TEST REPORT

IEC 61727:2004

TÜV SÜD Test report for Photovoltaic (PV) systems – Characteristics of the utility interface

Report reference No. ..... :	64.290.16.00044.02
Date of issue ..... :	2017-12-18
Project handler ..... :	Max Fang, Kennen Wang
Testing laboratory ..... :	TÜV SÜD Certification and Testing (China) Co., Ltd. Guangzhou Branch
Address ..... :	5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou 510656, P. R. China
Testing location ..... :	as above
Client ..... :	Shenzhen Kstar New Energy Company Limited
Address ..... :	The 9th Floor, R&D Building, Kstar Industrial Park, Guangming Hi-tech Industrial Zone, 518107 Shenzhen, Guangdong Province, PEOPLE'S REPUBLIC OF CHINA
Standard ..... :	This TÜV SÜD test report form is based on the following requirements: IEC 61727(ed.2); IEC 62116(ed.2);
TRF originated by. ..... :	TÜV SÜD Product Service Co., Ltd.
Copyright blank test report ..... :	This test report is based on the content of the standard (see above). The test report considered selected clauses of the a.m. standard(s) and experience gained with product testing. It was prepared by TUV SUD Product Service GmbH. TUV SUD Group takes no responsibility for and will not assume liability for damages resulting from the reader's interpretation of the reproduced material due to its placement and context.
Test procedure ..... :	☐ GS, ☒ TÜV Mark, ☐ EU-Directive, ☐ without certification ☐ Type verification of conformity
Non-standard test method ..... :	N/A
National deviations ..... :	N/A
Number of pages (Report) ..... :	22 pages
Number of pages (Attachments) ..... :	For safety IEC/EN 62109-1 and EIC/EN 62109-2 test, refer to TUV test report No.: 64.290.16.00045.03, part 1 and part 2.

Compiled by ..... : Max Fang, Kennen Wang — Approved by .... : Billy Qiu

(+ signature) Max Fang, Kennen Wang — (+ signature)

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Test sample……..:	PV grid-interactive inverter	
Type of test object ……..:	Photovoltaic	
Trademark ……..:	KSTAR	
Model and/or type reference ……..:	KSG-30K, KSG-36K-HV, KSG-50K, KSG-60K, KSG-60K-HV	
Rating(s) ……..:	See Page 6	
Manufacturer……..:	Shenzhen Kstar New Energy Company Limited	
Manufacturer number… ……..:	75386	
Address……..:	The 9th Floor, R&D Building, Kstar Industrial Park, Guangming Hi-tech Industrial Zone, 518107 Shenzhen, Guangdong Province, PEOPLE'S REPUBLIC OF CHINA	
Sub-contractors/ tests (clause) ……..:	N/A	
Name ……..:	N/A	
Order description… ……..:	☒	Complete test according to TRF
	☐	Partial test according to manufacturer's specifications
	☐	Preliminary test
	☐	Spot check
Date of order…….……..:	27 November 2015	
Date of receipt of test item ……..:	27 November 2015	
Date(s) of performance of test ……..:	10 January 2016 ~ 13 May 2016 and 8 December 2017 to 15 December 2017	

General remarks:

"(see remark #)" refers to a remark appended to the report.
"(see appended table)" refers to a table appended to the report.
Throughout this report a comma is used as the decimal separator.
The test results presented in this report relate only to the object tested.
This report shall not be reproduced except in full without the written approval of the testing laboratory.

Revision history
This report is based on original report No.: 64.290.16.00044.01 (Certificate No.: Z2 16 05 75386 039), with the parameters of 60 Hz added. Original test report and certificates are cancelled.

Summary of testing:

☐ Abweichung festgestellt / deviation(s) found

☒ keine Abweichung festgestellt / no deviations found

Name and address of factory (ies)……..:

Factory name: Shenzhen Kstar New Energy Company Limited
Address: The 9th Floor, R&D Building, Kstar Industrial Park, Guangming Hi-tech Industrial Zone, 518107 Shenzhen, Guangdong Province, PEOPLE'S REPUBLIC OF CHINA

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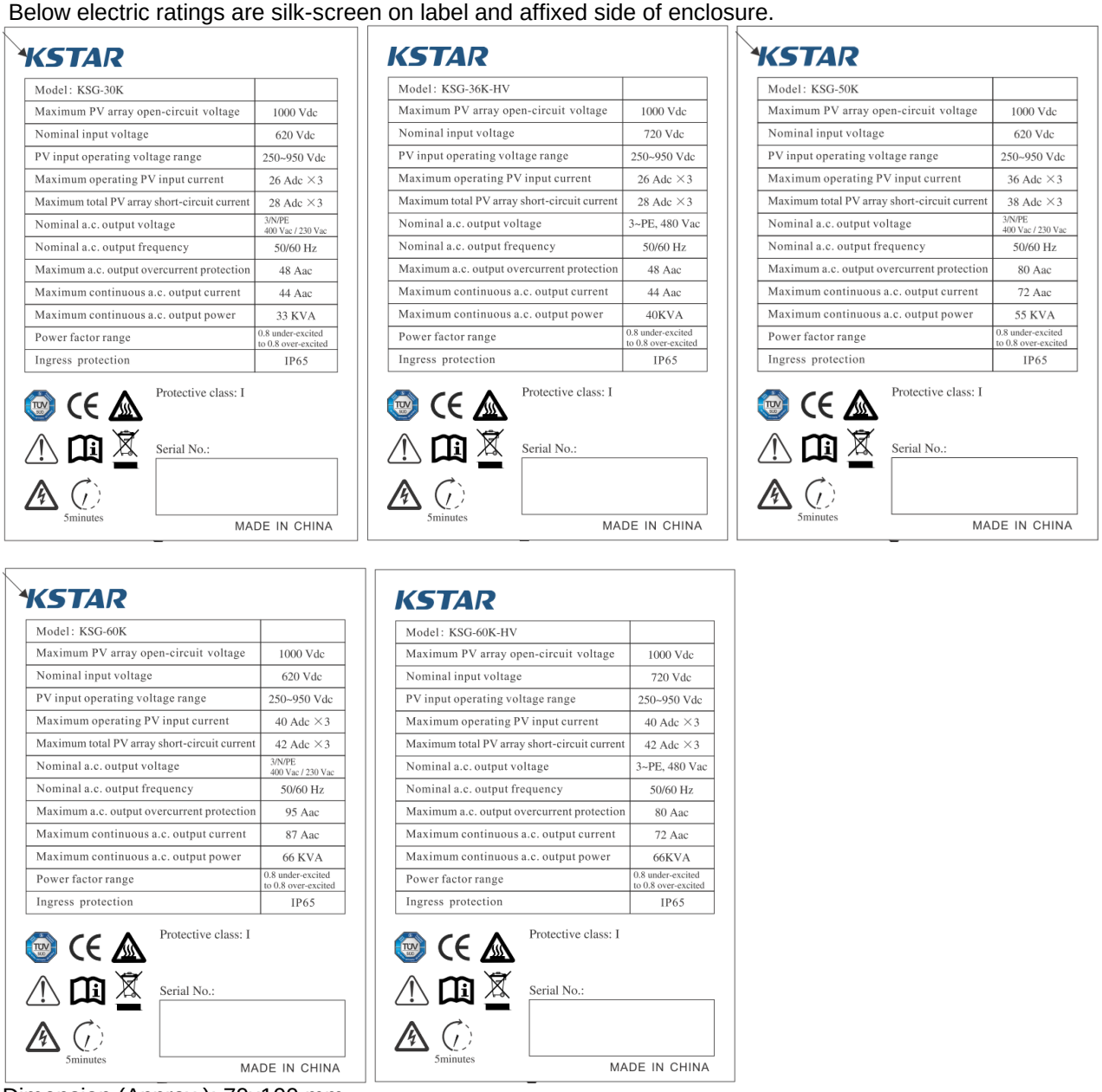
Copy of marking plate:

Below electric ratings are silk-screen on label and affixed side of enclosure.



KSTAR

Model: KSG-30K	
Maximum PV array open-circuit voltage	1000 Vdc
Nominal input voltage	620 Vdc
PV input operating voltage range	250~950 Vdc
Maximum operating PV input current	26 Adc ×3
Maximum total PV array short-circuit current	28 Adc ×3
Nominal a.c. output voltage	3/N/PE 400 Vac / 230 Vac
Nominal a.c. output frequency	50/60 Hz
Maximum a.c. output overcurrent protection	48 Aac
Maximum continuous a.c. output current	44 Aac
Maximum continuous a.c. output power	33 KVA
Power factor range	0.8 under-excited to 0.8 over-excited
Ingress protection	IP65

Protective class: I

Serial No.:

5minutes

MADE IN CHINA

KSTAR

Model: KSG-36K-HV	
Maximum PV array open-circuit voltage	1000 Vdc
Nominal input voltage	720 Vdc
PV input operating voltage range	250~950 Vdc
Maximum operating PV input current	26 Adc ×3
Maximum total PV array short-circuit current	28 Adc ×3
Nominal a.c. output voltage	3~PE, 480 Vac
Nominal a.c. output frequency	50/60 Hz
Maximum a.c. output overcurrent protection	48 Aac
Maximum continuous a.c. output current	44 Aac
Maximum continuous a.c. output power	40KVA
Power factor range	0.8 under-excited to 0.8 over-excited
Ingress protection	IP65

Protective class: I

Serial No.:

5minutes

MADE IN CHINA

KSTAR

Model: KSG-50K	
Maximum PV array open-circuit voltage	1000 Vdc
Nominal input voltage	620 Vdc
PV input operating voltage range	250~950 Vdc
Maximum operating PV input current	36 Adc ×3
Maximum total PV array short-circuit current	38 Adc ×3
Nominal a.c. output voltage	3/N/PE 400 Vac / 230 Vac
Nominal a.c. output frequency	50/60 Hz
Maximum a.c. output overcurrent protection	80 Aac
Maximum continuous a.c. output current	72 Aac
Maximum continuous a.c. output power	55 KVA
Power factor range	0.8 under-excited to 0.8 over-excited
Ingress protection	IP65

Protective class: I

Serial No.:

5minutes

MADE IN CHINA

KSTAR

Model: KSG-60K	
Maximum PV array open-circuit voltage	1000 Vdc
Nominal input voltage	620 Vdc
PV input operating voltage range	250~950 Vdc
Maximum operating PV input current	40 Adc ×3
Maximum total PV array short-circuit current	42 Adc ×3
Nominal a.c. output voltage	3/N/PE 400 Vac / 230 Vac
Nominal a.c. output frequency	50/60 Hz
Maximum a.c. output overcurrent protection	95 Aac
Maximum continuous a.c. output current	87 Aac
Maximum continuous a.c. output power	66 KVA
Power factor range	0.8 under-excited to 0.8 over-excited
Ingress protection	IP65

Protective class: I

Serial No.:

5minutes

MADE IN CHINA

KSTAR

Model: KSG-60K-HV	
Maximum PV array open-circuit voltage	1000 Vdc
Nominal input voltage	720 Vdc
PV input operating voltage range	250~950 Vdc
Maximum operating PV input current	40 Adc ×3
Maximum total PV array short-circuit current	42 Adc ×3
Nominal a.c. output voltage	3~PE, 480 Vac
Nominal a.c. output frequency	50/60 Hz
Maximum a.c. output overcurrent protection	80 Aac
Maximum continuous a.c. output current	72 Aac
Maximum continuous a.c. output power	66KVA
Power factor range	0.8 under-excited to 0.8 over-excited
Ingress protection	IP65

Protective class: I

Serial No.:

5minutes

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Dimension (Approx.): 70x100 mm.

Note: The above artwork nameplate may be only a draft. For the final production, the additional markings or

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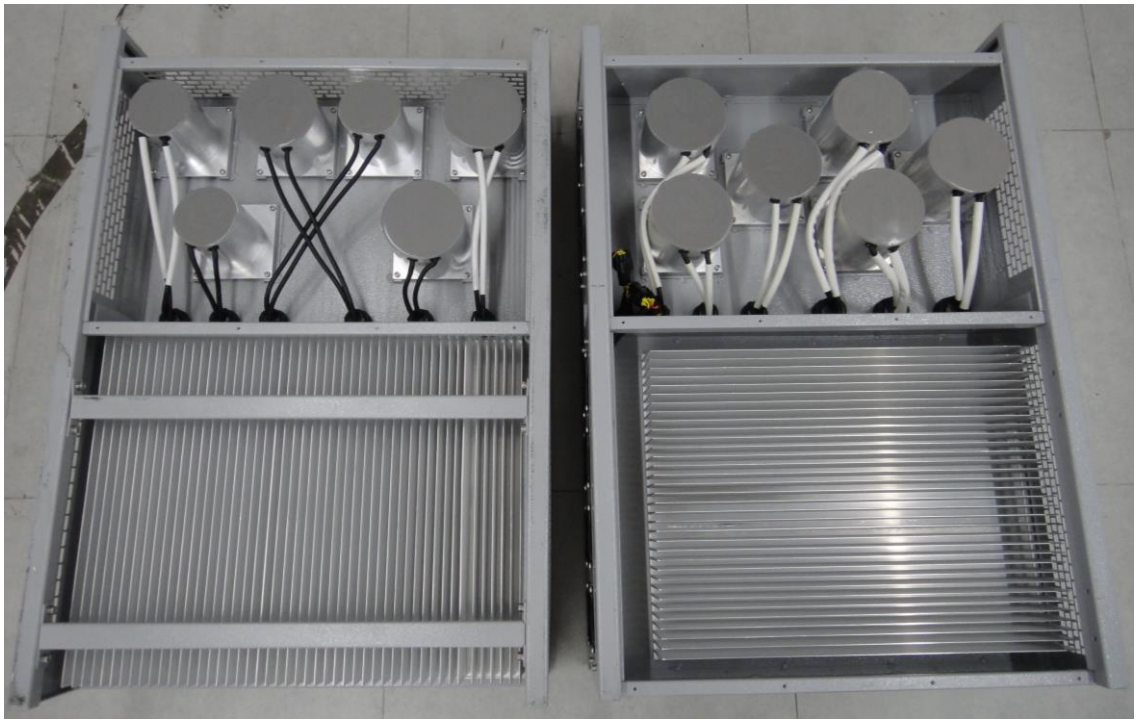
Picture of the product:

Overall view of the unit



Rear view of the unit. The left photo is model: KSG-30K, KSG-36K-HV, the right photo is model: KSG-50K, KSG-60K, KSG-60K-HV.

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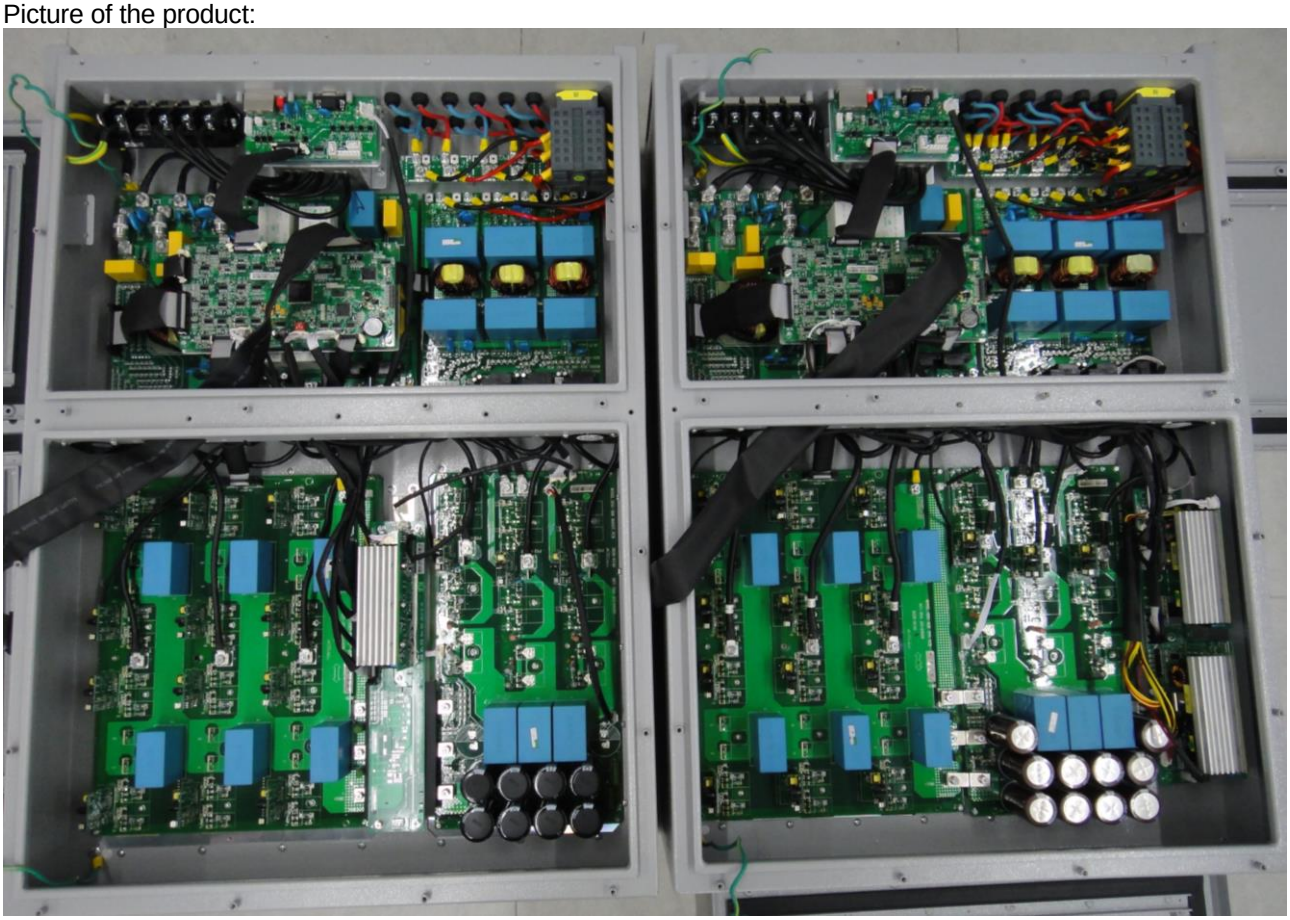
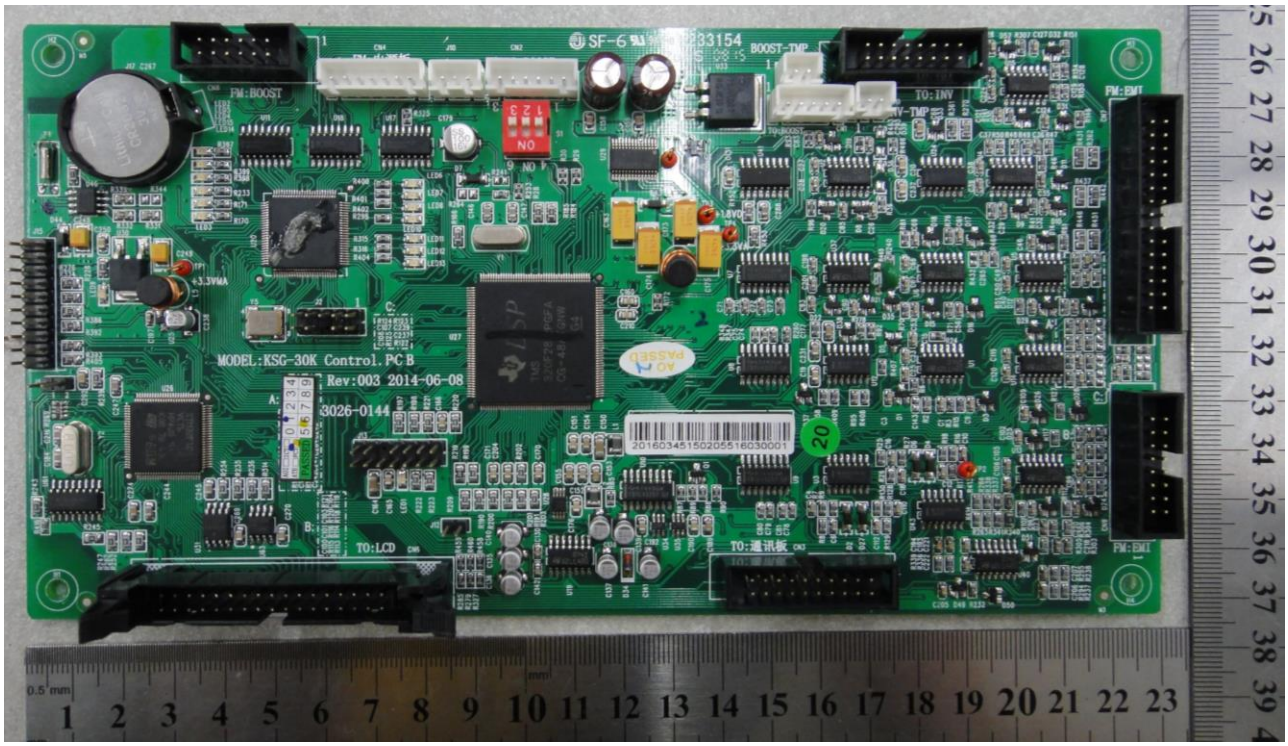
Picture of the product:



Internal viewof the unit: The left photo is model: KSG-30K, KSG-36K-HV, the right photo is model: KSG-50K, KSG-60K, KSG-60K-HV



PCB top view of the control board

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Test item particulars	:	PV grid-connected inverter
Equipment mobility	:	☐ movable ☐ hand-held ☒ stationary ☒ fixed ☐ transportable ☐ for building-in
Connection to the mains	:	☐ pluggable equipment ☐ direct plug-in ☒ permanent connection ☐ for building-in
Enviromental category	:	☒ outdoor ☐ indoor unconditional ☐ indoor conditional
Over voltage category Mains	:	☐ OVC I ☐ OVC II ☒ OVC III ☐ OVC IV
Over voltage category PV	:	☐ OVC I ☒ OVC II ☐ OVC III ☐ OVC IV
Mains supply tolerance (%)	:	+/- 10%
Tested for power systems	:	TN or TT system for models: KSG-30K, KSG-50K, KSG-60K; IT system for models: KSG-36K-HV, KSG-60K-HV
IT testing, phase-phase voltage (V)	:	N/A
Class of equipment	:	☒ Class I ☐ Class II ☐ Class III ☐ Not classified
Mass of equipment (kg)	:	Net weight: 61 kg ~ 67,4 kg (Approx.)
Pollution degree	:	3 (External), 2 (Internal)
IP protection class	:	IP65

Possible test case verdicts:

- test case does not apply to the test object	:	N/A / not included in the order
- test object does meet the requirement	:	P / (pass)
- test object does not meet the requirement	:	F. / (fail)

Possible suffixes to the verdicts:

- suffix for detailed information for the client…….	- C / (comment)
- suffix for important information for factory inspection:	- M / (manufacturing)

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General product information:

(1)	The unit is non-isolated (transformerless) PV grid-interactive DC-AC inverter for connection with public low voltage grid, for outdoor or indoor use.
(2)	The unit shall be used at specified ambient range. Temperature: -25 °C ~ +60 °C, Auto-derating after 45 °C; Altitude: < 2000 m; Overvoltage category: II(DC side), III(AC side); Relative humidity range: 4 % ~ 100 %.
(3)	The PV grid-interactive inverter provides six disconnection relays, two for each line conductor. The internal control is redundant built. It consists of one main DSP (U27) and another slave DSP (U20). Both DSP can open relays independently and communicate with each other.
(4)	For this standard test, the inverter is designed to be operated with a fixed Cos phi=1 settings inside. The power factor can be adjustable via RS 485 communication port and it's adjustable range is not evaluated in this report.
(5)	The grid connection protection system is evaluated according to IEC 61727:2004. Clause 5.3 of IEC 61727:2004 islanding protection test is performed according to IEC 62116:2014.
(6)	In order to protect the PCE, user and installer, external DC and AC circuit breakers shall be equipped at the end-use application.
(7)	Low voltage electrical installations shall comply with national and local regulation.
(8)	The setting of rated frequency and protection are described in the user manual.

Model differences:

The five models have same enclosure, same PCB layout, similar electrical control circuits, with mainly differences as below:

(1) Model: KSG-30K, KSG-36K-HV are natural cooling, model: KSG-50K, KSG-60K, KSG-60K-HV are fans forced cooling.

(2) Have different amounts of bus capacitors. For detail, see CDF.

(3) Have different parameter of boost, invert inductor and AC output EMI inductor. For detail, see CDF.

(4) Have different parameter of power semiconductors. For detail, see CDF.

(5) Have different parameter of X capacitor on AC EMI board. For detail, see CDF.

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Characteristic data:

Model	KSG-30K	KSG-36K-HV	KSG-50K	KSG-60K	KSG-60K-HV
Vmax PV	1000 Vd.c.	1000 Vd.c.	1000 Vd.c.	1000 Vd.c.	1000 Vd.c.
Isc PV	28 Ad.c. x 3	28 Ad.c. x 3	38 Ad.c. x 3	42 Ad.c. x 3	42 Ad.c. x 3
MPPT range (full load)	480 ~ 800 Vd.c.	550 ~ 800 Vd.c.	480 ~ 800 Vd.c.	500 ~ 800 Vd.c.	550 ~ 800 Vd.c.
MPPT tracker / strings	3 / 2	3 / 2	3 / 4	3 / 4	3 / 4
Nominal AC voltage	3/N/PE, 230/400 Va.c.	3~PE, 480 Va.c.	3/N/PE, 230/400 Va.c.	3/N/PE, 230/400 Va.c.	3~PE, 480 Va.c.
Nominal Frequency	50/60 Hz	50/60 Hz	50/60 Hz	50/60 Hz	50/60 Hz
Max. Continuous output current	44 Aa.c.	44 Aa.c.	72 Aa.c.	87 Aa.c.	72 Aa.c.
Nominal output power	30 kW	36 kW	50 kW	60 kW	60 kW
Max. Continuous output power	33 kVA	40 kVA	55 kVA	66 kVA	66 kVA
Power factor (full load)	>0,99	>0,99	>0,99	>0,99	>0,99
Protective class	I	I	I	I	I
Ingress protection	IP65	IP65	IP65	IP65	IP65
Temperature	-25 °C ~ +60 °C	-25 °C ~ +60 °C	-25 °C ~ +60 °C	-25 °C ~ +60 °C	-25 °C ~ +60 °C

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IEC 61727(ed.2)			
Clause	Requirement + Test	Result - Remark	Verdict

4	Utility compatibility		P
	The quality of power provided by the PV system for the on-site AC loads and for power delivered to the utility is governed by practices and standards on voltage, flicker, frequency, harmonics and power factor.		P
	Deviation from these standards represents out-of-bounds conditions and may require the PV system to sense the deviation and properly disconnect from the utility system.		P
4.1	Voltage, current and frequency		P
	The PV system AC voltage, current and frequency shall be compatible with the utitliy system.		P
4.2	Normal voltage operating range		P
	Utility-interconnected PV systems do not normally regulate voltage, they inject current into the utility. Therefore, the voltage operating range for PV inverters is selected as a protection function that responds to abnormal utility conditions, not as a voltage regulation function.		P
4.3	Flicker		P
	The operation of the PV system should not cause voltage flicker in excess of limits stated in the relevant sections of IEC 61000-3-3 for systems less than 16 A or IEC 61000-3-5 for systems with current of 16 A and above.	(see appended table)	P
4.4	DC injection		P
	The PV system shall not inject DC current greater than 1 % of the rated inverter output current, into the utility AC interface under any operating condition.	(see appended table)	P
4.5	Normal frequency operating range		P
	The PV system shall operate in synchronism with the utility system, and within the frequency trip limits defined in 5.2.2.		P
4.6	Harmonics and waveform distortion	(see appended table)	P
	Total harmonic current distortion shall be less than 5 % at rated inverter output. Each individual harmonic shall be limited to the percentages listed in Table 1.		P
	Even harmonics in these ranges shall be less than 25 % of the lower odd harmonic limits listed.		P

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IEC 61727(ed.2)			
Clause	Requirement + Test	Result - Remark	Verdict
	Table 1 – Current distortion limits **Odd harmonics** / **Distortion limit** 3rd through 9th / Less than 4,0 % 11th through 15th / Less than 2,0 % 17th through 21st / Less than 1,5 % 23rd through 33rd / Less than 0,6 % **Even harmonics** / **Distortion limit** 2nd through 8th / Less than 1,0 % 10th through 32nd / Less than 0,5 %		P
4.7	The PV system shall have a lagging power factor greater than 0,9 when the output is greater than 50 % of the rated inverter output power.	(see appended table)	P
5	Personnel safety and equipment protection		P
	This Clause provides information and considerations for the safe and proper operation of the utility-connected PV systems.	Internal protection function provided.	P
5.1	Loss of utility voltage		P
	To prevent islanding, a utility connected PV system shall cease to energize the utility system from a de-energized distribution line irrespective of connected loads or other generators within specified time limits.	Islanding protection test methods refer to IEC 62116:2014.	P
	A utility distribution line can become de-energized for several reasons. For example, a substation breaker opening due to fault conditions or the distribution line switched out during maintenance.	Three phase PV grid-interactive inverter. Two mechanical disconnect relays series in each line conductor.	P
5.2	Over/under voltage and frequency		P
	The abnormal utility conditions of concern are voltage and frequency excursions above or below the values stated in this Clause, and the complete disconnection of the utility, presenting the potential for a distributed resource island.		P
5.2.1	Over/under voltage		P
	When the interface voltage deviates outside the conditions specified in Table 2, the photovoltaic system shall cease to energize the utility distribution system. This applies to any phase of a multiphase system.	(see appended table)	P

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IEC 61727(ed.2)			
Clause	Requirement + Test	Result - Remark	Verdict
	Table 2 – Response to abnormal voltages Voltage (at point of utility connection) / Maximum trip time* V < 0,5 × Vnominal / 0,1 s 50 % ≤ V < 85 % / 2,0 s 85 % ≤ V ≤ 110 % / Continuous operation 110 % < V < 135 % / 2,0 s 135 % ≤ V / 0,05 s * Trip time refers to the time between the abnormal condition occurring and the inverter ceasing to energize the utility line. The PV system control circuits shall actually remain connected to the utility to allow sensing of utility electrical conditions for use by the "reconnect" feature.		P
5.2.2	Over/under frequency		P
	When the utility frequency deviates outside the specified conditions the photovoltaic system shall cease to energize the utility line. The unit does not have to cease to energize if the frequency returns to the normal utility continuous operation condition within the specified trip time.	(see appended table)	P
	When the utility frequency is outside the range of ±1 Hz, the system shall cease to energize the utility line within 0,2 s. The purpose of the allowed range and time delay is to allow continued operation for short-term disturbances and to avoid excessive nuisance tripping in weak-utility system conditions.		P
5.3	Islanding protection		P
	The PV system must cease to energize the utitliy line within 2 s of loss of utility.	Test method refer to IEC 62116:2014.	P
5.4	Response to utility recovery		P
	Following an out-of-range utility condition that has caused the photovoltaic system to cease energizing, the photovoltaic system shall not energize the utility line for 20 s to 5 min after the utility service voltage and frequency have recovered to within the specified ranges.	(see appended table)	P
5.5	Earthing		P
	The utility interface equipment shall be earthed/grounded in accordance with IEC 60364-7-712.		P
5.6	Short circuit protection		P
	The photovoltaic system shall have short-circuit protection in accordance with IEC 60364-7-712.	External DC and AC circuit breaker shall be equipped at the end-use application;	P
5.7	Isolation and switching		P

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IEC 61727(ed.2)			
Clause	Requirement + Test	Result - Remark	Verdict
	A method of isolation and switching shall be provided in accordance with IEC 60364-7-712.	External DC and AC circuit breaker shall be equipped at the end-use application;	P

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4.3	Flicker								P
Model:	**KSG-30K**								
		Starting			Stopping			Running	
		d_{max}	d_c	$d_{(t)}$	d_{max}	d_c	$d_{(t)}$	P_{st}	P_{lt} 2 hours
Measured Values	L1	0,64%	0,39%	0	0,55%	0,23%	0	0,45	0,28
	L2	0,58%	0,46%	0	0,51%	0,22%	0	0,44	0,27
	L3	0,62%	0,41%	0	0,53%	0,20%	0	0,41	0,25
Limits		4%	3,3%	3,3% 500ms	4%	3,3%	3,3% 500ms	1,0	0,65
Supplementary information: The tests based on the limits of the IEC 61000-3-11 for Equipment with rated current ≤75 A.									

4.3	Flicker								P
Model:	**KSG-60K-HV**								
		Starting			Stopping			Running	
		d_{max}	d_c	$d_{(t)}$	d_{max}	d_c	$d_{(t)}$	P_{st}	P_{lt} 2 hours
Measured Values	L1	1,12 %	0,87%	0	0,97%	0,63%	0	0,65	0,32
	L2	1,08%	0,94%	0	0,91%	0,52%	0	0,64	0,35
	L3	1,10%	0,98%	0	0,95%	0,58%	0	0,61	0,38
Limits		4%	3,3%	3,3% 500ms	4%	3,3%	3,3% 500ms	1,0	0,65
Supplementary information: The tests based on the limits of the IEC 61000-3-11 for Equipment with rated current ≤75 A.									

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4.4	Direct current injection								P
Rated output current (A)	Ratio of rated output power (VA)	Measured DC output current between terminals (mA)						Isolated transformer? (Yes/No)	Limit (mA)
		R-S	R-T	S-T	R	S	T		
Model:	**KSG-30K, Input: 480 Vd.c.**								
43.48	10%	--	--	--	98	19	89	No	435
43.48	50%	--	--	--	82	4	87	No	435
43.48	100%	--	--	--	5	7	4	No	435
Model:	**KSG-60K, Input: 500 Vd.c.**								
86.96	10%	--	--	--	90	18	68	No	870
86.96	50%	--	--	--	17	14	16	No	870
86.96	100%	--	--	--	146	33	19	No	870
Remark: N/A									

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4.6	Harmonics and waveform distortion							P
Model:	**KSG-30K**			**KSG-60K-HV**				
Harmonic	% of Fundamental			% of Fundamental			Limits (% of Fundamental)	--
	L1	L2	L3	L1	L2	L3		
2	0.07%	0.07%	0.05%	0.09%	0.09%	0.10%	1.0%	--
3	0.31%	0.31%	0.07%	0.30%	0.05%	0.30%	4.0%	--
4	0.04%	0.02%	0.03%	0.03%	0.02%	0.03%	1.0%	--
5	1.51%	1.52%	1.29%	1.88%	1.88%	1.87%	4.0%	--
6	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	1.0%	--
7	0.90%	0.90%	0.91%	1.29%	1.29%	1.29%	4.0%	--
8	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	1.0%	--
9	0.07%	0.06%	0.06%	0.06%	0.06%	0.06%	4.0%	--
10	0.01%	0.02%	0.01%	0.01%	0.01%	0.01%	0.5%	--
11	0.38%	0.40%	0.39%	0.71%	0.46%	0.71%	2.0%	--
12	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.5%	--
13	0.22%	0.23%	0.23%	0.43%	0.41%	0.42%	2.0%	--
14	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.5%	--
15	0.02%	0.03%	0.02%	0.02%	0.03%	0.03%	2.0%	--
16	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.5%	--
17	0.09%	0.09%	0.09%	0.26%	0.26%	0.25%	1.5%	--
18	0.02%	0.02%	0.01%	0.04%	0.02%	0.03%	0.5%	--
19	0.02%	0.02%	0.04%	0.20%	0.20%	0.18%	1.5%	--
20	0.01%	0.02%	0.01%	0.01%	0.01%	0.01%	0.5%	--
21	0.01%	0.01%	0.01%	0.01%	0.01%	0.02%	1.5%	--
22	0.01%	0.01%	0.01%	0.02%	0.02%	0.01%	0.5%	--
23	0.01%	0.01%	0.01%	0.16%	0.16%	0.16%	0.6%	--
24	0.09%	0.06%	0.05%	0.12%	0.06%	0.09%	0.5%	--
25	0.02%	0.01%	0.01%	0.08%	0.09%	0.08%	0.6%	--
26	0.02%	0.02%	0.01%	0.02%	0.02%	0.01%	0.5%	--
27	0.01%	0.01%	0.01%	0.01%	0.02%	0.01%	0.6%	--
28	0.01%	0.01%	0.01%	0.02%	0.01%	0.01%	0.5%	--
29	0.01%	0.01%	0.02%	0.07%	0.08%	0.08%	0.6%	--
30	0.02%	0.02%	0.02%	0.05%	0.01%	0.04%	0.5%	--
31	0.01%	0.01%	0.01%	0.04%	0.05%	0.04%	0.6%	--
32	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.5%	--
33	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.6%	--
THD	3.708%	3.635%	3.635%	2.490%	2.442%	2.438%	5.0%	--

Supplementary information:

(1) Input: Vmax. PV=1000 Vd.c., Nominal output power.

(2) As the power generation unit's topology and the controlling software is identical to the each other, the above two type test models and other models meeting the requirements of Maximum permissible harmonic current limits as per IEC/EN 61000-3-2 and IEC/EN 61000-3-12 Class A.

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4.7	Power factor								P
Model:	**KSG-30K**								
Test power level	20%			50%			100%		
Phase	L1	L2	L3	L1	L2	L3	L1	L2	L3
Measured Power factor	0.9821	0.9856	0.9847	0.9992	0.9994	0.9991	0.9998	0.9997	0.9999
Limit	>0.9			>0.9			>0.9		

5.2.1 & 5.4	Over/under voltage & Response to utility recovery					
Model	**KSG-60K**					
No.	**Utility point Voltage (V)**	**Maximum trip time (s)**	**Measured trip time (ms)**	**Utility return to starting range (V)**	**Measured Self-check time (s)**	**Limit of Self-check time (s)**
01	L1=0,49 Vn=112.7 Vac	0.1 s	56 ms	195.5 V	65.4 s	20 s – 300 s
	L2=0,49 Vn=112.7 Vac	0.1 s	56 ms	195.5 V	65.2 s	20 s – 300 s
	L3=0,49 Vn=112.7 Vac	0.1 s	49 ms	195.5 V	65.5 s	20 s – 300 s
02	L1=0,5 Vn=115 Vac	2.0 s	56 ms	195.5 V	65.2 s	20 s – 300 s
	L2=0,5 Vn=115 Vac	2.0 s	58 ms	195.5 V	64.9 s	20 s – 300 s
	L3=0,5 Vn=115 Vac	2.0 s	68 ms	195.5 V	64.8 s	20 s – 300 s
03	L1=0,84 Vn=193.2 Vac	2.0 s	106 ms	195.5 V	64.4 s	20 s – 300 s
	L2=0,84 Vn=193.2 Vac	2.0 s	88 ms	195.5 V	63.9 s	20 s – 300 s
	L3=0,84 Vn=193.2 Vac	2.0 s	110 ms	195.5 V	63.2 s	20 s – 300 s
04	L1=1,11 Vn=255.3 Vac	2.0 s	912 ms	253 V	64.1 s	20 s – 300 s
	L2=1,11 Vn=255.3 Vac	2.0 s	920 ms	253 V	64.4 s	20 s – 300 s
	L3=1,11 Vn=255.3 Vac	2.0 s	908 ms	253 V	64.8 s	20 s – 300 s
05	L1=1,34 Vn=308.2 Vac	2.0 s	50 ms	253 V	65.2 s	20 s – 300 s
	L2=1,34 Vn=308.2 Vac	2.0 s	50 ms	253 V	65.2 s	20 s – 300 s
	L3=1,34 Vn=308.2 Vac	2.0 s	49 ms	253 V	64.9 s	20 s – 300 s
06	L1=1,35 Vn=310.5 Vac	0.05 s	34 ms	253 V	65.4 s	20 s – 300 s
	L2=1,35 Vn=310.5 Vac	0.05 s	44 ms	253 V	65.7 s	20 s – 300 s
	L3=1,35 Vn=310.5 Vac	0.05 s	38 ms	253 V	65.1 s	20 s – 300 s
07	L1=0,85 Vn=195.5 Vac	Continuous operation		--	--	--

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	L2=0,85 Vn=195.5 Vac	Continuous operation	--	--	--
	L3=0,85 Vn=195.5 Vac	Continuous operation	--	--	--
08	L1=1,10 Vn=253 Vac	Continuous operation	--	--	--
	L2=1,10 Vn=253 Vac	Continuous operation	--	--	--
	L3=1,10 Vn=253 Vac	Continuous operation	--	--	--

Supplementary information:

(1) Vn=230 Vac(L - N), three phase. For voltage test, each phase tested independently.

(2) Reconnection voltage range(L-N): 195.5 V ~ 253 V.

5.2.1 & 5.4	**Over/under voltage & Response to utility recovery**	P
Model:	**KSG-36K-HV**	

No.	Utility point Voltage (V)	Maximum trip time (s)	Measured trip time (ms)	Utility return to starting range (V)	Measured Self-check time (s)	Limit of Self-check time (s)
01	L1-L2=0,49Vn=235.2Vac	0.1 s	23 ms	408Vac	65.8 s	20 s – 300 s
	L2-L3=0,49Vn=235.2Vac	0.1 s	13 ms	408Vac	65.4 s	20 s – 300 s
	L3-L1=0,49Vn=235.2Vac	0.1 s	16 ms	408Vac	65.6 s	20 s – 300 s
02	L1-L2=0,5Vn=240Vac	2.0 s	12 ms	408Vac	66.4 s	20 s – 300 s
	L2-L3=0,5Vn=240Vac	2.0 s	14 ms	408Vac	66.5 s	20 s – 300 s
	L3-L1=0,5Vn=240Vac	2.0 s	22 ms	408Vac	65.8 s	20 s – 300 s
03	L1-L2=0,84Vn=403.2Vac	2.0 s	550 ms	408Vac	65.1 s	20 s – 300 s
	L2-L3=0,84Vn=403.2Vac	2.0 s	538 ms	408Vac	64.9 s	20 s – 300 s
	L3-L1=0,84Vn=403.2Vac	2.0 s	526 ms	408Vac	64.8 s	20 s – 300 s
04	L1-L2=1,11Vn=532.8Vac	2.0 s	540 ms	528Vac	65.1 s	20 s – 300 s
	L2-L3=1,11Vn=532.8Vac	2.0 s	552 ms	528Vac	65.4 s	20 s – 300 s
	L3-L1=1,11Vn=532.8Vac	2.0 s	568 ms	528Vac	65.8 s	20 s – 300 s
05	L1-L2=1,34Vn=643.2Vac	2.0 s	30 ms	528Vac	66.2 s	20 s – 300 s
	L2-L3=1,34Vn=643.2Vac	2.0 s	35 ms	528Vac	66.2 s	20 s – 300 s
	L3-L1=1,34Vn=643.2Vac	2.0 s	23 ms	528Vac	65.9 s	20 s – 300 s
06	L1-L2=1,35Vn=648Vac	0.05 s	36 ms	528Vac	66.4 s	20 s – 300 s
	L2-L3=1,35 Vn=648Vac	0.05 s	20 ms	528Vac	66.2 s	20 s – 300 s
	L3-L1=1,35 Vn=648Vac	0.05 s	37 ms	528Vac	66.5 s	20 s – 300 s
07	L1-L2=0,85Vn=408Vac	Continuous operation		--	--	--
	L2-L3=0,85Vn=408Vac	Continuous operation		--	--	--

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	L3-L1=0,85Vn=408Vac	Continuous operation	--	--	--
08	L1-L2=1,1Vn=528Vac	Continuous operation	--	--	--
	L2-L3=1,1Vn=528Vac	Continuous operation	--	--	--
	L3-L1=1,1Vn=528Vac	Continuous operation	--	--	--

Supplementary information:

(1) Vn=480 Vac(L - L), three phase. For voltage test, each phase tested independently.

(2) Reconnection voltage range(L-N): 408 V ~ 528 V.

5.2.2 & 5.4	**Over/under frequency & Response to utility recovery**					P
Model	**KSG-60K**					
No.	**Utility point Frequency (Fn)**	**Maximum trip time (s)**	**Measured trip time (ms)**	**Utility return to starting frequency (Hz)**	**Measured Self-check time (s)**	**Limit of Self-check time (s)**
01	F= 50+1	0.2 s	117.0 ms	50 Hz	70.4 s	20 s – 300 s
02	F= 50-1	0.2 s	119.0 ms	50 Hz	69.8 s	20 s – 300 s

Supplementary information:

(01) Fn=50 Hz, three phase.

(02) As the power generation unit's topology and the controlling software is identical to the each other, for the Over/under frequency & Response to utility recovery test, all the models are comply this clause.

(03) Reconnection frequency range: 49.2 Hz ~ 50.8 Hz.

5.2.2 & 5.4	**Over/under frequency & Response to utility recovery**					P
Model	**KSG-60K**					
No.	**Utility point Frequency (Fn)**	**Maximum trip time (s)**	**Measured trip time (ms)**	**Utility return to starting frequency (Hz)**	**Measured Self-check time (s)**	**Limit of Self-check time (s)**
01	F= 60+1	0.2 s	88.0 ms	60 Hz	41.1 s	20 s – 300 s
02	F= 60-1	0.2 s	96.0 ms	60 Hz	35.0 s	20 s – 300 s

Supplementary information:

(01) Fn=60 Hz, three phase.

(02) As the power generation unit's topology and the controlling software is identical to the each other, for the Over/under frequency & Response to utility recovery test, all the models are comply this clause.

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5.3	Islanding protection								P
Model	**KSG-36K-HV**								
No.	P_{EUT} (% of EUT rating)	Reactive Load (% of Q_L)	P_{AC} (% of nominal)	Q_{AC} (% of nominal)	Run on time (ms)	P_{EUT} (kW)	Actual Q_f	V_{DC} (V)	Remarks
1	100	100	0	0	334.2	36.0	1.04	700	Test A at IB
2	66	66	0	0	247.4	24.0	1.03	550	Test B at IB
3	33	33	0	0	523.4	12.0	1.03	400	Test C at IB
4	100	100	-5	-5	239.2	34.2	1.07	700	Test A at IB
5	100	100	-5	0	375.2	34.2	1.09	700	Test A at IB
6	100	100	-5	5	367.2	34.2	1.12	700	Test A at IB
7	100	100	0	-5	260.2	36.0	1.01	700	Test A at IB
8	100	100	0	5	202.2	36.0	1.06	700	Test A at IB
9	100	100	5	-5	262.2	38.2	0.96	700	Test A at IB
10	100	100	5	0	252.2	38.2	0.99	700	Test A at IB
11	100	100	5	5	225.2	38.2	1.02	700	Test B at IB
12	100	100	-10	10	225.2	32.4	1.21	700	Test A at IB
13	100	100	-5	10	235.2	34.2	1.16	700	Test A at IB
14	100	100	0	10	254.4	36.0	1.11	700	Test A at IB
15	100	100	5	10	224.4	38.2	1.06	700	Test A at IB
16	100	100	10	10	217.4	39.6	1.00	700	Test A at IB
17	100	100	-10	5	327.4	32.4	1.20	700	Test A at IB
18	100	100	10	5	203.4	39.6	0.99	700	Test A at BL
19	100	100	-10	0	355.4	32.4	1.17	700	Test A at IB
20	100	100	10	0	364.4	39.6	0.95	700	Test A at IB
21	100	100	-10	-5	187.4	32.4	1.14	700	Test A at IB
22	100	100	10	-5	218.4	39.6	0.94	700	Test A at IB
23	100	100	-10	-10	178.4	32.4	1.14	700	Test A at IB
24	100	100	-5	-10	182.4	34.2	1.08	700	Test A at IB
25	100	100	0	-10	228.4	36.0	1.02	700	Test A at IB
26	100	100	5	-10	217.4	38.2	0.97	700	Test A at IB
27	100	100	10	-10	207.4	39.6	0.93	700	Test A at IB
28	66	66	0	-5	227.4	24.0	1.00	550	Test B at IB

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29	66	66	0	-4	325.4	24.0	1.01	550	Test B at IB
30	66	66	0	-3	216.4	24.0	1.01	550	Test B at IB
31	66	66	0	-2	359.4	24.0	1.02	550	Test B at IB
32	66	66	0	-1	329.4	24.0	1.03	550	Test B at IB
33	66	66	0	1	679.4	24.0	1.04	550	Test B at BL
34	66	66	0	2	395.4	24.0	1.05	550	Test B at IB
35	66	66	0	3	330.4	24.0	1.05	550	Test B at IB
36	66	66	0	4	371.4	24.0	1.05	550	Test B at IB
37	66	66	0	5	237.4	24.0	1.06	550	Test B at IB
38	33	33	0	-5	265.4	12.0	1.00	400	Test C at IB
39	33	33	0	-4	267.4	12.0	1.01	400	Test C at BL
40	33	33	0	-3	343.4	12.0	1.01	400	Test C at IB
41	33	33	0	-2	327.4	12.0	1.02	400	Test C at IB
42	33	33	0	-1	270.4	12.0	1.02	400	Test C at IB
43	33	33	0	1	298.4	12.0	1.03	400	Test C at IB
44	33	33	0	2	259.4	12.0	1.04	400	Test C at IB
45	33	33	0	3	313.4	12.0	1.04	400	Test C at IB
46	33	33	0	4	286.4	12.0	1.05	400	Test C at IB
47	33	33	0	5	201.4	12.0	1.06	400	Test C at IB

Supplementary information:

(1) As the model: KSG-36K-HV and KSG-60K-HV's topology and the controlling software is identical to the each other, for Islanding protection test, these two models comply with this clause.

(2) Test method are refer to IEC 62116:2014.

5.3	**Islanding protection**								P
Model	**KSG-60K**								
No.	P_{EUT} (% of EUT rating)	Reactive Load (% of Q_L)	P_{AC} (% of nominal)	Q_{AC} (% of nominal)	Run on time (ms)	P_{EUT} (kW)	Actual Q_f	V_{DC} (V)	Remarks
1	100	100	0	0	496.4	60.0	1.01	700	Test A at IB
2	66	66	0	0	518.4	39.6	1.01	550	Test B at IB
3	33	33	0	0	528.4	19.8	1.02	400	Test C at IB
4	100	100	-5	-5	208.4	57.0	1.04	700	Test A at IB
5	100	100	-5	0	338.4	57.0	1.00	700	Test A at IB
6	100	100	-5	5	238.4	57.0	1.02	700	Test A at IB

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7	100	100	0	-5	204.4	60.0	0.93	700	Test A at IB
8	100	100	0	5	210.4	60.0	0.97	700	Test A at IB
9	100	100	5	-5	264.4	63.0	0.94	700	Test A at IB
10	100	100	5	0	258.4	63.0	0.91	700	Test A at IB
11	100	100	5	5	210.4	63.0	0.93	700	Test B at IB
12	100	100	-10	10	190.4	54.0	1.11	700	Test A at IB
13	100	100	-5	10	154.4	57.0	1.05	700	Test A at IB
14	100	100	0	10	184.4	60.0	0.99	700	Test A at IB
15	100	100	5	10	262.4	63.0	0.95	700	Test A at IB
16	100	100	10	10	164.4	66.0	0.91	700	Test A at IB
17	100	100	-10	5	240.4	54.0	1.08	700	Test A at IB
18	100	100	10	5	312.4	66.0	0.89	700	Test A at BL
19	100	100	-10	0	284.4	54.0	1.06	700	Test A at IB
20	100	100	10	0	252.4	66.0	0.86	700	Test A at IB
21	100	100	-10	-5	289.4	54.0	1.03	700	Test A at IB
22	100	100	10	-5	210.4	66.0	0.84	700	Test A at IB
23	100	100	-10	-10	162.4	54.0	1.00	700	Test A at IB
24	100	100	-5	-10	170.4	57.0	0.94	700	Test A at IB
25	100	100	0	-10	196.4	60.0	0.90	700	Test A at IB
26	100	100	5	-10	180.4	63.0	0.91	700	Test A at IB
27	100	100	10	-10	188.4	66.0	0.87	700	Test A at IB
28	66	66	0	-5	224.4	39.6	0.91	550	Test B at IB
29	66	66	0	-4	272.4	39.6	0.92	550	Test B at IB
30	66	66	0	-3	368.4	39.6	0.92	550	Test B at IB
31	66	66	0	-2	224.4	39.6	1.00	550	Test B at IB
32	66	66	0	-1	292.4	39.6	1.00	550	Test B at IB
33	66	66	0	1	340.4	39.6	1.01	550	Test B at BL
34	66	66	0	2	212.4	39.6	1.02	550	Test B at IB
35	66	66	0	3	204.4	39.6	1.02	550	Test B at IB
36	66	66	0	4	316.4	39.6	1.03	550	Test B at IB
37	66	66	0	5	222.4	39.6	1.04	550	Test B at IB
38	33	33	0	-5	238.4	19.8	1.00	400	Test C at IB
39	33	33	0	-4	274.4	19.8	1.00	400	Test C at BL
40	33	33	0	-3	558.4	19.8	0.96	400	Test C at IB

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41	33	33	0	-2	304.4	19.8	1.02	400	Test C at IB
42	33	33	0	-1	354.4	19.8	1.02	400	Test C at IB
43	33	33	0	1	232.4	19.8	1.03	400	Test C at IB
44	33	33	0	2	248.4	19.8	1.03	400	Test C at IB
45	33	33	0	3	408.4	19.8	1.04	400	Test C at IB
46	33	33	0	4	214.4	19.8	1.04	400	Test C at IB
47	33	33	0	5	208.4	19.8	1.05	400	Test C at IB

Supplementary information:

(1) As the model: KSG-60K and KSG-30K, KSG-50K's topology and the controlling software is identical to the each other, for Islanding protection test, these three models comply with this clause.

(2) Test method are refer to IEC 62116:2014.

……..End of test report……..…….

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