WHAT TO DO WHEN IT'S TIME TO REPLACE YOUR FAILED 600-VOLT PV INVERTER

How to apply galvanically isolated DC-DC converters to replace failed 600-volt solar inverters with new 1000 and 1500-volt transformerless inverters

Abstract

This white paper discusses the challenges in replacing failed 600-volt PV inverters and solutions to be considered when doing so.

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Contents

Large scale solar is starting to enter relative old age for the first time. Specifically, many 600-volt PV plants are now reaching five to ten years of operation or more and are starting to show signs of their age. One of the primary, particularly debilitating symptoms they are presenting: The central inverters which were initially installed in these plants are beginning to fail with a high degree of regularity and now need to be replaced.

The fact that these older central inverters are needing to be replaced is not coming as much of a surprise to a number of these PV systems' owners. Indeed, many project owners reserved for significant repairs like inverter replacements. What has caught the solar industry by surprise is that now, as we arrive at the point where these 600-volt inverters need to be replaced a few unanticipated facts exist:

1. Major inverter companies by and large no longer build 600-volt inverters, so like for like replacements simply are not available.
2. Many of the original manufacturers of the installed inverters either no longer exist or are no longer in the PV inverter business, including once market leading names like Satcon, Xantrex, Advanced Energy and Eaton among others.
3. While central inverters are still being manufactured, most of the appropriate choices from a power rating perspective for replacing failed 600-volt inverters are transformerless string inverters. Removing isolation transformers from inverters has been one of the leading drivers in the steep reduction seen in inverter pricing on a cents per watt basis over the past five to ten years.

Challenges Presented When Replacing a Failed 600 Volt Central Inverter

While the failure of older 600-volt inverters was anticipatable, the challenges presented above have caught the PV industry largely flat footed as to what to do in the face of this growing epidemic.

Challenge 1: Old String to New Inverter Voltage Mismatch

Specifically, 600-volt rated PV strings, which typically generate voltage anywhere between 300 – 450 volts, just don't generate enough voltage to turn on and maintain the operation of today's modern 1000 or 1500-volt inverters that represent the replacement candidates for the failed, currently installed inverters.

Challenge 2: Grounding Mismatch

Another challenge to be aware when looking to replace failed 600-volt inverters is what to do about grounding. Specifically, almost all the older, 600-volt larger commercial and utility scale PV systems in North America have grounded PV arrays. Most of these arrays are negatively grounded, though several of them are positively grounded, particularly in the case of older vintage SunPower panels. In either case, this grounding needs to be accounted for. Specifically, the challenge here is that the newer, transformerless string inverters that represent the logical replacement for failed 600-volt inverters require PV arrays to be floating, i.e. ungrounded. Ungrounding older arrays in many cases may simply be a non-starter as doing so could either void the PV panel warranty all together or introduce other unintended consequences such as potential induced degradation (PID). (Visit https://alenconsystems.com/learning/PID/ to learn more about this potentially detrimental condition). Clearly, you always want to avoid any remedial measure where the cure is actually worse than the disease.

Older 600-volt inverters typically came installed with an isolation transformer that isolated the grounding of the PV system from the medium voltage transformer connected to the grid. This transformer was needed because the AC voltage coming from these arrays was typically 208 volts and thus needed to be "stepped up" to 480 volts to interact with the medium voltage transformer that provided interconnection to the power distribution grid. Newer, 1000-volt inverters are able to form 480-volt output without such a step-up, thus they do not require a transformer and thus can be built for a much lower cost than their predecessors.

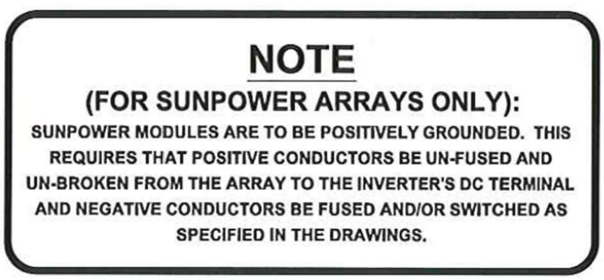
NOTE
(FOR SUNPOWER ARRAYS ONLY):
SUNPOWER MODULES ARE TO BE POSITIVELY GROUNDED. THIS REQUIRES THAT POSITIVE CONDUCTORS BE UN-FUSED AND UN-BROKEN FROM THE ARRAY TO THE INVERTER'S DC TERMINAL AND NEGATIVE CONDUCTORS BE FUSED AND/OR SWITCHED AS SPECIFIED IN THE DRAWINGS.

FIGURE 1: A TYPICALLY FOUND CALL OUT ON AS BUILT DRAWINGS ON 600 VOLT PV SYSTEMS WITH SUNPOWER PANELS. SUCH CALL OUTS INDICATE THE IMPORTANCE OF MAINTAINING THE ARRAY IN A POSITIVE GROUNDED CONFIGURATION. NEWER, 1000 AND 1500-VOLT TRANSFORMERLESS STRING INVERTERS WILL NOT WORK WHEN DIRECTLY CONNECTED TO THE GROUNDING SCHEMES OF SUCH OLDER PV SYSTEMS

The Role of the Galvanically Isolated DC-DC Optimizer

If you are the owner or operator of a PV array with a failing or perhaps already failed 600-volt inverter, what can do you? One very expedient option for facilitating the replacement of a failed 600-volt inverter is to insert a galvanically isolated DC-DC optimizer between the PV array and the new inverter. Here at Alencon Systems, we build just such a device – the SPOT – short for String Power Optimizer and Transmitter. The Alencon SPOT can solve both of the problems identified above thanks to its patented implementation of galvanic isolation technology.

The SPOT takes a unique approach to DC-DC conversion in that it includes an internal, high frequency isolation transformer. Thus, internally, unlike traditional "buck boost" DC-DC converters, the SPOT converters power from DC to AC back to DC internally. The SPOT is able to make these conversions in an incredibly efficient way because it is built with cutting edge, high speed silicon carbide transistors as opposed to other devices that use more traditional insulated-gate bipolar transistor (IGBTs). In other words, the SPOT is able to solve the unique challenge of failed inverter replacement with novel technology.

In essence, for replacing failed 600-volt inverters, the SPOT acts like a DC transformer. It is thus able to map the large voltage differential between the older 600-volt PV panels and the newer 1000 or 1500-volt inverter. At the same time, because it is isolated, it is able replace the isolation of grounds between the older grounded PV panels and the grid that is lost when the older, isolated 600-volt inverter is replaced with a non-isolated, less expensive transformerless inverter.

Deployment Considerations for Failed Inverter Replacement

When making the move to replace a failed 600-volt inverter, there can be several decisions to be made. The first choice is often which new inverter to select. Specifically, you will need to decide whether to go with a 1000- or 1500-volt inverter. Typically speaking, here at Alencon, we see plant owners opting to go with 1000-volt inverters for such replacement activities because doing so eliminates the need to replace the medium voltage transformer which can be an expensive and labor-intensive process in and off itself. That said, if you determine the medium voltage transformer needs to be replaced, a 1500-volt inverter may represent a more cost-effective solution. The SPOT is agnostic to whether it works with a 1000 or 1500-volt inverter.

This part of the decision highlights the importance of assuring inverter replacement projects are executed in the most labor efficient way to minimize both the time to conduct them and the cost of doing so in order maintain the highest possible ROI for the existing plant.

Installing SPOTs in Front of the Combiner Box

When replacing failed 600-volt inverters, the Alencon SPOTs can be installed in between the existing PV strings and combiner boxes. This approach will have the benefit of allowing for string level maximum power point tracking (MPPT) while solving the voltage mismatch and grounding challenges identified above. One example of such an arrangement is shown below:

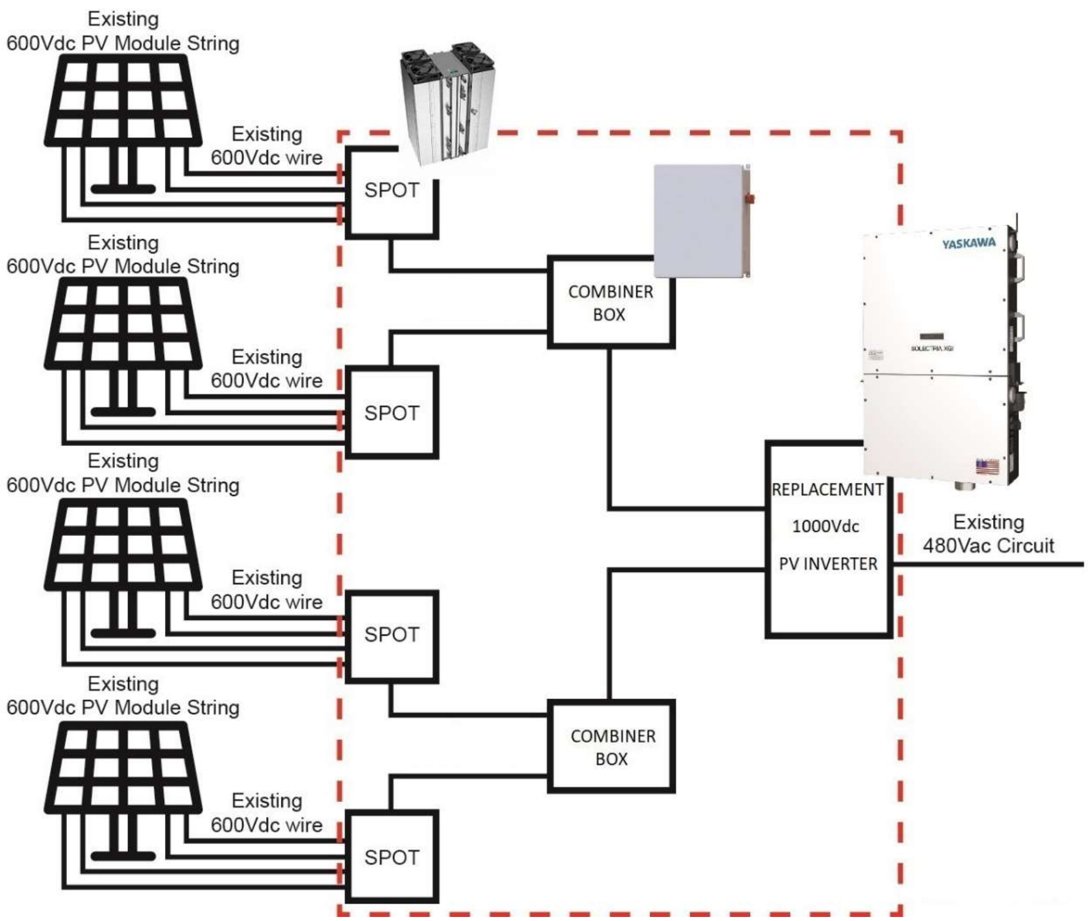

FIGURE 2: THE DIAGRAM ABOVE SHOWS HOW A PV ARRAY CAN BE REWIRED TO ACCOMMODATE THE REPLACEMENT OF A NEW, 1000-VOLT INVERTER. CREDIT: DIAGRAM CREATED IN COLLABORATION WITH YASKAWA SOLECTRIA SOLAR.

Thanks to the unique characteristics of the SPOT and how it can interact with transformerless string inverters, these benefits can be achieved with minimal field labor, allowing existing 600-volt conduit to remain in place.

This can be done as follows:

1. The SPOTs will take 600-volt PV strings into their input. You can input as many PV strings into each SPOT input as allowed by each input's maximum current rating.
2. While the input of the SPOT is grounded to the same grounding scheme of the existing PV array, the output is floating to make it compatible with the new transformerless inverter
3. The SPOT will step up voltage to preferred voltage of the inverter. For example, this could be 750 volts
4. As the new inverter is floating, or grounded in the middle, the SPOT will output (in this case) +375 through its positive output and -375 through its negative output, distributing voltage across the two conduits. Previously, because the system was grounded, all of the voltage was only stressing one of the conduits. With this approach, voltage will be distributed across both positive and negative, so even though the voltage has been stepped up, it will not exceed the insulation rating of the existing cable. This isn't bi-polar, but rather just floating.

5. This viability of this approach will depend on the configuration of the combiner box. However, because voltage is actually lower and current will be lower, most 600-volt combiners should be able to accommodate this change with relatively minor reconfiguration
6. This approach also assures that the replacement of the failed inverter itself is quite quick and easy

Installing SPOTs Behind the Combiner Box

Another approach to replacing failed inverters with SPOTs is to install SPOTs after the combiner box. In this approach. This approach can be particularly advantageous for rooftop systems where the PV is installed on the roof and the inverters are on the ground. In this approach, the SPOT units can be installed behind the plants' combiner boxes as shown below:

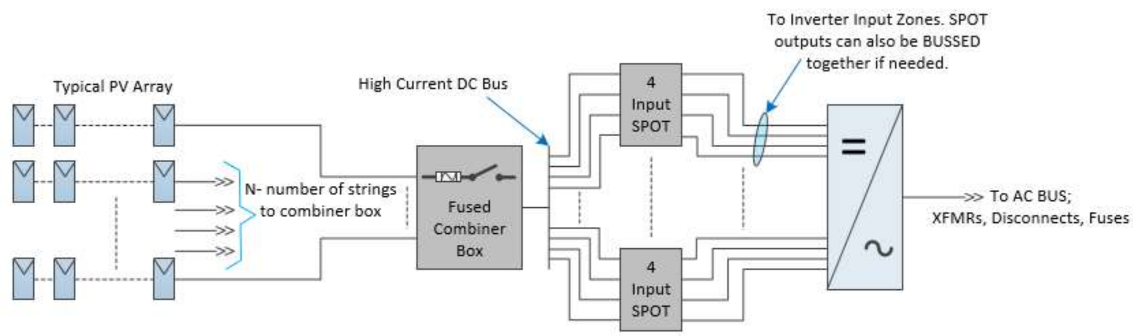

FIGURE 3: THE DIAGRAM ABOVE SHOWS HOW SPOTS CAN BE PLACED IN PARALLEL AFTER A COMBINER BOX TO FACILITATE THE REPLACEMENT OF A FAILED 600-VOLT INVERTER WITH A NEW INVERTER.

Inverter Replacement Projects – A Consultative Process

In both of the inverter replacement strategies explained above, a consultative approach needs be taken in concert with both the plant owner as well as the selected inverter supplier. Not all inverters can work in all cases and there could be variety tradeoffs, depending on the situation. What is important to understand is that inverter replacement is by definition a "retrofitting activity" where you are installing equipment into a plant that was not designed with the specifications of that equipment mind. You may need to make certain trade-offs between such factors as equipment cost and field labor.

Here at Alencon, we can offer guidance on the optimal approach for doing so. Additionally, we maintain close working partnerships with a number of leading inverter suppliers including such companies as Yaskawa Solectria Solar, SMA, ABB/Fimer, TMEIC, Ginlong Solis, GE, SIC (support arm for Satcon), Bold Renewables (support arm for Advanced Energy) and others so that we can team up to offer you collaborative solutions to extending the productive life of your PV array.