Innovative

Teaching DC Electricity with a Stand-Alone Solar PV Lab Demonstration Board

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Introduction

The American Association for Agricultural Education (AAEE) National Research Priority Area 2 addresses adoption of new technologies, practices, and products (Roberts, Harder &, Brashears, 2016). Interest in renewable energy sources as an alternative to fossil fuel energy sources continues to grow both nationally and globally. Rural villages in third-world countries without access to an electrical grid depend on fossil fuels to power pumps and generators to provide power for lighting, cooking, and access to pumped water (Harrison, Scott, & Hogarth, 2016).

The solar PV demonstration board (Shoemaker, 2019) was a hands-on activity presented during the CREATE solar professional development workshop for teachers at Shoreline Community College in Shoreline, WA in August 2019.

The board demonstrates the fundamentals of a stand-alone (off-grid) solar PV-powered battery-based electrical circuit. Attached to the 24-inch plywood board is a 10-amp charge controller rated for a 12-volt system. Three sets of 12-gauge conductors are wired to the charge controller. One set of conductors connects to a 20-watt solar module. A second set of conductors connects to a 12-volt Ah battery, and the third set is connected to a plastic lamp holder mounted to a plastic ceiling lamp box. A triple-gang switch box with three single-pole switches are used to connect and disconnect the components from the charge controller. Using a digital clamp-on multimeter, instructors can have students measure system voltage (V), system current (A), and calculate system power (W). Portions of the circuit can be isolated by de-energizing components.

How it Works

The board consists of a 10-amp charge controller, a direct current (DC) load, a deep-cycle sealed rechargeable solar PV battery, and a solar PV module. To isolate each component, a triple-gang plastic box for three single-pole switches. Non-metallic sheathed cable (14-gauge) connects all electrical components. Red is used for positive (+) and black is used for negative (-). The DC load is a DC lamp bulb screwed into a plastic keyless lamp holder. When the lamp is not available, a 12-volt DC powered bilge pump connected to a fountain in a five-gallon bucket serves as the load. Charge controllers have connections for both positive negative leads for solar PV modules, solar batteries, and DC loads.

Results to Date

Eight lab boards were constructed by students in the AGTM 200 Solar PV Energy Source class. Students cut plywood, mounted charge controllers, plastic switch boxes, and plastic ceiling-mount lamp boxes. Fourteen-gauge electrical wire interior Romex® recycled from a residential electrical wiring unit was used to make the wiring connections between system components. In spring 2020, after viewing a CREATE webinar about the stand-alone solar demo

board, we modified one of our boards replacing the plastic triple-gang switch box with a steel three-space combiner box and fit it with three 15A DC circuit breakers.

Future Plans/Advice to Others

One existing board was modified replacing the triple-gang switch box with a combiner box and three 15-amp DC breakers. A video on the use of the board was made and shown to students after spring break during the university closure from the pandemic. Coming up with multiple DC loads operable on 12VDC current provides variety. Examples are DC lamp bulbs, fans, water pumps, and radios; virtually anything electronic which normally operates on batteries could serve as a DC load for the lab demonstration board.

During a recent webinar organized by CREATE, the DC laboratory board was presented along with a student worksheet and teacher key (Liddicoat, 2020). Both the recorded power point presentation and copies of the worksheets are available from the www.createenergy.org website.

We have modified the worksheets to fit our collegiate-student audience and our choice of direct current (DC) load. We are using a 12-volt bilge pump fitted to a PVC pipe fountain. Our students are instructed to use the solar irradiance meter to measure sunlight intensity, a direct current clamp-on digital meter to measure system voltage and amperage.

Costs/Resources Needed

Here is a table of the costs of materials for one lab demonstration board:

Table 1. *Expenses related to the construction of the stand-alone solar PV dem lab board.*

	Item	No.	Cost	Vendor
a.	12V 7.0 Ah Solar Battery	1	$19.00	Elliott Electronics - Tucson
b.	24”x 24” Plywood	1	$5.73	Home Depot/Lowes
c.	Sunsaver© 12V 10A Charge Controller	1	$62.00	Amazon.com
d.	14/3 Romex (6 ft)	1	$5.82	Home Depot/Lowes
e.	Triple-Gang Switch Box	1	$2.37	Home Depot/Lowes
f.	15A Single-pole switch	3	$0.68	Home Depot/Lowes
g.	Plastic Round Ceiling Box	1	$1.98	Home Depot/Lowes
h.	Plastic Keyless Lamp holder	1	$1.37	Home Depot/Lowes
i.	Romex staples	12	$1.05	Home Depot/Lowes
j.	12V DC amp bulb	1	$4.00	Local RV Store
k.	Flat-head wood screws (1 lb. pack)	8	$7.87	Home Depot/Lowes
l.	Red felt tip marker(pack)	1	$3.97	Home Depot/Lowes
m.	Female spade connectors	2	$0.09	Home Depot/Lowes
	Total Cost per Board		$116.33	

The modification of our single board replacing the triple-gang switch box and three single-pole switches with a steel three-space combiner box and three 15A DC circuit breakers cost was $78.00. Not included are a clamp-on multimeter and a solar irradiance meter. No costs for training or implementation, just materials.

References

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