I. Abstract

Google recently announced the Little Box Challenge which is an engineering design competition to shrink the size of inverter. An inverter is the equipment used to enable us to get electricity from the renewable energy of the Sun through solar panels. In response to this challenge, a team of students with a faculty advisor and a researcher was formed and has officially registered for the competition. This proposal therefore aims to obtain the required funding to construct the Cal Poly's inverter. To win the competition, the team will bring in new and innovative methods which include the use of modern semiconductor devices, unique circuit topology, more effective energy filtering system, and advanced circuit layout design. Based on our initial computer simulations, our proposed design has demonstrated the promise of reducing the inverter size, and hence we strongly believe that we will have a good chance of winning the competition. We feel that the proposed project is important since upon its successful completion, the Cal Poly inverter will promote the use of renewable energy thus providing contribution in the global effort to create a more sustainable world. In addition, the proposed project will further exhibit Cal Poly's commitment to sustainability. Lastly, should the proposed inverter get selected as a finalist or a winner, Cal Poly's world-wide recognition and reputation will be enhanced.

II. Introduction

As the 21st century progresses, fossil fuel consumption continues to plague our society. More than ever, researchers are looking towards renewable energy sources to provide power to homes and businesses. Inverters play a key role in allowing renewable energy sources to convert power from renewable energy sources to household power, in order to drive home appliances. Currently the sizes of these inverters are quite bulky; thus, the need to reduce their size for easier adoption and implementation. Reducing the size of inverters will also allow home appliances to operate on

renewable energy from a compact system. Furthermore, the reduction in inverter size will pave the way for portable inverters that in turn will open up a plethora of ideas for tapping into renewable energy anywhere and anytime, and thus revolutionizing the power industry while stimulating a sustainable future. This is the main reason behind Google's Little Box Challenge where the reduction of a 2 kW inverter is targeted from a cooler size down to a laptop size. While realizing the technical challenges for designing such an inverter, we believe that our approaches will be able to address most if not all the issues in shrinking the size of our inverter. We propose to design and build a prototype high-density inverter that meets the requirements outlined by the Little Box Challenge. The inverter will incorporate several techniques to address issues associated with noise, energy losses, and minimizing components. To win the challenge, we will start with an inverter topology that minimizes or eliminates the aforementioned concerns. We have already come up with a new topology utilizing a method that will produce minimum amount of heat while practically giving out no output noise. The less-heat-producing topology along with the absence of output noise are the key to reducing inverter size since energy wasted by the inverter will be significantly minimized. Another method that we will implement is the techniques to manage the distribution of heat more effectively by incorporating modern and efficient components and strategically placing them on the circuit board. This way the inverter won't be needing any fan for cooling during its peak operation, thus avoiding additional size and weight of the inverter. To further reduce the inverter size, we will be using smaller components made possible by operating the inverter at very high switching frequency. We will use the latest and greatest semiconductor components to enable the operation of the proposed inverter at the high frequency while giving off minimum heat. Another major improvement that we believe will be the key to a winning inverter is the new method we have for suppressing the input noise of

inverter. The input noise is a major contributor of the large size of commercially available inverters, and so preventing the noise will mean a significantly reduced inverter size. Based on our initial computer simulations, our new methods have shown promising results, and so we are convinced that our inverter will have a good chance of winning the challenge. However, building a prototype of the proposed inverter will require funding, hence this proposal. In addition to the support requested in this proposal, we currently seek supports from companies and so far three companies have made verbal commitments mainly in the form of components. Equally important, however, is that these sponsors will enable us to interact with industry and develop professional relationships. The team involves a researcher from Surya University in Indonesia. This partnering university will enable us to learn engineering team work and concepts on a global scale. This project entails the design process required by any product from concept to completion and in turn supports the "learn by doing" philosophy. This project would allow us to learn important aspects of an engineering project which typically include; team work, problem identification, problem solution, interaction with industry, design process, and budgeting. In addition the project will enforce us to learn the importance of deadlines for project completion.

III. Objectives

1. We will design a 2-killowatt compact high-density inverter (above 50 W/in^3) that should fit into a rectangular enclosure of no more than 40 inches^3 with no dimension smaller than 0.5 inches and no dimension greater than 20 inches.
2. We will design an inverter that is able to connect to solar panel as its source and outputs a voltage that can operate common household appliances.
3. We will design a 2-killowatt inverter that is at least 95% efficient meaning up to 100 watts will be allowed to be dissipated inside the inverter.

4. We will design an inverter that does not use external liquid, or other means of cooling
5. We will design an inverter that we will submit to Google as part of the Little Box Challenge, and thus the inverter will be designed following the technical specifications outlined by Google in their Little Box Challenge website.
6. We will disseminate results of our proposed inverter at engineering conference(s).

IV. Methodology

In building the proposed inverter, we will first conduct more in-depth study and analysis using computer simulations to verify our initial design and initial simulation results, and to select proper components for optimized performance of the inverter. Following this step we will design the layout of components onto a printed circuit board (PCB). Once layout design is done, a Bill of Materials (BOM) will be generated for a complete listing of components used in the proposed inverter along with their part numbers, manufacturers, number required, and unit price. When all the components are acquired we will start the hardware construction of the inverter. The last step involves testing and troubleshooting the hardware prototype. Design improvements and modifications will be iteratively performed as necessary. Once the inverter prototype performs as we desire, we will turn in the inverter to Google as part of the requirement in the competition.

V. Timeline

Timeline	Due Date
Computer simulation and analysis	11/15/2014
Draft design on paper including component selection and BOM	12/01/2014
PCB Layout design and order parts	12/15/2014
Hardware construction	02/01/2015
Test and troubleshoot	03/01/2015

Design and layout improvement if necessary	03/15/2015
Second test and design	04/01/2015
Inverter housing design	05/01/2015
Final test and performance analysis	06/01/2015
Submission of inverter to Google for demonstration	06/17/2015

VI. Final Products and Dissemination

The final product of this project is the compact and efficient inverter to compete in the Google Little Box Challenge. The product will be tested at the National Renewable Energy Laboratory against other competitors to judge the winner. Aside from the competition, the group plans to present their work from this project at an IEEE conference, to showcase the new topology and use of new technology components. One or more patents are planned to be filed for these new developments. All students involved are in the Master's program in the Electrical Engineering department and are planning on writing their Master's thesis based on this project.

VII. Budget Justification

The majority of the costs involved in this project are for materials. The circuit board used for this project will be required to hold components in very high density and dissipate considerable amount of heat. This requires designing more complex circuit boards that are more difficult to manufacture, and thus significantly more expensive. The components to be placed on these circuit boards will be new technologies and able to function in harsh environments, also quite costly. The remaining budget is allocated for travel. Upon completion of this project, the team will travel to the National Renewable Energy Lab in Colorado to test the inverter. The team will also be travelling to an IEEE conference to present results of the work.

PROPOSAL BUDGET

Student Applicants:	Niels Smidth, Alfredo Medina, Vatssalya Karnam
Faculty Advisor:	Taufik
Project Title:	**High Density Inverter**
Travel *subtotal*	**$2500**
Travel: In-state	**$500**
Travel: Out-of-state	**$2000**
Travel: International	**$**
Operating Expenses *subtotal*	**$3000**
Non-computer Supplies & Materials	**$3000 (Board, Components)**
Computer Supplies & Materials	**$**
Software/Software Licenses	**$**
Printing/Duplication	**$**
Postage/Shipping	**$**
Registration	**$**
Membership Dues & Subscriptions	**$**
Multimedia Services	**$**
Advertising	**$**
Journal Publication Costs	**$**
Contractual Services *subtotal*	**$**
Contracted Services	**$**
Equipment Rental/Lease Agreements	**$**
Service/Maintenance Agreements	**$**
TOTAL	**$ 5,500**

California Polytechnic State University
San Luis Obispo, CA 93407

Electrical Engineering Department
(805) 756-2781 Fax (805) 756-1458
http://www.ee.calpoly.edu

October 21, 2014

Dear Baker and Koob Endowments Selection Committee:

I am writing this letter of support on behalf of three graduate students in electrical engineering who have formed a team to participate in the Google's Little Box Challenge.

The Little Box Challenge is a competition recently announced by Google with the goal of shrinking the size of a 2 kW inverter operating from solar panels. To be able to compete, the team will have to overcome technical challenges in building the inverter. At present, the team is planning to implement several innovative methods to decrease the size of the inverter. Two of the methods are unique but feasible, and so the team is planning to file for US patents for the ideas. The objectives and timeline outlined in the proposal are also reasonable and definitely achievable.

The three students involved in the project are all graduate students in electrical engineering. These students are the crème of the crop with excellent academic skills and knowledge, positive attitude toward learning, rise to a challenge, and outstanding work ethic. With the rapport these students have, I have no doubt that they will be able to accomplish the task of constructing the inverter, be a finalist or a winner in the competition; thus, enhancing Cal Poly's reputation nationally and globally.

To ensure that deadlines and objectives are met, I will work closely with the students and will have regular meetings to review their progresses. In addition, I will also be assisting them in any help they will need in the design process and lab testing phase. In conducting the project, the students will mainly be using the Power Electronics lab (20-104) well equipped with equipment to construct and test the inverter. Additional lab for them to use is the Sustainable Energy Lab (20-150) that is equipped with solar panels and their related metering equipment. With these labs, I am more convinced that the students will be able to build the prototype inverter successfully.

Knowing the academic and technical ability of the three students supported by the well-equipped labs, I therefore give my fullest support for the students to compete in the challenge. I look forward to working with the students in this exciting project. Please let me know if you have any questions pertaining to any one of the students or the facility.

Best regards,

Dr. Taufik
Professor of Electrical Engineering
Cal Poly State University, San Luis Obispo, CA
Phone: 805-756-2318