

Design Issues

Compact DC-AC Power Inverter / Design Team 7

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Introduction

The project goal for design team 7 was to design a compact, high power DC-AC inverter inspired by the Little Box Challenge, a contest jointly hosted by Google and IEEE. Desired specifications include a 1 kilo-watt power rating, an enclosure size of 40 cubic inches or less, a 60 hertz output of 120 volts rms, FCC part 15 B compliance, and a maximum enclosure surface temperature of 60 degrees centigrade.

In addition to these goals, design team 7 has considered 4 other important design issues: project lifecycle management, standards, product safety, and logistics. Each of these issues will be analyzed with respect to the compact power inverter; potential improvements of the inverter with regards to these issues will also be discussed.

Project Lifecycle Management

Project lifecycle management (PLM) is an important aspect of nearly every project, including the compact power inverter. This design issue involves the project at any age - in operation and its future post-operation. Any required maintenance is also included.

The first PLM issue to be considered is how long the inverter can be in operation before replacement. A longer lifecycle is more valuable to the customer, but is also more susceptible to becoming outdated. An example of this would be the fact that solar efficiency is continuously increasing while the price per watt is dropping. A likely outcome of these trends is a need for larger power input and output when parts of the system, specifically solar panels, are upgraded. The next PLM issue concerns how the inverter wears down over time. Since outdoor use is within the realm of possibility, special attention should be paid to how susceptible the product is to heat, cold, moisture, vibration, and dust. The final PLM consideration is the wearing out of parts for various reasons. These include wear-and-tear caused by handling the product, the aging of capacitors, and mounting hardware breaking during potential relocation.

To combat these issues, a number of improvements can be made. The first involves the enclosure: adding sealant to the joints of the unit will make a large difference in protecting the device from moisture and dust; maintaining proper heat dissipation is important. The use of a sealed aluminum enclosure goes a long way towards protecting circuit elements and wiring from corrosion, but outside connections made of iron will still be susceptible to iron-oxide, or rust. Silver plating over exposed connections would protect against this, albeit at a cost increase. Alternatively, plastic connectors that protect the conducting wire could be used. Another improvement to the PLM is an easily replaceable DC-DC converter component; this ensures that minor differences in solar capacity/efficiency would not require full replacement of the inverter; since the inverters power transistors are not yet being used to full capacity, this single upgrade would help to “future proof” the inverter. The final PLM improvement is the use

of recyclable materials. Aluminum enclosure and heat sinks are easily meet this requirement, but disposing electronic components is a different story. Using RoHS-certified parts would help to prevent hazardous waste from entering the environment. Recycling programs could also be implemented to responsibly dispose of and reuse parts.

Standards

Following standards at all levels will help to assure that the power inverter will be able to interface with other products and adhere to regulations. Standards may vary at the municipal, state, and federal level and between industries. Designing for a specific market segments with different standards may be necessary to assure success.

An important standard developer is the National Electrical Manufacturers Association (NEMA) which has set power plug standards for most of North and parts of South America. If the inverter is to be in an application setting that requires an output for a 120 volt device to be directly connected in this location it would be necessary to follow NEMA plug standards to assure users would be able to connect their devices. There are many other plug standards globally that would need to be adhered to if market share were in the global marketplace.

Other standardization would occur in the manufacturing, supply, and device support stages of the product for a streamlined process. As the current device is in a prototype stage, standards will help to assure a uniform, long-lasting, and safe mass produced product.

Product Safety

Safety is a crucial concern for all manufacturers, especially if the project is going to be possibly utilized by an uninformed consumer. The heading product safety includes both how a product affects its customers and how it affects other products connected to it.

The compact power inverter has a few safety concerns to keep in mind. The first being the fact that the power inverter will have high power input and output. With approximately 1 kVA of power running through the project, safety of the customer is paramount during the design of this device. Because the compact power inverter may be used in the residential market, anyone whom has the necessary infrastructure and money can purchase a unit. Because of this wide market base the device needs to be designed with simplicity of use in mind so that any user can connect the device in the most straightforward way possible. Along with these concerns the device must also be designed to handle the possibility of short circuiting the output leads.

A few improvements could be made to address the possible concerns brought forth in the paragraph above. In order to prevent harm to the customer an isolation transformer would be implemented in future designs. This isolation transformer would reduce the chance of shock to the customer. An isolation transformer protects the user by isolating the output terminals of the inverter from the main circuit. Thus if the output lead was touched, there wouldn't be a return path to ground. This would not eliminate the possibility of a user being shocked, but it can protect against many different use cases. Another improvement that could be made would be introducing fuses into the circuit. This would reduce the chance of damaging the attached load if it started to draw more current than what it could handle. The compact power inverter would utilized for a variety of different load specifications so a load sensing circuit would be another improvement that would be beneficial if introduced into the circuit design. This circuit would immediately sense if a new load was attached and adjust the switching power supply accordingly to properly account for this new load. This would in turn allow the

power output to be constant without any serious ill effects of power supply ringing and keep any serious voltage spikes from appearing in the circuit. Short circuiting is another problem customers could face if the output leads touched. This would result in the power inverter burning itself up. A fuse would help this but it is not an efficient solution. A better solution to this problem would be to introduce a protection circuit similar to those used in standard lab power supplies. These work by using a current sensor to open a circuit breaker. This would protect the customer from burning up the circuit and also protect the attached device from receiving a massive spike in current.

Logistics

As the team's business model is to license the intellectual property for the team's power inverter design, manufacturers will be producing in large quantities. The goal of any manufacturing process is produce product in the most efficient way possible. While safety, available capital, and labor all improve manufacturing efficiency, logistics is a critical area that manufacturers should not overlook. There are three main areas that should be taken into consideration: procurement, production, and distribution.

The final design of the product will have numerous supply inputs such as analog components, microcontrollers, enclosures, and connectors. It is likely not feasible to get these all from one supplier at the best possible cost in a timely manner. Negotiating the delivery of these supplies for production will ensure a cheaper final product cost and to produce quantities to specification. At the manufacturing plant, warehousing would need to be altered for the new inputs to the manufacturing process. Altering the existing warehouse control system will allow the manufacturer to collect data on the efficiency of product delivery, effectively talk with operators on the plant floor, and help govern daily operations at the plant.

In the production of the power inverters, ensuring each workstation has the right input at the right time will reduce inefficiencies in the manufacturing process. Existing

manufactures may need to alter their existing facilities to accommodate production of these power inverters. Capital such as automated conveyors, robots, and additional employees may be needed to produce a finished product.

Once the power inverter has been produced and packaged, the product will need to be transported to its final destination. Assuming that most of these power inverters will be used for commercial solar array installations around the country, the manufacturer should ship the inverters to regional distribution centers. Given the expected volume and low weight of the product, it would be wise for the manufacturer to contract a third party logistics firm to handle the shipping of product from the manufacturing plant to the regional distribution center. When a customer installs a solar array, the power inverter will be available regionally and can be delivered in a timely manner by a third party logistics firm, like FedEx Freight.

By implementing logistical improvements at the manufacturing site to handle the construction of a new product, the manufacturer can help efficiently deliver low cost, high quality products across the globe.