Tigo®

Troubleshooting Guide

TS4-F, TS4-R-F, TS4-A-F and
RSS Transmitter

IMPORTANT SAFETY INSTRUCTIONS

LETHAL VOLTAGE MAY BE PRESENT IN ANY PV INSTALLATION

SAVE THESE INSTRUCTIONS

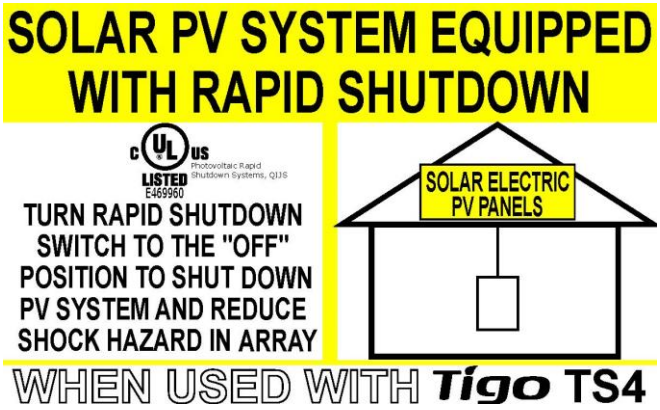
- This manual contains important instructions for installation and maintenance of the Tigo Energy® ("Tigo") product models TS4-F, TS4-R-F, TS4-A-F and the RSS Transmitter.
- Risk of electric shock, do not remove cover, disassemble, or repair, no user serviceable parts inside. Refer servicing to qualified service personnel.
- Before installing or servicing the Tigo system, please read all instructions and warning markings on the Tigo products, appropriate sections of your inverter manual, photovoltaic (PV) module installation manual, and other available safety guides.
- Failure to adhere to these instructions may result in injury or death, damage to the system or voiding the factory warranty.
- To reduce risk of fire and shock hazard, install this device with strict adherence to National Electric Code (NEC), ANSI/NFPA 70 and/or any other local electrical codes. When a photovoltaic array is exposed to light, it supplies DC voltage to the Tigo TS4 units. TS4 units that are of models TS4-D, TS4-M, TS4-R-M, TS4-R-M-Duo, TS4-A-M, TS4-S, TS4-R-S, TS4-R-S-Duo, TS4-A-S, TS4-O, TS4-R-O, TS4-R-O-Duo, TS4-A-O, TS4-A-O-Duo, and TS4-L start in "**ON**" state and, when connected to a module, the output voltage may be as high as the PV module's open circuit voltage (V_{OC}). An installer should use the same caution when handling electrical cables from PV modules with or without TS4 units attached.
- Installation, service and maintenance must be performed by trained professionals only. Tigo does not assume liability for loss or damage resulting from improper handling, service, installation, or misuse of products.
- Remove all metallic jewelry prior to installing the Tigo TS4 units to reduce the risk of contacting live circuitry. Do not attempt to install or service in inclement weather.
- Do not operate the Tigo TS4 units if they have been physically damaged. Check existing cables and connectors, ensuring they are in good condition and appropriate in rating. Do not operate Tigo TS4 units with damaged or substandard wiring or connectors. Tigo TS4 units must be mounted on the high end of the PV module back sheet or racking system, and in any case above ground.

Do not connect or disconnect under load. Turning off the Inverter and/or the Tigo products may not reduce this risk. Internal capacitors within the inverter can remain charged for several minutes after disconnecting all power sources. Verify capacitors have discharged by measuring voltage across inverter terminals prior to disconnecting wiring if service is required.

IMPORTANT SAFETY INSTRUCTIONS

Continued…

- TS4-F, TS4-R-F and TS4-A-F are shipped in the "**OFF**" position and will measure 0.6V at the output when no keep-alive signal is present. Always assume TS4 units are in "**ON**" state, or may turn on when restarting.
- Beware that Tigo TS4-F, TS4-R-F and TS4-A-F units do not go to safe mode unless the communication is down, i.e. RSS Transmitter is turned OFF.
- Failing to follow the sequence of installation, connection or disconnection steps may result in TS4 unit damage not covered under warranty.
- Power off the RSS Transmitter before disconnecting all TS4-F, TS4-R-F or TS4-A-F units.
- Disconnect all TS4-R-F or TS4-A-F outputs in series before disconnecting the TS4-R-F units from their respective PV modules.
- Never apply an external voltage source to equipment with TS4-F, TS4-R-F or TS4-A-F units.
- If parallel string connections are present, first turn off the RSS transmitter(s) and disconnect strings with modules or TS4 units to be checked from the other parallel strings. Next, disconnect the TS4-R-F or TS4-A-F outputs from each other, and only then disconnect the TS4-R-F or TS4-A-F from the PV module.
- It is recommended not to mix between TS4-F products to TS4-S, TS-O or TS4-L.
- Make sure Rapid Shutdown System label is placed no more than 1m (3ft) from initiator (AC disconnect) or service panel containing means of disconnection if not at same location.



Rapid Shutdown System label to be placed in proper location

The transmitter control power supply MUST be on the same AC branch circuit as the inverter to meet rapid shutdown requirements.

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1. SYSTEM OVERVIEW

1.1 RAPID SHUTDOWN SYSTEM

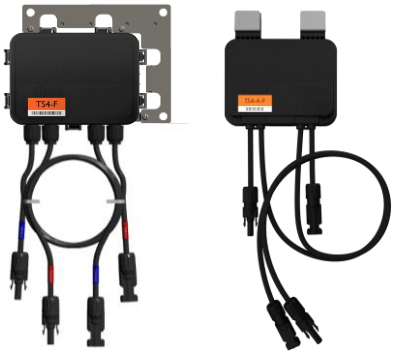
Module Level Power Electronics

- NEC 2017 690.12 Rapid shutdown compliant
- Module-level deactivation
- Plug & play, no configuration required
- PLC communication, Sunspec signaling

TS4-F

- Module level power electronics (MLPE) are contained in the junction box, installed at the PV module factory.
- Connected in series like regular modules.
- No additional wiring connections to make.

TS4-R-F or TS4-A-F



- Bracket clips to module frame without tools.
- TS4-R-F and TS4-A-F outputs are connected in series to form a string.
- No additional grounding required.
- MLPE are external to the module.

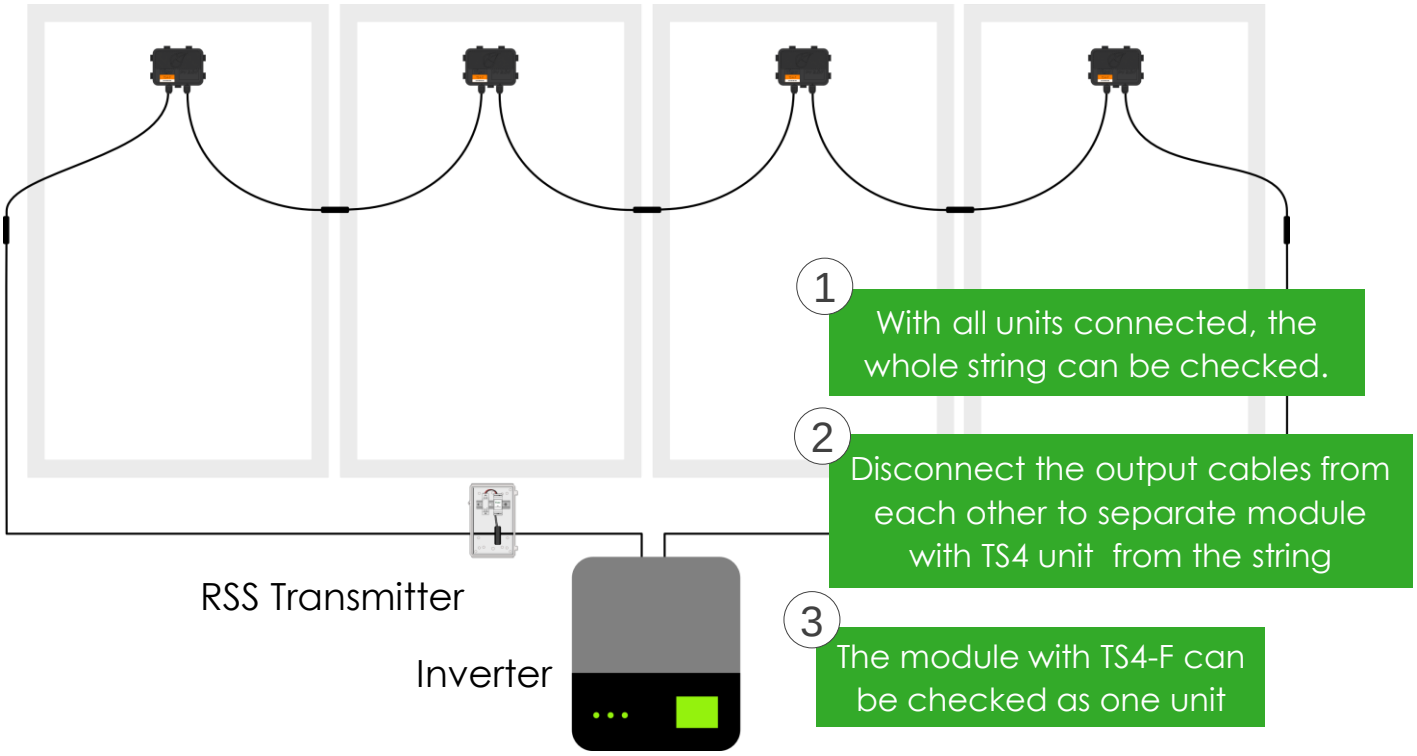
RSS Transmitter

- Rapid Shutdown System transmitter for rapid shutdown activation of TS4-F or TS4-R-F units.
- The external device that provides a keep-alive signal to the TS4-F device via Power Line Communication.

1.2 SYSTEM CONFIGURATIONS

1.2.1 TS4-F (PV module integrated)

TS4 Smart Module
Powered by Tigo

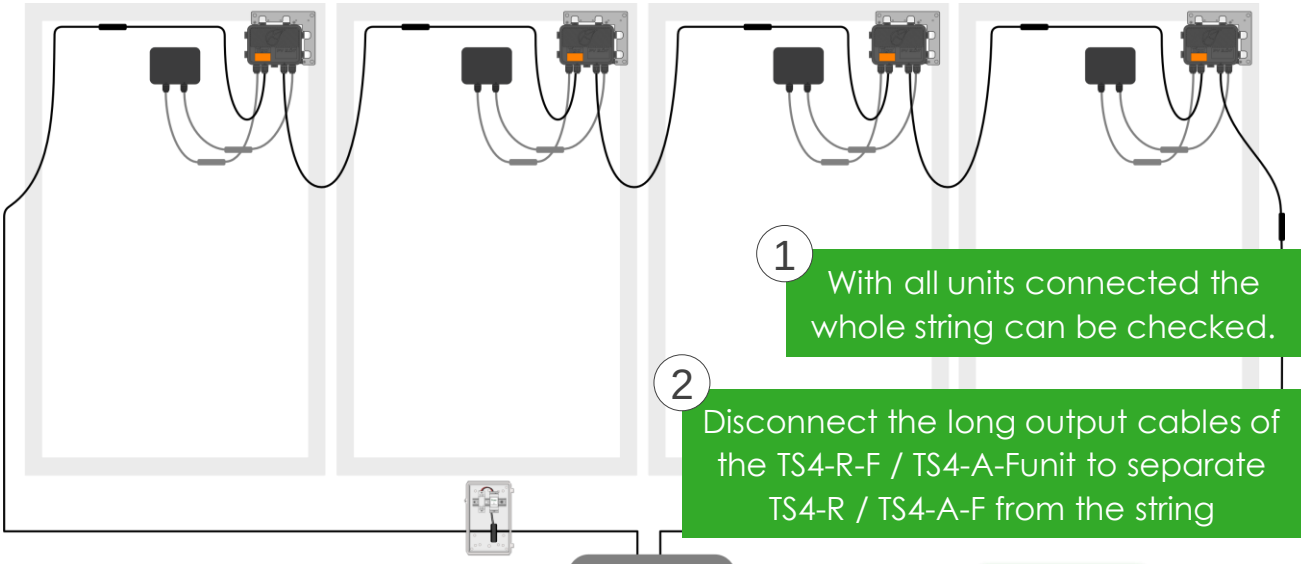


Smart modules with an integrated TS4 Junction box installed in series are disconnected just like standard PV modules.

Power off the RSS Transmitter before disconnecting modules with TS4-F in series

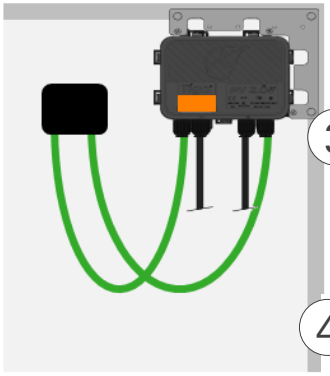
1.2.2 TS4-R-F and TS4-A-F (add on/retrofit)

TS4-R-F / TS4-A-F Retrofit, Add-on
Powered by Tigo



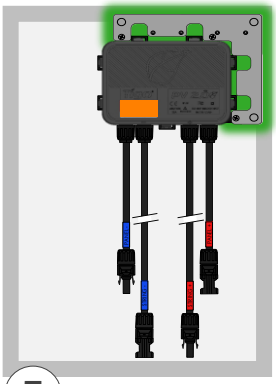
1 With all units connected the whole string can be checked.

2 Disconnect the long output cables of the TS4-R-F / TS4-A-Funit to separate TS4-R / TS4-A-F from the string



3 The TS4-R-F / TS4-A can be checked with the module connected.

4 Disconnect the short leads of the TS4-R-F / TS4-A from the PV module



5 The TS4-R-F / TS4-A unit and the PV module can be checked individually

Note:

- **TS4-R / TS4-A outputs must be disconnected from other TS4-R / TS4-A outputs BEFORE disconnecting the modules!**
- **Modules must be reconnected to TS4-R / TS4-A inputs BEFORE reconnecting TS4-R / TS4-A outputs!**

1.3 RAPID SHUTDOWN OPERATION

Communication Protocol

One way of fulfilling the Rapid Shutdown requirement of the NEC 2017 690.12 is a protocol for Power Line Communication (PLC) defined by the SunSpec Alliance. TS4-F, TS4-R-F and TS4-A-F comply with this protocol.

Method of Operation

TS4-F, TS4-R-F and TS4-A-F units start in the OFF position and measure 0.6V at the output. Upon connection to the Tigo RSS Transmitter or other SunSpec-compliant PLC transmitter (or "initiator"), the units turn ON, allow full PV module voltage to pass to the string, and enable energy production.

The units constantly receive a 'keep-alive' or 'heartbeat' signal from the transmitter over PLC. When power to the initiator is cut or the signal is interrupted, e.g. when wiring is damaged, this keep-alive signal vanishes, sending all TS4-F, TS4-R-F and TS4-A-F into shutdown mode, separate the module from the string, and reduce the output voltage to 0.6V.

DO NOT make any changes on the DC side until 30 seconds after shutdown has initiated.

After the keep-alive signal is re-established, shutdown mode is disengaged; turning ON TS4-F, TS4-R-F and TS4-A-F, reconnecting the PV modules to the string, restoring full PV module voltage. Normal operation can then resume.

2. TROUBLESHOOTING 101

2.1 STEP-BY-STEP GUIDE - PREREQUISITE

This chapter will give you a step-by-step guide on how to service a Rapid Shutdown System with issues related to a TS4-F, TS4-R-F, TS4-A-F unit, and/or a Tigo RSS Transmitter.

Troubleshooting this kind of system will require basic system knowledge and the ability to measure voltage from the service technician.

2.2 GENERAL SERVICE GUIDELINE

Before and during all service or maintenance activities on a solar array, the service technician should constantly look for visible equipment damage. Any physical damage on PV modules, wires, connectors or MLPE units, should be checked for and acted upon.

Whenever damage is encountered on an MLPE unit, please take clear pictures of the unit. The serial numbers should be legible and the damage visible.

2.3 SYSTEM COMPONENTS

The following system configuration questions should be answered before starting service and troubleshooting activities:

Was the system configured with Tigo Smart Modules (TS4-F integrated) or with Tigo Retrofit units (TS4-R-F or TS4-A-F)?

Does the system utilize the Tigo RSS Transmitter, or a different (non-Tigo) RSS transmitter?

All RSS Transmitter related troubleshooting steps in this guide refer to the Tigo RSS Transmitter, whether stand alone, or installed inside the combiner box or inverter. If a non-Tigo transmitter is deployed, please refer to the manufacturer's manual for service information.

2.4 POTENTIAL ISSUES

2.4.1 String has no DC voltage (0.0V)

Issue 1	String has no DC voltage (0.0V)
Description	TS4-F, TS4-R-F and TS4-A-F should pass 0.6 V per unit when the string is not connected to an active transmitter. If the output voltage is measured at **0.0V** on a string, there is an open circuit condition. This is most often caused by a wiring issue within the string.
Troubleshooting	
Step 1	Verify the string has been correctly disconnected from the inverter and any parallel strings before the individual string voltage is measured.
Step 2	Perform a visual inspection of the modules, TS4 units, wiring, and connectors. Check if all equipment is connected properly.
Step 3	Apply standard electrical tests to localize the potential open circuit condition.
Step 4	Should the source for the open circuit condition be located within a TS4-F integrated module, go to section 2.4.2, '*TS4-F Module has no DC Voltage (0.0V)*'. Should the source be located within a TS4-R-F or TS4-A-F unit, go to section 2.4.3, '*TS4-R-F / TS4-A-F has no DC Voltage (0.0V)*'.

2.4.2 TS4-F Module has no DC Voltage (0.0V)

Issue 2	TS4-F integrated Module has no DC Voltage (0.0V)	
Description	An integrated TS4-F unit should pass 0.6V when connected to a PV module and the string is not connected to an active transmitter. If an output voltage of 0.0V is measured on a TS4-F integrated module, a connection problem between the junction box base and the cover might be present. It is also possible that the unit is running into a high current or over temperature event.	
Troubleshooting		
Step 1	Check whether the problem is present in adjacent PV modules. If yes, the issue is likely to do with high current and standard test procedures should be taken to verify the integrity of the circuit, string, and isolators. Once the short or leakage is detected and fixed, TS4-F unit will resume normal operation.	
Step 2	Verify that the TS4-F cover is properly installed onto the junction box base. If not, please address, then proceed. Take a clear picture of the cover with the serial number visible. Shut down the system and disconnect the output leads of the unit. • If 0.6V is read after 30s, please review your system. • If the output is still 0V after 30s, please proceed with the troubleshooting guide.	*Note: these actions require Tigo approval! Contact Tigo support before proceeding* *For detailed instructions see section 3.2.1*
Step 3	Remove the TS4-F cover from the base using the Tigo Key.	*For detailed instructions see section 3.2.1*
Step 4	Take clear pictures of the inside of the cover and the entire inside of the base from above noting any bent pins or other damage. Also, measure and record the voltages between the four clips in the base.	*For detailed instructions see section 3.2.1*
Step 5	Swap the cover with another cover known to be working fine. • If the functioning cover also has issues once swapped, it is a base/module problem. • If the functioning cover is still fine once swapped, it is an issue with the original cover. If this is deemed a cover issue, please proceed to section 2.5.	*For detailed instructions see section 3.2.1*

2.4.3 TS4-R-F/TS4-A-F has no DC Voltage (0.0V)

Issue 3	TS4-R-F / TS4-A-F has no DC Voltage (0.0V)
Description	A TS4-R-F / TS4-A-F unit should pass 0.6V when connected to a working module and the string is not connected to an active transmitter. If an output voltage of 0.0V is measured on a TS4-R-F / TS4-A-F unit, it is possible there is a wiring issue, the unit has a problem, or the module has an issue.
Troubleshooting	
Step 1	Check whether the problem is present in adjacent PV modules. If yes, the issue is likely to do with high current and standard test procedures should be taken to verify the integrity of the circuit, string, and isolators. Once the short or leakage is detected and fixed TS4-R-F / TS4-A-F unit will resume normal operation.
Step 2	Verify that the TS4-R-F / TS4-A-F is properly wired to the PV module: • Make sure there are no visible issues in the wiring • Confirm that the leads are snugly connected • In the case of TS4-R-F: check that the cover is fully seated on the base
Step 3	Shut down the system and disconnect the output leads of the unit. If there was a short, the output will be 0V for 30s. • If 0.6V is read after this time, the unit shorted or there was an installation issue. At this point, please review your system for possible issues. • If the output is still 0V after 30s, please proceed with the troubleshooting guide.
Step 4	If there are no visible issues with the unit, redo the wiring and test the output voltages. First, test the output voltage of the TS4-R-F / TS4-A-F unit. Then, test the output voltage of the module. • If the output voltage of the TS4-R-F unit is now 0.6V, the issue has been resolved Otherwise, the issue may be the TS4-R-F / TS4-A-F unit or the module. • If the voltage of the module is 0V, there is a module issue. • If the voltage of the TS4-R-F / TS4-A-F unit is 0V, but the module voltage is between 16V and Voc, the issue may be the TS4-R-F / TS4-A-F unit. Please proceed to the next step.
Step 5	Swap the TS4-R-F / TS4-A-F unit with another unit known to be functioning. • If the functional unit now reads 0V, there is a module issue. • If the functional unit still reads 0.6V, as it should without a signal, the issue is the original TS4-R-F / TS4-A-F unit there. Please proceed to section 2.5.

2.4.4 TS4-F/ TS4-R-F / TS4-A-F not passing full Voltage

Issue 4	TS4-F / TS4-R-F or TS4-A-F with active Transmitter not passing full Voltage	String has at least 0.6V per module
Description	The RSS transmitter is turned on and appears active, but the TS4-F, TS4-R-F or TS4-A-F are not passing full PV module output voltage to the string. This is most often caused by the transmitter's signal being interrupted. The interruption may be related to improper installation of the transmitter, transmitter failure, or improper string/inverter wiring.	
Troubleshooting		

Step 1	Confirm proper design and installation guidelines were followed:
	• Confirm the TS4-F / TS4-R-F or TS4-A-F and inverter are listed as compatible
	• Up to 10 strings per RSS Transmitter Core (CT)
	• Up to 30 modules per string
	• Max 150A per RSS Transmitter Core
	• Verify RSS Transmitter Core is properly connected
	• Verify distance:
	  • Tigo RSS Transmitter: String length up to 1000 ft (total length from the positive to the negative homerun at the inverter)
	  • 3rd party transmitter: check distance according to transmitter manufacturer
	• Homeruns through RSS Transmitter Core must be of the same polarity (all positive or all negative)
	• Use the Tigo RSS Signal Detector, section 3.1, '*RSS Signal Detector*', to check whether an RSS signal is present.	

Step 2	Check if the RSS transmitter is working correctly. • Should the transmitter be a Tigo RSS Transmitter, please go to section 2.4.6, '*RSS Transmitter Operation Check*' • For a non-Tigo transmitter refer to the OEM transmitter manual	
Step 3	Confirm the strings have been properly wired through the transmitter to the inverter: • Begin with one string and turn on the transmitter • Then try the same process with a second string • If the issue persists, go to section 2.5, '*Unresolved Issues*'	

2.4.5 Reduced String Production

Issue 5	Reduced Production
Description	The performance of a solar array shows a visible reduction in production within a short period of time, not related to changing environmental factors like weather, insolation, etc. An issue with the TS4-F or TS4-R-F / TS4-A-F units is suspected.
Troubleshooting	
Step 1	Prior to troubleshooting the system components, external factors should be ruled out. Verify there are no shading conditions, including - but not limited to: • Shade • Dirt • Debris • Other foreign objects
Step 2	Check the string voltage with an active transmitter at V_{OC}: • If the voltage is less than the module Voc times the number of modules, there might be an issue with the RSS transmitter, go to section 2.4.6, '*RSS Transmitter Operation Check*'. • Visually inspect the modules, TS4-F / TS4-R-F / TS4-A-F units, and the wiring for signs of damage.
Step 3	Check the string voltage without an active transmitter. If the voltage is less than 0.6V times the number of modules, there might be an issue with one or several TS4-F or TS4-R-F units having 0.0V output voltage. Locate the units with no voltage; • If these are TS4-F units, go to section 2.4.2. • If these are TS4-R-F / TS4-A-F, go to section 2.4.3,
Step 4	If the TS4-F or TS4-R-F units provide the correct voltages with and without an active RSS transmitter, the performance issue can not be attributed to the Tigo components.

2.4.6 Tigo RSS Transmitter Operation Check

Issue 6	Tigo RSS Transmitter Operation Check	
Description	When AC power is connected to the power supply unit, the RSS Transmitter should be turned on and the 'heartbeat' signal should be activated. The TS4-F, TS4-R-F and TS4-A-F units will then provide full voltage to their string.	
Troubleshooting		
Operation	When AC power is connected to the power supply unit, the Tigo RSS Transmitter should be turned on and signaling be activated. The power LED is blue while the signal LED is green. Check if the RSS Transmitter is working correctly: a. Power LED is '*Solid*' and Signal LED is '*Blinking*': the transmitter is ON and functioning properly b. Power LED and Signal LED are 'Off': the transmitter is OFF or is not receiving power. Review wiring to transmitter, verify power supply is functional, and that AC power is on. c. Power LED is ON, but the Signal LED is OFF: power cycle the unit, if Signal LED stays off, please go to section 2.5	
Wiring	Check RSS transmitter wiring is according to manufacturer's instructions. In case a Tigo RSS Transmitter is being used, refer to section 3.3, *'Tigo RSS Transmitter Wiring'*.	
Signaling	Verify that there is no internal transmitter in the inverter in addition to an external Tigo RSS Transmitter. This could cause the signals to collide and cancel, placing the units in the off position. If using a non-Tigo transmitter: • Refer to the manufacturer's troubleshooting manual or support for assistance. • If the above fails, deactivate the 3rd party RSS transmitter and use a Tigo RSS Transmitter. This will verify whether the issue is transmitter related. Use the Tigo Signal Detector, details in section 3.1, to check if the RSS heartbeat signal from the Tigo RSS Transmitter is received by the TS4-F or TS4-R-F / TS4-A-F units. • Should the signal not be detected, there is likely an open circuit condition. Please go to section 2.4.1. • Should the LEDs on the transmitter indicate proper function, but the signal not be received by any unit, please go to section 2.5.	

2.5 UNRESOLVED ISSUES

Before contacting Tigo Support	In any event where the inverter has an error code, please check the inverter's operation and safety manual for troubleshooting guidance or contact the inverter manufacturer for further assistance. Should an issue persist after following the troubleshooting steps as described in this manual, a summary of the performed tests and a list of system related information detailed below should be provided to **Tigo support**.
Unresolved Issues	**Contact Tigo Technical Support**
Required Information	
System	Provide the following system information: • System name • System owner • System address • System Installer
Technical Info	Provide the following technical information: • Serial number(s) of the affected TS4-F or TS4-R-F / TS4-A-F units in the system • Number of strings per MPPT • Total length of each string from the positive to the negative homerun at the inverter • Inverter error code(s) or 'no error code' • Inverter production, current, and voltage graphs (*if applicable and available*)
Datasheets	Provide the following product documentation: • Module datasheets • Inverter datasheets
Send	Provide the information to technical support at Tigo: Support@tigoenergy.com

For more details on troubleshooting and servicing solutions powered by Tigo, please visit:

- Tigo Academy
- Resource Center

For sales info:
sales@tigoenergy.com or 1.408.402.0802

For product info:
Visit www.tigoenergy.com/products

For technical info:
http://training.tigoenergy.com

For service info:
http://support.tigoenergy.com

For additional info and product selection assistance, use Tigo's online design tool at www.tigoenergy.com/design

APPENDIX

3. APPENDIX

3.1 Tigo Signal Detector

Tigo's RSS (Rapid Shutdown) Signal Detector is a functionality testing device for sensing the power-line communication (PLC) signal from Tigo's RSS Transmitter to Tigo's UL-certified TS4-F (Fire Safety) units.

Operation

- Flip the switch on the RSS Signal Detector to the ON position.
- Place the sensor area of the RSS Signal Detector within 2in (5cm) of a TS4-F unit. Make sure the TS4-F, TS4-R-F, or TS4-A-F unit is fully installed and the RSS Transmitter is connected and powered on.
- When the keep-alive signal is detected, the LED will change from blue to yellow and an audible alert will sound to confirm.
- If the signal is not detected, the LED will remain blue and there will be no sound.

3.2 OPEN AND CLOSE A TS4-F UNIT

3.2.1 Detaching the TS4-F Cover

Open a TS4 cover only if so instructed by Tigo support!

Verify that the TS4-F cover is properly latched into the base, and that the latches are not damaged.

- Take a clear picture of the attached cover with the serial number of the TS4 cover visible.
- Using the Tigo Key, remove the TS4 cover.

1. JAWS FOR SECURING COVER TO BASE
2. CLIP OPENER
3. COVER SEPARATOR

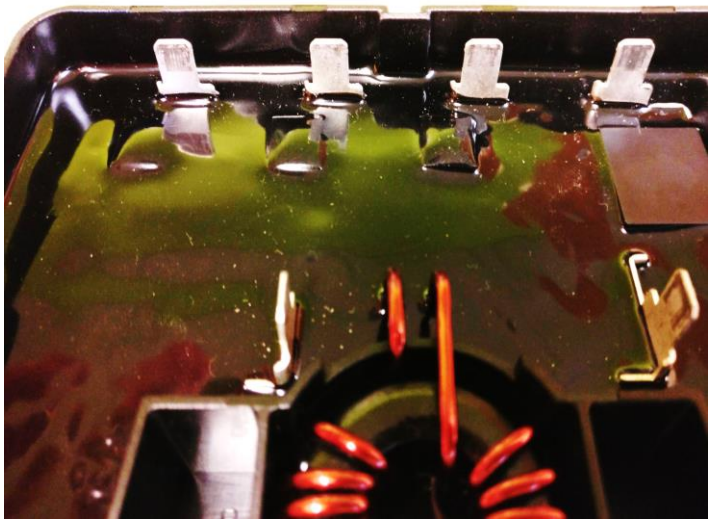
! DO NOT use a flat head screw driver !

Using a flat head screw driver is likely to damage the latches and will void the warranty.

- Use only the TS4 key; it is designed to install and remove covers without exerting any force on the PV module.
- To unlock the cover from the base, insert the clip opener into a clip release point and gently pull away from the cover. Each clip will unlock in the latch with an audible click. Unlock the clips in a circular order.
- Do not twist the key when unlocking the clips.

3.2.2 Inside the TS4

Examining the TS4 cover



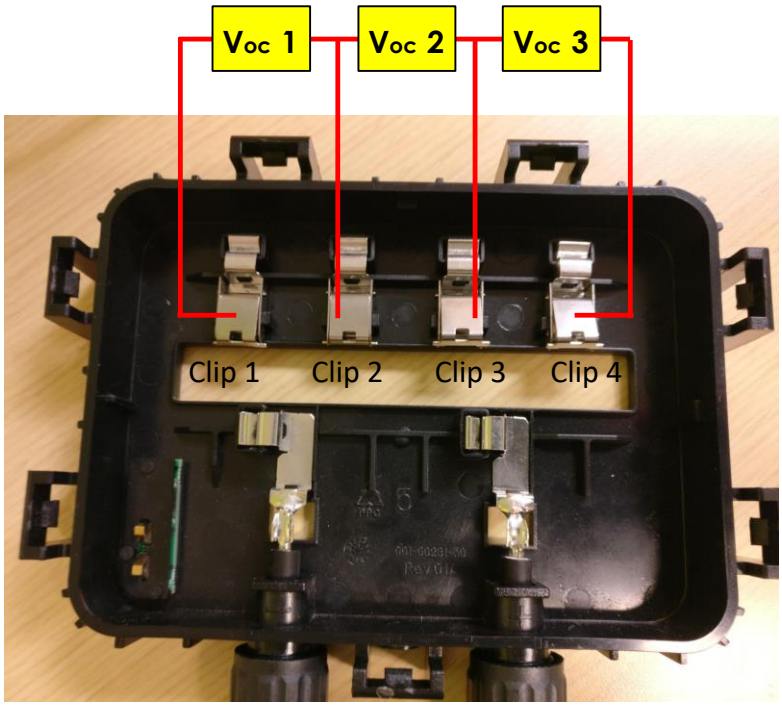
- Visually inspect the cover for any abnormalities.
- Take a clear picture of the inside of the cover and note any bent pins or damage.
- Take a clear picture of the entire base from above and note any damage.
- Measure and record the voltages of the base from clip 1 to clip 2, clip 2 to clip 3, and clip 3 to clip 4.

CAUTION

Use appropriate safety precautions!

Be aware that there are considerable exposed contacts. If a module is even minimally exposed to sunlight, there will be voltage!

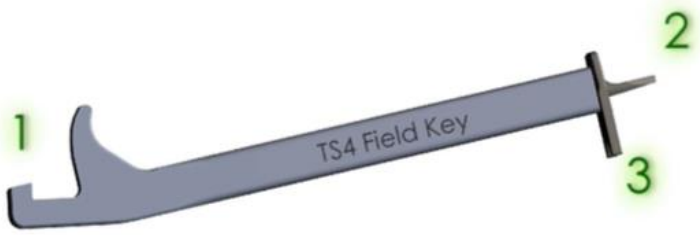
These tests must be performed by certified electricians and PV professionals!



3.2.3 Reattaching the TS4-F Cover

If the cover will be re-installed on the base of the junction box, please use the Tigo key.

- Seat the cover in the base as evenly as possible applying even force.



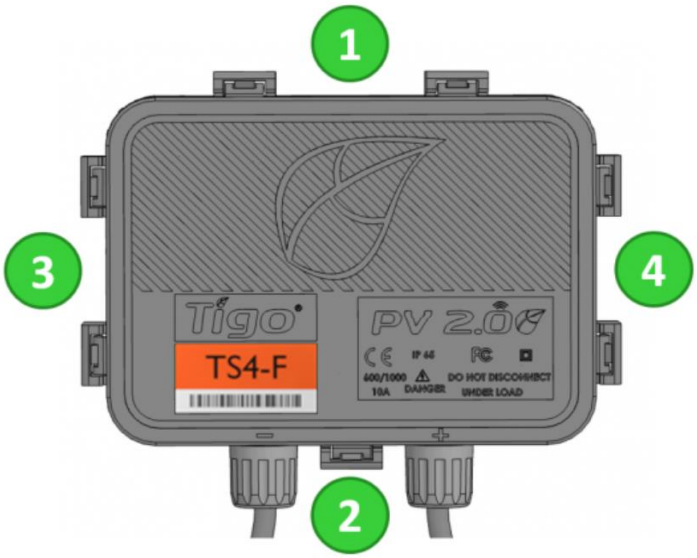
1. JAWS FOR SECURING COVER TO BASE
2. CLIP OPENER
3. COVER SEPARATOR

- Use the jaws of the Tigo key to latch the cover to the base the in the following order:

Top ❶ → Bottom ❷ → Left ❸ → Right ❹.

- The lower jaw of the Tigo Key hooks under the bottom of the latch, the key is then tilted towards the center of the unit.

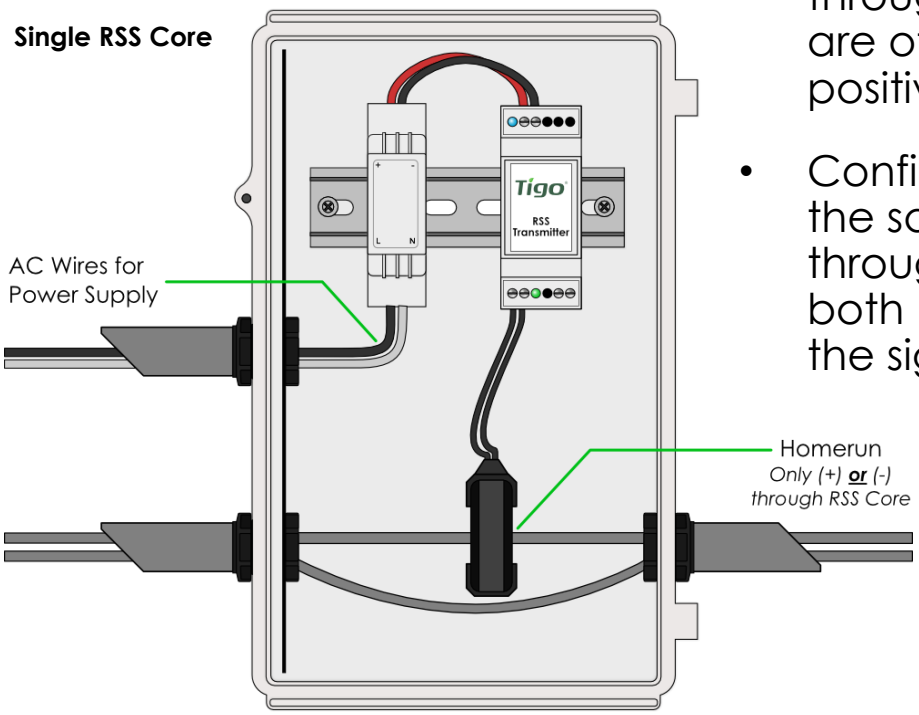
- Each clip will lock in the latch with an audible click.



3.3 Tigo RSS TRANSMITTER WIRING

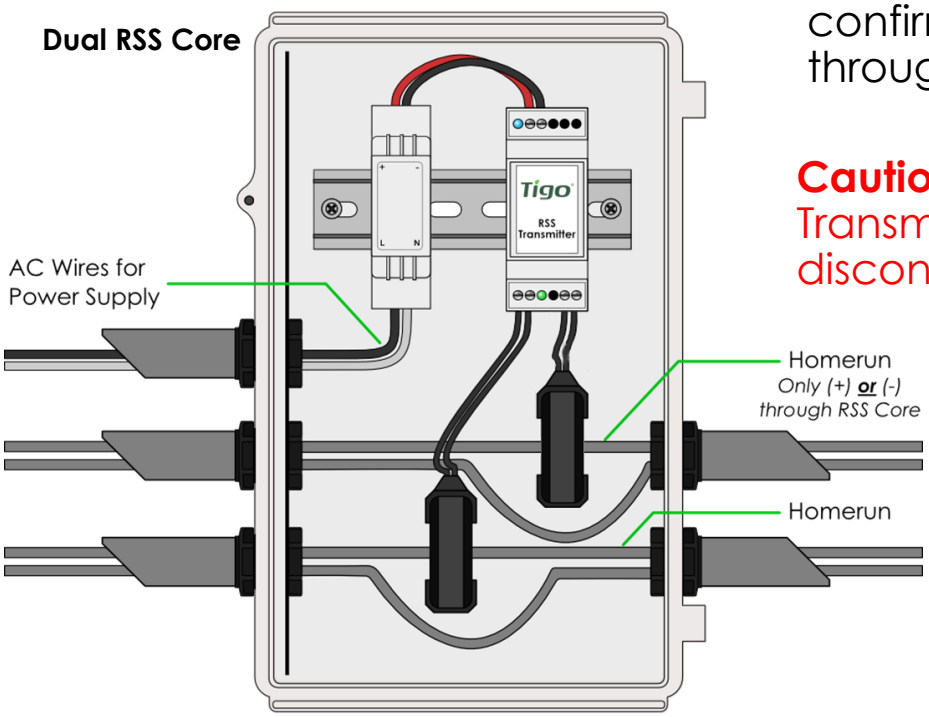
Verify that the homeruns are correctly wired in the RSS Transmitter enclosure.

Single RSS Core



- Confirm all homeruns passing through the transmitter core are of the same polarity (all positive **or** all negative).
- Confirm only one homerun of the same string is passing through the transmitter core; both homeruns would cancel the signal.

Dual RSS Core



- In the case of Dual RSS Core confirm no homerun passes through both cores.

Caution: Power off the RSS Transmitter **before** disconnecting TS4 units!

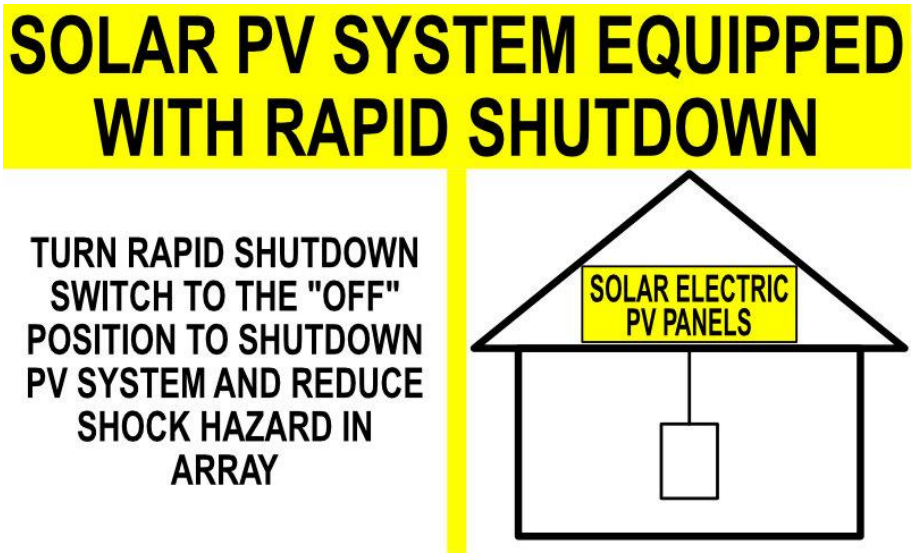
3.4 TESTING RAPID SHUTDOWN

TS4-F, TS4-R-F or TS4-A-F and a SunSpec-compliant transmitter or initiator (e.g. Tigo RSS Transmitter) are a solution to meet NEC 2014 & 2017 690.12 Rapid Shutdown requirements.

TS4-F, TS4-A-F, and TS4-R-F units automatically enter rapid shutdown mode when the RSS transmitter is switched off. Rapid shutdown mode is disengaged when power is restored to the RSS transmitter.

Test your rapid shutdown system by switching off the AC power to the RSS Transmitter or SunSpec-compliant inverter.

TS4-F or TS4-R-F units will reduce their output to 0.6V when the RSS Transmitter is powered off.



Place Rapid Shutdown System label in proper location.

The RSS Transmitter control power supply MUST be on the same AC branch circuit as the inverter to meet rapid shutdown requirements.

CLICK HERE for more info about Rapid Shutdown

3.5 CONTACT INFORMATION

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