Improved Fire Safety for Commercial PV Systems

The commercial rooftop photovoltaic (PV) market is one of the largest segments of the solar industry, and these commercial PV systems contribute a rapidly growing percentage of electricity energy demands. Fires resulting from commercial rooftop PV systems are infrequent, but pose a concern for the solar industry. Two PV fires have gained significant industry attention. These occurred in Bakersfield, California on April 5, 2008 and in Mount Holly, North Carolina on April 16, 2011. Both of these fires had the same root cause due to a blindspot in commercial PV inverters that has been documented in industry literature.[1,2]

The Blindspot in Commercial PV Systems

The PV industry now recognizes that a blindspot exists in commercial PV inverter fault detection safety systems and is seeking solutions to fix this. A revision to the UL1741(Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources) standard that regulates PV inverters is currently being considered to eliminate the blindspot.

In the governing UL1741, current PV inverters are required to detect and respond to faults that can cause fires. A fault is a short between the conductor and earth ground. This protection is provided by GFDI (Ground Fault Detection and Interupt) fuses.

However, the existing regulations and inverter products have several issues that have been identified from the recent PV fires.

- Existing US commercial PV inverter systems can only detect for faults on the ungrounded conductor, but not on the grounded conductor. In the case of both of these fires, the PV system initially had a fault on the grounded conductor, which went undetected. By itself, the grounded conductor fault can not start a fire, but if an additional fault later occurs on the ungrounded conductor, the GFDI protection will not stop the current flow and a fire can occur. It is recommended that PV inverters need to detect for faults on both the grounded and ungrounded conductor.

- A secondary issue is that 100kW to 1MW commercial rooftop arrays typically use 100kW or larger commercial-scale inverters that have large GDFI fuses in the range of 5 Amps. These large fuses have low GDFI sensitivity. The sensitivity of the GFDI protection needs to be improved to the range of 300–500mA, typical of residential PV inverter systems.

Eliminating the Blindspot on Grounded Conductors

Ideal Power Converters (IPC), a developer and manufacturer of innovative electronic power converters, has already integrated a solution to this problem into its initial 30kW PV inverter product. Unlike many other industry proposed solutions, IPC's approach is available immediately and does not add any system cost to provide this additional fire safety protection.

Ideal Power Converters IPV-30kW-480 photovoltaic inverter provides fault detection on the grounded conductor that eliminates the blindspot.

A typical array configuration for the IPC inverter is shown in Figure 1. (Note: *Only trained professionals should design PV arrays and always refer to manufacturer datasheets.*) The system operates with a bipolar array configuration with matching postitive and negative arrays. Each array has a grounded conductor, but the ungrounded conductors have opposite polarity.

As illustrated in Figure 2, inside the inverter, both grounded conductors are connected together to a common 1 Amp GFDI fuse. Each grounded conductor has an electronic disconnect switch, which allows the system to lift or disconnect the grounded conductor. The electronic disconnect is normally open when control power is

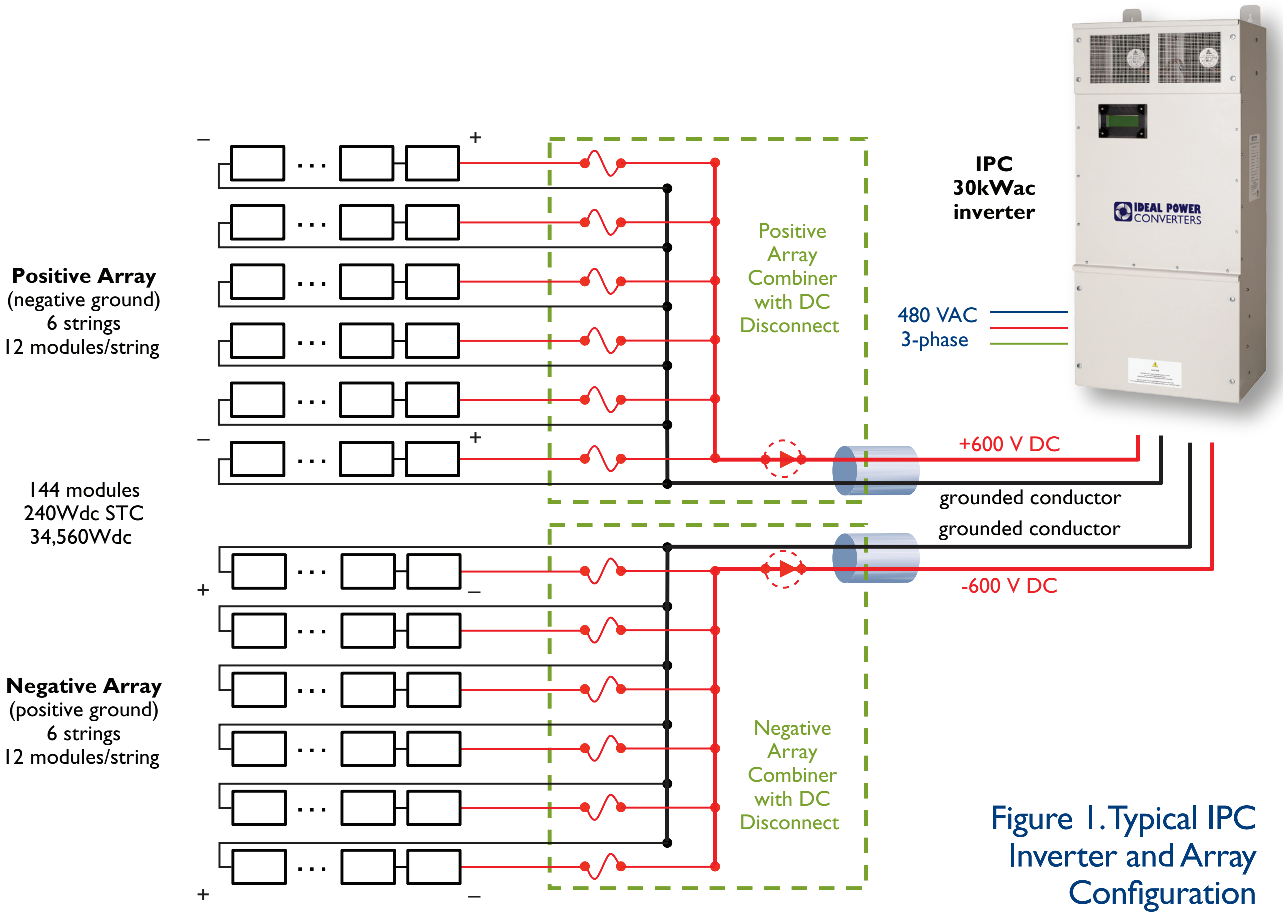

Figure 1. Typical IPC Inverter and Array Configuration

not applied. During the inverter power up sequence in the morning or whenever the inverter is restarted, the voltages on each grounded conductor are checked prior to closing this switch. If the voltage is abnormal a fault on the grounded conductor is detected. If this occurs the inverter will not start and a fault on the grounded conductor will be reported.

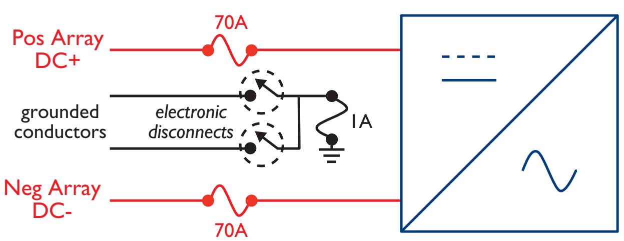

Figure 2. Disonnects on Grounded Conductors inside inverter

A detailed view of the inverter wiring compartment is shown in Figure 3. The electronic disconnects, fuses and connectors are clearly illustrated.

Increased GFDI Sensitivity

The inherent blindspot in commercial-scale PV inverters is more problematic due to the pratice of using 100kW or higher sized inverters with high DC currents and large GFDI fuses. 100kW PV inverters are frequently utilized in commercial rooftop arrays of 100kW to 1MW. These systems have DC input current to the inverter in the range of 200 Amps and DC fuses in the range of 300 Amps. GFDI fuses of 5 Amps are required to eliminate nuisance trips.

In the case of both fires, GFDI fault currents of 2–3 Amps occurred during the initial grounded conductor fault, but this was too small to trip the 5 Amp GFDI fuses. Reducing the relative size of the inverters is one approach to increase GFDI sensitivity and safety. 100kW to 1MW

1. AC fuse (50A)
2. AC fuse (50A)
3. AC fuse (50A)
4. AC ground
5. Ethernet
6. RS-485
7. DC ground
8. Neg Array DC- fuse (70A)
9. Neg Array grounded conductor
10. Neg Array grounded conductor
11. Pos Array DC+ fuse (70A)
12. Electronic Disconnect (2x)
13. GFDI fuse (1A)

Figure 3. Inverter Wiring Compartment

commercial rooftop PV arrays would be supported using a higher number of smaller inverters.

The IPC 30kW inverter accepts up to 50 Amps of DC current and has 70 Amp DC fuses. The GFDI fuse is only 1 Amp. The GDFI fault currents of the documented fires would have blown this small GDFI fuse. Furthermore, the IPC inverter has an additional current sensor on the GFDI fuse line. The GFDI current sensor has accuracy to the mA level, and provides a programmable soft trip point that further increases GDFI sensitivity. The default setting for the soft GFDI current limit is in the range of 300mA to 500mA and the GFDI current is shown on the inverter display.

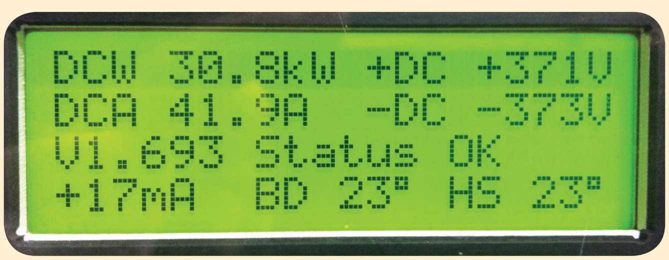

Figure 4. Inverter Display

Increased safety without additional cost or effort

The solar industry is rapidly maturing, and fire safety is one of the issues where the industry needs to respond to concerns. IPC has implemented an improved fire safety system that eliminates a blindspot in commercial PV inverters. IPC's solution is already running successfully in several commercial PV installations in the range of 30kW-200kW, and it can easily be scaled to larger arrays. This simple off-the-shelf solution to fire safety adds no additional cost to the inverter system or commercial PV installation.

REFERENCES

1. "The Bakersfield Fire, A Lesson In Ground Fault Detection", Bill Brooks, SolarPro February 2011

2. "Improving the Safety and Reliability of Commercial Solar Electric Systems, A Technical Paper by Southern Energy Management", Charles Ladd, 2011