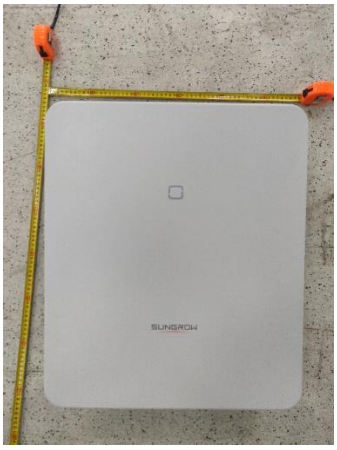
Prüfbericht - Nr.: *Test Report No.:*	50367016 001	**Auftrags-Nr.:** *Order No.:*	244218062	**Seite 1 von 31** *Page 1 of 31*
Kunden-Referenz-Nr.: *Client Reference No.:*	417691	**Auftragsdatum:** *Order date:*	19.02.2020	
Auftraggeber: *Client:*	**Sungrow Power Supply Co., Ltd.** No. 1699, Xiyou Rd, New & High Technology Industrial Development Zone, Hefei, Anhui 230088, P.R. CHINA			
Prüfgegenstand: *Test item:*	**Hybrid Inverter**			
Bezeichnung / Typ-Nr.: *Identification / Type No.:*	SH10RT, SH8.0RT, SH6.0RT, SH5.0RT			
Auftrags-Inhalt: *Order content:*	Test report			
Prüfgrundlage: *Test specification:*	IEC 60730-1:2013, IEC 60730-1:2013/AMD1:2015			
Wareneingangsdatum: *Date of receipt::*	2020-02-19			
Prüfmuster-Nr.: *Test sample No.:*	Engineering sample			
Prüfzeitraum: *Testing period:*	2020-02-19 to 2020-04-20			
Ort der Prüfung: *Place of testing:*	Sungrow Power Supply Co., Ltd.			
Prüflaboratorium: *Testing Laboratory:*	TÜV Rheinland (Shanghai) Co., Ltd.			
Prüfergebnis*: *Test Result*:*	Pass			



geprüft/ *tested by:*

28.05.2020	Bowen Dong / Engineer	
Datum *Date*	**Name/Stellung** *Name/Position*	**Unterschrift** *Signature*

kontrolliert/ *reviewed by:*

28.05.2020	Yue Yin/ Reviewer	
Datum *Date*	**Name/Stellung** *Name/Position*	**Unterschrift** *Signature*

Sonstiges/ *Other Aspects:*

– See the following pages for General product information and comment.

Zustand des Prüfgegenstandes bei Anlieferung:
Condition of test item at delivery:
Prüfmuster vollständig und unbeschädigt
Test item complete and undamaged

* Legende:	1 = sehr gut	2 = gut	3 = befriedigend	4 = ausreichend	5 = mangelhaft
	P(ass) = entspricht o.g. Prüfgrundlage(n)		F(ail) = entspricht nicht o.g. Prüfgrundlage(n)	N/A = nicht anwendbar	N/T = nicht getestet
Legend:	*1 = very good*	*2 = good*	*3 = satisfactory*	*4 = sufficient*	*5 = poor*
	P(ass) = passed a.m. test specification(s)		*F(ail) = failed a.m. test specification(s)*	*N/A = not applicable*	*N/T = not tested*

V04

Test Report issued under the responsibility of:

TÜVRheinland®

TEST REPORT

IEC 60730-1
Automatic electrical controls for household and similar use
Controls using software

Report Number..... :	**50367016 001**
Date of issue ..... :	**See cover page**
Total number of pages..... :	**See cover page**
Name of Testing Laboratory preparing the Report ..... :	**See cover page**
Applicant's name..... :	**See cover page**
Address..... :	**See cover page**
Test specification:	
Standard..... :	**See cover page**
Test procedure..... :	**See cover page**
Non-standard test method ..... :	N/A
Test Report Form No. ..... :	IEC60730_1i_SOFTWARE
Test Report Form(s) Originator.... :	UL(US)
Master TRF ..... :	2018-05

If this Test Report Form is used by non-IECEE members, the IECEE/IEC logo and the reference to the CB Scheme procedure shall be removed.

This report is not valid as a CB Test Report unless signed by an approved CB Testing Laboratory and appended to a CB Test Certificate issued by an NCB in accordance with IECEE 02.

General disclaimer:

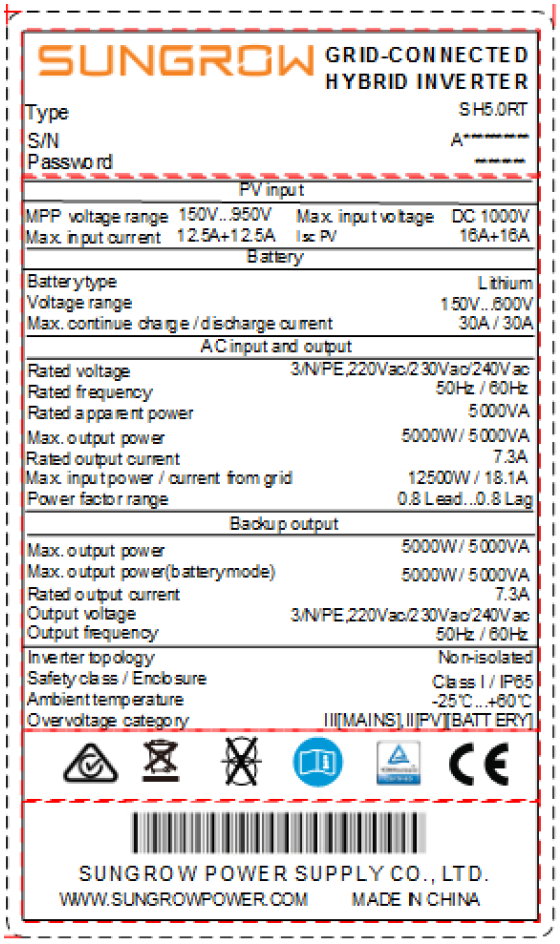
The test results presented in this report relate only to the object tested.
This report shall not be reproduced, except in full, without the written approval of the Issuing CB Testing Laboratory. The authenticity of this Test Report and its contents can be verified by contacting the NCB, responsible for this Test Report.

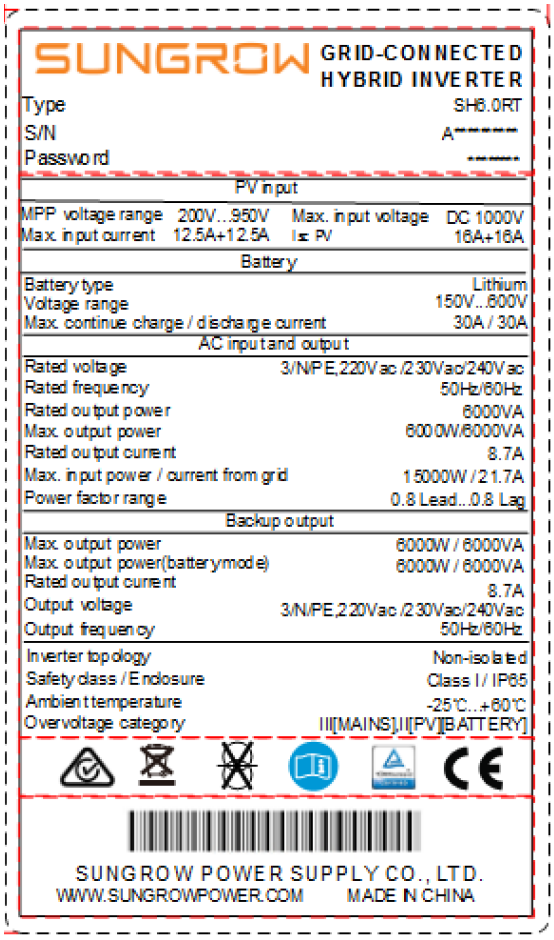
Test Item description	**Hybrid Inverter**
Trade Mark	阳 光 电 源 SUNGROW
Manufacturer.....	See cover page
Model/Type reference	SH10RT, SH8.0RT, SH6.0RT, SH5.0RT
Ratings	See GENERAL PRODUCT INFORMATION
Software module(s) and associated version(s).....	Master DSP SW Designation: SAPPHIRE-H_03011.01.01 Slave DSP SW Designation: SUBCTL-S_04011.01.01 LCD MCU SW Designation: SAPPHIRE-H_01011.01.05

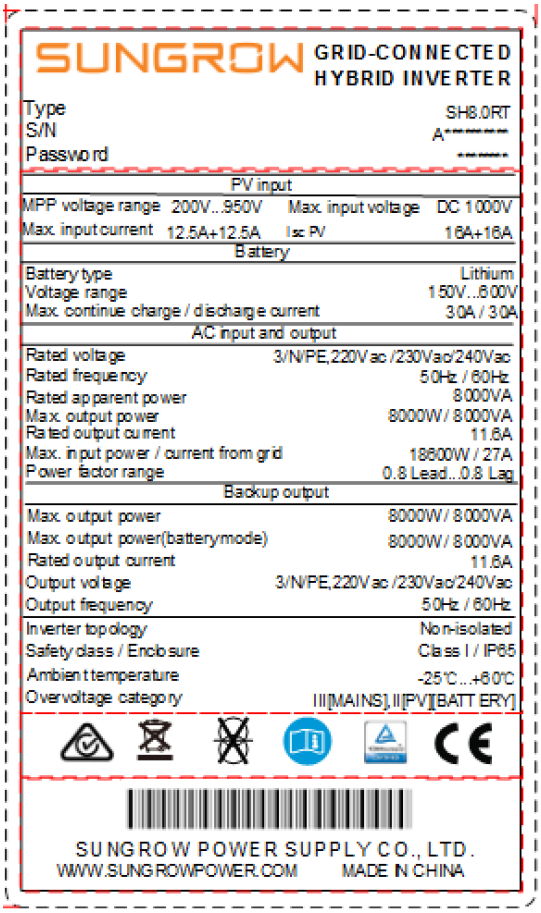
Responsible Testing Laboratory (as applicable), testing procedure and testing location(s):			
☐	**CB Testing Laboratory:**		
Testing location/ address .....:			
Tested by (name, function, signature) .....:			
Approved by (name, function, signature)..:			
☐	**Testing procedure: CTF Stage 1:**		
Testing location/ address .....:			
Tested by (name, function, signature) .....:			
Approved by (name, function, signature)..:			
☐	**Testing procedure: CTF Stage 2:**		
Testing location/ address .....:			
Tested by (name + signature) .....:			
Witnessed by (name, function, signature).:			
Approved by (name, function, signature)..:			
☐	**Testing procedure: CTF Stage 3:**		
☐	**Testing procedure: CTF Stage 4:**		
Testing location/ address .....:			
Tested by (name, function, signature) .....:			
Witnessed by (name, function, signature).:			
Approved by (name, function, signature)..:			
Supervised by (name, function, signature):			

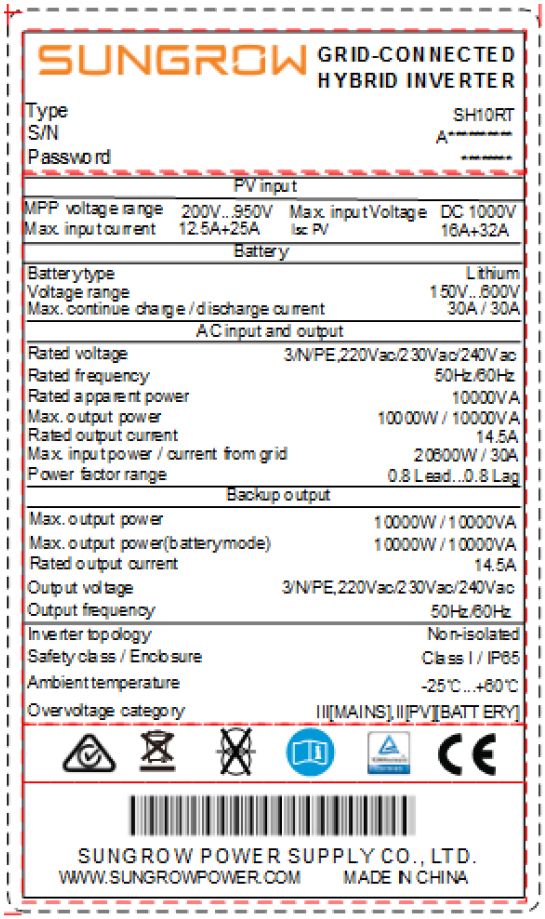
List of Attachments (including a total number of pages in each attachment): -Attachment 1 - FMEA and fault insert testing
Summary of compliance with National Differences (List of countries addressed): N/A

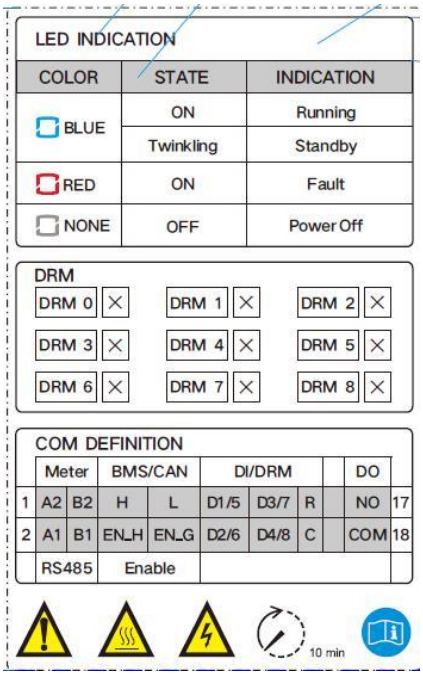
Copy of marking plate:






SUNGROW
GRID-CONNECTED
HYBRID INVERTER
Type SH8.0RT
S/N A*******
Password ******
PV input
MPP voltage range 200V...950V Max. input voltage DC 1000V
Max. input current 12.5A+12.5A Isc PV 16A+16A
Battery
Battery type Lithium
Voltage range 150V...600V
Max. continue charge / discharge current 30A / 30A
AC input and output
Rated voltage 3/N/PE,220Vac /230Vac/240Vac
Rated frequency 50Hz / 60Hz
Rated apparent power 8000VA
Max. output power 8000W / 8000VA
Rated output current 11.6A
Max. input power / current from grid 18600W / 27A
Power factor range 0.8 Lead...0.8 Lag
Backup output
Max. output power 8000W / 8000VA
Max. output power(batterymode) 8000W / 8000VA
Rated output current 11.6A
Output voltage 3/N/PE,220Vac /230Vac/240Vac
Output frequency 50Hz / 60Hz
Inverter topology Non-isolated
Safety class / Enclosure Class I / IP65
Ambient temperature -25℃...+60℃
Overvoltage category II[MAINS],II[PV][BATTERY]
SUNGROW POWER SUPPLY CO., LTD.
WWW.SUNGROWPOWER.COM MADE IN CHINA


SUNGROW
GRID-CONNECTED
HYBRID INVERTER
Type SH10RT
S/N A*******
Password ******
PV input
MPP voltage range 200V...950V Max. input Voltage DC 1000V
Max. input current 12.5A+25A Isc PV 16A+32A
Battery
Battery type Lithium
Voltage range 150V...600V
Max. continue charge / discharge current 30A / 30A
AC input and output
Rated voltage 3/N/PE,220Vac/230Vac/240Vac
Rated frequency 50Hz/60Hz
Rated apparent power 10000VA
Max. output power 10000W / 10000VA
Rated output current 14.5A
Max. input power / current from grid 20800W / 30A
Power factor range 0.8 Lead...0.8 Lag
Backup output
Max. output power 10000W / 10000VA
Max. output power(batterymode) 10000W / 10000VA
Rated output current 14.5A
Output voltage 3/N/PE,220Vac/230Vac/240Vac
Output frequency 50Hz/60Hz
Inverter topology Non-isolated
Safety class / Enclosure Class I / IP65
Ambient temperature -25℃...+60℃
Overvoltage category II[MAINS],II[PV][BATTERY]
SUNGROW POWER SUPPLY CO., LTD.
WWW.SUNGROWPOWER.COM MADE IN CHINA


LED INDICATION
COLOR STATE INDICATION
BLUE ON Running
Twinkling Standby
RED ON Fault
NONE OFF Power Off
DRM
DRM 0 DRM 1 DRM 2
DRM 3 DRM 4 DRM 5
DRM 6 DRM 7 DRM 8
COM DEFINITION
Meter BMS/CAN DI/DRM DO
1 A2 B2 H L D1/5 D3/7 R NO 17
2 A1 B1 EN_H EN_G D2/6 D4/8 C COM 18
RS485 Enable
10 min

TEST ITEM PARTICULARS:	
Manufacturer's specified maxium operating ambient:	60°C
POSSIBLE TEST CASE VERDICTS:	
- test case does not apply to the test object.....:	N/A
- test object does meet the requirement.....:	P (Pass)
- test object does not meet the requirement.....:	F (Fail)
TESTING:	
Date of receipt of test item .....:	See cover page
Date (s) of performance of tests.....:	See cover page
GENERAL REMARKS:	

"(See Enclosure #)" refers to additional information appended to the report.
"(See appended table)" refers to a table appended to the report.

This Test Report is only applicable to controls using software. This TRF is to be used in conjunction with the IEC 60730-1, Edition 5.1 Test Report.

Throughout this report a ☐ comma / ☒ point is used as the decimal separator.

When differences exist; they shall be identified in the General product information section.

Name and address of factory (ies)..... :	Sungrow Power Supply Co., Ltd. Address: No. 1699, Xiyou Rd, New & High Technology Industrial Development Zone, Hefei, Anhui 230088, P.R. CHINA

GENERAL PRODUCT INFORMATION:

Product Description –

The PCEs under test (EUTs) are four types of three-phase Grid-connected hybrid Inverter which utilizes the advanced power electronics conversion components such as MOSFET, IGBT to convert the variable DC power generated from the photovoltaic (PV) arrays as well as batteries to the stable utility AC power which can be fed into the commercial electrical grid. The battery port is able to be charged by the energy from either PV port or AC grid port.

Model Differences –

The models SH8.0RT, SH6.0RT, SH5.0RT are identical to SH10RT except for the model name and electrical ratings.
Unless otherwise specified, all the tests were conducted on the basic model of SH10RT to represent the others.

Below is the parameter list of all the models.

MODELS LIST		SH5.0RT	SH6.0RT
PV INPUT	V_{MAX} PV [Vdc]	1000	
	I_{SC} PV [A]	16/16	
	MPP Voltage Range V_{MPP} [Vdc]	150~950	200~950
	Max. Input Current I_{MAX} [A]	12.5/12.5	
	MPP Full Power Voltage Range [Vdc]	210-850	250-850
	Startup PV Voltage[Vdc]	180	250
	Overvoltage Category(OVC)	II	
AC Input and Output Data	Rated Output Voltage Ur [Vac]	3/N/PE, 220/230/240	
	Normal Operating Voltage Range Un[Vac]	270-480	
	Rated Output Frequency F_{NETZ}[Hz]	50 / 60	
	Normal Operating Frequency Range Fn[Hz]	45~55Hz/55~65Hz	
	Rated Output Power [W]	5000	6000
	Max. Output Power [W]	5000	6000
	Max. Apparent power [VA]	5000	6000
	Rated Output Current Ir[A]	7.3	8.7
	Max. Output Current Imax[A]	7.6	9.1
	Power Factor cosφ [λ]	[-0.8, +0.8]	
	THD [I] (100% full power)	<3%	
	DC injection [I] (%, 100% full power)	<0.5In	
	Overvoltage Category(OVC)	III	
Backup Data	Rated Output Voltage Ur [Vac]	3/N/PE, 220/230/240	
	Rated Output Frequency [Hz]	50 / 60	
	Rated Output Power [W]	5000	6000
	Peak output power[W]	6000(5 min) 10000 (10s)	7200(5 min) 10000 (10s)
	THD [I] (100% full power)	<2%	
	Overvoltage Category(OVC)	II	
Battery Data	V_{MAX} BAT [Vdc]	600V	
	Battery Type	Li-ion battery	
	Voltage Range	150-600	
	Max. Charge/Discharge Current I_{MAX} [A]	30/30	
	Max. Charge/Discharge power [W]	7500/6000	9000/7200
	Backfeed Current [A]	0	
	Overvoltage Category(OVC)	II	

System data	Type of inverter	Non-isolated
	Separated by	--
	Type of Charger	Non-isolated
	Separated by	--
	Protective Class	I
	Enclosure Protection (IP)	IP65
	Operating Temperature Range [ºC]	-25 to +60 (>45 derating)
	Pollution degree (PD)	PD3
	Altitude [m]	4000
	Size [mm]	460 * 540 * 170
	Weight [kg]	27

MODELS LIST		SH8.0RT	SH10RT
PV INPUT	V_{MAX} PV [Vdc]	1000	
	I_{SC} PV [A]	16/16	16/32
	MPP Voltage Range V_{MPP} [Vdc]	200~950	
	Max. Input Current I_{MAX} [A]	12.5/12.5	12.5/25
	MPP Full Power Voltage Range [Vdc]	330-850	280-850
	Startup PV Voltage[Vdc]	250	
	Overvoltage Category(OVC)	II	
AC Input and Output Data	Rated Output Voltage Ur [Vac]	3/N/PE, 220/230/240	
	Normal Operating Voltage Range Un[Vac]	270-480	
	Rated Output Frequency F_{NETZ}[Hz]	50 / 60	
	Normal Operating Frequency Range Fn[Hz]	45~55Hz/55~65Hz	
	Rated Output Power [W]	8000	10000
	Max. Output Power [W]	8000	10000
	Max. Apparent power [VA]	8000	10000
	Rated Output Current Ir[A]	11.6	14.5
	Max. Output Current Imax[A]	12.1	15.2
	Power Factor cosφ [λ]	[-0.8, +0.8]	
	THD [I] (100% full power)	<3%	
	DC injection [I] (%, 100% full power)	<0.5In	
	Overvoltage Category(OVC)	III	
Back up	Rated Output Voltage Ur [Vac]	3/N/PE, 220/230/240	
	Rated Output Frequency [Hz]	50 / 60	

	Rated Output Power [W]	8000	10000
	Peak output power[W]	12000 (5min)	12000 (5min)
	THD [I] (100% full power)	<2%	
	Overvoltage Category(OVC)	II	
Battery Data	V_{MAX} BAT [Vdc]	600V	
	Battery Type	Li-ion battery	
	Voltage Range	150-600	
	Max. Charge/Discharge Current I_{MAX} [A]	30/30	
	Max. Charge/Discharge power [W]	10600 / 10600	
	Backfeed Current [A]	0	
	Overvoltage Category(OVC)	II	
System data	Type of inverter	Non-isolated	
	Separated by	--	
	Type of Charger	Non-isolated	
	Separated by	--	
	Protective Class	I	
	Enclosure Protection (IP)	IP65	
	Operating Temperature Range [ºC]	-25 to +60 (>45 derating)	
	Pollution degree (PD)	PD3	
	Altitude [m]	4000	
	Size [mm]	460 * 540 * 170	
	Weight [kg]	27	

Additional application considerations – (Considerations used to test a component) –
N/A

DESCRIPTION OF SAFETY FUNCTION(S)

	Safety function 1 – **Detection and protection of non-disconnectable bypass contactor**
	Software protection
Description	The MCU samples the AC voltage at the Grid port periodically. In stand-alone mode, If the MCU detects AC voltage at the grid port, the bypass contactor is deemed non-disconnectable. Then the MCU switches all the AC relays.
Input	AC voltage
threshold value	non-disconnectable contactor
Response time	120ms
Output	Switch off all the AC relays

IEC 60730-1 (Software)			
Clause	Requirement + Test	Result - Remark	Verdict
H.6	Classification, additions		
H.6.18	Class of control function (A, B,C) ..... :	Class B	—
H.7	Information in addition to Table 1 provided:		P
	66 - Software sequence documentation; clause: H.11.12.2.9; method: X..... :		P
	67 - Program documentation; clause: H.11.12.2.9, H.11.12.2.12; method: X..... :		P
	68 - Software fault analysis; clause: H.11.12, H.27.1.1.4; method: X..... :		P
	69 - Software class(es) and structure; clause: H.11.12.2, H.11.12.3, H.27.1.2.2.1, H.27.1.2.3.1; method: D ..... :		P
	70 - Analytical measures and fault/error control techniques employed; clause: H.11.12.1.2, H.11.12.2.2, H.11.12.2.4; method: X..... :		P
	71 - Software fault/error detection time(s) for controls with software Classes B or C; clause: H.2.17.10, H.11.12.2.6; method: X..... :		P
	72 - Control response(s) in case of detected fault/error; clause: H.11.12.2.7; method: X..... :		P
	93 – Maximum number of reset actions within a time period; clause H.11.12.4.3.6, H.11.12.4.3.4; method: D..... :		P
	94 – Number of remote reset actions; clause H.17.1.4.3; method: X..... :		N/A
	m – Controls with software classes B or C had information provided for safety-related segments of the software. Information on the non-safety related segments was sufficient to establish that they did not influence safety-related segments..... :		P
	n – Software sequence was documented and, together with the operating sequence, included a description of the control system philosophy, the control flow, data flow and the timings..... :		P

IEC 60730-1 (Software)			
Clause	Requirement + Test	Result - Remark	Verdict
	o - Safety-related data and safety-related segments of the software sequence, the malfunction of which could result in non-compliance with the requirements of Clauses 17, 25, 26 and 27, are identified..... :		P
	– Included the operating sequence..... :		P
	– Software fault analysis was related to the hardware fault analysis in Clause H.27..... :		P
	q - Programming documentation was supplied in a programming design language declared by the manufacturer..... :		P
	r – Different software classes applied to different control functions ..... :		N/A
	s - Measures declared are chosen by manufacturer from the requirements of Clauses H.11.12.1.2 to H.11.12.2.4 inclusive..... :		P
H.8	Protection against electric shock		P
H.8.1	General requirements		P
H.8.1.10	Accessible parts shall not be considered as hazardous live parts if separated from the supply by protective impedance.		P
H.8.1.10.1	When protective impedance is used, the current between the part or parts and either pole of the supply source shall not exceed 0,7 mA (peak value) a.c. or 2 mA d.c		N/A
H.11	Constructional requirements		P
H.11.12	Controls using software		P
	Controls using software were so constructed that the software did not impair control compliance with the requirements of this standard		P
H.11.12.1	Requirements for the architecture		P
H.11.12.1.1	Control functions with software class B or C use measures to control and avoid software-related faults/errors in safety-related data and safety-related segments of the software, as detailed in H.11.12.1.2 to H.11.12.3 inclusive	Class B considered	P

IEC 60730-1 (Software)			
Clause	Requirement + Test	Result - Remark	Verdict
H.11.12.1.2	Control functions with software class C have one of the following structures:		N/A
	– single channel with periodic self-test and monitoring (H.2.16.7)	Class B	N/A
	– dual channel (homogenous) with comparison (H.2.16.3)		N/A
	– dual channel (diverse) with comparison (H.2.16.2)		N/A
	Control functions with software class B have one of the following structures:		P
	– single channel with functional test (H.2.16.5)	Used	P
	– single channel with periodic self-test (H.2.16.6)	Used	P
	– dual channel without comparison (H.2.16.1)	Not used	N/A
H.11.12.1.3	Other structure permitted with equivalent level of safety to those in H.11.12.1.2..... :		P
H.11.12.2	Measures to control faults/errors		P
H.11.12.2.1	Redundant memory with comparison provided on two areas of the same component: data stored in different formats		P
H.11.12.2.2	Software class C using dual channel structures with comparison: additional fault/error detection means		N/A
H.11.12.2.3	Software class B or C: means for recognition and control of errors in transmission to external safety-related data paths: Means took into account errors of data, addressing, transmission timing and sequence of protocol		P
H.11.12.2.4	Software class B or C: within the control, measures are taken to address the fault/errors in safety-related segments and data indicated in Table H.1 and identified in Table 1 requirement 68.		P
H.11.12.2.5	Measures others than those specified in H.11.12.2.4 utilized to satisfy the requirements listed in Table H.1		P
H.11.12.2.6	Software fault/error detection:		P

IEC 60730-1 (Software)			
Clause	Requirement + Test	Result - Remark	Verdict
	– occur not later than declared time(s), Table 1, requirement 71		P
	– acceptability of declared time(s): evaluated during fault analysis of the control		P
H.11.12.2.7	For controls with functions, classified as Class B or C, detection of fault/error:		P
	– results in the response declared in Table 1, requirement 72		P
	– for Class C: independent means capable of performing this response provided		N/A
H.11.12.2.8	Class C, dual channel structure, loss of dual channel capability: deemed to be an error		N/A
H.11.12.2.9	Software referenced:		P
	– to relevant parts of the operating sequence		P
	– to the associated hardware functions		P
H.11.12.2.10	Labels used for memory locations are unique		N/A
H.11.12.2.11	Software protected from user alteration of safety-related segments and data		P
H.11.12.2.12	Software and safety-related hardware under its control is initialized to and terminates at a declared state, Table 1, requirement 66 ..... :		P
H.11.12.3	Measures to avoid errors		P
H.11.12.3.1	For controls with software class B or C the measures shown in Figure H.1 to avoid systematic faults are applied		P
	Other methods utilized that incorporate disciplined and structured processes including design and test phases		P
H.11.12.3.2	Specification		P
H.11.12.3.2.1	Software safety requirements		P
H.11.12.3.2.1.1	The specification of the software safety requirements includes:		P

IEC 60730-1 (Software)			
Clause	Requirement + Test	Result - Remark	Verdict
	• A description of each safety related function to be implemented, including its response time(s): - functions related to the application including their related software classes - functions related to the detection, annunciation and management of software or hardware faults		P
	• A description of interfaces between software and hardware		P
	• A description of interfaces between any safety and non-safety related functions		P
H.11.12.3.2.2	Software architecture		P
H.11.12.3.2.2.1	The description of software architecture include the following aspects:		P
	• Techniques and measures to control software faults/errors (refer to H.11.12.2)		P
	• Interactions between hardware and software		P
	• Partitioning into modules and their allocation to the specified safety functions		P
	• Hierarchy and call structure of the modules (control flow)		P
	• Interrupt handling		P
	• Data flow and restrictions on data access		P
	• Architecture and storage of data		P
	• Time based dependencies of sequences and data		P
H.11.12.3.2.2.2	The architecture specification is verified against the specification of the software safety requirements by static analysis		P
H.11.12.3.2.3	Module design and coding		P
H.11.12.3.2.3.1	Software is suitably refined into modules. Software module design and coding are implemented in a way that is traceable to the software architecture and requirements. The module design specified:		P

IEC 60730-1 (Software)			
Clause	Requirement + Test	Result - Remark	Verdict
	– function(s)		P
	– interfaces to other modules		P
	– data		P
H.11.12.3.2 .3.2	Software code is structured		P
H.11.12.3.2 .3.3	Coded software is verified against the module specification, and the module specification is verified against the architecture specification by static analysis		P
H.11.12.3.2 .4	Design and coding standards		P
	Program design and coding standards is used during software design and maintenance		P
	Coding standards .....:		—
	– specified programming practice		P
	– proscribed unsafe language features		P
	– specify procedures for source code documentation		P
	– specify data naming conventions		P
H.11.12.3.3	Testing		P
H.11.12.3.3 .1	Module design (software system design, software module design and coding)		P
H.11.12.3.3 .1.1	A test concept with suitable test cases is defined based on the module design specification.		P
H.11.12.3.3 .1.2	Each software module is tested as specified within the test concept		P
H.11.12.3.3 .1.3	Test cases, test data and test results are documented		P
H.11.12.3.3 .1.4	Code verification of a software module by static means includes such techniques as software inspections, walk-throughs, static analysis and formal proof		P

IEC 60730-1 (Software)			
Clause	Requirement + Test	Result - Remark	Verdict
	Code verification of a software module by dynamic means includes functional testing, white-box testing and statistical testing		P
H.11.12.3.3 .2	Software integration testing		P
H.11.12.3.3 .2.1	A test concept with suitable test cases is defined based on the architecture design specification		P
H.11.12.3.3 .2.2	The software is tested as specified within the test concept		P
H.11.12.3.3 .2.3	Test cases, test data and test results are documented		P
H.11.12.3.3 .3	Software validation		P
H.11.12.3.3 .3.1	A validation concept with suitable test cases is defined based on the software safety requirements specification		P
H.11.12.3.3 .3.2	The software is validated with reference to the requirements of the software safety requirements specification as specified within the validation concept		P
	The software is exercised by simulation or stimulation of:		P
	• input signals present during normal operation		P
	• anticipated occurrences		P
	• undesired conditions requiring system action		P
H.11.12.3.3 .3.4	Test cases, test data and test results are documented		P
H.11.12.3.4	Other Items		P
H.11.12.3.4 .1	Equipment used for software design, verification and maintenance was qualified appropriately and demonstrated to be suitable for purpose in manifold applications		P
H.11.12.3.4 .2	Management of software versions: All versions are uniquely identified for traceability		P
H.11.12.3.4 .3	Software modification		P

IEC 60730-1 (Software)			
Clause	Requirement + Test	Result - Remark	Verdict
H.11.12.3.4.3.1	Software modifications are based on a modification request which details the following:		P
	• the hazards which may be affected		P
	• the proposed change		P
	• the reasons for change		P
H.11.12.3.4.3.2	An analysis is carried out to determine the impact of the proposed modification on functional safety.		P
H.11.12.3.4.3.3	A detailed specification for the modification is generated including the necessary activities for verification and validation, such as a definition of suitable test cases		P
H.11.12.3.4.3.4	The modification is carried out as planned		P
H.11.12.3.4.3.5	The assessment of the modification is carried out based on the specified verification and validation activities.		P
H.11.12.3.4.3.6	All details of modification activities are documented		P
H.11.12.3.5	For class C control functions: One of the combinations (a–p) of analytical measures given in the columns of table H.9 is used during hardware development.....	Class B	N/A
H.11.12.4	Remotely actuated control functions		P
H.11.12.4.1.1	Data Exchange – General – Remotely actuated control functions are connected to separate, independent devices, which may themselves contain control functions or provide other information and any data exchange between these devices does not compromise the integrity of class B control function or class C control function.		P
H.11.12.4.1.2	Type of data - Message types for data exchange in a control function or functions are allocated to class A control function, class B control function or class C control function. The safety or protective relevance or influence, message types or data exchange are allocated only to class B control function or class C control functions, see Table H.10.		P

IEC 60730-1 (Software)			
Clause	Requirement + Test	Result - Remark	Verdict
H.11.12.4.1 .3.1	Communication of Safety Related Data – Transmission – Safety relevant data is transmitted authentically concerning:		P
	– data corruption		P
	– address corruption		P
	– wrong timing or sequence		P
	Data variation or corrupted data did not lead to an unsafe state		P
	Before transmitted data was used it was ensured that data corruption, address corruption and wrong timing or sequence are addressed using the measures as given in Annex H.		P
	The following failure modes are addressed		—
	– permanent “auto-sending” or repetition,		P
	– interruption of data transfer		P
H.11.12.4.1 .3.2	Access to data exchange - All types of access to class B control function or class C control function related data exchange systems is clearly restricted		P
	Adequate hardware/software measures are taken to prevent unauthorized access to the control functions (class B and C; operating data, configuration parameters and/or software modules)		P
	Access to data exchange of class B control function or class C control function related operating data through public networks, has appropriate cryptographical techniques implemented.		P
H.11.12.4.1 .3.3	For class B and class C software revisions the requirements of H.11.12.3 and hardware configuration management are applied and the control maintains its protective functions		P
H.11.12.4.1 .4	Remotely actuated control function operation have the duration or limits set before switching on except when automatic switching off is realized at the end of a cycle or the system is designed for permanent operation.		P

IEC 60730-1 (Software)			
Clause	Requirement + Test	Result - Remark	Verdict
H.11.12.4.2	Priority of remotely actuated control functions over control functions does not lead to a hazardous condition.		P
H.11.12.4.3.1	Remote reset action is manually initiated.		P
	Reset functionality initiated by a hand-held device required at least two manual actions to activate		P
H.11.12.4.3.2	Reset functions are capable of resetting the system as intended		P
H.11.12.4.3.3	Unintended resets from safe state do not occur.		P
H.11.12.4.3.4	Any fault of the reset function does not cause the control or controlled function to result in a hazardous condition, and was evaluated for its Class B classification		P
H.11.12.4.3.5	For reset functions initiated by manual action not in visible sight of the appliance, the following additional requirements apply:		P
	– the actual status and relevant information of the process under control is visible to the user before, during and after the reset action;		P
	– the maximum number of reset actions within a time period is declared. Following this, any further reset is denied unless the appliance is physically checked		P
H.11.12.4.3.6	The reset function is evaluated on the final application.		P
	Manual switching of a thermostat or device with similar function that activates a reset is declared by the manufacturer and is suitable in the final application		P
H.11.12.4.4	Software Download and Installation		N/A
	Software updates provided by the manufacturer and transmitted to the control via remote communication were checked prior to its use:		N/A

IEC 60730-1 (Software)			
Clause	Requirement + Test	Result - Remark	Verdict
	– against corruption through communication ensuring Hamming distance 3 for software class B, or Hamming distance 4 for software class C;		N/A
	– that the software version is compatible with the hardware version of the control according to the version management documentation.		N/A
	The software which performs the above mentioned checks had measures to control the fault/error conditions specified in H.11.12.2.		N/A
H.11.12.4.4.2	In case of software download via remote communication, the cryptographic techniques in H.11.12.4.5 were provided. In addition to the requirements in H.11.12.4.5, identification procedures were provided for the software packages.		N/A
	The cryptographic techniques employed were part of the control, did not rely upon part of the router or similar data transmission device itself, and were performed prior to transmission.		N/A
H.11.12.4.4.3	Each update of software had provisions for authorization by the user and a version ID number which were accessible.		N/A
H.11.12.4.4.4	The installation of class B software or class C software was permitted during and after which the software installation process the control remained in compliance with the requirements of this standard.		N/A
H.11.12.4.5	Cryptographical techniques		N/A
	In cases where class B control function or class C control function related operating data, configuration parameters and/or software modules were transmitted over a public network, and/or where software updates were provided by the manufacturer via remote communication, cryptographic techniques were employed.		N/A
H.20	Creepage distances, clearances and distances through insulation		P
H.20.1.15	Electronic controls		P

IEC 60730-1 (Software)			
Clause	Requirement + Test	Result - Remark	Verdict
H.20.1.15.1	Creepage distances, clearances and distances through insulation between live parts connected electrically to the mains supply and accessible surfaces or parts shall comply with the requirements of Clause 20.		P
H.20.1.15.2	Creepage distances, clearances and distances through insulation shall comply:		P
	– across protective impedance with the requirements of Clause 20 for double insulation or reinforced insulation;		P
	– across each separate component of protective impedance with the requirements of Clause 20 for supplementary insulation.		P
H.20.1.15.3	Creepage distances and clearances providing functional insulation shall comply with the requirements of Clause 20.		P
H.27.1.2	Protection against internal faults to ensure functional safety		P
H.27.1.2.1	Design and construction requirements		P
H.27.1.2.1.1	Fault avoidance and fault tolerance		P
	Controls incorporating control functions of class B or C are designed according to H.27.1.2 taking into account the failure modes of Cl. H.11.12 for software		P
	Systematic errors are avoided		P
	Random faults are dealt with by a proper system configuration		P
	Functional analysis of the application resulted in a structured design with:		P
	– Control flow		P
	– Data flow		P
	– Time related functions required by the application		P
	For custom-chips special attention was made to minimize systematic errors		P

IEC 60730-1 (Software)			
Clause	Requirement + Test	Result - Remark	Verdict
	System configuration was failsafe or:		P
	Incorporated components with direct safety-critical functions guarded by safeguards that cause a completely independent safety shut-down in accordance to H.11.12 software class B or C		P
	- safeguards are built into hardware and,		P
	- safeguards are supplemented by software		P
	Time slot monitoring is sensitive to both an upper and a lower limit of the time interval.		P
	Faults resulting in a shift of the upper and/or lower limit are taken into account.		P
	In a class C control function when a single fault in a primary safeguard can render the safeguard inoperative, a secondary safeguard is provided		N/A
	The reaction time of the secondary safeguard is in accordance with Clause H.27.1.2.3.		P
H.27.1.2.1.2	Documentation		P
	The documentation was based on H.11.12.3.2		P
	The functional analysis of the control and the safety related programs under its control are documented in a clear hierarchical way in accordance with the safety philosophy and the program requirements.		P
	Documentation provided for assessment included:		—
	• A description of the system philosophy, the control flow, data flow and timings.		P
	• A clear description of the safety philosophy of the system with all safeguards and safety functions clearly indicated. Sufficient design information is provided to enable the safety functions or safeguards to be assessed		P
	• Documentation for any software within the system		P
	Programming documentation is supplied in a programming design language declared by the manufacturer.....		P

IEC 60730-1 (Software)			
Clause	Requirement + Test	Result - Remark	Verdict
	Safety related data and safety related segments of the operating sequence are identified and classified according to H.11.12.3		P
	There is a clear relationship between the various parts of the documentation		P
H.27.1.2.2	Class B control function		P
H.27.1.2.2.1	Design and construction requirements		P
	Software complies with software class B		P
H.27.1.2.3	Class C control function		N/A
H.27.1.2.3.1	Design and construction requirements		N/A
	Software complies with software class C		N/A
H.27.1.2.5	Circuit and construction evaluation		P
H.27.1.2.5.3	Assessment		P
	Only the safety related software (software class B and C) as identified according to H.27.1.2.1.2 were subjected to further assessment		P

TABLE H.1 – MEASURES TO ADDRESS FAULT/ERRORS (Software Class B) Software of Master DSP			
Component	Fault/error	Declared measures	Verdict
1. CPU	-	-	-
1.1 Registers	Stuck at	**1. Functional test** The DSP will switch off the relays under the below conditions: Fault of ADC registers: the sample values exceed the limit. Fault of ePWM registers: PWM is in abnormal condition. The current exceeds the limit. **2. Comparison of redundant CPUs by reciprocal comparison** The DSP will switch off the relays under the below conditions: Fault of SPI registers: the communication between the master DSP and the slave DSP is abnormal. Fault of CAN registers: the communication between the master DSP and the LCD MCU is abnormal.	Pass
1.3 Program counter	Stuck at	**Periodic self-test**	Pass
2. Interrupt handling and execution	No interrupt	**Functional test** The DSP will switch off the relays under the below conditions: • Timer interrupt • PWM Zero-cross interrupt • PWM periodic interrupt • CAN interrupt	Pass

	Too frequent interrupt	**Functional test** The DSP will switch off the relays under the below conditions: • Timer interrupt • PWM Zero-cross interrupt • PWM periodic interrupt CAN interrupt	Pass
3. Clock	Wrong frequency (for quartz synchronized clock: harmonics/ sub-harmonics only)	**Functional test** The communication will be abnormal under the condition of clock. Then the DSP switches off the relays.	Pass
4. Memory	-	-	-
4.1 Invariable memory	All single bit faults	**Functional test** The program is stored in the flash. The communication will be abnormal under the condition of flash. Then the DSP switches off the relays.	Pass
4.2 Variable memory	DC fault	**Periodic self-test** for the RAM 0x122-0x3FF, periodically write 0xAAAA, then write 0x5555, and check the value wroten. 2s one cycle.	Pass
4.3. Addressing (relevant to variable and invariable memory)	Stuck at	**Comparison of redundant CPUs by reciprocal comparison**	Pass
5. Internal data path	-	-	-
5.1 Data	Stuck at	**Functional test** The program is stored in the flash. The communication will be abnormal under the condition of flash. Then the DSP switches off the relays.	Pass
5.2 Addressing	Wrong address	**Comparison of redundant CPUs by reciprocal comparison**	Pass

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6. External communication	-	-	-
6.1 Data	Hamming distance 3	**Functional test** CRC periodically	Pass
6.2 Addressing	Wrong address	**Functional test** CRC periodically	Pass
6.3 Timing	Wrong point in time	**Comparison of redundant CPUs by reciprocal comparison** The timing error will cause the fault of communication. The DSP will switch off the relays.	Pass
	Wrong sequence	**Comparison of redundant CPUs by reciprocal comparison** The timing error will cause the fault of communication. The DSP will switch off the relays.	Pass
7. Input/output periphery	-	-	-
7.1 Digital I/O	Fault conditions specified in Cl.H.27	**Functional test**	Pass
7.2 Analog I/O	-	-	-
7.2.1 A/D and D/A-convertor	Fault conditions specified in Cl. H.27	**Functional test** Periodically sampling the 1.5V power supply.	Pass
7.2.2 Analog multiplexer	Wrong addressing	Same as above	Pass
9. Custom chips e.g. ASIC, GAL, gate array	Any output outside the static and dynamic functional specification	N/A	N/A

TABLE H.1 – MEASURES TO ADDRESS FAULT/ERRORS (Software Class B)
Software of Slave DSP

Component	Fault / Error	Declared measures	Verdict
1. CPU	-	-	-

IEC 60730-1 (Software)			
1.1 Registers	Stuck at	**1. Functional test** The DSP will switch off the relays under the below conditions: Fault of ADC registers: the sample values exceed the limit. **2. Comparison of redundant CPUs by reciprocal comparison** The DSP will switch off the relays under the below conditions: Fault of SPI registers: the communication between the master DSP and the slave DSP is abnormal.	Pass
1.3 Program counter	Stuck at	**Comparison of redundant CPUs by reciprocal comparison**	Pass
2. Interrupt handling and execution	No interrupt	**Functional test** • PWM periodic interrupt **Comparison of redundant CPUs by reciprocal comparison** • SPI interrupt	Pass
	Too frequent interrupt	**Functional test** • PWM periodic interrupt **Comparison of redundant CPUs by reciprocal comparison** SPI interrupt	Pass
3. Clock	Wrong frequency (for quartz synchronized clock: harmonics/ sub-harmonics only)	**Functional test** The communication will be abnormal under the condition of clock.	Pass
4. Memory	-	-	-
4.1 Invariable memory	All single bit faults	**Functional test** The program is stored in the flash. The communication will be abnormal under the condition of flash. Then the DSP switches off the relays.	Pass

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4.2 Variable memory	DC fault	**Periodic self-test** for the RAM 0x122-0x3FF, periodically write 0xAAAA, then write 0x5555, and check the value wroten. 2s one cycle.	Pass
4.3. Addressing (relevant to variable and invariable memory)	Stuck at	**Comparison of redundant CPUs by reciprocal comparison**	Pass
5. Internal data path	-	-	s-
5.1 Data	Stuck at	**Functional test** The program is stored in the flash. The communication will be abnormal under the condition of flash. Then the DSP switches off the relays.	Pass
5.2 Addressing	Wrong address	**Comparison of redundant CPUs by reciprocal comparison**	Pass
6. External communication	-	-	-
6.1 Data	Hamming distance 3	**Functional test** CRC periodically	Pass
6.2 Addressing	Wrong address	**Functional test** CRC periodically	Pass
6.3 Timing	Wrong point in time	**Comparison of redundant CPUs by reciprocal comparison** The timing error will cause the fault of communication. The DSP will switch off the relays.	Pass
	Wrong sequence	**Comparison of redundant CPUs by reciprocal comparison** The timing error will cause the fault of communication. The DSP will switch off the relays.	Pass
7. Input/output periphery	-	-	-
7.1 Digital I/O	Fault conditions specified in Cl.H.27	**Functional test**	Pass

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7.2 Analog I/O	-	-	-
7.2.1 A/D and D/A-convertor	Fault conditions specified in Cl. H.27	**Comparison of redundant CPUs by reciprocal comparison**	Pass
7.2.2 Analog multiplexer	Wrong addressing	**Comparison of redundant CPUs by reciprocal comparison**	Pass
9. Custom chips e.g. ASIC, GAL, gate array	Any output outside the static and dynamic functional specification	N/A	N/A

- End of Test Report -