System reliability aspects of currently available PV modules with atypical string length

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Observations

It has been brought to our attention by one of our customers that many of their standalone systems were failing after 12 to 18 months. They had tried to systematically replace batteries, believing them to be at fault, but the trouble continued to recur. We were made aware of the problem, because we supplied the charge controllers which were found to be performing correctly.

One of the first issues that came under our scrutiny was the number of cells in the module they had chosen. This module had only 32 cells in series.

Performance measurements

One of these 32-cell modules was used in our tests. An Ameresco 90-J was also tested as a 36-cell comparison. I-V curves were taken at midday with a Day-Star curve tracer.

Both performed within their stated specifications on a bright spring day in Tomball TX. The 32-cell module tested exhibited a Vpmax at temperature of 14.3v. The Ameresco 90-J module used as a control exhibited a Vpmax of 16.5v under similar conditions.

Discussion

But do those design specifications permit this 32 cell module to fully charge a 12v battery under midday conditions in typical field applications?

Back in the early days of PV we determined that modules that have fewer than 35 cells in series have a difficult time maintaining battery health over the intended life of the system. This involves several issues: 1) the actual

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Vpmax of the module at expected performing temperatures; 2) the voltage required to adequately charge the battery and the need to fully charge and “equalize” that charge on a regular basis; 3) tare losses associated with system wiring and blocking diodes; and 4) the tare losses associated with the functioning of charge controllers either from the device’s series resistance or the controller’s required algorithms.

Discussions with the staff at Morningstar determined that their product line with the exception of one product require a ‘headroom’ of 1v over battery voltage for proper functioning. Since most system sizing calculations are based upon performance near Pmax that reduces the effective battery charging voltage of this module to 13.3v. The addition of any additional derating factors like wiring resistance, isolating diodes, and connection degradation can only further exacerbate the situation.

Depending on the choice of battery technology, the typical max charging voltage required for 12v service is from 14.1 to 14.5 volts. So the 32-cell test module performed at about 1 volt lower than required. Note that the module could perform at a higher Vpmax under cooler conditions or lower irradiance conditions, but this would severely curtail the available sun-hours for systems designed with such a module. This curtailment would need to be taken onto account within the system-sizing algorithm.

This should not be news to anyone who has been in the off-grid PV business for a long time. In the early days, it was determined by trial and error that at least 35 cells in series were required to produce survivable 12v battery-charging systems. But in recent times there are entire manufacturing companies with no experience in standalone system and their module design is merely a response to cell size and the market’s footprint requirements. That, coupled with our industry’s focus on cost reduction, has produced modules which are not suited for their intended use.

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