Rapid Shutdown Solutions Product & System Introduction

Global Multi Platform MLPE Technology Leader

MLPE + SaaS
EMA Software

MLPE DC Series
MLRSD, Smart modules

Residential ESS

MLPE AC Series
Microinverter
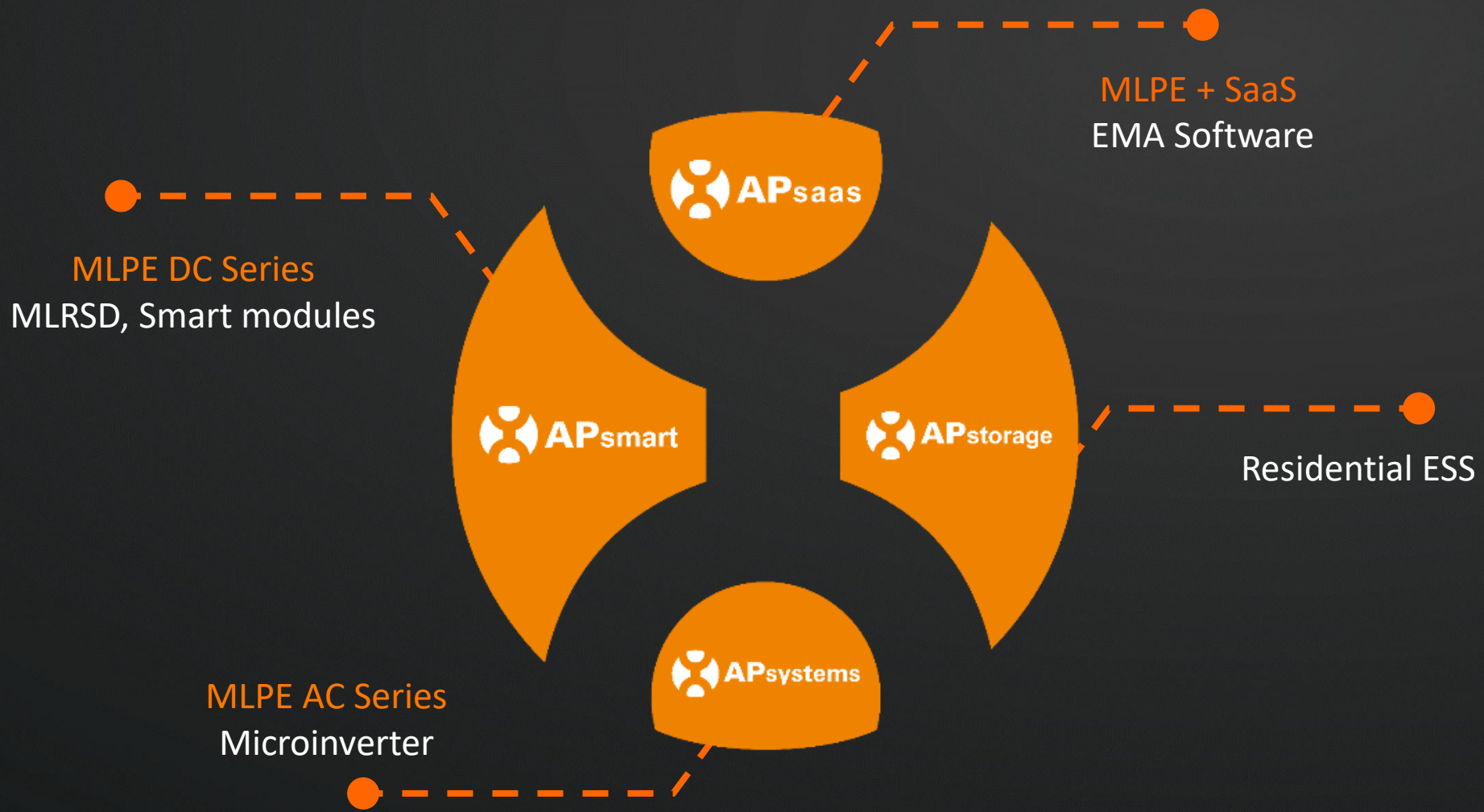
NEC 2017/2020 690.12 Module Level Rapid Shutdown

NEC® in Effect 10/1/2021

2020 NEC® - 14
2017 NEC® - 26
2014 NEC® - 4
2008 NEC® - 2
County/Municipality NEC® regulation only - 4

Source: diysspc.net (c)

PV module-level power control and safety ("rapid shutdown") is required in 24 states starting in January 2019
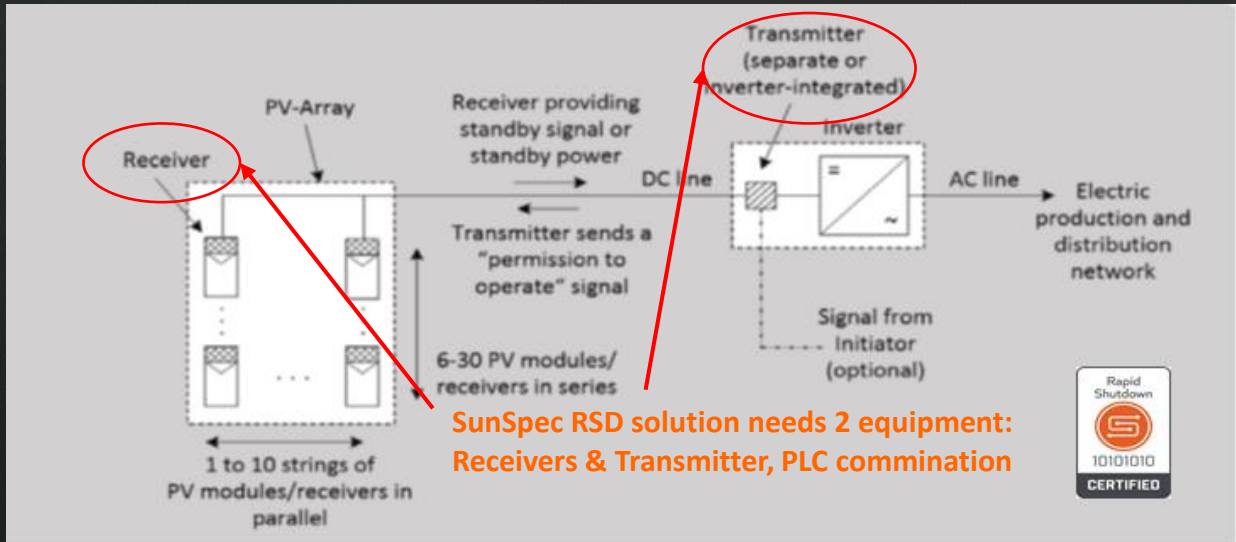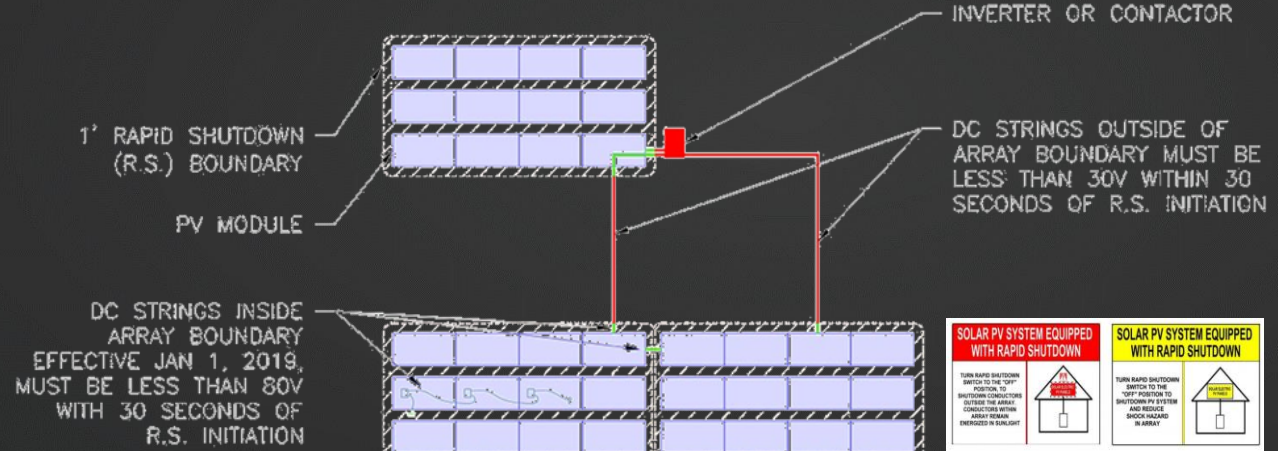
SunSpec Alliance global leaders have developed an open standard rapid shutdown communication solution

SunSpec is launching a Rapid Shutdown Certification Program

SunSpec Communication Signal for Rapid Shutdown Functional Specification

SunSpec RSD solution needs 2 equipment: Receivers & Transmitter, PLC commination
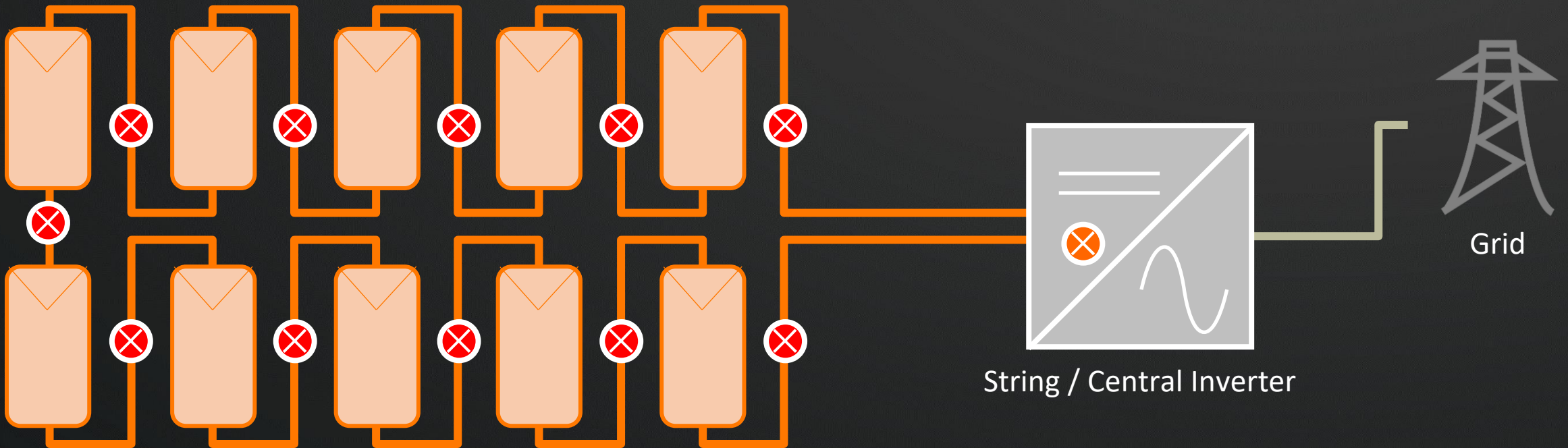
3

APsmart Rapid Shutdown System Solution for SunSpec

Rapid shutdown the output of PV modules,

Module DC Voltage < 80V within 30s in 1 foot.

(NEC2017/2020)

Rapid shutdown the output of strings,

Array DC Voltage < 30V within 30s.

(NEC2014)

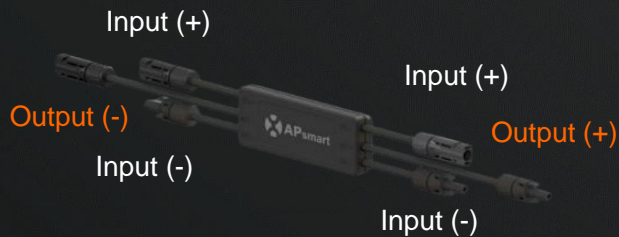Grid

String / Central Inverter

RSD-S-PLC/RSD-D (receiver) connects to each PV module to realize module-level rapid shutdown, receive the "heartbeats" signals sent from **Transmitter-PLC (transmitter)**.

Receivers: Products highlines

Input (+)

Input (-)

Output (+)

Output (-)

RSD-S-PLC

Input (+)

Input (+)

Output (-)

Output (+)

Input (-)

Input (-)
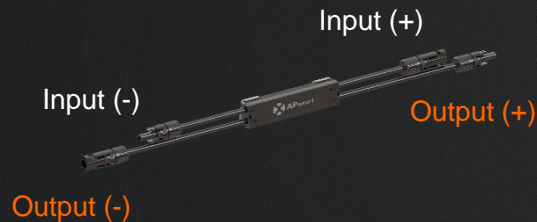
RSD-D

✪ **Simple** as meets NEC 2017(690.12) & SunSpec RSD requirements only.

✪ **No monitoring and optimizer functions**, depend on string inverter monitoring portal.

✪ **Small and light**, clips to module frame with no drilling.

✪ Works with **Bifacial** & corner J-box applications.

✪ Can survive over **40A reverse current**, feasible to **25A fuse** rated PV modules.

✪ High temperature protection: **100C**.

✪ It is feasible with PV + Storage **hybrid / off-grid** PV systems.

✪ Dual-Input channels allowing two modules controlled by one RSD device, **cheaper**.

✪ Inputs 500mm/ Output default **2400mm**.

✪ Designed for large cell PV modules **up to 900W**.

✪ Come with 3 models based on its maximum input current (Imax): 15A, **20A**, 25A.

✪ RSD-D-15A feasible for current PV modules **below 450W**.

✪ RSD-D-20A feasible for any module **above 450W with bifacial**.

Transmitter-PLC: Products highlines

Transmitter-PLC

Transmitter-PLC Outdoor Kit
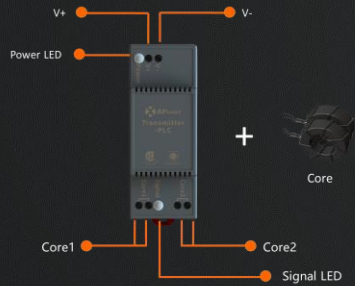
✤ Meets NEC 2017 (690.12) and SunSpec requirements only.

✤ Equipped with single/dual core, each core can pass up to **10** strings, its maximum allowing current is up to 200A, each string maximum allowing **30** PV modules based on SunSpec required.

✤ Maximum length for homerun with stabilized PLC signals from PV (+) to PV (-) on inverter is **1500** ft (~ 450m) .

✤ Pass either positive or negative homerun wiring through cores only.
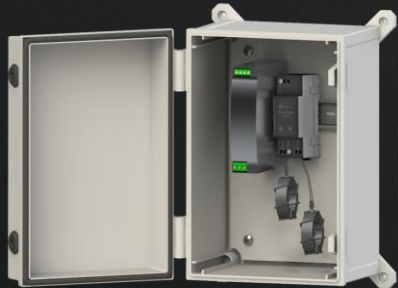
✤ Full package includes AC/DC power supply & transmitter-PLC, for any non-SunSpec RSD compliant string inverters, **hybrid inverters**, or retrofit systems.

✤ Equipped with single core with 85-264VAC power supply for **single phase (residential)**.

✤ Equipped with dual cores with 180-550VAC power supply for **3 phases (commercial).**

✤ Connect wires (22AWG) to AC side of power supply must be from the grid AC branch.

✤ Connect wires (18 -14AWG) between AC/DC power supply and Transmitter-PLC.

Application #1: For SunSpec RSD Compliant Inverters with RSD
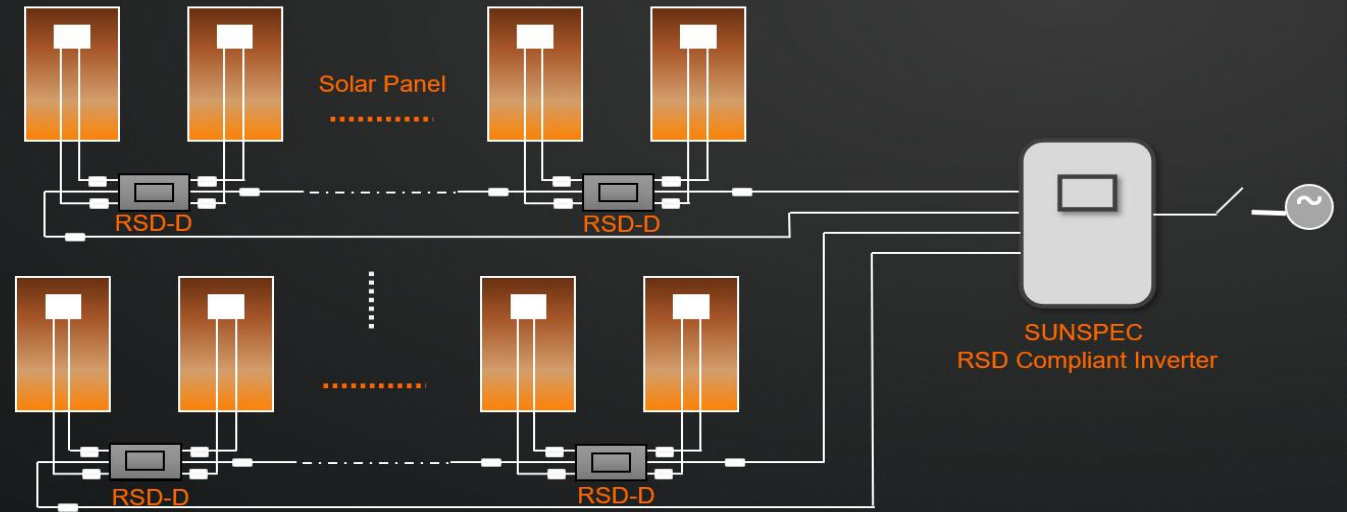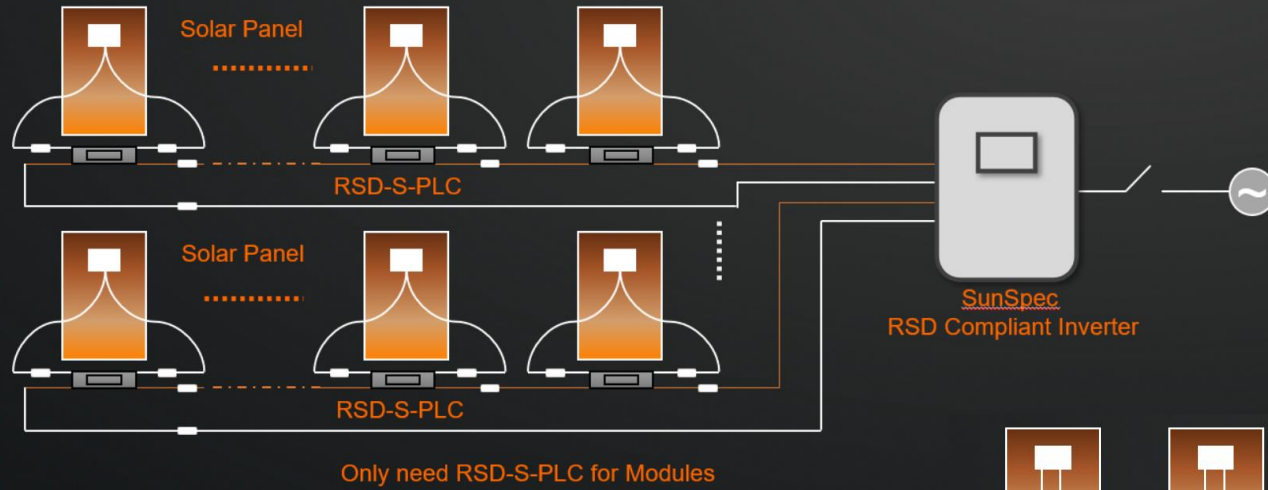
Application #2: Non SunSpec RSD Compliant Inverters with RSD
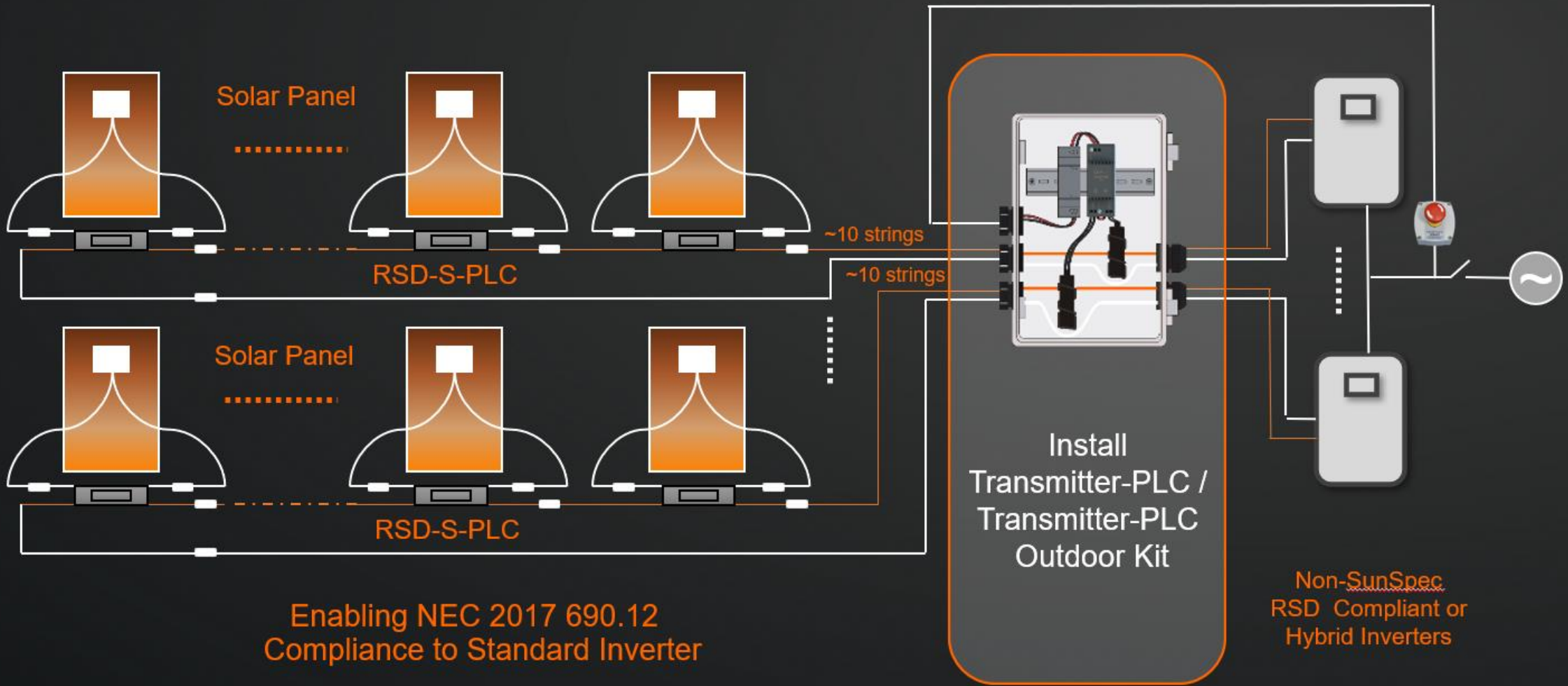
Application #3:   Hybrid Inverter Solution

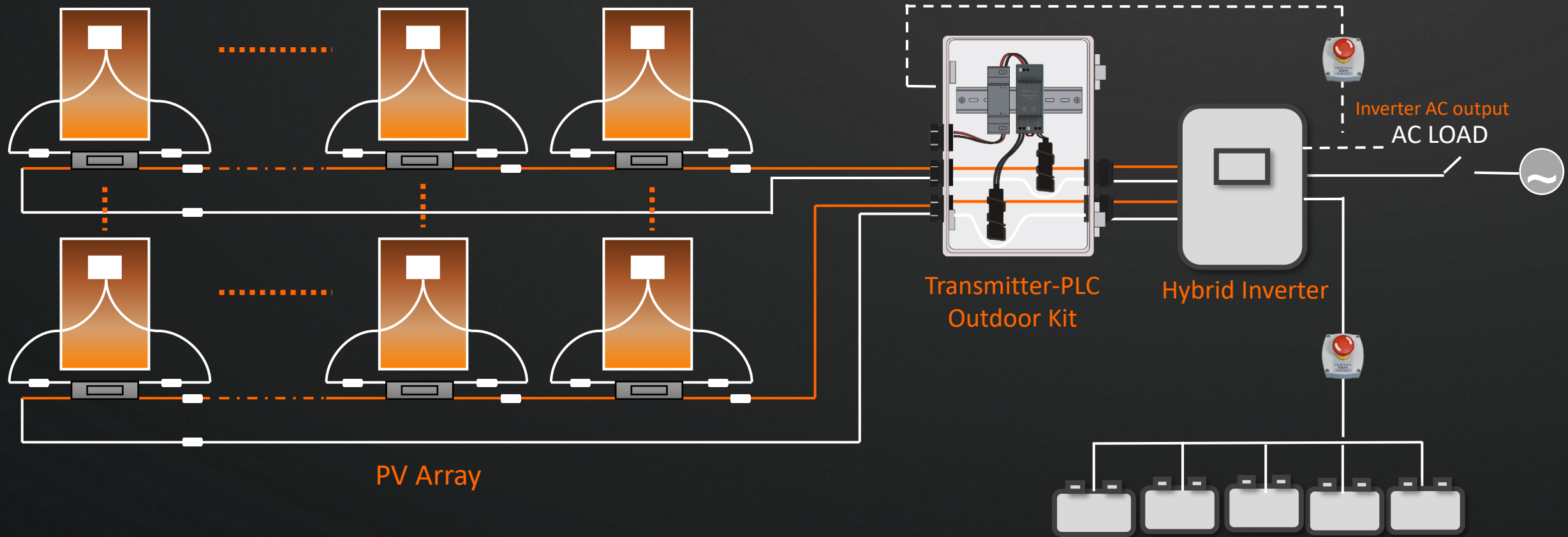- Off Grid Mode: **Power supply and Transmitter-PLC turn on after Grid off, hybrid inverter quickly turn to battery charge and continue AC output.**


Inverter AC output
AC LOAD

Transmitter-PLC
Outdoor Kit

Hybrid Inverter

PV Array

Compatible with PVRSS Inverters: https://apsmartglobal.com/inverters-compatibilities/

APsmart Rapid Shutdown Solutions Compatibility

APsmart

SUNSPEC Listed		PVRSS Matching Listed					
SMA	CHINT	FRONIUS	SOLIS	GOODWE	CSI	LG	
SB3.0-1SP-US-41	CPS SCA20KTL-DO-R/US-480	Primo GEN24 3.8 208-240	Solis-50K-US-SW; Solis-50K-US-LSW;	GW9600A-ES; GW8600A-ES	CSI-66K-T480GL01-UB	D007KEEN261	
SB3.8-1SP-US-41	CPS SCA25KTL-DO-R/US-480	Primo GEN24 5.0 208-240	Solis-66K-US-F-SW; Solis-66K-US-F-LSW;	GW7600A-ES; GW7000A-ES	CSI-60K-T480GL01-UB		
SB5.0-1SP-US-41	CPS SCA50KTL-DO/US-480	Primo GEN24 6.0 208-240	Solis-60K-US-F-SW; Solis-60K-US-F-LSW;	GW6000A-ES; GW5000A-ES	CSI-50K-T480GL01-UB	**GROWATT**	
SB6.0-1SP-US-41	CPS SCA60KTL-DO/US-480	Symo Advanced 10.0-3 208-240	Solis-50K-US-F-SW; Solis-50K-US-F-LSW;	GW9600A-MS; GW8600A-MS	CSI-40K-T480GL01-UB	Growatt SPH 3000TL BL-US;	
SB7.0-1SP-US-41	CPS SCA25KTLDO/US-208	Symo Advanced 12.0-3 208-240	Solis-40K-US-F-SW; Solis-40K-US-LSW;	GW7600A-MS; GW7000A-MS	CSI-36K-T480GL01-UB	Growatt SPH 3600TL BL-US	
SB7.7-1SP-US-41		Symo Advanced 15.0-3 480	Solis-40K-US-SW; Solis-36K-US-SW;	GW6000A-MS; GW5000A-MS	CSI-30K-T480GL01-UB	Growatt SPH 4000TL BL-US	
STP 50-US-41	**YASKAWA**	Symo Advanced 20.0-3 480	Solis-36K-US-F-SW; Solis-36K-US-LSW;	GW9600A-IS; GW8600A-IS	CSI-25K-T480GL01-UB	Growatt SPH 4600TL BL-US	
STP 33-US-41	PVI 50TL-480	Symo Advanced 22.7-3 480	Solis-30K-US-F-SW; Solis-30K-US-LSW;	GW7600A-IS; GW7000A-IS	CSI-25KTL-GS-FLB	Growatt SPH 5000TL BL-US	
STP 62-US-41	PVI 60TL-480	Symo Advanced 24.0-3 480	Solis-30K-US-SW; Solis-25K-US-SW;	GW6000A-IS; GW5000A-IS	CSI-30KTL-GS-FLB	Growatt SPH 6000TL BL-US	
	PVI 20TL-480-R		Solis-25K-US-F-SW; Solis-25K-US-LSW;	GW9600H-ES; GW8600H-ES	CSI-36KTL-GS-FLB	MIN 8200TL-XH-US,	
	PVI 25TL-480-R		Solis-1P10K-4G-US; Solis-1P9K-4G-US;	GW7600H-ES; GW7000H-ES	CSI-40KTL-GS-FLB	MIN 9000TL-XH-US,	
	PVI 25TL-208		Solis-1P8.6K-4G-US; Solis-1P8K-4G-US;	GW6000H-ES; GW5000H-ES	CSI-40KTL-GS-B	MIN 10000TL-XH-US,	
		SOLAX	Solis-1P7.6K-4G-US; Solis-1P7K-4G-US;		CSI-50KTL-GS-FLB	MIN 11400TL-XH-US,	
	DELTA	A1-Hybird-6.0-US	Solis-1P6K-4G-US; Solis-1P6K2-4G-US;	**Q CELLS**	CSI-50KTL-GS-B	MIN 3000TL-XH-US,	
	M10-4-TL-US	A1-Hybird-7.0-US	Solis-1P5K-4G-US; Solis-1P4.6K-4G-US;	Q.HOME- HYB-G1-6.0,	CSI-60KTL-GS-B	MIN 3800TL-XH-US,	
	M10-TL-US	A1-Hybird-7.6-US	Solis-1P4K-4G-US; Solis-1P3.6K-4G-US;	Q.HOME- HYB-G1-7.0,	CSI-66KTL-GS-B	MIN 5000TL-XH-US,	
	M8-TL-US	A1-Hybird-8.6-US	Solis-1P3K-4G-US; Solis-1P2.5K-4G-US;	Q.HOME- HYB-G1-7.6,		MIN 6000TL-XH-US,	
	M6-TL-US	A1-6.0-US	Solis-1P2K-4G-US; Solis-1P1.5K-4G-US;	Q.HOME- HYB-G1-8.6;		MIN 7600TL-XH-US	
	M5-TL-US	A1-7.0-US	Solis-1P1K-4G-US; RHI-1P5K-HVES-5G;	Q.HOME- AC-G1-6.0,			
	M4-TL-US	A1-7.6-US	RHI-1P6K-HVES-5G; RHI-1P7K-HVES-5G;	Q.HOME- AC-G1-7.0,			
	E8-TL-US	A1-8.6-US	RHI-1P7.6K-HVES-5G; RHI-1P8K-HVES-5G;	Q.HOME- AC-G1-7.6,			
	E6-TL-US		RHI-1P9K-HVES-5G; RHI-1P10K-HVES-5G;	Q.HOME- AC-G1-8.6;			
	E4-TL-US						

Note: The listed inverter products are operationally compatible with APsmart RSD-S-PLC.

Altenergy Power Systems Inc. CSA file No.: 259077

Note: The listed inverter products are operationally compatible with both APsmart RSD-S-PLC and RSD-D.

600 Ericksen Ave, Suite 200 Seattle, WA 98110
1-737-218-8486| info@APsmartGlobal.com| APsmartGlobal.com

Updated on Mar. 29th, 2021

Receivers: DC Outputs Default Values under Shutdown (Safety Voltages)

RSD-S DC Output: Value: 0.78v
Range: 0.6 ~ 1v

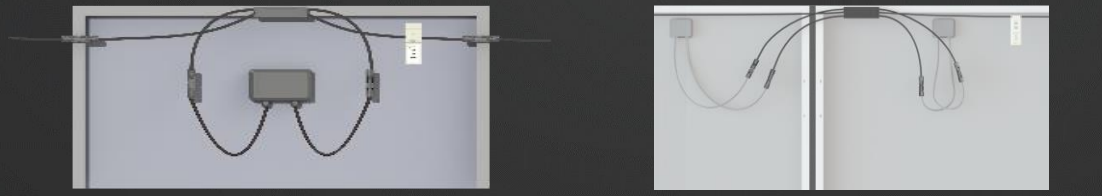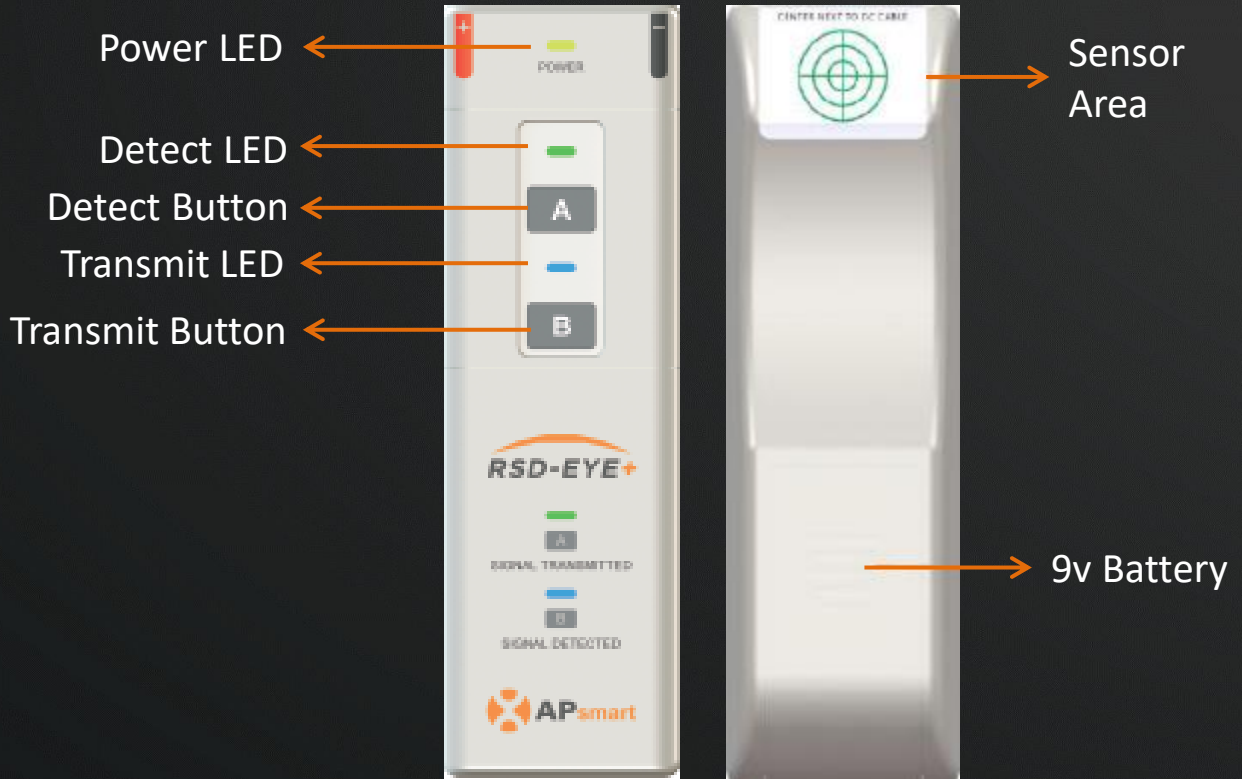**RSD-D DC Output: Value: 1.55v**
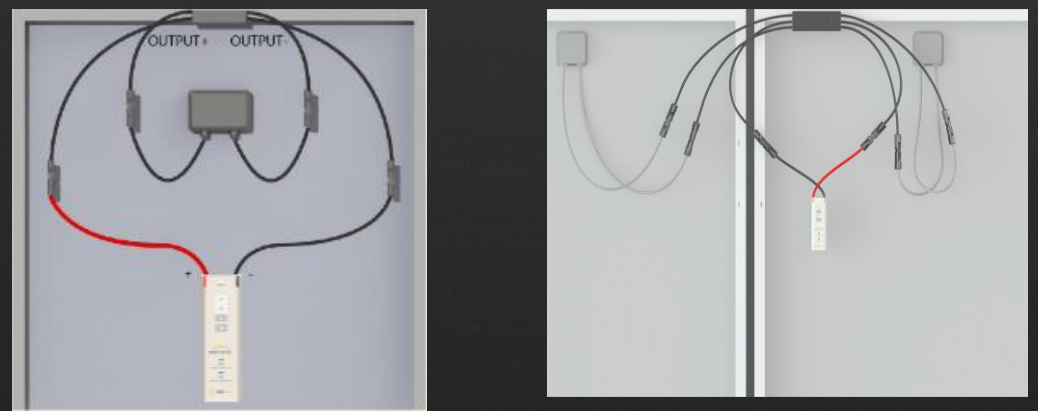**Range: 1.25 ~ 1.85v**
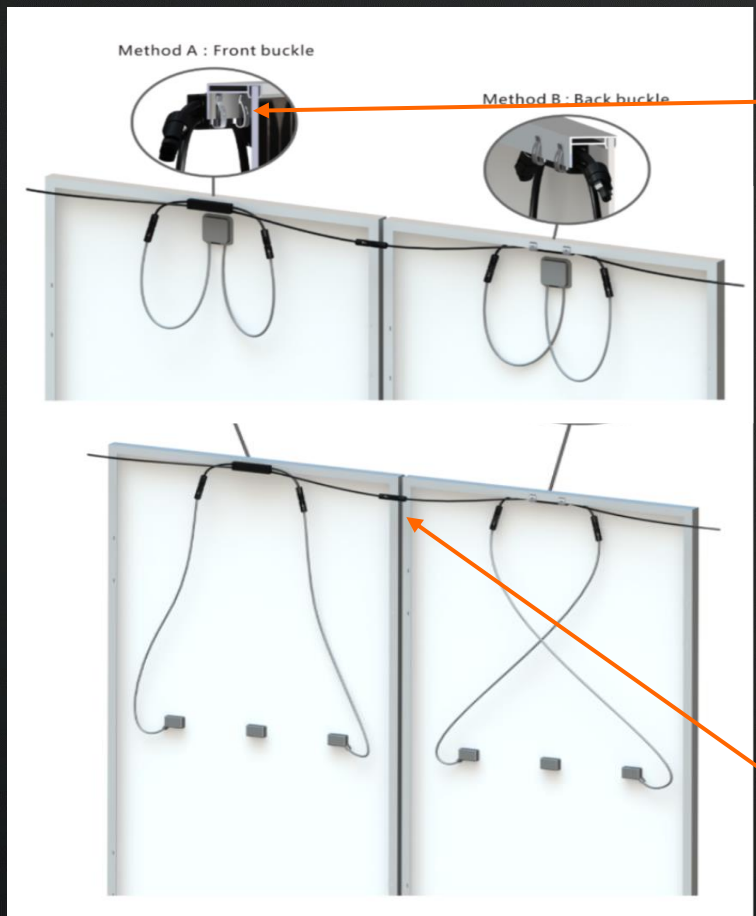
Recommend Mounting Outside of frame
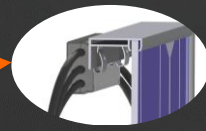
Recommend negative wires away from any conductors

11

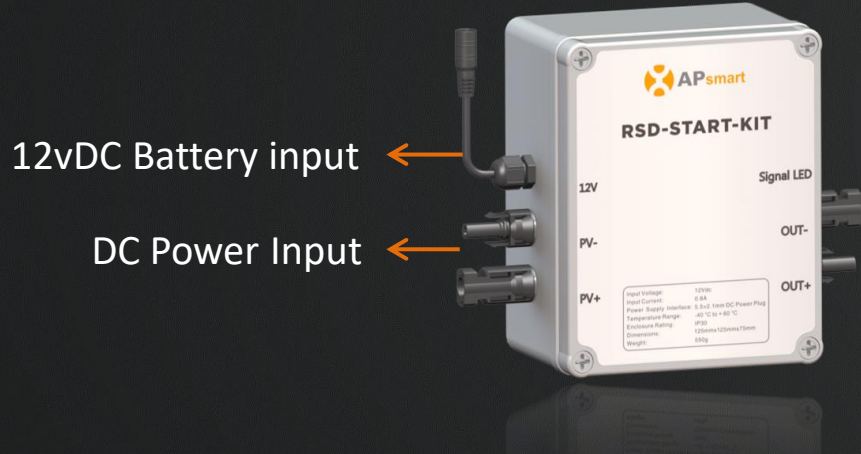# Tool: RSD-EYE+ Detector for SunSpec PLC Signals Detecting

Power LED

Detect LED

Detect Button

Transmit LED

Transmit Button

Sensor Area

9v Battery

Detect Mode

Transmit Mode

# Tool: RSD-START KIT for Commissioning and Troubleshooting

12vDC Battery input

DC Power Input

For PV system installed SunSpec RSD compliant solutions:

- Perform string level Voc test with DMM.
- Perform megger/insulation tests.
- Perform string level IV curve by PV Analyzer.
- Perform string inverter self-checking.

RSD-S-PLC

12VDC Battery Bank

Power LED

RSD START KIT

IV Analyzer

PV-
PV+
PV-
PV+
OUT-
OUT+
PV-
PV+
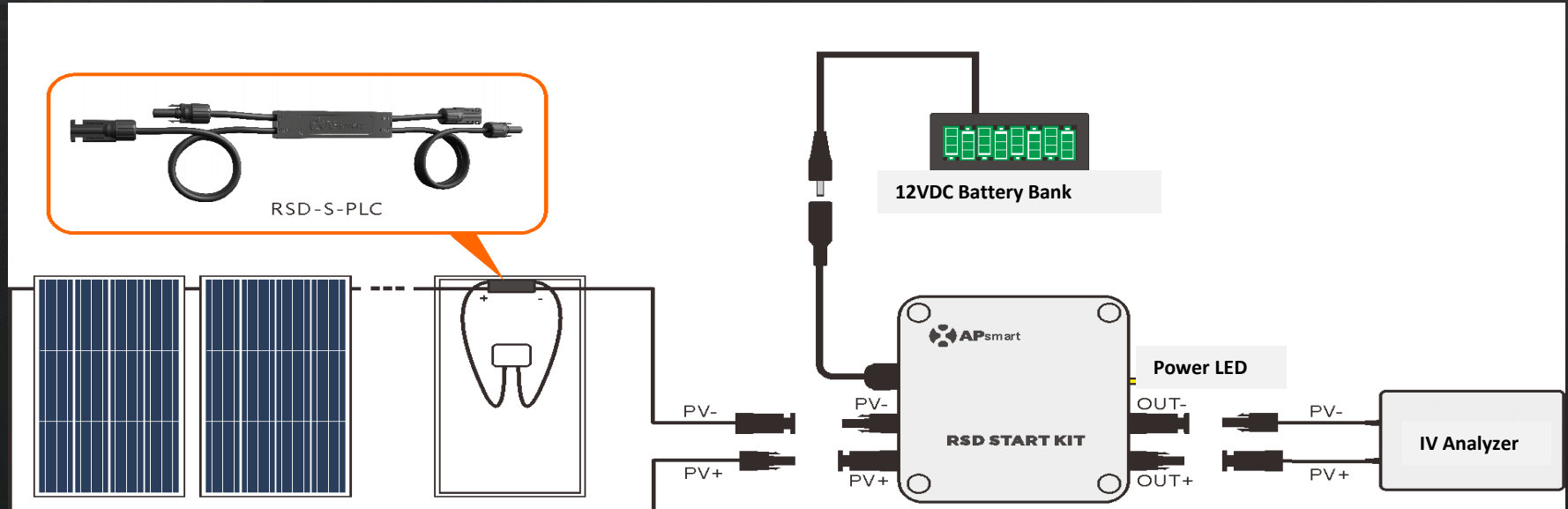
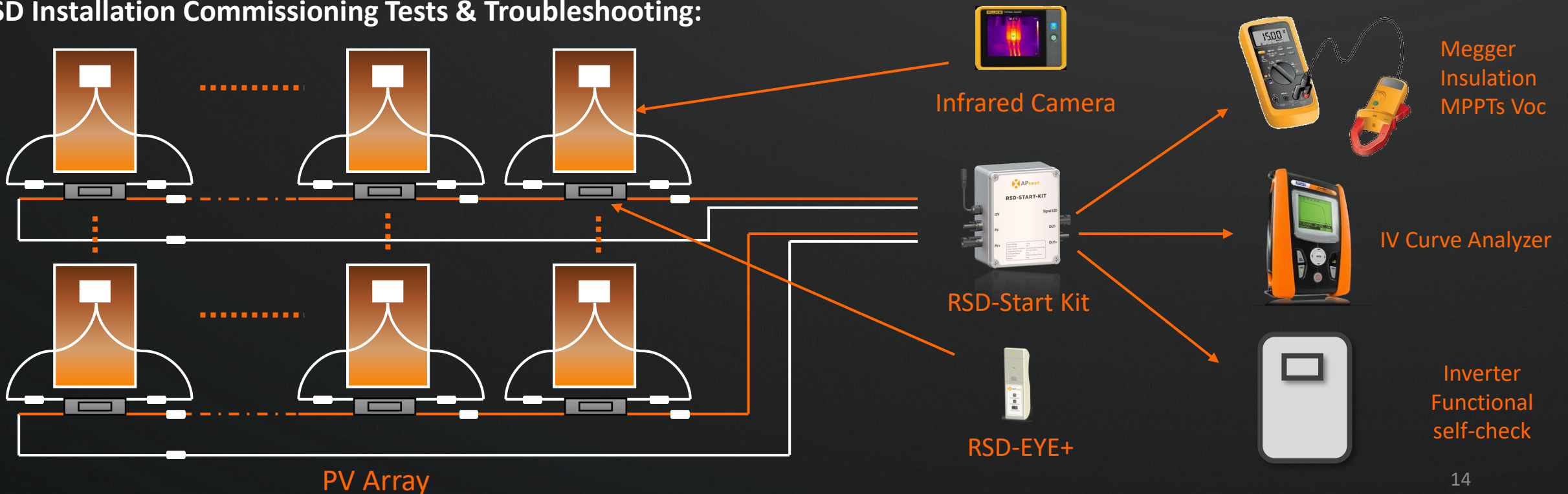| Step 1: RSD-S-PLC Mounting | Step 2: Connect With PV Module | Step 3: String Wiring | Step 4: Connect to String Inverter |

RSD system Installation Best Practice: keeping positive/negative wires separated away from receivers inside strings to avoid fire hazard

- Checking RSD device's DC output **AFTER** mounting on PV modules to confirm device functional: V_rsd = -S:0.6 -1v or -D:1.25 - 1.85v

- Checking string open-air DC voltages **AFTER** wiring to confirm string connections: V_string = V_rsd X #RSDs

- Checking string VOC & current **AFTER** turning on RSD Start Kit to confirm string fully powering up: VOC = V_mpp X #Modules

RSD Installation Commissioning Tests & Troubleshooting:

Infrared Camera

RSD-Start Kit

RSD-EYE+

Megger
Insulation
MPPTs Voc

IV Curve Analyzer

Inverter
Functional
self-check

PV Array

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Most Questions for RSD-S Installations in the Field

- **Why cannot get full power from the system after installing RSD?**

  As NEC code required, Rapid Shutdown receivers will be shutdown mode as default to seal up module's power, it is only be able to turn on all receivers after switching on breaker from Grid and turn on inverter.

- **How could I know the installation is good?**

  Measuring string open-air voltages is the easiest way to collect DC voltage data after installed full strings, calculate by previously introduced equation then comparing both voltage values. Normally all strings on the same MPPT requires to be balanced by modules installed inside each string, so its DC open-air voltages should be identical within tiny variations.

- **How can I find out the failed receiver location inside the string?**

  V_string < V_avg or V_string >> V_avg – Using DMM to measure receiver's DC output, it failed if: V_rsd = 0 or > 1v

  V_string = 0 – Bypassing half of string to measure its open-air DC voltages, repeating same steps down to quarter, 1/8….., until find out the break down location.

Most Questions for RSD-D Installations in the Field

- **If RSD-D can be installed with RSD-S-PLC together?**

  Yes, but only for RSD-D-15A can be mixed with RSD-S-PLCs in the same string, NOT for RSD-D-20A because RSD-S-PLC continues Impp = 15A, will be damaged if connected with large cell PV modules.

- **Can RSD-D connect with single module rather than 2 modules?**

  Yes, it can connect with single module by INPUT#1 channel only, then shorting positive and negative on INPUT#2, and its DC output remain the same.

- **Why it must be connected with INPUT#1 channel if only have one module need to install with Duo device?**

  Because RSD-D device is charged by INPUT#1 channel only, if connected with INPUT#2 instead, both INPUT channels will NOT work at all, then this device will be bypassed inside string.

- **RSD-D two input channels are in parallel or in series?**

  Both inputs from modules are in series connecting.

- **To fulfill NEC 690.12 RSD requirement, what's different between UL 3741 certified vs. SunSpec MLRSD systems?**

  Both are qualified to fulfill NEC 690.12 standard, the different is UL 3741 will certify the whole system including every equipment includes panel/rack/inverter/conductors….. SunSpec MLPE has more compatible to equipment selection, more flexible with "PV+ storage" options, more reliable to maintain power to customers when grid is not available.

Most Mistakes Made In The Field During RSD Installation

- **Loosing connectors:**

  It is very often happened during installation, if it happens on modules side (inputs), RSD will be bypassed and V_$_{rsd}$ = 0v, if it happens on string homerun side (outputs), V_$_{string}$ = 0v, string is opened circuit.

- **Connecting with wrong cables:**

  It was rare but happened frequently, especially on residential rooftop installations, installers had limited visibility to connect cables under modules. This will burn out RSD devices immediately.

- **Shorting RSD output cables:**

  It was very rare, installers shorted output cables before moving module on the roof. This will burn out RSD devices immediately.

- **Reversed string positive/negative to connect inverter:**

  It was frequently happened, installer accidently reversed string positive/negative when connect to inverters, the inverter will not turn on same as modules.
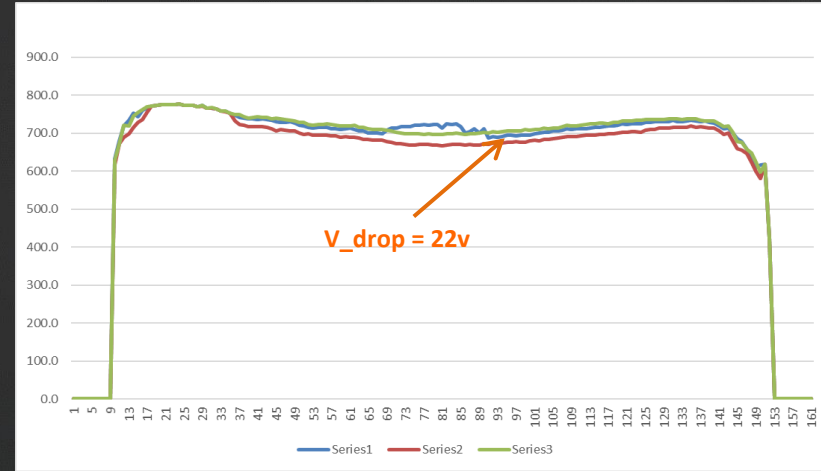
- **Bending devices output cables:**

  It was often, if bending with large force, will potentially delaminated output solder joins, caused device internal arcing to trigger inverter AFCI alert, shutdown the system.
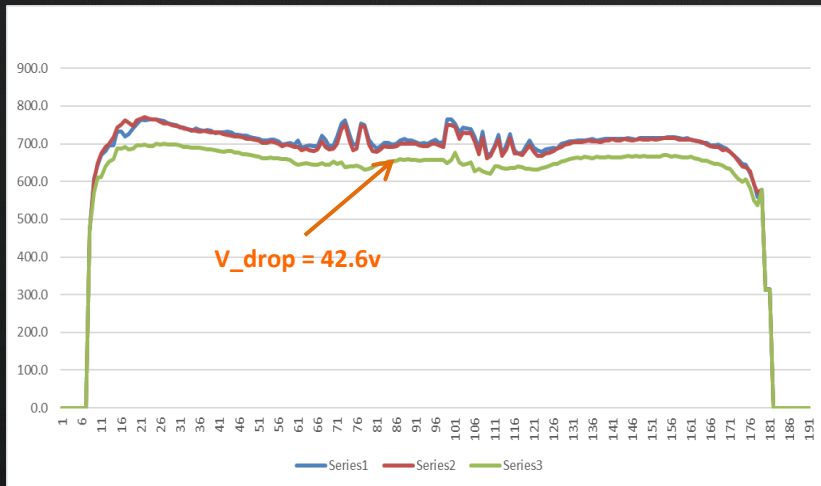
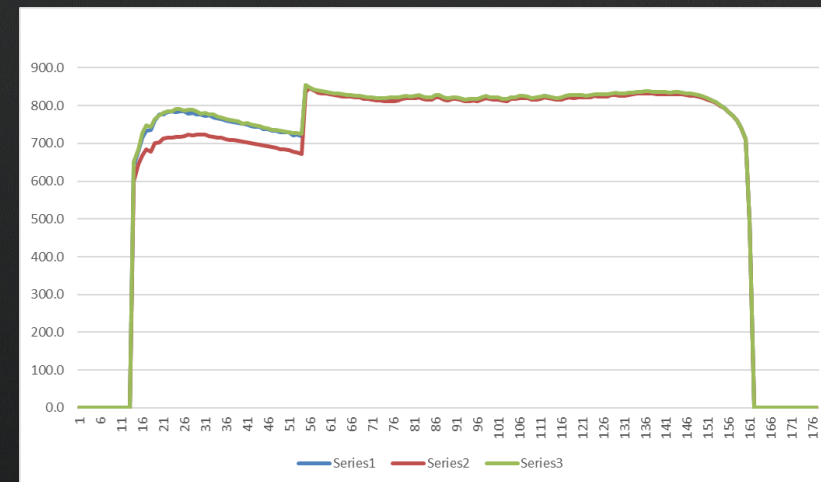# System Level Monitoring Capability – Inverter/MPPT's Operating Voltages Drop
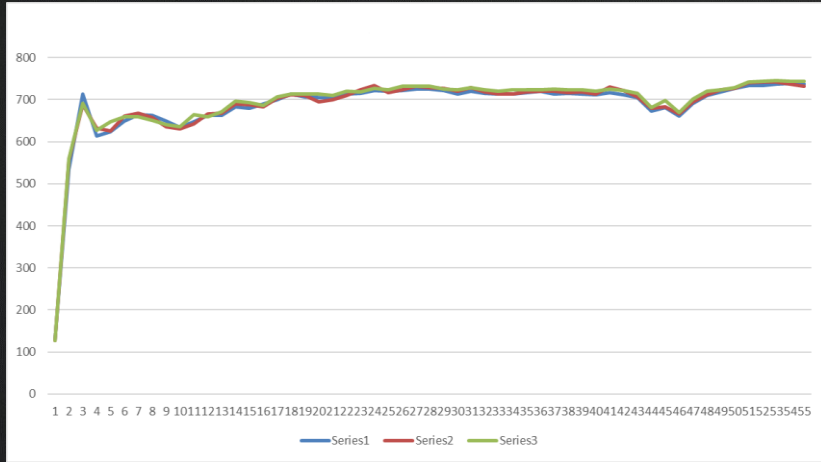
Inverter has no failed devices

Inverter has one failed devices in MPPT#3

V_drop = 22v

Inverter has 2 failed devices in MPPT#3

V_drop = 42.6v

Inverter replaced failed devices and system recovered

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SunSpec PLC Signals Cross-Talk Fact – Only for Multiple Transmitters Systems

Power Line Communications (PLC) signals crosstalk fact:
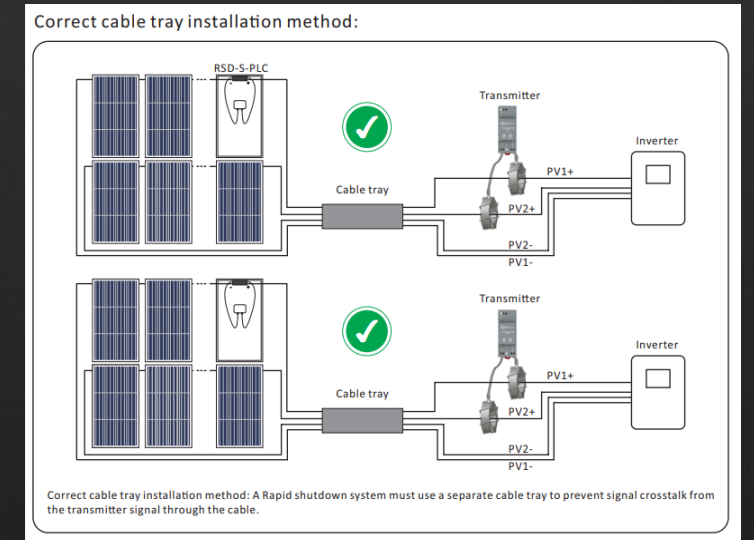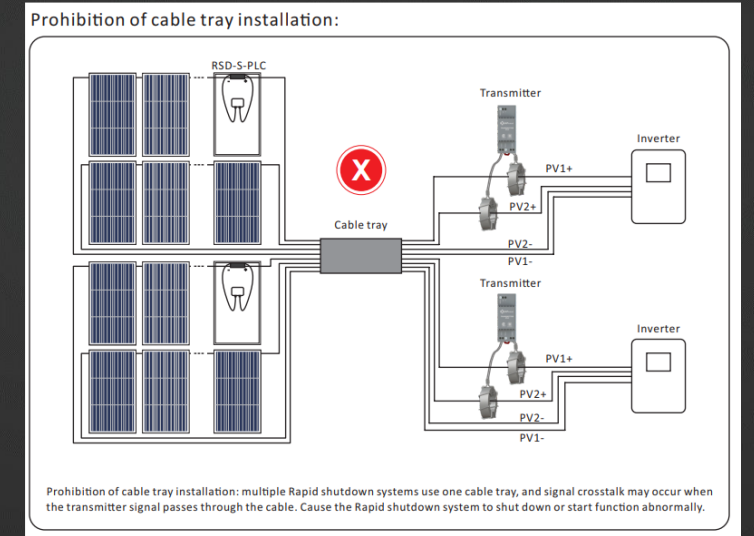
- Crosstalk is the nature of PLC technology when multiple signal resources(transmitters) installed closely, happening on two locations: **transmitters-PLCs & powerlines.**

- Due to filed data feedback, crosstalk will **NOT** influence on PV systems performance during the operation but has **electrical shock safety hazard** to operators when systems need shutdown for maintains, also reducing receivers' **life cycling and long-term reliability.**

PV system wiring recommendations:

- The distance between trays need above **20cm**, the distance between Transmitter-PLCs need above **2m**.

Preventive best practices: adding following steps inside operation SOP/regulations

- **De-energizing** PV arrays **first** to prevent crosstalk risks for safety.

- **Switching-off** DC disconnect or fuses **after** turning off inverter.

- **Disconnecting** connections from MPPTs inside inverter, **before** performing any electrical tests inside the string.

Prohibition of cable tray installation:

Prohibition of cable tray installation: multiple Rapid shutdown systems use one cable tray, and signal crosstalk may occur when the transmitter signal passes through the cable. Cause the Rapid shutdown system to shut down or start function abnormally.

Correct cable tray installation method:

Correct cable tray installation method: A Rapid shutdown system must use a separate cable tray to prevent signal crosstalk from the transmitter signal through the cable.

Reliability Evaluation Program by PVEL – Passed Accelerated Lifetime Test

PVEL ALT Program
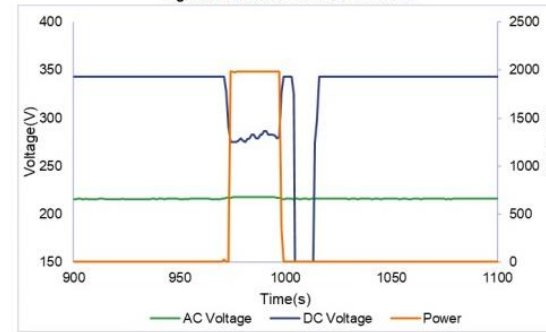
Thermal Cycling 400 Cycles Result

Certifications – https://apsmartglobal.com/library/

CSA certified

TUV certified

FCC certified

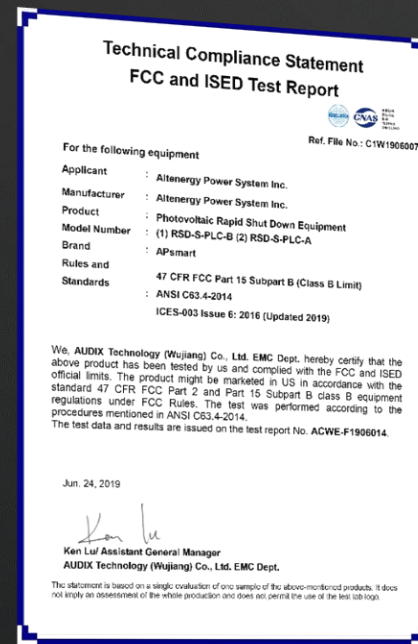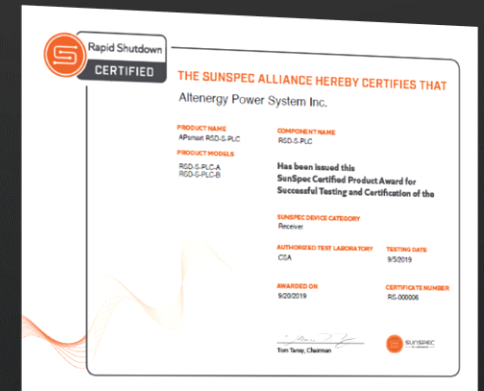**SUNSPEC certified**

APsmart RSD Solutions Performance in the Field Summary

- Since APsmart RSD devices exactly followed NEC 2017 690.12 Rapid Shutdown standard, it only applied single PV module voltages (< 80v) on DC terminals, and fully potted by Silicone within UL rated enclosure, the worst cases by low-voltages arcing melted out devices totally, before turning into fire. Based on 5 years field data, it has been proved APsmart RSD solution will NOT cause fire on the rooftop, with 0% & 0 case over 1.6M units shipped out worldwide. It will be safer with string inverter's low-voltages (<80v) AFCI detection applied.

- The highest rate of failed component is MOSFET, caused them either opened or shorted with thermal runaway, then will bypass the module. Failures can be early detectable by monitoring string inverter's performance portal MPPT voltage levels, by investing troubleshoot as early as possible can effectively ignoring the worst case of melting out devices.

- The overall field failure rate is < 0.03% based on total 1,600,000 devices were shipped out Worldwide (based on the RMA data from Q2 2022), and we are continuing to collect data to monitor products quality.

Global Services and Support

Our team here at APsmart are committed to providing the highest quality service to our customers and partners.

01

Applications Support

Phone: **737-218-8486**

Email: info@APsmartGlobal.com

02

Installers Support

Support Hotline: **1-866-374-8538**

Web: apsmartglobal.com/library/

03

O&M/RMA Support

Web: **apsmartglobal.com/support/**

Email: **support@APsmartGlobal.com**

01

Warranty

APsmart offers a **25 year** limited warranty on all our RSD products.

02

Training

APsmart offers full **in-person** or **web-based** trainings including products, system design, installation, commissioning, and sales approach.

03

Technical support

APsmart offers full **in-person technical support**, trouble-shooting with **Toll-Free** number and a **rapid response RMA service.**

Thank you!

For more information, visit

APsmartglobal.com

You can also email us at: info@APsmartGlobal.com
call us at: 7372188486