Testing Report

Rapid Shut Down (RSD)

of

United International University (UIU)

Location: United City, Madani Avenue, Badda, Dhaka, Dhaka 1212, Bangladesh.

Tested By:

Huawei Technologies Co., Ltd.

Testing Date:

16-October-2024

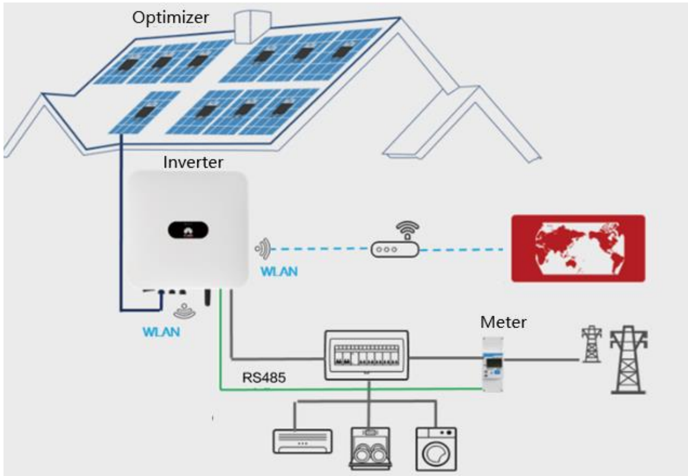
Contents

1 Introduction

The integration of solar energy into the global energy landscape has necessitated advancements in safety protocols and technology efficiency. One critical aspect of solar system design is the implementation of rapid shutdown capabilities, which are essential for ensuring the safety of both personnel and equipment during emergency situations or maintenance. This report focuses on the rapid shutdown testing of a solar photovoltaic (PV) system equipped with Huawei's PV optimizers, which are designed to enhance performance and facilitate improved safety measures.

Huawei's PV optimizers play a pivotal role in maximizing energy yield while providing real-time monitoring and individual module management. However, the effectiveness of these optimizers in executing a rapid shutdown during fault conditions is of paramount importance. This study aims to evaluate the functionality, reliability, and compliance of the rapid shutdown mechanism, examining how it interacts with the overall solar system to mitigate risks.

Through a series of controlled tests, this report will outline the procedures, findings, and implications of the rapid shutdown performance, contributing valuable insights into the operational safety of solar energy systems. The results will be instrumental for installers, operators, and regulatory bodies in assessing the viability of deploying Huawei's PV optimizers within modern solar installations.



If a PV module catches fire due to other causes, firefighters cannot put out the fire because of high DC voltage on the roof. Otherwise, life may be endangered. Therefore, the RSD function in the PV system to eliminate the DC high voltage on the roof is of great significance to ensure personal safety. The following describes AFCI test with RSD in the lab and onsite.

2 Equipment Specification

2.1 Inverter Specification

Here in this test SUN2000-50KTL-M3 inverter has been used. Inverter datasheet attached bellow:

SUN2000-50KTL-M3

Technical Specification

Technical Specification	SUN2000-50KTL-M3
	Efficiency
Max. Efficiency	98.5%
European Efficiency	98.0%
	Input
Max. Input Voltage [1]	1,100 V
Max. Current per MPPT	30 A
Max. Current per Input	20 A
Max. Short Circuit Current per MPPT	40 A
Start Voltage	200 V
MPPT Operating Voltage Range [2]	200 V ~ 1,000 V
Rated Input Voltage	600 V
Number of Inputs	8
Number of MPP Trackers	4
	Output
Rated AC Active Power	50,000 W
Max. AC Apparent Power	55,000 VA
Max. AC Active Power (cosφ=1)	55,000 W
Rated Output Voltage	400 Vac / 480 Vac, 3W+(N) + PE
Rated AC Grid Frequency	50 Hz / 60 Hz
Rated Output Current	72.2 A @ 400Vac, 60.1 A @ 480Vac
Max. Output Current	79.8 A @ 400Vac, 66.5 A @ 480Vac
Adjustable Power Factor Range	0.8 LG ... 0.8 LD
Max. Total Harmonic Distortion	<3%
	Protection
Input-side Disconnection Device	Yes
Anti-islanding Protection	Yes
AC Overcurrent Protection	Yes
DC Reverse-polarity Protection	Yes
PV-array String Fault Monitoring	Yes
DC Surge Arrester	Type II
AC Surge Arrester	Type II
DC Insulation Resistance Detection	Yes
Residual Current Monitoring Unit	Yes
Arc Fault Protection	Yes
Ripple Receiver Control	Yes
Integrated PID Recovery [3]	Yes
	Communication
Display	LED Indicators, Bluetooth + APP
RS485	Yes
Smart Dongle	WLAN/Ethernet via Smart Dongle-WLAN-FE (Optional) 4G / 3G / 2G via Smart Dongle-4G (Optional)
Monitoring BUS (MBUS)	Yes (Isolation Transformer required)
	Optimizer Compatibility
DC MBUS Compatible Optimizer	MERC-1100/1300W-P
	General Data
Dimensions (W x H x D)	640 x 530 x 270 mm (25.2 x 20.9 x 10.6 inch)
Weight (with mounting plate)	49 kg (108.1 lb)
Operating Temperature Range	-25℃ ~ 60℃ (-13°F ~ 140°F)
Cooling Method	Smart Air Cooling
Max. Operating Altitude	4,000 m (13,123 ft.)
Relative Humidity	0% RH ~ 100% RH
DC Connector	Amphenol HH4
AC Connector	Waterproof Connector + OT/DT Terminal
Protection Degree	IP 66
Topology	Transformerless
Nighttime Power Consumption	≤ 5.5W
	Standard Compliance (more available upon request)
Safety	EN 62109-1/-2, IEC 62109-1/-2, EN 50530, IEC 62116, IEC 60068, IEC 61683
Grid Connection Standards	IEC 61727, VDE-AR-N4105, VDE 0126-1-1, BDEW, G59/3, UTE C 15-712-1, CEI 0-16, CEI 0-21, RD 661, RD 1699, P.O. 12.3,RD 413, EN-50438-Turkey, EN-50438-Ireland, C10/11, MEA, Resolution No.7, NRS 097-2-1, DEWA

1. The maximum input voltage is the upper limit of the DC voltage. Any higher input DC voltage would probably damage inverter.
2. Any DC input voltage beyond the operating voltage range may result in inverter improper operating.
3. SUN2000-30~50KTL-M3 raises potential between PV- and ground to above zero through integrated PID recovery function to recover module degradation from PID. Supported module types include: P-type (mono, poly), N-type (nPERT, HIT)
4. 50KTL Platform only supports C&I Optimizer(MERC-1100/1300W-P). The current version does not support this function and it can be upgraded to optimizer version via new inverter software version(Dec 30th, 2022)

Refer to HTTP://solar.Huawei.com/

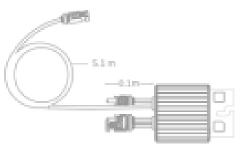
2.2 Optimizer specification

Here in this test SMART MODULE CONTROLLER MERC-1100W-P inverter has been used. Inverter datasheet attached bellow:

Technical Specification	MERC-1100W-P	MERC-1300W-P
	Input	
Rated input DC power [1]	1100 W	1300 W
Absolute max. input voltage	125 V	
MPPT operating voltage range	12.5 ~ 105 V	
Max. short-circuit current (Isc)	20 A	
Max. efficiency	99.5%	
Weighted efficiency	99.0%	
Overvoltage category	II	
	Output	
Max. output voltage	80 V	
Max. output current	22 A	
Output bypass [2]	Yes	
Safety output voltage [3]	1 V	
	Standards Compliance	
Safety	IEC62109-1 (class II safety)	
RoHS	Yes	
	General Specification	
Dimension (W X H X D)	149 mm x 104 mm x 48.8 mm (5.9 in. x 4.1 in. x 1.9 in.)	
Weight (including wires)	1.0 kg (2.2 lb.)	
Installation part (optional)	PV Module Frame Plate/T-shaped Bolt [4]	
Input connector	Staubli MC4	
Input wire length	0.1 m (+/-) (short-input-cable version) [5]	
Output connector	Staubli MC4	
Output wire length	0.1 m (+), 5.1 m (-) (short-input-cable version) [5]	
Operating temperature	-40°C to +85°C [6]	
Relative humidity	0% ~ 100%	
IP rating	IP68	
Compatible inverters	SUN2000-8/10/12/15/17/20KTL-M2, SUN2000-30/36/40KTL-M3, SUN2000-12/15/17/20/25KTL-M5, SUN2000-50KTL-M3	

PV System Design [7/8/9]	SUN2000-12~25K-MB0	SUN2000-12~25KTL-M5	SUN2000-30~40KTL-M3	SUN2000-50KTL-M3
Minimum String Length (Power Optimizers)	8	8	8	8
Maximum String Length (Power Optimizers)	25	25	25	20
Maximum DC Power per String	20,000 W	20,000 W	20,000 W	20,000 W

Short-input-cable Version



*1 The maximum power of PV module at STC shall NOT exceed the "Rated Input DC Power" of MERC-1100/1300W-P. PV Modules with up to +5% power tolerance are allowed.

*2 Any power optimizer, which is connected to an operating inverter in a PV string, will be bypassed when it fails.

*3 When the MERC-1100/1300W-P is disconnected from inverter or when the inverter is off, its output voltage will become 1 V.

*4 It is for PV module frame/extruded aluminum profile racking system installation.

*5 Pay attention to the PV module wire length. To match PV modules with a split junction box and short output wire, the long-input-cable version (input wire: 1.3 m (+/-); output wire: 0.1m (+)/2.9m (-)) of MERC-1100/1300W-P is available upon request.

*6 When the operating temperature of the MERC-1100/1300W-P reaches 70 °C to 85 °C, it may shut down due to over-temperature protection and report an over-temperature alarm. After the temperature decreases, it can automatically resume working without causing any damage.

*7 Each PV module under the same inverter must be equipped with a MERC-1100/1300W-P.

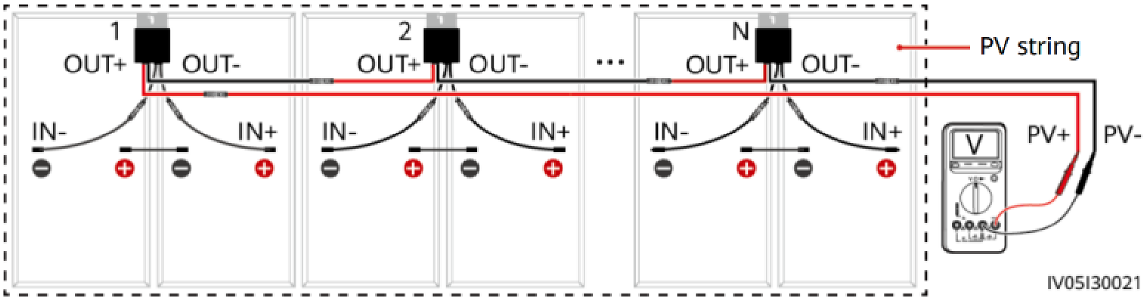
*8 SUN2000-450W-P2/600W-P and MERC-1100/1300W-P can NOT be used in mixture under the same Smart Energy/PV Controller.

*9 It is recommended that strings under the same inverter have an equal capacity. If this is not feasible, the capacity difference between strings under the same inverter must not exceed 2 kW. Otherwise, the energy yield will be reduced.

Disclaimer: the preceding values are measured by an internal laboratory of Huawei in a specific environment. The actual values may vary with products, software versions, usage conditions, and environmental factors.

3 Onsite test for RSD

3.1 Connection diagram



When the PV system is not powered on, the DC optimizer outputs >30 V by default, ensuring personal safety.

3.2 RSD Methods

To implement fast power-off, perform the following operations to trigger fast power-off:

1) Method 1: Disconnect the AC circuit breaker so that the inverter triggers a power-off state. Turn off the voltages of all PV strings connected to the inverters under the open circuit.

2) Method 2: Turn off the DC switch of the inverter (only the voltage of the PV string connected to the inverter is turned off).

3) Method 3: Remote shutdown of inverter using FusionSolar management system

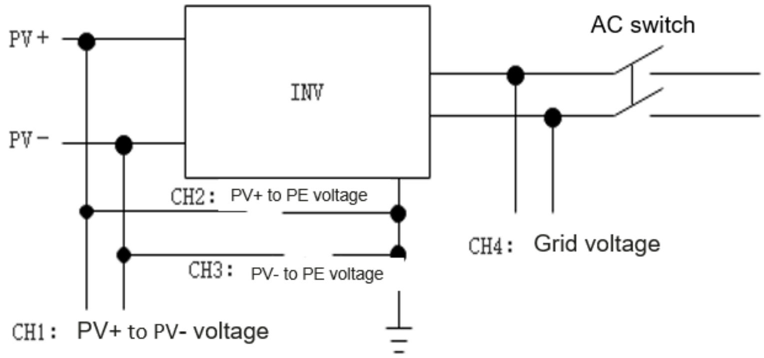
1）The time between the power grid disconnection and the voltage between PV+ to PV - voltage, PV+ to PE voltage and PV- to PE voltage are less than 30 V.

3.3 Test metric

2） PV+ to PE voltage and PV- to PE voltage are less than 30 V.

3.4 Testing procedure：

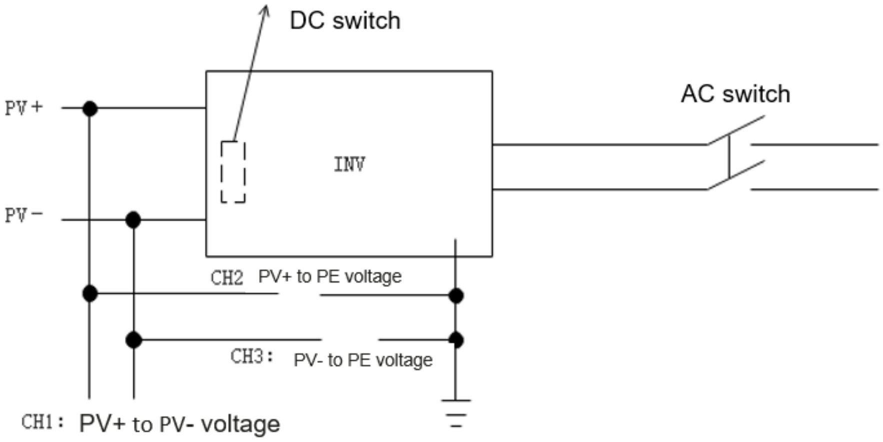
1) Fast shutdown triggered by AC power failure:



1. By keep the inverter running properly. We used a multimeter to collect the voltage of the inverter power grid voltage, PV+ to PV - voltage, PV+ to PE voltage and PV- to PE voltage；Then we Turned off the power grid switch on the AC, and recorded the voltage between PV+ to PV - voltage, PV+ to PE voltage and PV- to PE voltage are less than 30 V.

Figure: After AC switch turned off the string voltage is 3.8V DC (>30V DC)

2) Fast shutdown triggered by the DC switch



1. By keep the inverter running properly. We Used a multimeter to collect the voltage of the inverter power grid voltage, PV+ to PV - voltage, PV+ to PE voltage and PV- to PE voltage；Turn off the power grid switch on the AC, and record the voltage between PV+ to PV - voltage, PV+ to PE voltage and PV- to PE voltage are less than 30 V.

Figure: After DC switch turned off the string voltage is 8.9V DC (>30V DC)

2) Fast shutdown triggered by the Remote Shutdown

- We turned off the inverter remotely from smartphone using FusionSolar management system

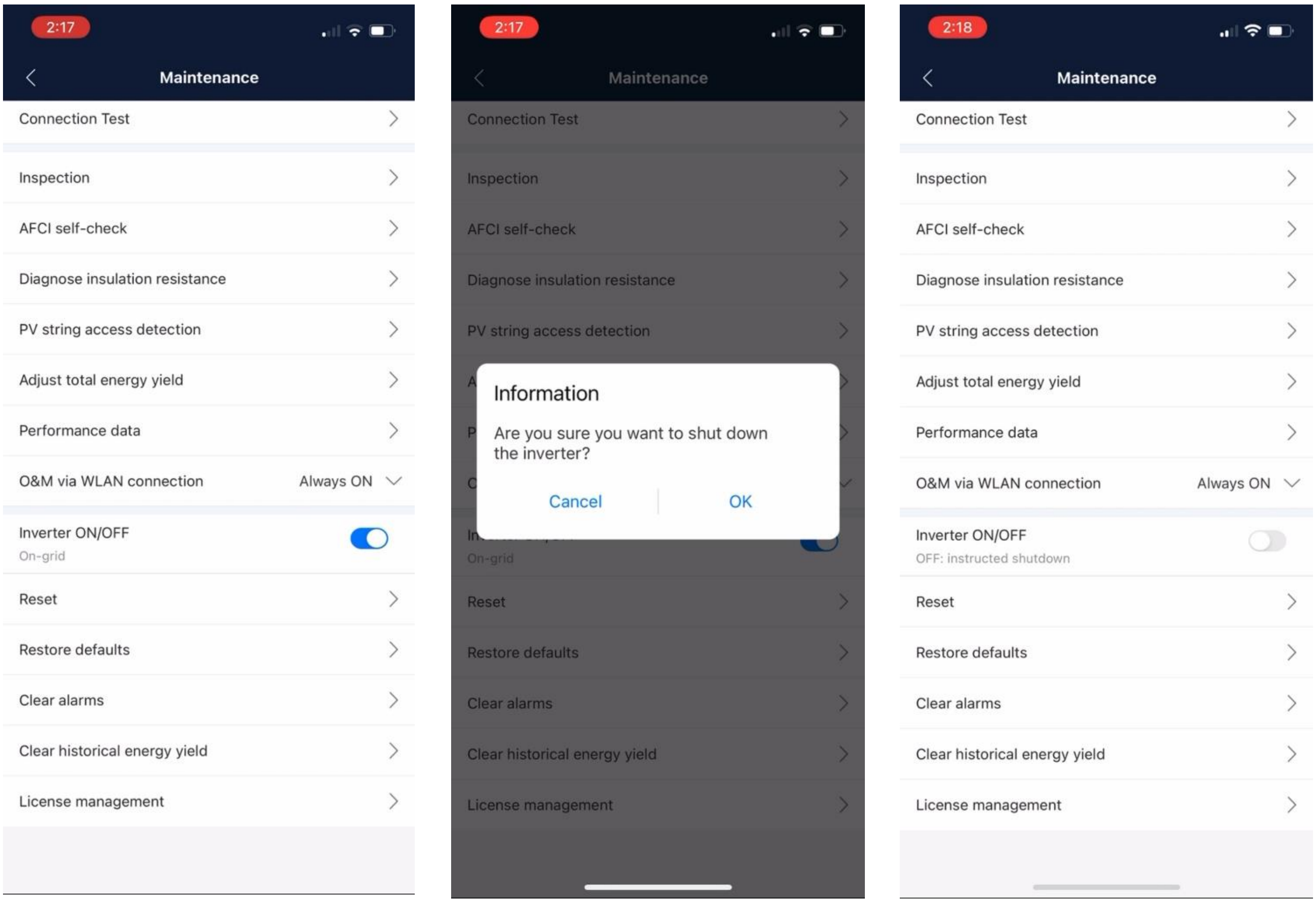


Figure: Inverter remotely shutdown from FusionSolar management system

- The voltage between string positive terminal PV+ and negative PV- terminal is less than 30 V.

Figure: After remote shutdown the string voltage is 8.6V DC (>30V DC)

Figure: All string current is 0.61A DC after remote shutdown

3.5 Testing verification：

During the final phase of our testing, we conducted a verification step to assess the system's behavior under rapid shutdown conditions. After confirming that all strings were operating within safe voltage and current ranges, we connected the positive (PV+) and negative (PV-) terminals of one string together. This action resulted in a measured current of 0.5 A flowing through the shorted connection. This finding indicates that, while the rapid shutdown function effectively reduces the voltage and current to safe levels, there remains a small residual current when the string terminals are shorted. This observation highlights the importance of understanding potential residual currents in safety protocols and underscores of such findings for system design and safety standards.

Figure: PV+ and PV- is shorted after remote shutdown

3.6 Testing outcome：

SN	Equipment	Usage	Result	Outcome
1	AC switch	Disconnect the power grid	The string voltage is less than 30V and current is close to 0, insuring safety	Rapid shutdown from PV side insured
2	DC switch	Disconnect the PV string	The string voltage is less than 30V and current is close to 0, insuring safety	Rapid shutdown from PV side insured
3	Remote shutdown	Remotely shutdown from FusionSolar management system	The string voltage is less than 30V and current is close to 0, insuring safety	Rapid shutdown from PV side insured

4 Conclusion

The rapid shutdown tests conducted on the rooftop solar plant utilizing MERC 1100W-P optimizers and a Huawei SUN2000-50KTL-M3 inverter demonstrated the effectiveness and reliability of the rapid shutdown protocols across multiple methods. All three methods—cutting off the inverter AC, turning off the inverter DC switch, and remote shutdown—successfully activated the rapid shutdown feature, also if there is an alarm on the inverter and the inverter shuts down the RSD triggered also, ensuring compliance with safety regulations. During the rapid shutdown state, the system maintained a PV string voltage of 8.7 V and a current of 0.61 A, both within safe operational limits.

However, the observation of a 0.5 A residual current flowing when the string terminals were shorted regarding potential residual currents. Overall, the test results affirm the system’s ability to perform effectively under rapid shutdown conditions, reinforcing the importance of robust safety measures in solar energy installations.