Engineering Bulletin

Why Isn't a 12-Volt PV Module Really 12 Volts?

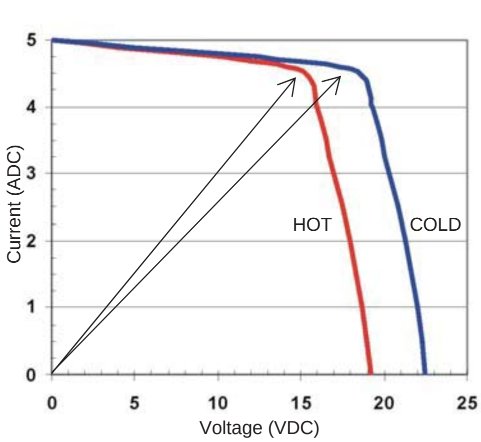
A nominal 12-volt photovoltaic (PV) module actually operates at a peak voltage (rated output voltage) between 16.0 and 17.5 volts. A nominal voltage is assigned to modules to define their voltage class. Why is there a difference between nominal voltage and peak voltage?

In order to understand peak voltage, we need to look at a current-voltage IV curve for a PV module. An IV curve is a representation of the current versus the voltage as the load is increased from the short circuit (no load) condition to the open circuit (maximum voltage) condition. The shape of the curve characterizes module performance.

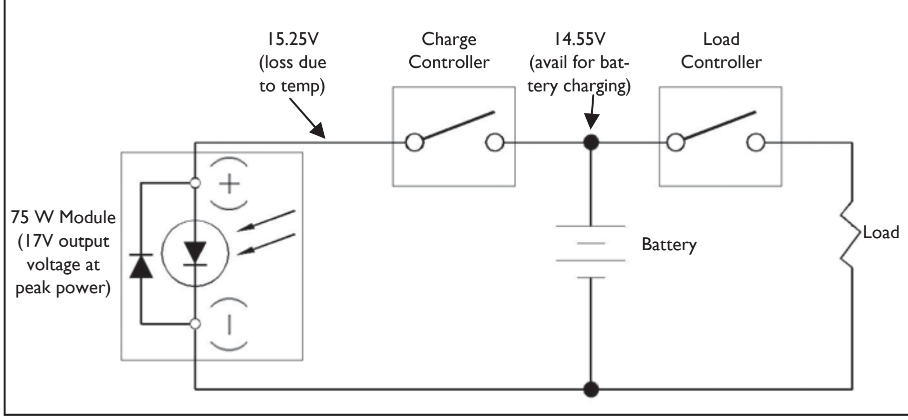
If you draw a straight line from the zero points of each axis at approximately a 45°angle, you will intersect the IV curve at the peak power point.

By definition, this point is the output current at peak power and the output voltage at peak power.

Photovoltaic IV Curve



System Schematic with 75 Watt PV Module
(at 30°C (86°F) ambient temperature)



How does module voltage affect battery charging?

1. A 12-volt battery requires about 14.0 to 15.0 volts to become fully recharged at 25°C. So, the module must have a high enough output voltage to insure there is an adequate final voltage at the battery to fully recharge during warm or hot weather.

2. The battery charging process is regulated by the charge controller. The typical charge controller creates about a 0.7 voltage drop between the solar array and the battery.

3. As the temperature of the solar cells increases due to solar heating above the ambient temperature, the output voltage decreases. For example, a 75-watt module with a rated output of 17.0 volts will have 15.25 voltage output when the ambient temperature is 30°C (86°F).

When we combine these factors, the result is: 15.25 volts-0.7 volts = 14.55 volts available to charge the battery.

We now see we need a module capable of producing at least 15.0 volts during the heat of the day. That is why a nominal 12-volt module is designed to produce around 17.0 volts under standard (cooler) conditions.

What would happen if the peak voltage were less than 15.0 volts? If we go back to the IV curve for our PV module, we see shortly past the peak power point the current rapidly approaches the X-axis, or the zero current point. If there is insufficient voltage, we run the risk of operation with insufficient current to charge the battery. Repeated operation in that mode will cause us to lose the load to a low battery condition.

Since loss of load is unacceptable, especially when addressing a critical piece of equipment at an industrial remote site, we safeguard against loss of load with modules that have a sufficient peak operating voltage.

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