

# WM982-15 Power electronic converter design and manufacturing

**22/23**

**Department**

WMG

**Level**

Taught Postgraduate Level

**Module leader**

Borislav Dimitrov

**Credit value**

15

**Module duration**

1 week

**Assessment**

100% coursework

**Study locations**

University of Warwick main campus, Coventry Primary

Distance or Online Delivery

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## Description

### Introductory description

This module provides in-depth knowledge of power electronic devices and converter topologies for hybrid and electric vehicles. It includes the integration, reliability and manufacturing of power electronic converters. Advanced PWM control methods and electromagnetic compatibility are introduced. This module covers modelling and design of power converters in detail through lectures, workshops and practical. It also introduces future power electronics technologies for the upcoming EV applications.

### Module aims

This module aims to:

Extend students' depth of knowledge of power electronic circuits and components for hybrid and electric vehicles.

Introduce integration, reliability and manufacturing considerations of power electronic converters. Introduce thermal modelling and cooling design of power electronic converters.

Provide students with skills and techniques necessary for analysis, modelling and design of power electronics and related control systems for automotive applications.

## Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

Power electronics in automotive applications overview

Power semiconductor devices

Manufacturing, life time and reliability of power electronic converters

DC/DC converters (Buck/Boost)

Isolated DC/DC converters

AC/DC converters, rectifier and PFC circuit

DC-AC inverters

Advanced PWM control methods

Battery charging and Wireless charging circuits

Electromagnetic compatibility, integration and thermal management of power converter

Power converter modelling and design

Power converter design workshop

Power converter testing practical demonstrations – converter or inverter characterisation.

Future technology direction: state-of-art power semiconductor devices and converter technologies for hybrid and electric vehicles

## Learning outcomes

By the end of the module, students should be able to:

- Critically evaluate characteristics of power semiconductor devices and select devices for a range of automotive applications.
- Differentiate power converter topologies, operation, control and practicalities for real-world application to hybrid and electric vehicles.
- Evaluate detailed operation, losses and efficiency of power electronics converters through use of analytical methods and modelling techniques.
- Interpret the integration, reliability and manufacturing of power electronic components for automotive applications.
- Systematically design power electronic subsystem/ system for hybrid and electric vehicles and critique design trade-offs and technology advances.
- Select and critically evaluate technical literature and other sources of information to solve complex problems.

## Indicative reading list

1. Mohan N "Power Electronics - Converters Applications & Design" Wiley
2. Rashid, Muhammad H. "Power electronics : devices, circuits, and applications " Pearson; 4 edition 2014
3. Kassakian, J.G "Principles of Power Electronics" Addison-Wesley 1991
4. John G. Hayes, G. Abas Goodarzi "Electric powertrain : energy systems, power electronics & drives for hybrid, electric and fuel cell vehicles" John Wiley & Sons 2018

## Subject specific skills

Ability to applying and developing analytical techniques for design of power converters.

Ability to simulate and design power converters using commercial software.

Ability to evaluate the limitations of design software and choose appropriate methods and tools for designing power converters.

Ability to propose design concepts and principles relating to the development of power converters, services and specifications

Ability to interpret integration challenges, EMC, cooling concepts including material applications and systems methodology as applicable.

Ability to identify diagnostic methods, monitoring and test equipment required for integration of power converters for EV and hybrid vehicles.

Ability to interpret the packaging and manufacturing of power electronic converters for automotive applications.

## Transferable skills

Practical competence to deliver innovative products and services

Ability to Interpret and analyse test results.

Ability to work with manufacturing specialists to ensure design can translate to manufacturing processes and system

A comprehensive understanding of the relevant scientific principles of electrical machines

A critical awareness of current problems and/or new insights most of which is at, or informed by, the forefront of the specialisation.

Ability both to apply appropriate engineering analysis methods for solving complex problems in engineering and to assess their limitations.

Ability to use fundamental knowledge to investigate new and emerging technologies.

Knowledge and comprehensive understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations.

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## Study

### Study time

Type	Required
Lectures	9 sessions of 1 hour 30 minutes (9%)
Seminars	2 sessions of 8 hours (11%)
Tutorials	1 session of 30 minutes (0%)
Online learning (scheduled sessions)	2 sessions of 2 hours (3%)
Online learning (independent)	5 sessions of 6 hours (20%)
Assessment	86 hours (57%)
Total	150 hours

## Private study description

No private study requirements defined for this module.

## Costs

No further costs have been identified for this module.

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## Assessment

You must pass all assessment components to pass the module.

### Assessment group A1

	<b>Weighting</b>	<b>Study time</b>
Post Module Assessment report	70%	70 hours
The first part of the PMA summarises the converter testing practical and includes critical discussion of test observations. The second part of the PMA is design proposal of a power conversion system for an EV application and critiques of electrical, mechanical, thermal design aspects as well as reliability and manufacturing considerations.		
Power semiconductor characteristics worksheet	10%	2 hours
After the online pre-learning, students will submit worksheets to answer multiple choice questions and evaluate characteristics of power semiconductor devices including diode, thyristor, BJT, MOSFET and IGBT.		
Video presentation on power converter design	20%	14 hours
The students will submit a video to present loss calculation and thermal simulation of their converter design from the design workshop. They will also discuss integration challenges and cost considerations of their design.		

### Feedback on assessment

The semiconductor characteristics worksheets will be marked and returned to students 4 weeks before the PMA deadline so that the feedback will help students with their PMA.

The video presentation will be marked with an assessment report which will be returned to students 3 weeks before the PMA deadline.

The PMA will be marked based on comprehension, effort and presentation.

An overall mark of the module is sent to students with the PMA assessment report.

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## Availability

### Courses

This module is Core optional for:

- MSc in Sustainable Automotive Electrification (PT) [New Course]

This module is Core option list A for:

- Engineering Competence (Sustainable Automotive Electrification) [New Course]
- MSc in Sustainable Automotive Electrification (FT) [New Course]