A Novel Curriculum Development in Solar and Wind Energy Systems in an Engineering Technology Program

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Abstract

Introduction of renewable energy and smart grid applications to an existing conventional electrical power systems curriculum in the Engineering Technology Department at Sam Houston State University has positively impacted students, faculty, and the university community and promoted the adoption of sustainable, reliable, flexible, and better quality energy technologies. This paper presents the development of a novel power systems curriculum with an emphasis on renewable energy and smart grid technologies for a new junior-level power and machinery class in the Electronics and Computer Engineering Technology (ECET) BS degree program. Teaching modules covered are (1) stand-alone home energy production, (2) grid-tied home energy production using an inverter, and (3) a large-scale energy storage for the implementation of a basic smart grid. The results of the new curriculum are very promising in terms of increasing student interest and enthusiasm for modern electrical power systems that are integrated to a smart grid through a state-of-the-art data acquisition and instrumentation system. One of the major industrial partners and employers of ECET graduates, Quanta Services Inc., provides strong support for the department and the program and wants universities to provide companies like theirs with graduates who have up-to-date competencies in next-generation electrical transmission, distribution, and procurement areas.

Introduction

Fossil fuel power plants have been major sources of electrical power in the conventional grid; however, aging infrastructure, coupled with a rising demand for reliable and stable electricity, and environmental concerns regarding the industry's carbon footprint have made it crucially important for the grid to transform its existing and outdated infrastructure into a next generation smart grid enhanced with distributed generation (DG). DG is the electricity generated from multiple renewable energy resources such as wind, solar, hydrogen fuel cell, micro-combined heat power generators, small-scale micro-hydro turbine generators, and diesel power units (Celeita, Justo, Mwasilu, Lee, & Jung, 2013; El-Khattam, & Salama, 2004; Celeita, Hernandez, Ramos, Penafiel, Rangel, & Bernal, 2016; Cardenas, Gemoets, Ablanedo Rosas, & Sarfi, 2014; Uludag, Lui, Ren, & Nahrstedt, 2016).

A smart grid is an intelligent, adaptive-balancing, self-monitoring power grid that accepts any source of fuel and transforms it into a consumer's end use with minimum human intervention and maximum reliability (Cardenas et al., 2014; Uludag et al., 2016; Luo, Shi, & Tu, 2014; Wadghule, 2013). In addition, the smart grid allows for the optimization of renewable energy use and minimizes the cumulative carbon footprint. Synchronization of all operating power plants introduces new challenges due to their various infrastructure and operating characteristics. DG is an emerging approach to provide electric power in the heart of the power system, and this approach depends on the installation and operation of a portfolio of small sized, compact, and clean electric power generating units at or near electrical loads (Yong, Ramachandaramurthy, Tan, & Mithulananthan, 2015; Sandeep & Saurabh, 2018). The DG of electricity integrates with renewable energy technologies such as photovoltaic (PV) arrays, wind turbines, micro-hydro turbines, tidal units, biogas systems, and hydrogen fuel cell units (Sandeep & Saurabh, 2018).

The implementation of DG sources in a conventional grid may result in many advantages, such as providing high efficiency and reducting the carbon footprint, reducing transmission and distribution losses, supporting the local grid, and enhancing system stability. However, application of individual DG may also cause as many additional issues as it may solve, and there are research problems to be solved in the grid-tied operation of conventional and DG fields (Sandeep & Saurabh, 2018; Khodayar & Wu, 2015; Jerin, Prabaharan, Kumar, Palanisamy, Umashankar, & Siano, 2018). When the grid includes DG sources, the term "smart grid" becomes an umbrella to refer to new technologies that address today's electrical grid challenges associated with grid reliability and reactive maintenance, smooth integration of renewables, and disturbance detection that may arise from any section of the grid, from an inverter failure from a large PV farm to a tree branch short circuit of the alternative current (AC) transmission line in the grid (Khodayar & Wu, 2015; Jerin et al., 2018; Fang, Misra, Xue, & Yang, 2012). A combination of smart micro grids is expected to modify the conventional electrical power system enhancing reliability, accessibility, flexibility and power quality (Sandeep & Saurabh, 2018; Khodayar & Wu, 2015; Jerin et al., 2018; Fang, Misra, Xue, & Yang, 2012).

The increasing importance of renewable energy sources in smart grid technologies also requires additional workforce and engineers, in many cases beginning with undergraduate students. This will require learning what a smart grid is and how it functions, as well as the integration of major renewable energy sources such as solar and wind energy systems to the existing grid (Fang et al., 2012; Justo, Mwasilu, Lee, & Jung, 2013; Jennings, 2009). An example of a program, which would coincide with courses such as solar and wind energy systems, is already being implemented into undergraduate curricula at University of Alaska Anchorage (Belu & Cioca, 2016). For a student to gain a solid understanding of the smart grid, a multidisciplinary course covering various aspects is essential (Justo et al., 2013; Jennings, 2009; Belu & Cioca, 2016; Dumitru & Gligor, 2014). Another undergraduate junior-level course on smart grids that covers grid fundamentals, system structure, major components, analysis, system operation and management, has been offered successfully (Jennings, 2009; Belu & Cioca, 2016; Dumitru & Gligor, 2014).

It is imperative that future engineers and technical managers have up-to-date knowledge of the electrical grid system that they will be working on. The curriculum covered in three different institutions, which focuses on power electronics and specifically the smart grid, benefits all those who are involved in the modern electrical power industry (Jennings, 2009; Belu & Cioca, 2016). This paper reports results of a summer faculty and student team research and development award that was funded for developing a new curriculum to strengthen the electrical power class as requested by industrial advisory board members from electrical power industries. The curriculum includes development of the following teaching modules in smart grid technologies: (1) stand-alone home energy production, (2) grid-tied home energy production using an inverter, and (3) a large-scale energy storage for the implementation of a basic smart grid using a commercially available state-of-the-art power system data acquisition module.

Smart Grid Project Implementations

A smart grid technology training system developed by Festo Corporation was used in this curriculum development work (Festo, Home, 2017; Festo, Smart, 2017). Undergraduate research students established a test bench with a PV panel emulator for the implementation of stand-alone and grid-tied home energy production (HEP) with Festo power systems training workbench as seen in Figure 1. Students also established the same system by actual PV modules connected to the grid-tied HEP instrumentation system. This scheme provides understanding of the necessary fundamentals for further inclusion of multiple energy generation sources developed for a small-scale smart grid system during various operating times and demand (Festo, Smart, 2017; Reka & Dragicevic, 2018; Qadrdan, Jenkins, & Wu, 2018). The test bench used in this study is a stand-alone PV system that includes a solar panel emulator, battery, DC to DC converter, boost chopper, an LC filter, and a single phase PWM inverter.

The low voltage data acquisition and control (LVDAC) instrumentation module allows for real time measurement and monitoring of voltage, current, power, power factor, phase shift, and other meter settings as shown in Figure 2. The LVDAC module is an effective tool for precise data acquisition and analysis. Various controls within each function of the LVDAC module and the four-quadrant dynamometer are available, such as a solar power inverter, solar panel emulator, HEP window, phasor analyzer, oscilloscope, etc.

The Smart Grid Technologies Training System in Figure 1 includes the following modules:

- A resistive load bank is used to simulate loads at the user end of an energy system similar to resistive loads at residential buildings.
- Data acquisition and control interface (DACI) allows for the monitoring of various types of data in an experiment. It may also be used to control aspects of an experiment when used with the LVDAC software.
- A low frequency transformer can be used for isolation between DC and AC sides of a power system when galvanic isolation is required and the DC to DC converter is not used and to achieve the voltage measurements necessary for proper operation.
- IGBT chopper/inverter is used to boost DC voltage to the necessary DC bus voltage for inversion to AC. This can also be used as a buck chopper, which reduces voltage to meet the DC bus needs. This module allows electrical power flow in either direction.
- Filtering inductors/capacitors are used to smooth out the current waveform on the AC side of the system. The capacitors improve power factor and keep constant voltage.
- AC power network interface provides AC power from the inverter that can be used to operate a load, or as a means to inject power back to the AC power network.
- The power supply that is a four-quadrant dynamometer has many functions available to generate power when simulating PVs and other renewable resources.
- Lead acid battery pack serves as a power source, as well as a bank for power storage when being implemented in a smart grid.
- Power supply provides 3-phase power and AC voltage of 24V to the system units.

Figure 1. FESTO Smart Grid Technology Training System and students are working on the smart grid curriculum (Festo, Home, 2017; Festo, Smart, 2017). Reprinted with permission.

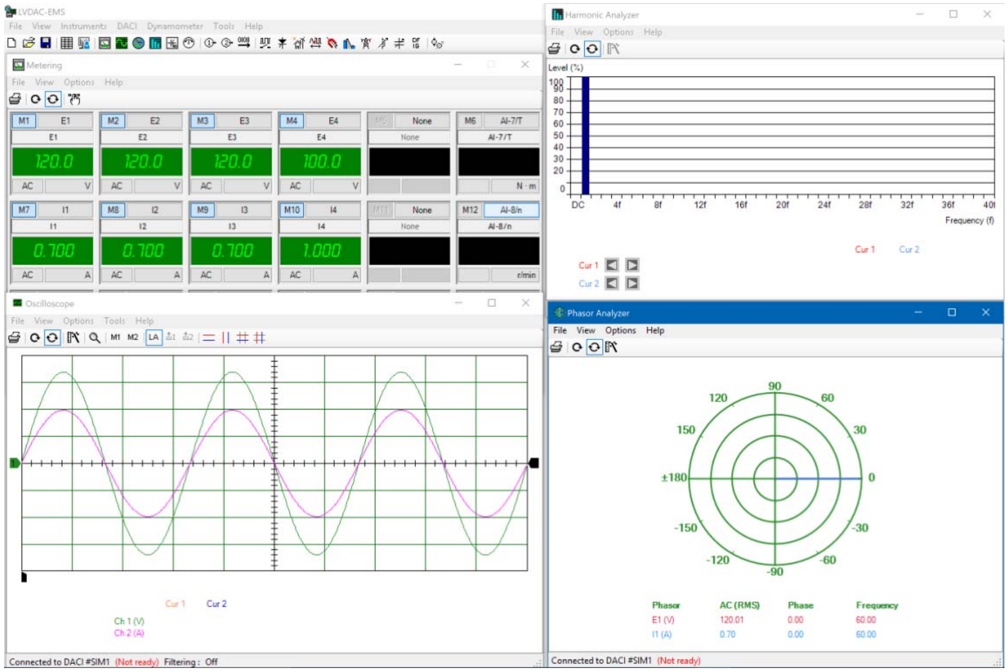

Figure 2. Example of LVDAC-EMS software interface run in the project (Festo, Home, 2017; Festo, Smart, 2017). Reprinted with permission.

Project 1: Stand-Alone HEP

This experiment demonstrated the power flow from the source to the AC load, with the excess power charging the battery. The students initially setup a battery power circuit connected to the boost chopper, single-phase PWM inverter, filtering inductors, and a resistive load as seen in Figure 3. This enabled students to calculate the power efficiency of the system as 86.6% using a measured load power of 109.8W and a battery power of 126.8W. The load power was increased to demonstrate its effects on the voltage values from the DC bus, load, battery, and duty cycle. As demonstrated in Figure 4, the load voltage decreases and the load current increases as the load power increases. DC bus voltage and battery voltage remain relatively the same. The duty cycle increases from 77% to 79% as the load power increases. The power generation was switched from the battery to a solar panel emulator implemented by the Festo four-quadrant dynamometer. The array was set up to have seven PV panels in series and thirty-eight PV panels in parallel. This setup produced a voltage of 67.9V, a current of 4.0A, and a power rating of about 271W.

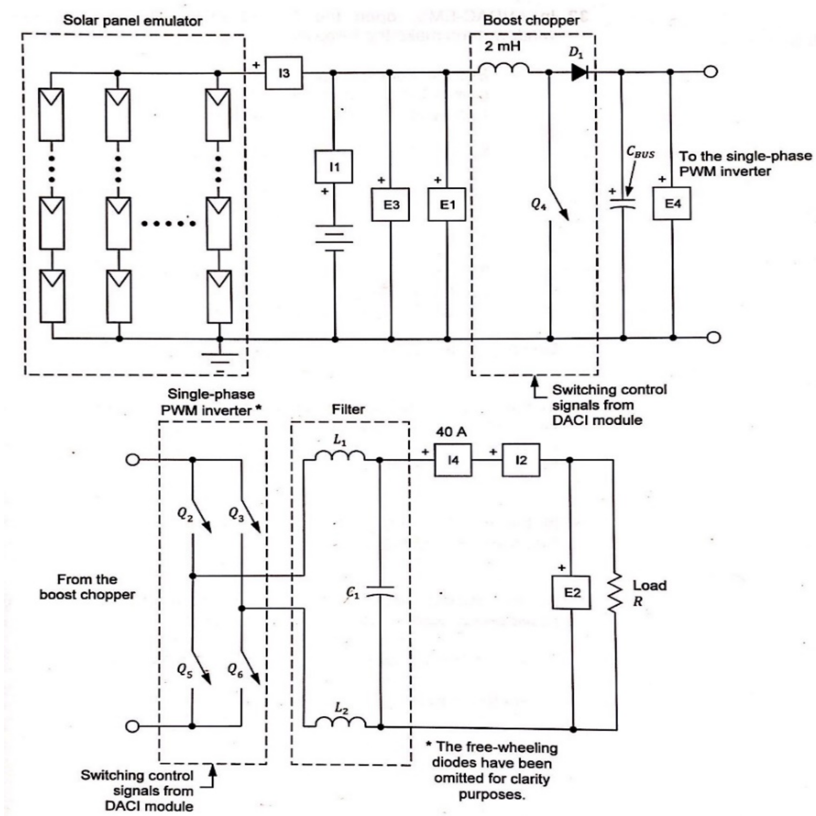

Figure 3. Stand-alone energy production circuit diagram (Festo, Home, 2017; Festo, Smart, 2017). Reprinted with permission.

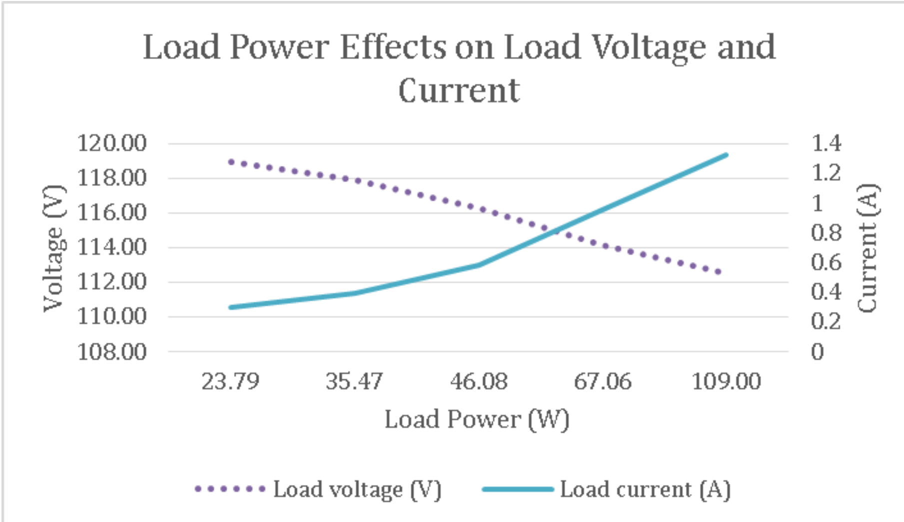

Figure 4. Load current and voltage as load power increases.

Figure 5 illustrates how excess power can be used to recharge the battery bank while simultaneously operating a load. When the battery was not being recharged, the PV emulator fully supplies power to the load under high solar irradiance. When solar irradiance drops below about 810W/m^2, the battery is used to supplement power that is needed by the load.

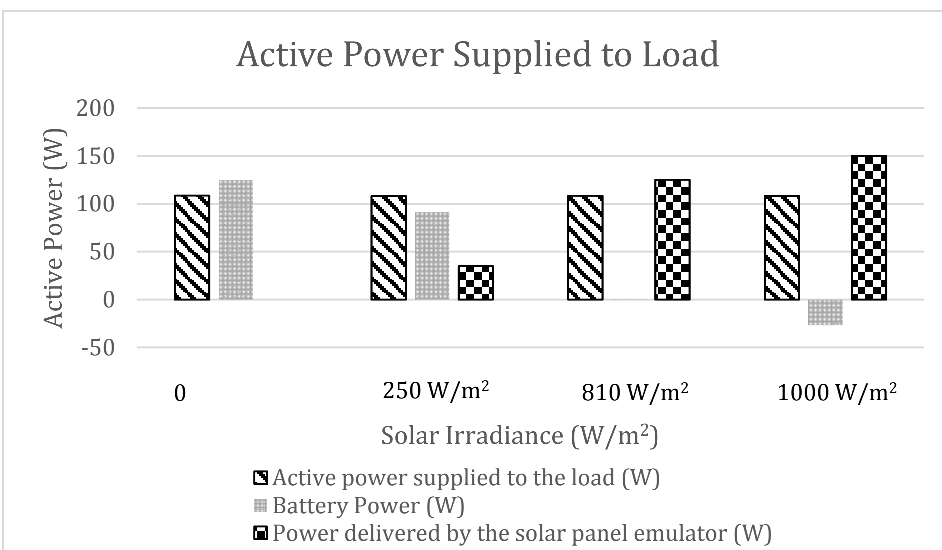

Figure 5. Active power supplied to load with supplemental battery power and battery charging.

ISBN 978-1-60643-379-9

Project 2: Grid-Tied HEP Using a Solar Power Inverter without DC to DC Converter

This project describes small-scale generation of electrical power from solar PV panels in which the active and reactive power flow direction was tested under different polarities of each respective current command and their consequential effects on power to and from the grid; see Figure 6. Figures 7a-7d outline the power readings when the active and reactive current commands were set with different polarities in the LVDAC HEP and the single-phase grid-tied inverter function was used.

Figures 7a and 7d show that when the active current command is positive, active power is injected into the local AC power network. When the active current command is negative, as in Figures 7b and 7c, power is withdrawn from the local AC power network into the single-phase grid-tied inverter. Power is converted to DC voltage and charges the battery. When the reactive current command is positive, reactive power is injected into the single-phase grid-tied inverter. When the reactive current command is negative, reactive power is injected into the local AC power network.

The next part of this project demonstrated that a low frequency transformer can be used to isolate the DC side from the AC side if this is required in a real-world application. The transformer not only provides isolation from the DC and AC sides of the system but allows for a lower DC input voltage that is stepped up on the AC side to meet local AC power network requirements.

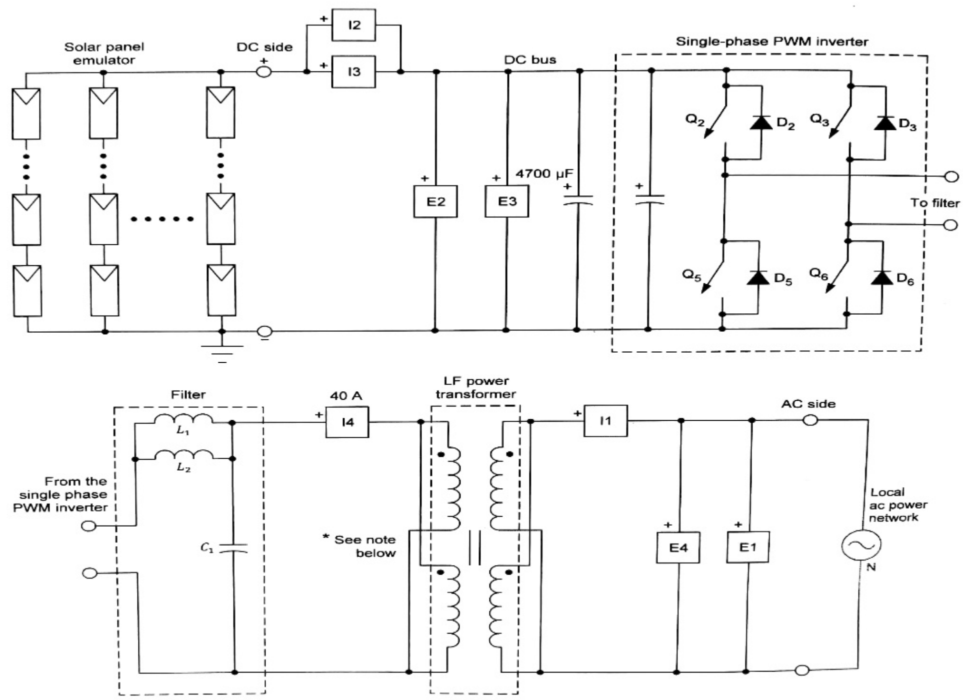

Figure 6. Implementing a grid-tied HEP by PV panels and a low frequency transformer (Festo, Home, 2017; Festo, Smart, 2017). Reprinted with permission.

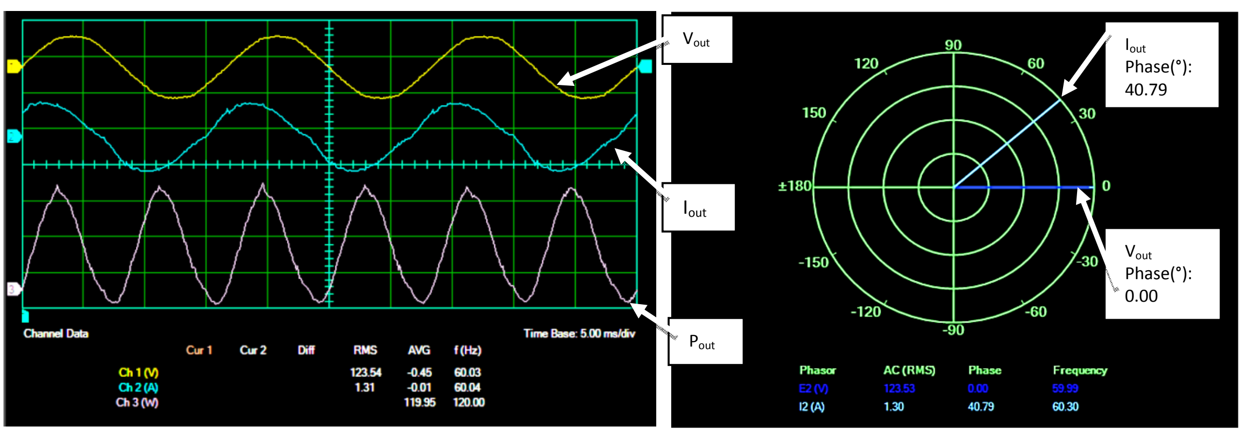

Figure 7a. Load power with active and reactive command currents of +1A.

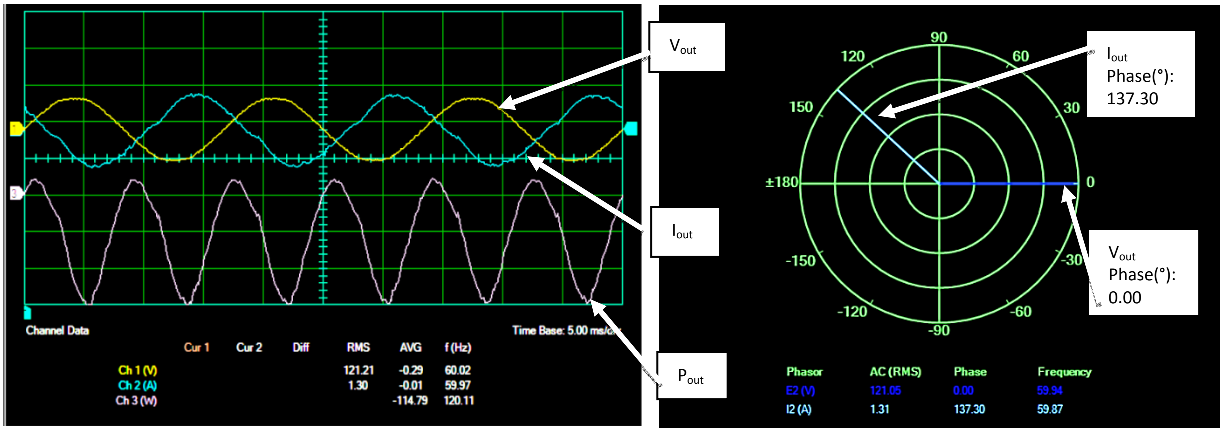

Figure 7b. Load power with active and reactive command currents of -1A and +1A.

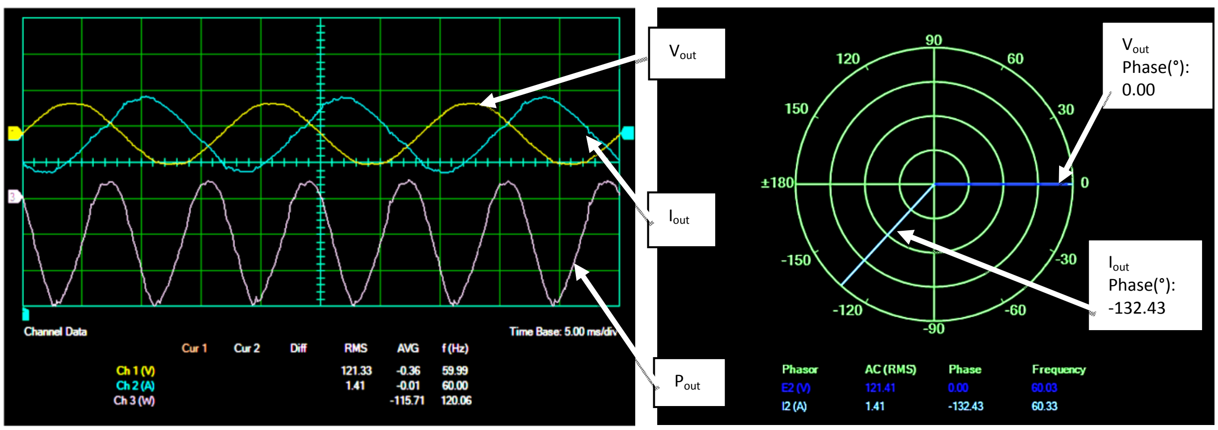

Figure 7c. Load power with active and reactive command currents of -1A and -1A.

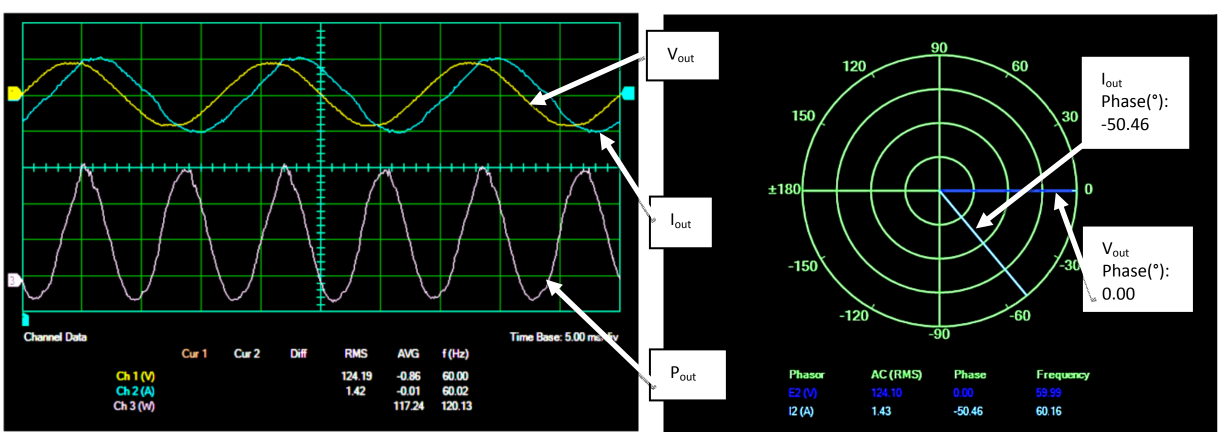

Figure 7d: Load power with active and reactive command currents of +1A and -1A.

As seen in Figure 8, the solar irradiance of the PV emulator was increased in intervals of 100 W/m^2 from an initial value of 300 W/m^2 to 1000 W/m^2. The DC voltage remained constant in this situation, and the output power continued to increase. This is a result of the transformer being used on the AC side of the system adjusting the output voltage to that of the AC power network and the MPPT keeping the active current command set to deliver the maximum power to the network. As seen in Figure 8, the input power is greater than the output power. This is due to losses through the inverter and filtering inductors. As the irradiance level increased, the input power, output power, and output current all steadily increased as well.

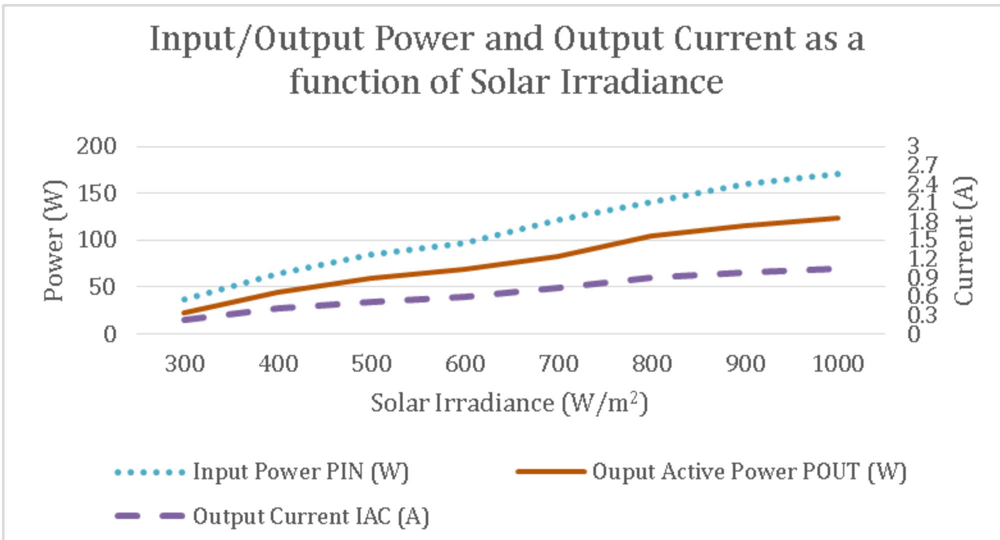

Figure 8. Input/output power and output current as a function of solar irradiance.

Figure 9 (left) shows the variables $V_{in,DC}$, $I_{out,AC}$, and $V_{out,AC}$ at solar irradiance level of 500 W/m^2, and Figure 9 (right) shows measurements at solar irradiance level of 1000 W/m^2. While the $V_{out,AC}$ remained constant, the MPPT varied the active current command with the use of the P&O algorithm to determine and operate the PV emulator at the maximum power point. Before balancing out to what is shown in Figure 9 (right), the amplitude of the $I_{out, AC}$ line was visibly increasing and decreasing while attempting to determine the operating point.

ISBN 978-1-60643-379-9

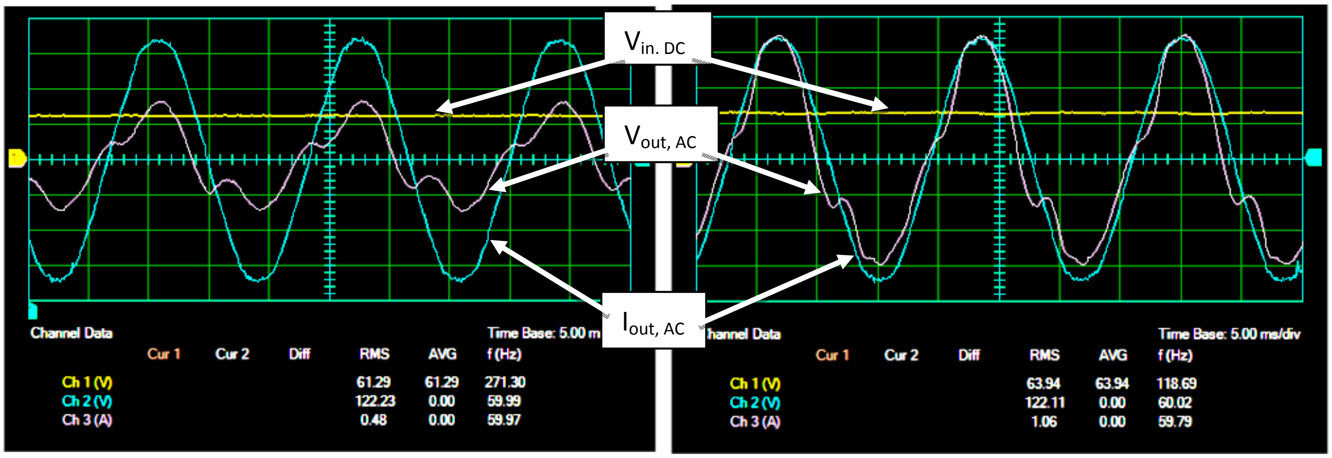

Figure 9. Oscilloscope measurements at solar irradiance levels of 500W/m^2 and 1000W/m^2.

Project 3: Large-Scale Energy Storage to Implement a Smart Grid with Electrical Vehicles

Widespread use of grid-tied inverters and batteries enables additional storage of large amount of energy that can be fed to the AC grid when a demand exists. One of the best practices of this project is consideration of plug-in vehicles (PEVs) and plug-in hybrid electric vehicles (PHEVs) that will enable large-scale energy storage in a smart grid system (Qadrdan, Jenkins, & Wu, 2018; Zahedi, 2018).

This experiment studied a set of daytime and nighttime cycles, measuring the power demand and home energy consumption from the grid, both with and without the use of energy storage. As the circuit diagram in Figure 10 shows, daytime and nighttime cycles were simulated with the use of resistive loads. Daytime demands are higher than nighttime; therefore, to demonstrate this fact, all of the parallel connected resistive loads are switched on to achieve a low resistance load of 57 ohms. After five minutes for the daytime cycle, a nighttime demand was simulated by increasing the resistance to 240 ohms. This case can be updated further when charging PEVs and PHEVs at nighttime. Without energy storage, the nighttime demand for power was about four times less than that of the daytime demand, as shown on Table 1.

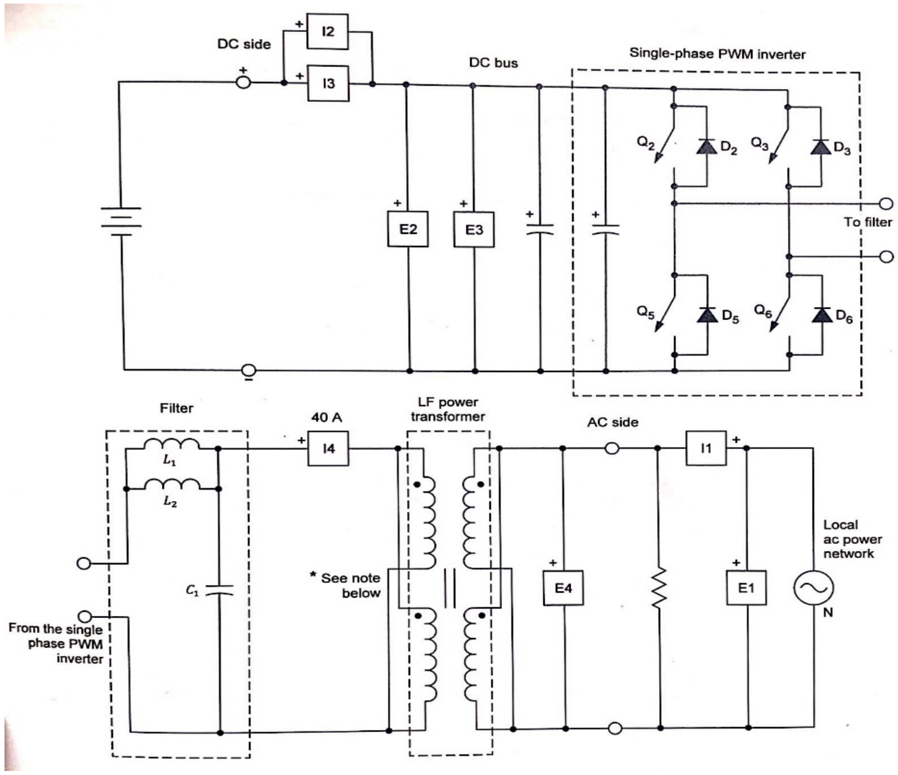

Figure 10. Large-scale energy storage circuit diagram (Festo, Home, 2017; Festo, Smart, 2017). Reprinted with permission.

Table 1. Daytime/nighttime cycle power measurements without energy storage.

Power and energy measurements	Daytime	Nighttime
Home power demand (active power at the ac side of the single-phase grid-tied inverter) P_{grid}, (W)	257.9	67.83
Battery power (power at the dc side of the single-phase grid-tied inverter), $P_{BATT.}$, (W)	3.1	3.1
Home energy consumption (energy which the grid supplied to the home during the simulated daytime/nighttime cycle, E_{Grid}, (Wh)	30.1	

The measurement of power demand and consumption from the grid was then explored for times when an energy storage is used, instead of relying on immediate power generation from the grid at the time of demand (Table 2). In this part of the procedure, the battery was charged by the grid during the nighttime cycle when the power demand from the grid was lower. The charged battery then supplied power to the grid during the daytime cycle to lower the power demand from the generation sources.

Table 2. Daytime/nighttime cycle power measurements with energy storage.

Power and energy measurements	**Daytime**	**Nighttime**
Home power demand (active power at the ac side of the single-phase grid-tied inverter) P_{grid} (W)	192.7	192.4
Battery power (power at the dc side of the single-phase grid-tied inverter), $P_{BATT.}$ (W)	87.8	-89.1
Energy exchange at the battery after the simulated daytime interval, $E_{BATT.,DAY}$ (Wh)	7.8	
Home energy consumption (energy which the grid supplied to the home during the simulated daytime/nighttime cycle, E_{Grid} (Wh)	44.52	
Energy exchange at the battery after the simulated daytime/nighttime interval, $E_{BATT.,DAY/NIGHT}$, (Wh)	0.7	

Learning Outcomes of the Electrical Power and Machinery Course

The students are expected to gain foundational knowledge of standalone and grid tied energy production using power system operation, battery storage, and energy conversion techniques in conventional and alternative energy systems. Through the course of the laboratory projects, students will become familiar with the components used in grid-tied and standalone energy systems, such as a boost chopper, a single-phase inverter/rectifier, and transformer for use of voltage isolation, insulated DC-to-DC converter, DACI, and the LVDAC system software by Festo.

Upon completion of the course, students will achieve the following outcomes that will also enhance the program's data collection and assessment efforts aligned with ABET-ETAC criteria:

- Apply the theory of electrical machines—motors-generators-transformers—to the practical industrial settings with appropriate drives and controls.
- Learn the theory of single phase and three phase electrical power, stationary and rotating electrical machines operating on DC/AC, and their relevant control systems.
- Establish the concepts of electrical power production, transmission, application, and the control relating to the industrial and commercial settings.
- Learn fundamentals of the National Electric Code and Electrical Safety Rules.
- Apply creativity in the design of components and systems based on specified requirements and known design techniques.
- Design and carry out experiments and tests, analyze and interpret data, and make iterative improvements by using safe and technically correct laboratory methods.
- Collaborate with each other in laboratory and classroom settings to work effectively in teams.

Conclusions

An undergraduate summer research project at SHSU has produced an effective teaching curriculum with laboratory projects in the area of smart grid electrical power systems. A new junior-level class on electrical power and machinery will be offered in 2018-19 academic year with the laboratories described in this paper. The teaching modules covered are (1) stand-alone home energy production, (2) grid-tied home energy production using an inverter, and (3) a large-scale energy storage for the implementation of a basic smart grid. The results of new curriculum are very promising in terms of increasing student interest and enthusiasm about modern electrical power systems integrated to a smart grid through a state-of-the art data acquisition and instrumentation system. This paper also reported the work of undergraduate students in smart grids to investigate and implement a self-healing from power quality issues, providing efficient energy management, incorporating smart metering, and integration of distributed power generation, renewable energy resources including solar, wind, and hydrogen fuel cell and power storage units.

Acknowledgments

SHSU Office of Research Administration is greatly appreciated for providing summer funding, Enhancing Undergraduate Research Experiences and Creative Activities, Faculty and Student Team Award. The authors also thank Philippe Ranger from Festo Didactic Inc., for his valuable guidance and delivering informative instructions on the smart grid electrical power system equipment used in the project.

References

Belu, R. G., & Cioca, L. I. (2016). Development and implementation of an undergraduate course on smart grids. *Proceedings of the 123rd ASEE Annual Conference & Exposition*. Washington, DC: ASEE.

Cardenas, J. A., Gemoets, L., Ablanedo Rosas, J. H., & Sarfi, R. (2014). A literature survey on smart grid distribution: An analytical approach. *Journal of Cleaner Production, 65*(C), 202-216.

Celeita, D., Justo J. J., Mwasilu, F., Lee, J., & Jung, J. W. (2013) AC-microgrids versus DC-microgrids with distributed energy resources: A review. *Renewable Sustainable Energy Review*, *24*, 387-405.

Celeita, D., Hernandez, M., Ramos, G., Penafiel N., Rangel, M., & Bernal, J. D. (2016). Implementation of an educational real-time platform for relaying automation on smart grids. *Electrical Power System Research, 130*(12), 156-166. Retrieved from http://dx.doi.org/10.1016/j.epsr.2015.09.003

Dumitru, C., & Gligor, A. (2014). Designing of a renewable energy training program for engineering education. *Procedia Technology, 12*, 753-758.

El-Khattam, W., & Salama, M. A. (2004). Distributed generation technologies, definitions and benefits. *Journal of Electric Power Systems Research*, *71*(2), 119-128.

Fang, X., Misra, S., Xue, G., & Yang, D. (2012). Smart grid–The new and improved power grid: A survey. *IEEE Communications Surveys & Tutorials*, *14*(4), 944-980. Retrieved from https://ieeexplore.ieee.org/document/6099519/

Festo Didactic Inc. (2017). *Home energy production*. Québec, Canada: Festo Didactic Ltee/Ltd.

Festo Didactic Inc. (2017). *Smart grid technologies training system-Unit 8010-C, Festo Didactic Inc.* Eatontown, NJ: Festo.

Jennings, P. (2009). New directions in renewable energy education. *Renewable Energy*, *34*(2), 435-439. Retrieved from https://doi.org/10.1016/j.renene.2008.05.005
Jerin, A. R. A., Natarajan, P., Kumar, N. M., Kaliannan, P., Subramaniam, U., Pierluigi, S. (2018). Smart grid and power quality issues. In F. Hina, N. Parbaharan, K. Akhtar, M. Saad, & J. Jackson (Eds.). *Hybrid-Renewable Energy Systems in Microgrids* (pp. 195-202). Philadelphia: Woodhead Publishing.
Justo, J. J., Mwasilu, F., Lee, J., & Jung, J. W. (2013). AC-microgrids versus DC-microgrids with distributed energy resources: A review. *Renewable and Sustainable Energy*, *24*(C), 387-405.
Khodayar, M. E., & Wu, H. (2015). Demand forecasting in the smart grid paradigm: Features and challenges. *The Electricity Journal*, *28*(6), 51-62. Retrieved from https://www.sciencedirect.com/science/article/pii/S1040619015001268
Luo, Y., Shi, L., & Tu, G. (2014). Optimal sizing and control strategy of isolated grid with wind power and energy storage system. *Energy Conversion Management*, *80,* 407-415.
Qadrdan, M., Jenkins, N., & Wu, J. (2018). Smart grid and energy storage. In S. A. Kalogirou (Ed.), *McEvoy's handbook of photovoltaics* (pp. 915-928). Atlanta, GA: Elsevier Academic Press. Retrieved from https://doi.org/10.1016/B978-0-12-809921-6.00025-2
Reka Sofana, S. and Dragicevic, T. (2018). Future effectual role of energy delivery: A comprehensive review of Internet of Things and smart grid. *Renewable and Sustainable Energy Reviews, 91*, 90-108. Retrieved from https://doi.org/10.1016/j.rser.2018.03.089
Sandeep, K., & Saurabh, C. (2018). Smart operations of smart grids integrated with distributed generation: A review. *Journal of Renewable & Sustainable Energy Review, 81*, 524-535.
Uludag, S., Lui, K. S., Ren, W., & Nahrstedt, K. (2016). Secure and scalable data collection with time minimization in the smart grid. *IEEE Transactions on Smart Grid*, *7*(1), 43-54.
Wadghule, T. M. (2013). A review of plug-in hybrid electric vehicles as new storage & transportation system for smart grid. *International Journal of Engineering Research & Technology*, *2*(3), 1-7.
Yong, J. Y., Ramachandaramurthy, V. K., Tan, K. M., & Mithulananthan, N. (2015). A review on the state-of-the-art technologies of electric vehicle, its impacts and prospects. *Renewable Sustainable Energy Review, 49*, 365-385. Retrieved from https://doi.org/10.1016/j.rser.2015.04.130
Zahedi, A. (2018). Smart grids and the role of the electric vehicle to support the electricity grid during peak demand. In L. A. Lamont & A. Sayigh (Eds.), *Application of Smart Grid Technologies* (pp. 415-428). Elsevier Academic Press. Retrieved from https://doi.org/10.1016/B978-0-12-803128-5.00013-1

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