GridSTART

Hawai'i Natural Energy Institute | University of Hawai'i

Grid System Technologies Advanced Research Team

Potential EE496 Projects Available with HNEI Grid*START*

Background

The Grid Systems Technology Advanced Research Team (Grid***START***) of the Hawaii Natural Energy Institute (HNEI), University of Hawaii, has been developing a fully integrated, low-cost, high-fidelity combination grid power monitor and distributed controller called ARGEMS. The device will be utilized to support HNEI's smart grid research and field demonstration by enhancing real-time visibility and control of the electric grid under high penetrations of renewable energy.

Student Opportunities

Grid***START*** is seeking interested undergraduate students to participate in applications and research related to ARGEMS through the UH Department of Electrical Engineering's EE496 project courses. Below is a summary of the opportunities that are available for the Fall 2020 semester. All projects involve literature review or other directed learning; engineering design, programming, and/or analysis; and oral and written presentation consistent with EE496 requirements. Interested students are directed to the contacts below.

1. Automated Distribution Circuit PV Hosting Capacity

Advisor: Yan Chen, Ph.D.; Postdoctoral Fellow
Email: yc2@hawaii.edu

This research endeavors to develop an automated means to efficiently assess and determine the capacity of selected distribution circuits to accept additional rooftop PV installations ("PV hosting capacity"). This is in contrast to traditional utility PV hosting capacity analysis which is offline and static. Further, the capability of the application will be extended to provide distributed control of PV inverters with the goal of increasing a distribution circuit's hosting capacity. A critical part of PV hosting capacity analysis is power flow simulation, but existing power flow solvers are not compatiable with the ARGEMS device's ARM processor.

During the upcoming semester, students will help pursue one of the following approaches:

(1) Implementing, testing, and validating well-established power flow solvers on a central server using data from ARGEMS in near real-time. The work will also involve volt/var control algorithms to improve PV hosting capacity.
(2) Implement a new power flow solver that converges quickly and accurately on the ARM processor. If possible, this solver will be deisgned such that multiple cores or processors can work together to cover a larger distribution network or execute more quickly.

2. EV bi-directional charging control

Advisor: Saeed Sepasi, Ph.D.; Assistant Researcher
Email: sepasi@hawaii.edu

Grid***START*** is collaborating with Hitachi, Ltd. on a development and demonstration project to install two bi-directional electric vehicle (EV) chargers (Hitachi hybrid-PCS) on the campus of the University of Hawaii at Manoa. This research endeavors to develop, test, and evaluate new algorithms to optimize the charge/discharge of shared fleet EVs on this demonstration platform. Such algorithms have the potential to enhance the ability of EVs to support grid operation by acting as a buffer for variable renewable energy resources including PV. Thus far, Grid***START*** has develped an optimization algorithm that minimizes the amount of PV that is curtailed or not used.

The goal for the upcoming semester is to have this algorithm (with some possible modifications) running on the ARGEMS device and test it. The tasks are to:

(1) Develop Python code for EV charge/discharge control optimization and user interfaces. Optimization methods include but are not limited to machine learning.
(2) Integrate the developed control optimization and user interfaces code into ARGEMS.
(3) Test, analyze, and evaluate the performance of the system in a model-based simulation environment and laboratory setting utilizing Grid***START***'s hardware-in-the-loop (HIL) equipment.

3. Transformer health monitoring

Advisor: Quynh Tran, Ph.D.; Postdoctoral Fellow
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Distribution service transformers are a critical and costly utility asset but can fail due to numerous reasons including oil leakage, thermal stress due to overload, harmonics, and unbalanced loading. This research endeavors to assess the *in situ* health of distribution service transformers using non-intrusive sensors, contextual or environmental data, and real-time, distributed algorithms implemented on ARGEMS. The primary approaches being pursued are (1) through near real-time thermal modeling in conjunction with thermal and electrical measurement and (2) vibration measurement and analysis including harmonics. Previously, fuzzy logic and machine learning algorithms were pplied to provide an overall health index of a simulated 50 kVA distribution transformer using estimated top oil temperature and measured data.

During the upcoming semester, students will complete one or more the activities listed below. The resulting application should be tested and validated on the ARGEMS by the end by the semester.

(1) Model the electro-thermal transformer dynamics including the harmonic load current.
(2) Investigate the health impact of harmonic current due to nonlinear loading.
(3) Propose algorithms that can reduce the rate of transformer degradation and extend lifetime by controlling devices such as PV inverters and smart appliances.

4. Enhancement of the core ARGEMS platform

Advisor: Kevin Davies, Ph.D.; Assistant Researcher
Email: kdavies@hawaii.edu

The core ARGEMS device and platform is complete, but it continues to be enhanced to improve its value to electric utilities and support future research. Third generation devices have been field deployed in Okinawa, Japan, and at a University of Hawaii College of Education building for extended testing. The fourth-generation ARGEMS, assembled and soon to be deployed, adds significant real-time computational capability for analysis and controls using a field-programmable gate array (FPGA).

During the upcoming semester, students can contribute to and learn from one of the following potential enhancements to the ARGEMS platform. It is expected that new features(s) will be implemented, tested, and reported by the end of the semester.

(1) Visualization and web interface: Design and implement (primarily in JavaScript) novel, effective methods of presenting near real-time data relating to power quality and grid resiliency.
(2) Support for external sensors: Design circuits and write software (C and Python) to measure, analyze, and report vibration, temperature, and/or solar irradiation.
(3) High-speed electrical measurement: Write and evaluate software (primarily C) to gather voltage and current measurements up to 8 kHz and implement signal processing techniques to support applications such as power quality analysis and fault identification and location.