. How to select an appropriate heat sink?
6. What are the main properties of gate drivers?
7. How to simulate a converter in PLECS?
8. How to derive the power converter topology of a give converter?

PRIOR KNOWLEDGE REQUIRED

1. A strong knowledge of circuit theory and electromagnetism is required.
2. A basic knowledge on power electronics and the most utilized converter topologies (buck, boost, flyback, ...) is desired

- Design and reverse engineering of power electronic convertors -

| PRACTICAL ORGANISATION | | |
|-------------------------------------|---|---|
| | Virtual part | Physical part |
| ORGANISER | KU Leuven | KU Leuven |
| ERASMUS CODE | 2025-1-BE02-KA131-HED-000316037-4 | |
| WHEN | Start AJ till 31/12/2025 | 1/12/2025 – 5/12/2025 |
| WHERE | Online | EnergyVille (Thor Park – Genk – BE) |
| TEACHER(s) INSTRUCTOR(s) | <ul style="list-style-type: none"> • Wilmar Martinez (KU Leuven – Campus Diepenbeek) • Simon Ravyts (KU Leuven – Campus Gent) • Lars Haegemann (RWTH) • Julius Kleutgens (RWTH) | <ul style="list-style-type: none"> • Wilmar Martinez (KU Leuven – Campus Diepenbeek) • Simon Ravyts (KU Leuven – Campus Gent) • PhD Researchers and Postdoctoral Researchers |
| COURSE MATERIAL | BBs available in the Building Block Platform www.xdemia.com | BBs available in the Building Block Platform www.xdemia.com |
| SOFTWARE USED | PLECS & LTSpice | PLECS & LTSpice |
| OTHER MATERIAL | | |
| MAX ATTENDEES | 18 (6 teams of 3 studs) | 18 (6 teams of 3 studs) |
| REGISTRATION |  | https://forms.office.com/e/B3Cuzwsj3b |
| CONTACT PERSON | Annick.dexters@kuleuven.be | |
| EVALUATION | Report of Design Assignment | Presentation + report Reverse Engineering Assignment |

| Week | Date Exact timing | Location | TOPIC | Responsible |
|------|---------------------------------------|---------------------|--|---------------------------------------|
| W1 | Mon 29/9/25 10.00 – 12.00h | 1 x 2h online | Introduction - 1. ARCHITECTURES | KU Leuven Wilmar |
| W2 | Mon 6/10/25 10.00 – 12.00h | 1 x 2h online | Q&A session - 2. DIODES + TRANSISTORS + Design Assignment | KU Leuven Simon |
| W3 | Mon 13/10/25 10.00 – 12.00h | 1 x 2h online | Q&A session - 3. GATEDRIVERS + Design Assignment | KU Leuven Simon |
| W4 | Mon 20/10/25 14.00 – 16.00h | 1 x 2h online | Q&A session - 4. CAPACITORS + Design Assignment | KU Leuven Simon |
| W5 | Mon 27/10/25 14.00 – 16.00h | 1 x 2h online | Q&A session - 5. HEAT SINKS + Design Assignment | KU Leuven Wilmar |
| W6 | Mon 3/11/25 10.00 – 12.00h | 1 x 2h online | Q&A session - 6. INDUCTORS + TRANSFORMERS + Design Assignment | KU Leuven Wilmar |
| W7 | Mon 10/11/25 10.00 – 12.00h | 1 x 2h online | Q&A session - 7. CONTROL + Design Assignment | KU Leuven Wilmar |
| W8 | Mon 17/11/25 10.00 – 12.00h | 1 x 2h online | FB session on Design Assignment Report Design Assignment (deadline 21/11/2025) | KU Leuven Simon |
| W9 | Mon 24/11/25 10.00 – 12.00h | 1 x 2h online | Preparation Reverse Engineering Assignment | KU Leuven Wilmar |
| W10 | WEEK 1 till 5/12/25 | EnergyVille (BE) | Physical part – Reverse Engineering Assignment Presentation end of the week 5/12/2025 Report Reverse Engineering Assignment (deadline 12/12/2025) Survey first impressions course | Simon 1,2,3/12 Wilmar 4,5/12 |

- Design and reverse engineering of power electronic convertors -

| | | | | |
|-----|----------------------------------|---------------|--|-------------------|
| W11 | Mon 8/12/2025 10.00 – 12.00h | 1 x 2h online | Q&A about 11. MV convertors – ACDC Topologies | RWTH Lars |
| W12 | Mon 15/12/2025 10.00 – 12.00h | 1 x 2h online | Q&A about 12. MV convertors – DCDC Topologies Report MV convertors Assignment (deadline 19/12/2025) | RWTH Julius |
| W13 | Mon 12/1/2026 10.00 – 12.00h | 1 x 2h online | FB report (deadline 17/1/2025) More in depth Evaluation | Simon + Wilmar |