SPS EMC Software modules

Software modules for EMC
emission and immunity standards and their
requirements of specific hardware

Basic software unit SPS TestManager

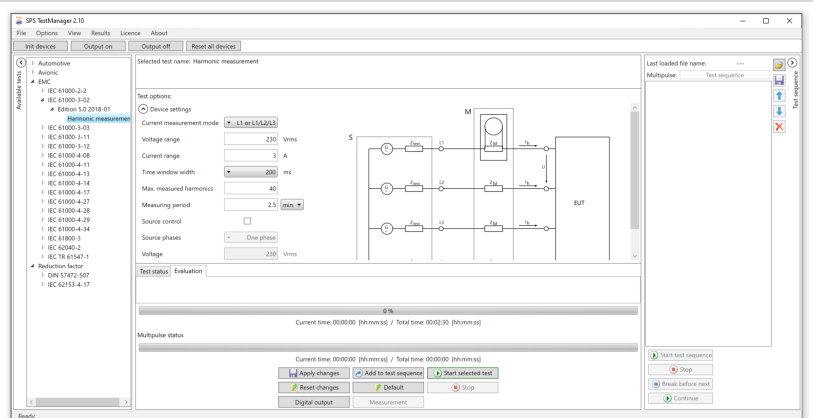Framework for Basic EMC System software application

Fig. 1: Example screenshot

Software module IEC 61000-3-2/-3/-11/-12

Automatic testing and measuring of harmonic emissions and flicker according to the following standards:

▲ IEC 61000-3-02
    ▲ Edition 5.0 2018-01
        Harmonic measurement
▲ IEC 61000-3-03
    ▲ Edition 3.1 2017-05
        Flicker measurement
▲ IEC 61000-3-11
    ▲ Edition 2.0 2017-04
        Flicker measurement
▲ IEC 61000-3-12
    ▲ Edition 2.0 2011-05
        Harmonic Measurement

IEC 61000-3-2:2018 Ed 5.0
Limits for harmonic current emissions, equipment input current ≤16A per phase
IEC 61000-3-3:2017 Ed 3.1
Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems,
input current ≤16A per phase
IEC 61000-3-11:2017 Ed 2.0
Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems,
input current >16A and ≤75A
IEC 61000-3-12:2011 Ed 2.0
Limits for harmonic currents produced by equipment connected to public low-voltage systems,
input current >16A and ≤75A

Integrated functions of the software module:
- Control of APS (power source) and AIS (harmonic analyser, flickermeter, line impedance simulating network)
- measurement of harmonics: Uh, Ih
- measurement of flicker values: Pst, Plt, dc, dmax, Tmax
- tabular and graphical display of measured values
- calculation of further values from the measured values
- predefined limits according to the standards
- evaluation according to the standards
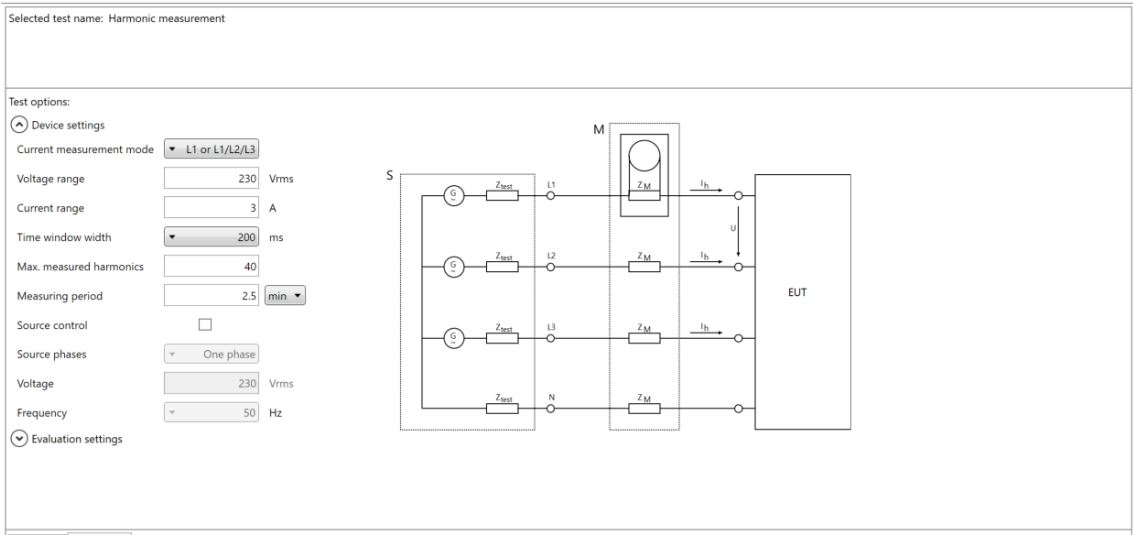- tabular and graphical version of test reports

Selected test name: Harmonic measurement

Test options:

Device settings

Current measurement mode	L1 or L1/L2/L3	
Voltage range	230	Vrms
Current range	3	A
Time window width	200	ms
Max. measured harmonics	40	
Measuring period	2.5	min
Source control	☐	
Source phases	One phase	
Voltage	230	Vrms
Frequency	50	Hz

Evaluation settings

Fig. 2: Test setup for measuring harmonic currents – 3-phase testing

Selected test name: Flicker measurement

Test options:

Device settings

Nominal frequency	50	Hz
Lamp model	230V	
Short time interval (T_{short})	10	min
Number of short time intervals (N_{long})	12	
Nominal voltage	230	Vrms
d_t threshold	3.3	%
Voltage range	230	Vrms
Impedance R_A	240	mΩ
Impedance X_A	150	mΩ
Impedance R_N	160	mΩ
Impedance X_N	100	mΩ
Source control	☐	
Voltage	230	Vrms

Test status | Results

EUT values

No.	$P_{inst, max}$	P_{st}	T_{max} [s]	d_{max} [%]	d_c [%]

Source values

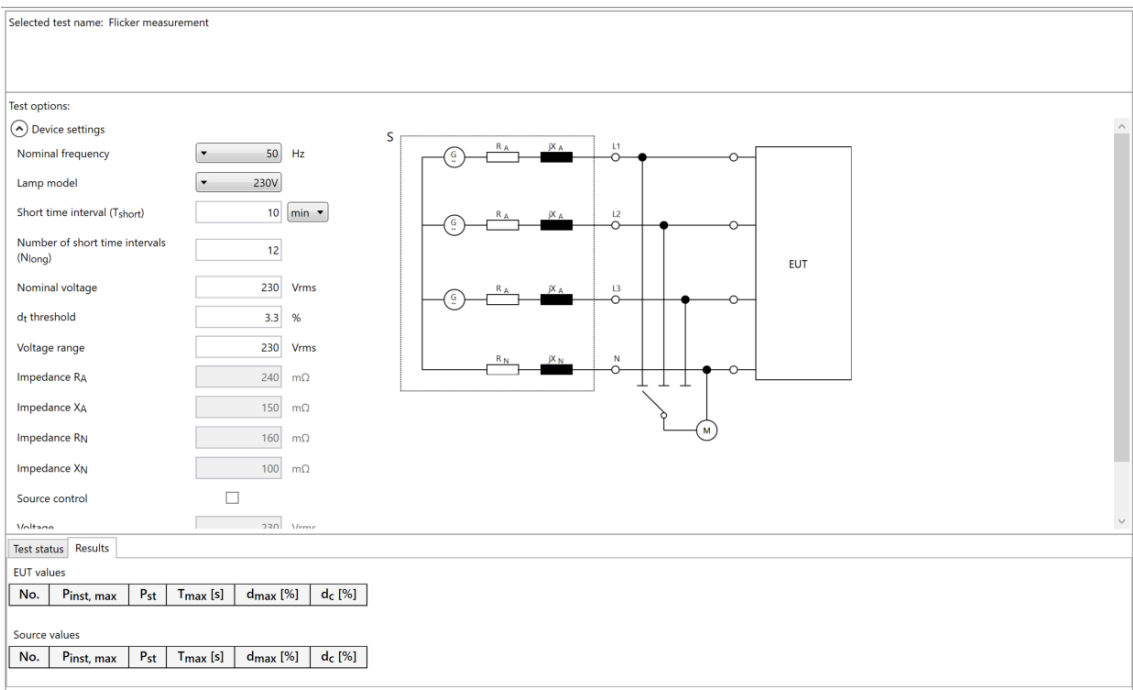| No.	$P_{inst, max}$	P_{st}	T_{max} [s]	d_{max} [%]	d_c [%]

Fig. 3: Test setup for flicker measurements – 3-phase testing

required hardware:
- 4-quadrant amplifier APS
- measuring instrument AIS (harmonic analyser, flickermeter, line impedance simulating network)
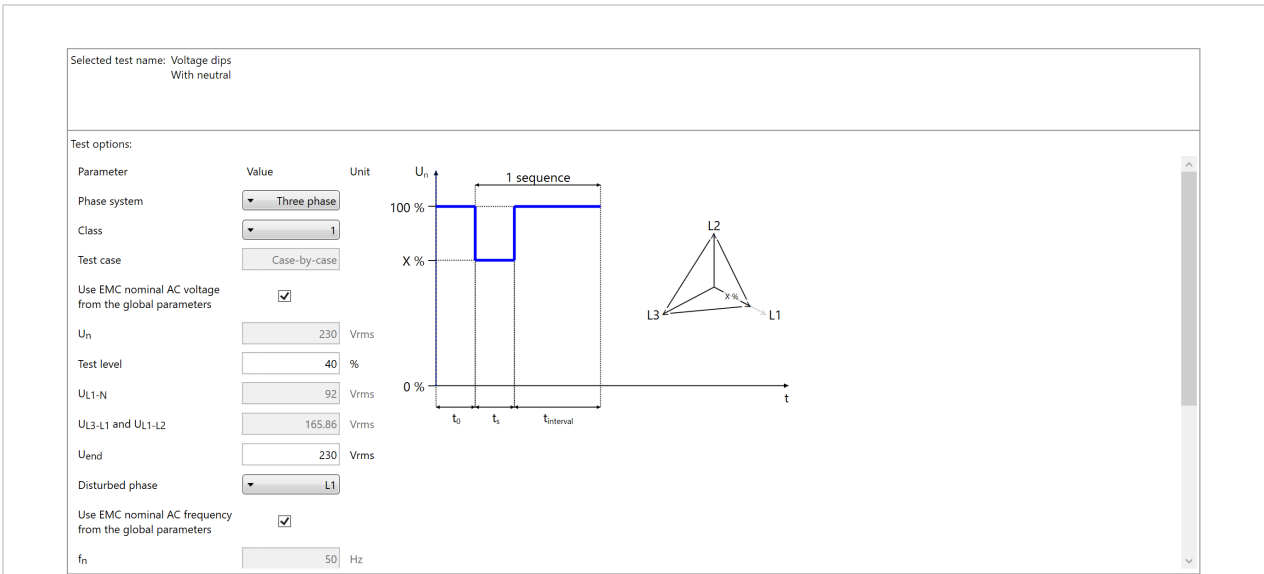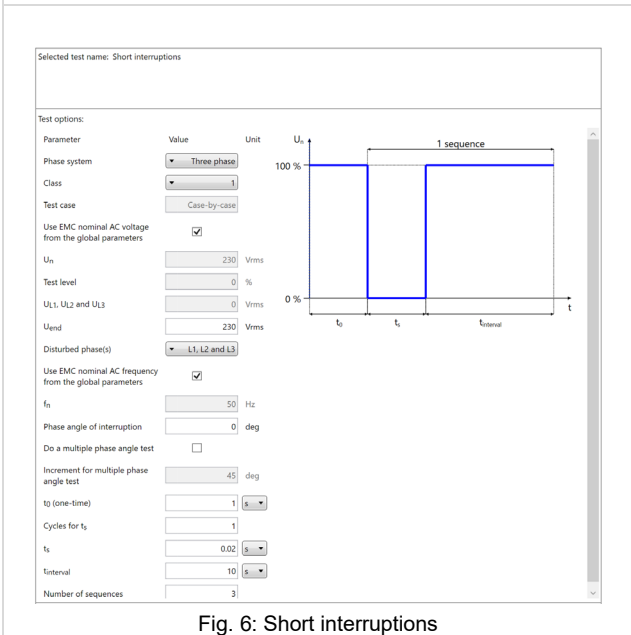
Software module IEC 61000-4-11
Automatic testing according to IEC 61000-4-11:2020 Ed 3.0

Voltage dips, short interruptions and voltage variations immunity tests

Integrated functions of the software module:
- control of APS amplifier
- sequential operation of defined pulses
- automatic capturing of the waveforms of voltage and current
- graphical documentation of the generated voltage dips and/or voltage changes in the test report

required hardware:
- 4-quadrant amplifier APS
- inrush current source ICS 500 if inrush current capability of APS is <500A
 see application note "Source inrush current capability of APS amplifiers – weblink: 1103

Power source version depending on the EUT:
single (APS) or 3-phase model (DM /APS)

Selected test name: Voltage dips
                     Without neutral - Method A

Test options:

Parameter	Value	Unit
Phase system	Three phase	
Class	1	
Test case	Case-by-case	
Use EMC nominal AC voltage from the global parameters	☑	
U_n	230	Vrms
Test level	40	%
U_{L1-N}	121.7	Vrms
U_{L1-L2}	92	Vrms
U_{L3-L1}	200.51	Vrms
U_{end}	230	Vrms
Disturbed phases	L1-L2	
Use EMC nominal AC frequency from the global parameters	☑	
f_n	50	Hz
Phase angle of voltage dip	0	deg
Do a multiple phase angle test	☐	
Increment for multi phase angle test	45	deg
t_0 (one-time)	1	s
Cycles for t_s	1	
t_s	0.02	s

Fig. 4: Voltage dips without neutral

Fig. 5: Voltage dips with neutral

Fig. 6: Short interruptions

Fig. 7: Voltage variations

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Software module IEC 61000-4-13

Automatic testing according to IEC 61000-4-13:2015 Ed 1.2

◢ IEC 61000-4-13
  ◢ Edition 1.1 2009-07
    Harmonic combination test flat curve
    Harmonic combination test over swing
    Test method "Sweep in frequencies"
    Individual harmonics with a specified test level sequence
    Interharmonics with a specified test level sequence
    Meister curve test
    ◢ Complete test process
      Class 1
      Class 2
      Class 3
  ◢ Edition 1.2 2015-12
    Harmonic combination test flat curve
    Harmonic combination test over swing
    Test method "Sweep in frequencies"
    Individual harmonics with a specified test level sequence
    Interharmonics with a specified test level sequence
    Meister curve test
    ◢ Complete test process
      Class 1
      Class 2
      Class 3

Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests

Integrated functions of the software module:
- control of APS amplifier
- harmonic combination test "flat curve" and "over swing"
- test method "sweep in frequencies"
- individual harmonics and interharmonics with specified test levels
- Meister curve test
- complete test process

Required hardware:

4-quadrant amplifier APS

Selected test name: Complete test process
                  Class 2

Test options:

⌃ Parameters for all tests

Phase system	▼ Three phase	
Use free adjustable values (Class X)	☐	
Use EMC nominal AC voltage from the global parameters	☑	
U_n	230	Vrms
U_{end}	230	Vrms
Use EMC nominal AC frequency from the global parameters	☑	
f_n	50	Hz
t_0 (one-time before every sequence)	1	s ▼

Figure 1 - Harmonic combination test flat curve

Figure 2 - Harmonic combination test over swing

Figure 3 - Meister curve / "Sweep in frequencies"

Figure 4 - Individual harmonics and interharmonics

⌄ Parameters for "flat curve"
⌄ Parameters for "over swing"
⌄ Parameters for "sweep in frequencies"
⌄ Parameters for "Meister curve"
⌄ Parameters for "individual harmonics"
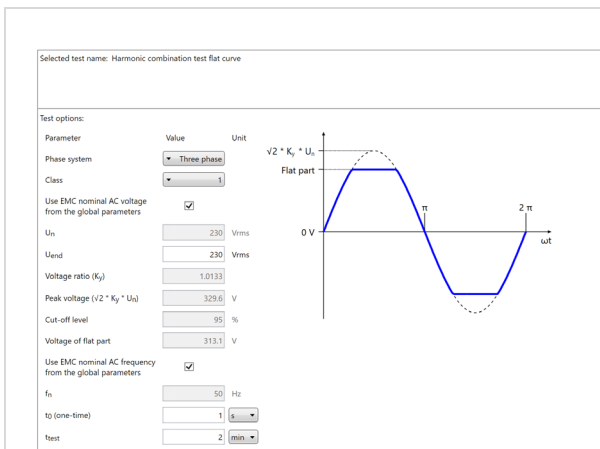⌄ Parameters for "interharmonics"

Fig. 8: Complete test process
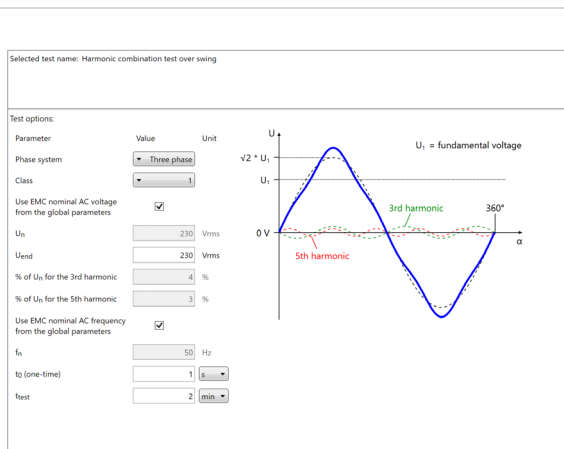
Fig. 9: Harmonic combination flat curve
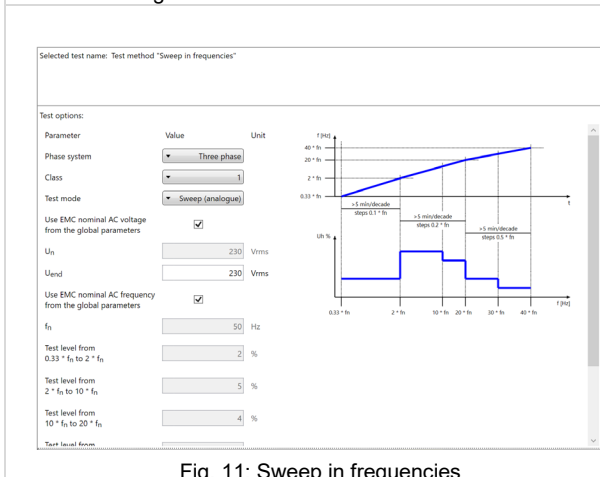

Fig. 10: Harmonic combination overswing
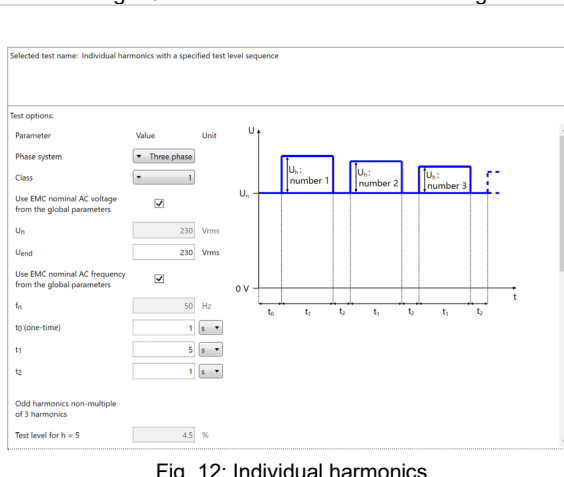

Fig. 11: Sweep in frequencies

Fig. 12: Individual harmonics

Software module IEC 61000-4-14

Automatic testing according to IEC 61000-4-14:2009 Ed 1.2

- ▲ IEC 61000-4-14
  - ▲ Edition 1.2 2009-08
    - ▲ Voltage fluctuation immunity test
      - ▲ Single-phase system
        - Class 2
        - Class 3
        - Class X
      - ▲ Three-phase system
        - Class 2
        - Class 3
        - Class X

Voltage fluctuation immunity test for equipment with input current not exceeding 16 A per phase

Integrated functions of the software module:
- control of APS amplifier
- generation of voltage fluctuations as defined in IEC standard
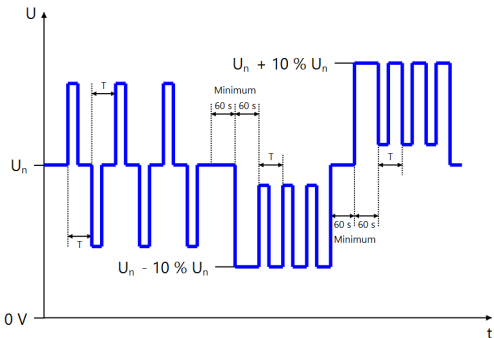
Required hardware:
4-quadrant amplifier APS

Selected test name: Voltage fluctuation immunity test for equipment with input current not exceeding 16 A per phase
Single-phase system
Class 2

Test options:

Parameter	Value	Unit
Use EMC nominal AC voltage from the global parameters	☑	
U_n	230	Vrms
ΔU (... % U_n)	8	%
U_{end}	230	Vrms
Use EMC nominal AC frequency from the global parameters	☑	
f_n	50	Hz
t_0 (one-time)	1	s
Repetition period T	5	s
Duration t	2	s
Interval time	60	s
Number of sequences	3	

Fig. 13: Voltage fluctuations

Software module IEC 61000-4-17

Automatic testing according to IEC 61000-4-17:2009 Ed 1.2

◢ IEC 61000-4-17
    ◢ Edition 1.2 2009-01
        ◢ Ripple on d.c. input power port immunity test
            1 time the power frequency
            2 times the power frequency
            3 times the power frequency
            6 times the power frequency
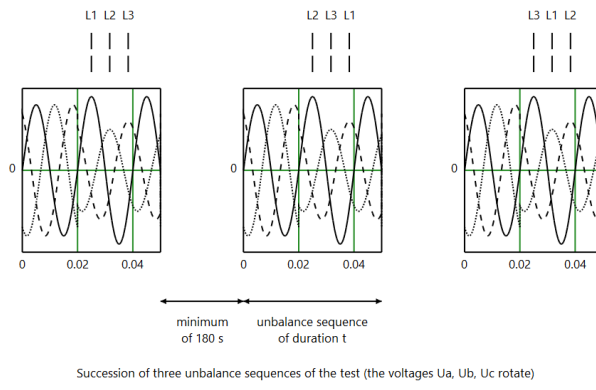
Ripple on d.c. input power port immunity test

Integrated functions of the software module:
- control of APS amplifier
- generation of ripple on d.c. power supply as defined in IEC standard

Required hardware:

4-quadrant amplifier APS
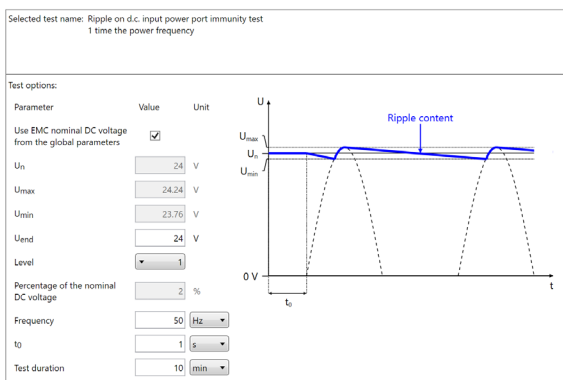
Fig. 14: Ripple with power frequency
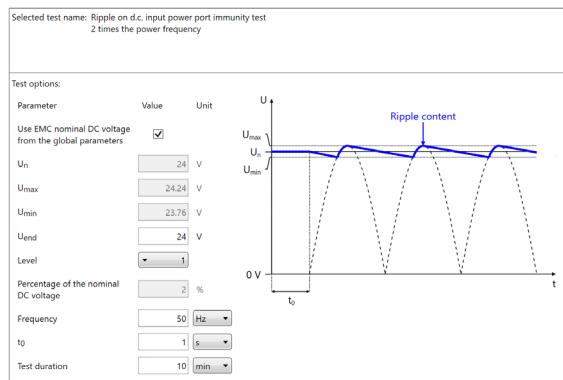
Fig. 15: Ripple with 2x power frequency
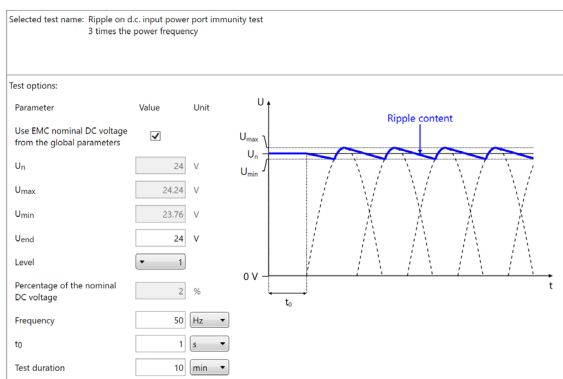
Fig. 16: Ripple with 3x power frequency
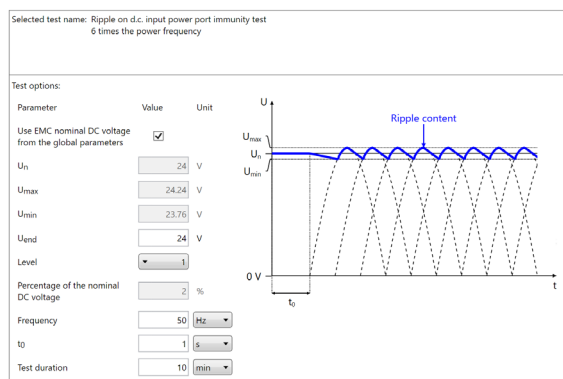
Fig. 17: Ripple with 6x power frequency

Software module IEC 61000-4-27

Automatic testing according to IEC 61000-4-27:2009 Ed 1.1

◢ IEC 61000-4-27
   ◢ Edition 1.1 2009-04
      ◢ Unbalance, immunity test for equipment with input
         ◢ Test 1
            Class 2
            Class 3
            Class X
         ◢ Test 2
            Class 2
            Class 3
            Class X
         ◢ Test 3
            Class 2
            Class 3
            Class X

Unbalance, immunity test for equipment with input current not exceeding 16 A per phase

Integrated functions of the software module:
- control of APS amplifier
- generation of unbalance immunity tests as defined in IEC standard

Required hardware:

4-quadrant amplifier APS (3-phase version DM /APS)

Selected test name: Unbalance, immunity test for equipment with input current not
exceeding 16 A per phase
Test 1
Class 2

Test options:

Parameter	Value	Unit
Use EMC nominal AC voltage from the global parameters	☑	
U_n	230	Vrms
U_{end}	230	Vrms
% of U_n for U_a	100	%
U_a	230	Vrms
Angle of U_a	0	deg
% of U_n for U_b	95.2	%
U_b	218.96	Vrms
Angle of U_b	125	deg
% of U_n for U_c	90	%
U_c	207	Vrms
Angle of U_c	240	deg
Use EMC nominal AC frequency from the global parameters	☑	
f_n	50	Hz
t_0 (one-time)	1	s
Duration t	30	s
Time between sequences	180	s

minimum of 180 s   unbalance sequence of duration t

Succession of three unbalance sequences of the test (the voltages Ua, Ub, Uc rotate)

NOTE These figures apply to 50 Hz systems

Fig. 18: Unbalance

Software module IEC 61000-4-28

Automatic testing according to IEC 61000-4-28:2009 Ed 1.2

◢ IEC 61000-4-28
    ◢ Edition 1.2 2009-04
        ◢ Variation of power frequency, immunity test for equipment
            ◢ Single-phase system
                Test level 2
                Test level 3
                Test level 4
                Test level X
            ◢ Three-phase system
                Test level 2
                Test level 3
                Test level 4
                Test level X

Variation of power frequency, immunity test for equipment with input current not exceeding 16 A per phase

Integrated functions of the software module:
- control of APS amplifier
- generation of variation of power frequency immunity tests as defined in IEC standard

Required hardware:

4-quadrant amplifier APS

Selected test name: Variation of power frequency, immunity test for equipment with input current not exceeding 16 A per phase
Single-phase system
Test level 2

Test options:

Parameter	Value	Unit
Use EMC nominal AC voltage from the global parameters	☑	
U_n	230	Vrms
U_{end}	230	Vrms
Use EMC nominal AC frequency from the global parameters	☑	
f_n	50	Hz
$+\Delta f/f_n$	3	%
$-\Delta f/f_n$	3	%
t_0 (one-time)	1	s
t_1	60	s
t_2	120	s
t_p	10	s
Number of cycles	3	

Fig. 19: Power frequency variation
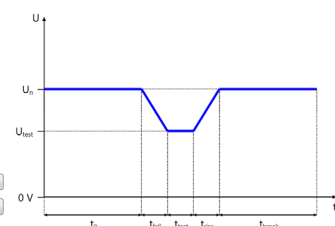
Software module IEC 61000-4-29

Automatic testing according to IEC 61000-4-29:2000 Ed 1.0

▲ IEC 61000-4-29
   ▲ Edition 1.0 2000-08
      Voltage dips
      Short interruptions
      Voltage variations

Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests

Integrated functions of the software module:
- control of APS amplifier
- control of electronic switch EPS 100/4-29
- generation of voltage changes on d.c. power supply as defined in IEC standard

Required hardware:
- 4-quadrant amplifier APS for low impedance interruptions testing

electronic switch EPS 100/4-29 if high impedance interruptions testing is additionally required

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Selected test name: Voltage dips

Test options:

Parameter	Value	Unit
Use EMC nominal DC voltage from the global parameters	☑	
U_n	24	V
Test level	40	%
U_{test}	9.6	V
U_{end}	24	V
t_0	1	s
t_{test}	0.01	s
t_{break}	10	s
Number of cycles	3	

Fig. 20: Voltage dips

Fig. 21: Short interruptions

Fig. 22: Voltage variations

Software module IEC 61000-4-34

Automatic testing according to IEC 61000-4-34:2009 Ed 1.1

- IEC 61000-4-34
  - Edition 1.1 2009-11
    - Voltage dips
      - Single-phase system
      - Three-phase system
        - With neutral
        - Without neutral - Method A
        - Without neutral - Method B
    - Short interruptions
      - Single-phase system
      - Three-phase system
        - Class 1 - Case-by-case
        - Class 2 - 0 % during 250/300 cycles
        - Class 3 - 0 % during 250/300 cycles
        - Class X - 0 % during X cycles
    - Voltage variations
      - Single-phase system
      - Three-phase system
        - Voltage test level 70 %
        - Voltage test level X

Voltage dips, short interruptions and voltage variations immunity tests for equipment with mains current more than 16 A per phase

Integrated functions of the software module:
- control of APS amplifier
- generation of voltage dips, short interruptions and voltage variations as defined in IEC standard
- sequential operation of defined pulses
- automatic capturing of waveforms of voltage and current
- graphical documentation of the generated voltage dips and/or voltage changes in the test report

Required hardware:
- 4-quadrant amplifier APS

Compliance testing for EUTs ≤ 50A requires the option 'Inrush current source' ICS 500 or minimum the 4-quadrant amplifier APS 15000.
For EUTs >50A minimum the 4-quadrant amplifier APS 30000 is required.
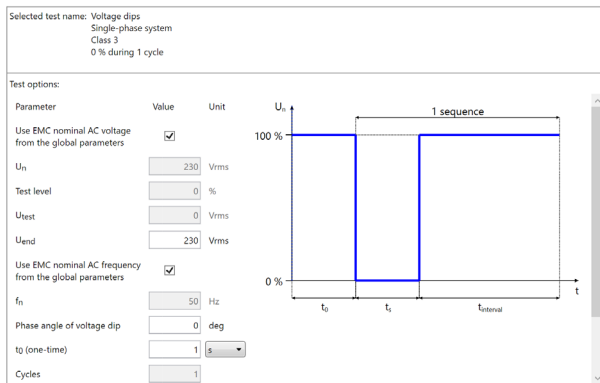
Fig. 23: Voltage dips 0%
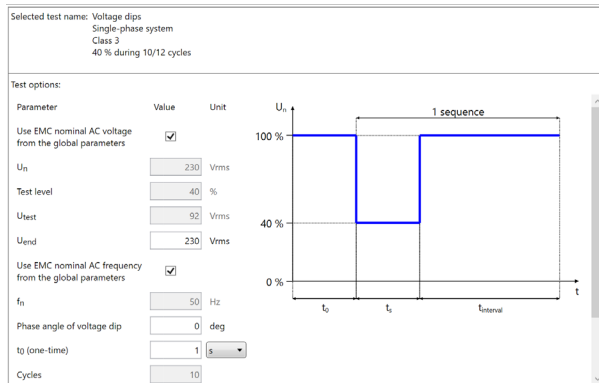
Fig. 24: Voltage dips 40%
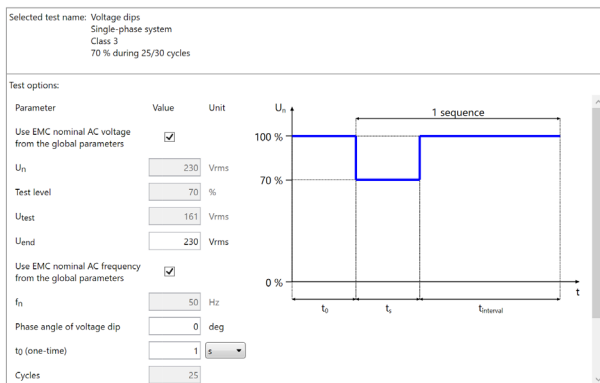
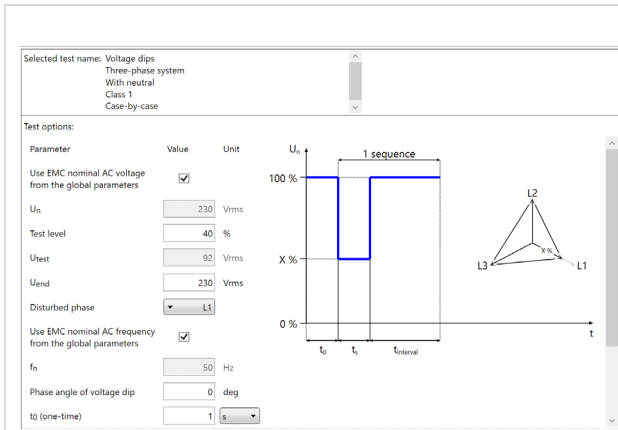Fig. 25: Voltage dips 70%
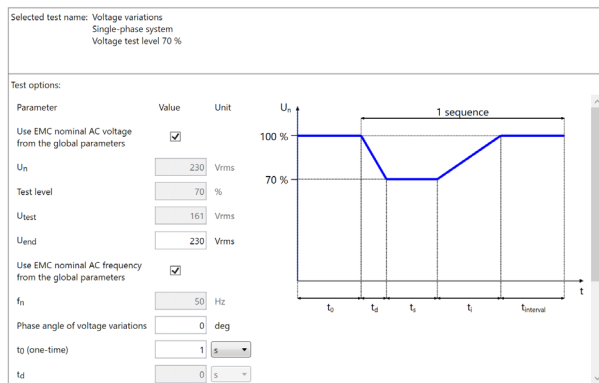
Fig. 26: Voltage variations

Fig. 27: Voltage dips 3-phase with neutral

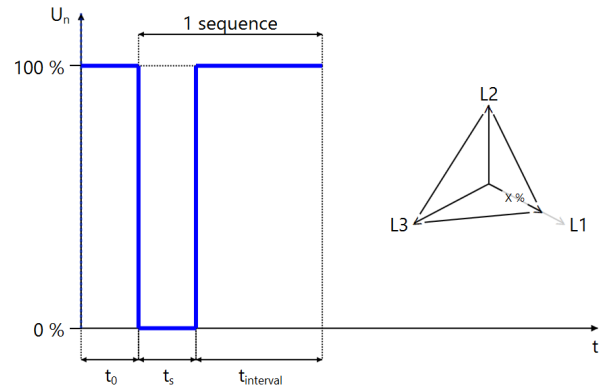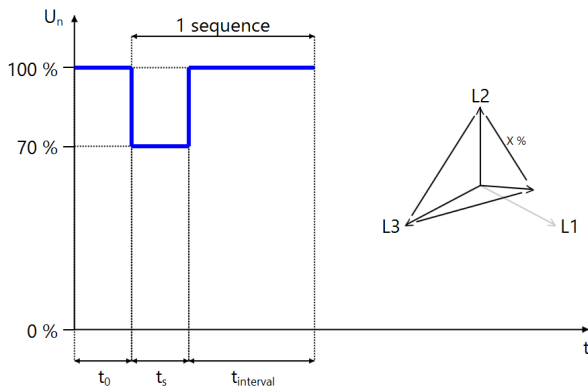

Fig. 28: Voltage dip 0% with neutral
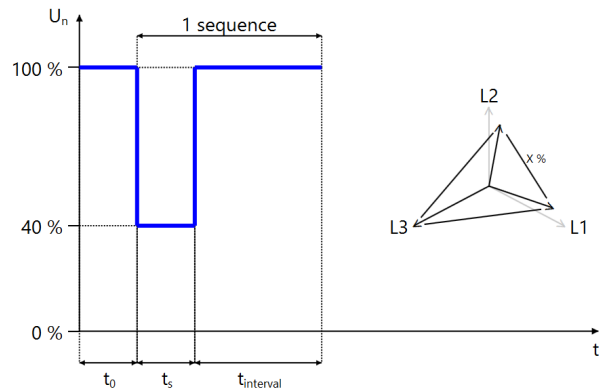

Fig. 29: Voltage dip 70% without neutral - method A

Fig. 30: Voltage dip 40% with without neutral – method B

Software module IEC 61000-2-2

Automatic testing according to IEC 61000-2-2:2018 Ed 2.2

◢ IEC 61000-2-2
  ◢ Edition 2.2 2018-05
    Harmonics
    Voltage unbalance
    Temporary power frequency variation

Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems

Integrated functions of the software module:
- control of APS amplifier
- generation of: 4.3 Harmonics
- generation of: 4.6 Voltage unbalance
- generation of: 4.8 Temporary power frequency variation

Required hardware:
4-quadrant amplifier APS

Selected test name: Harmonics

Test options:

Parameter	Value	Unit
Use EMC nominal AC voltage from the global parameters	☑	
U_n	230	Vrms
U_{end}	230	Vrms
Use EMC nominal AC frequency from the global parameters	☑	
f_n	50	Hz
Phase system	▼ Single phase	
Effect duration	▼ Long-term effect	
Disturbed phase(s)	▼ L1	
Use free adjustable values	☐	
t_0 (one-time)	1	s ▼
Test time	10	min ▼
factor k	1	

Odd harmonics (non-multiple of 3)

Test level for h = 5	6	%
Test level for h = 7	5	%
Test level for h = 11	3.5	%
Test level for h = 13	3	%
Test level for 17 ≤ h ≤ 37	▼ 2.27 * (17 / h) - 0.27	%
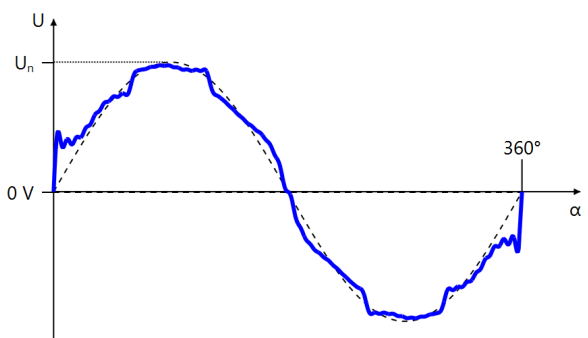
Fig. 31: Harmonics

Selected test name: Voltage unbalance

Test options:

Use EMC nominal AC voltage from the global parameters	☑	
U_n	230	Vrms
U_{end}	230	Vrms
% of U_n for L1	100	%
L1	230	Vrms
Start angle of L1	0	deg
% of U_n for L2	98	%
L2	225.4	Vrms
Start angle of L2	121	deg
% of U_n for L3	95.2	%
L3	218.96	Vrms
Start angle of L3	240	deg
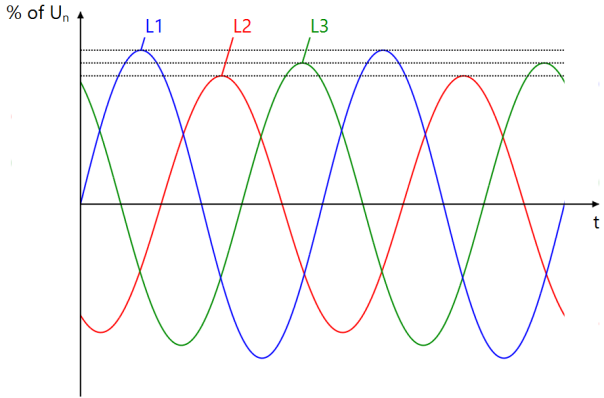
Fig. 32: Voltage unbalance

Selected test name: Temporary power frequency variation

Test options:

Parameter	Value	Unit
Use EMC nominal AC voltage from the global parameters	☑	
U_n	230	Vrms
U_{end}	230	Vrms
Use EMC nominal AC frequency from the global parameters	☑	
f_n	50	Hz
Phase system	▼ Single phase	
Compatibility level (±)	1	Hz
$f_{end, 1}$	51	Hz
$f_{end, 2}$	49	Hz
t_0 (one-time)	1	s ▼
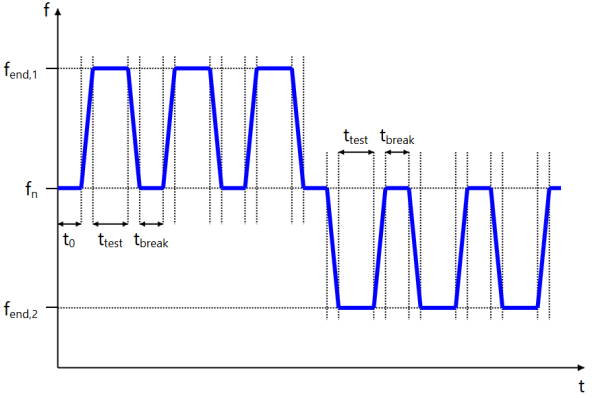
Fig. 33: Power frequency variation

Software module IEC 61800-3

Automatic testing according to IEC 61800-3:2017 Ed 3.0

◢ IEC 61800-3
  ▷ Edition 2.1 2012-03
  ◢ Edition 3.0 2017-02
    ◢ Harmonics and commutation notches/voltage distortion
      ▷ Single phase
      ▷ Three phase
    ◢ Voltage deviations, dips and short interruptions
      ▷ Single phase
      ▷ Three phase
    ◢ Voltage unbalance and frequency variations
      ▷ Single phase
      ▷ Three phase

Adjustable speed electrical power drive systems

Integrated functions of the software module:
- control of APS amplifier
- 5.2 Basic immunity requirements - low frequency disturbances
- 5.2.2 Harmonics and commutation notches/voltage distortion
- 5.2.3 Voltage deviations, dips and short interruptions
- 5.2.4 Voltage unbalance and frequency variations

Required hardware:

4-quadrant amplifier APS
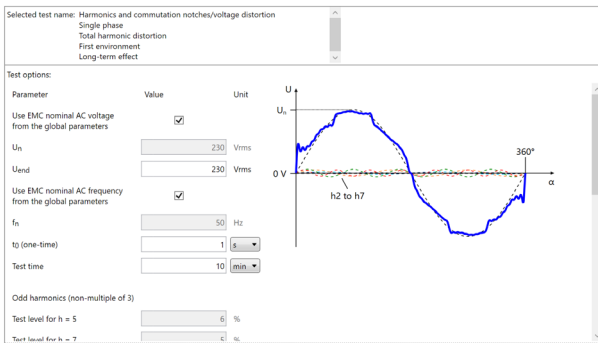
Fig. 34: Harmonics combination
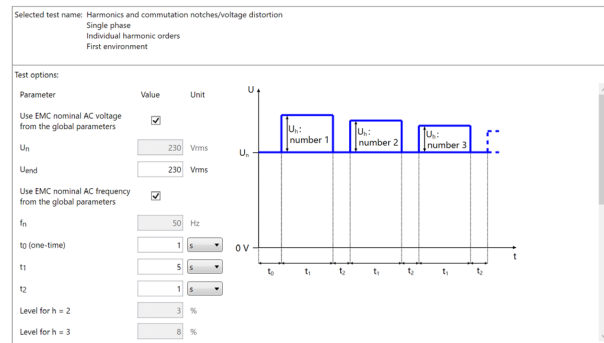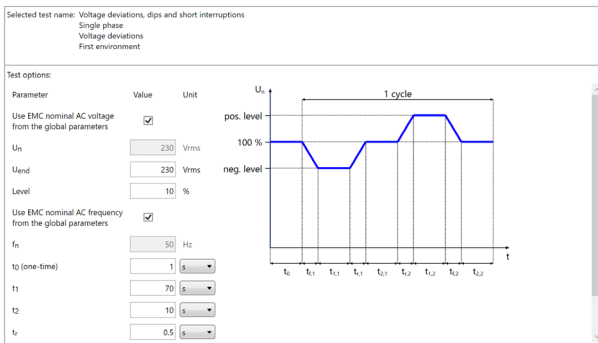

Fig. 35: Individual harmonics
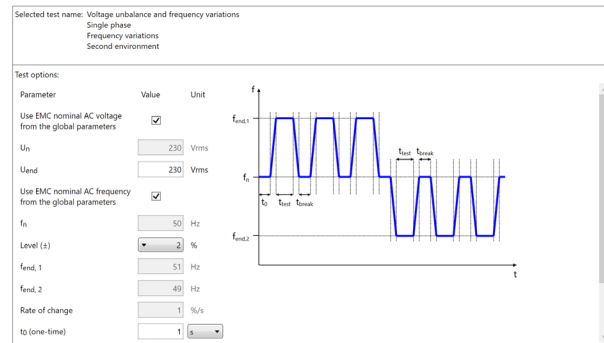

Fig. 36: Voltage deviations
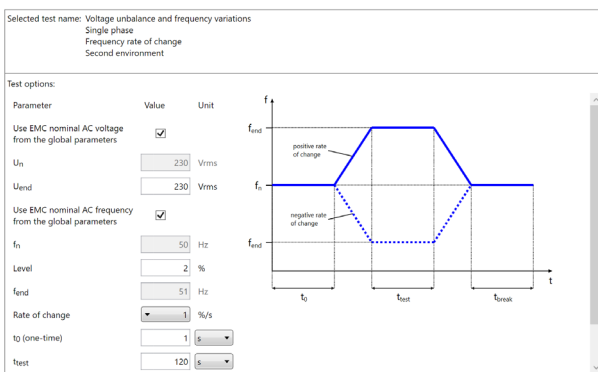

Fig. 37: Frequency variations
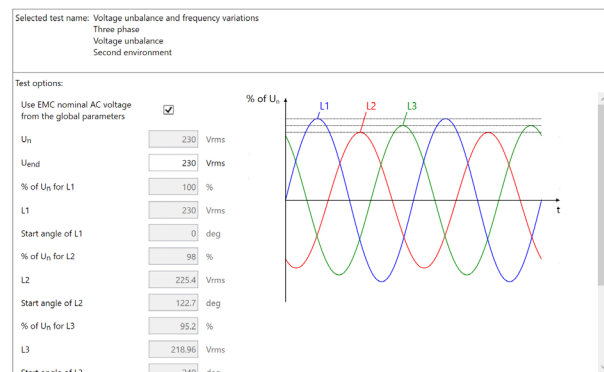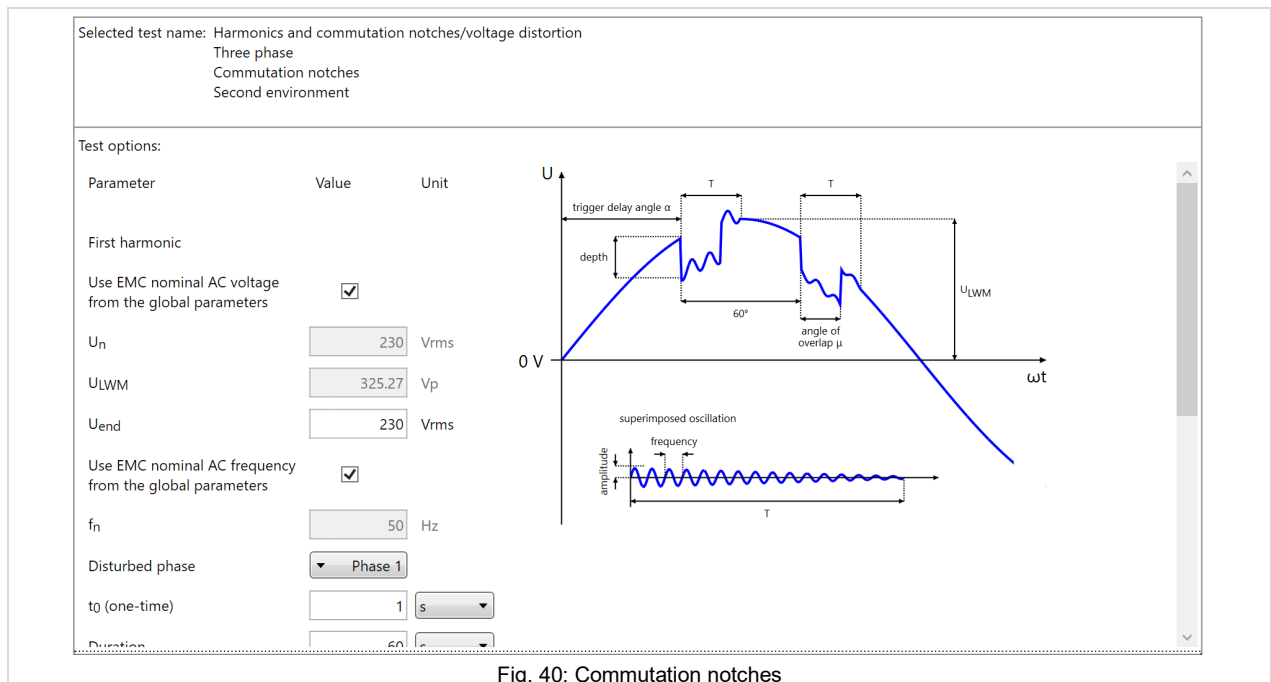

Fig. 38: Frequency rate of change

Fig. 39: Voltage unbalance 3-phase

Fig. 40: Commutation notches

Software module IEC 62040-2

Automatic testing according to IEC 62040-2:2016 Ed 3.0

Uninterruptible power systems (UPS)

Integrated functions of the software module:
- control of APS amplifier
- D.6 Immunity to low-frequency signals
- D.6.1 Power line harmonics and inter-harmonics
- D.6.2 Power line unbalance (three-phase UPS systems only)

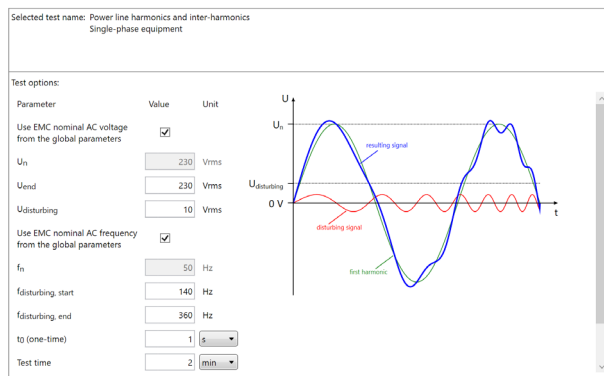Required hardware:

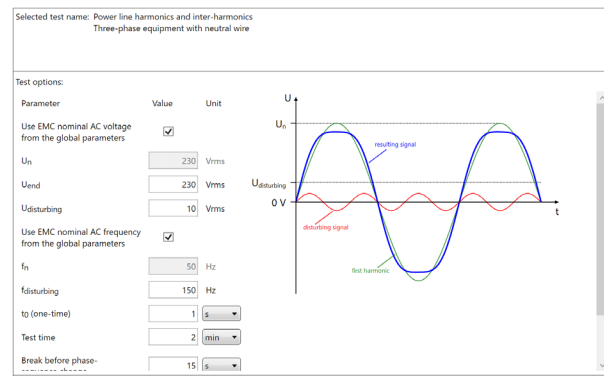4-quadrant amplifier APS

Fig. 41: Harmonics and interharmonics
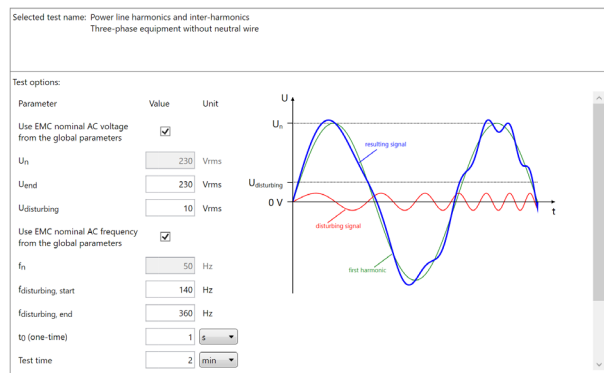

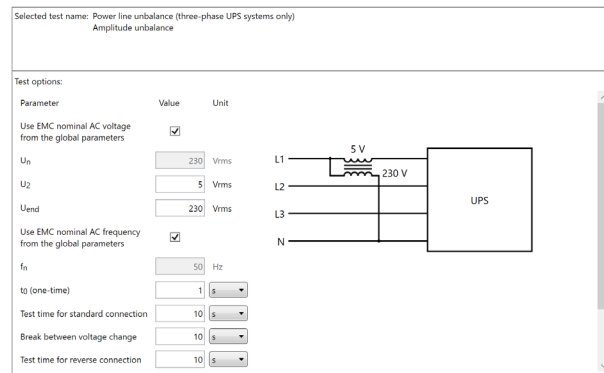Fig. 42: 3-phase with neutral

Fig. 43: 3-phase without neutral

Fig. 44: Amplitude unbalance

Software module IEC TR 61547-1

Automatic testing according to IEC TR 61547-1:2020 Ed 3.0

◢ IEC TR 61547-1
  ▷ Edition 2.0 2017-10
  ◢ Edition 3.0 2020-07
    ◢ Voltage fluctuations
      39 cpm at 0.325 Hz
      110 cpm at 0.9167 Hz
      1056 cpm at 8.8 Hz
      1620 cpm at 13.5 Hz
      4000 cpm at 33 ⅓ Hz
      4800 cpm at 40 Hz
      Free adjustable values

Simulation of voltage fluctuations

Integrated functions of the software module:
- control of APS amplifier
- simulation of voltage fluctuations

Required hardware:

4-quadrant amplifier APS

Selected test name: Voltage fluctuations
                     1056 cpm at 8.8 Hz

Test options:

Parameter	Value	Unit
Nominal voltage	230	Vrms
End voltage	230	Vrms
Nominal frequency	50	Hz
Voltage change per minute cpm	1056	
Modulation frequency f_m	8.8	Hz
Relative voltage fluctuation $d = \Delta U / U$	0.275	%
t_0 (one-time)	1	s
Test time	180	s
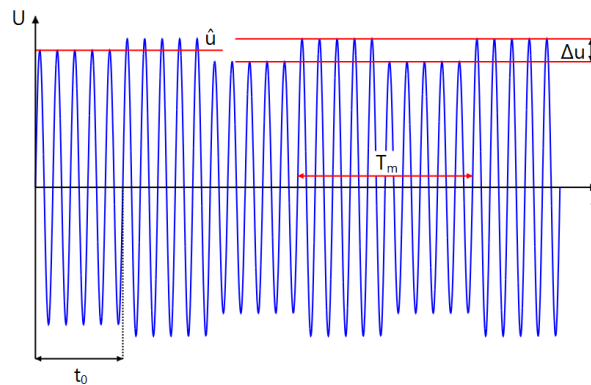
Fig. 45: Voltage fluctuations

Software modules under development – available soon…

Software module IEC 60146-1-1 Automatic testing according to IEC 60146-1-1:2009 Ed 4.0	Simulation of commutation notches - control of APS amplifier - simulation of commutation notches/ Part 1
Software module IEC 61131-2 Testing according to IEC 61131-2:2017 Ed 4.0	Programmable controllers - Part 2: Equipment requirements and tests - control of APS amplifier - testing with voltage and frequency deviation - superposition of the third harmonic - generation of short voltage dips - generation of continuous changes, slow - generation of continuous changes, partial
Software module IEC 61496-1 Automatic testing according to IEC 61496-1:2020 Ed 4.0	Safety of machinery - Electro-sensitive protective equipment - Part 1: General requirements and tests - control of APS amplifier - 5.4.1 Rated supply voltage (voltage variation, frequency variation and harmonic simulation) - 5.4.3.1 Supply voltage variation - 5.4.3.2 Supply voltage interruptions
Software module DNVGL-CG-0339 Automatic testing according to Germanischer Lloyd – DNVGL-CG-0339:2019	a.c. interference on d.c. mains and simulation of harmonics on a.c. mains - control of APS amplifier - 14.4 Conducted low frequency immunity test
Software module SEMI F47-0706 Automatic testing according to SEMI F47-0706:2006	Specification for semiconductor processing equipment voltage sag immunity - control of APS amplifier - sequential operation of defined pulses - automatic capturing of the waveforms of voltage and current - graphical documentation of the generated voltage dips and/or voltage changes in the test report
Software module IEC 61000-4-4 Automatic testing according to IEC 61000-4-4:2012 Ed 3.0	Electrical fast transient/burst immunity test - control of APS amplifier, Multi-CE5 - generating fast transient disturbances as defined in IEC standard
Software module IEC 61000-4-5 Automatic testing according to IEC 61000-4-5:2017 Ed 3.1	Surge immunity test - control of APS amplifier, Multi-CE5 - generating fast transient disturbances as defined in IEC standard

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