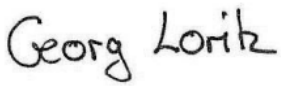
TEST REPORT

CEI 0-21

Reference technical rules for the connection of active and passive users to the LV networks of electrical distribution companies

Report reference number ..... :	**13TH0057-CEI0-21_3**
Date of issue ..... ::	2016-09-27
Total number of pages ..... ::	67
Testing laboratory name ..... :	**Bureau Veritas Consumer Products Services Germany GmbH**
Address ..... :	Businesspark A96 86842 Türkheim Germany
Applicant's name ..... :	**Bender GmbH & Co. KG**
Address ..... :	Londorfer Str. 65, 35305 Grünberg, Germany
Test specification	
Standard..... :	CEI 0-21:2012-06 CEI 0-21:V1:2012-12 edizione Dicembre 2012 CEI 0-21:V2:2013-12 edizione Dicembre 2013 CEI 0-21:2014-09 CEI 0-21:V1:2014-12 edizione Dicembre 2014
Certificate..... :	**Certificate of compliance**
Test report form number. ..... :	CEI0-21
Master TRF ..... :	Bureau Veritas Consumer Products Services Germany GmbH
Test item description ..... :	**Network and system protection (NS-protection) unit**
Trademark..... :	
Model / Type ..... :	VMD460
Ratings ..... :	**VMD460**
Supply voltage range [V] ..... :	AC / DC 75…300
Supply frequency range [Hz]..... :	0 / 40…70
Monitoring voltage range [V] ..... :	0…300 (L-N) / 0…520 (L-L)
Monitoring frequency range [Hz]..... :	45…65
Description ..... :	Three-Phase voltage and frequency monitor for wind power stations, hydroelectric power plants and photovoltaic systems

Testing Location .....:	**Bureau Veritas Consumer Products Services Germany GmbH**
Address .....:	Businesspark A96, 86842 Türkheim, Germany
Tested by (name and signature) .....:	Domenik Koll 
Approved by (name and signature) .....:	Georg Loritz 
Manufacturer's name .....:	**Bender GmbH & Co. KG**
Factory address .....:	Londorfer Str. 65, 35305 Grünberg, Germany

Document History

Date	Internal reference	Modification / Change / Status	Revision
2013-04-04	Ingo Röhr	Initial report was written	0
2013-07-24	Ingo Röhr	Software version updated for Messtechnik from D398 V1.04 to D398 V1.13 and for Display from D403 V2.26 to D403 V2.26. The update includes only minor changes that have no effect on the performed tests.	1
2014-05-28	Ingo Röhr	Software version update D398 V1.13 to D398 V1.21 - Vector jump detection included - G59/2, G83/2 and DIN V VDE V 0126-1-1 included - Parameter to set delayed contact monitoring for motors conductors - Set values for df/dt (ROCOF) limits from 0,1Hz/s to 0,05Hz/s changed The update includes only minor changes and affects only other country settings. There is no effect on the performed CEI 0-21 tests.	2
2016-09-27	Domenik Koll	Update to CEI 0-21 Revision 2014	3

Supplementary information:

Test items particulars	
Equipment mobility..... :	Permanent connection
Operating condition..... :	Continuous
Class of equipment ..... :	Class I
Protection against ingress of water.. :	IP20/30 according to EN 60529
Mass of equipment [kg]..... :	360 g

Test case verdicts

Test case does not apply to the test object..... :	N/A
Test item does meet the requirement..... :	P(ass)
Test item does not meet the requirement..... :	F(ail)

Testing

Date of receipt of test item ..... :	2013-03-04
Date(s) of performance of test ..... :	2013-03-12 to 2013-03-27

General remarks:

The test result presented in this report relate only to the object(s) tested.
This report must not be reproduced in part or in full without the written approval of the issuing testing laboratory.

”(see Annex #)" refers to additional information 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.

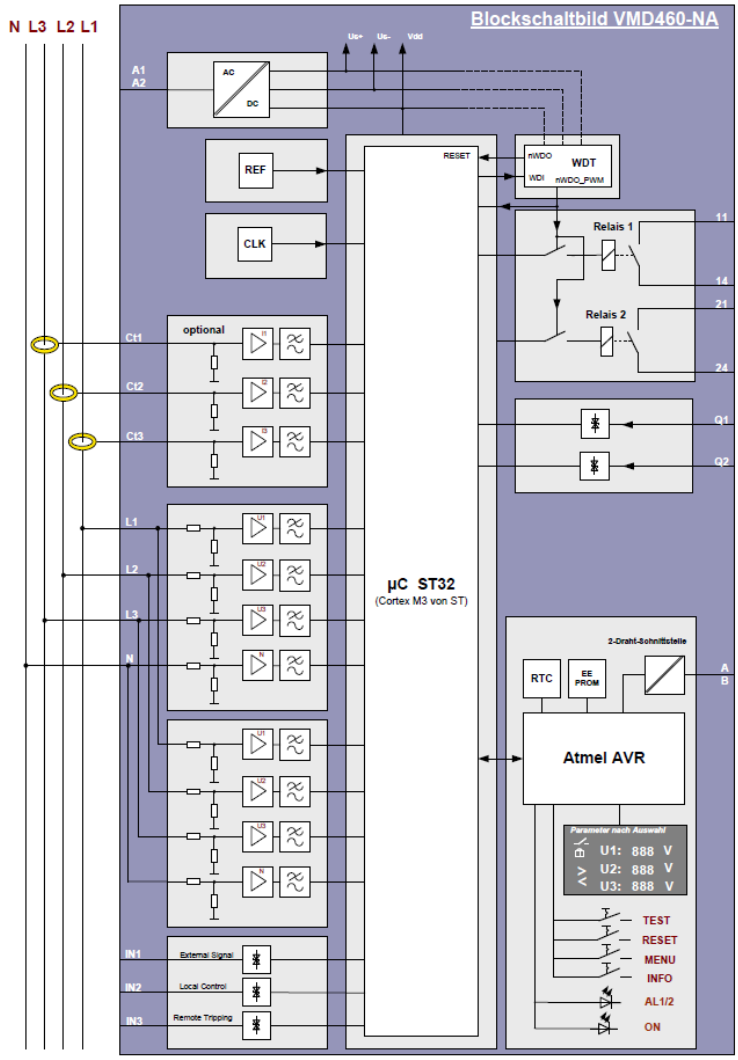
This Test Report consists of the following documents:

1. Test Results
2. Annex No. 1 – ISO 9001 certificate
3. Annex No. 2 – EMC Test Report
4. Annex No. 3 – Pictures of the unit
5. Annex No. 4 – Test equipment list

Copy of marking plate

General product information:

The purpose of the SPI is to disconnect a system of solar inverters from the grid. This occurs, if any kind of frequency or voltage rise/fall exceeding the limits of the SPI.



The product was tested on
software version:
Display: D 403, V2.26
Messtechnik : D398, V1.21
Watchdog: D397, V1.03

TOPOLOGY OF THE DEVICE, WHICH THIS CERTIFICATE IS BASED ON

Disconnection Device	Interface Protection Device	Device For Static Conversion	Rotating Generator Device
	X		

CEI 0-21 (2012-06)		
Clause	**Test**	**Result**
A.3.1-3.4	Adjustable ranges of the interface protection system	**P**
A.4.3	Functional tests on the interface protection system (SPI)	**P**
A.4.4	Self-test	**P**
A.4.5	EMC compatibility tests	**P**
A.4.6	Climatic compatibility tests	**P**
A.4.7	Insulation tests	**P**
A.4.8	Tests for the overload capacity of measuring circuits	**P**
A.4.9	Compliance of equipment	**P**
A.4.10	Automatic mechanism to prevent current imbalance during production	**N/A**

A3.1-3.4								**P**
Adjustable ranges								
A.3	All thresholds must be adjustable							**P**
Voltage values								
Threshold	85% (27.S1)	tmin (27.S1)	40% (27.S2)	tmin (27.S2)	110% (59.S1)	tmax (59.S1)	115% (59.S2)	tmax (59.S1)
Range	0,2-1,0 U_n	0,05-5s	0,0-1,0 U_n	0,05-5s	1,0-1,2 U_n	0,2-10s	1,0-1,3 U_n	0,2-10s
Steps	0,05 U_n	0,05s	0,05 U_n	0,05s	0,01 U_n	0,1s	0,01 U_n	0,05s
Frequency values								
Threshold	49,50Hz (81<.S1)	tmin (81<.S1)	47,50Hz (81<.S2)	tmin (81<.S2)	50,50Hz (81>.S1)	tmax (81>.S1)	51,50Hz (81>.S2)	tmax (81>.S2)
Range	47,0-50,0Hz	0,05-5s	47,0-50,0Hz	0,05-5s	50,0-52,0Hz	0,05-5s	50,0-52,0Hz	0,05-5s
Steps	0,1 Hz	0,05s	0,1 Hz	0,05s	0,1 Hz	0,05s	0,1 Hz	0,05s
A.1	External SPI stays in operation conditions for 5s after disconnecting the mains voltage							P
A.3.3/3.4	Insensitive against 40ms frequency transients, so that the unit will not trip							P
A.4.4	Control of the Self-test function							P

Note:

The external SPI need a separate USV-system for the 5s mains disconnection. A relevant note is placed in the user manual in chapter 2.1.

A.4.3 Functional tests on the interface protection system (SPI) CEI 0-21 (2012-06)		
Clause	**Test**	**Result**
A3.1-3.4	Checking the adjustable values and the describtion in the user manual	**P**
A.4.3.1	Checking of connection and reconnection conditions	**P**
A.4.3.2	Checking gradual supply of active power	**P**
A.4.3.3	Additional requirements for functional tests	**P**
	A.4.3.3.1 Insensitivity to harmonics of the frequency relay	**P**
	A.4.3.3.2 Remote trip signal	**P**
	A.4.3.3.3 Communication signal	**P**

A.4.3 Functional tests on the interface protection system (SPI)	P

Purpose of testing:

The tests for checking the functions and the measurement of accuracy are listed below:

a) checking all functions;

b) measuring the accuracy of tripping thresholds;

c) measuring the accuracy of trip times;

d) measuring the accuracy of the falling ratio (not required for an interface protection system (SPI) integrated into the inverter up to a maximum of 6 kW);

e) Measuring accuracy of the falling time (not required for an interface protection system (SPI) integrated into the inverter up to a maximum of 6 kW).

A.4.3.1 and A4.3.2 Test procedure for maximum/minimum frequency						**P**
Operating time of the monitoring device						
	Under frequency:			**Over frequency:**		
A) STEPS for trip value [Hz to Hz]:	1,01 threshold -> decrease by max 10mHz steps			0,99 threshold -> increase by max 10mHz steps		
D) STEP trip time [Hz to Hz]:	1,01 threshold -> 0,99 threshold			0,99 threshold -> 1,01 threshold		
	Ambient temperature					
Limit [Hz]:	47,50 Hz			51,50 Hz		
Measurement accuracy of the tripping value [Hz]:	47,50 Hz	47,50 Hz	47,50 Hz	51,51 Hz	51,51 Hz	51,51 Hz
	100 ms			100 ms		
Measurement the trip time [ms]:	98 ms	98 ms	98 ms	105 ms	105 ms	105 ms
	-10°C temperature					
Limit [Hz]:	47,50 Hz			51,50 Hz		
Measurement accuracy of the tripping value [Hz]:	47,50 Hz	47,50 Hz	47,50 Hz	51,51 Hz	51,51 Hz	51,51 Hz
	100 ms			100 ms		
Measurement the trip time [ms]:	98 ms	98 ms	100 ms	105 ms	106 ms	106 ms
	+55°C temperature					
Limit [ms]:	47,50 Hz			51,50 Hz		
Measurement accuracy of the tripping value [Hz]:	47,50 Hz	47,50 Hz	47,50 Hz	51,51 Hz	51,51 Hz	51,51 Hz
	100 ms			100 ms		
Measurement the trip time [ms]:	87 ms	87 ms	87 ms	105 ms	104 ms	106 ms

Test:
To measure the disconnection time a step of 1%f_n is taken from the nominal frequency for underfrequency and overfrequency.

Assessment criterion:

For frequencies of between 47,5 Hz and 51,5 Hz (±0,1% f_n) automatic disconnection from the network as a result of a deviation in frequency is not permitted.

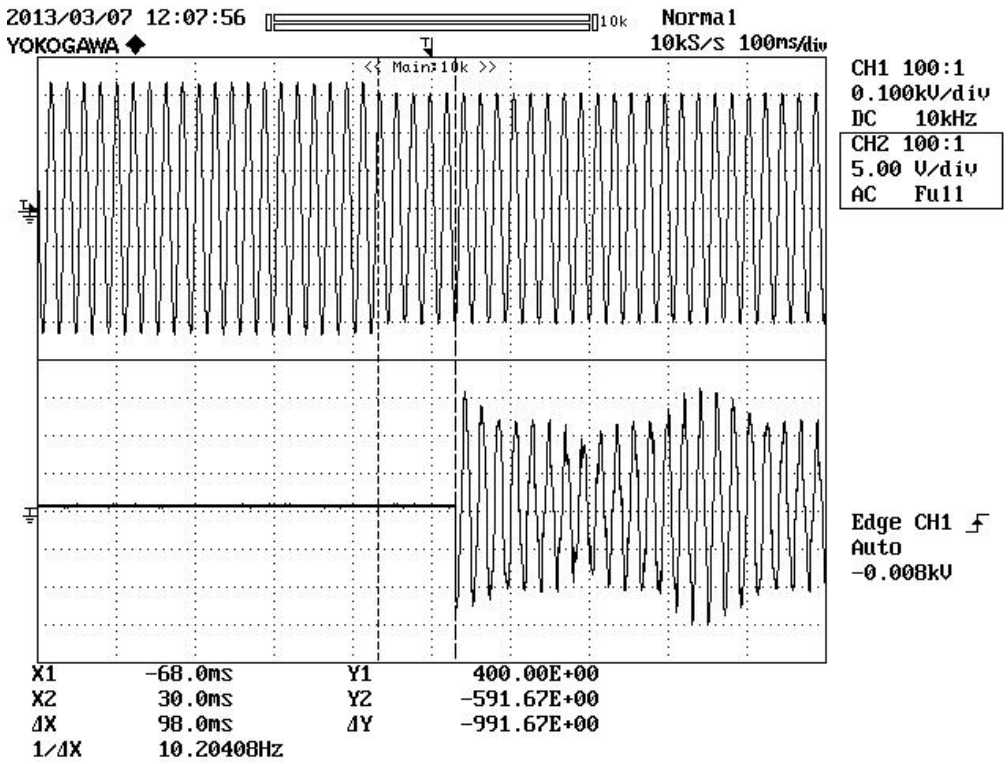
Limit values:

Frequency decrease protection	f<	47,5 Hz	100 ms
Frequency increase protection	f<	51,5 Hz	100 ms

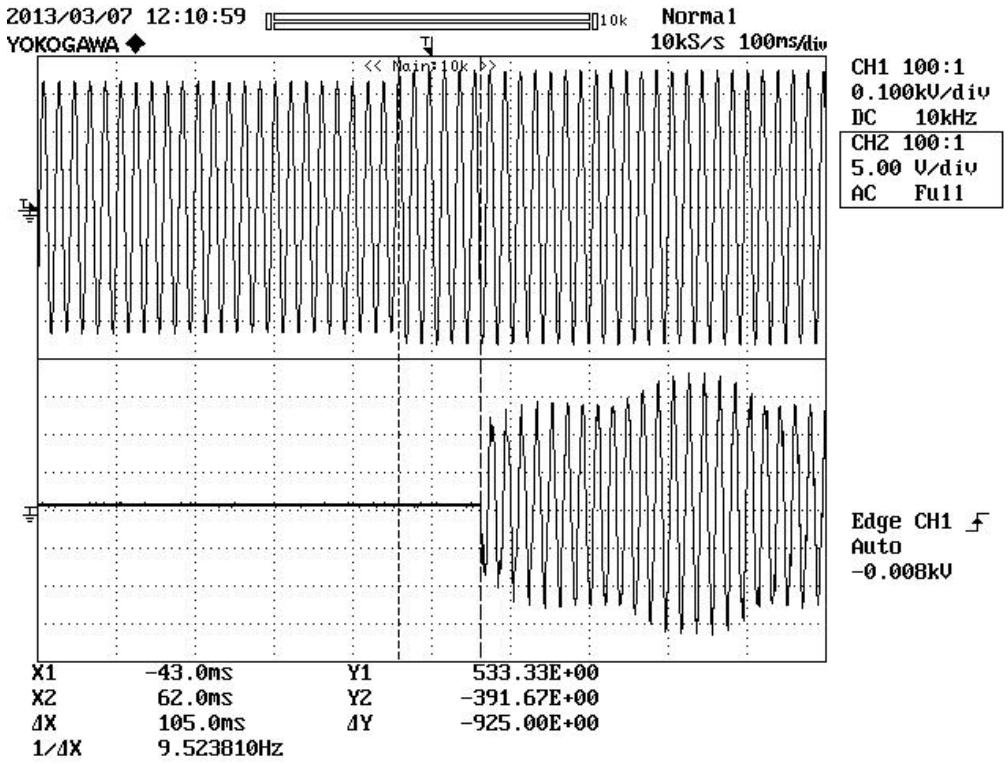
For each repetition of the tests, the max tolerances of the values are:
Voltage: 2%
Frequency: ±20mHz
Trip times: 1%±20ms

Note:
The setting value and the trip value of the frequency may not vary by more than **±20mHz** and **3%±20ms**.
Differences between the test values: **±20mHz** and **1%±20ms.**

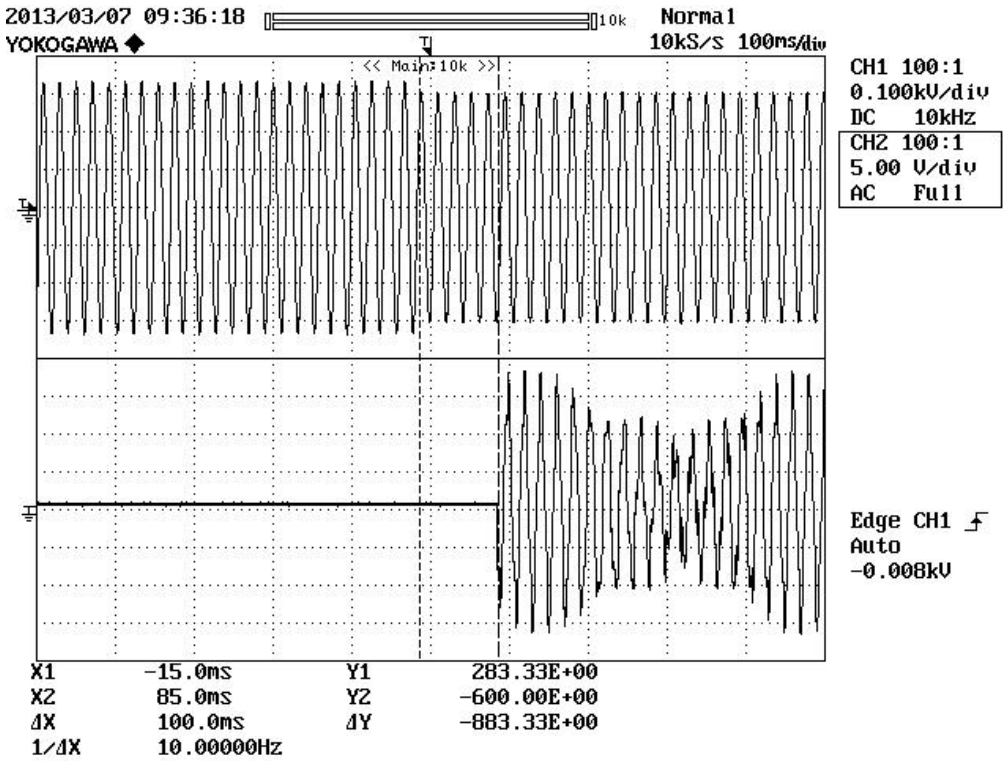
Under frequency (ambient)



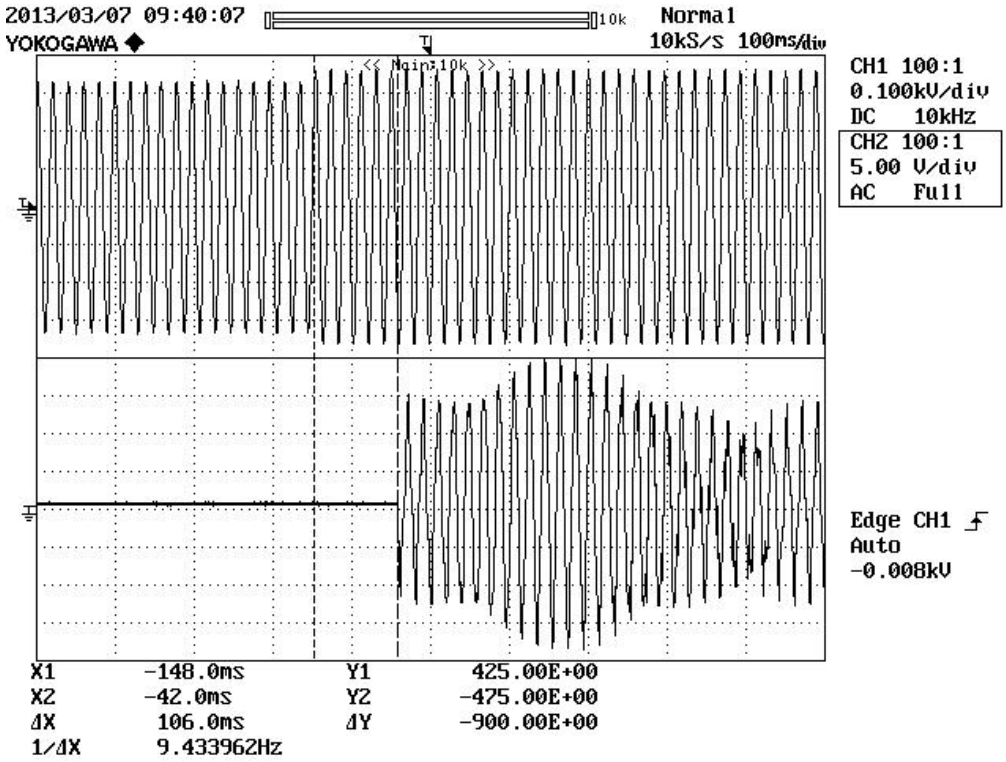
Over frequency (ambient)



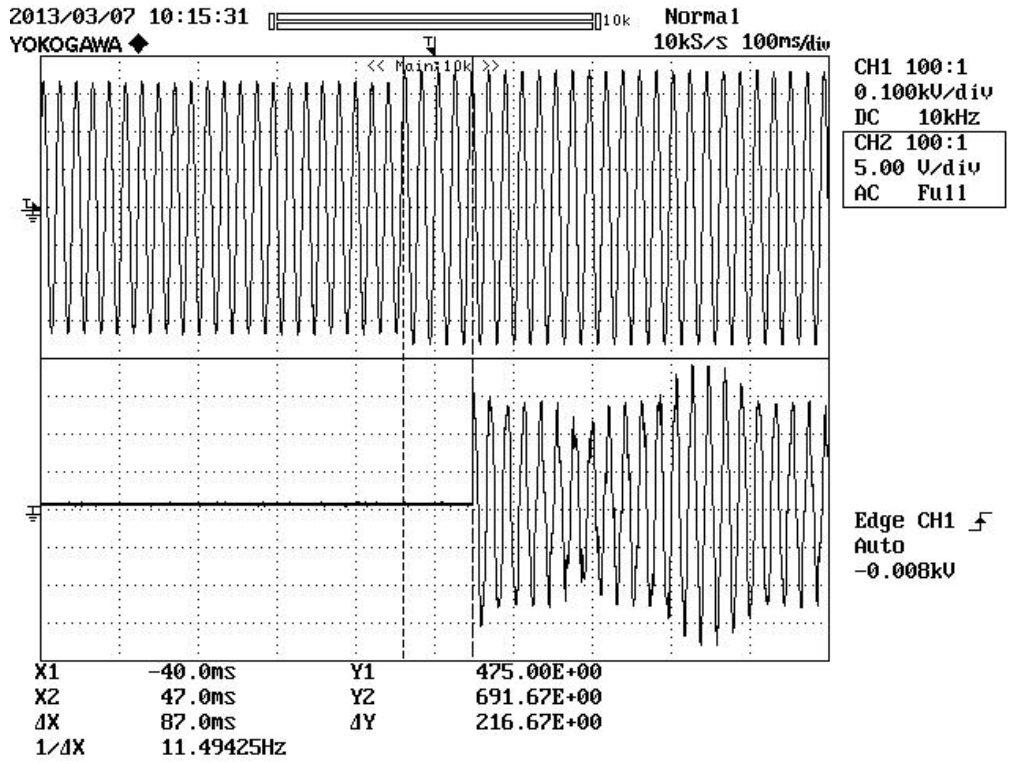
Under frequency (-10°C)



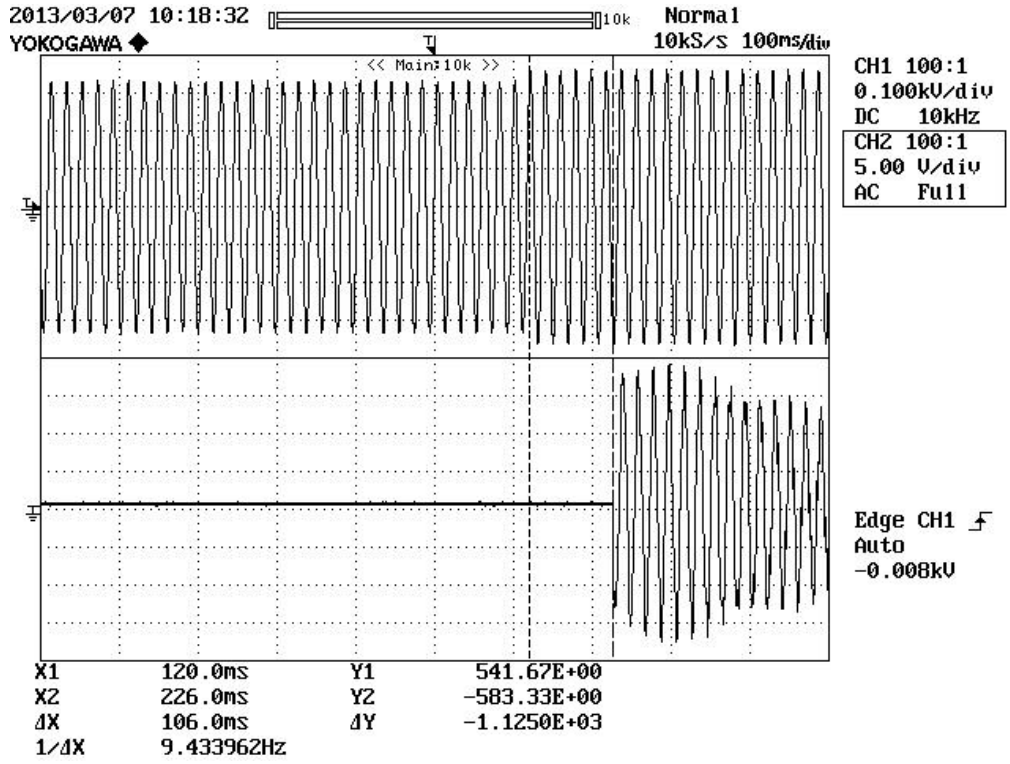
Over frequency (-10°C)



Under frequency (55°C)



Over frequency (55°C)



A.4.3.1 and A4.3.2 Test procedure for maximum/minimum frequency							P
Operating time of the monitoring device							
	Under frequency:			**Over frequency:**			
A) STEPS for trip value [Hz to Hz]:	1,01 threshold -> decrease by max 10mHz steps			0,99 threshold -> increase by max 10mHz steps			
D) STEP trip time [Hz to Hz]:	1,01 threshold -> 0,99 threshold			0,99 threshold -> 1,01 threshold			
	Ambient temperature						
Limit [Hz]:	49,50 Hz			50,50 Hz			
Measurement accuracy of the tripping value [Hz]:	49,50 Hz	49,50 Hz	49,50 Hz	50,51 Hz	50,51 Hz	50,51 Hz	
	100 ms			100 ms			
Measurement the trip time [ms]:	99ms	98 ms	98 ms	97 ms	97 ms	95 ms	
	-10°C temperature						
Limit [Hz]:	49,50 Hz			50,50 Hz			
Measurement accuracy of the tripping value [Hz]:	49,51 Hz	49,51 Hz	49,51 Hz	50,51 Hz	50,51 Hz	50,51 Hz	
	100 ms			100 ms			
Measurement the trip time [ms]:	97 ms	96 ms	99 ms	96 ms	96 ms	97 ms	
	+55°C temperature						
Limit [ms]:	49,50 Hz			50,50 Hz			
Measurement accuracy of the tripping value [Hz]:	49,50 Hz	49,50 Hz	49,50 Hz	50,51 Hz	50,51 Hz	50,51 Hz	
	100 ms			100 ms			
Measurement the trip time [ms]:	97 ms	97 ms	96 ms	96 ms	98 ms	97 ms	

Test:
To measure the disconnection time a step of 1%f_n is taken from the nominal frequency for underfrequency and overfrequency.

Assessment criterion:

For frequencies of between 49,5 Hz and 50,5 Hz (±0,1% f_n) automatic disconnection from the network as a result of a deviation in frequency is not permitted.

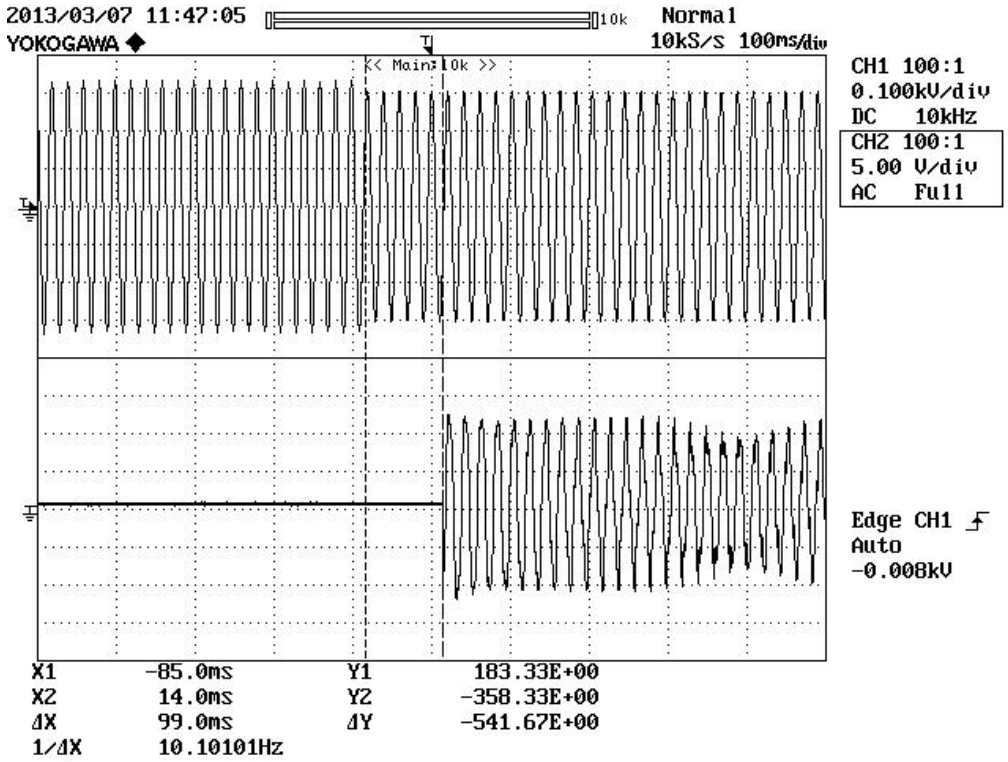
Limit values:

Frequency decrease protection	f<	49,5 Hz	100 ms
Frequency increase protection	f<	50,5 Hz	100 ms

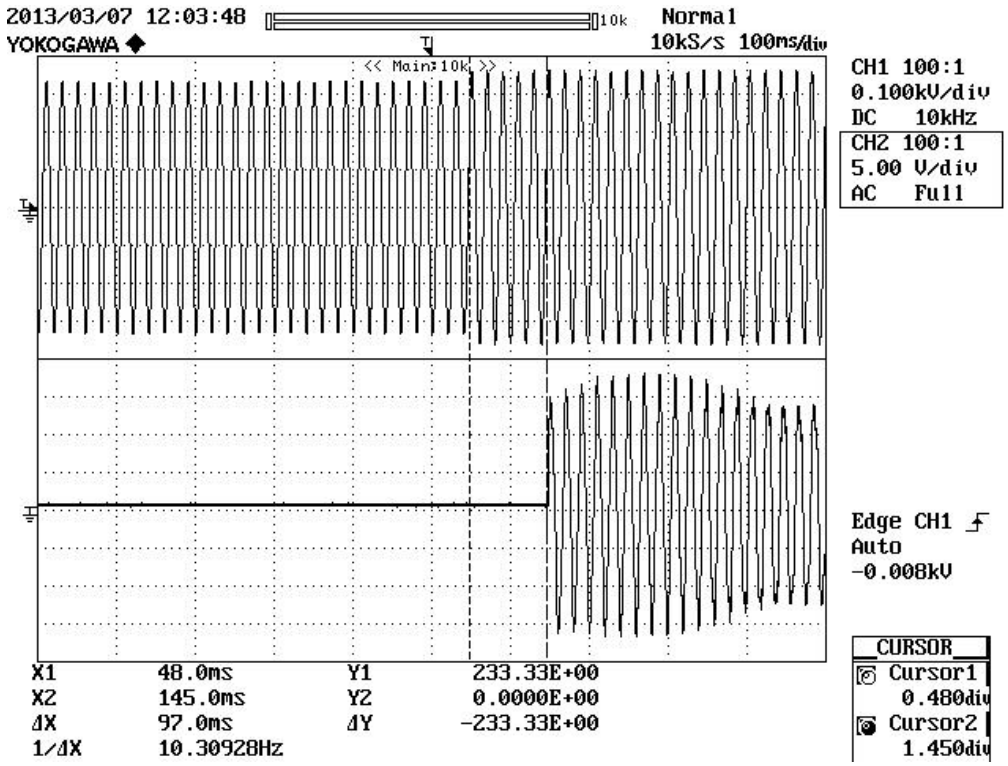
For each repetition of the tests, the max tolerances of the values are:
Voltage: 2%
Frequency: ±20mHz
Trip times: 1%±20ms

Note:
The setting value and the trip value of the frequency may not vary by more than **±20mHz** and **3%±20ms**.
Differences between the test values: **±20mHz** and **1%±20ms.**

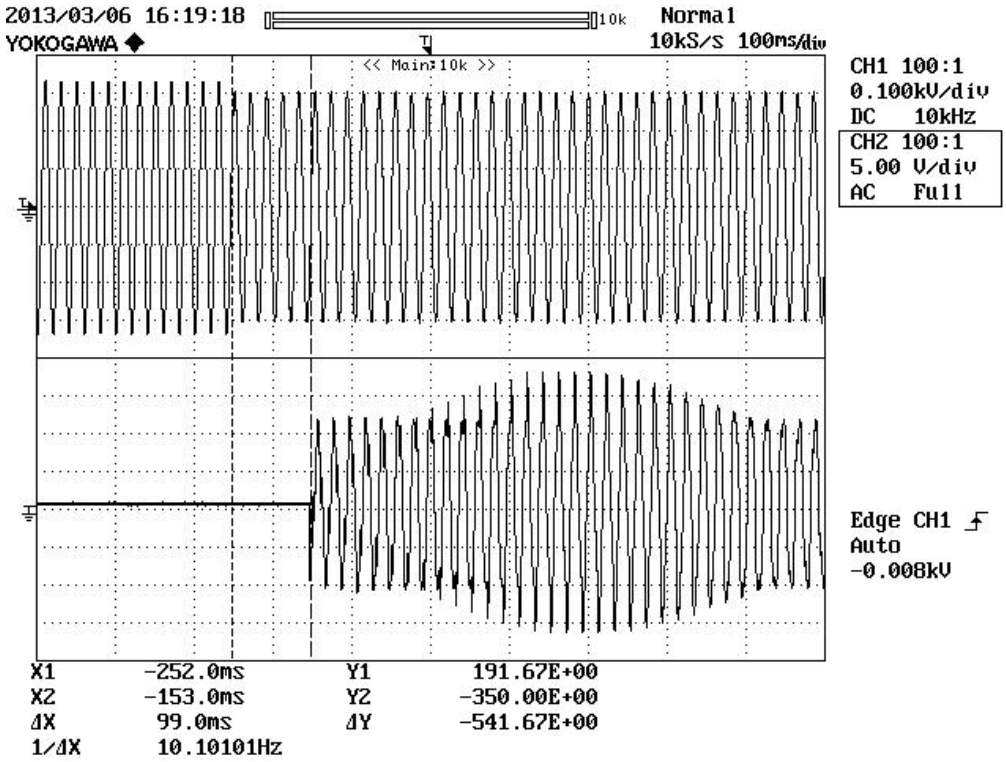
Under frequency (ambient)



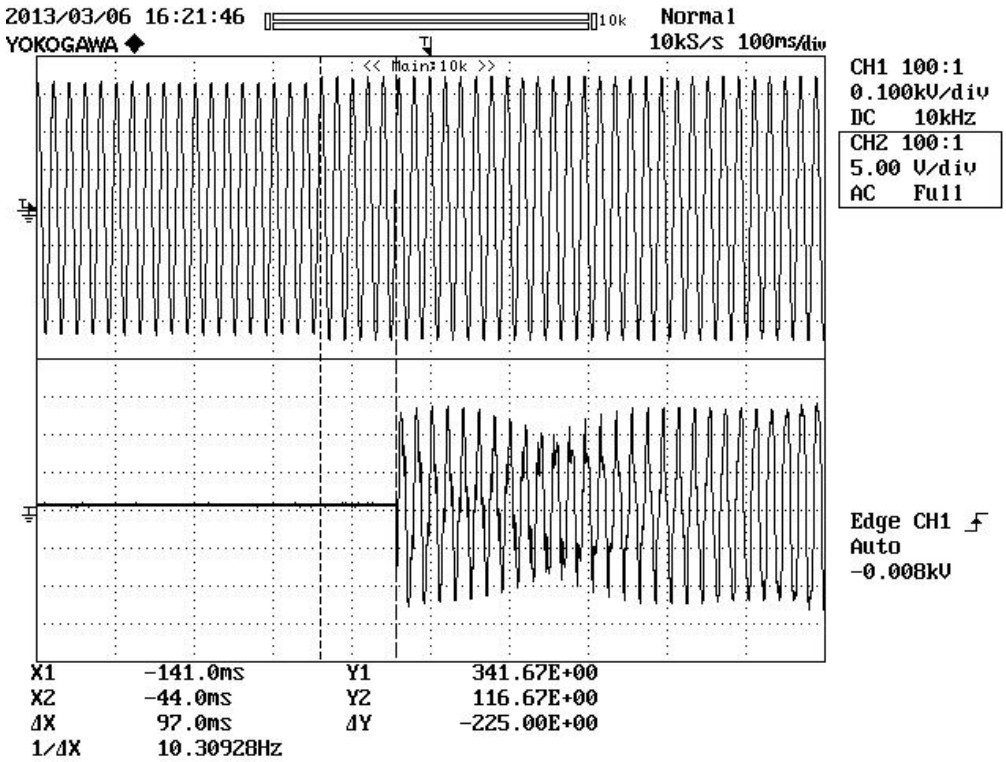
Over frequency (ambient)



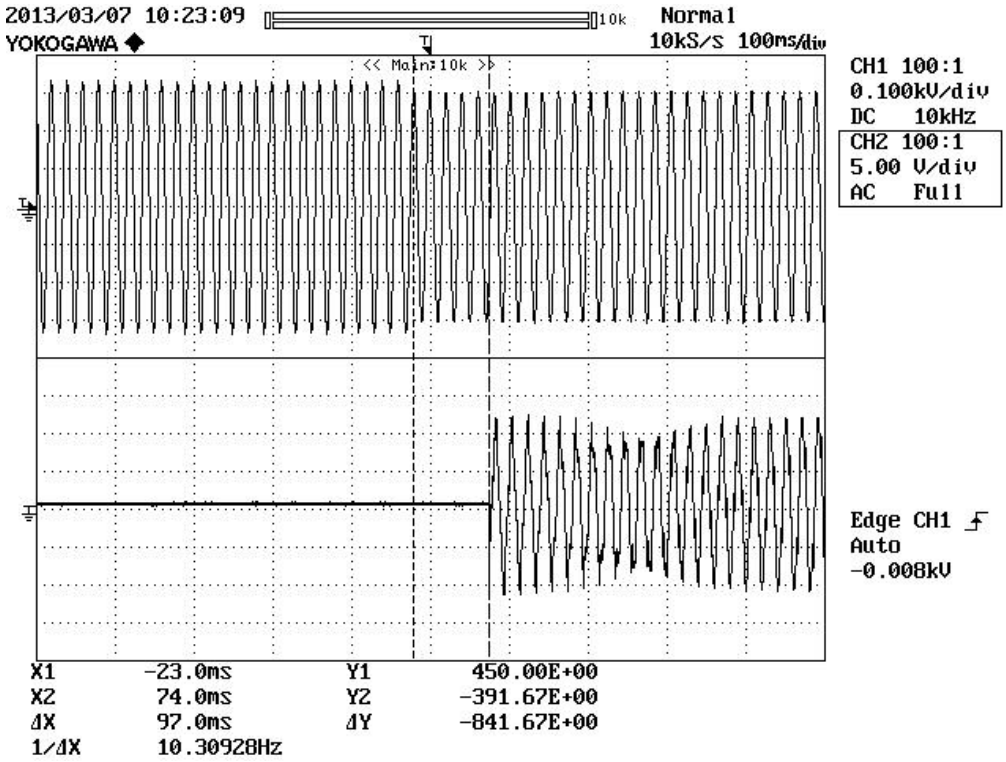
Under frequency (-10°C)



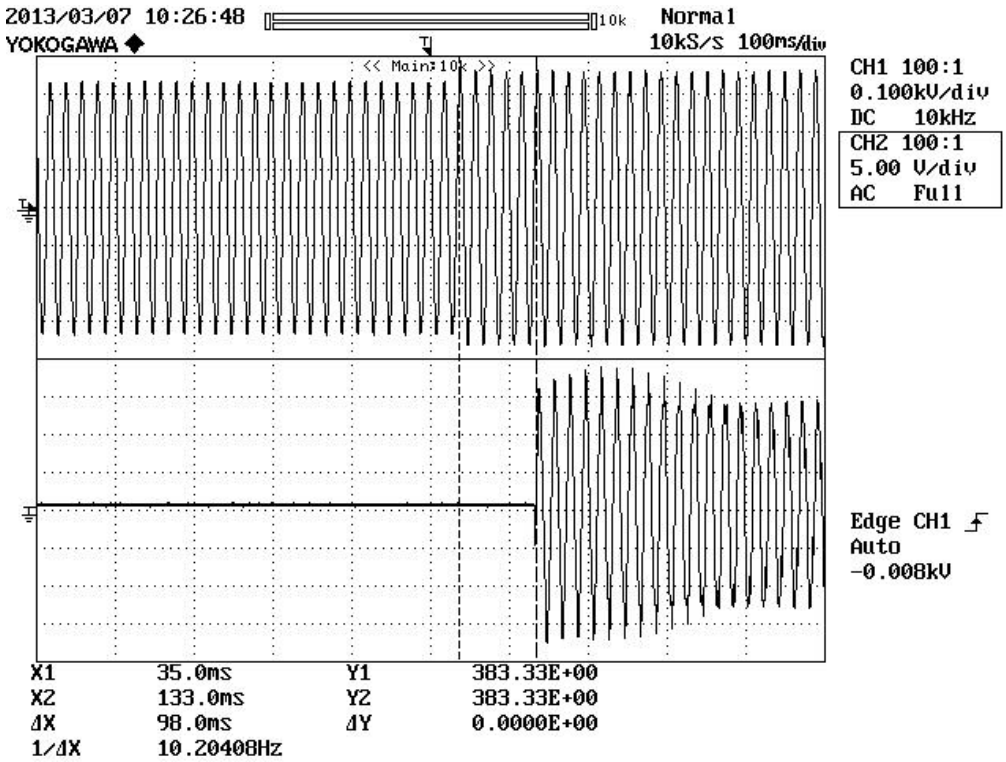
Over frequency (-10°C)



Under frequency (55°C)



Over frequency (55°C)



A.4.3.1 and A4.3.2 Test procedure for maximum/minimum voltage							P
Operating time of the monitoring device							
	Under voltage:			**Over voltage:**			
A) STEPS for trip value [V to V]:	1,1 threshold -> decrease by max 5V steps			0,9 threshold -> increase by max 5V steps			
D) STEP for trip time [V to V]:	1,1 threshold -> 0,9 threshold			0,9 threshold -> 1,01 threshold			
	Ambient temperature						
Limit [V]:	195,5 V (27.S1)			264,5 V (59.S2)			
Measurement accuracy of the tripping value [V]:	195,8 V	195,8 V	195,8 V	264,3 V	264,3 V	264,3 V	
	400 ms			200 ms			
Measurement the trip time [ms]:	413 ms	414 ms	417 ms	186 ms	188 ms	189 ms	
	-10°C temperature						
Limit [V]:	195,5 V (27.S1)			264,5 V (59.S2)			
Measurement accuracy of the tripping value [V]:	195,7 V	195,7 V	195,7 V	263,8 V	263,8 V	263,8 V	
	400 ms			200 ms			
Measurement the trip time [ms]:	412 ms	411 ms	411 ms	193 ms	193 ms	193 ms	
	+55°C temperature						
Limit [V]:	195,5 V (27.S1)			264,5 V (59.S2)			
Measurement accuracy of the tripping value [V]:	195,8 V	195,8 V	195,8 V	264,3 V	264,3 V	264,3 V	
	400 ms			200 ms			
Measurement the trip time [ms]:	412 ms	414 ms	418 ms	192 ms	193 ms	194 ms	

Test:
To measure the disconnection time a step of 84%U_n is taken from the nominal voltage and of 116%U_n from the nominal voltage for undervoltage and overvoltage.
The voltages should be measured per phase conductor, in which current is fed between the line conductor and the neutral conductor.

Assessment criterion:
Limit values:

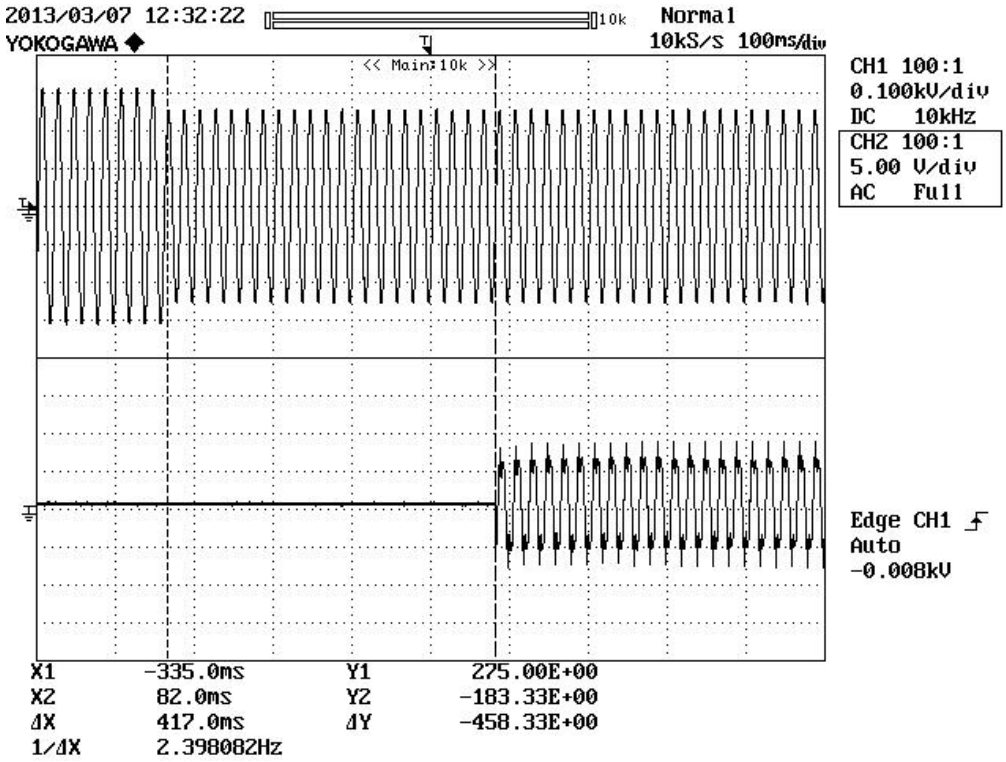
Voltage drop protection	59.S2	0.85 U_n	400 ms
Rise-in voltage protection	27.S1	1.15 U_n	200 ms

The setting value and the trip value of the frequency may not vary by more than **≤5%V_n** and **3%±20ms**.

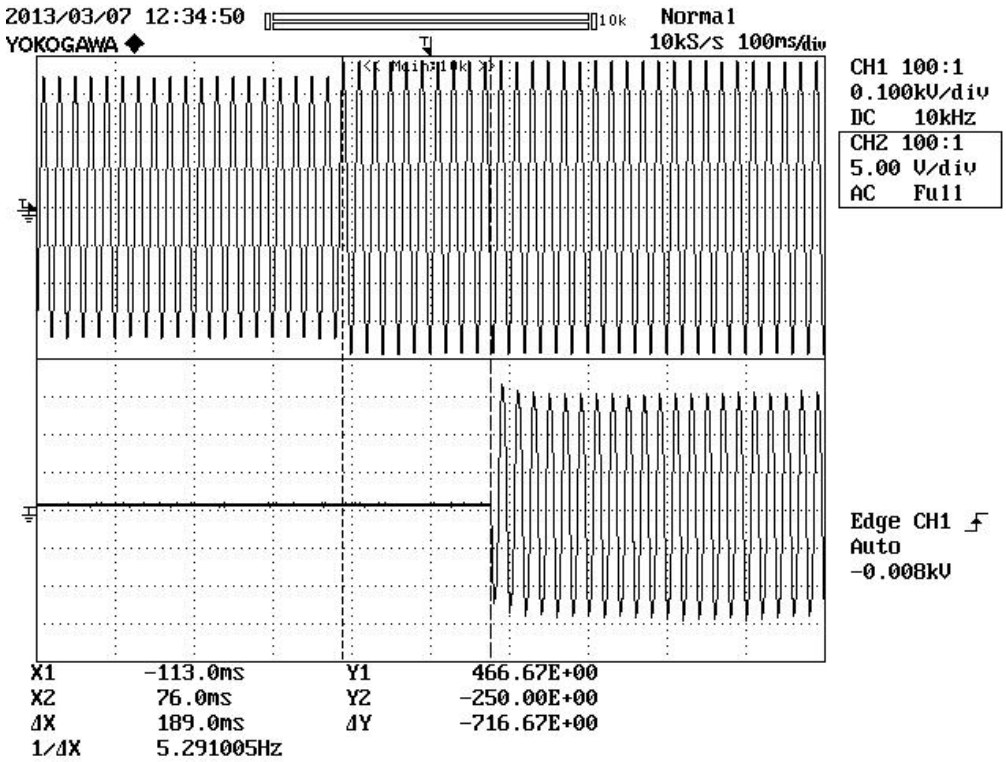
For each repetition of the tests, the max tolerances of the values are:
Voltage: 2%
Frequency: ±20mHz
Trip times: 1%±20ms

Note:

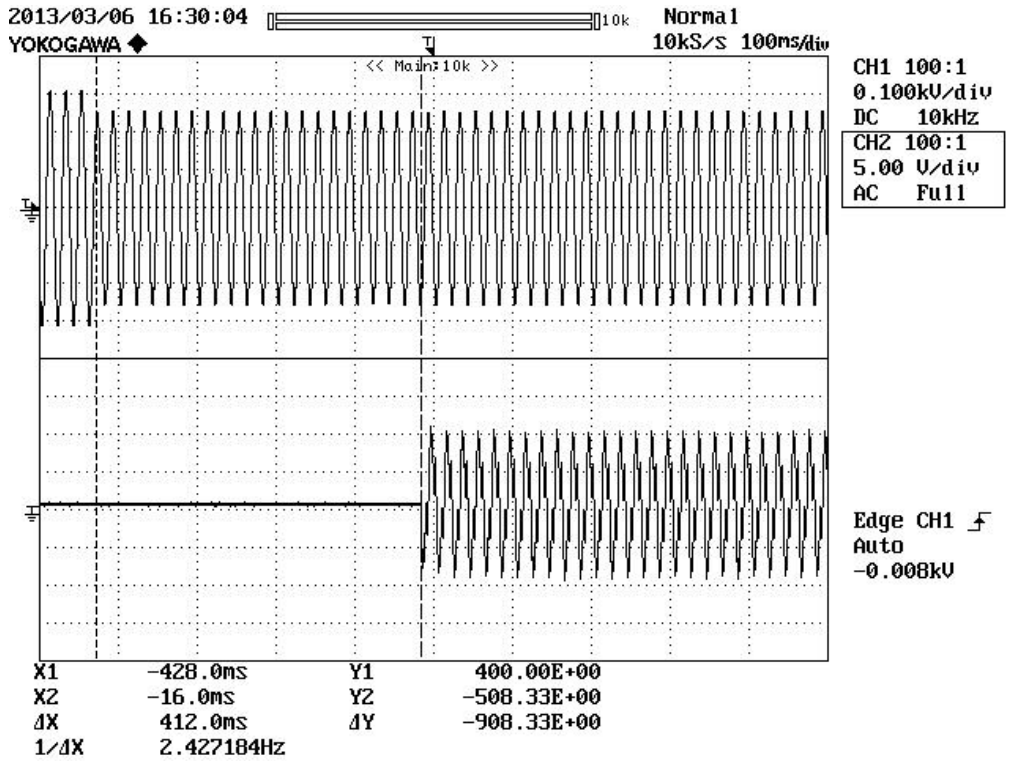
Under voltage (ambient)



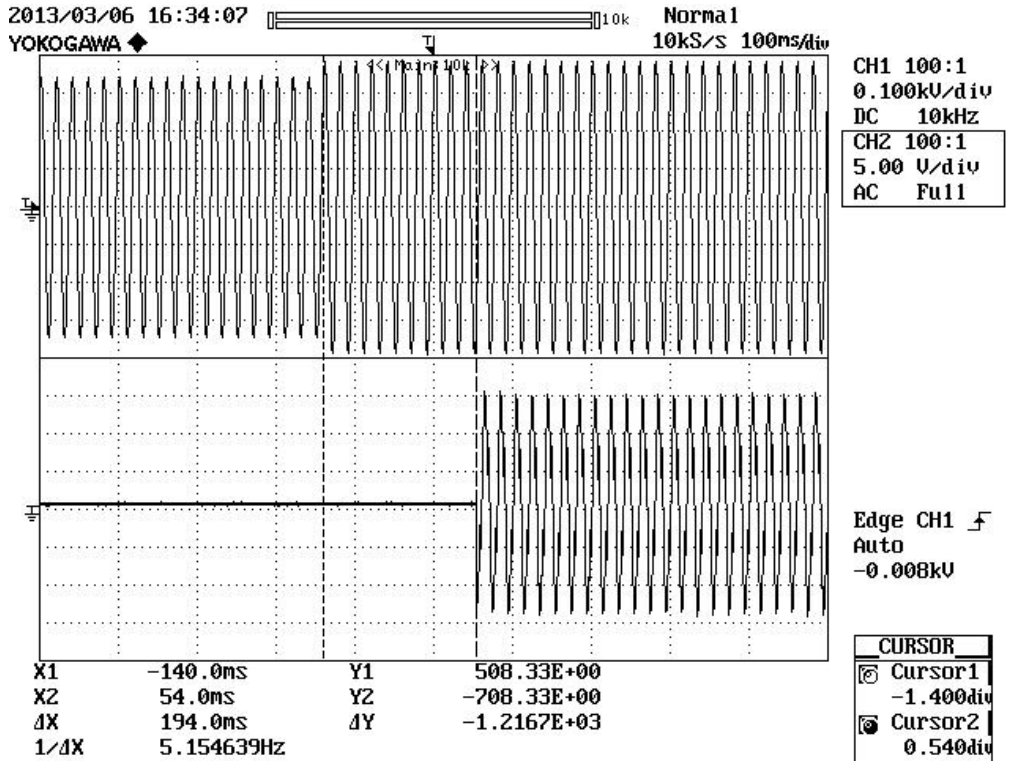
Over voltage (ambient)



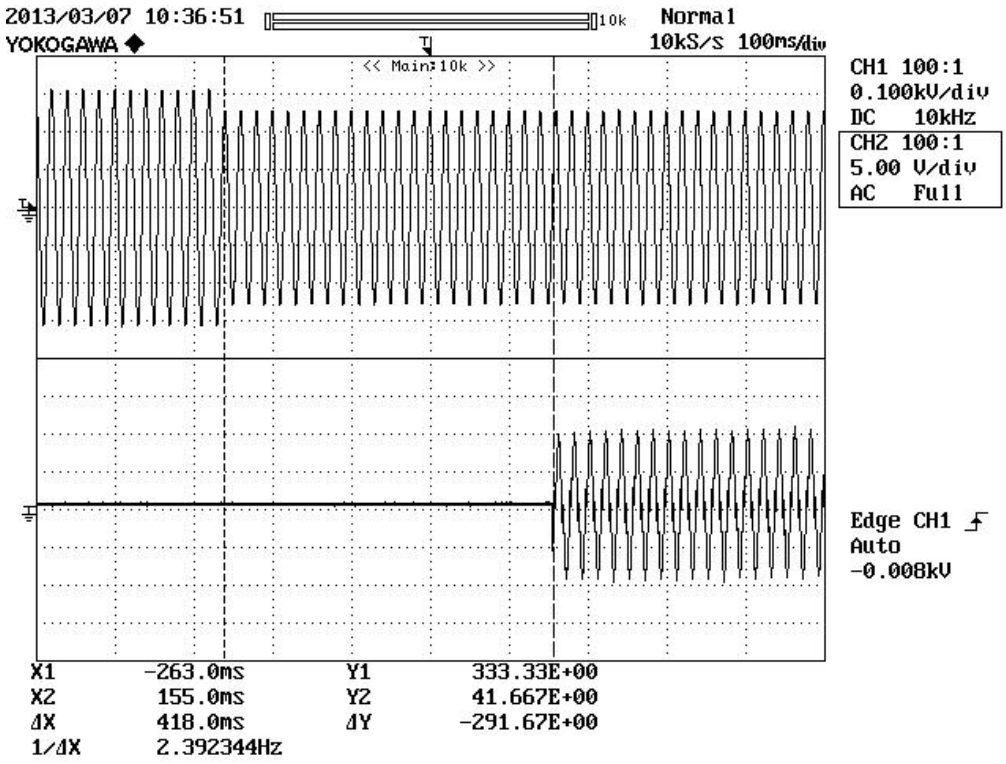
Under voltage (-10°C)



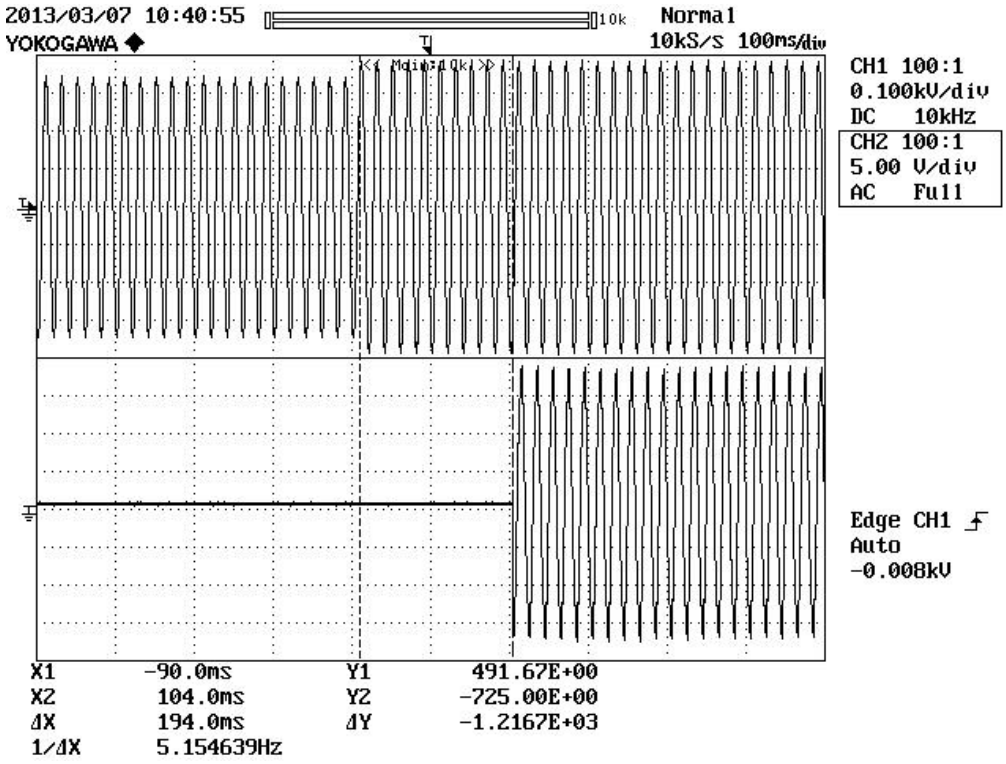
Over voltage (-10°C)



Under voltage (55°C)



Over voltage (55°C)



A.4.3.1 and A4.3.2 Test procedure for maximum/minimum voltage			**P**
Operating time of the monitoring device			
	Under voltage:		
A) STEPS for trip value [V to V]:	1,1 threshold -> decrease by max 5V steps		
D) STEP for trip time [V to V]:	U_n -> 0,4 U_n		
	Ambient temperature		
Limit [V]:	92 V (27.S2)		
Measurement accuracy of the tripping value [V]:	92 V	92 V	92 V
	200 ms		
Measurement the trip time [ms]:	186 ms	187 ms	187 ms
	-10°C temperature		
Limit [V]:	92 V (27.S2)		
Measurement accuracy of the tripping value [V]:	92 V	92 V	92 V
	200 ms		
Measurement the trip time [ms]:	186 ms	187 ms	184 ms
	+55°C temperature		
Limit [V]:	92 V (27.S2)		
Measurement accuracy of the tripping value [V]:	92 V	92 V	92 V
	200 ms		
Measurement the trip time [ms]:	184 ms	184 ms	184 ms

Test:
To measure the disconnection time a step of 84%U_n is taken from the nominal voltage and of 116%U_n from the nominal voltage for undervoltage and overvoltage.
The voltages should be measured per phase conductor, in which current is fed between the line conductor and the neutral conductor.

Assessment criterion:
Limit values:

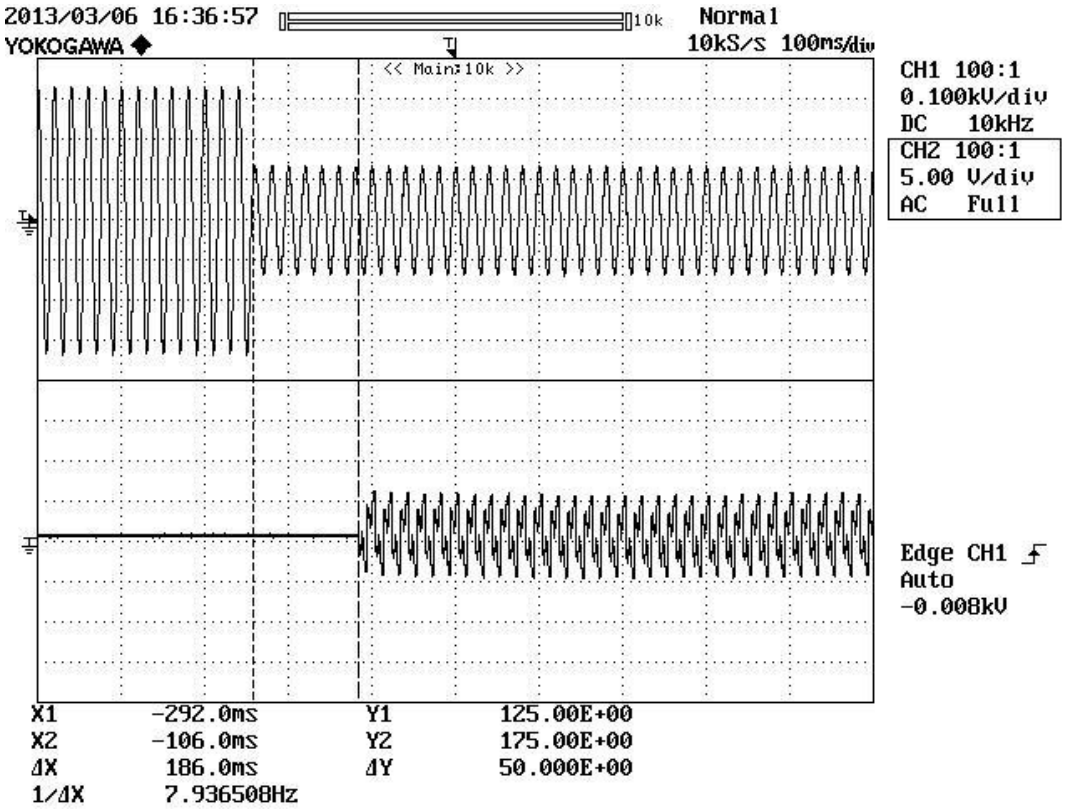
Voltage drop protection	59.S2	0.85 U_n	400 ms
Rise-in voltage protection	27.S1	1.15 U_n	200 ms

The setting value and the trip value of the frequency may not vary by more than **≤5%V_n** and **3%±20ms**.

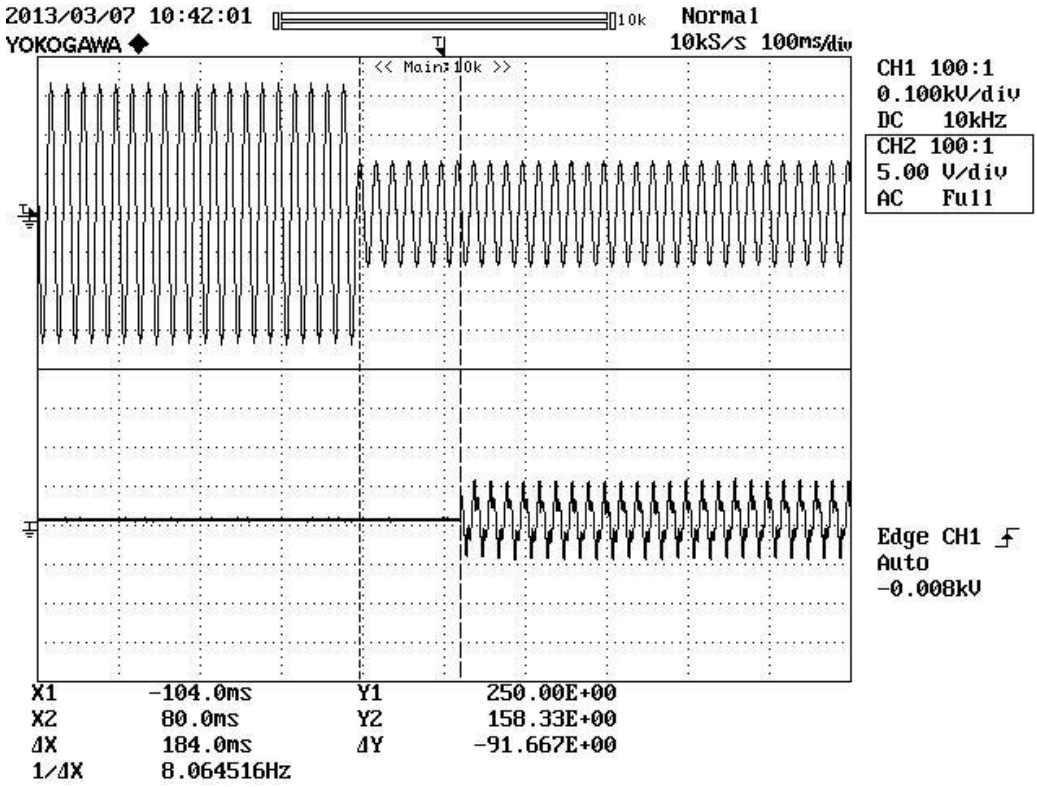
For each repetition of the tests, the max tolerances of the values are:
Voltage: 2%
Frequency: ±20mHz
Trip times: 1%±20ms

Note:

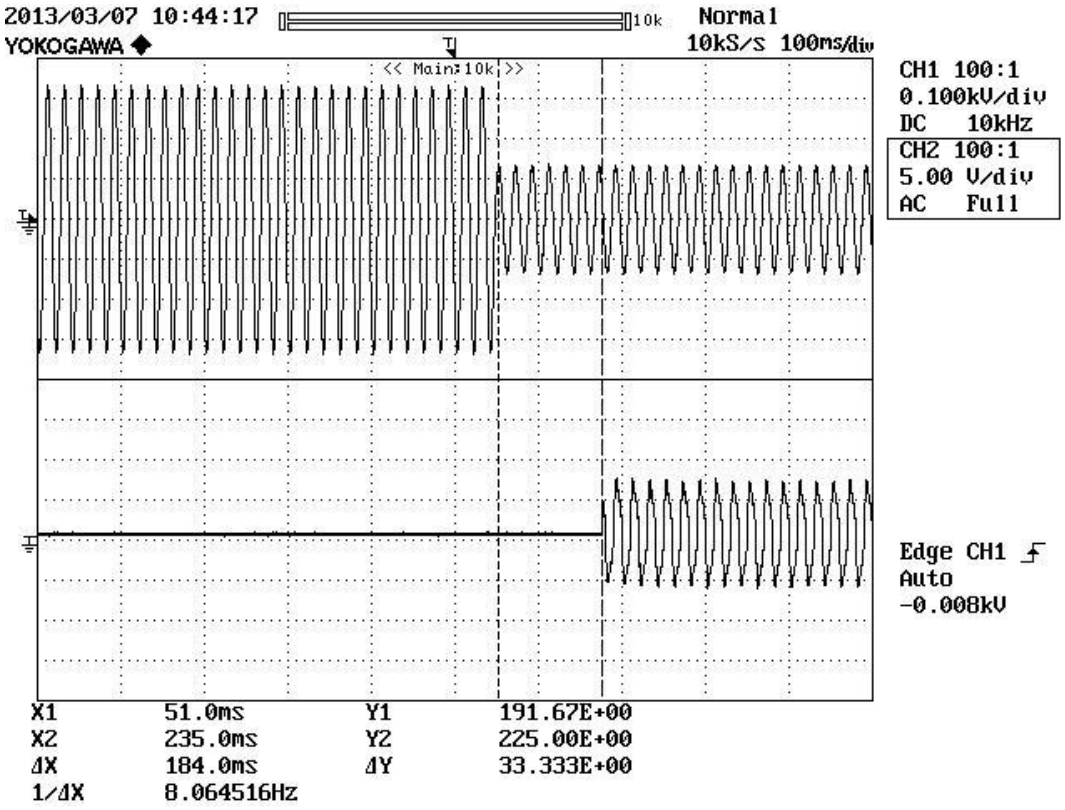
Under voltage (ambient)



Under voltage (-10°C)



Under voltage (55°C)



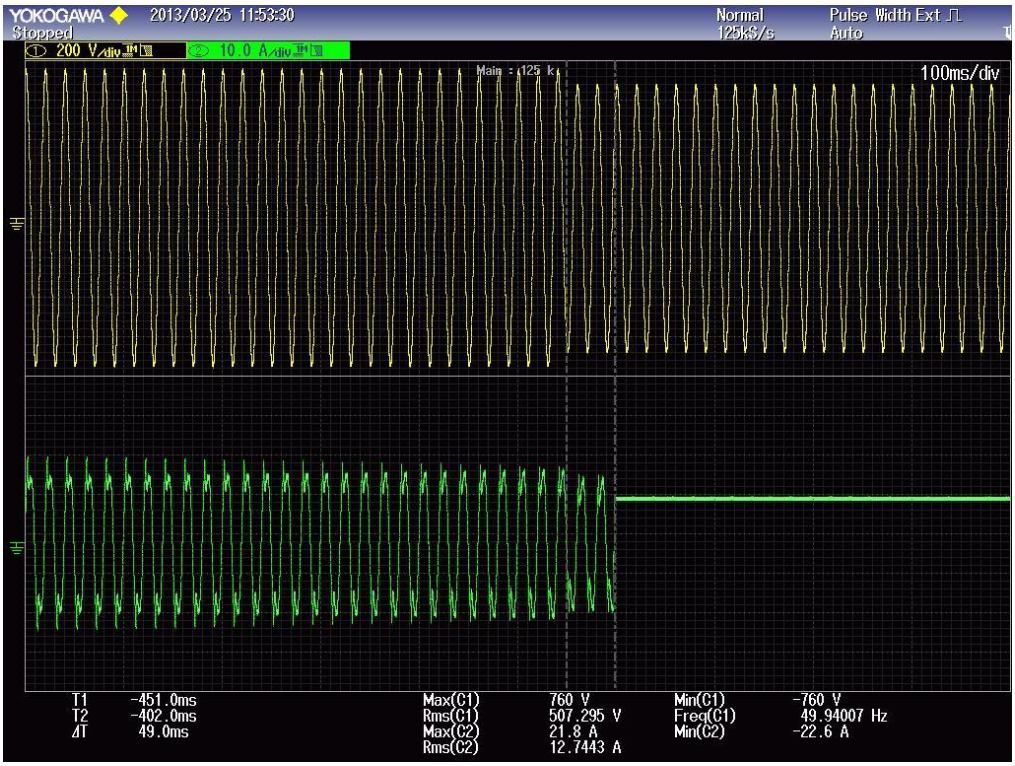
A.4.3.1 and A4.3.2 Test procedure for falling time							P
Operating time of the monitoring device							
	Falling time at under voltage			**Falling time at over voltage:**			
B) STEP [V to V]:	real threshold (of A)-> increase by one step to 1,1 threshold			real threshold (of A)-> decrease by one step to 0,9 threshold			
	Ambient temperature						
Limit [ms]:	40-100ms			40-100ms			
Falling time [ms]:	42 ms	40 ms	49 ms	49 ms	49 ms	48 ms	
	-10°C temperature						
Limit [ms]:	40-100ms			40-100ms			
Falling time [ms]:	47 ms	46 ms	44 ms	42 ms	50 ms	42 ms	
	+55°C temperature						
Limit [ms]:	40-100ms			40-100ms			
Falling time [ms]:	43 ms	42 ms	51 ms	43 ms	48 ms	51 ms	
	Falling time at under frequency			**Falling time at over frequency:**			
B) STEP [Hz to Hz]	real threshold (of A)-> increase by one step to 1,01 threshold			real threshold (of A)-> decrease by one step to 0,99 threshold			
	Ambient temperature						
Limit [ms]:	40-100ms			40-100ms			
Falling time [ms]:	64 ms	64 ms	64 ms	63 ms	64 ms	64 ms	
	-10°C temperature						
Limit [ms]:	40-100ms			40-100ms			
Falling time [ms]:	59 ms	60 ms	60 ms	70 ms	70 ms	69 ms	
	+55°C temperature						
Limit [ms]:	40-100ms			40-100ms			
Falling time [ms]:	67 ms	66 ms	66 ms	67 ms	66 ms	67 ms	

Note:
The measuring points are the trip signal of the AC source and the output of the SPI to control the relays (DDI).

For each repetition of the tests, the max tolerances of the values are:
Voltage: 2%
Frequency: ±20mHz
Trip times: 1%±20ms

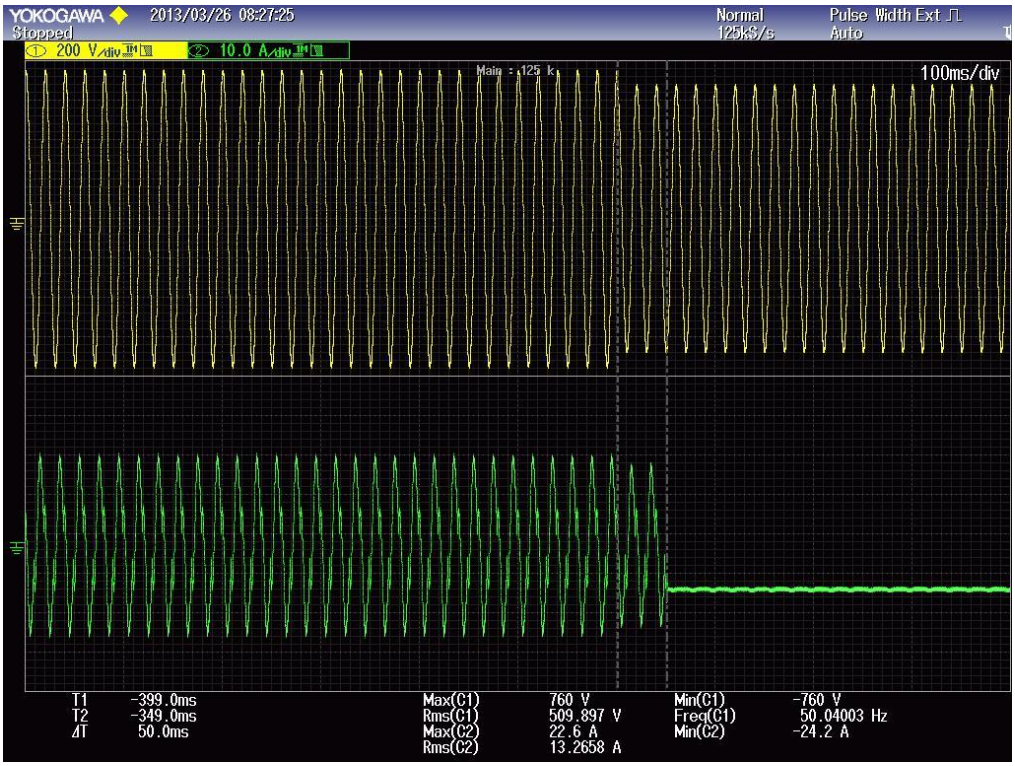
Falling time (under voltage ambient)

Falling time (over voltage ambient)



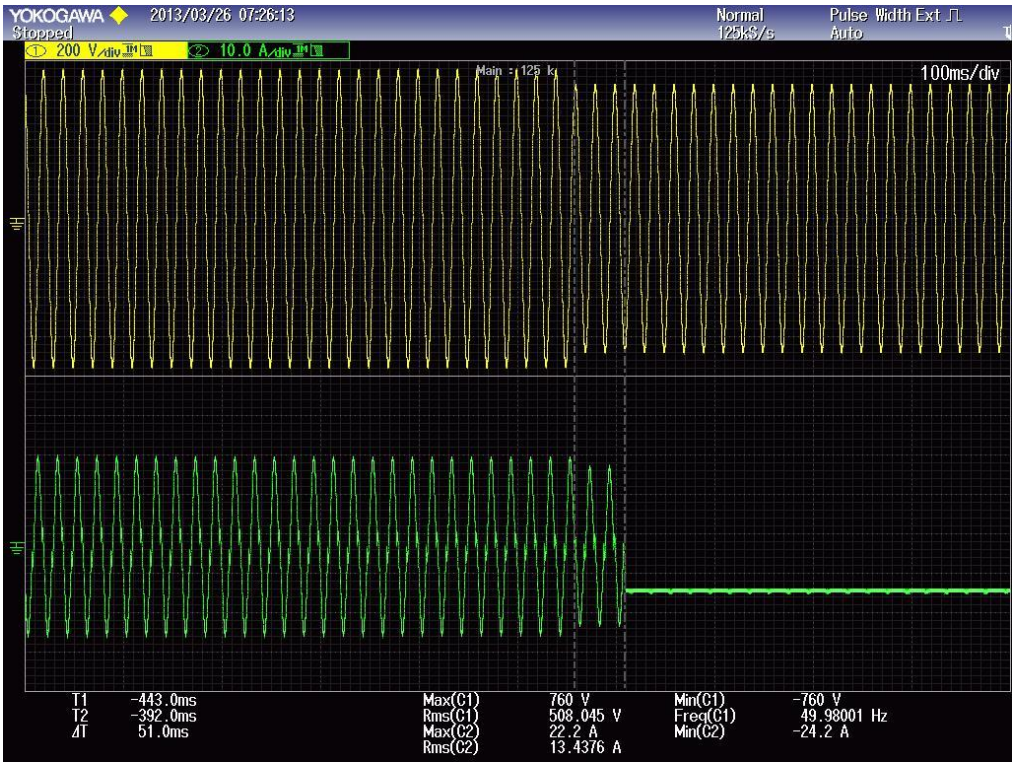
Falling time (under voltage -10°C)

Falling time (over voltage -10°C)

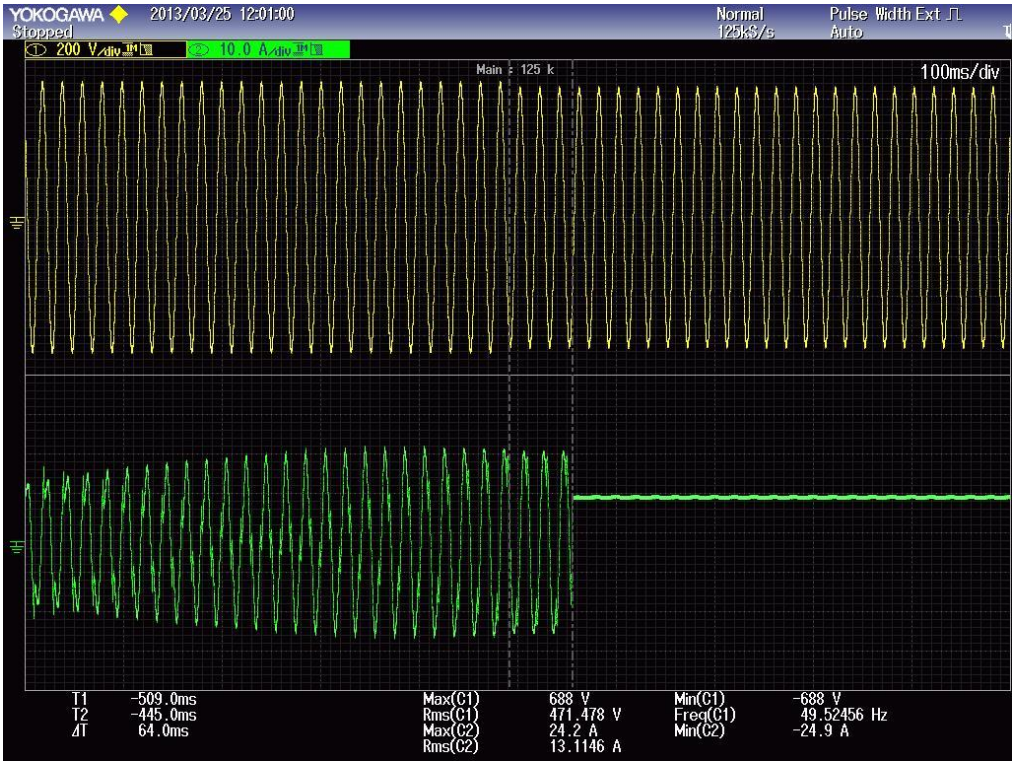


Falling time (under voltage +55°C)

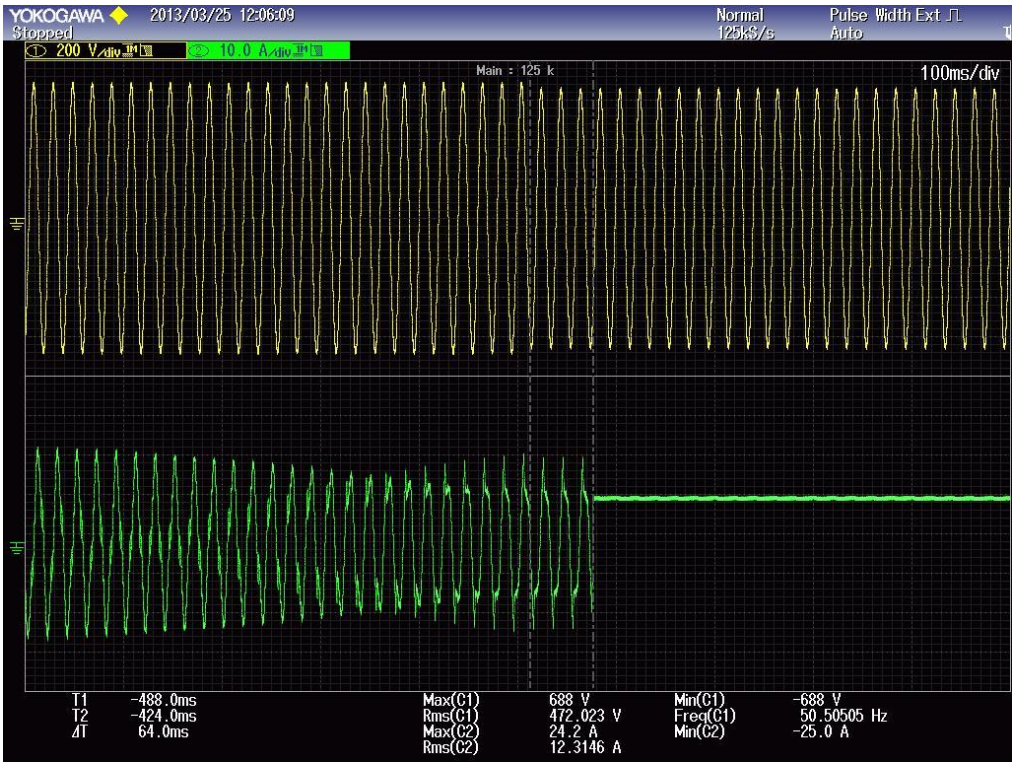
Falling time (overvoltage +55°C



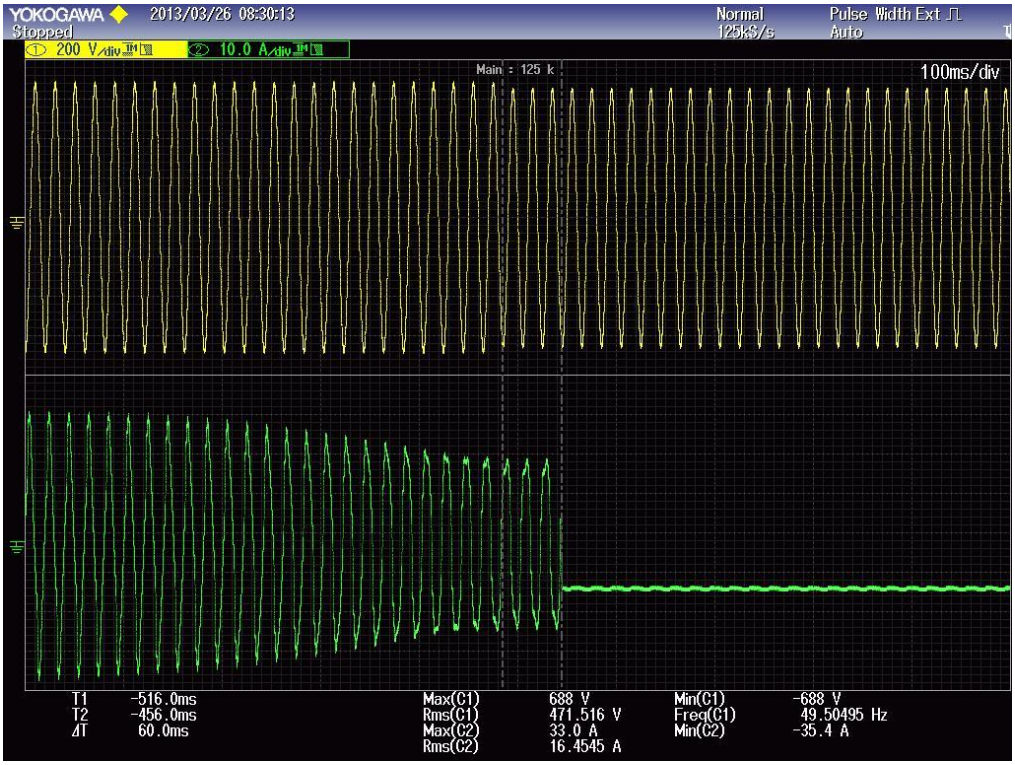
Falling time (under frequency ambient)



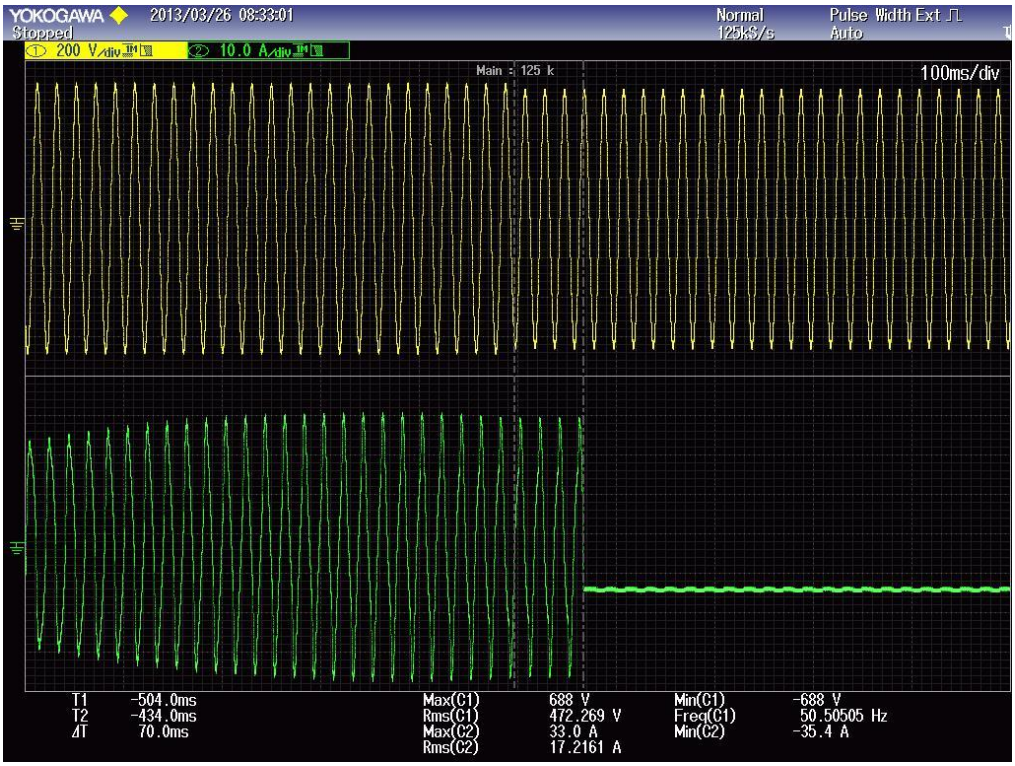
Falling time (over frequency ambient)



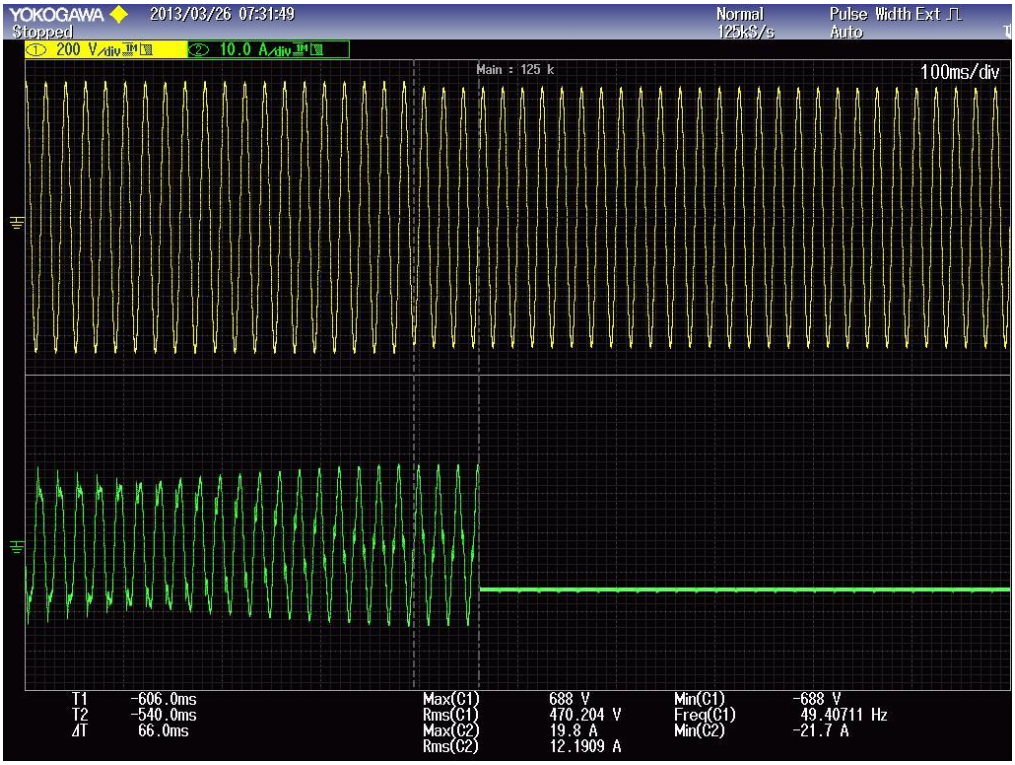
Falling time (under frequency -10°C)



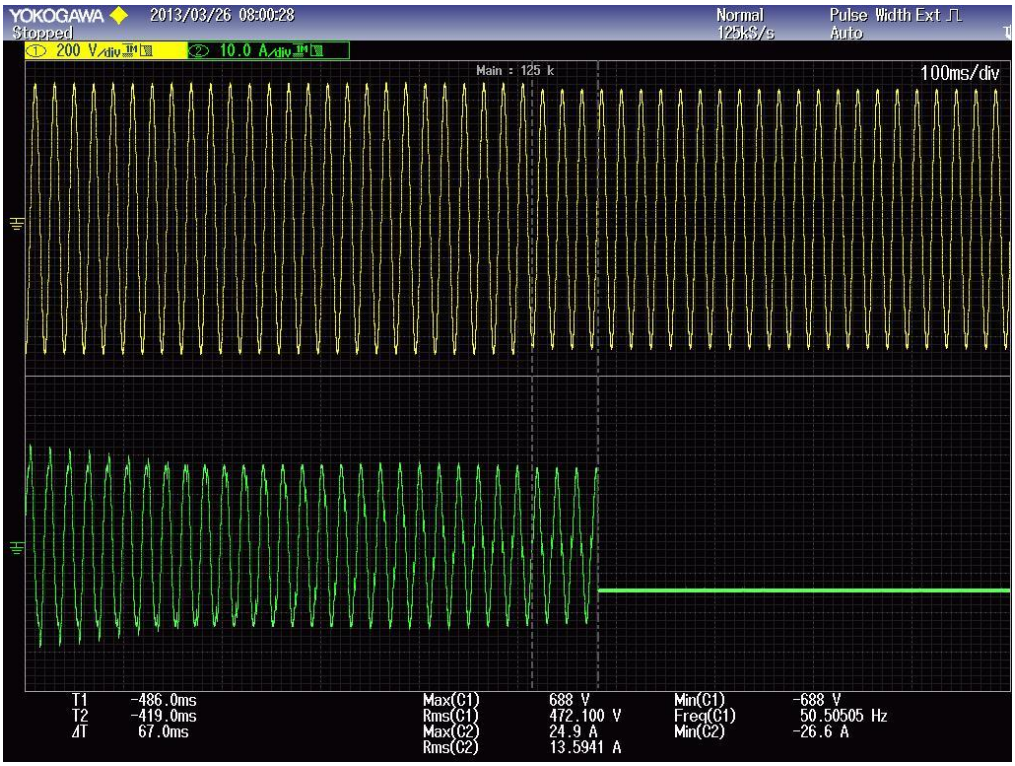
Falling time (over frequency -10°C)



Falling time (under frequency +55°C)



Falling time (over frequency +55°C)



A.4.3.1 and A4.3.2 Test procedure for falling ratio (voltage)						**P**
Operating time of the monitoring device						
	Falling ratio at under voltage			**Falling ratio at over voltage:**		
C) STEP [V to V]:	0,8 threshold -> increase by max 5V steps until reset value is reached			1,2 threshold -> decrease by max 5V steps until reset value is reached		
	Ambient temperature					
Limit of ratio:	1.03-1.05			0.95-0.97		
Measurement reset value [V]:	203,8 V	203,7 V	203,7 V	253,3 V	253,4 V	253,3 V
Calculated falling ratio V_{in}/V_{end}:	1,04	1,04	1,04	0,96	0,96	0,96
	-10°C temperature					
Limit of ratio:	1.03-1.05			0.95-0.97		
Measurement reset value [V]:	203,6 V	203,7 V	203,6 V	253,0 V	252,9 V	253,0 V
Calculated falling ratio V_{in}/V_{end}:	1,04	1,04	1,04	0,96	0,96	0,96
	+55°C temperature					
Limit of ratio:	1.03-1.05			0.95-0.97		
Measurement reset value [V]:	203,7 V	203,8 V	203,8 V	253,5 V	253,5 V	253,5 V
Calculated falling ratio V_{in}/V_{end}:	1,04	1,04	1,04	0,96	0,96	0,96

Test:
To measure the falling ratio, the voltage or frequency brought out the operation range by 20%of the nominal and in-/decrease in maximal 10mHz or 5V steps until the SPI connects.

Assessment criterion:
Calculation:

$$\frac{\mathbf{V_{in}\ (reset\ value)}}{\mathbf{V_{end}\ (trip\ value)}} \qquad \frac{\mathbf{f_{in}\ (reset\ value)}}{\mathbf{f_{end}\ (trip\ value)}}$$

Limit values:

The setting value and the trip value of the frequency may not vary by more than **≤5%V_n** and **±20ms**.
The value of the falling ratio may not vary by more than **≤2%**.
The ratio limits: 85% (27.S1) between 1.03 and 1.05
115% (59.S2) between 0.95 and 0,97
49,50Hz (81<S1) 1,001-1,003
50,50Hz (81>S1) 0,997-0,999

Note:

A.4.3.1 and A4.3.2 Test procedure for falling ratio (frequency)						**P**
Operating time of the monitoring device						
	Falling ratio at under frequency			**Falling ratio at over frequency:**		
C) STEP [Hz to Hz]	0,8 threshold -> increase by max 10mHz steps until reset value is reached			1,2 threshold -> decrease by max 10mHz steps until reset value is reached		
Limit of ratio:	**Ambient temperature**					
	1,001-1,003			0,997-0,999		
Measurement reset value [Hz]:	49,60 Hz	49,60 Hz	49,60 Hz	50,40 Hz	50,40 Hz	50,40 Hz
Calculated falling ratio f_{in}/f_{end}:	1,002	1,002	1,002	0,998	0,998	0,998
	-10°C temperature					
Limit of ratio:	1,001-1,003			0,997-0,999		
Measurement reset value [Hz]:	49,60 Hz	49,60 Hz	49,60 Hz	50,40 Hz	50,40 Hz	50,40 Hz
Calculated falling ratio f_{in}/f_{end}:	1,002	1,002	1,002	0,998	0,998	0,998
	+55°C temperature					
Limit of ratio:	1,001-1,003			0,997-0,999		
Measurement reset value [Hz]:	49,60 Hz	49,60 Hz	49,60 Hz	50,40 Hz	50,40 Hz	50,40 Hz
Calculated falling ratio f_{in}/f_{end}:	1,002	1,002	1,002	0,998	0,998	0,998

Test:
To measure the falling ratio, the voltage or frequency brought out the operation range by 20%of the nominal and in-/decrease in maximal 10mHz or 5V steps until the SPI connects.

Assessment criterion:
Calculation:

$$\frac{\mathbf{V_{in}\ (reset\ value)}}{\mathbf{V_{end}\ (trip\ value)}} \qquad \frac{\mathbf{f_{in}\ (reset\ value)}}{\mathbf{f_{end}\ (trip\ value)}}$$

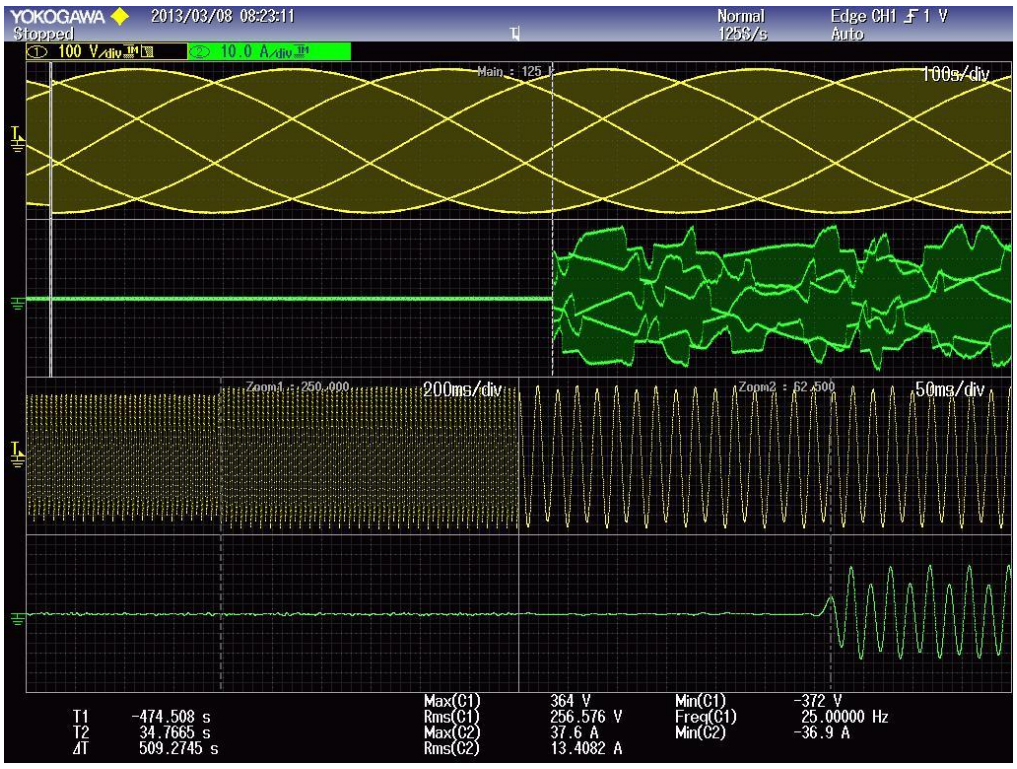
Limit values:

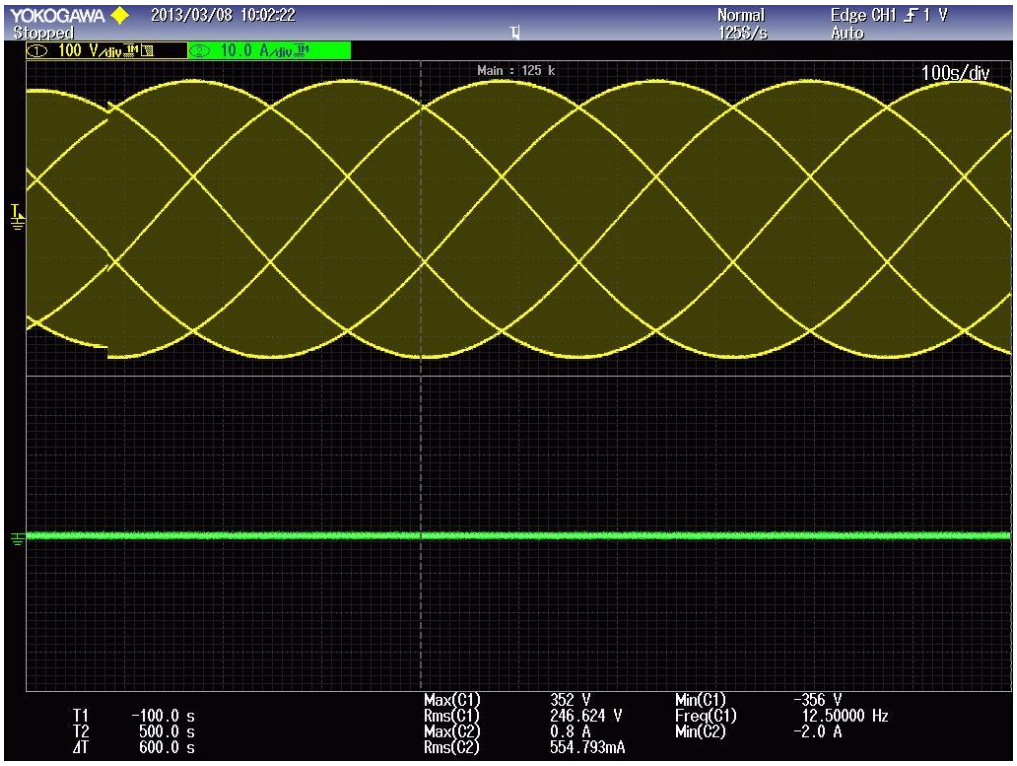
The setting value and the trip value of the frequency may not vary by more than **≤5%V_n** and **±20ms**.
The value of the falling ratio may not vary by more than **≤2%**.
The ratio limits: 85% (27.S1) between 1.03 and 1.05
115% (59.S2) between 0.95 and 0,97
49,50Hz (81<S1) 1,001-1,003
50,50Hz (81>S1) 0,997-0,999

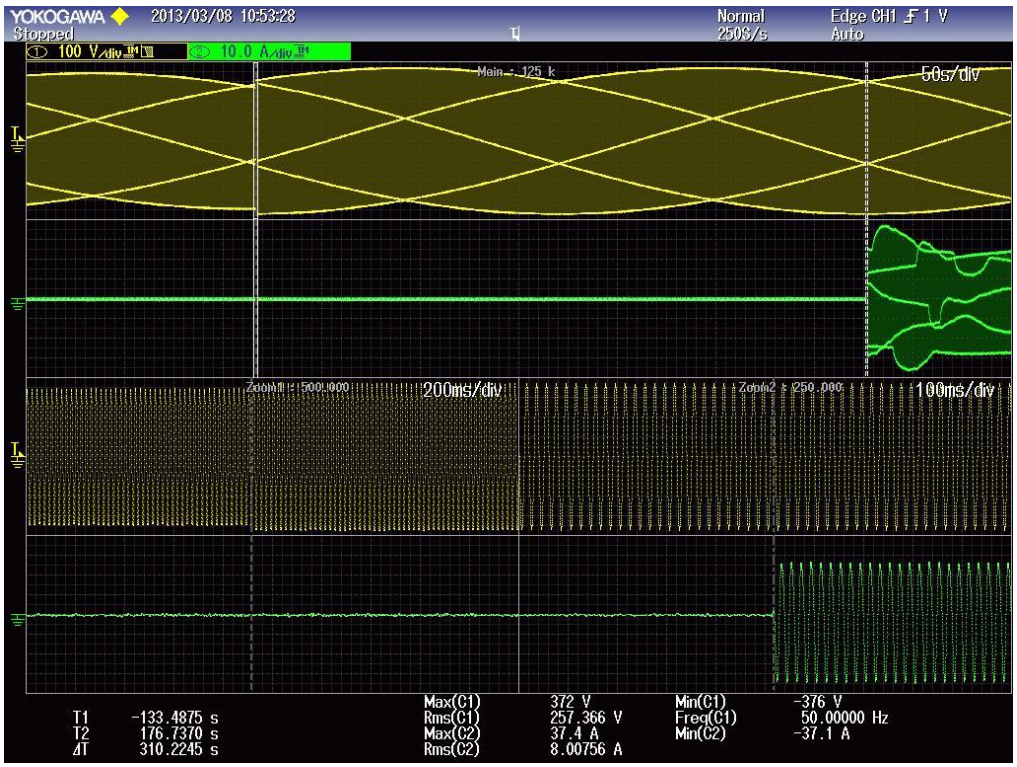
Note:

Measuring the rise-in voltage protection as a running 10-minute mean value			**P**
Test:			
		Disconnection time:	Limit:
a)	The voltage is set to 100% U_n and held for 600 s. Thereafter the voltage is set to 112% U_n. Disconnection must take place within 600 s.		
	Phase 1	503 s	≤ 600 s
	Phase 2	509 s	
	Phase 3	509 s	
b)	The voltage is set to U_n for 600 s and then to 108% U_n for 600 s. No disconnection should take place.		
	Phase 1	No disconnection	Disconnection should not take place.
	Phase 2	No disconnection	
	Phase 3	No disconnection	
c)	The voltage is set to 106 % U_n and held for 600 s. Thereafter the voltage is set to 114 % U_n. Disconnection must take place within 300 s or about 50 % of the disconnection time measured in point a).*		
	Phase 1	302 s	The disconnection time should be about 50 % of the value measured in a). *
	Phase 2	310 s	
	Phase 3	229 s	

Note:
*If the setting value is set to 600 s, then the disconnection time can be in the range between 225 s and 375 s.







A.4.3.3.2 Remote trip signal	P
Operating time of the monitoring device	
Test:	Remote tripping signal for the external disconnection
Limit [ms]:	50
Reaction time of the tripping value [ms]:	28 ms
Note: The protection interface has to have a maximum delay of the remote tripping signal from receiving to transmitting to the DDI of 50ms.	

A.4.3.3.1 Insensitivity to harmonics of the frequency relay							P
Operating time of the monitoring device							
	Under frequency:			**Over frequency:**			
A) STEPS for trip value [Hz to Hz]:	1,01 threshold -> decrease by max 10mHz steps			0,99 threshold -> increase by max 10mHz steps			
D) STEP trip time [Hz to Hz]:	1,01 threshold -> 0,99 threshold			0,99 threshold -> 1,01 threshold			
Limit [Hz]:	47,50 Hz			51,50 Hz			
Measurement accuracy of the tripping value [Hz]:	47,50 Hz	47,50 Hz	47,50 Hz	51,51 Hz	51,51 Hz	51,51 Hz	
	100 ms			100 ms			
Measurement the trip time [ms]:	100 ms	98 ms	98 ms	106 ms	105 ms	104 ms	

Test:

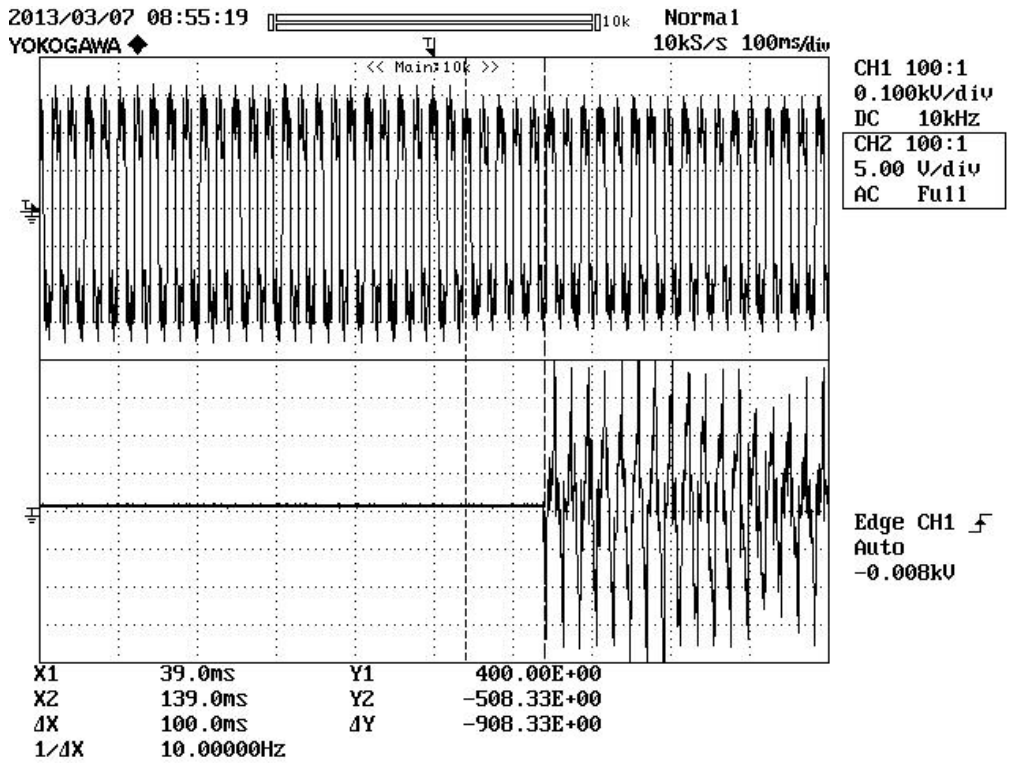
The test setup for the harmonics distortion, was set with the fallowing values:

Harmonics order:	2nd	3rd	5th	7th	9th	11th	13th	17th
$\%U_n$:	4,0	10,0	12,0	10,0	3,0	7,0	6,0	4,0

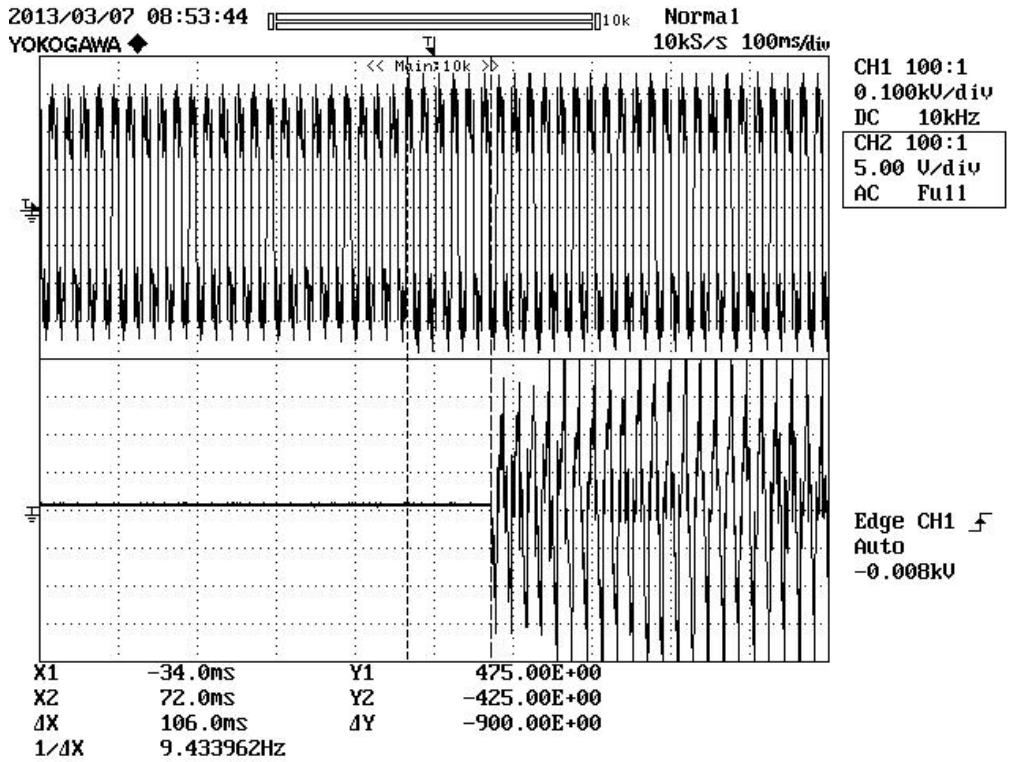
The frequency test was performed as in A.4.3

Note:
The setting value and the trip value of the frequency may not vary by more than **±20mHz** and **3%±20ms**.
Differences between the test values: **±20mHz** and **1%±20ms.**

Under frequency (harmonics)



Over frequency (harmonics)



A.4.3.3.1 Insensitivity to harmonics of the frequency relay							P
Operating time of the monitoring device							
	Under frequency:			**Over frequency:**			
A) STEPS for trip value [Hz to Hz]:	1,01 threshold -> decrease by max 10mHz steps			0,99 threshold -> increase by max 10mHz steps			
D) STEP trip time [Hz to Hz]:	1,01 threshold -> 0,99 threshold			0,99 threshold -> 1,01 threshold			
Limit [Hz]:	49,50 Hz			50,50 Hz			
Measurement accuracy of the tripping value [Hz]:	49,50 Hz	49,50 Hz	49,50 Hz	50,51 Hz	50,51 Hz	50,51 Hz	
	100 ms			100 ms			
Measurement the trip time [ms]:	100 ms	101 ms	99 ms	99 ms	97 ms	98 ms	

Test:

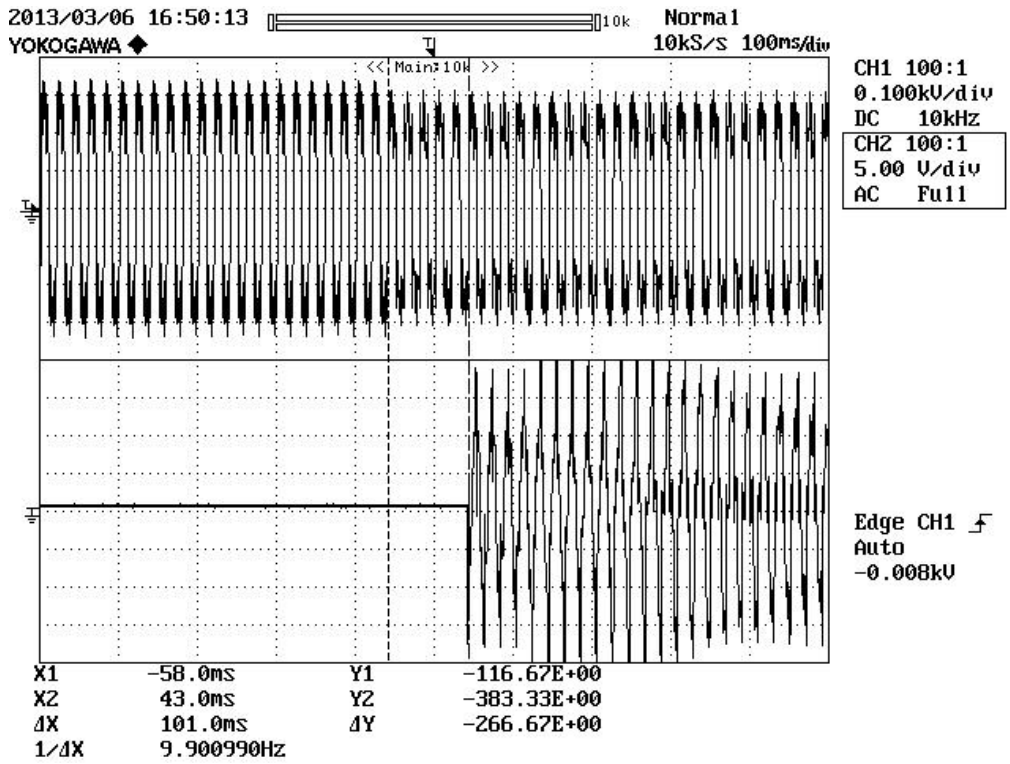
The test setup for the harmonics distortion, was set with the fallowing values:

Harmonics order:	2nd	3rd	5th	7th	9th	11th	13th	17th
$\%U_n$:	4,0	10,0	12,0	10,0	3,0	7,0	6,0	4,0

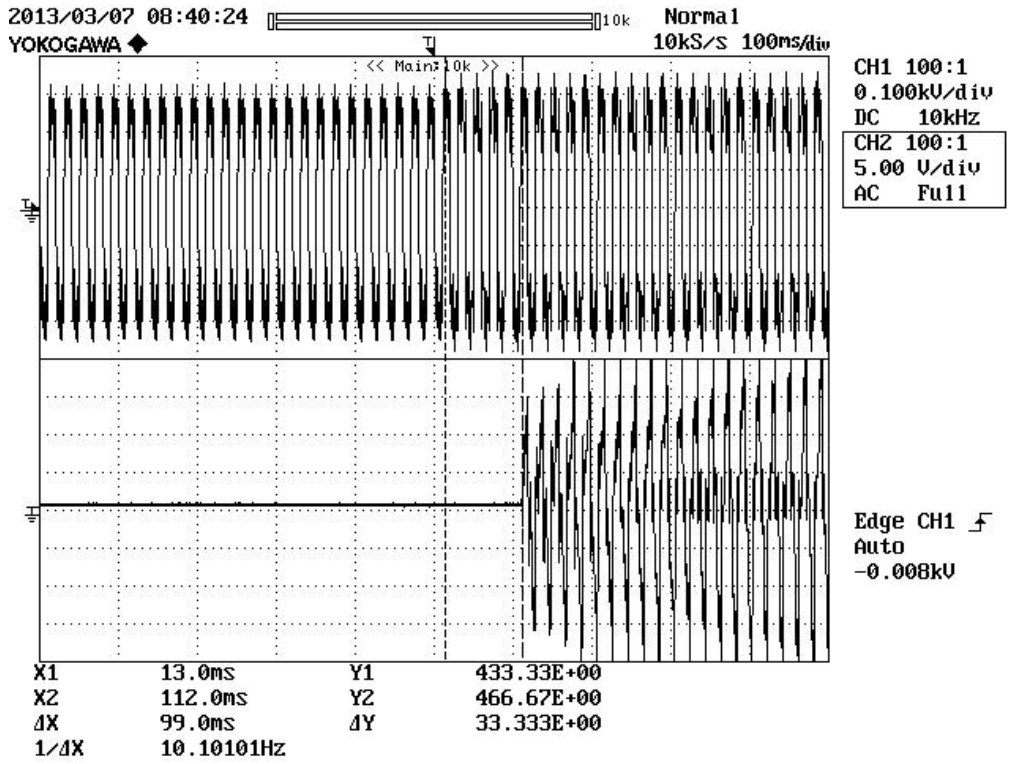
The frequency test was performed as in A.4.3

Note:
The setting value and the trip value of the frequency may not vary by more than **±20mHz** and **3%±20ms**.
Differences between the test values: **±20mHz** and **1%±20ms.**

Under frequency (harmonics)



Over frequency (harmonics)



A.4.3.3.3 Communication Signal		P
Enlargement of the frequency limits:		
Without communication signal		
f_{soll}	**f_{ist}**	**Limit:**
49,50 Hz	49,50	<81.S1
50,50 Hz	50,51	>81.S1
With communication signal		
47,50 Hz	47,50	<81.S2
51,50 Hz*	51,51	>81.S2
Note:		

A.4.4 Self-test	N/A

Self-test function

If the interface protection functions are integrated in the inverter, at least one self-test system must be provided which checks the maximum/minimum frequency and maximum/minimum voltage functions provided in the interface protection system (SPI), as described below:

- for each frequency and voltage protection function, the tripping threshold varies linearly upward or downward with a slope of ≤ 0.05 Hz/s or ≤ 0.05 Vn/s respectively for the frequency and voltage protection;
- This will determine, at a certain point in the test, whether the threshold and the actual value of the controlled parameter (frequency or voltage) coincide, and thus whether the protection was triggered and the interface device subsequently opened.

For each test, the person conducting the test must be able to view the quantity and trip time values, in addition to the current value of the voltage and frequency detected by the converter.

The tests must measure the:

- accuracy of tripping thresholds;
- accuracy of trip times.

After each test, the inverter must exit the test mode, reset the normally used settings and automatically reconnect to the network when the conditions are appropriate.

Any user must be able to activate the procedure and it must be clearly described in the converter user manual.

Note:
The SPI is external.

A.4.6 Climatic compatibility tests		**P**
Testing in non connected state of the unit:		
Temperature	Relative humidity	Test time
70°C	50%	16h
40°C	93%	4 giorni
-25°C	10%	10h
-25°C -> +70°C	---	3h @ -25°C, 3h @ +70°C
Testing, while unit is running.		
Temperature	Relative humidity	Test time
55°C	50%	16h
40°C	93%	4 giorni
-25°C	10%	10h
-25°C -> +55°C	---	3h @ -25°C, 3h @ +55°C
Note: The unit was not damaged during testing.		

A.4.7 Insulation tests		**P**
Rigidity of electricity:		
Location	Test voltage	Result
AC to PE	2kVac / 2,8kVdc	No damage at 2kVas
DC to PE	2kVac / 2,8kVdc	No damage at 2kVas
Impulse test:		
AC and DC inputs	4kV (1,2/50µs)	No breakthrough
Measurement of the insulation resistance:		
AC and DC inputs	>100MΩ at 500Vdc	More than 200MΩ at 500Vdc
Note:		

A.4.8 Tests for the overload capacity of measuring circuits		**P**
Voltage	Test time	Result:
≥130%U_N	permanente	**No damage**
≥150%U_N	1s	**No damage**
Note: The unit is not allowed to be damaged while testing. The measurement circuit must show after the test the same values like before the test.		

A.4.10 Automatic mechanism to prevent current imbalance during production		N/A
Voltage	Test time	Result:
6kW to 10kW	30min	
>10kW	1min	
Note: The SPI will not be used in systems, which are not capable to prevent current imbalance via communication or through their symmetical behavior. A relevant note is placed in the user manual in chapter 2.1.		

Annex 1

ISO 9001 certificate

DNV·GL

MANAGEMENT SYSTEM CERTIFICATE

Certificate No.:	Initial date:	Valid:
104769-2011-AQ-GER-DAkkS	ISO 14001: 21.10.2011 ISO 9001: 07.10.1992	21.10.2014 - 20.10.2017

This is to certify that the management system of

Bender GmbH & Co. KG

with the sites:
Londorfer Str. 65, 35305 Grünberg Hessen - Germany
Apfelborn 10, 06308 Siersleben - Germany

has been found to conform to management system standards:

ISO 9001:2008, ISO 14001:2004

This certificate is valid for the following scope:

Site Grünberg: Design, Production, Sales, Repair and Calibration of Insulation Monitoring Devices, Fault Location Systems, Network Relays, Residual Current Relays, Test Systems and Safety Tester

Site Siersleben: Production of Insulation Monitoring Devices, Fault Location Systems, Network Relays, Residual Current Relays, Test Systems and Safety Tester

Place and date:
Essen, 30.09.2014

DAkkS
Deutsche
Akkreditierungsstelle
D-ZM-18453-01-00

For the Accredited Unit:
DNV GL Business Assurance Zertifizierung und Umweltgutachter GmbH

Thomas Beck
Technical Manager

This certificate replaces the certificate 122166-2012-AQ-GER-TGA issued 20.09.2012.
Lack of fulfilment of conditions as set out in the Certification Agreement may render this Certificate invalid.
ACCREDITED UNIT: DNV GL Business Assurance Zertifizierung und Umweltgutachter GmbH, Schnieringshof 14, 45329 Essen, Germany.
Tel.: +49 201 7296 222. www.dnvgl.de/assurance

Annex 2

The EMC Test Report is stored at Bureau Veritas Consumer Products Services Germany GmbH Türkheim in the project 13TH0057

Bureau Veritas Consumer Products Services Germany GmbH

TEST REPORT
EN 61000-6-2 + EN 61000-6-3 and CEI 0-21:2012, chapter A 4.5

Report Reference No. ..... :	13TH0057_VMD-460_61000-6-x-CEI_0
Compiled by (+ signature)	F. Mayer
Approved by (+ signature)	U. Gronert
Date of issue ..... :	12-April-2013
Total number of pages	64
Testing Laboratory ..... :	Bureau Veritas Consumer Products Services Germany GmbH
Address ..... :	Businesspark A96 86842 Türkheim; Germany
Applicant's name ..... :	Bender GmbH & Co. KG
Address ..... :	Londorfer Straße. 65 35305 Grünberg
Test specification:	
Standard ..... :	EN 61000-6-2:2005 EN 61000-6-3:2007 + A1:2011 CEI 0-21:2012 chapter A 4.5 (partial test) *with reference to the following basic standards:* EN 61000-3-2:2006 + A1:2009 + A2:2009 EN 61000-3-3:2008
Test procedure ..... :	N/A
Non-standard test method ..... :	N/A
Test Report Form No. ..... :	EN61000-x_CEI 0-21_B
Test Report Form(s) Originator ..... :	Bureau Veritas Consumer Products Services Germany GmbH
Master TRF ..... :	Date 15-February-2013
Test item description	External interface protection system
Trade Mark	BENDER
Manufacturer	Bender GmbH & Co. KG
Model/Type reference	VMD460-NA-D-2
Ratings	Us = 100 - 240V 50/60Hz P@ Us 230V = 7VA / 2W Um = 0V – 300V 45/65Hz

History Sheet			
F. Mayer	12 April 2013	Initial report was written	

Summary of testing:

1. One device was tested according to the applicable EMC standards.

2. Tested software version was V1.03
   Tested hardware version V1.00

3. The device passed the tests.
   After the immunity tests the properly function of the device was controlled.

4. Internal frequencies are lower than 108MHz.

Report Index:		
Item	Description	page

Possible test case verdicts:	
- test case does not apply to the test object . :	N/A
- test not ordered by customer	N/O
- test object does meet the requirement ..... :	P (Pass)
- test object does not meet the requirement . :	F (Fail)
Testing ..... :	
Date of receipt of test item ..... :	4-March-2013
Date (s) of performance of tests..... :	5-March-2013 to 12 April-2013

General remarks:

The test results presented in this report relate only to the object tested.

The results contained in this report reflect the results for this particular model and serial number. It is the responsibility of the manufacturer to ensure that all production models meet the intent of the requirements detailed within this report.

This report shall not be reproduced, except in full, without the written approval of the Issuing testing laboratory.

"(see Annex #)" refers to additional information appended to the report.

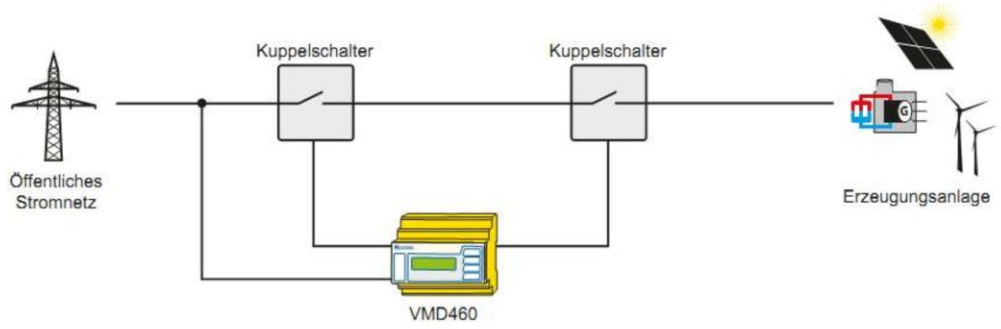
Throughout this report a comma (point) is used as the decimal separator.

1. General information

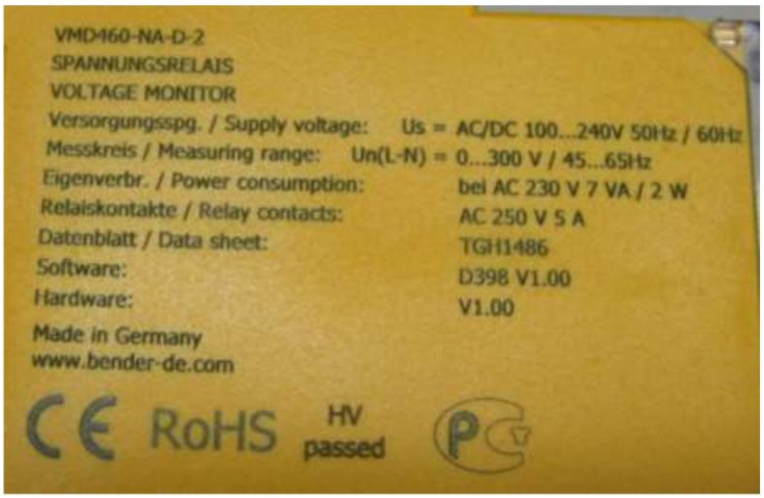
1.1. Equipment Description

General product information:

The purpose of the SPI is to disconnect a system of solar inverters from the grid. This occurs, if any kind of frequency or voltage rise/fall exceeding the limits of the SPI.



1.2. Equipment Marking Plate



1.3. Equipment Used During Test

Use*	Product Type	Manufacturer	Model	Comments
EUT	External interface protection system	Bender GmbH & Co. KG	VMD460	3NAC 400/230V

Note:

* Use = EUT - Equipment Under Test,
AE - Auxiliary/Associated Equipment, or
SIM - Simulator (Not Subjected to Test)

1.4. Input/Output Ports

Port #	Name	Type*	Cable Max. >3m	Cable Shielded	Comments
0	Enclosure	N/E	—	—	—
1	Mains	AC	yes	no	L1,L2,L3,N
2	Input: .A1,A2	AC/DC	yes	no	U_{supply} (100-240V)
3	Dig inputs. DG1/2, D1, D2, D3, D4, RT1, RTG	DC	no	no	0 – 4 V / 5mA
4	Relay contacts:11,12,14 21,22,24		yes	no	
5	RS485 (A,B)		yes		Only service purpose

*Note: AC = AC Power Port DC = DC Power Port N/E = Non-Electrical
I/O = Signal Input or Output Port (Not Involved in Process Control)
TP = Telecommunication Ports

1.5. EUT Internal Operating Frequencies

Frequency (MHz)	Description
< 108 (Declared by manufacturer)	Switching frequency, all other frequencies

1.6. Power Interface

Mode #	Voltage (V)	Current (A)	Power (W)	Frequency (DC/AC-Hz)	Phases (#)	Comments
Controlled voltage	3 x 400 max 3 x 520			45 -65	3	
supply	100 -240			DC /AC		7VA / 2W
contacts	max 250	max 5				

1.7. EUT Operation Modes

Mode #	Description
1	Continuous operation normally status
2	Continuous operation failure status
3	
4	

1.8. EUT Configuration

Mode #	Description
General	☐ floor standing equipment ☒ top hat rail montage ☐ combined floor standing / table top equipment
1	Testing in setup according to relevant basic standard.

1.9. Immunity performance criteria

Criterion	Description
A	As defined in EN 61000-6-2 Further definition provided by the manufacturer: none
B	As defined in EN 61000-6-2 Further definition provided by the manufacturer: none
C	As defined in EN 61000-6-2 Further definition provided by the manufacturer: none

1.10. Deviations from standards

Standard	Deviation
EN 61000-6-2	none
EN 61000-6-3	none
EN 61000-3-2	none
EN 61000-3-3	none
CEI 0-21 chapter A 4.5	none

2. Result Summary

EN 61000-6-3:2007			
Cl.	Requirement – Test	Remark	Verdict
7 Table 1.1	Limits of radiated disturbance in the frequency range 30 MHz to 1000 MHz		**P**
7 Table 1.2	Limits of harmonics currents, voltage changes, voltage fluctuations and flicker		**P**
7 Table 1.2	Limits of disturbance voltages in the frequency range 150 kHz to 30 MHz *(AC mains)*		**P**
7 Table 1.2	Limits of discontinuous disturbances in the frequency range 150 kHz to 30 MHz		**N/A**
7 Table 1.3	Limits of disturbance voltages in the frequency range 150 kHz to 30 MHz *(DC supply)*		**P**
7 Table 1.4	Limits of terminal disturbance voltages in the frequency range 150 kHz to 30 MHz *(signal lines)*		**N/A**

EN 61000-6-2:2005			
Cl	Requirement – Test	Remark	Verdict
8 Table 1.1	Power-frequency magnetic field *according to IEC 61000-4-8*		**P**
8 Tab. 1.2-4	Radio frequency electromagnetic field *according to IEC 61000-4-3*		**P**
8 Table 1.5	Electrostatic discharge *according to IEC 61000-4-2*		**P**
8 Table 2.1	Radio-frequency common mode (signal lines) *according to IEC 61000-4-6*		**P**
8 Table 2.2	Fast transients (signal lines) *according to IEC 61000-4-4*		**P**
8 Table 3.1	Radio-frequency common mode (DC power ports) *according to IEC 61000-4-6*		**P**
8 Table 3.2	Surges (DC power ports) *according to IEC 61000-4-5*		**P**
8 Table 3.3	Fast transients (DC power ports) *according to IEC 61000-4-4*		**P**
8 Table 4.1	Radio-frequency common mode (AC power ports) *according to IEC 61000-4-6*		**P**
8 Table 4.2	Voltage dips (AC power ports) *according to IEC 61000-4-11*		**P**
8 Table 4.3	Voltage interruptions (AC power ports) *according to IEC 61000-4-11*		**P**
8 Table 4.4	Surges (AC power ports) *according to IEC 61000-4-5*		**P**
8 Table 4.5	Fast transients (AC power ports) *according to IEC 61000-4-4*		**P**

EN 61000-3-2:2006			
Cl.	Requirement - Test	Remark	Verdict
6	General requirements		**P**
7	Harmonic current limits (equipment ≤16A)		**P**

EN 61000-3-3:2008			
Cl.	Requirement – Test	Remark	Verdict
5	Limits of voltage changes, voltage fluctuations and flicker (equipment ≤16A)		**P**

CEI 0.21:2011			
EN61000-4-16			
Cl.	Requirement - Test	Remark	Verdict
5	Power frequency immunity test		**P**
EN61000-4-18			
Cl.	Requirement - Test	Remark	Verdict
5 Table 1	1 MHz oscillatory wave immunity tests		**P**
EN61000-4-29			
Cl.	Requirement - Test	Remark	Verdict
Table 1 a	Immunity against voltage various and short voltage interrupts on DC mains		**P**
		b	
EN60255-22-5			
4 Table 1	Surge immunity requirements for measuring and protection equipment		**P**

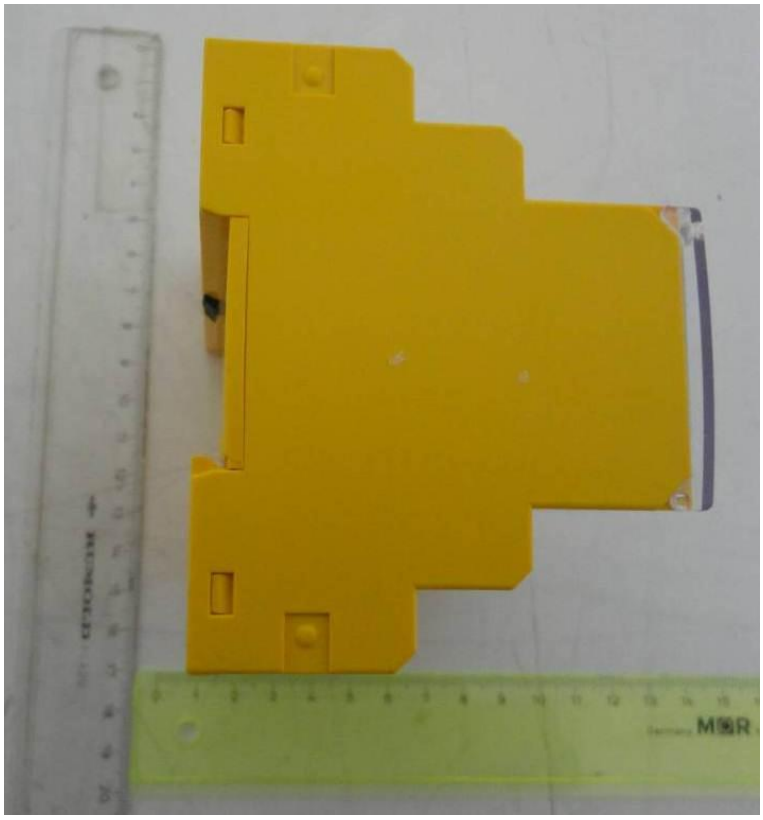
Annex 3

Pictures of the unit

Enclosure front

Enclosure (connectors)

Enclosure left side



Enclosure right side

Enclosure back

Annex 4

Test equipment list

Equipment	Internal no.:	Manufacturer:	Type:	Serial no.:	Last calibration
Power Meter	948	ZES Zimmer Electronic Syst.	LMG-500-3	2441006	Okt. 12
AC Source	944	Chroma	61705	617050000142	
Oscilloscope	984	Yokogawa	DLM2022	91L512341	Jul. 11
Differential Probe	1050	Saphire Instruments	SI-9002	118138	Aug. 12
Differential probe head	496	Yokogawa	19/7019-21	71237	Sep. 11