IMPROVING PHOTOVOLTAIC SYSTEM SAFETY WITH TIGO ENERGY PV-SAFE™

The Tigo Energy® PV-Safe Feature

Tigo Energy Inc.
420 Blossom Hill Road
Los Gatos, CA 95032

COMPANY PROFILE

Tigo Energy, Inc.

Tigo Energy has revolutionized solar by developing a solution to the issue of energy loss from poorly performing modules in an array. Tigo Energy's solar optimizer allows systems to harvest the maximum amount of power available from PV arrays without losing energy due to shading, mismatch or other common issues. Like other distributed balance-of system (BOS) architectures, Tigo Energy optimizers extract energy from each module, virtually eliminating the negative effect of weaker modules on the rest of the PV array. However, the Tigo Energy products do so with unprecedented efficiency and accuracy, with very few incremental electronic components for maximum reliability and minimum cost. Tigo Energy optimizers are available as an add-on product for retrofits or new arrays, but can also be bought as a component of smart modules, integrated directly info the junction boxes of leading module manufacturers, further reducing part count and increasing the simplicity of this elegant solution. This paper will highlight the safety benefits of Tigo Energy system during installation, system operation, maintenance, and hazard detection.

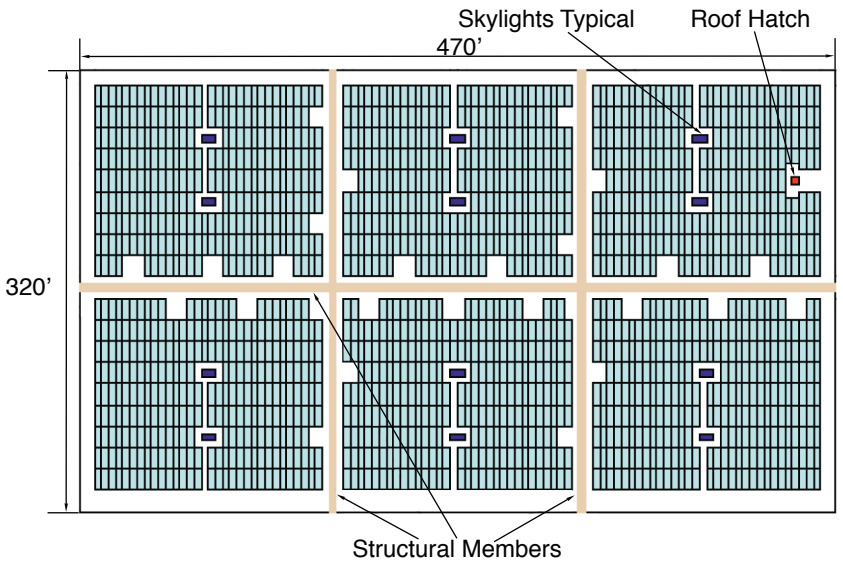
INTRODUCTION

Standard solar PV systems today have a reliable track record. With over 30 years of PV installations the industry has proven to be relatively safe. As the industry continues to expand, however, there is a growing call from building inspectors, insurers, and safety personnel to use state-of-the-art technology to navigate some of the known risks of these arrays. The most commonly expressed concern is the DC-bus, which is always charged with high voltage as long as there is sufficient irradiance on solar modules. This is true even after the DC disconnect is activated, as power will flow from the modules to the disconnect (see Figure 2). Due to the serial connectivity of the string, each module and cable (on the roof and through the structure to the inverter) can be carrying a lethal charge of up to 600V in the United States and 1000V in other parts of the world. The potential for arcing and electrocution from water hazards or disrupting a cable is a risk that has not been fully addressed in today's standard solar architectures. Furthermore, systems today are not fully equipped to detect arcing hazards and deactivate the system when such threats are detected.

In an attempt to address these issues, local building authorities are slowing approvals and requiring expensive "quick-release" racking systems which add a burden to the cost of solar installations. Some jurisdictions require additional offsets and walkways, which can greatly reduce the available surface area for a PV project (See Figure 1). Procedural solutions such as covering PV modules with tarpaulins are clumsy, time consuming and pose other dangers in windy conditions. Some inspectors are requiring roof-top disconnects, even on residential homes which adds expense and installation time to solar installations.

Tigo Energy's PV-Safe™ function provides another solution to address these issues. The Tigo Energy optimizer contains a small circuit distributed to each module that is able to "disconnect" each module from the interconnecting cabling, deactivating the array and limiting exposure to the open circuit voltage of an individual module (See Figure 2). The full system solution is known as the Tigo Energy PV-Safe feature.

Figure1: Commercial PV Rooftop Utilization Requirements by the City of Anaheim, Ca



Details of the Tigo Energy PV-safe implementation

Tigo Energy PV-Safe is implemented with elements contained within their solar optimizers (PV module electronics), Management Units, and software, providing a comprehensive safety solution. The implementation provides the protection, reliability and flexibility necessary to put emergency personnel, building owners, and insurers at ease.

The heart of the system resides at each PV module as circuitry on the optimizer. There are two components of the solution at the module, including the control logic and the voltage switch. This module-level control is considered essential for PV safety by some fire departments. In the "off" state, the voltage switch operates the module as an open circuit. This means that Voc (typically between 20 and 60V) of the module is present in the wiring from the junction box to the optimizer, however, no voltage or current flows from the optimizer to the DC-bus. In the module-integrated version of the Tigo Energy product, the voltage in the module leads while "off" will be 0V.

During operation in the "on" state the optimizer runs each module at Vmp (typically about 15 to 20% lower than Voc) and allows voltage and current onto the bus as in a normal solar installation.

Optimizers can be turned "off" via the management unit. The management unit provides a highly visible electrical contact switch integrated into the membrane on the front panel, protected by a NEMA 4 rated clear plastic cover (see FigureXX). The button is red and clearly marked "Power Off," it includes the symbol of a fire helmet, and is further labeled "use in case of an emergency." Other labels on the inverter or external disconnect switches can also indicate the presence of the PV-safe feature. Pressing this switch will enable on-site responders to deactivate all the cabling between modules and the inverters by turning the optimizers "off." The system can also be deactivated remotely through Tigo Energy's online software portal. A Tigo Energy equipped PV system is capable of being deactivated by a 9-1-1 operator even before fire fighters arrive at the site.

Once the on-site button is pressed or activated remotely, the management unit sends a signal to each optimizer on the array communication network (either DC power line or wireless) to turn off. This deactivates the central bus. The management unit then visibly displays that PV-Safe has been activated. The system cannot be reactivated remotely; this ensures the system is not accidentally turned on while someone can be exposed to voltage.

Figure 2: Tigo Energy Management Unit

In the event of an AC outage, the system will automatically default to turn the optimizers off. This means that if a firefighter deactivates the breakers, PV-Safe automatically initiates without the pressing the button or activating through the remote software. When the AC comes back on the system will automatically reboot (this prevents the need to manually restart the system whenever AC power goes down). If, however, the PV-Safe function is activated before the AC outage, the system will need to be manually turned back on after AC power comes back.

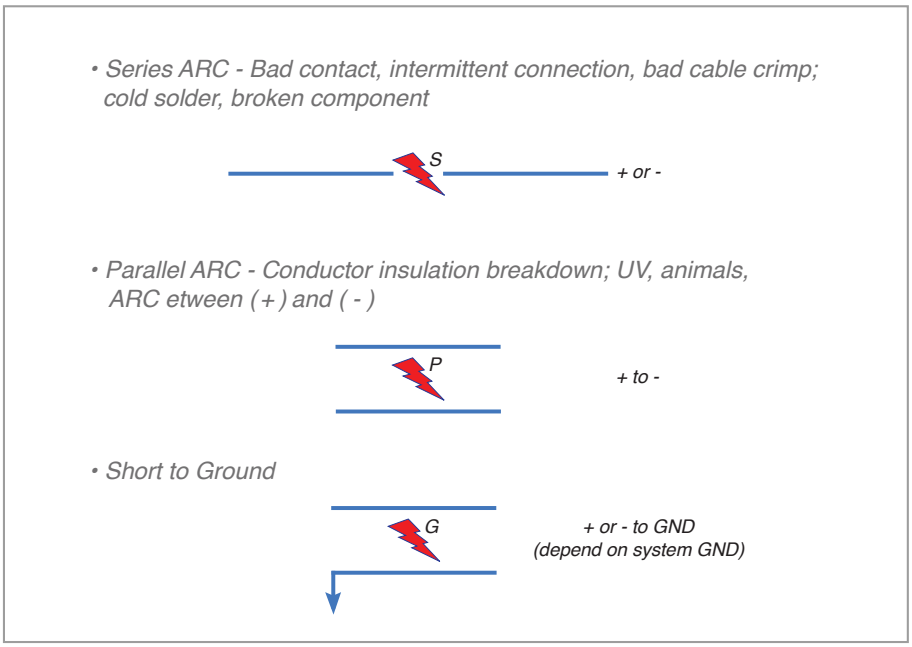
When a system is reactivated PV-Safe turns the optimizers on in programmed stages to bring system voltage up slowly and evenly. This prevents voltage surges and spikes that can cause longevity issues with modules and inverters. This function can also be used by installers at system startup as a new best-practice to improve the wake-up function of the inverter and prevent accidental damage to system components. (see Figure XX)

Arcing

Arcing is not common in solar installations; however it has been attributed as the cause to several fire-related issues on commercial PV systems. Arcing occurs in three forms (see figure XX): series arcs (from a bad contact in + or -), parallel arcs (from insulator break down + to -), or a short to ground (+ or – discharge to ground). The danger from arcing is that if an arc continues undetected its heat can cause combustion. Arcs are often in excess of XX degrees F.

When Tigo Energy's PV-Safe functionality is paired with the String-Level Arc Detector, arcing on a PV system can be safely detected and deactivated automatically at the module-level. When an arc is detected the optimizers turn off to isolate the impacted section of the PV-array. An alert is then sent to the facility manager and whomever else the user designates. These alerts can be sent via email, text message, or phone. Alerts can also be sent to security systems and building management systems.

Figure 3:



Safety Features

Remote shut-off – Systems can now be shut off remotely in the event of an emergency. This can be enacted via the monitoring portal or at the management unit.

Single panel short-circuit – The control circuitry in each optimizer can detect a short- circuit and will automatically remove the module from the string. An alert will immediately be sent to facilities managers and owners to remove the faulty module.

Over Voltage, Current, Temperature – Whenever a Tigo Energy optimizer detects and unsafe voltage, current or temperature, it will automatically shutoff power out of that panel to eliminate risks.

Arc prevention during short-circuit – In the unlikely case of arcing the Tigo Energy PV- Safe feature detects and halts arcing by immediately turning all optimizers “off” and eliminating voltage from the shorted string.

Alerting – Even if a fault condition can be detected in the system and module or string deactivated, if it is left unnoticed by the system operator, energy production suffer significant loss. Tigo Energy software recognizes and diagnoses the fault condition, color-codes the affected modules to red in the system power map and alerts the system administrator immediately by his/her chosen method (text, email, etc.).

Conclusion

As photovoltaic installations become more prevalent and produce a greater percentage of urban and suburban energy needs, it will become critical that PV systems continue to be safe sources of power generation. Regional procedures for design, installation, operation and emergencies should be in place to provide for the safest possible use of PV energy. As the industry refines these procedures, it is also important that solutions are economically viable, easy to install and accelerate the adoption of solar power generation. As part of a comprehensive project design for safety, the Tigo Energy PV-Safe technology will enhance system safety and reduce the need for more costly or complex physical alternatives. Please see www.tigoenergy.com for more information on the Tigo Energy optimizer system.