Laboratory 3: Grid-Connected PV System Assembly and Checkout

Florida Solar Energy Center

Introduction

This laboratory session involves the assembly and operational checkout of a grid-connected PV system. There are a variety of inverters on the market today, both in terms of power ratings and the allowable DC voltage input window. For a PV system to operate properly, the installer must be able to determine the appropriate number of PV modules in series and parallel to connect to an inverter. As part of this laboratory, you will assemble certain parts of the system, conduct pre-operational checks, and operate the system as part of the utility grid. Finally, you will make measurements of power and energy production for the system, and compare with expectations for system performance.

Objectives

- Determine the appropriate number of modules in series and parallel to connect to a particular inverter.
- Assemble, operate and checkout a fully-operational code-compliant grid-connected PV system.
- Understand purpose, ratings and locations of required circuit protective features such as disconnects, overcurrent devices and surge suppressors.
- Measure and observe the operating conditions of the PV array and the inverter AC output.
- Measure the power, energy output, and efficiency of the system using standard utility watt-hour meters.

Equipment

- PV Modules and Array Support
- Grid-Connected Inverter
- Electrical BOS Hardware
- Irradiance and Temperature Sensors
- AC Watt-Hour Meter
- Voltmeter, Ammeter and Power Quality Analyzer
- System Electrical Schematics

Procedure and Results

Caution: *Use extreme care when working with this electrical equipment. Follow the electrical schematics. Do not touch any bare terminals inside the inverter cabinet. Leave all disconnects open until an instructor has checked your wiring.*

1. Determine the nameplate ratings of the PV modules and the inverter that have been assembled for this lab. Record those ratings below.

	SMA 700
Name:	
AC Power Output	
AC Voltage Output	
DC Voltage Input Window	
Maximum DC Voltage Input	
Maximum DC Current Input	
Maximum ST DC Power Input	

	BP 175
Name:	
Open-Circuit Voltage, Voc	
Short-Circuit Current, Isc	
Maximum Power Voltage, Vmp	
Maximum Power Current, Imp	
Maximum Power	
Warranted Max Power	

2. For the SMA 700, how many modules can be connected in series to the inverter for it to work properly? Remember you must never use a source-circuit that has an open circuit voltage above 600 V. Consult NEC 690.7 for temperature correction factors.

3. Make source circuits appropriate for the inverter and measure their output along with irradiance and module temperature. Do these numbers match what you expect?

BP 175
Source-Circuit: Voc _______ (volts) Isc ________ (amps)
Irradiance _______ (W/m^2) Cell Temperature ________ (^oC)

4. Neglecting temperature, correct the source circuit Isc measurement to an irradiance level of 1000 W/m^2. How do these compare with the rated specifications?

BP 175 Module
Source-Circuit 1 Isc @ 1000 W/m^2 _________ (amps)   Rated Isc ________ (amps)

Sharp 165 Module
Source-Circuit 2 Isc @ 1000 W/m^2 _________ (amps)   Rated Isc ________ (amps)

5. Make sure all circuit breakers to the inverter are off. Insert the array source circuits and fuses (if any) and follow the inverter instructions. If the sun is out and the array is not shaded, the inverter will begin to operate in a few minutes.

6. With the inverter operating, measure and record the operating voltage and current for each of the source circuits and for the array. Make these measurements with the assistance of one of the instructors.

SMA 700
Source Circuit (1,2 and 3): Vop _______ (volts)Iop ________ (amps)
Irradiance _______ (W/m^2)

7. Now, correct the operating current to 1000 W/m^2, neglecting temperature effects. How does this value compare with the expected current at maximum power (Imp)?

SMA 700
Source Circuit (1, 2, and 3):   Imp @ 1000 W/m^2 _________ (amps)
Panel Rated   Imp ________ (amps)

8. Measure the DC current and DC Voltage and determine the DC power input to the inverter. Measure the AC power output of the inverter and determine the inverter efficiency. If there is more than one input voltage, determine the DC power from each of the different sources and add them together.

	BP 175
DC Operating Voltage	
DC Operating Current	
DC Power	
Total Power	

	SMA 700
AC Current	
AC Voltage	

AC Power	
Inverter Efficiency	

Review Questions

1. Assume a grid-connected PV system produces an average AC power output of 1600 watts for 6 hours per day. What is the amount of energy (kWh) produced?

2. What is the general procedure for building a PV array?

3. List some of the unique differences between PV inverters operating in stand-alone mode and those connected to the grid.

4. A grid-connected inverter required a DC input voltage of 240 volts from the array. If the maximum power voltage (Vmp) of each module is 17.1 volts at STC, and the peak array operating temperature is 75 ^{o}C, how many series connected modules are required?

5. Using the system you just completed, what is the design current for each of the three-module source circuits?