



TIGO ENERGY PV-OFF™

Improving PV Safety
with PV-OFF™ for Rapid Shutdown

Introduction

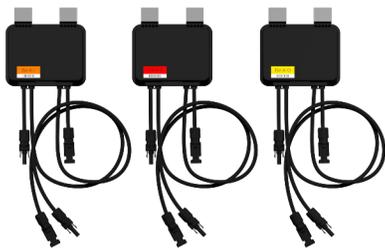
Safety requirements and hazard controls are on the rise for PV systems across the globe. From design regulations to installation best practices, installers are being held to a higher standard for safety as the solar market progresses. Solar equipment - including module-level power electronics (MLPE) - is helping to mitigate the known risks of these arrays.

PV modules are charged with high voltage when exposed to the sun, which is the primary safety concern for installers and other personnel working near the array. 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 charge of 600V, 1000V, or even 1500V, depending on the maximum system voltage allowed. Systems today are not fully equipped to detect PV safety hazards without specialized hardware.

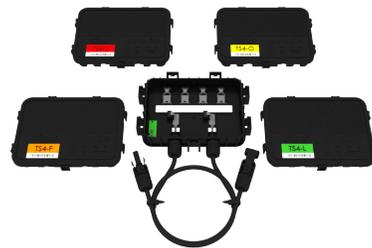
Although the USA currently has the strictest solar electric codes, other countries are quickly following with similar requirements to protect solar assets and system owners. Tigo is the only UL-certified multivendor module-level rapid shutdown solution that meets the latest requirements.

Tigo PV-Off™ provides enhanced safety through on-site manual or automatic module-level disconnect. In PV-Off mode, each module output drops to 0W and 0V (or 0.6V per unit for TS4-F.) This revolutionary disconnect provides installers, firefighters, and maintenance personnel absolute certainty that no high voltage is present.

Module-Level Hardware with PV-Off



TS4-A-F, TS4-A-S, & TS4-A-O



TS4-F, TS4-S, TS4-O, & TS4-L

PV-Off can be manually activated on-site, or automatically triggered by certain conditions like AC grid loss.

The Tigo power electronics can be integrated in smart modules or installed as an add-on with standard modules and enter PV-Off mode by disconnecting the PV module from the interconnecting cabling. PV-Off shuts off the array at the module level and limits voltage exposure to the open circuit voltage of an individual module.

PV-Off 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 system manager and whomever else the user designates. These alerts can be sent via email or text message.

TS4-A-F, TS4-A-S, TS4-A-O, TS4-F, TS4-S, TS4-O, TS4-L, TS4-R-F, TS4-R-S, TS4-R-O, and TS4-A-2F are UL-certified as a rapid shutdown solution when installed as directed and are compliant with NEC 2014 and 2017 690.12 rapid shutdown requirements.

AC Breaker Deactivation

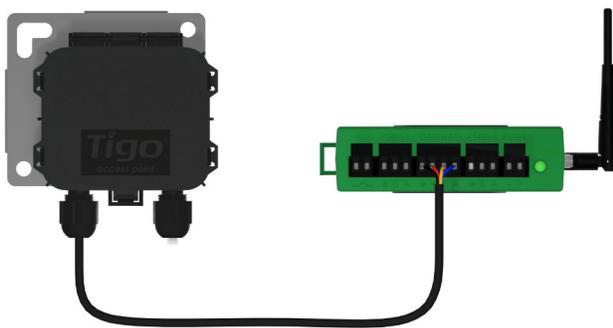
In the case of an emergency such as a fire, first responders routinely shut down the building's AC mains supply and/or breaker to the facility upon arriving on-site, and before attempting to contend with the fire or hazard.

For PV systems equipped with TS4 smart modules incorporating PV-Off, no other action is required in order to make sure DC string voltage drops to $0V_{DC}$ (or $0.6V_{DC}$ for each TS4-F unit). Note that in the event of an AC grid outage, the system will automatically default into PV-Off mode. This important operation is designed to reduce the amount of time needed for firefighters to shut down DC system power for the array. Instead of searching for additional DC ground-mounted or roof-mounted isolators, emergency personnel can rest assured with Tigo TS4 PV-Off operation that once the building's AC is disconnected the PV array's DC voltage is off as well.

By connecting Tigo's Cloud Connect Advanced (CCA) or RSS Transmitter to the same AC main service as the inverter, you can ensure that the entire system will be de-energized when the breaker is turned off. The system will automatically enter PV-Off mode when the CCA or RSS Transmitter is switched off.

While the AC breaker is off, PV-Off will keep the modules off throughout the entire installation, including strings and home runs. When the AC breaker is switched on again the units will receive the keep-alive signal from the RSS Transmitter or CCA & TAP and the system will reactivate. The TS4 modules with PV-Off will wake up and resume normal power production without the need for any direct user interface.

PV-Off Activating Hardware



TAP and CCA
for Flex MLPE



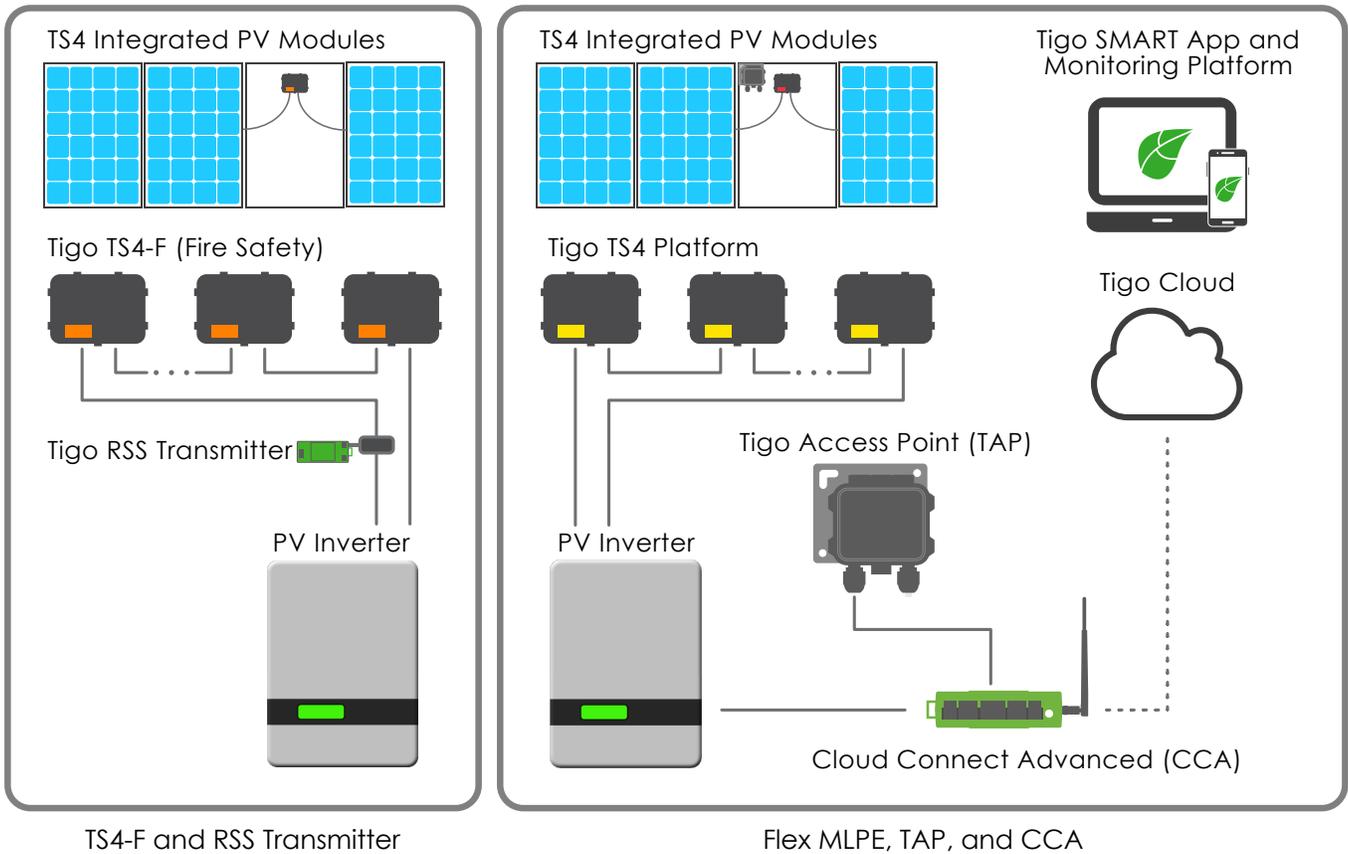
RSS Transmitter
for TS4-F

The CCA and TAP supply the keep-alive signal for the TS4-S, TS4-O, TS4-L (integrated), TS4-A-S, and TS4-A-O (add-on) units. The CCA also enables module-level monitoring via the Tigo SMART website and app.

The RSS Transmitter supplies the keep-alive signal for the TS4-F (integrated), TS4-A-F (add-on), and TS4-A-2F (add-on for two modules.)

Refer to the installation manuals for complete instructions.

Sample System Installation



Module-Level Hazard Detection

TS4 units with wireless communication are constantly measuring module-level voltage and current. If a safety hazard such as overvoltage or overcurrent is detected, the TS4 unit will switch off at the module level and communicate the potential hazard to the TAP and CCA. Tigo's Ultra High Definition monitoring provides quick and accurate detection of potential hazards while ensuring maximum performance for the array.

Conclusion

PV systems should be designed, installed, and monitored with safety in mind. However, due to evolving equipment, changing regulations, and unforeseen risks, additional safety technology is always a good idea. Tigo's PV-Off™ enhanced safety through on-site manual and automatic module-level disconnect protects your assets throughout your PV system's lifetime. Strings and modules are easily disconnected, voltages are controlled, safety hazards are detected, and dangerous situations are avoided. Tigo provides this revolutionary disconnect and helps keep systems safe so you can focus on the PV benefits and return on investments.

Learn more at www.tigoenergy.com.

Tigo Energy, Inc.

Tigo® is a Silicon Valley company founded in 2007 by a team of experienced technologists. Combining a unique systems-level approach with expertise in semiconductors, power electronics, and solar energy, the Tigo team developed the first-generation Smart Module Optimizer technology for the solar industry. Tigo's vision is to leverage integrated and retrofitted Flex MLPE (module-level power electronics) and communications technology to drive the cost of solar electricity down. By partnering with tier 1 module and inverter manufacturers in the industry, Tigo is able to focus on its key innovation with the smartest TS4 modular platform and leverage the broader ecosystem. Tigo has operations in the USA, across Europe, Japan, China, Australia and the Middle East.

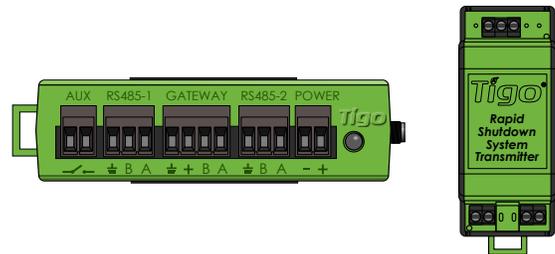
Annex: National Electrical Code 690.12 Rapid Shutdown of PV Systems

To activate Rapid Shutdown:

1. Switch off AC disconnect (with CCA or RSS Transmitter installed on same AC main panel as inverter.)



2. LED on CCA or RSS Transmitter will be unlit until AC power is restored. Module output can be tested with a voltmeter.



When PV-Off 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 CCA or RSS Transmitter and inverter. System will resume operation.

