ECE 445

SENIOR DESIGN LABORATORY

DESIGN DOCUMENT

Microgrids

Team #445

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1 Introduction

1.1 Problem

In recent years, the power system has faced challenges stemming from increasing load and transmission capacity, as well as high costs, operational difficulties, and weak regulation of large, interconnected power grids with centralized generation and long-distance transmission. However, advances in new power electronics technology have led to the proliferation of distributed generation based on renewable sources such as wind, solar, and storage. Distributed power generation offers various advantages, including high energy utilization, low environmental pollution, high power supply flexibility, and low input cost. Developing and utilizing efficient, economical, flexible, and reliable distributed power generation technology presents an effective approach to addressing the energy crisis and environmental issues.

The inherent characteristics of the grid itself, such as its security and isolation, make it impossible to perform certain system analyses based solely on the grid. Additionally, due to the complex nature of the grid, experimenting with the entire system can result in devastating consequences. Furthermore, the interconnected nature of the grid makes it challenging to move and partition specific parts of it independently. Moreover, the grid is not cost-effective, has a high environmental impact, and can lead to significant pollution.

Given these issues, it is imperative to explore alternative solutions that are mobile and independent of the grid while taking into account the unique characteristics of the grid. Such an approach would require a fundamental shift away from the grid-based model and towards more sustainable and eco-friendly alternatives. By doing so, we can reduce our dependence on traditional energy sources and move towards a more sustainable future.

Thus, the concept of microgrid, which aims to mitigate the impact of large-scale distributed power supply to the grid and leverage the benefits of distributed power generation technology[1], was introduced. The microgrid represents a promising solution to address the limited carrying capacity of the power system for the extensive penetration of distributed power supply

1.2 Solution

To assess the feasibility of the microgrid design, a small-scale prototype will be constructed on a PCB board. This prototype will incorporate all the major components of the microgrid, including the power generation subsystem (comprising of solar panels), the transmission subsystem (comprising of wires), the power consumption subsystem (including light bulbs and fans), the energy storage device (i.e., batteries), and the parallel connection subsystem with the larger grid.

The prototype will enable the testing of the microgrid's ability to operate autonomously and perform critical power system functions, such as load balancing and frequency regulation. Moreover, it will provide an opportunity to evaluate the system's performance under varying operating conditions and validate the accuracy of the simulation models used to design the microgrid. We will conduct an efficiency analysis of the microgrid model, taking into consideration the clean energy input and power output to the entire circuit. Our goal is to evaluate the efficiency of the microgrid and ensure that it meets the requirements of a green environment, reducing pollution to the surroundings. Additionally, microgrids provide a platform for conducting experiments that explore the characteristics of the grid without compromising the safety of the entire system. Furthermore, the presence of microgrids makes it easy to relocate the grid, providing added flexibility. Ultimately, the results of the prototype testing will inform the design and implementation of larger scale microgrid systems, enabling the deployment of reliable and sustainable energy solutions for a wide range of applications.

1.3 Visual Aid

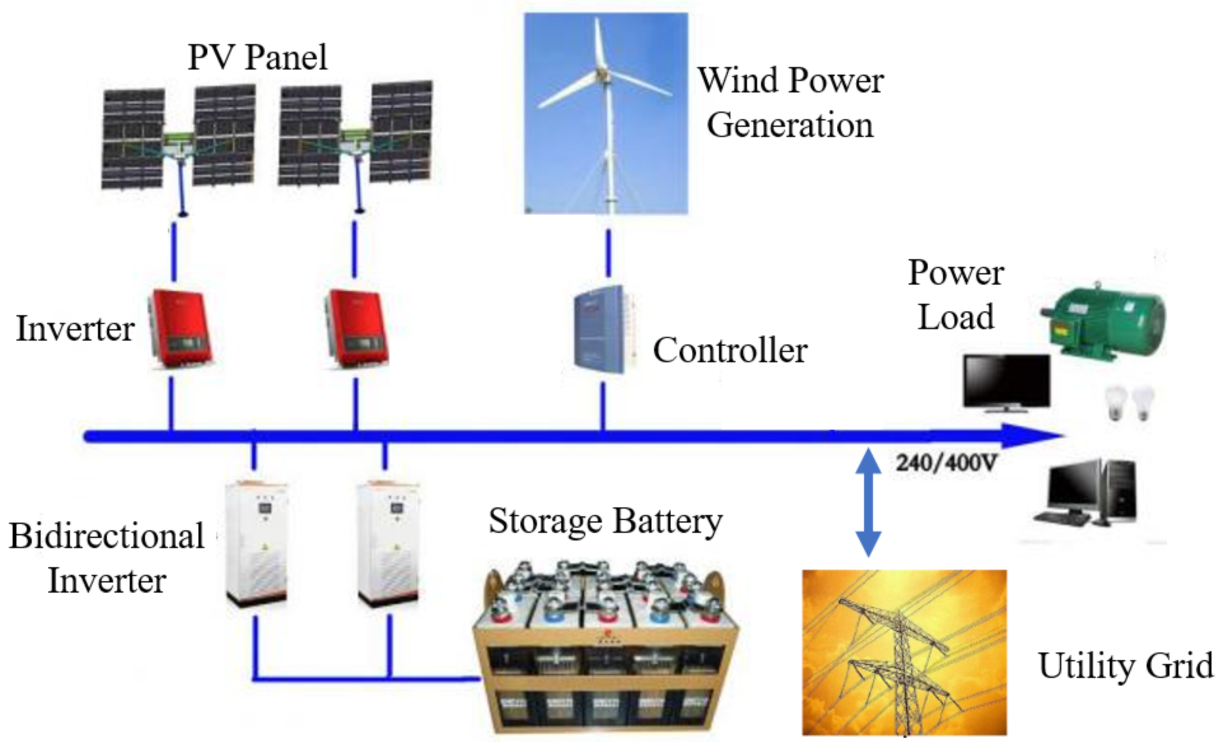

Figure 1: Visual Aid

1.4 High-level requirements list

Our micro grid system must meet the following high-level requirements:

1. Bus Voltage: The system must operate at a minimum bus voltage of 24V ($\pm 2V$) to support the use of larger circuit components. This requirement will allow us to

design and implement the necessary functions of the microgrid, while also ensuring that the system can provide a reliable and efficient power source.

Change: It is indeed necessary to set the tolerance. Here we set the tolerance to be $\pm 2V$*, refer to the normal voltage tolerance of the utility power grid, which is +7% to -10%. However, the voltage of the bus is 24V but not* $\pm 24V$*, because our bus is a DC bus.*

2. Power Requirement: The system must have a minimum power requirement of 80W - 100W to meet the energy needs of the microgrid. This requirement will enable us to ensure that the microgrid can provide power to its connected loads, while also allowing for scalability and expansion of the system as needed.

3. State Transition Time: The microgrid must have a carrier state transition time of less than 200ms to ensure that the system can seamlessly connect and disconnect from the larger power grid. This requirement will help to avoid any disruptions or instabilities in the power supply and maintain the reliability and stability of the system.

These high-level requirements are crucial for the successful development and implementation of our micro grid system. By meeting these requirements, we can ensure that our system is efficient, reliable, and scalable, and can provide a sustainable energy source for our needs.

2 Design

2.1 Block Diagram

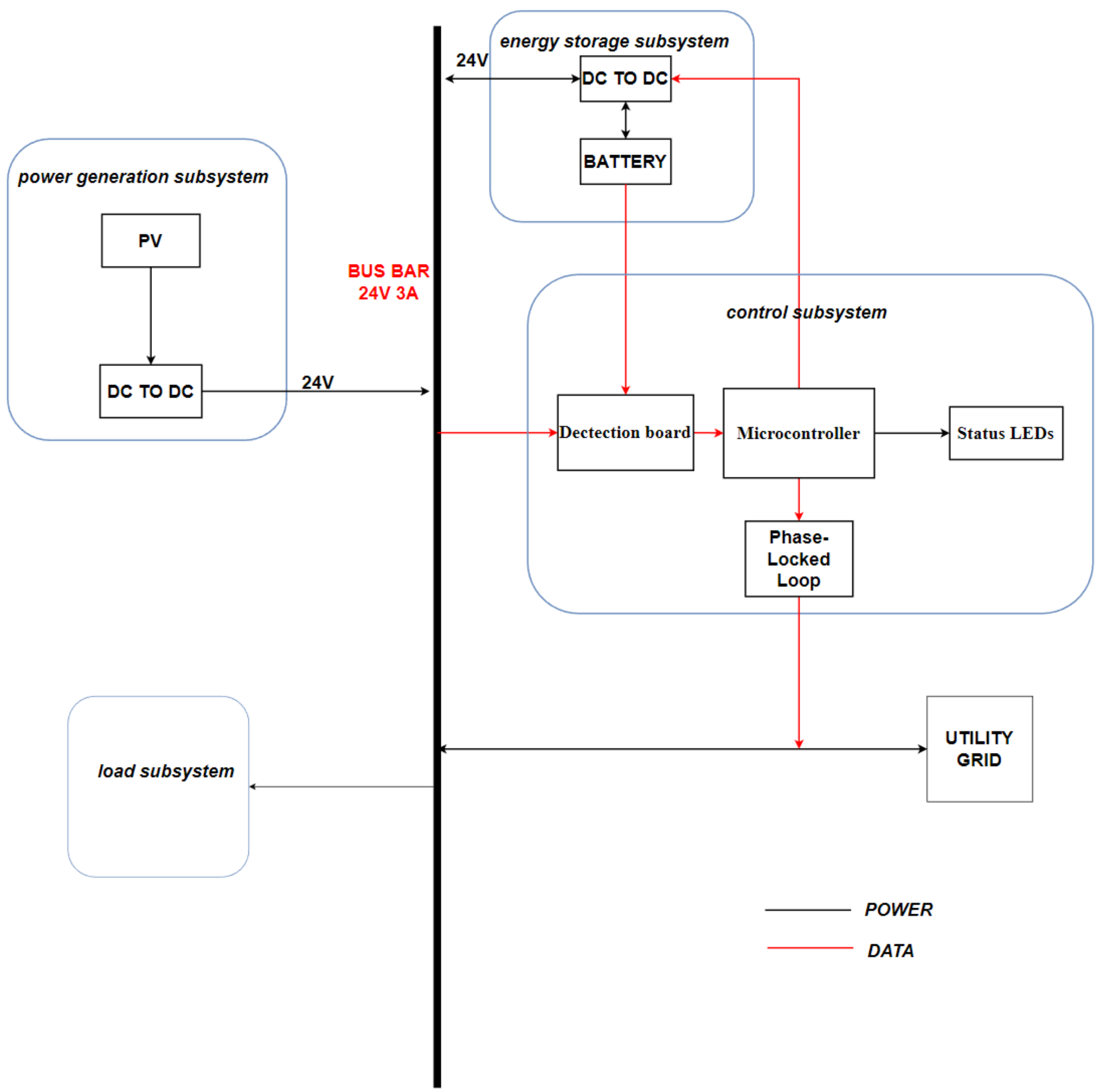

Figure 2: Block Diagram

Change: We canceled the shadowing effect to avoid distracting. And we also fixed spelling mistakes.

2.2 Subsystem Overview

- Power Generation Module: The power generation module generates the power needed to operate the microgrid system and charge the load system. It meets the minimum power requirement of 80W - 100W, as specified in the high-level requirements.
- Energy Storage Module: The energy storage module utilizes a battery to store the energy generated by the power generation module. This module helps to ensure a reliable and stable power supply, especially during periods of low power generation or high demand.
- Control System: The control system regulates and controls the microgrid system's operation. It utilizes a DSP board to monitor and manage the various subsystems, including the power generation and energy storage modules. The control system ensures that the microgrid operates within the specified voltage and frequency range to maintain a stable power supply.
- Load Module: The load module tests the microgrid system's ability to supply power to connected loads and secure the system. This module provides a load on the microgrid system to test its reliability and stability.
- Simulink Module: The Simulink module simulates the microgrid system and tests its stability, reliability, and performance. It allows for the evaluation of various scenarios and configurations to optimize the microgrid system's performance and ensure its feasibility.

These subsystems are essential for the successful development and implementation of a reliable and efficient microgrid system that meets the high-level requirements specified.

2.3 Subsystem Requirements

2.3.1 Power Generation Subsystem

The power generation system is designed to harness solar energy and provide it to the Microgrid. It comprises a Photovoltaic (PV) board, a Maximum Power Point Tracking (MPPT) module and a DC-DC convertor. The PV board captures energy from the sun and supplies it to the Microgrid. The MPPT module detects the power generated by the PV board and adjusts the output power to achieve the highest possible output. This subsystem and the energy storage subsystem will form a hybrid power supply. This hybrid power supply arrangement will ensure a stable and reliable power supply for the microgrid, even under variable weather conditions that may affect the solar panel's output.[2].

Photovoltaic Panel: This part consists of PV panel and MPPT controller. It harnesses solar energy from the sun and supplies it to the Microgrid, allowing it to generate power and become self-sufficient. It will provide the power of approximately 100W. The MPPT

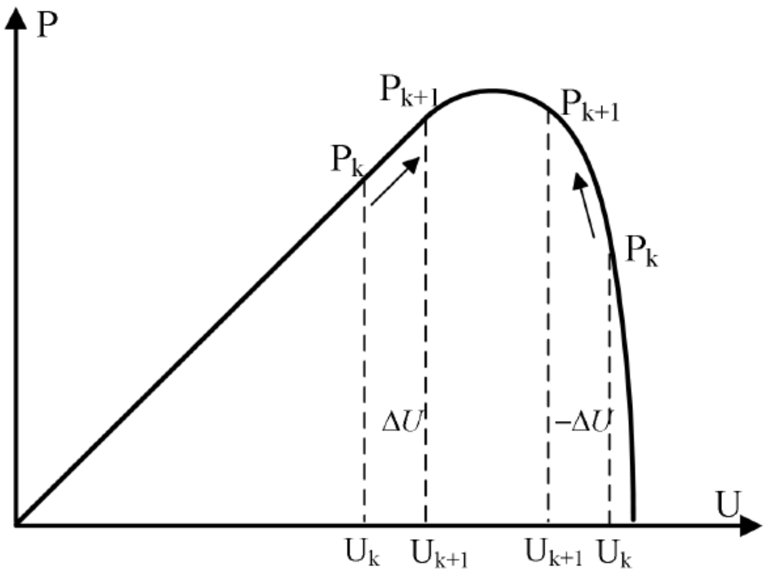

Figure 3: PU Curve

module measures the current and voltage of the PV board to determine the output power. It then compares this value to the previous value and adjusts the reference voltage accordingly. If the current output power is greater than the previous value, the reference voltage is increased. If it is lower, the reference voltage is reduced. The output of MPPT module will change the duty cycle of the DC-DC convertor. Through this process, the MPPT module ensures that the system operates at maximum efficiency to produce the highest possible output..

Requirement	Verification
The PV panel should have output power of 80W - 100W under the MPPT controller in the condition of illumination intensity of about 7000 lx.	Use Avometer to measure the output power of the PV when under the control of MPPT controller and illumination intensity of about 7000 lx.

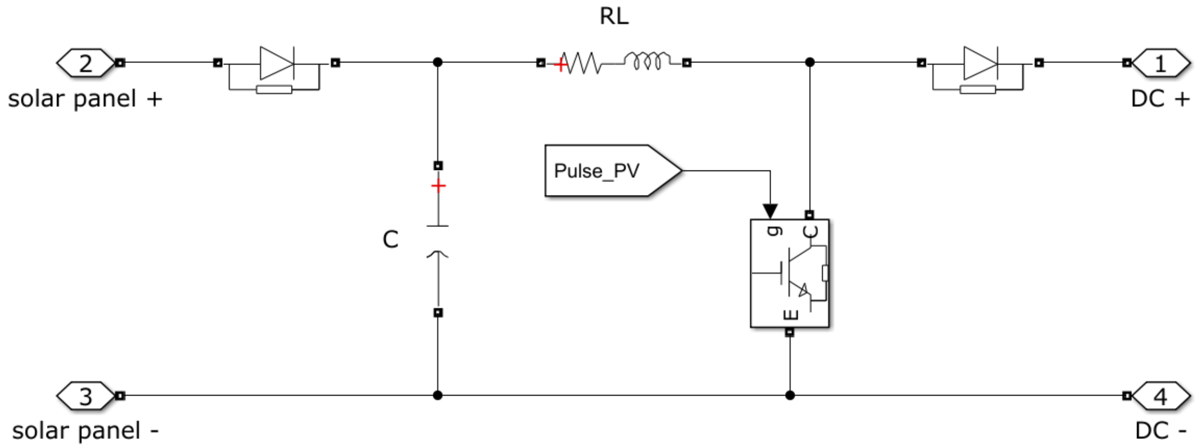

Figure 4: MPPT

Maximum Power Point Tracking (MPPT) module: The MPPT module measures the current and voltage of the PV Panel to determine the output power. It then compares this value to the previous value and adjusts the reference voltage accordingly. If the current output power is greater than the previous value, the reference voltage is increased. If it is lower, the reference voltage is reduced. The output of MPPT module will change the duty cycle of the DC-DC converter. Through this process, the MPPT module ensures that the system operates at maximum efficiency to produce the highest possible output.

DC-DC converter: Our bus-bar currently has a voltage of 24V and a current of 3A. To convert the voltage from the PV board to 24V DC voltage, we use a DC-DC converter.

Requirement	Verification
The converter must supply a stable voltage of 24V ± 0.5V and the output current of 3A ± 0.5A.	Use the oscilloscope and the current probe to measure the output voltage and the output current to ensure it fit the bus-bar voltage and current..

2.3.2 Energy Storage Subsystem

The energy storage subsystem consists of a chargeable battery of 40000 MAh and a DC-DC Bidirectional inverter. To enable energy storage for the microgrid, a battery will be integrated into the PCB board. The battery will function as an energy storage device that can capture, and store excess energy generated by the solar panel when the power generation exceeds the system load. Conversely, when the power generation is lower than the system load, the battery will discharge stored energy to supplement the power supply.

Battery: the chargeable battery will function as an energy storage module. It will storage energy when the PV board provides enough power; and supply the Microgrid when the

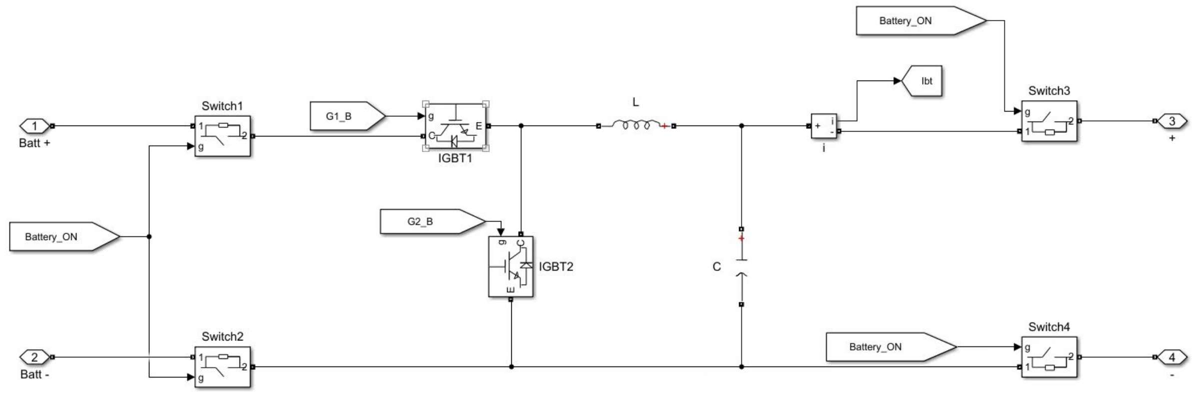

Figure 5: DC-DC Inverter

PV board is lack of power.

Requirement	Verification
Has a capacity of 40000 MAh and can be charged when the PV board provides power larger than 72 W; can charge the Microgrid system when the power provided by PV board is less than 72W.	Get the power output information by MPPT module to compared with the value of 72 W. Measure the voltage of battery to make sure the station of battery (charged or supply).

DC-DC Bidirectional inverter: The bidirectional inverter serves the purpose of regulating voltage on both sides of the inverter, thus enabling energy storage and charge functions. This essential component plays a critical role in ensuring seamless power transfer and efficient operation of the system.

Requirement	Verification
The converter must supply a stable voltage of 24V ± 0.5V and current of 3A ± 0.5A on the bus-bar side.	Use the oscilloscope and the current probe to measure the output voltage and the output current to ensure it fit the bus-bar voltage and current.

2.3.3 Load Subsystem

We plan to employ an electric fan as a test function to assess the performance of our load module. The fan is equipped with a DC motor and has a rated power of 60W, while operating at 220V and 50Hz. Its dimensions are 657*237*505mm. The use of the electric fan as a load test for our microgrid can help us obtain more transparent and comprehensible results. By analyzing the fan's rotation speed and the stability of its blade rotation, we can assess the microgrid's condition, such as its power output and the overall circuit stability.

Requirement	Verification
The fan will has a rated power of 60W when supplied by voltage of 220V 50HZ.	Use Avometer to measure the power of the fan when being supplied by voltage of 220V 50Hz.

2.3.4 Control Subsystem

The control system employs a control method that relies on the DC bus voltage signal to regulate the performance of the grid. This method allows the control system to accurately detect the different operating states of the grid based on the network architecture, distributed power supply capacity, and load size. By analyzing this information, the control system can adjust the output of the distributed power supply to match the requirements of the grid, thus ensuring stable and reliable operation. Additionally, the control system can provide real-time feedback on the status of the grid, allowing operators to quickly identify and address any issues that may arise.

Microcontroller: The microcontroller employed for the microgrid is the DSP28377 chip, which receives analog control signals from other modules. To facilitate the desired control functionality, a C program will be implemented on the DSP28377 chip. This program will enable the control module to execute the necessary control algorithms to regulate the microgrid in accordance with the received signals. The use of the DSP28377 chip offers numerous advantages, including high performance, low power consumption, and flexible configurability[3]. The DSP28377 is a powerful digital signal processor (DSP) specifically designed for control applications. Its high computational power, real-time processing capability, and integrated control peripherals make it an ideal choice for implementing complex control algorithms with high precision and accuracy.

Requirement	Verification
1.Must be able to control multiple PWM channels simultaneously.	1.Generate PWM signals with different duty cycles and frequencies on multiple channels of the microcontroller. Confirm that the signals are accurate and synchronized, and that the microcontroller can adjust the PWM output on each channel in real-time.
2.Must be able to read analog inputs from multiple sensors.	2.Connect multiple sensors to analog inputs of the microcontroller and take readings from each sensor. Confirm that the readings are accurate and that the microcontroller can differentiate between the inputs from each sensor. Additionally, verify that the microcontroller can sample the analog inputs at the required rate and that there is no signal interference or crosstalk between the inputs.

Detection board: The detection board is a crucial component of the system, responsible for accurately measuring the voltage and current at the point to be detected. It achieves this by utilizing Hall elements, which can measure the magnetic field generated by a current-carrying conductor. The voltage and current data obtained from the Hall elements is then transmitted to the microcontroller for further processing and analysis. The use of Hall elements ensures that the voltage and current measurements are highly accurate, and that the system can effectively monitor and control the flow of electricity.

Requirement	Verification
1.The detection board must accurately measure the voltage at the point to be detected.	2.The detection board must accurately measure the current at the point to be detected.
2.The detection board must accurately measure the current at the point to be detected.	2.Apply a known current to the point to be detected and compare the current measured by the detection board to the actual current applied. The difference between the measured and actual current should be within a specified tolerance.

Status LEDs: The status LEDs are powered by the Microcontroller and serve as indicators of the DC bus voltage status. Specifically, the LEDs will display whether the voltage is stable and falls within the available range. This feature is crucial in ensuring that the system is operating safely and efficiently, as voltage fluctuations can cause damage to the equipment and interrupt operations.

Requirement	Verification
The LEDs must be visible from a distance of at least 3 meters in daylight conditions.	Conduct visual testing under daylight conditions from a distance of 3 meters to ensure that the LEDs are clearly visible. The testing can involve a group of people, where each individual will confirm if the LEDs are visible or not. The test can also involve the use of a light meter to measure the intensity of the LEDs' illumination to ensure it meets the required standards.

Phase-Loop Lock: The Connection part plays a critical role in the microgrid system by enabling seamless switching between island mode and parallel mode, which enhances the system's flexibility and reliability[4]. To facilitate this transformation, we employ a phase-locked loop (PLL) as the conversion device. The PLL matches the frequency and phase of the utility grid within a relatively short time-frame, enabling safe and reliable connection of the microgrid to the grid[5]. This technology offers numerous benefits, including efficient frequency synchronization and robust performance characteristics.

Requirement	Verification
The connection subsystem shall be capable of matching the frequency and phase of the utility grid within 50 milliseconds to enable safe and reliable connection of the microgrid to the grid.	During testing, the connection subsystem will be subjected to various grid conditions, including changes in frequency and phase. The subsystem's performance will be evaluated by measuring the time it takes to match the frequency and phase of the utility grid. If the subsystem can match the frequency and phase within 50 milliseconds, the requirement will be considered met.

2.3.5 Simulink system

The simulation system includes a Matlab-based Simulink simulation of several other subsystems. Initially, we systematically built the Simulink simulation system and evaluated its feasibility by inputting the base input values that satisfy the minimum criteria. Subsequently, we gradually increased the input parameters to examine the maximum power and efficiency achievable by the system. The obtained results guided the modification and construction of the actual circuit. Therefore, the simulation system served as a valuable tool for optimizing the performance of the electrical circuit.

The simulation module is composed of several modules:

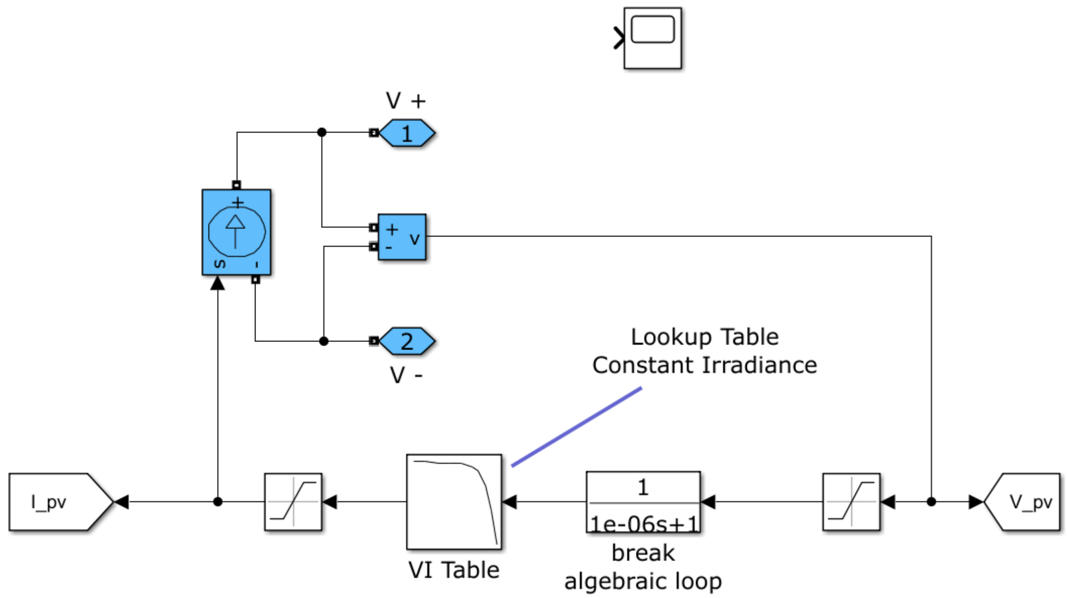

Figure 6: Power Module

Function Modules: The module comprises fundamental microgrid functions, including power supply, energy storage, and load management. It is essential to note that these core functions form the basis of the microgrid's operation.

Figure 6 showcases a power module, which is employed to collect and store solar power data in a VI table. This table facilitates the analysis of various currents associated with different voltages, thereby enabling the determination of the maximum power derived from solar energy.

Connection modules: This module primarily consists of converters and wiring systems that interconnect the distinct functional modules. The integral components of this module comprise the DC-DC converter, DC-AC converter, and busbar. the busbar provides a reliable means of distributing power throughout the module, ensuring that each functional module receives a consistent and adequate power supply. Overall, the efficient and effective operation of this module depends heavily on the proper functioning and integration of these key components.

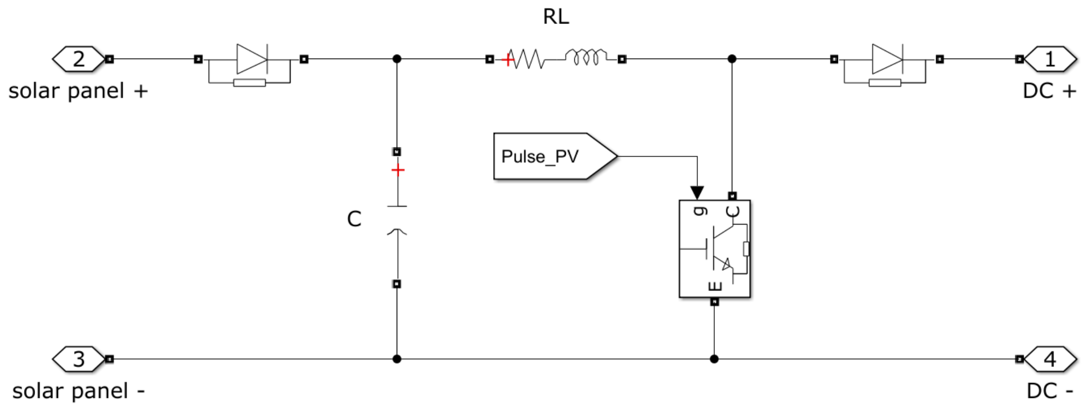

Figure 7: Connection Module

Management module: The presented image showcases a power module, which is employed to collect and store solar power data in a VI table. This table facilitates the analysis of various currents associated with different voltages, thereby enabling the determination of the maximum power derived from solar energy.

Measurement module: This module encompasses the surveillance and observation of various control signals, such as those pertaining to the load module, battery switch, and grid switch. Additionally, it incorporates the monitoring of the power output of individual modules within the entirety of the microgrid, including the solar power module and the grid module. Through this comprehensive monitoring system, the module is able to track and analyze the performance and functionality of key components in the microgrid, allowing for prompt detection and resolution of any issues that may arise.

Requirement	Verification
The simulation should accurately replicate the real-world conditions of the microgrid by verifying the input and output power of the microgrid with precise simulations. Additionally, the power loss of each module and the bus voltage should also be simulated accurately. And The largest error rate between real micro grid and Simulink should be less than 20%.	We will provide identical input parameters and control conditions to both systems, and then observe their outputs. This experiment will be repeated 20 times, with different input parameters used for each iteration, but with the same inputs applied to both the microgrid and the simulation program. We will use an oscilloscope to record the power, voltage, and current parameters of the microgrid's components, and compare this data with the results obtained from the simulation to get the average error rate between microgrid and Simulink.
The simulation should correctly implement the MPPT algorithm to achieve the maximum power output of the entire power module. And the error rate between actual maximum power of power generation and value we get from the Simulink should be less than 5%.	Using an oscilloscope for the power generation module to achieve real-time monitoring, repeat the experiment 20 times, each time to input a new group of 10 solar voltage and current, observe whether it can achieve the maximum power output for each experiment, and compare with the actual maximum power which is calculated by us to get the error rate.

2.4 PCB Board

We have already designed two PCB board. One is a Power board, which is used for power transmission (about 70W). The other is a control board, which is used to transmit the signal and control the whole system.

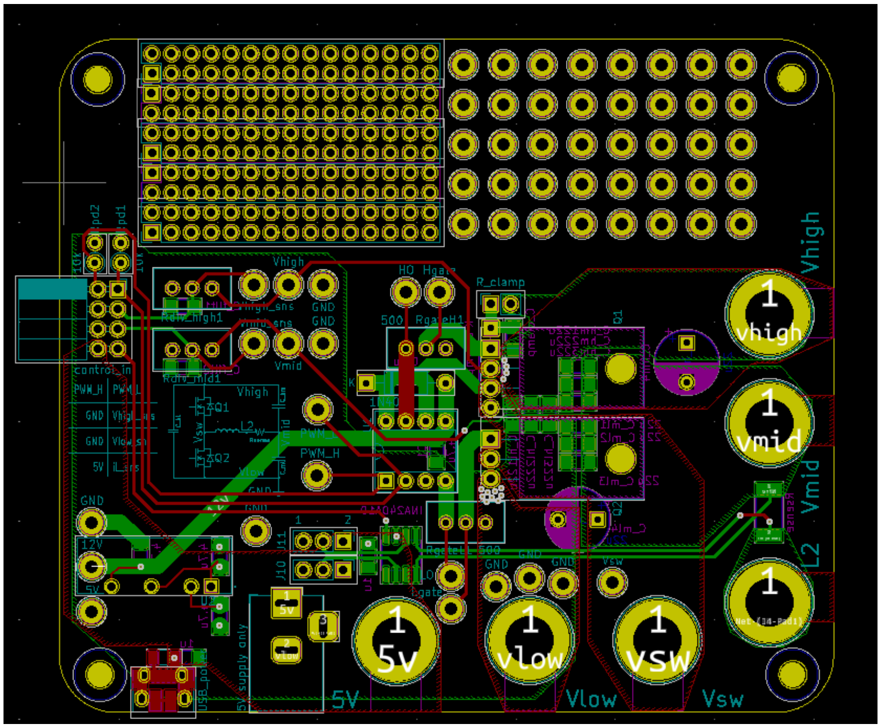

Figure 8: Power Board

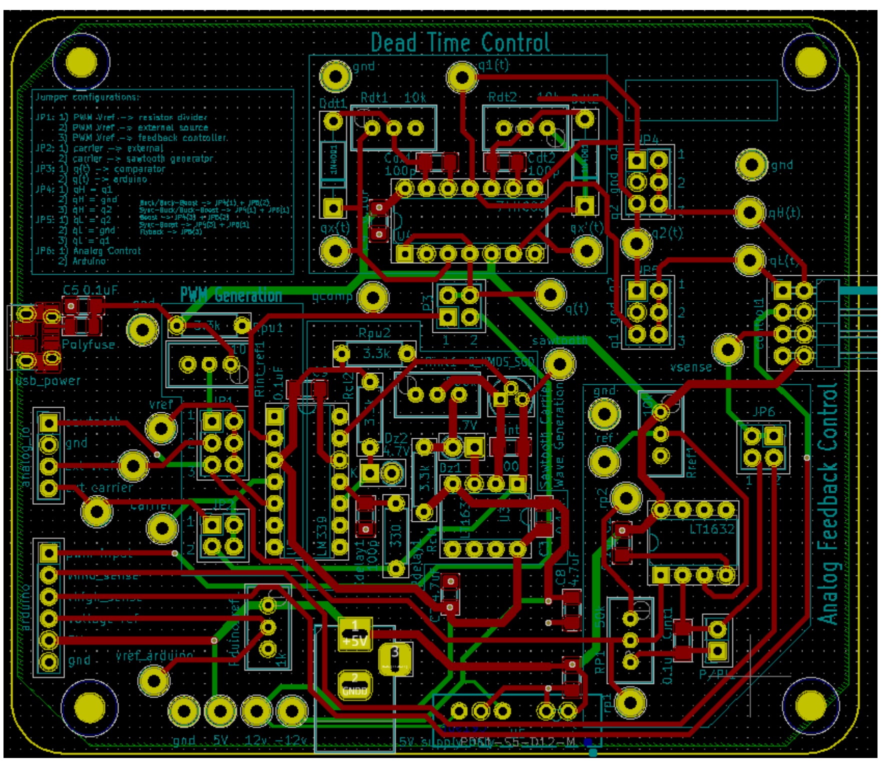

Figure 9: Control Board

2.5 Tolerance Analysis

1. To mitigate the effects of damage to our circuit components during testing and operation, we have taken steps to prevent any resulting functional failures. Specifically, we have replaced the SMD capacitors and SMD transistors with plug-in components. Although this change has resulted in a slight reduction in the overall stability of the PCB board, we believe that the final result is still within acceptable tolerances.
2. The microgrid generates inherent delays between each component, while the voltage source and energy storage systems also produce potential delays. These factors together contribute to a significant overall delay. However, a certain level of delay is tolerable, as the entire system would be connected to the electrical grid. Therefore, as long as the delay does not affect the system's ability to perform its primary function, it is not of great importance.
3. In order to connect the microgrid in parallel with the unity grid, it is crucial to have proper control over the microgrid's voltage. While the Phase-locked loop and the accompanying variable voltage control cannot precisely regulate the bus voltage to 220V, they can maintain a voltage range of 219-223V, which does not impact the overall results. This fluctuation is tolerable within the larger voltage range and does not affect the microgrid's operation.

One of the major challenges we encountered during our project was conducting a thorough capacity analysis of the battery, also referred to as the energy storage module. This was particularly crucial because we needed to ensure that the bus voltage remained stable using DSP. To achieve this, we had to continually discharge and charge the battery in order to stabilize the output voltage of the entire system.

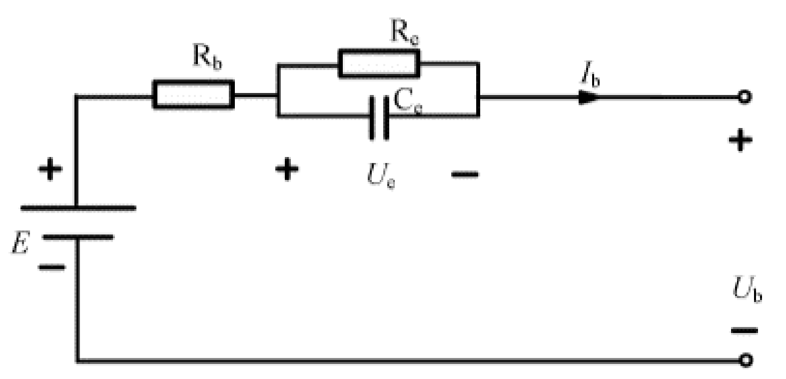

Figure 10: Battery Sketch

We intend to use the Thevenin model from the electrical model to describe the battery. The internal resistance and port voltage of a battery change during operation with its own battery capacity and the external ambient temperature. The remaining capacity of the battery is often expressed in terms of the State of Charge (SOC), which can be expressed in terms of the remaining battery capacity and the battery capacitance.

$$\mathrm{SOC} = \frac{Q_{\mathrm{r}}}{C} \tag{1}$$

$$\mathrm{SOC}_{(\mathrm{t})} = \mathrm{SOC}_{(\mathrm{t}-\mathrm{t}_0)} + \frac{\int_{\mathrm{t}_0}^{\mathrm{t}} I \mathrm{dt}}{C} \tag{2}$$

Where, Q_r is the remaining capacity of the battery and C is the energy storage capacity. Thus, The real-time SOC of the battery can be roughly calculated by charging and discharging current. I is the battery charging current. When the battery is discharged, I would be a negative value. In this way, we could implement the capacity analysis of the battery and then use DSP to control the charge and discharge of it so that our bus-bar could maintains stable voltage.

3 Cost and Schedule

3.1 Cost Analysis

Our fixed development costs are estimated to be 40¥/hour, 10 hours/week, in total 8 weeks for four people.

Member	CHY/Hrs	Hrs/Week	Weeks	Multiplier	Total(CNY)
Ao Dong	40	18	8	2.5	14400
Kaijie Xu	40	18	8	2.5	14400
Bohao Zhang	40	18	8	2.5	14400
Yuqiu Zhang	40	18	8	2.5	14400

Table 1: Labor Cost

Below is an estimate of our purchasing cost:

Description	Quantity	Manufacturer	Vendor	Cost/unit(CNY)	Total cost (CNY)
Storage battery	1	Chenke	Taobao	69.8	69.8
Fan	3	Qinyang	Taobao	6	18
LED bulb	3	Bull	Taobao	6.5	19.5
XDS200 emulator	1	Yanxu	Taobao	580	580
DSP28377	2	Yanxu	Taobao	800	1600

Table 2: Purchasing Cost

For the quoted machine shop labor hours, the cost will be:

$$100/\text{hour} \cdot 10\text{hours/week} \cdot 5\text{weeks} = 5,000(CNY) \tag{3}$$

Above all, the total cost of our project is:

$$14400 \cdot 4 + 69.8 + 18 + 19.5 + 580 + 1600 + 5000 = 64887.3(CNY) \tag{4}$$

3.2 Schedule

Week	Ao Dong	Kaijie Xu	Bohao Zhang	Yuqiu Zhang
3/13/23 - 3/19/23	Research and select appropriate energy storage components	Research and select appropriate microgrid control algorithms	Research and select appropriate power generation components	Research and select appropriate voltage regulation components
3/20/23 - 3/26/23	Design and model energy storage components in Simulink	Design and model microgrid control algorithms in Simulink	Design and model power generation components in Simulink	Design and model voltage regulation components in Simulink
3/27/23 - 4/2/23	Implement energy storage components in the hardware	Implement microgrid control algorithms in the hardware	Implement power generation components in the hardware	Implement voltage regulation components in the hardware
4/3/23 - 4/9/23	Test and debug energy storage components	Test and debug microgrid control algorithms	Test and debug power generation components	Test and debug voltage regulation components
4/10/23 - 4/16/23	Integrate energy storage components with microgrid control system	Integrate microgrid control system with power generation components	Integrate power generation components with voltage regulation system	Design and model connection subsystem in Simulink
4/17/23 - 4/23/23	Conduct system-level testing and optimization	Conduct system-level testing and optimization	Conduct system-level testing and optimization	Implement connection subsystem in the hardware
4/24/23 - 4/30/23	Finalize documentation and prepare for the Demo	Finalize documentation and prepare for the Demo	Finalize documentation and prepare for the Demo	Finalize documentation and prepare for the Demo
5/1/23 - 5/7/23	Practice Demo	Practice Demo	Practice Demo	Practice Demo

Table 3: Schedule

4 Ethics and Safety

We are unwavering in our commitment to upholding the IEEE Code of Ethics and ensuring the safety of individuals using our microgrids.

4.1 Ethics

As a team, we are dedicated to following the IEEE Code of Ethics 1, which emphasizes the paramount importance of ensuring the safety, health, and welfare of the public[6]. In accordance with this, our approach to designing microgrids involves a comprehensive consideration of the potential impacts on public safety and health, as well as a commitment to maximizing the contribution of microgrids to public welfare. We believe that ethical design and sustainable development practices are crucial to the long-term success and viability of microgrid technology, and we strive to embody these principles in all aspects of our work. With a focus on safety, health, and sustainability, we are confident that our microgrid solutions will benefit communities and society as a whole.

Our project aligns with the IEEE Code of Ethics 5, which calls for the honest evaluation and constructive criticism of technical work and the acknowledgement and correction of errors[6]. We recognize that in conducting a microgrid project, mistakes are bound to happen. However, we believe that true progress can only be achieved through the willingness to address and rectify these mistakes. As such, we are committed to being transparent and accountable in our work, and we value constructive feedback that can help us improve our project at every step. By prioritizing the pursuit of knowledge and continuous improvement, we are confident in our ability to create effective and sustainable microgrid solutions that meet the needs of communities and contribute to the greater good.

At the core of our values is the IEEE Code of Ethics 7, which emphasizes the importance of treating all individuals with fairness and respect[6]. In a world where discrimination is a growing concern, we believe that it is essential for each of us to examine our own biases and stereotypes, and to prioritize treating others with dignity and respect. We strive to create an inclusive and welcoming environment where all team members and stakeholders feel valued and heard, regardless of their race, ethnicity, gender identity, sexual orientation, or any other characteristic.

4.2 Safety

Ensuring safety in the production process is of utmost importance to our team. As such, we have implemented several measures to maintain a safe environment in the laboratory. To begin with, we always ensure that there are at least two people present during production and processing. Moreover, we have made it mandatory for all students participating in experiments to complete the online safety training program of the laboratory and obtain certificates as proof of their competence in safety protocols.

Safety in production and use is of paramount importance to our team when dealing with materials that have the potential to cause harm to humans. Therefore, we have implemented strict safety protocols to mitigate any risks associated with the handling and processing of these materials. Our team ensures that all necessary safety equipment and protective gear is used during the production process and that all precautions are taken to avoid any accidents or injuries. The busbar voltage is designed to be 24 V, which is below the human safety voltage of 36 V and is rated at 3A. Also the voltage on the PCB is designed to be below 36 V. By prioritising safety, we can ensure that our team members and those around us are protected from potential harm.

When it comes to mechanical structure safety, our team takes every precaution to ensure the safety of our products. One of our primary measures is to carefully choose the safest shell shape and mechanical structure for each product. By doing so, we can reduce the risk of accidents or malfunctions. Our team adheres to industry best practices and standards when selecting the shell shape and mechanical structure to ensure that our products are not only effective but also safe to use.

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