Product Service

Technical Report No.: 70.409.20.011.01-00

Date: 2020-11-20

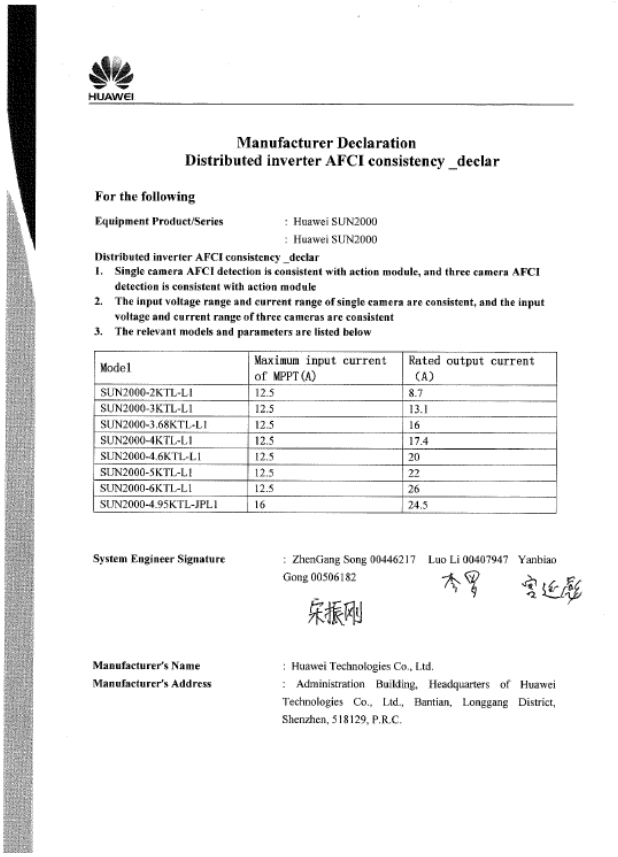
Client:	Huawei Technologies Co., Ltd. Address: Administration Building Headquarters of Huawei Technologies Co., Ltd., Bantian, Longgang District, 518129 Shenzhen, PEOPLE'S REPUBLIC OF CHINA
Manufacturing place:	Huawei Machine Co., Ltd. No. 2 City Avenue, Songshan Lake Sci. & Tech. Industry Park, 523808 Dongguan, Guangdong, PEOPLE'S REPUBLIC OF CHINA
Test subject:	Product: Solar Inverter Type: SUN2000-2KTL-L1, SUN2000-3KTL-L1, SUN2000-3.68KTL-L1, SUN2000-4KTL-L1, SUN2000-4.6KTL-L1, SUN2000-5KTL-L1, SUN2000-6KTL-L1, SUN2000-4.95KTL-JPL1
Test specification:	Draft standard IEC 63027 ED1, 82/1636/CDV DC arc detection and interruption in photovoltaic power systems
Purpose of examination:	• (Visual / Partial -) inspection according to the test specification
Test result:	The test result show that the presented product is in compliance with the specific requirements.

Any use for advertising purposes must be granted in writing. This technical report may only be quoted in full. This report is the result of a single examination of the object in question and is not generally applicable evaluation of the quality of other products in regular production. For further details please see testing and certification regulation, chapter A-3.4.

1. Description of the test subject

1.1 Function

These devices are transformer-less grid-connected PV inverters which converts direct current optimized by photovoltaic DC conditioner to alternating current, and they are intended to be connected in parallel with the public LV distribution grid directly. In addition, the inverter is integrated with DC arc fault detection and interruption function.
They are intended for professional incorporation into PV system, and they are assessed on a component test basis.
The AFCI function module integrated into the inverter are the same for this series products, including hardware and control logic in programmable electronic components. Also refer to declaration from Huawei in below.



HUAWEI

Manufacturer Declaration
Distributed inverter AFCI consistency _declar

For the following

Equipment Product/Series : Huawei SUN2000
: Huawei SUN2000

Distributed inverter AFCI consistency _declar

1. **Single camera AFCI detection is consistent with action module, and three camera AFCI detection is consistent with action module**
2. **The input voltage range and current range of single camera are consistent, and the input voltage and current range of three cameras are consistent**
3. **The relevant models and parameters are listed below**

Model	Maximum input current of MPPT(A)	Rated output current (A)
SUN2000-2KTL-L1	12.5	8.7
SUN2000-3KTL-L1	12.5	13.1
SUN2000-3.68KTL-L1	12.5	16
SUN2000-4KTL-L1	12.5	17.4
SUN2000-4.6KTL-L1	12.5	20
SUN2000-5KTL-L1	12.5	22
SUN2000-6KTL-L1	12.5	26
SUN2000-4.95KTL-JPL1	16	24.5

System Engineer Signature : ZhenGang Song 00446217 Luo Li 00407947 Yanbiao Gong 00506182

宋振刚

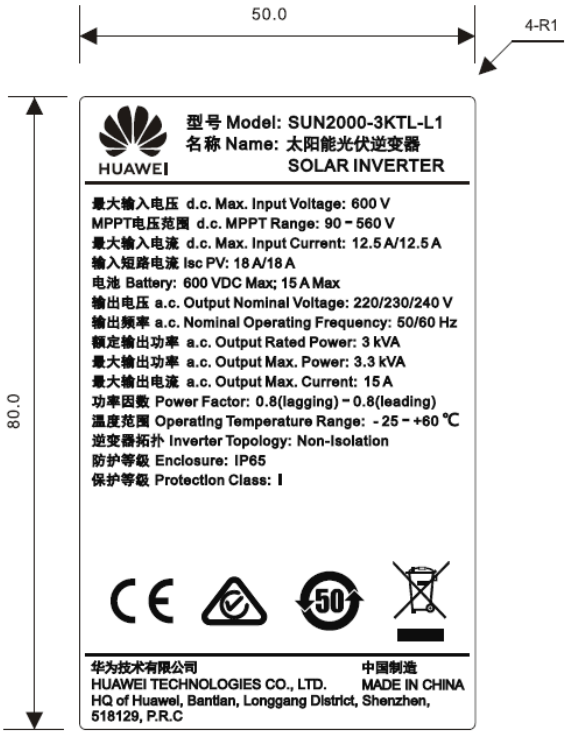
Manufacturer's Name : Huawei Technologies Co., Ltd.
Manufacturer's Address : Administration Building, Headquarters of Huawei Technologies Co., Ltd., Bantian, Longgang District, Shenzhen, 518129, P.R.C.

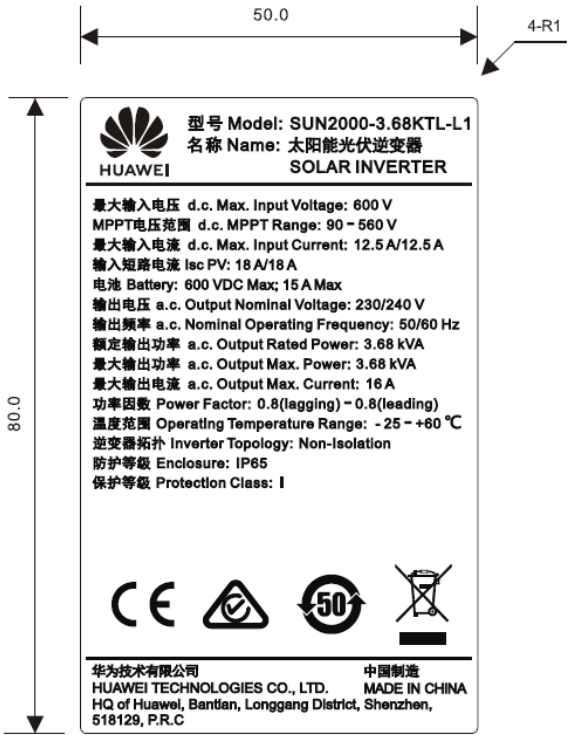
Firmware version related to AFCI function: SUN2000LV200R001C00SPC102

1.2 Consideration of the foreseeable use

☐ Not applicable
☒ Covered through the applied standard
☐ Covered by the following comment
☐ Covered by attached risk analysis

1.3 Technical Data




50.0
4-R1
80.0
HUAWEI
型号 Model: SUN2000-3.68KTL-L1
名称 Name: 太阳能光伏逆变器
SOLAR INVERTER
最大输入电压 d.c. Max. Input Voltage: 600 V
MPPT电压范围 d.c. MPPT Range: 90 ~ 560 V
最大输入电流 d.c. Max. Input Current: 12.5 A/12.5 A
输入短路电流 Isc PV: 18 A/18 A
电池 Battery: 600 VDC Max; 15 A Max
输出电压 a.c. Output Nominal Voltage: 230/240 V
输出频率 a.c. Nominal Operating Frequency: 50/60 Hz
额定输出功率 a.c. Output Rated Power: 3.68 kVA
最大输出功率 a.c. Output Max. Power: 3.68 kVA
最大输出电流 a.c. Output Max. Current: 16 A
功率因数 Power Factor: 0.8(lagging) ~ 0.8(leading)
温度范围 Operating Temperature Range: - 25 ~ +60 ℃
逆变器拓扑 Inverter Topology: Non-Isolation
防护等级 Enclosure: IP65
保护等级 Protection Class: I
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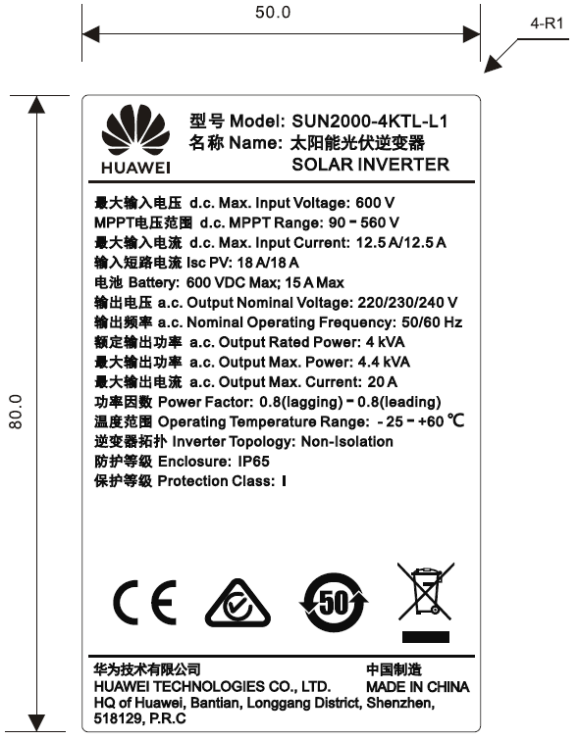
50.0
4-R1
80.0
HUAWEI
型号 Model: SUN2000-4KTL-L1
名称 Name: 太阳能光伏逆变器
SOLAR INVERTER
最大输入电压 d.c. Max. Input Voltage: 600 V
MPPT电压范围 d.c. MPPT Range: 90 ~ 560 V
最大输入电流 d.c. Max. Input Current: 12.5 A/12.5 A
输入短路电流 Isc PV: 18 A/18 A
电池 Battery: 600 VDC Max; 15 A Max
输出电压 a.c. Output Nominal Voltage: 220/230/240 V
输出频率 a.c. Nominal Operating Frequency: 50/60 Hz
额定输出功率 a.c. Output Rated Power: 4 kVA
最大输出功率 a.c. Output Max. Power: 4.4 kVA
最大输出电流 a.c. Output Max. Current: 20 A
功率因数 Power Factor: 0.8(lagging) ~ 0.8(leading)
温度范围 Operating Temperature Range: - 25 ~ +60 ℃
逆变器拓扑 Inverter Topology: Non-Isolation
防护等级 Enclosure: IP65
保护等级 Protection Class: I
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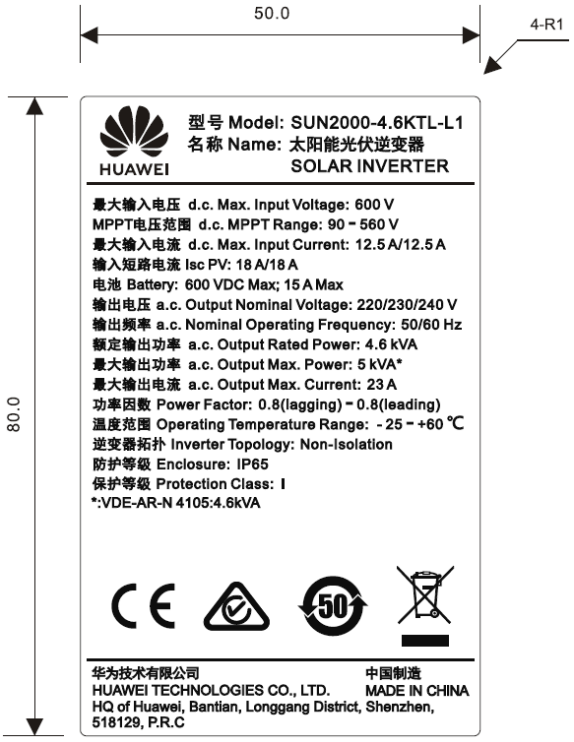
50.0
4-R1
80.0
HUAWEI
型号 Model: SUN2000-4.6KTL-L1
名称 Name: 太阳能光伏逆变器
SOLAR INVERTER
最大输入电压 d.c. Max. Input Voltage: 600 V
MPPT电压范围 d.c. MPPT Range: 90 ~ 560 V
最大输入电流 d.c. Max. Input Current: 12.5 A/12.5 A
输入短路电流 Isc PV: 18 A/18 A
电池 Battery: 600 VDC Max; 15 A Max
输出电压 a.c. Output Nominal Voltage: 220/230/240 V
输出频率 a.c. Nominal Operating Frequency: 50/60 Hz
额定输出功率 a.c. Output Rated Power: 4.6 kVA
最大输出功率 a.c. Output Max. Power: 5 kVA*
最大输出电流 a.c. Output Max. Current: 23 A
功率因数 Power Factor: 0.8(lagging) ~ 0.8(leading)
温度范围 Operating Temperature Range: - 25 ~ +60 ℃
逆变器拓扑 Inverter Topology: Non-Isolation
防护等级 Enclosure: IP65
保护等级 Protection Class: I
*:VDE-AR-N 4105:4.6kVA
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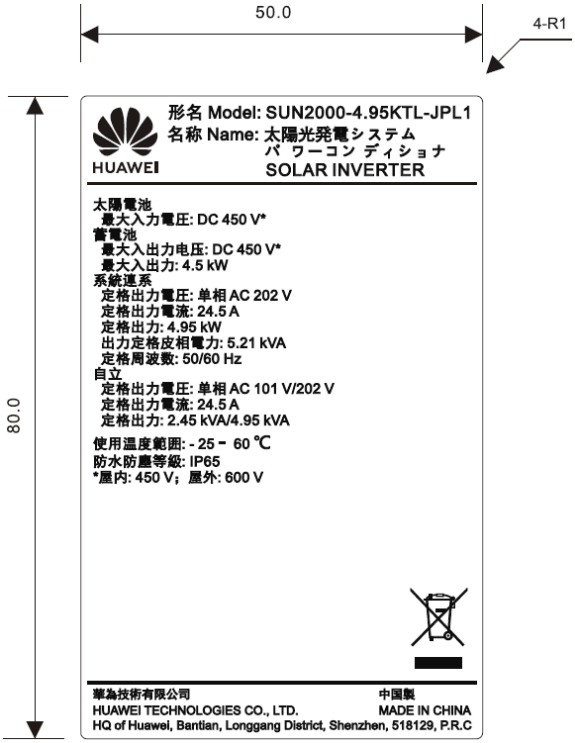
50.0
4-R1
80.0
HUAWEI
形名 Model: SUN2000-4.95KTL-JPL1
名称 Name: 太陽光発電システム
パ ワーコン ディショナ
SOLAR INVERTER
太陽電池
最大入力電圧: DC 450 V*
蓄電池
最大入出力电压: DC 450 V*
最大入出力: 4.5 kW
系統連系
定格出力電圧: 単相 AC 202 V
定格出力電流: 24.5 A
定格出力: 4.95 kW
出力定格皮相電力: 5.21 kVA
定格周波数: 50/60 Hz
自立
定格出力電圧: 単相 AC 101 V/202 V
定格出力電流: 24.5 A
定格出力: 2.45 kVA/4.95 kVA
使用温度範囲: - 25 ~ 60 ℃
防水防塵等級: IP65
*屋内: 450 V；屋外: 600 V
華為技術有限公司
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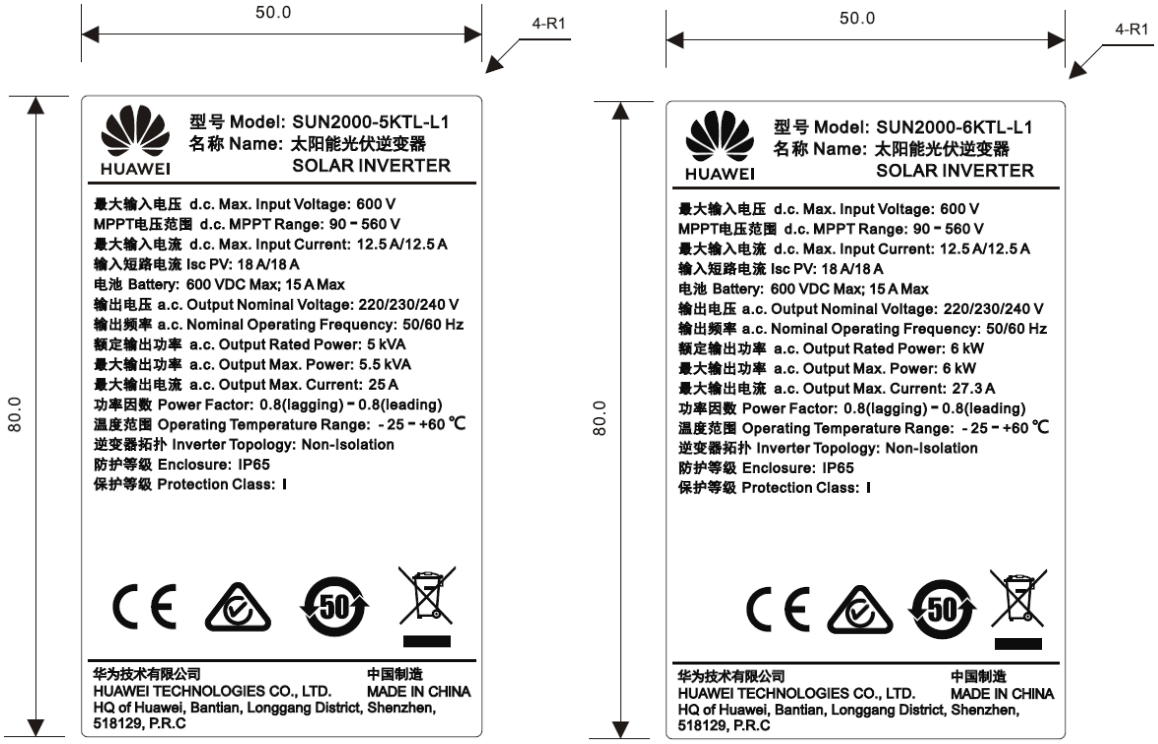


Note: inverter marking only, a seperated marking regarding to arcing characteristic should be provided on inverter as well according to draft standard IEC 63027 ED1, 82/1636/CDV

2. Order

2.1 Date of Purchase Order, Customer's Reference

2020-07-14

2.2 Receipt of Test Sample, Condition, Location

2020-10-21

2.3 Date of Testing	**Witness tested by TUV SUD engineer from 2020-10-21 to 2020-11-17**
2.4 Location of Testing	**Huawei Technologies Co., Ltd.** No.127,Jinye Road, Xi'an High-Tech Development District, Xi'an,710077,P.R.C

2.5 Points of Non-Compliance or Exceptions of the Test Procedure

N/A

3. Test Results

As requested by manufacturer, only series arc fault test and reconnection test were conducted at this stage. The other requirements and tests which are applicable, will be involved at next stages, and test report should be issued accordingly.

Full test was conducted on representative mode SUN2000-6KTL-L1. Additional test was conducted on SUN2000-4.95KTL-JPL1 due to different input port / channel current.

Clause	Requirement - Test	Measurement result - remark	P
4	Classification		P
4.1	According to the protection coverage		P
	Two types of classification are defined:		P
	Code: F; AFP is provided from the PV modules up to the inverter input terminals. (Full coverage)		P
	Code: P; AFP is provided from the PV modules up to the parallel connection of the strings. No AFP is provided for wiring between the parallel connection and the inverter input terminals. (Partial coverage)		N/A
4.2	According to the method of implementation		P
4.2.1	PCE integrated device (I)		P
4.2.2	Standalone device (S)		N/A
4.2.3	Distributed detection system (D)		N/A
4.3	According to the functionality		P
4.3.1	AFPE: detection and interruption capability provided		P
4.3.2	AFD: Only detection / no interruption capability provided		N/A
4.4	According to the number of monitored strings (S)		P
4.4.1	Single string		P
4.4.2	Parallel string		N/A
4.5	According to the number of Input ports (I)		P
	An AFD or AFPE may be provided with one or more input ports per monitored channel.	Only one input port per channel	P

4.6	According to the number of monitored channels (C)		P
4.6.1	Single channel		N/A
4.6.2	Multi-channel		P
4.7	According to the reconnection method	One of three type of method can be chosen, default as automatic reconnection	P
4.7.1	Manual reconnection		P
4.7.2	Remote manual reconnection		P
4.7.3	Automatic reconnection		P
5	Ratings of AFPEs and AFDs		P
5.1	PCE integrated AFPEs and AFDs		P
5.1.1	Rated and limiting values		P
5.1.1.1	Rated channel current	Details see appendix table	P
5.1.1.2	Maximum current per input port	Details see appendix table	P
5.1.1.3	Rated interruption current	Details see appendix table	P
5.1.1.4	Other ratings	Not checked	N/A
	Other ratings of the AFPE or AFD correspond to the input characteristics of the PCE according to IEC 62109-1.		N/A
5.2	Standalone AFPEs and AFDs		N/A
5.2.1	Rated and limiting values		N/A
5.2.1.1	Rated voltages		N/A
5.2.1.1.2	Rated insulation voltage (*U*i)		N/A
5.2.1.1.3	Rated impulse withstand voltage (*U*imp)		N/A
5.2.1.2	Currents		N/A
5.2.1.2.1	Rated channel current		N/A
5.2.1.2.2	Maximum current per input port		N/A
5.2.1.2.3	Rated interruption current		N/A
5.2.1.3	Rated duty		N/A
5.2.2	Utilization category		N/A
6	Product information		N/A
6.1	PCE integrated devices	Not evaluated at this stage, manual or specification not	N/A

		finalized as per this draft standard	
	In addition to the product information relevant according to IEC 62109-1 clause 5, the following information shall be provided.		N/A
	– Protection coverage (F for “full” or P for “partial”)		N/A
	– Method of implementation (D for ‘distributed’ or I for fully integrated systems)		N/A
	– Maximum number of strings per input or input port (derived from number of channels and maximum number of monitored strings per channel)		N/A
	– Reconnection method		N/A
	– Functionality (AFD, AFPE)		N/A
	In addition to the marking and documentation requirements described in IEC 62109-1 subclause 5.1, Table 1 requirements apply. Table 1 - Marking and documentation requirements Marking or information item / Visible on product when installed / In a manual a Protection coverage: x / x b Method of implementation: / x c Maximum number of strings per input or input port: / x d Reconnection method: / x e Functionality: x / x		N/A
6.2	Standalone devices		N/A
6.2.1	Nature of information		N/A
	Subclause 5.1 of IEC 60947-1 applies as appropriate for a particular design with the following additions.		N/A
	– Protection coverage (F for “full” or P for “partial”)		N/A
	– Method of implementation (D for ‘distributed’ or S for standalone device)		N/A
	– Maximum number of strings per input or input port (derived from number of channels and maximum number of monitored strings per channel)		N/A
	– Reconnection method		N/A
	– Functionality (AFD, AFPE)		N/A
	– Rated interruption current (where applicable)		N/A
	– Reconnection method		N/A

<table>
<tr><td></td><td>Type of reconnection. If more than one type can be selected, indication for the preset (or default) method shall be given</td><td></td><td>N/A</td></tr>
<tr><td></td><td>Procedure for manual reconnection (if applicable)</td><td></td><td>N/A</td></tr>
<tr><td></td><td>Procedure for remote manual reconnection (if applicable)</td><td></td><td>N/A</td></tr>
<tr><td></td><td>Time settings for automatic reconnection (if not configurable)</td><td></td><td>N/A</td></tr>
<tr><td></td><td>– Information regarding compatibility with specific PCE models and other components according to subclauses 8.3 and 9.2.10.</td><td></td><td>N/A</td></tr>
<tr><td>6.2.2</td><td>Marking</td><td></td><td>N/A</td></tr>
<tr><td></td><td>Subclause 5.2 of IEC 60947-1 applies as appropriate for characteristics defined in Table 2
Table 2 – Requirements for documentation, marking and position of marking
<table>
<tr><th></th><th>Marking or information item</th><th>Position of the marking or information</th><th></th><th></th></tr>
<tr><th></th><th></th><th>Visible on product when installed</th><th>On the product</th><th>In a leaflet</th></tr>
<tr><td>a</td><td>Protection coverage</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>b</td><td>Method of implementation</td><td></td><td>x</td><td>x</td></tr>
<tr><td>c</td><td>Rated current</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>d</td><td>Maximum number of strings per input or input port</td><td></td><td>x</td><td>x</td></tr>
<tr><td>e</td><td>Orientation</td><td></td><td>x</td><td>x</td></tr>
<tr><td>f</td><td>Reconnection method</td><td></td><td></td><td>x</td></tr>
<tr><td>g</td><td>Functionality</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>h</td><td>Information regarding compatibility</td><td></td><td></td><td>x</td></tr>
</table></td><td></td><td>N/A</td></tr>
<tr><td>6.2.3</td><td>Instructions for installation, operation and maintenance</td><td></td><td>N/A</td></tr>
<tr><td></td><td>Subclause 5.3 of IEC 60947-1 applies.</td><td></td><td>N/A</td></tr>
<tr><td>7</td><td colspan="2">Normal service, mounting and transport conditions</td><td>N/A</td></tr>
<tr><td>7.1</td><td>PCE integrated AFPEs</td><td>Not evaluated at this stage</td><td>N/A</td></tr>
<tr><td></td><td>For PCE integrated AFPEs the normal service, mounting and transport conditions of IEC 62109-1 apply.</td><td></td><td>N/A</td></tr>
<tr><td></td><td>In case a manual test function is incorporated, the frequency of manual operation shall be stated.</td><td></td><td>N/A</td></tr>
<tr><td>7.2</td><td>Stand-alone AFPEs</td><td></td><td>N/A</td></tr>
<tr><td></td><td>Clause 6 of IEC 60947-1 applies with the following addition.</td><td></td><td>N/A</td></tr>
<tr><td></td><td>Unless otherwise stated by the manufacturer, the equipment is intended for installation under environmental conditions of pollution degree 3.</td><td></td><td>N/A</td></tr>
<tr><td></td><td>In case a manual test function is incorporated, the frequency of manual operation shall be stated.</td><td></td><td>N/A</td></tr>
</table>

8	Construction and performance requirements		P
8.1	General requirements for PCE integrated AFDs/AFPEs and Stand-alone AFDs/AFPEs	Only 8.1.2 and 8.1.3 evaluated	P
8.1.1	Annunciator of arc fault events	Not evaluated at this stage	N/A
	AFDs and AFPEs shall be provided with an annunciator (local or remote) that provides a visual indication that the device has operated when an arc fault is detected.		N/A
	Where the reconnection is required to be performed manually, this indication shall not reset automatically. This applies to manual reconnection, remote manual reconnection and also in case 389 automatic reconnection after the fifth interruption within a 24 h period.		N/A
8.1.1.2	Programmable circuit components	Not evaluated at this stage	N/A
	Any circuit that employs a programmable circuit component shall comply with IEC 61508 or IEC 62109-1 Annex B.		N/A
8.1.2	Operation in case of series arc fault event		P
	The AFD shall detect the arc within 2.5 s or before the arc energy exceeds 750 J, whichever occurs first.		P
	The AFPE shall detect the arc and interrupt it within 2,5 s or before the arc energy exceeds 750 J, whichever occurs first.		P
	If the AFPE can extinguish the arc before exceeding 200 J and within 2,5 s, then annunciation of an arc detection is not required.		P
8.1.3	Reconnection capability of AFPE		P
	After detecting an arc, the circuits shall remain interrupted even in case of loss of power supply. For restart the following restart methods apply.		P
8.1.3.1	Manual reconnection	Use APP within distance of 5m to PV inverter	P
	To restart the AFPE and close circuits a manual procedure is required.		P
8.1.3.2	Remote manual reconnection		P

	To restart the AFPE and close circuits a manual procedure is required (button or external signal, triggered by manual operation on-site or remote activation).		P
8.1.3.3	Automatic reconnection		P
	Adjustable automatic reconnection times are allowed for compliance with local installation standards or owner/operator preferences, provided that a minimum reconnection delay is ensured.		P
	The reconnection times can be adjusted via parameter settings or manual switches (e.g. rotary switches).		P
	To restart the AFPE no manual procedure is required:		P
	After a minimum interruption time of 5 min the AFPE is allowed to continue operation of the array.		P
	In case of subsequent interruptions by the AFPE, the time for reconnection shall not be lower than 10 min		P
	When interrupting the fifth time within a 24 h period, the AFPE shall be reset manually according to 8.1.3.1 or 8.1.3.2 until the automatic reconnection mode is set again manually.		P
8.1.4	Test function	Not evaluated at this stage	N/A
	AFDs and AFPEs shall be provided with a manual or an automatically initiated test function or both that allows for regular checks of the arc detection circuit.		N/A
	The manual test function shall allow for periodic testing of the device by manual means that does not require the use of a tool or key.		N/A
	The automatic test function shall be performed before starting operation and at least once in a 24 h period.		N/A
	During automatic testing the AFPE is not required to interrupt.		N/A
	In case of manual test, the AFPE shall interrupt.		N/A
	In case a malfunction of the AFD or AFPE is detected during the test, the AFD shall		N/A

	indicate the result and the AFPE shall interrupt and indicate the result according to 8.1.1.1.		
8.2	PCE integrated AFDs and AFPEs	Not evaluated at this stage	N/A
	For PCE integrated AFDs and AFPEs, the normal service, mounting and transport conditions of IEC 62109-1 with the additional requirements defined under 8.1 apply.		N/A
8.3	Stand-alone AFDs and AFPEs		N/A
	Stand-alone AFDs and AFPEs shall comply with 7.1 of IEC 60947-1 in addition to the requirements described below and in 8.1 Stand-alone AFPEs shall also comply with 7.1 of IEC 60947-3.		N/A
	AFDs and AFPEs shall be compatible with the PCE and their power line communication devices. AFD and AFPE functionality shall not be compromised by the PCE or power line communication.		N/A
9	Tests		P
9.1	General		P
	The tests defined in this section are broadly applicable to all AFD and AFPE devices. Additional specific requirements apply as follows:		P
	- Stand-alone AFDs and AFPEs: Clause 8 of IEC 60947-1.		N/A
	- Stand-alone AFPEs: IEC 60947-3.		N/A
	- PCE integrated devices: Clause 4 of IEC 62109-1.	Not evaluated at this stage	N/A
9.2	Series arc fault test		P
9.2.1	General		P
	To ensure that detection is achieved in all application cases defined by the manufacturer, different test scenarios shall be applied. The major distinctions are related to		P
	– single string case		P
	– parallel string case		N/A
	– single channel case		N/A
	– multi-channel case		P

	– single module case		N/A
9.2.2	Arc generator		P
9.2.3	DC source		P
	The source required for testing shall consist of a DC power source, either		P
	a constant voltage source with additional resistance to simulate PV specific IV-characteristics, or		N/A
	a PV simulator. Since a PV simulator may produce unwanted tripping or may inhibit the AFPE from detecting arcing, referee tests shall be made using a suitable array of PV modules when deemed necessary.		P
9.2.3.1	Constant voltage source		N/A
9.2.3.2	PV simulator		P
9.2.3.3	Decoupling network		P
9.2.4	Array line impedance network	Test with C4=20 uF and 300 nF as half string model were carried out	P
9.2.5	Line Impedance		P
9.2.6	Test procedure		P
	Table 3 lists all arcing test conditions. **Table 3 – Arcing test conditions** Test # | Minimum I_{arc} (A)* | I_{mpp} (A) | Sep. Rate (mm/s) | V_{mpp} (V) | V_{OC} (V) | R_{tot} (ohms) | Gap (mm) 1 | 2,5 | 3,0 | 2,5 | 312,0 | 480,0 | 56,0 | 0,8 2 | 7,0 | 8,0 | 5,0 | 318,0 | 490,0 | 21,0 | 0,8 3 | 14,0 | 16,0 | 5,0 | 318,0 | 490,0 | 11,0 | 1,1 4 | 7,0 | 8,5 | 5,0 | 607,0 | 810,0 | 24,0 | 2,5 5 | 0,9 IMax,DUT | IMax,DUT | 5,0 | 318,0 | 490,0 | $\frac{V_{OC}}{V_{mpp}@IMax,DUT}$ | 2,5 *Values given shall provide an indication of currents that likely occur. The actual value depends on several factors.		P
	Tests 1-5 shall be performed as follows:		P
	Test 1: This test shall be applied to all DUTs.		P
	Test 2: This test shall be applied where the maximum input current of the DUT is 8 A or higher.		P
	Test 3: This test shall be applied where the maximum input current of the DUT is 16 A or higher.	Only for test with SUN2000-4.95KTL-JPL1	P
	Test 4: This test shall be applied where the maximum input voltage of the DUT is 810 V or higher.		N/A

	Test 5: This test shall be applied where the maximum rated sensing current of a single channel of the DUT is 24 A or higher and where the maximum arcing current is not limited by the input ratings of the DUT to less than 24 A (see Figure 6.).		N/A
	The arc generator shall be positioned as shown in the applicable figures in Annex B.		P
	In general, the arc generator shall be positioned close to the PV terminal (positive or negative) of the DUT that results in the most severe condition.	Both positive and negative conditions were tested	P
	If more than one PV module can be connected in series to the DUT input, an additional test shall be performed with the arc generator in the middle of the series connected modules.		P
	Each test (arc-gap and current combination) shall be performed two times.		P
	For multi-channel devices each channel shall be tested according the single channel setups.		P
	Where the same hardware and software modules are used for each channel, the number of tests may be reduced as follows: Test one channel according to the full set of applicable tests required for one channel. Test the remaining channels only with the most adverse arc location determined in the original tests.		P
9.2.7	Arc energy and response time measurement		P
	The voltage across the arc gap, the arc duration, and the current through the arc shall be measured and recorded.		P
	These measurements are then used to calculate the total energy generated by the arc prior to detection or interruption.		P
	For arc duration measurements,		P
	- The arc period for AFPEs begins when the arc voltage reaches 10 V and ends when the arc current falls below 250 mA.		P
	- The arc period for AFDs begins when the arc voltage reaches 10 V and ends at the indication of an arc event.		P

9.2.8	Test function	Not evaluated at this stage	N/A
9.2.8.1	Test function without malfunction		N/A
9.2.8.2	Test function with malfunction		N/A
9.2.8.2.1	Detection malfunction		N/A
9.2.8.2.2	Interruption malfunction		N/A
9.2.8.2.3	Automatic test function before starting operation		N/A
9.2.8.2.4	Automatic test function during operation		N/A
9.2.9	Reconnection test		P
9.2.9.1	Manual reconnection		P
9.2.9.2	Remote manual reconnection		P
9.2.9.3	Automatic reconnection		P
9.2.10	Immunity test		N/A
	The detection capability of stand-alone devices shall not be compromised by expected internal or external interference.		N/A
Annex A	String and channel examples (informative)		P
Annex B	Test setups following different application cases (normative)		P
	Test setups according to B.1 shall be performed for AFPE with method of implementation classified as I for		P
	• Inverter integrated AFPE, except micro-inverters	As installation method without DC-DC converter specified by manufacturer	P
	• Standalone AFPE with one input port per channel		N/A
	Test setups according to B.2 shall be performed for AFPE with system integration classified as I for		N/A
	• Micro-inverter integrated AFPE		N/A
	Test setups according to B.3 shall be performed for AFPE with system integration classified as I or D for	As installation method with DC-DC converter specified by manufacturer	P
	• AFPE for DC-DC converter systems	Test on site based on manufacturer's request and specified conditions	P
	Test setups according to B.4 shall be performed for AFPE with system integration classified as S for		N/A

	• AFPE integrated in combiner boxes		N/A
	• Standalone AFPE with more than one input port per channel		N/A
B.0	PV source models		P
	Depending on the application and the test setup, four different PV source models are defined with the respective parameter values for the LRC components in Table B.0.2:		P
	(1) Half string model (2) Full string model (3) Module based model (4) Parallel string model		P
B.1	Application String inverter		P
B.2	Application Micro inverter		N/A
B.3	Application module level DC/DC conversion		P
B.3.1	Input setups		P
B.3.2	Output setups		P
B.4	Application external combined strings		N/A
B.4.1	Input setups		N/A
B.4.2	Output setups		N/A
Annex C	Application examples (informative)		N/A

Appendix Tables:

A) Test setup: according to B.1, typical application case for string inverter

Inverter configuration:
Two channels (1-2): each arc detection channel consists of one MPP tracker and one input port per MPP tracker

Maximum input voltage of the DUT is less than 810V.

1) Parameters as in normal installations for arc detection related:

$I_{mpp\ max\ per\ input\ port}$	$I_{max\ per\ MPP\ tracker}$	Rated channel current	rated interruption current	Number of channels
12,5 A	12,5 A	12,5 A	12,5 A	2
16 A	16 A	16 A	16 A	2

Note: 16 A only applicable to SUN2000-4.95KTL-JPL1

Table 3 – Arcing test conditions

Test #	Minimum I_{arc} (A)*	I_{mpp} (A)	Sep. Rate (mm/s)	V_{mpp} (V)	V_{OC} (V)	R_{tot} (ohms)	Gap (mm)
1	2,5	3,0	2,5	312,0	480,0	56,0	0,8
2	7,0	8,0	5,0	318,0	490,0	21,0	0,8
3	14,0	16,0	5,0	318,0	490,0	11,0	1,1
4	7,0	8,5	5,0	607,0	810,0	24,0	2,5
5	0,9 IMax,DUT	IMax,DUT	5,0	318,0	490,0	$(V_{OC}-V_{mpp})/Imax,DUT$	2,5

*Values given shall provide an indication of currents that likely occur. The actual value depends on several factors.

Tests 1), 2) were chosen to be carried out in below table where is applicable.

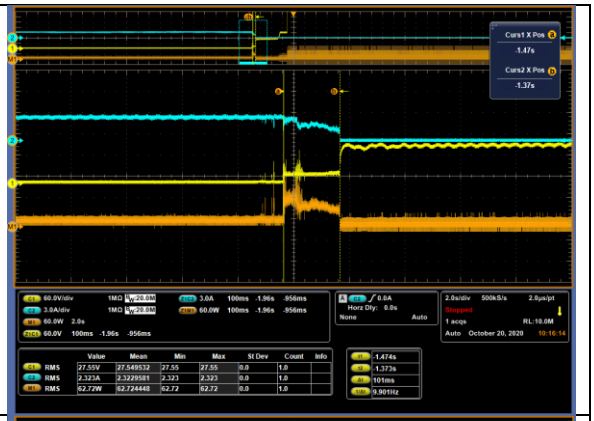
Details conditions for testing:

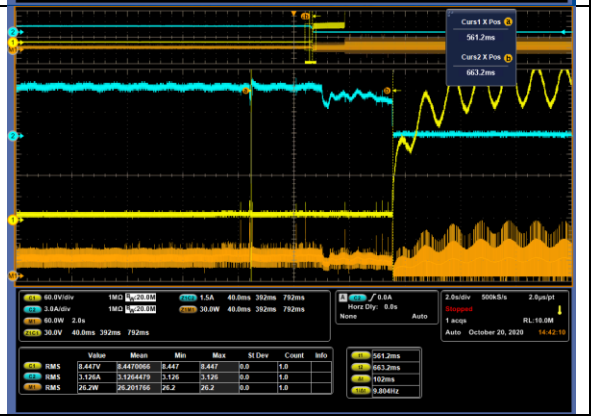
Test number	Channel under test	Iarc (A) (as defined by Table 3)	Impp (A)	I parallel (A) (as calculated according clause 9.2.6)	V mpp (V) (as defined by Table 3 or calculated)
1)	1-2	2,5	3	N/A	312
2)	1-2	7	8	N/A	318
3)	1-2	14	16	N/A	318

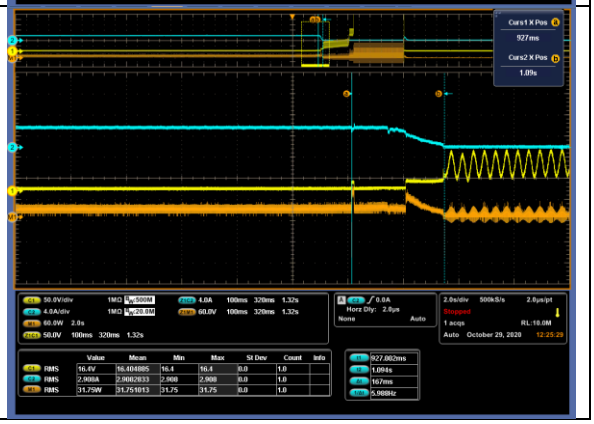
Note: Test 1) and 2) were conducted on representative mode SUN2000-6KTL-L1.
Test 3) only applicable to SUN2000-4.95KTL-JPL1

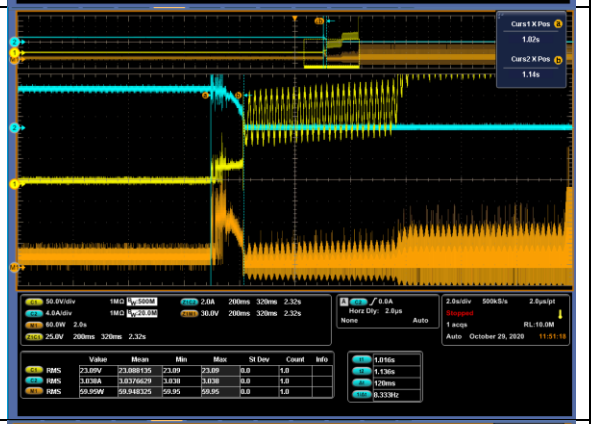
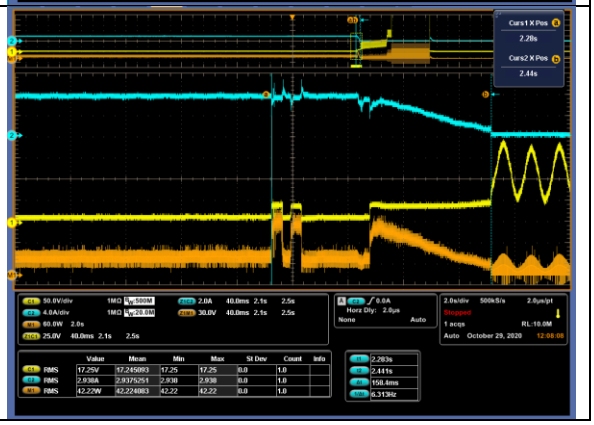
9.2.7	Arc energy and response time measurement	P
Test scenarios 1: Single string test setup Waveform channels description: Channel 1: voltage across the arc gap Channel 2: the current through the arc M1: arc power		
Arc detection and interruption channel 1		

Test no.	C4 condition (uF)	Arc energy (J)	Arc position	Response time (ms)	Waveform

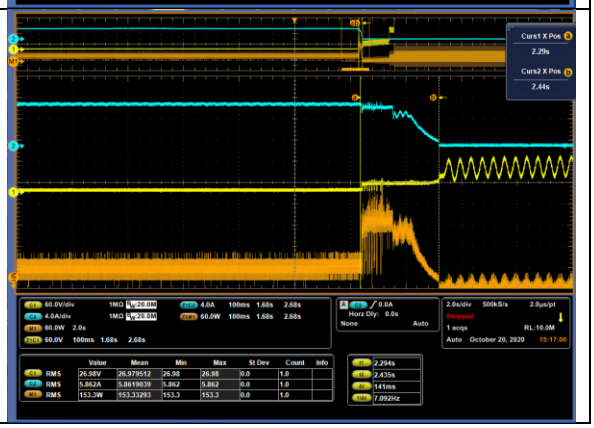
1)-1	0,3	6,8	Pos.	101	
1)-2	0,3	7,1	Pos.	122	
1)-3	20	7,8	Pos.	117	

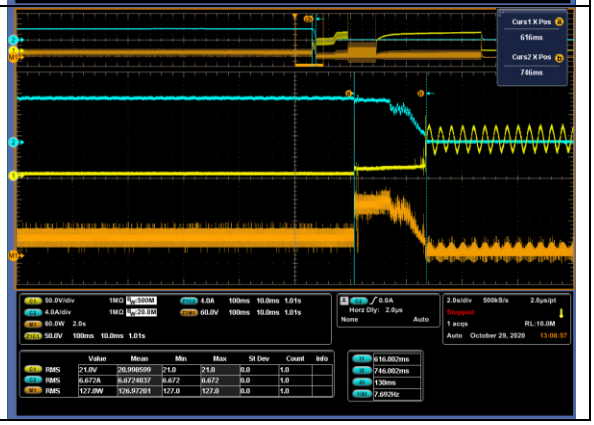
1)-4	20	3,2	Pos.	57	
1)-5	0,3	8,4	Mid.	151	
1)-6	0,3	2,7	Mid.	102	

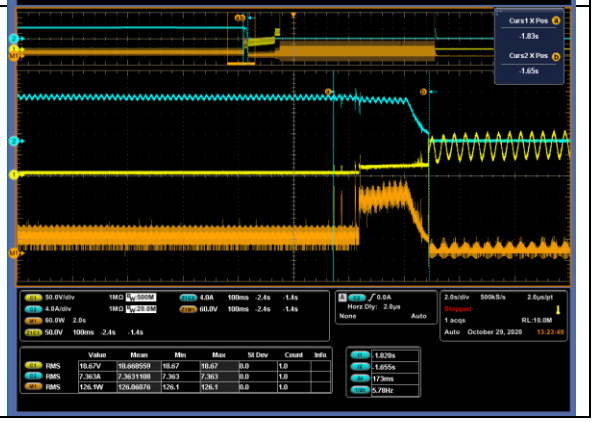
1)-7	20	9,4	Mid.	170	
1)-8	20	28,5	Mid.	348	
1)-9	0,3	5,3	Neg.	167	

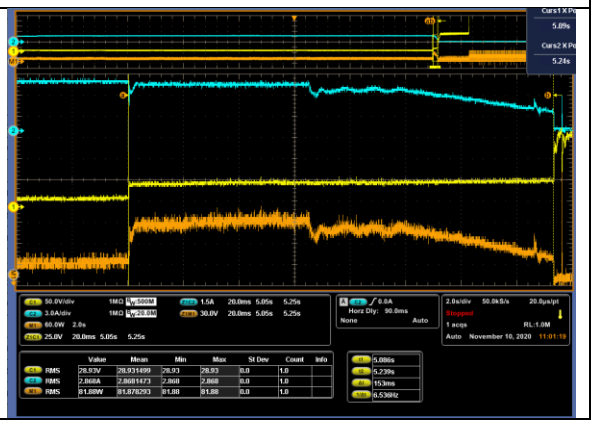
1)-10	0,3	8,8	Neg.	181	
1)-11	20	7,2	Neg.	120	
1)-12	20	6,7	Neg.	158	

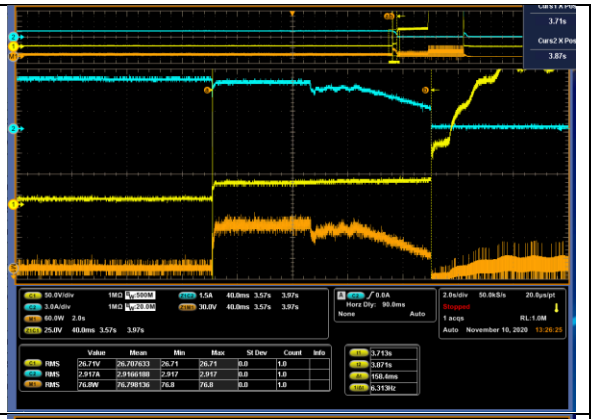
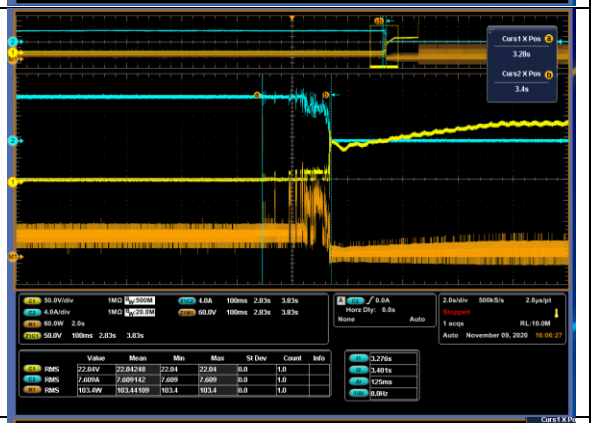
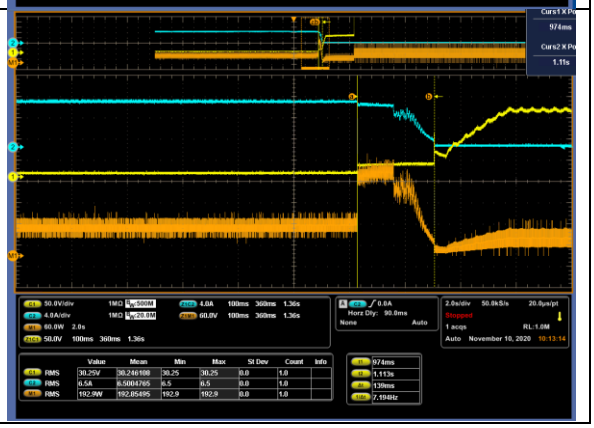
2)-1	0,3	18,7	Pos.	142	
2)-2	0,3	20,2	Pos.	149	
2)-3	20	16,8	Pos.	136	

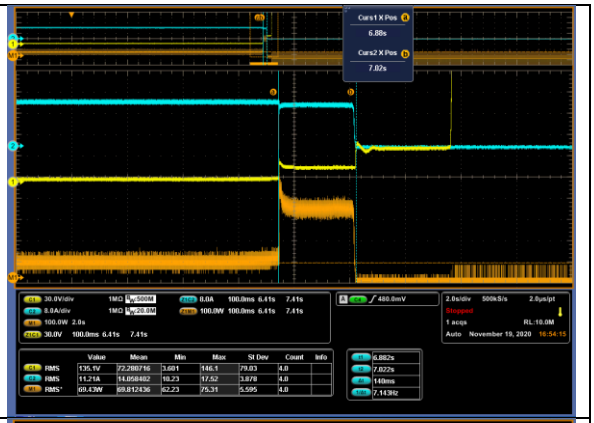
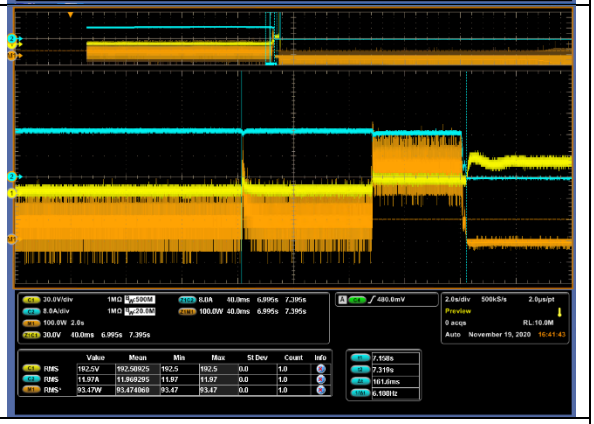
2)-4	20	16,2	Pos.	140	
2)-5	0,3	17,9	Mid.	124	
2)-6	0,3	21,6	Mid.	141	

2)-7	20	14,7	Mid.	107	
2)-8	20	20,3	Mid.	150	
2)-9	0,3	16,5	Neg.	130	

2)-10	0,3	15,5	Neg.	130	
2)-11	20	17,4	Neg.	159	
2)-12	20	21,8	Neg.	173	

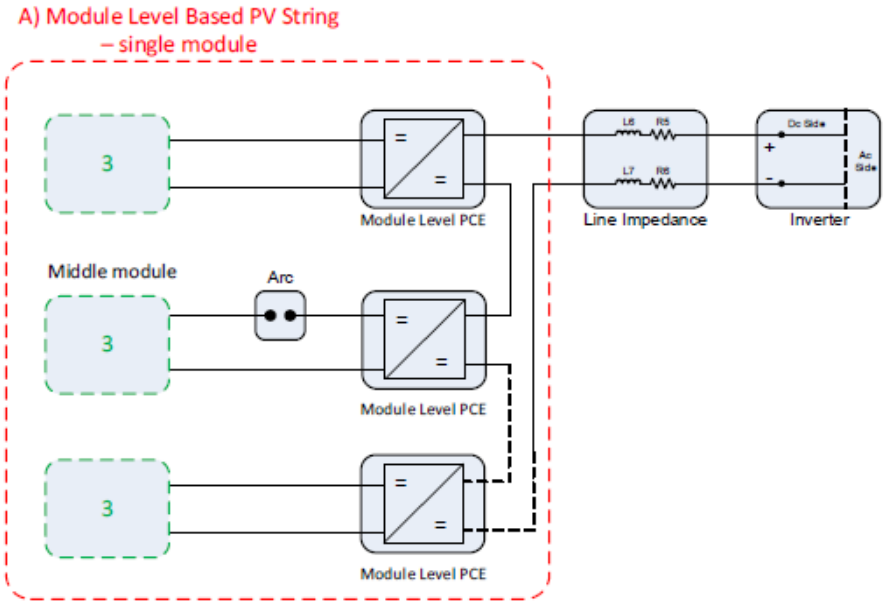
3)-1	0,3	33,6	Pos.	90	
3)-2	20	57,4	Pos.	173	
Arc detection and interruption channel 2					
Test no.	C4 condition (uF)	Arc energy (J)	Arc position	Response time (ms)	Waveform
1)-1	20	12,5	Mid.	153	

1)-2	20	12,2	Mid.	158	
2)-1	0,3	12,9	Pos.	125	
2)-2	0,3	26,8	Pos.	139	

3)-1	0,3	9,7	Pos.	140	
3)-2	20	15,1	Pos.	162	
Note: Test 3 for channel 1 only with the most adverse arc location. Test for channel 2 only with the most adverse arc location determined in the channel 1 tests.					

B) Test setup: according to B.3, typical application case for DC/DC converter based system (SUN2000-4.95KTL-JPL1 not applicable)

Inverter and DC/DC converter configuration:
Two channels for inverter: each arc detection channel consists of one MPP tracker and one input port per MPP tracker
The DC/DC converter system are configured as in below figure to connect to the input port of inverter



Maximum input voltage of the DUT is less than 810V.

1) Parameters as in normal installations for arc detection related:

$I_{mpp\ max\ per\ input\ port}$	$I_{max\ per\ MPP\ tracker}$	Rated channel current	rated interruption current	Number of channels
12,5 A	12,5 A	12,5 A	12,5 A	2

Table 3 – Arcing test conditions

Test #	Minimum I_{arc} (A)*	I_{mpp} (A)	Sep. Rate (mm/s)	V_{mpp} (V)	V_{OC} (V)	R_{tot} (ohms)	Gap (mm)
1	2,5	3,0	2,5	312,0	480,0	56,0	0,8
2	7,0	8,0	5,0	318,0	490,0	21,0	0,8
3	14,0	16,0	5,0	318,0	490,0	11,0	1,1
4	7,0	8,5	5,0	607,0	810,0	24,0	2,5
5	0,9 IMax,DUT	IMax,DUT	5,0	318,0	490,0	$(V_{OC}-V_{mpp})/Imax,DUT$	2,5

*Values given shall provide an indication of currents that likely occur. The actual value depends on several factors.

Tests 1), 2) were chosen to be carried out in below table where is applicable.

Details conditions for testing:

Test number	Channel under test	Iarc (A) (as defined by Table 3)	Impp (A)	I parallel (A) (as calculated according clause 9.2.6)	V mpp (V) (as defined by Table 3 or calculated)
1)	1-2	2,5	3	N/A	312
2)	1-2	7	8	N/A	318

On site test was carried out, test setup as described in below:

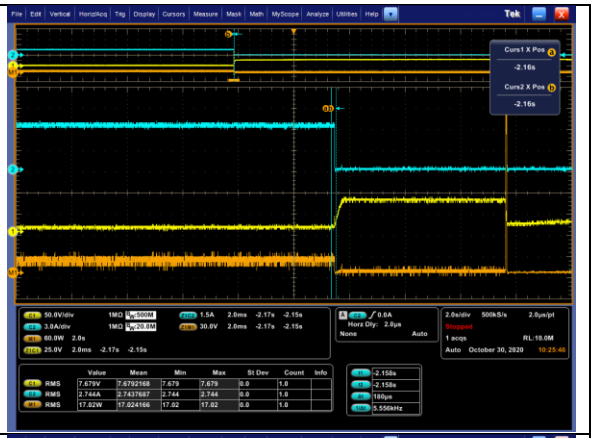
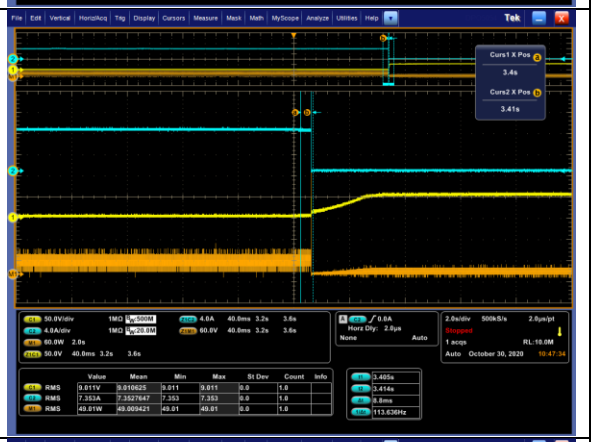
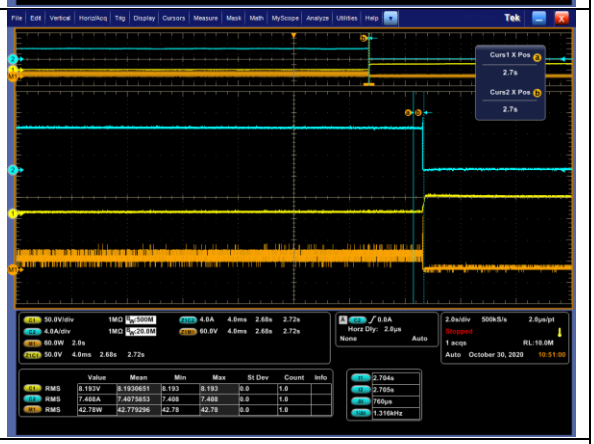
PV module type	DC converter type	Total numbers of series connected DC converter	Cable distance between PV module to DC converter (m)	Cable distance between DC converter to invterter (m)
BYD250P6C-30	SUN2000-450W-P	25	1,2	80

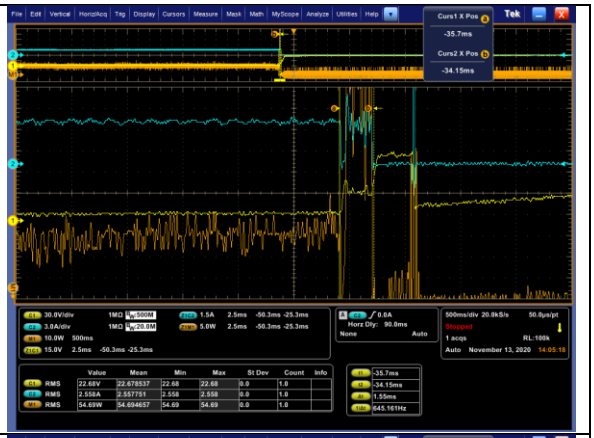
9.2.7	Arc energy and response time measurement	P

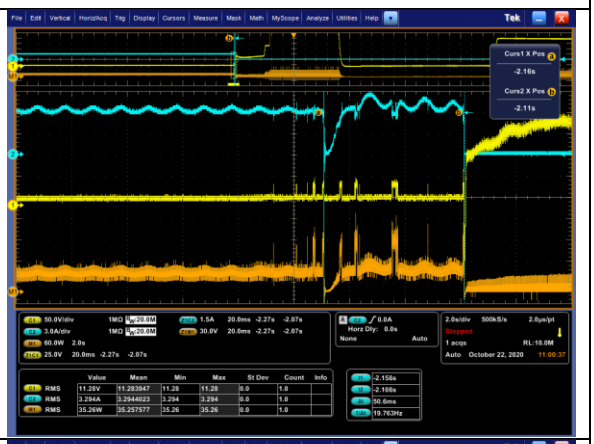
Test scenarios 1: Input setups – Figure B.3.1 Single string test setup
Waveform channels description:
Channel 1: voltage across the arc gap
Channel 2: the current through the arc
M1: arc power

Arc detection and interruption channel 1

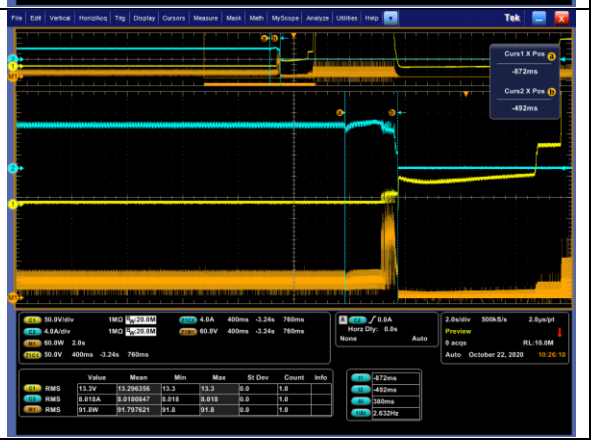
Test no.	C4 condition (uF)	Arc energy (J)	Arc position	Response time (ms)	Waveform
1)-1	N/A, see note [a]	0,11	Mid. module	6	

1)-2	N/A, see note [a]	0,003	Mid. module	0,18	
2)-1	N/A, see note [a]	0,43	Mid. module	8,8	
2)-2	N/A, see note [a]	0,033	Mid. module	0,76	
Arc detection and interruption channel 2					

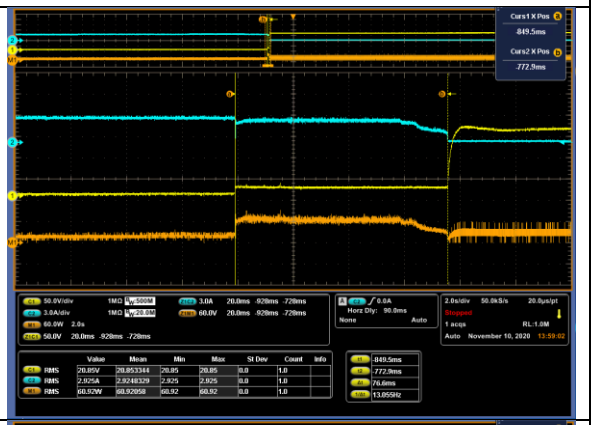
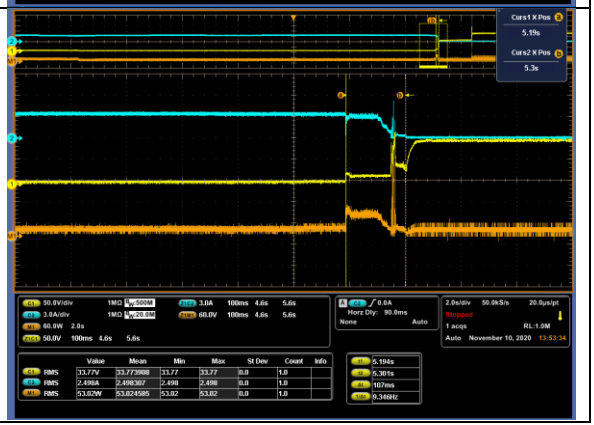
1)-1	N/A, see note [a]	0,085	Mid. module	1,55	
1)-2	N/A, see note [a]	0,006	Mid. module	0,36	
2)-1	N/A, see note [a]	0,018	Mid. module	0,545	

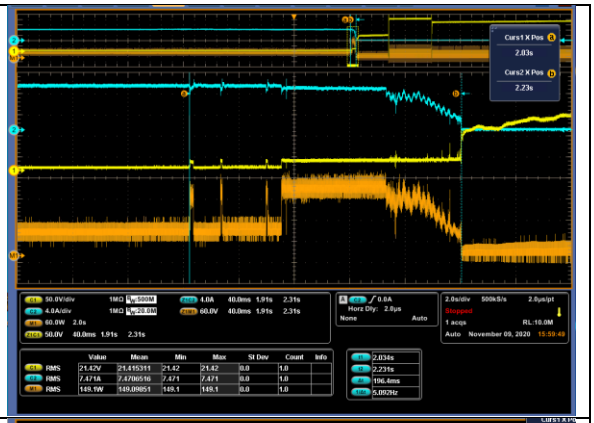
2)-2	N/A, see note [a]	0,025	Mid. module	0,725	
Note: the voltage across the arc is too low, the disconnection should be caused by loss of PV supply due to DC converter disconnected.					
Test scenarios 2: Output setups – Figure B.3.6 Single string test setup Waveform channels description: Channel 1: voltage across the arc gap Channel 2: the current through the arc M1: arc power					
Arc detection and interruption channel 1					
1)-1	N/A, see note [a]	1,8	Pos.	51	
1)-2	N/A, see note [a]	6,8	Pos.	97	

1)-3	N/A, see note [a]	44,8	Mid.	512	
1)-4	N/A, see note [a]	14,7	Mid.	294	
1)-5	N/A, see note [a]	5,9	Neg.	133	

1)-6	N/A, see note [a]	57,4	Neg.	724	
2)-1	N/A, see note [a]	23,5	Pos.	140	
2)-2	N/A, see note [a]	34,9	Pos.	380	

2)-3	N/A, see note [a]	177,4	Mid.	948	
2)-4	N/A, see note [a]	19,1	Mid.	136	
2)-5	N/A, see note [a]	106,4	Neg.	652	

2)-6	N/A, see note [a]	26,8	Neg.	210	
Arc detection and interruption channel 2					
1)-1	N/A, see note [a]	4,7	Mid.	77	
1)-2	N/A, see note [a]	5,7	Mid.	107	

2)-1	N/A, see note [a]	29,3	Mid.	196	
2)-2	N/A, see note [a]	29,0	Mid.	180	
Note: Test for channel 2 only with the most adverse arc location determined in the channel 1 tests. [a]: on site test as requested by manufacturer instead of standard test for this stage.					

9.2.9.1	Reconnection test – Manual reconnection	P
After arc-fault interruption, the AFPE shall neither reconnect automatically nor shall remote reconnection be possible. Compliance shall be demonstrated by tripping the AFPE three times. Manual reconnection shall be done by using APP within distance of 5m to PV inverter if set as this mode		

9.2.9.2	Reconnection test – Reomot manual reconnection	P

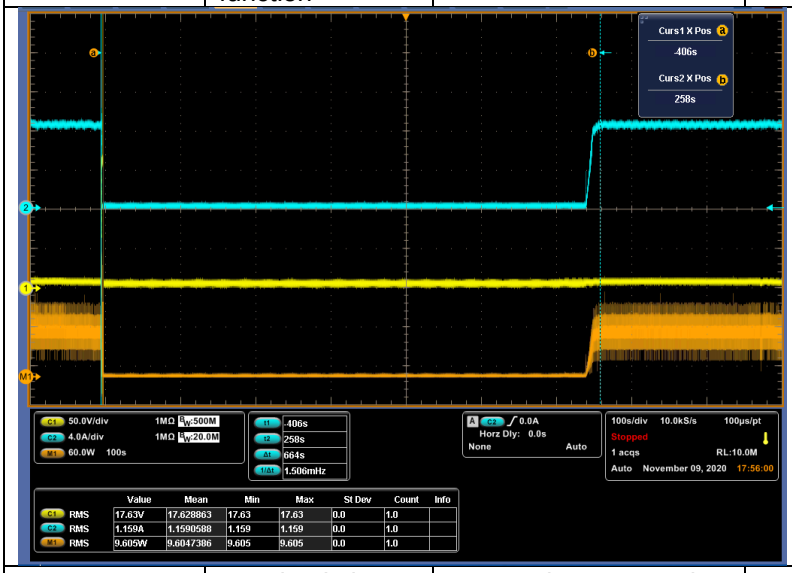
After arc-fault interruption, the AFPE shall not reconnect automatically.
Compliance shall be demonstrated by tripping the AFPE three times.

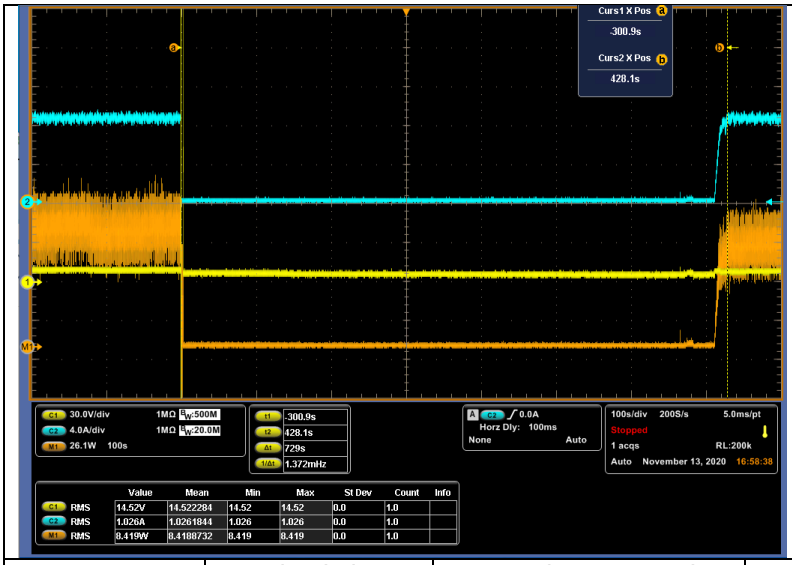
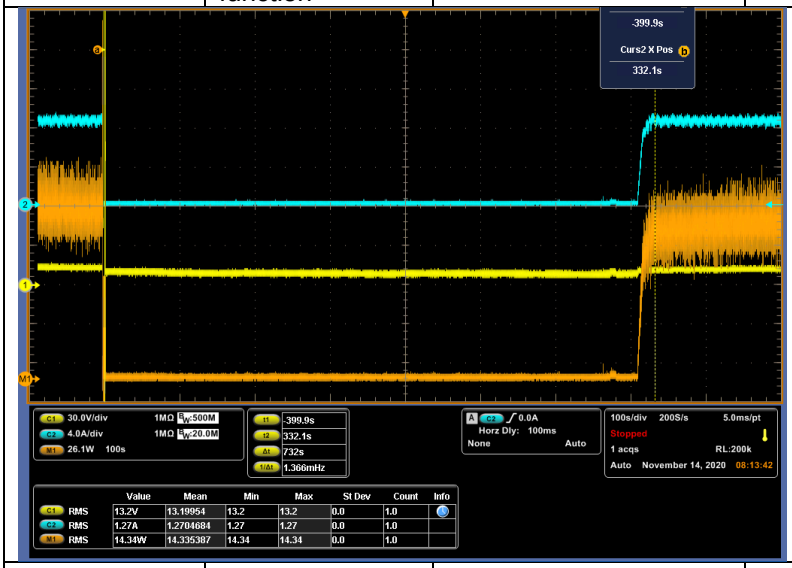
Remoto manual reconnection can be done by remote communication device if set as this mode

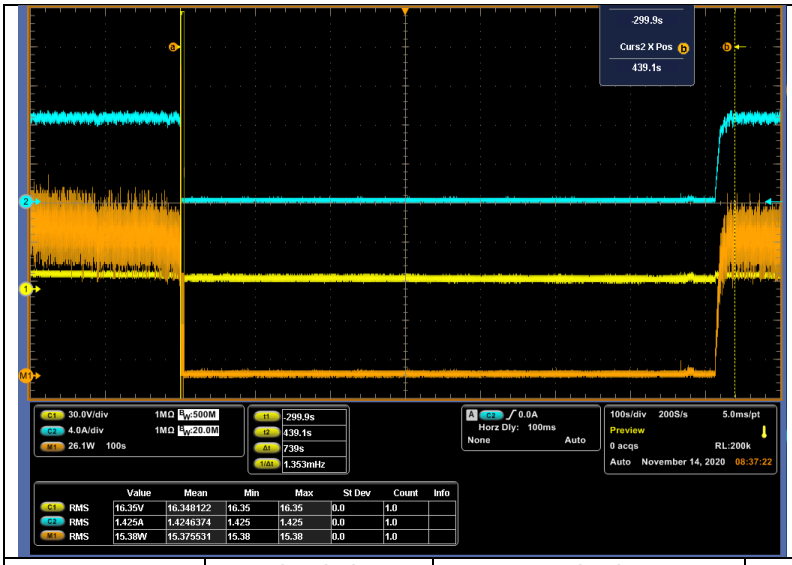
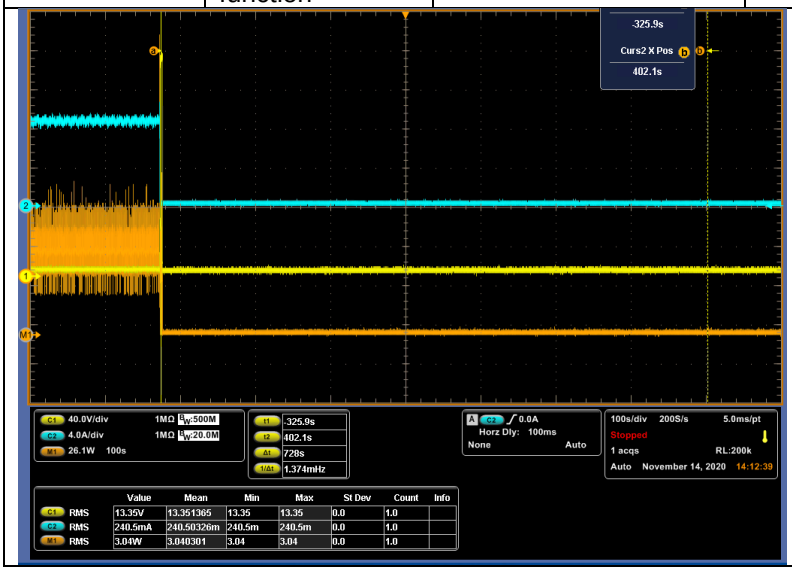
9.2.9.3	Reconnection test – automatic reconnection	P

After arc-fault interruption, the AFPE shall reconnect automatically within the limitations described in subclause 8.1.3.3.
Compliance shall be demonstrated by tripping the AFPE at least five times to demonstrate the manual reconnection state.

Note: Actual arc fault test was simulated
Waveform channels description:
Channel 1: trigger signal to simulate arc fault
Channel 2: MPP voltage of PV inverter input port under test
Channel 3: input current of PV inverter input port under test

After interrupting no.	Tripping method	Reconnection method	Reconnection time (s)	Reconnection time limit (s)
1	Arc simulation trigger by a test function	Automatic reconnection	664	≥ 300
				
2	Arc simulation trigger by a test function	Automatic reconnection	729	≥ 600

				
3	Arc simulation trigger by a test function	Automatic reconnection	732	≥ 600
				
4	Arc simulation trigger by a test function	Automatic reconnection	739	≥ 600

				
5	Arc simulation trigger by a test function	Reset required manually	No reconnection	-
				

3.1 Points of Non-Compliance according to the test specification

- N/A

4. Remark

- N/A

5. Documentation

- Not available at this stage

6. Summary

"The test specification(s) is (are) met" for which are evaluated at this stage.

TÜV SÜD Certification and Testing (China) Co., Ltd. Shanghai Branch

Tested by: Shan Huang

printed name, function & signature

Approved by: Kai Zhao

printed name, function & signature