Sun from a power supply
How to test your solar power electronics when the sun isn’t shining

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In project involving power electronics driven by photovoltaic panels (as in the above figure), we often want to test our systems when there is insufficient solar irradiance—at night, or on cloudy days, etc. Because of the poor efficiency of light sources, it is impractical to illuminate the panels with light bulbs and similar sources. Although it is possibly to buy or build a system that emulates the characteristics of a solar panel or array, these systems are complex, expensive, and may suffer from low bandwidth that causes them to malfunction with fast MPPT algorithms. So it is desirable find another way to drive the PV input of our power converter. Two simple alternatives are considered below.

1. Power supply plus linear resistor

In the figure below, the PV panel is replaced by a constant voltage power supply plus a series power resistor.

The maximum power point occurs at $V_{mp} = V_{PS}/2 = V_{mp}$ and $I_{pv,MPP} = V_{PS}/2R = I_{mp}$. The value of $V_{mp}$ can be adjusted via $V_{PS}$, and the power at this point can be adjusted via $R$.

The effective open circuit voltage (with $I_{pv} = 0$) is $V_{PV}|_{IPV = 0} = V_{PS} = V_{OC}$. This is substantially greater than would normally be obtained from an actual PV panel. Hence, this method requires that the power electronics be rated to handle a higher
input voltage (or a lower $V_{mp}$) than would normally be expected from a PV panel. Additionally, the shape of the $V_{pv}$ vs. $I_{pv}$ curve is substantially different from that of an actual PV panel, with a broader maximum in the power vs. $V_{pv}$ characteristic. This is likely to affect the accuracy and speed of the MPPT algorithm used by the power electronics.

2. PV panel plus current-limited power supply

In the figure below, the PV panel is augmented by a parallel-connected power supply. This power supply is operated in current limit mode.

Here, the power supply generates the current that would otherwise be generated by the solar irradiance, and the $V_{pv}$ vs. $I_{pv}$ curve seen by the power electronics is approximately the same as an illuminated PV panel. The **power supply current $I_{PS}$ must be set to a value less than the rated current of the PV panel** (in our lab, set the power supply current limit to no more than 4 A). The power supply voltage should be set to a value greater than the open-circuit voltage of the PV panel, so that the supply operates in current limit mode.

The maximum power point occurs at $V_{pv|MPPT} = V_{mp}$ close to the rated $V_{mp}$ of the panel. The effective irradiance and power $P_{mp}$ can be adjusted by changing the power supply current limit $I_{PS}$.

This approach has the advantage of creating a static $V_{pv}$ vs. $I_{pv}$ curve that is very close to that of the actual panel, with controllable effective irradiance. Its chief shortcoming is the fact that most power supplies contain large capacitors across their outputs, and hence a more accurate equivalent circuit is:

![Diagram of PV panel with current-limited power supply]
This capacitor can be quite considerable in size, and it causes $V_{mp}$ to respond more slowly to changes in $I_{pv}$. This may cause MPPT algorithms to operate more slowly, and it may necessitate that such algorithms be tuned differently than in the case of the actual PV panel alone.

In the event of bad weather during our Expo and solar competition, we will employ method #2 to enable us to run our solar competition indoors.