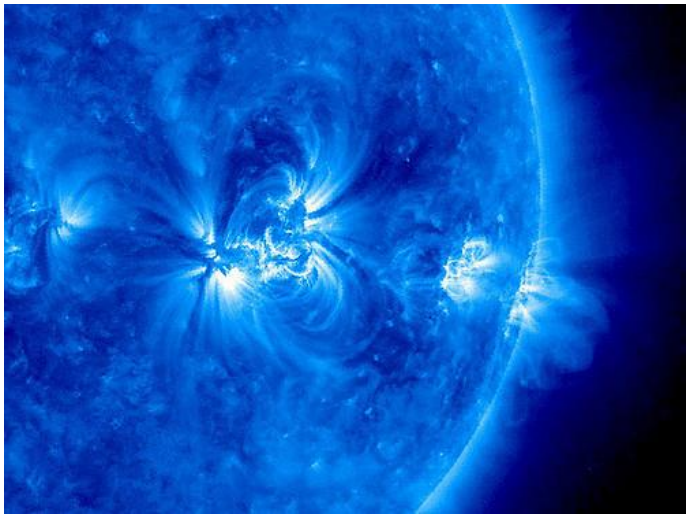
Highly Integrated Grid-Tied Power Module for PV and Storage (iPV++)



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Divide and Conquer

Sponsored by:
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1.0 Executive Summary

According to SEIA, “Solar energy is the cleanest and most abundant renewable energy source available, and the U.S. has some of the richest solar resources in the world”. As we know, the sun is an unlimited energy resource, and there are various ways to harvest this energy. Methods of harvesting consist of using photovoltaic cells, solar thermal collectors, solar concentration centers with mirrors and passive solar designs.

Starting with photovoltaic cells, they are able to convert solar rays into energy. “When sunlight hits a cell, the energy knocks electrons free of their atoms, allowing them to flow through the material. The resulting DC (direct current) electricity is then sent to a power inverter for conversion to AC (alternating current), which is the form in which electric power is delivered to homes and businesses”.

Our senior design project takes the average solar panel system and converts it into a single package, a modern photovoltaic system. A photovoltaic panel, battery, and inverter all three combined into one product that is intertwined within the power grid. “The main goal of this proposed effort is to investigate, design and develop an advanced integrated and cost-effective technology consisting of PV, smart inverter, and battery management”.

IPV++ is a multidisciplinary project, including mechanical and electrical engineers. This report will focus on the electrical design of power electronics and battery integration. Starting with the design of the dual-input isolated DC/DC converter, we will create an efficient 1.2 KW dual input converter. Extensive analysis and testing will be needed to reduce the cost and improve reliability . Next, the Bidirectional single-phase inverter will be constructed. This will be designed and tested with the input DC link voltage of 200V. Finally we will design and investigate the battery size. Ensuring that the proper battery size is obtained for the power that will be supplied from the PV panel. This battery design and inverter will also need to be implemented within the thermal packaging to ensure minimum energy losses. Collaboration with the mechanical engineers will be required in order to complete this task and provide adequate airflow to cool the system.

2.0 Project Specifications

2.1 Motivation

Our group, group 17, is composed of members who are very passionate about the power industry in general. Throughout our education at the University of Central Florida, we have carefully chosen classes which would make us much more attractive to potential employers within the

power industry. Although our passion for this began beforehand, through our individual research into the power industry, we became further enamored by taking the fundamentals of power systems course offered within our coursework. This class enlightened us on the multiple disciplines that we as newly graduated students could find employment within the power industry, the collective issues that exist within it, and the troubleshooting techniques and software that are popular within the industry.

This project, specifically, allows us to work with professionals who are deeply embedded within the power industry and have contributed ample amounts of progress to it. Through it, although we are sure it will be an arduous experience throughout our two semesters of senior design, we hope to gain valuable knowledge that will undoubtedly help us join the industry with experience that will help us stand out from our peers. We also hope that our final design will be robust and substantial enough to grant us a spot in some of the top projects at the end of our journey -- which will in turn cause more visiting industry professionals and faculty to be aware of the beauty within the power industry. Further, during the span of this project, tariffs were placed on the export of solar panels. We hope that projects like ours will help contribute to the overall opinion of clean energy within the country so that more industry professionals, politicians, and civilians alike will make the push for a more clean energy approach to energy distribution.

2.2 Design requirements

In this section, we will discuss the requirements set upon our group by our sponsor for our final design. Our group will base all our research and design procedures towards the following list so that our final design meets the full capabilities that our sponsor had in mind when he proposed the project.

- The solar panels will provide the main source of energy to the batteries and if full, provided to the grid.
- The integrated microcontroller will keep power flow steady using energy from the batteries if any disturbances occur when the solar panel is interrupted by clouds, residue, etc.
- Low current generated by the solar panel will be stepped up via the DC/DC converter to aid in faster charging of the batteries.
- The bidirectional single-phase inverter will allow the solar panels or batteries to power the grid with AC power or allow the grid to charge the battery when the demand is low and sun coverage is poor.

2.3 Goals and Objectives

The main goals for this project are to design and build an interesting and unique inclusion to the power industry. The design should be aesthetically pleasing and meet the design requirements proposed by our sponsor. The project will be technologically complex and shall be integrated in a timely manner, so as to meet our design schedule by the end our two semesters of senior

design. As such, both the technical and non-technical parts of the project shall be integrated closely to reinforce synergy and the ability to easily troubleshoot individual components and the overall system requirements.

2.4 House of Quality

The house of quality is a systematic graphical representation of product design information organized as a matrix, which provides an illustrative summary of useful product information. The following table represents the house of quality that our group devised for this project:

Legend:
↑Positive Correlation
↓Negative Correlation
↑↑Strong Positive Correlation
↓↓Strong Negative Correlation
(+) Positive Polarity
(-) Negative Polarity

Table 2.4-1 House of Quality

		(+)	(-)	(+)	(-)	(+)
	Interactivity (+)					
	Functionality (+)					
	Style (+)					
	Ease of Use (+)					
	Power Efficiency (+)					
	Energy Storage (+)					
	Cost (+)					

As shown, these parameters are qualitative and focus on the elements of the project which provide the largest influence in determining the marketability of the product. Our groups feels that the device should be very interactive, have ease of use and integration, feel intuitive, and be well documented from a non-technical standpoint.

The engineering parameters within this table provide information on the structural integrity of the product, and should follow the dimensions set by the design parameters and requirements proposed by our sponsor. Ideally, our device would have a low amount of heat dissipation and would store adequate amounts of energy.

3.0 Design constraints and standards

As in every engineering design, there are multiple limitations that must be examined, which will be referred to as constraints in this section. They will include financial, technological, legal, and deadline based constraints that must be discussed and handled appropriately.

4.0 Research and Background Information

This section will examine the research and various specifications that are achieved through thorough and ample comparison of available hardware components and software protocols.

Figure 1. Hardware Block Diagram

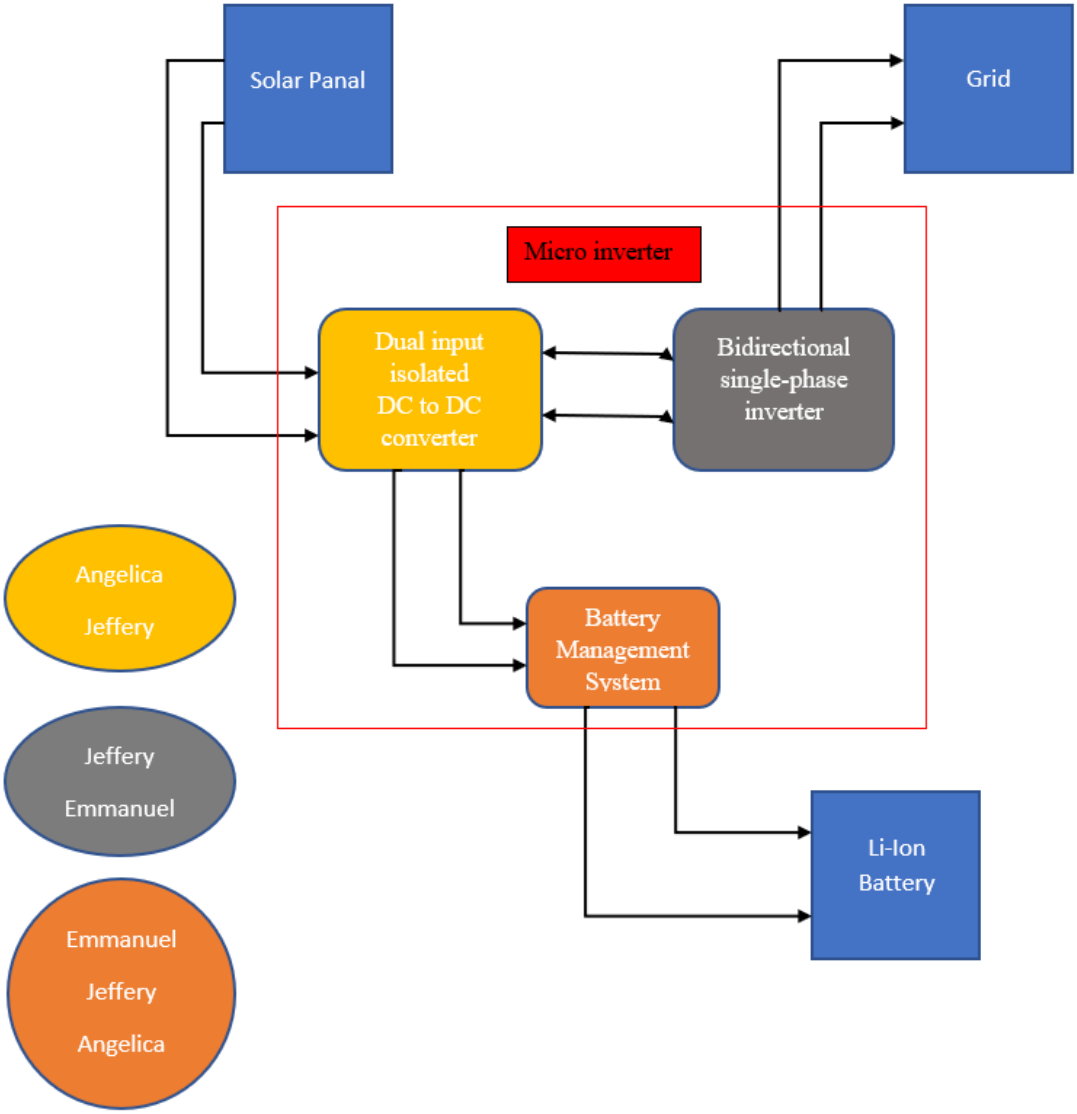
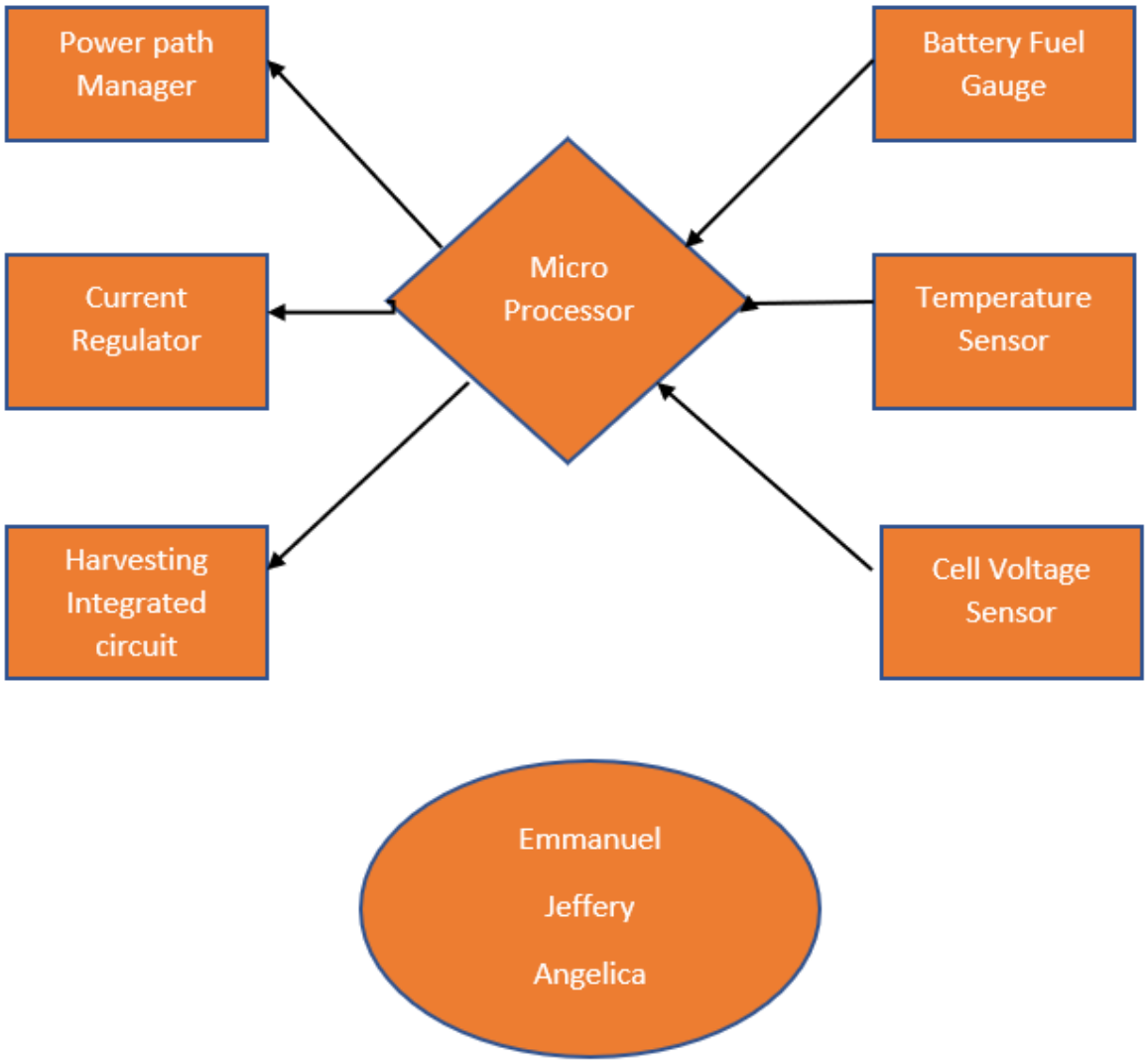


Figure 2. Software Block Diagram



5.0 Administrative Content

As with every engineering effort, careful consideration and planning of administrative content should be well documented. In this section, our group will discuss any the allocation of tasks that will be distributed evenly through our group through the span of this project. Each group member will maintain full administrative responsibility of this section throughout the execution of this project. This section contains high level overviews

of the financial contribution of individual group members. Further, project milestones and timelines for the project and the distribution of labor between team members.

Table 1. Budget and Financing

Item	Quantity	Price	Total Cost
Solar Panel	1	$195	$195
DC-DC Converter	1	$20	$20
Microcontroller	1	$30	$30
Lithium-ion Batteries	Unknown	$50	$50
Inverter	1	$20	$20
Total Cost			$315

Table 2. Spring 2018 Project Milestones

Task	Start	End	Status
Project Topic Selection	01/15/2018	01/18/2018	Completed

Divide and Conquer	01/22/2018	01/28/2018	In Progress
Hardware Research	01/28/2018	02/3/2018	Not Started
Rough Draft of Report	01/28/2018	04/2018	Not Started
Selection of needed Components	01/28/2018	02/28/2018	Not Started
Software Research	01/28/2018	04/2018	Not Started
Meeting with Mechanical Engineers	TBA	TBA	Not Started
Final Draft of Report	01/28/2018	05/2018	Not Started

Table 3. Summer 2018 Project Milestones

Task	Start	End	Status
Assembling the prototype	TBA	/2018	Not Started
Develop software for microcontroller	05/2018	/2018	Not Started
Troubleshooting	05/2018	/2018	Not Started
Design and buy PCB	05/2018	/2018	Not Started
Test and fine tune the PCB	05/2018	/2018	Not Started
Finalize Device with Mech. Engineers	06/2018	04/2018	Not Started
Presentation Preparation	07/2018	04/2018	Not Started
Presentation	07/2018	08/2018	Not Started

Works Cited

"About Solar Energy." *SEIA*, www.seia.org/initiatives/about-solar-energy.

"IPV++ Senior Design Document"

"What Are the Different Methods of Solar Power Generation? - Alternative Energy - ProCon.Org." *Can alternative energy effectively replace fossil fuels?*, alternativeenergy.procon.org/view.answers.php?questionID=001272.