

ECE480 Team 8

Maximum Power Point Tracker

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Design Issues

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Introduction

A maximum power point tracking (MPPT) system can be sold for industrial, governmental, and consumerist use. Military establishments often require solar panels to power their equipment when there is no electrical grid to connect to. Electric companies may install large solar farms to provide and sell power to regional homes. Businesses and homeowners can install solar panels to power their homes as well as sell their unused electricity back to the grid. All of these applications benefit from a MPPT to increase panel efficiency and subsequently power output. This means that governmental and public safety standards and regulations must be recognized and met to sell to each audience. Product Lifecycle Management, Standards and Safety, and Universal Design Principles will be discussed to address the real world design issues a MPPT system introduces to the marketplace.

Product Lifecycle Management

Product lifecycle management (PLM) is an “information and enterprise strategy”(1) to “manage and maintain product definition and business processes(2).” A MPPT system can benefit from product lifecycle management because of its technical complexity and configurability, materials used, and the inherent aspiration of “green” power intentions. Four phases, conceive, design, realize and service, of PLM is discussed alongside ideas to improve a theoretical MPPT product.

Conceive

The first phase of a PLM is to conceive the product. Due to the technical nature of the product, a “one size fits all” approach is not possible. Each design must adhere to its customer’s standards. A MPPT is designed with a certain input voltage and current, and an output voltage and current in mind. Military applications may require less efficiency, but more reliability and environment considerations. An energy company may

require higher voltages and currents due to the large solar arrays used. A homeowner may require less efficiency and lower voltages, but insist on costs savings. The team's MPPT system requires efficiency the most, along with minimal weight and size considerations, and a mid range power tolerance.

To encourage PLM, a program could be designed to input design restrictions, and various iterations could be performed to provide engineers in the design of the system. A few components could also be designed such that future adjustments be made by either the company selling the MPPT or engineer of the consumer company. An example of such is allowing capacitors and inductors to be swapped. By implementing this design approach, the rate at which the devices could be made as well as alleviating the engineering cost of customized MPPTs.

Design

A MPPT is a well-researched topic and design tools are available to reduce prototyping costs. While there are formulas to calculate the values of ideal components, it is usually necessary to deviate from the ideal models to help improve efficiency since no components used are truly ideal. It helps to sweep component values to find the best fit for a MPPT design instead of limiting the design to the characteristics of a single component.

To provide an example of what is meant, the team used numerous software programs to design the solar car MPPT. Labview was used to create formulas for calculating component values, and by sliding a component value or design characteristic, the effect on the entire system could be seen. This also allows values to be input when they are only available in standard values, such as capacitors. Inductor values required for the circuit are determined by changing the capacitor values in increments of its standard values because an inductor can easily be made in the lab. PSpice was another program used to see the time and frequency response of the

circuit. With more time, non-ideal component values can be modeled to portray a true system response.

Realize

As discussed in the conceive section, building component swappable items would allow for the ability to produce a limited number of designs for each consumer need, be that military, business, or consumer. This allows the manufacture of assembly boards and quality tests to be reduced.

A Restrictions of Hazardous Substances (RoHS) approach to component manufacture could benefit a MPPT product by allowing it to be sold in more countries and increase the “green initiative” solar power industry promotes (4). This means that hazardous substances, such as lead or mercury, not be used or limited to a designated concentration in any of the components used in a MPPT product.

Service

A MPPT system requires support to maintain safety and reliability when installing due to its potential dangerous nature. A product should come with a thorough manual and datasheet as a reference for consumers. On the product, it is suggested to label the product with a “High voltage” label to prevent accidents.

It is also recommended that the product provide a service number to call in case the manual gets lost alongside an identification number by which to refer it in case of questions or concerns. E-Waste, or electronic waste, telephone numbers should be given to aid consumers the correct technique an place to dispose of the product.

Standards/Safety

High Voltage & Current Protection

The voltage and current that an MPPT operate under depends on the application of the end user. The following table shows different category of voltage according to the International Electrotechnical Commission.

IEC Voltage Range	AC	DC	Defining Risk
High Voltage	>1000 RMS	>1500V	Electrical arcing
Low Voltage	50-1000 RMS	120-1500V	Electrical shock
Extra-low Voltage	<50 RMS	<120V	low risk

Safety of the MPPT needs to be addressed carefully on customize application since it can be used for both industrial and personal purpose. For this reason, the MPPT main circuitry needs to be enclosed to reduce the magnitude of risks and possible incidents. In addition to design for safety, the consideration of proper safety equipment is also important. Insulated rubber gloves and mats protect the user from electric shock. Therefore, proper recommendation and suggestion to the end user of using proper protective equipment should be part of the design process.

Safety labels

Proper safety labels need to be obvious and easy to recognize. ISO warning labels are developed for certain aspect of potential hazards. As an engineer of the MPPT, it is one's obligation to make sure proper warning labels and signs are visible on the product itself. For the case of an MPPT, the enclosing box must have safety labels that reminds user about different types of hazard. For instance, the following ISO labels will be required for MPPT that is charging a battery circuitry. Such labels not only helps

end user recognize the potential hazards but can also guide the user for proper maintenance or service if such action is needed.

	
Battery Charging	High Voltage Hazard
	
Electrical Shock Hazard	General Warning

Universal Design Principles

Universal Design Principles usually include seven guidelines for a design (7). The first is equitable use, which is design for people with diverse abilities to use the product. A MPPT design is limited in its ability to take into account this principle, but such a system could be made. For example, a beeper could be used to alert users when the controller is being powered for blind users. The second principle is flexibility in use. This recommends designs be able to fit a range of people's preferences and abilities. The wording on the MPPT box can be large enough for it to be easy to read.

The third principle is for it to be simple and intuitive. Simple wording in the manual should be used. It is also important to make sure that the design is easy to understand, regardless of the user's experience, knowledge, language skills or current concentration level. Some of the guidelines to implement this principle are to eliminate

unnecessary complexity; consistent with expectation and intuition; and to provide effective prompting and feedback during and after task completion. An LED will help to achieve the above requirement to enhance the universality of the MPPT. Variation such as light color, blinking frequency, intensity can all be used to make the product more intuitive. For instance, a green light can show that a task is done; a yellow light means task in progress; a red light indicates error and warning; a blinking light can be used to tell if the MPPT requires service.

The fourth principle requires a design to provide perceptible information. Easily discernible symbols should be used to tell users which part of the MPPT should be connected to. For example, a picture of a solar array should be by the connection where the solar array should be connected to. Another example is using a LCD display to provide information about the system such as the input voltage and current and output voltage and current alongside what frequency the system is running at and the instantaneous duty cycle. The fifth principle requires tolerance for error. An example in a MPPT system is require standard connections which do not allow plug polarities be reversed as well as system design protections such as a diode which only lets current flow in a certain direction.

The sixth principle requires low physical effort. The design should strive to be as low weight as possible while still adhering to design constraints. The seventh principle says that appropriate size and space be provided for users. The system will usually be put in a box and the PCB design should allow for adequate room for testing individual components.

Conclusion

Bringing a product to market does not only rely on technical design. Other important aspects also need to be taken into consideration in the prototype and refining process. Product lifecycle, standard/safety, and universality of products are all important areas that need to be carefully considered. A well planned product lifecycle management will enhance the production efficiency that can balance the market demand. Standards like protective design for high power application are also important because the safety of the end user will determine if such product will continue being sold on the market. In addition to economical purpose, it is the engineer's obligation to follow standards and safety requirements for ethical consideration. Although products are designed for a specific purpose, it is always helpful to improve the product by considering the universal design principle. This practice will enhance the usability of the product. Design is not a straight line from sketch to market, but a continuous refining process that constantly improve upon changes.

Bibliography

1. "What Is PLM Software?" *Http://www.plm.automation.siemens.com*. Siemens, n.d. Web. 20 Nov. 2014. <http://www.plm.automation.siemens.com/en_us/plm/>.
2. "All About PLM." *Cimdata*. N.p., n.d. Web. 20 Nov. 2014. <<http://www.cimdata.com/en/resources/about-plm>>.
3. "High Voltage." *Wikipedia*. Wikimedia Foundation, 14 Nov. 2014. Web. 20 Nov. 2014. <http://en.wikipedia.org/wiki/High_voltage>.
4. "National Measurement Office Enforcement Authority." N.p., n.d. Web. 20 Nov. 2014. <<https://www.gov.uk/government/collections/national-measurement-office-enforcement-authority>>.
5. "Standards Catalogue 29: Electrical Engineering." *ISO*. N.p., n.d. Web. 20 Nov. 2014. <http://www.iso.org/iso/iso_catalogue/catalogue_ics/catalogue_ics_browse.htm?ICS1=29>.
6. "The 7 Principles." - *Centre for Excellence in Universal Design*. N.p., n.d. Web. 20 Nov. 2014. <<http://universaldesign.ie/What-is-Universal-Design/The-7-Principles/#p3>>.
7. "Universal Design: Process, Principles, and Applications." *Universal Design: Process, Principles, and Applications*. N.p., n.d. Web. 20 Nov. 2014. <<http://www.washington.edu/doit/Brochures/Programs/ud.html>>.