FLORIDA STATE UNIVERSITY

Planning Grant: Real-Time Power Quality Study For Sustainable Energy Systems

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Description: The main objective of this project is the collection of preliminary data for IESES proposals that can be used to seek local, national and international sources of external funding from private and government sponsors. The overall project has been split up in several independent subprojects to allow a timely completion of the tasks. Four tasks have been completed and one task is still ongoing. The remaining task will be performed by the CO-PIs and their graduate students at Florida State University.

Budget: $15,000

Progress Summary

Task 1: "Sustainable Energy White Paper Development" has been completed. Two proposals have been submitted and one conference paper has been published: Indranil Bhattacharya and Simon Foo, "Indium Phosphide, Indium-Gallium-Arsenide and Indium-Gallium-Antimonide based High Efficiency Multijunction Photovoltaics for Solar Energy Harvesting," 1st Asia Symposium on Quality Electronic Design (ASQED '09), Kuala Lumpur, Malaysia, July 15-16, 2009.

Task 2: "IESES Collaboration within State of Florida" to develop dynamic models for fuel cell, battery and ultra-capacitors has nor been completed. We will travel to seek collaborations with the University of Miami and write proposals in the near future. Project funds will be used for travel expenses seeking collaboration opportunities within the State of Florida. This task is still ongoing.

Fig. 1 Instrumented PEM fuel cell station. 1.2 kW.

Task 3: "IESES International Collaborations" has been completed. To meet Florida's sustainable energy demands, we have addressed the important problems on power quality. The preliminary study showed that a custom microprocessor should be favored. Currently the leader in ESL design of microprocessors is the Processor Designer (PD) by Coware Inc. These tools have been originally developed at RWTH Aachen in Germany and are now commercial products. To learn the use of these tools, the PI visited the RWTH Aachen in the summer of 2009 for 2 month (June and July) and was trained on using the various design tools. In the following, we have successfully installed the Pocessor Designer tools at FSU College of Engineering computers and became member of the CoWare University program. The tools (16 seats having a total commercial value of 16x$120K=$1.920 MUSD) are in use in the Fall 2009 ASIC System design course (EEL5707). 3 students in this course were MS students from CAPS. Data produced during the research stay at RWTH Aachen resulted in the submission of 2 journal publications and will be used later to submit proposal in related calls.

Task 4: "Power Quality Preliminary Data Production" is complete. We have compared the preliminary study from the FSU Ph.D. thesis "FPGA-Based Real-time Processing of Time-varying waveform Distortions and Power Disturbances in Power Systems" by Jinglin Xu with current state-of-the art systems. It turns out that commercial switching to an alternative source after detecting a power distortion is done within 2ms. As a result the narrow band filter approach used in harmonic analysis cannot be used. The study of low latency, robust, and efficient systems uncover that a zero or first order Hilbert Transformer. We have successfully designed, built in MatLab/Simulink, simulated and tested on an FPGA board such a system using first and second order Hilbert transformers and could successfully implement a sag/swell detection under the 2 ms requirements. We have included this MatLab/Simulink experiments in the "DSP with FPGAs" CCLI phase II proposal to NSF in the spring 2010.

Task 5: "Power quality analysis of PEM fuel cell system" has been completed. We have made available to the team PEM fuel cell systems to evaluated prototypes of power quality control systems. In particular we collaborated with Dr. Li's group in the testing of hybrid energy storage systems for fuel cell applications. Our group provided a 1.2kW fuel cell which was integrated with the hybrid energy storage and power conversion systems. Our teams tested different load profiles representative of transportation applications. The imposed load profile resulted in the FC power output and fuel consumption was measured. The power management strategy target was to keep the FC output nearly constant and have the storage elements respond to load variations. Different control strategies were tested trying to identify the one that leads to minimum fuel consumption for a given mission (load characteristics).