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FACULTY OF ENGINEERING TECHNOLOGY

GROUP T LEUVEN CAMPUS

Project Sunflower

Energy 2

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ABSTRACT

In the abstract, the full paper is summarised. This way, readers can easily scan if your paper is what they are looking for. Provide a summary of the problem/goal, the solution/approach, and the results.

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1 INTRODUCTION

The advent of the 21st century has been characterized by an urgent global need to reduce dependency on fossil fuels, both to combat climate change and to build a sustainable future for mankind in the planet. Solar energy has now long been at the forefront of renewable technologies, due to the growing accessibility and utility of solar photovoltaic systems. The increase in global PV capacity has been exponential over the last decade, driven by both policy incentives as well as purely financial ones. Indeed, the advancements in PV technology have more affordable, efficient, and as a result, viable than ever before. (IRENA)

Project Sunflower aims to both develop a functional PV system for a practical application, as well as to contribute to the research in the field of solar power. Designed as part of KU Leuven Campus Groep T's initiative for innovation in the field of renewable energy, Project Sunflower is a PV system equipped with a PV cell, a Maximum Power Point Tracking (MPPT) controller, a battery for energy storage, as well as an array of other additional features.

MPPT technology is essential in photovoltaic systems. It enables the solar panel to operate at its optimal power point despite varying irradiance and temperature conditions, potentially enhancing system efficiency by up to 30% under certain conditions. Esram and Chapman (2007) Being an electronics engineering project at its core, the design of the MPPT controller is what Project Sunflower centers around. By implementing MPPT, the project aims to maximize the energy yield of the solar panel, addressing one of the core challenges in renewable energy-efficiency.

However, MPPT control is not the only way in which efficiency of PV systems can be increased. Studies suggest that sun-tracking systems, which involve rotating the PV cells, could help maximize system efficiency. Koussa et al. (2011) During our literature analysis, we found that most data provided by such studies focuses on biaxial rotation, which while being simple to implement on a small scale, is generally not scalable. Although some studies address uniaxial rotation, they frequently exclude the MPPT controller in their analysis. Consequently, the data on the benefits of combining uniaxial panel rotation with MPPT control remains rather limited, presenting an opportunity for our team to contribute valuable insights through this project.

1.1 Requirements analysis

Our project aims to develop a system that will leverage solar energy to deliver clean and renewable energy specifically tailored to function at the the Group T campus. And our project is designed with the following functional and non-functional requirements:

1. Power Generation and Storage:
   The solar panel must generate sufficient power under varying lighting conditions.
   A battery pack is to be charged using an MPPT controller, ensuring over 85% tracking efficiency. Efficiency is evaluated by measuring input and output power over time.

2. Stable Power Output:
   The system should provide a consistent 5V output suitable for charging small electronic devices like smartphones. We will use a multimeter or oscilloscope to verify this requirement and ensure voltage stability.

3. Real-Time Monitoring:
   A web interface should display metrics such as current power generation, battery charge status, and system performance in real time, updating at least once per minute. Data displayed in the app will be compared with real-time sensor readings.

4. Additional Features:
   Optional features include a biaxial solar tracking mechanism and an LCD display for key metrics, enhancing energy efficiency and user interaction. Tracking mechanism responsiveness is measured using angular displacement, while LCD output is cross-checked with sensor data.

In summary, the proposed system aims to create an eco-friendly and scalable energy solution, conducting research into its different aspects along the way.

2 DESIGN AND MATERIALS

2.1 Basics on solar-charging systems and MPPT approaches

A typical solar-charging system consists of solar arrays, MPPT controllers, power electronic converters and loads. Efficiency increasing in each part caused improving the solar-charging system. The single diode model of solar cell is illustrated in Fig 2.1. By putting the solar cells next to each other, the module will be obtained. A panel consists of connecting several modules, and an array consists of connecting several panels. The connections between these different modes can be done in series or in parallel. For example, a solar panel is created by connecting a series or parallel of modules.

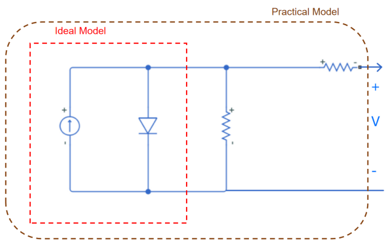

Figure 2.1: single diode circuit

2.1.1 operation principle of a MPPT system

Solar power-voltage characteristics' curve is presented in Fig. 1. The MPP is created near the top of the P-V curve,

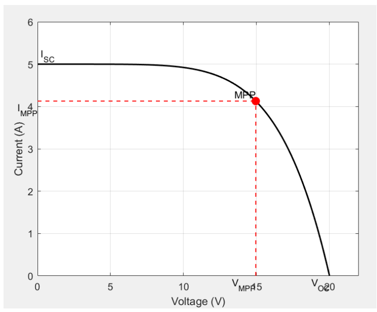

Figure 2.2: current-voltage

or the famous knee point of the P-V curve, where the generated PV power is maximized. As the MPP depends on solar radiation (S) and temperature (T), and these environmental conditions vary randomly, the MPP position is continuously changed. In order to ensure the operation point is always on the maximum power point, or near it, specific circuits, called MPP trackers, are employed. The DC-DC also applies the controller signal and brings the output to the desired level. Thus, by measuring different parameters (voltage, current or temperature), the maximum power point tracking algorithms calculate the optimal duty cycle (D) and deliver it to the converter to increase the power. Figure 2.3 shows the overview of PV system. As it is known, the MPP system must operate continuously in real time because the parameters to which the system depends (temperature and radiation) change throughout the day. Changes in the amount of radiations and temperature during the day are perfectly normal or there may be partial shading. As a result, duty cycle needs to be updated accurately and rapidly (as appropriate).

2.2 Materials

Important: do not provide results in this section.

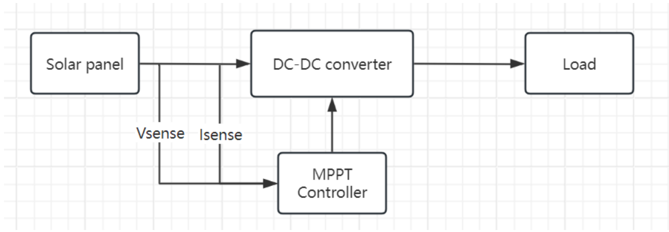

Figure 2.3: Implementation of MPPT system

3 IMPLEMENTATION

Important: do not provide results in this section.

3.1 Hardware implementation

3.1.1 DC-DC converter

The presence of a DC-DC converter leads in control and adjustment of the unregulated DC voltage of output voltage to optimal voltage. The advantages of presence of a DC-DC converter include increase or decrease the dc voltage and adjusting the output voltage according to load changes. These benefits are possible with change of the duty cycle (D). Depending on their output voltage value, different DC-DC converter configurations exist in literature boost, buck, buck-boost, flyback, forward, half and full bridge and etc.

3.2 Software implementation

[TEXT]

4 EVALUATION AND VALIDATION

Important: do not introduce new designs, materials or implementation methods in this section.

Table 4.1: An example table

Day	Min Temp (°C)	Max Temp (°C)
Monday	11	22
Tuesday	9	19
Wednesday	10	21

5 DISCUSSION

Critical reflection is important in this chapter.

6 CONCLUSION

[TEXT]

ACKNOWLEDGEMENTS

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LIST OF SYMBOLS

Symbols

λ_{ex}	Excitation wavelength
λ_{em}	Emission wavelength
$N(\ldots)$	Noise process

Acronyms

ADC	Analog to Digital Converter
CCD	Charge-Coupled Device

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APPENDICES

APPENDIX A : SOME EXTRA INFO

Delete the appendix if not needed.