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MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH
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Course Support for the Subject:

Simulation Software for Renewable Energy Systems

Intended for 2nd Year Bachelor's Students
Specialty: Renewable Energies and Environment

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Foreword

This manuscript is intended for 2nd Year Bachelor's (LMD) students, specializing in Renewable Energies and Environment. It complies with the official program.

The goal of this course is to equip students with fundamental knowledge of the software used to study the dynamic and static behavior, as well as the analysis of renewable resources.

I hope this document will be appreciated by my colleagues and will help the students. I would be very pleased to receive their comments and suggestions with gratitude.

Chapitre I. Matlab/Simulink software

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I.1 Introduction

MATLAB and Simulink are powerful computational tools widely used in engineering and scientific research. Their capabilities in numerical computing, system modeling, and simulation make them essential for analyzing and optimizing renewable energy systems.

MATLAB, short for **MAT**rix **LAB**oratory is a programming package specifically designed for quick and easy scientific calculations and I/O. It has literally hundreds of built-in functions for a wide variety of computations and many toolboxes designed for specific research disciplines, including statistics, optimization, solution of partial differential equations, data analysis.

Simulink, an extension of MATLAB, offers a graphical environment for simulating and analyzing dynamic systems. By using block diagrams, engineers can model and test complex energy systems, including solar photovoltaic (PV) arrays, wind turbines, and hybrid energy storage solutions.

I.2 MATLAB/Simulink for Renewable Energy Systems

The study and implementation of renewable energy systems require precise modeling and simulation before real-world deployment. MATLAB/Simulink provides several advantages, including:

- **Accurate System Modeling:** Enables the simulation of renewable energy sources like solar and wind power under real-world conditions.
- **Component-Level Simulation:** Models electrical components such as inverters, converters, batteries, and power grids.
- **Optimization and Control:** Develops control strategies for power management, maximum power point tracking (MPPT), and grid integration.
- **Prebuilt Toolboxes:** Includes dedicated toolboxes such as the *Simscape Electrical Toolbox* for power electronics and *Renewable Energy Toolbox* for energy system modeling.

I.2.1 Examples of Renewable Energy Applications in MATLAB/Simulink

1. Solar PV System Simulation:

- Modeling a photovoltaic (PV) array and analyzing its power output under varying sunlight and temperature conditions.
- Implementing Maximum Power Point Tracking (MPPT) algorithms to optimize energy extraction.

2. Wind Energy System Simulation:

- Designing wind turbine models and studying their response to different wind speeds.
- Simulating the power output and efficiency of wind farms connected to the grid.

3. Hybrid Renewable Energy Systems:

- Integrating solar and wind energy sources with battery storage.
- Developing energy management strategies for off-grid and grid-connected systems.

4. Microgrid and Smart Grid Analysis:

- Modeling distributed energy resources (DERs) for smart grid integration.
- Simulating demand-response mechanisms and grid stability analysis.

I.2.2 Installation and Setup of MATLAB/Simulink

To get started with MATLAB/Simulink, follow these steps:

1. Download and Install MATLAB:

- Visit the official MATLAB website (www.mathworks.com) and create a MathWorks account.
- Download the latest version of MATLAB and follow the installation instructions.

2. Activate the License:

- If you have an institutional or student license, enter your credentials during installation.
- For trial versions, MathWorks provides a free 30-day trial license.

3. Install Required Toolboxes:

- Open MATLAB and navigate to **Home > Add-Ons > Get Add-Ons**.
- Search for relevant toolboxes, such as *Simulink*, *Simscape Electrical*, and *Renewable Energy Toolbox*.
- Install them to enable specialized modeling capabilities.

4. Verify Installation:

- Launch MATLAB and enter `ver` in the command window to check installed toolboxes.
- Open Simulink by typing `simulink` in the MATLAB command window.

Conclusion

MATLAB and Simulink are essential tools for engineers working with renewable energy systems. By mastering these software packages, students can develop accurate models, optimize system performance, and contribute to the advancement of sustainable energy solutions. In the next sections, we will explore practical examples and step-by-step tutorials for implementing renewable energy models in MATLAB/Simulink.