TIGO ENERGY PV-SAFE™

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INTRODUCTION

Over the last 30 years, standard solar PV systems have proven to be a clean, safe way to produce power. With electricity, however, there are always safety risks. As the solar industry continues to expand, there is a growing call from building inspectors, insurers, and safety personnel to use state-of-the-art technology to mitigate the known risks of these arrays.

The DC-bus is one of the main safety concerns because it is charged with high voltage as long as there is sufficient irradiance on solar modules. In a standard array this is true even after the DC disconnect is activated because PV modules still carry open circuit voltage and are connected in series. Due to the serial connectivity of the string, each module and cable can be carrying a lethal charge of up to 1000V (or 600V in North America). Systems today are not fully equipped to detect solar safety hazards.

Tigo PV-Safe™ provides enhanced safety through on-site manual or automatic module-level disconnect. In PV-Safe mode, every module output drops to zero watts and zero voltage. This revolutionary disconnect provides installers, firefighters, and maintenance personnel absolute certainty that no high voltage is present.

PV-Safe Supporting Hardware Versions

MM-ES Optimizer
v4.00 and up

MM-2ES Dual Optimizer

JES Junction Box

TS4-S, TS4-O, TS4-L

PV-Safe Activation

PV-Safe can be manually activated on-site, or automatically triggered when a safety hazard is detected. Tigo performs dual micro-level automatic detection of potential threats and macro-level risk analysis and control commands.

The Tigo power electronics, whether embedded in smart modules or retrofitted to an array, enter PV-Safe mode by disconnecting the PV module from the interconnecting cabling. PV-Safe shuts off the array at the module level and limits voltage exposure to the open circuit voltage of an individual module. This means that PV module open circuit voltage (typically between 20V and 60V) is present in the wiring from the junction box to the add-on optimizer, however, no voltage or current flows from the optimizer to the DC-bus. With a smart module, TS4-L, TS4-O or TS4-S, the voltage in the PV module leads is 0V when PV-Safe is activated.

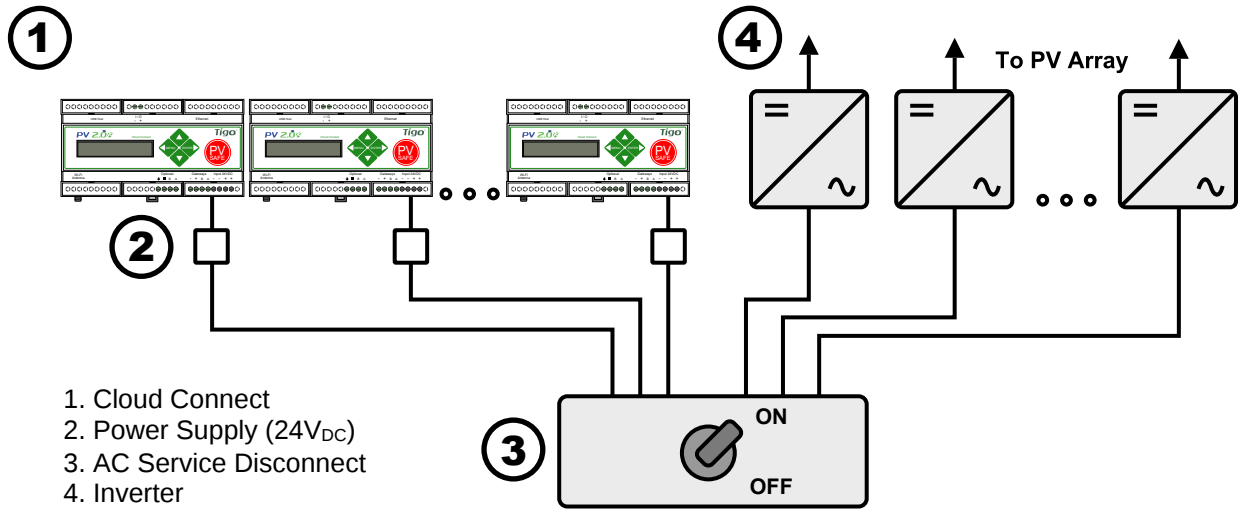
PV-Safe can be activated in case of emergency, maintenance, or any other reason requiring personnel to walk through the array. Whenever it activates, an alert is generated and sent to the facility manager and whomever else the user designates. These alerts can be sent via email or text message. Alerts can also be sent to security systems and building management systems. Using the online “Admin” tab on the installation page of the Tigo Asset Management Software, the home owner and installer can subscribe to the alert system.

AC Breaker Deactivation

In the case of an emergency such as a fire, firefighters routinely shut down the building's AC mains supply and/or breaker to the facility upon arriving on-site, and before attempting to contend with the fire or hazard.

For PV systems equipped with Tigo Energy's TS4 smart modules incorporating PV-Safe, no other action is required in order to make sure DC string voltage drops to $0V_{DC}$. Note that In the event of an AC grid outage, the system will automatically default into PV-Safe mode. This important operation is designed to reduce the amount of time needed for firefighters to shut down solar DC system power. Instead of searching for additional DC ground-mounted or roof-mounted isolators, emergency personnel can rest assured with Tigo TS4 PV-Safe operation that once the building's AC is disconnected the solar array's DC voltage is off as well.

Sample System Installation



By connecting the Cloud Connects and inverters to the same AC main service, you can ensure that the entire system will be de-energized when the breaker is turned off. The system will automatically enter PV-Safe mode when the inverters and Cloud Connects are switched off within the same minute.

As long as the AC breaker is off, PV-Safe will keep the modules off throughout the entire installation, including strings and homeruns. Only once the AC breaker is switched on again will the units see the inverter tracking for maximum power point and reactivate the system. The TS4 modules with PV-Safe will wake up and resume normal power production without the need for any direct user interface.

Please note: if the PV- Safe function was activated manually before the AC outage occurred, the system will need to be manually turned back on from the Cloud Connect unit (MODULES ON command) after AC power is restored.

Module-Level Hazards Detection

Tigo Energy’s TS4 optimizers are constantly measuring module-level current, voltage, and temperature. If a safety hazard is detected such as overvoltage or high thermal temperatures, the Tigo Energy TS4 optimizer will immediately switch off and will communicate the potential hazard to the Cloud Connect. The Cloud Connect unit will trigger PV-Safe for the module, string, or entire system if required.

Tigo Energy’s high resolution monitoring provides quick and accurate detection of potential hazards, while ensuring maximum protection for the array.

Conclusion

PV systems are a clean, green, and safe way to produce energy and should not be feared. However one must not forget that electricity and power should be handled properly. You can protect your system with a module level DC disconnect that ensures the strings are charged with zero volts while personnel are working on or near the array. With Tigo's PV-Safe, strings and modules can be easily disconnected, safety hazards can be detected, and dangerous situations can be avoided. Tigo provides the ultimate safety for your array while delivering all of the additional benefits of optimization and module-level monitoring.

COMPANY PROFILE

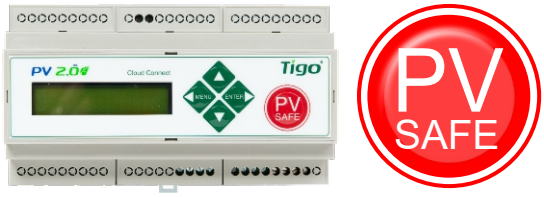
Tigo Energy, Inc.

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 into 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.

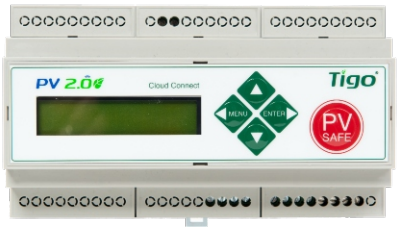
Annex: PV-Safe Operation
Manual Activation from Cloud Connect

To activate PV-Safe manually:

1. Press PV-Safe button on front panel of the Cloud Connect.



2. Verify module status on Cloud Connect LCD or measure with a voltmeter.



Manual Activation of PV-Safe Requires Manual Restoration of Module Power

To re-energize a system in PV-Safe mode:

From the front panel of the Cloud Connect:

1. Press **MENU** and **ENTER**. **1. Status** should be displayed on the screen.
2. Press the **DOWN** arrow. **2. Control** should be displayed on the screen. Press **ENTER**.
3. Press the **DOWN** arrow twice so that **2.2. Modules ON** is displayed.
4. Press **ENTER** to select **Modules ON** and then **ENTER** again to confirm.

Note: Pressing the PV-Safe button a second time will not re-energize the system.

Annex: National Electrical Code 2014 690.12
Rapid Shutdown Of PV Systems

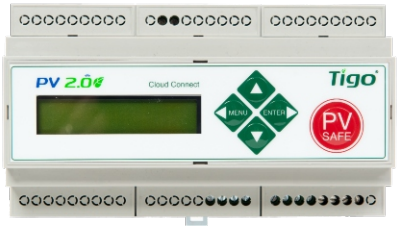
To activate Rapid Shutdown:

1. Switch off AC disconnect
(with Cloud Connect installed on same
AC main panel as inverter.)

2. If your inverter is *not* RSS compliant,
switch off the DC disconnect(s) as well.

PHOTOVOLTAIC SYSTEM EQUIPPED WITH RAPID SHUTDOWN

3. Cloud Connect LCD will be blank until AC
power is restored. Module output can be
tested with a voltmeter.



When PV-Safe is initiated (Rapid Shutdown):
String voltage across the PV array and conductors will drop lower than 30V within 10 seconds.

To re-energize a system after Rapid Shutdown:

Switch on AC disconnect to restore
power to Cloud Connect and inverter.
System will resume operation.