## MODULE DESCRIPTOR FORM
نموذج وصف المادة الدراسية

| Module Information | | | |
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| معلومات المادة الدراسية | | | |
| **Module Title** | **AC POWER CONVERTER** | **Module Delivery** | |
| **Module Type** | CORE | ✓ Theory Lecture ✓ Lab Tutorial ✓ Practical ✓ Seminar | |
| **Module Code** | **EET307** | | |
| **ECTS Credits** | 5 | | |
| **SWL (hr/sem)** | 125 | | |
| **Module Level** | 3 | **Semester of Delivery** | 2 |
| **Administering Department** | **DEPARTMENT OF ELECTRICAL ENGINEERING TECHNIQUES** | **College** | **AL-FURAT AL-AWSAT TECHNICAL UNIVERSITY AL-MUSAIB TECHNICAL COLLEGE** |
| **Module Leader** | | **e-mail** | zaidoon.waleed@mustaqbal-college.edu.iq |
| **Module Leader's Acad. Title** | zaidoon.waleed | **Module Leader's Qualification** | Doctor |
| **Module Tutor** | None | **e-mail** | None |
| **Peer Reviewer Name** | None | **e-mail** | None |
| **Review Committee Approval** | 1/10/2025 | **Version Number** | 1.0 |

| Relation With Other Modules | | | |
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| العلاقة مع المواد الدراسية الأخرى | | | |
| **Prerequisite module** | NONE | **Semester** | |
| **Co-requisites module** | None | **Semester** | |

| Module Aims, Learning Outcomes and Indicative Contents | |
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| أهداف المادة الدراسية ونتائج التعلم والمحتويات الإرشادية | |
| **Module Objectives** أهداف المادة الدراسية | **Students will learn the principle of ;** <br> 1. Understand the fundamental principles of AC power conversion, including AC voltage and current characteristics, power factor, and three-phase systems. <br> 2. Identify and analyze different AC power converter topologies, such as rectifiers, inverters, and AC-DC and DC-AC converters, understanding their working principles, advantages, and limitations. <br> 3. Design and analyze AC power converters for specific applications, considering parameters such as input and output voltage and current requirements, power factor correction, efficiency, and harmonic content. Select appropriate components and control strategies for achieving desired performance specifications. <br> 4. Develop proficiency in modeling and simulation techniques for AC power converters, using software tools or programming languages to analyze |

converter behavior under different operating conditions, evaluate performance metrics, and predict harmonic distortion.

5. Understand various control techniques used in AC power converters, such as pulse width modulation (PWM), sinusoidal pulse width modulation (SPWM), and space vector modulation (SVM). Analyze the stability and dynamic response of control loops.

6. Familiarize with passive and active components used in AC power converters, including transformers, capacitors, diodes, IGBTs, and thyristors. Understand their characteristics, selection criteria, and their impact on converter performance and reliability.

7. Gain awareness of practical considerations and challenges associated with AC power converter implementation, such as thermal management, electromagnetic interference (EMI), grid synchronization, and protection mechanisms. Learn techniques to mitigate these issues.

8. Evaluate the efficiency and power quality aspects of AC power converters, including efficiency calculations, harmonic content analysis, power factor correction, and techniques to reduce switching losses and improve grid integration.

9. Understand the integration of AC power converters in larger systems, such as renewable energy systems, electric grid interfaces, motor drives, and uninterruptible power supplies (UPS). Gain awareness of the interaction between converters and other system components.

10. Develop troubleshooting and problem-solving skills to diagnose and rectify issues related to AC power converters. Analyze and interpret experimental data, identify sources of errors or failures, and propose solutions.

By achieving these module objectives, students will gain a comprehensive understanding of AC power converters, enabling them to design, analyze, and implement efficient and reliable power conversion systems in various AC power applications.

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| **Module Learning Outcomes**<br><br>مخرجات التعلم للمادة الدراسية | Upon completing the AC power converter module, students should be able to:<br><br>1. Explain the fundamental principles of AC power conversion, including AC voltage and current characteristics, power factor, and three-phase systems.<br>2. Analyze and compare different AC power converter topologies, such as rectifiers, inverters, and AC-DC and DC-AC converters, in terms of their operation, advantages, and limitations.<br>3. Design and simulate AC power converters for specific applications, considering input and output voltage and current requirements, power factor correction, efficiency, and harmonic content. |

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4. Apply control techniques, such as pulse width modulation (PWM), sinusoidal pulse width modulation (SPWM), and space vector modulation (SVM), to regulate the output of AC power converters and achieve desired performance characteristics.
5. Evaluate and optimize the efficiency and power quality aspects of AC power converters, including efficiency calculations, harmonic content analysis, power factor correction, and techniques to reduce switching losses.
6. Select and analyze the appropriate passive and active components, such as transformers, capacitors, diodes, IGBTs, and thyristors, for AC power converter design, considering their characteristics, ratings, and impact on performance.
7. Demonstrate an understanding of practical considerations and challenges related to AC power converter implementation, including thermal management, electromagnetic interference (EMI), grid synchronization, and protection mechanisms.
8. Analyze and interpret experimental data obtained from AC power converter testing and troubleshooting activities, identify sources of errors or failures, and propose appropriate solutions.
9. Evaluate the integration of AC power converters into larger systems, such as renewable energy systems, electric grid interfaces, motor drives, and uninterruptible power supplies (UPS), considering the interaction between converters and other system components.
10. Demonstrate effective communication skills by presenting and explaining AC power converter designs, simulations, experimental results, and solutions to technical problems.

Overall, the module aims to equip students with the knowledge, skills, and practical experience necessary to design, analyze, and implement AC power converters for various applications, while considering efficiency, power quality, and system integration aspects.

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**Indicative Contents**
المحتويات الإرشادية

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1. AC-DC Rectifiers:
   Half-wave and full-wave rectifiers
   Diode rectifiers
   Controlled rectifiers
   Single-phase and three-phase rectifiers
2. DC-AC Inverters:
   Single-phase and three-phase inverters
   Pulse width modulation (PWM) techniques for inverter control
   Harmonic content analysis and filtering in inverters
3. AC-AC Converters:
   AC voltage and current characteristics
   Cycloconverters and matrix converters

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| | | Control strategies for AC-AC converters |
| | | Applications and advantages of AC-AC converters |
| | 4. | Multilevel Converters: |
| | | Diode-clamped and cascaded H-bridge multilevel converters |
| | | Pulse width modulation techniques for multilevel converters |
| | | Advantages and applications of multilevel converters |
| | 5. | Resonant Converters: |
| | | Series and parallel resonant converters |
| | | Zero-voltage and zero-current switching techniques |
| | | Soft-switching and high-frequency operation |
| | 6. | Grid-Connected Power Converters: |
| | | Grid synchronization and grid integration requirements |
| | | Grid-tied inverters for renewable energy systems |
| | | Power quality and reactive power compensation in grid-connected converters |
| | 7. | Control Techniques for AC Power Converters: |
| | | Pulse width modulation (PWM) strategies |
| | | Sinusoidal pulse width modulation (SPWM) |
| | | Space vector modulation (SVM) techniques |
| | 8. | Emerging Trends in AC Power Conversion: |
| | | High-frequency and high-power-density AC power converters |
| | | Application-specific power converter designs (e.g., electric vehicles, renewable energy systems) |
| | Note: The above indicative contents provide a broad overview of the topics typically covered in an AC power converter course. The specific depth and coverage of each topic can vary depending on the course level and duration. The contents can be adjusted or expanded based on the curriculum and the instructor's expertise and preferences. | |

## Learning and Teaching Strategies
استراتيجيات التعلم والتعليم

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| **Strategies** | 1. Lectures: Conduct lectures to introduce and explain the theoretical concepts, principles, and working mechanisms of AC power converters. Use visual aids such as slides, diagrams, and animations to enhance understanding. |
| | 2. Practical Demonstrations: Organize practical demonstrations to showcase the operation of AC power converters in real-world applications. This can include demonstrating the working of rectifiers, inverters, and other AC power conversion circuits using appropriate laboratory equipment. |
| | 3. Hands-on Lab Experiments: Provide students with hands-on experience by conducting laboratory experiments on AC power converters. Students can design, build, and test different converter topologies, measure |

performance parameters, and analyze the results. This will help reinforce theoretical concepts and develop practical skills.

4. Simulation Exercises: Utilize simulation software tools, such as MATLAB/Simulink or PSpice, to simulate AC power converter circuits and systems. Assign simulation exercises to students, allowing them to explore different scenarios, analyze performance, and validate theoretical concepts.

5. Case Studies: Present case studies of real-world AC power converter applications, such as renewable energy systems or motor drives. Discuss the design considerations, challenges faced, and the solutions implemented in these applications. Encourage students to analyze and propose improvements to the existing systems.

6. Group Projects: Assign group projects that require students to design and implement AC power converters for specific applications. This can involve selecting appropriate converter topologies, designing control strategies, and optimizing performance. Emphasize teamwork, problem-solving, and presentation skills.

7. Guest Speakers: Invite industry professionals or experts in AC power converters to deliver guest lectures or participate in panel discussions. They can share their practical experiences, current trends, and challenges in the field, providing valuable insights to students.

8. Problem-Solving Sessions: Organize problem-solving sessions or tutorials where students can discuss and solve challenging problems related to AC power converters. Encourage active participation, critical thinking, and collaboration among students.

9. Online Resources: Provide access to online resources, such as textbooks, research papers, and video lectures, to supplement classroom learning. Encourage students to explore these resources to deepen their understanding and gain additional knowledge.

10. Assessments: Conduct regular assessments, including quizzes, assignments, and exams, to evaluate students' understanding of AC power converters. Assessments should test both theoretical knowledge and practical application skills.

11. Industry Visits or Internships: Arrange visits to power electronics companies or facilitate internships at relevant organizations. This allows students to observe AC power converter manufacturing processes, interact with professionals, and gain practical industry experience.

By employing these teaching strategies, students can develop a strong foundation in AC power converters, enhance their problem-solving abilities, and acquire the practical skills necessary for designing, analyzing, and implementing AC power conversion systems.

## Student Workload (SWL)
### الحمل الدراسي للطالب

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| **Structured SWL (h/sem)**<br>الحمل الدراسي المنتظم للطالب خلال الفصل | 63 | **Structured SWL (h/w)**<br>الحمل الدراسي المنتظم للطالب أسبوعيا | 4.2 |
| **Unstructured SWL (h/sem)**<br>الحمل الدراسي غير المنتظم للطالب خلال الفصل | 62 | **Unstructured SWL (h/w)**<br>الحمل الدراسي غير المنتظم للطالب أسبوعيا | 4.13 |
| **Total SWL (h/sem)**<br>الحمل الدراسي الكلي للطالب خلال الفصل | 125 | | |

## Module Evaluation
### تقييم المادة الدراسية

| | | Time/Number | Weight (Marks) | Week Due | Relevant Learning Outcome |
|---|---|---|---|---|---|
| **Formative assessment** | **Quizzes** | 6 | 10% (10) | 2- 10 | LO #2, 10 |
| | **Assignments** | 8 | 10% (10) | 2- 12 | LO # 1-9 |
| | **Projects / Lab.** | 8 | 10% (10) | Continuous | All |
| | **Report** | 7 | 10% (10) | Continuous | All |
| **Summative assessment** | **Midterm Exam** | 1 hr | 10% (10) | 8 | LO # 1-8 |
| | **Final Exam** | 3 hr | 50% (50) | 15 | All |
| **Total assessment** | | | 100% (100 Marks) | | |

## Delivery Plan (Weekly Syllabus)
### المنهاج الاسبوعي النظري

| | Material Covered |
|---|---|
| | Here is a sample weekly delivery plan for an AC power converter module. Please note that the exact schedule may vary depending on the specific curriculum and course duration:<br><br>Week 1:<br><br>• Introduction to AC power conversion<br>• AC voltage and current characteristics<br>• Power factor and power quality considerations<br><br>Week 2, 3, 4, 5, and 6:<br><br>• AC-DC rectifiers: Half-wave and full-wave rectifiers<br>• Diode bridge rectifiers<br>• Controlled rectifiers<br>• Single and three phase rectifiers |
| | |

Week 7, 8,  and 9:

- DC-AC inverters: Single-phase and three-phase inverters
- Pulse width modulation techniques for inverter control

Week 10:

- Multilevel converters: Diode-clamped and cascaded H-bridge multilevel converters
- Pulse width modulation techniques for multilevel converters

Week 11:

- Resonant converters: Series and parallel resonant converters
- Zero-voltage and zero-current switching techniques

Week 12:

- AC-AC converters: Cycloconverters and matrix converters
- Control strategies for AC-AC converters

Week 13:

- Grid-connected power converters: Grid synchronization and grid integration requirements

Week 14:

- Review and revision
- Project presentations and discussions

Week 15:

* Final Exam:

Note: This is a general guideline for a 14-week semester, and the topics can be adjusted based on the curriculum and course requirements. It's important to allocate time for practical exercises, laboratory sessions, assignments, and assessments throughout the module

**Delivery Plan (Weekly Lab. Syllabus)**

| المنهاج الاسبوعي للمختبر |
|---|

| | Material Covered |
|---|---|
| | Here is a sample weekly lab syllabus for an AC power converter module. This plan focuses on hands-on practical exercises and laboratory experiments related to AC power converters:<br><br>Week 1: |
| | Introduction to the lab equipment and safety procedures<br>Familiarization with basic power electronics components (diodes, capacitors, resistors)<br>Measurement techniques (voltage, current, power) and use of laboratory instruments |
| | Week 2 and 3: |
| | Lab exercise: Half-wave and full-wave rectifier circuits<br>Measurement and analysis of rectifier performance (ripple voltage, output voltage) |
| | Week 4 and 5: |
| | Lab exercise: Diode and controlled bridge rectifier circuit<br>Measurement and analysis of rectifier performance (ripple voltage, output voltage) |
| | Week 6 and 7: |
| | Lab exercise: Single-phase half and full bridge inverter design and implementation<br>Measurement and analysis of inverter output waveform and harmonics |
| | Week 8 and 9: |
| | Lab exercise: Three-phase 120 and 180 degree inverter design and implementation<br>Measurement and analysis of three-phase inverter output waveform and harmonics |
| | Week 10: |
| | Lab exercise: Multilevel converter design and implementation<br>Measurement and analysis of multilevel converter output waveform and harmonics |
| | Week 11: |
| | Lab exercise: Power quality analysis in AC power converters<br>Measurement and analysis of harmonic content, power factor, and total harmonic distortion (THD) |

| | Week 12, and 13: |
|---|---|
| | Project work: Matlab simulation to design and implementation of an AC power converter for a specific application |
| | Note: This lab syllabus is a general guideline and can be modified based on the available resources, equipment, and time constraints. It is important to provide clear instructions, documentation, and support during the lab sessions to ensure students' understanding and successful completion of the experiments. |
| | Week 14 |
| | Review |
| | |

## Learning and Teaching Resources
### مصادر التعلم والتدريس

| | Text | Available in the Library? |
|---|---|---|
| **Required Texts** | Mohummed Rashid" Power electronics circuits, Devices and application" 4th edition, 2014. | Yes |
| **Recommended Texts** | | No |
| **Websites** | | |

**APPENDIX:**

| GRADING SCHEME مخطط الدرجات | | | | |
|---|---|---|---|---|
| **Group** | **Grade** | **التقدير** | **Marks (%)** | **Definition** |
| **Success Group (50 - 100)** | **A -** Excellent | امتياز | 90 - 100 | Outstanding Performance |
| | **B -** Very Good | جيد جدا | 80 - 89 | Above average with some errors |
| | **C -** Good | جيد | 70 - 79 | Sound work with notable errors |
| | **D -** Satisfactory | متوسط | 60 - 69 | Fair but with major shortcomings |
| | **E -** Sufficient | مقبول | 50 - 59 | Work meets minimum criteria |
| **Fail Group (0 – 49)** | **FX** – Fail | مقبول بقرار | (45-49) | More work required but credit awarded |
| | **F** – Fail | راسب | (0-44) | Considerable amount of work required |
| | | | | |

Note:

NB Decimal places above or below 0.5 will be rounded to the higher or lower full mark (for example a mark of 54.5 will be rounded to 55, whereas a mark of 54.4 will be rounded to 54. The University has a policy NOT to condone "near-pass fails" so the only adjustment to marks awarded by the original marker(s) will be the automatic rounding outlined above.