Transformerless Inverters: What you need to know

Background

As the US PV market continues its rapid growth, newer technologies are beginning to make their way into the market. KACO has recently launched ideally sized 6400 watt and 7600 watt transformerless inverters. Traditionally, PV inverters in the US have included transformers to provide galvanic isolation from DC to AC. The intent here is to prevent a DC sourced fault transmitting over to the AC circuit. These transformer based inverters typically use a grounded PV array where either the negative or positive current carrying conductor is grounded. (Note: only applicable for systems > or = 50Vdc.)

Ground Fault Protection

Grounded inverters accomplish the ground connection through the GFDI circuit. Article 690.5 requires that the GFP device or system shall be capable of detecting a ground fault current, interrupting the fault current and providing indication of the fault. This is done with the GFDI circuit and a fuse. Transformerless inverters use a resistive grounding method which can detect changes in ground current as low as 300mA. This can also be sensitive enough to detect faults many array technology types, including low current thin-film modules, which can be more challenging to detect leakage currents. In other words, transformerless inverters use a more advanced and robust ground fault detection method, which results in a safer PV system and reduces the chance of an arc related fire.

What is Ungrounded?

When discussing grounded arrays, it's important to discern what is described as a grounded array. Article 250 of the NEC dedicated to grounding. Grounding is the largest section, and one of the most confusing and detailed parts of the NEC related to photovoltaic installations. To further understand transformerless inverters a working knowledge of commonly used terms is helpful. Here are some of the most prevalent:

Ground:	The common point of Earth reference
Grounded conductor:	Either the positive or negative conductor that is bonded to ground, through the GFDI circuit on the inverter.
Equipment Grounding conductor:	The equipment grounding conductor that is physically and electrically bonding all metallic equipment together. May also be referred to as a "system ground".
Grounding Electrode:	Ground rod / Ufer ground / ground ring
Ungrounded:	This refers to PV systems that use Transformerless inverters, where there is no connection between DC positive or DC negative to ground.

KACO new energy.

Why now?

Transformerless inverters have been allowed since the 2005 NEC Code Cycle, in 690.35. A major inhibiting factor was the need for "double jacketed" PV wire / PV cable. These cables have not been available in the US until recently. Double jacketed wire offers additional protection to the conductor. This is important because the wire is no longer grounded. There were some early pioneers into the transformerless inverter space, but their products were unsuccessful in the market because of the double PV wire installation requirements of the NEC section 690.35. Some installers installed these units regardless of the requirement using PV Modules that did not use PV wire, while others literally installed conduit between the PV module junction boxes to comply with the NEC.

Why get rid of the transformer?

Removing the transformer reduces weight, cost and boosts efficiency. It's a different topology, commonly used around the world for PV installations. The adoption of this technology in the US has been slow. KACO plans to help further the use of the technology and will continue to share information with the industry.

Is it Safer?

A PV array that is ungrounded is safer than a grounded PV array. Once you bond either DC positive or DC negative to ground, you have created a potential for shock. When one of the conductors of the DC side of the system has been grounded, touching ground and the ungrounded conductor completes the circuit. This scenario allows the flow of current thereby creating the potential for a painful shock. An ungrounded array provides a system without voltage reference in relation to ground. Now the installer can touch either positive, negative and ground but not receive a shock. Ungrounded systems make for safer systems when installing, commissioning, troubleshooting and maintaining.

But wait, no grounding?

An ungrounded PV array still has equipment grounding. This means all PV module frames, racking, and anything metal will continue to have equipment/system grounding. Ungrounded only refers to the lack of connection between DC conductors and ground. Don't let this confuse you, when we are referring to ungrounded PV arrays, it's paramount that you understand the difference between equipment grounding and a grounded PV array.

Disconnects / Over current Protection

One major change with transformerless inverters is the aspect of DC over current protection. With a grounded PV array, the grounded conductor (typically DC minus) cannot be broken or switched. The ungrounded conductor requires over current protection according to NEC 690.9 when more than two strings are connected in parallel. In transformerless systems, both DC plus and DC minus are ungrounded, therefore over current protection is required for both conductors when multiple DC source circuits are connected in parallel.

Conclusion

Transformerless inverters offer better pricing, lighter weight, higher efficiencies, and a more efficient technology than galvanic isolated inverters (transformer based). There are some important installation changes regarding wire type and over current protection, otherwise, not much will change. The success of transformerless inverters may help pave the way for the NEC and the US Solar Industry to adopt 1000V systems, which will further reduce installation costs.

KACO new energy.