ZES ZIMMER
Electronic Systems

CE-Conformity • SYS61K Test System

EN 61000-3-2 Harmonics
EN 61000-3-3 Flicker

SYS61K

SYS61K e 11.00

Electromagnetic compatibility and CE mark

Electrical installations, systems and devices which are to be marketed within the EC must be given the CE mark of conformity by the manufacturer or the importer. The products must be tested to ensure that they satisfy the requirements of the law relating to Electromagnetic Compatibility (EMC). The standards of the EMC law classify the permissible degree of electromagnetic interference emission as well as immunity to it.
An electric device with a non-linear load characteristic creates current harmonics – even with a purely sinusoidal voltage.
Through the impedance of the mains, these harmonics cause voltage drops and distort the line voltage – an effect perturbating mains that proceeds from the device and reduces the voltage quality. To regulate power consumption, certain devices (such as hotplates, instant water heaters etc.) switch on erratically and repeatedly. Due to the reference impedance, these sudden current variations change the line voltage level in the same way. This gives rise to line voltage fluctuations which cause fluctuations in the brightness of electrical lighting, so-called flickering, an undesirable effect.
Measuring methods and limits for these **low-frequency perturbation on mains** caused by **current harmonics** and **flicker** are also specified in the **standards relating to the EMC law**.
Conformity must be tested.
The EN61000-3-2/-3 is almost identical to IEC61000-3-2/-3.

EN61000-3-2 Harmonics analysis

The above-mentioned perturbation effects could be reduced or even eliminated by reducing the mains network impedance. However, it was decided to tackle the problem at the source and to limit the generation of current harmonics in the devices and electrical appliances.
The permissible limit values and measuring methods are laid down in the standard EN61000-3-2.
There are 4 device classes (A, B, C, D), for which different evaluation methods and limit values apply. Below is the table for classifying devices according to EN61000-3-2/A14.

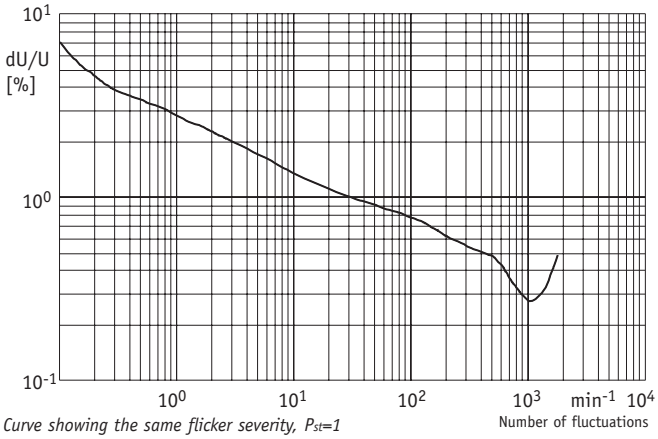
Class A	- Balanced three-phase equipment - Household appliances except equipment identified as Class D - Tools excluding portable tools - Dimmers for incandescent lamps - Audio equipment
Class B	- Portable tools
Class C	- Lighting equipment
Class D	- Equipment having a specified power according less than or equal to 600W, of the following types: - Personal computers and personal computer monitors - Television receivers

Classification of devices according to EN61000-3-2/A14

For EN61000-3-2 an other classifying is used.
The ZES ZIMMER power measuring devices from the LMG series (LMG95 and LMG450) can carry out an evaluation of compliance with the standard according to the relevant device class.
In a standardised test, the test sample is fed by a purely sinusoidal and stable voltage from a power source.
It must be made clear that the measured current harmonics come from the test sample and are not generated from the source.
The LMG devices test the freedom from distortion and voltage stability of the source in each analysis window of 10, 12 or 16 periods.

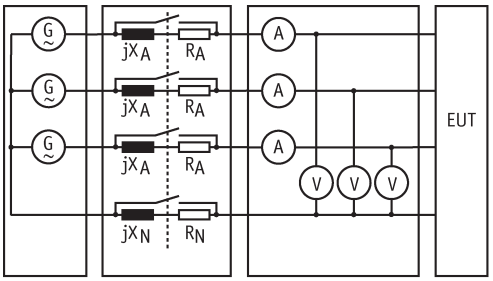
EN61000-3-3 Flicker and voltage changes

Flicker is determined by the amplitude and frequency of line voltage fluctuations. Voltage fluctuations in turn occur in the mains network impedance through the repeated sudden current variations of a consumer.
In order to obtain comparable measured results, a standardised mains network impedance must be inserted between the infeed source and the test sample when measuring flicker. The impedance values for this reference impedance are defined as $(0.24+j0.15)\Omega$ in the phases and $(0.16+j0.10)\Omega$ in the neutral.
The adjacent diagram shows the curve of the same flicker severity $P_{st}=1$. This curve has been established in many experiments with persons, and determines what voltage changes may occur within a certain measuring interval and how often, without people regarding these changes and the resultig flicker as annoying.
The curve of the same flicker strength shows that at 1058 fluctuations per minute (approx. 8.8 Hz) sensitivity for flicker phenomena is greatest (this is where the relative voltage fluctuations for $P_{st}=1$ are lowest). The standard EN61000-3-3 also defines limits for the maximum voltage change (d_{max}) caused by appliances. Also that deviation which may only occur at switch-on. For this reason the devices which do not create any flicker in its operation have to be tested on d_c and d_{max}.



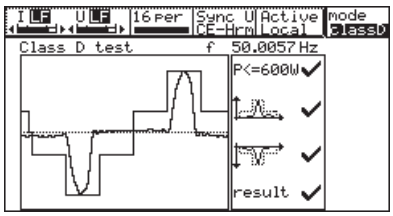
Curve showing the same flicker severity, $P_{st}=1$

Measuring set-up

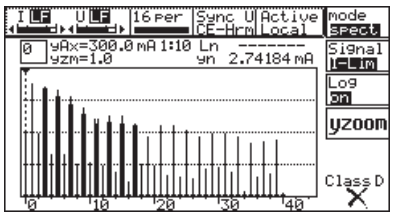


Measuring set-up for measurements in accordance with EN61000-3, 3-phase

With the LMG series of high-precision power meters/analysers, direct measurements can be carried out in accordance with the adjacent block diagram, with good result visualisation on the graphic monitor of the LMG devices.



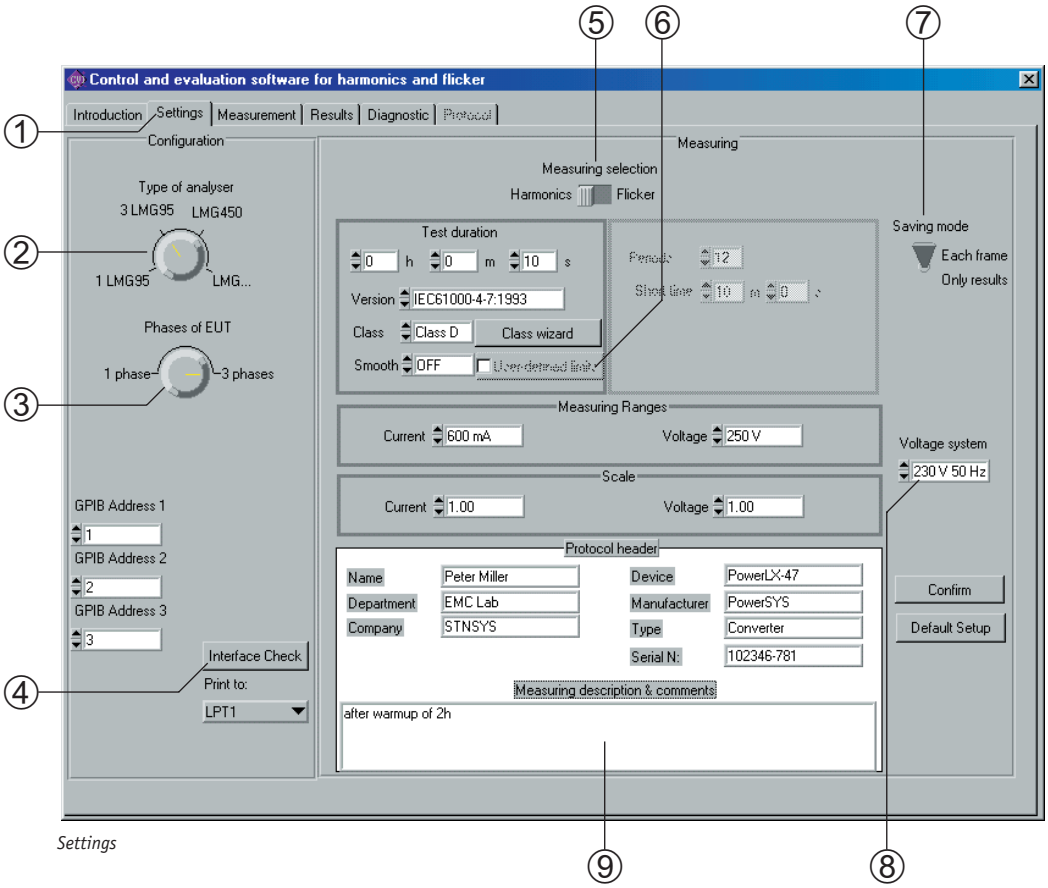
Device classification for Class D



Current harmonics with limit values in accordance with Class D (analysis window over 10, 12 or 16 periods in accordance with EN61000-3-2)

System software for SYS61K

All operating states of the test sample must be run through in standardised tests.
To establish long-term flicker P_{lt}, 2 h are required, the examination of the harmonics of a washing machine with various washing cycles, for example, also takes several hours. This requires system software that monitors all settings, archives measured data from each analysis window for subsequent evaluation and diagnostics and prints out the test protocols required for a CE declaration.



Settings

The “Settings” screenshot shows the set-up menu for the system software of the SYS61K (order no. SYS61K-Soft).
“Settings” (1) has been selected in the upper selection bar for the various parts of the program. In the “Configuration” field the type of measuring instrument used is selected with the selection button (2), and the system, whether 1-phase or 3-phase, is selected with the selection button (3).
In the lower part of the “Configuration” field, the addresses are set for the measuring instruments used and the printer port. The settings can be checked with the “Interface Check” button (4). In the “Measuring” field the “Measuring selection” slide control (5) is used to set the required test run, and the “Version” selection window is used to define the standard (new, old or future) according to which the test is to be carried out.
The device class can be set using “Class”, and the “Class wizard” button allows the class to be defined automatically. “Smooth” is used to toggle the 1.5 s filter. Limit values can be specified by the user with the “User defined limits” button (6). The scope of result archiving is selected with switch (7). In the “Voltage System” selection window (8) it is possible to switch to a different line voltage and/or frequency.
The protocol header (9) shows the set test conditions, and test-specific data can also be entered here.

Measurement of harmonics

The “Measurement” menu in the screenshot above shows the current measurement as defined in the “Settings” menu for testing harmonics.

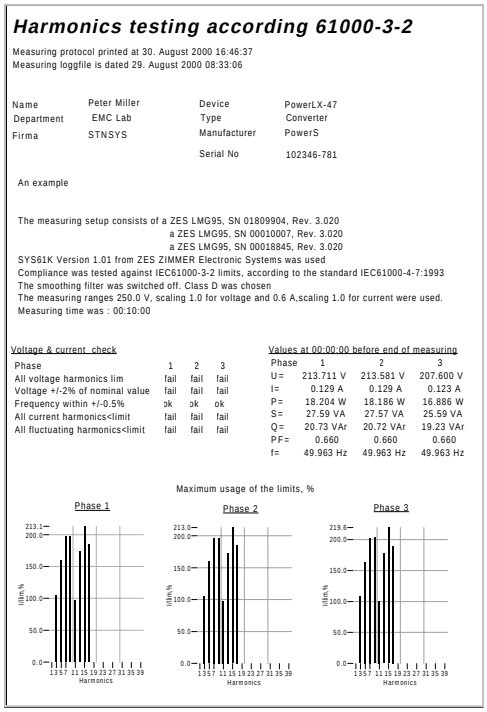
Measurement of flicker

This screenshot shows a flicker measurement in progress. The 1st, 6th and 10th short time flicker value P_{st} is above the permissible value P_{st}=1 in all three phases. The “Remaining time” window shows the time still required to determine a long time flicker value P_{lt}. P_{lt} is calculated as an average of the 12 P_{st} values.

Result/test protocol

The test protocol generated automatically by the program is shown in the "PROTOCOL" menu. Test-specific information can be added in this menu.

The "PRINT" button can be used to print out a shortened protocol, which is however sufficient as a CE certificate, and the "ADVANCED" button is used to print out an extended protocol with tables and graphs. The graph shows the maximum value of each harmonic related to its limit (usage of limits).



Harmonics testing according 61000-3-2

Measuring protocol printed at 30. August 2000 16:46:37
Measuring logfile is dated 29. August 2000 08:33:06

Name	Peter Miller	Device	PowerLX-47
Department	EMC Lab	Type	Converter
Firma	STNSYS	Manufacturer	PowerS
		Serial No	102346-781

An example

The measuring setup consists of a ZES LMG95, SN 01809904, Rev. 3.020
a ZES LMG95, SN 00010007, Rev. 3.020
a ZES LMG95, SN 00018845, Rev. 3.020
SYS61K Version 1.01 from ZES ZIMMER Electronic Systems was used
Compliance was tested against IEC61000-3-2 limits, according to the standard IEC61000-4-7:1993
The smoothing filter was switched off. Class D was chosen
The measuring ranges 250.0 V, scaling 1.0 for voltage and 0.6 A,scaling 1.0 for current were used.
Measuring time was : 00:10:00

Voltage & current check

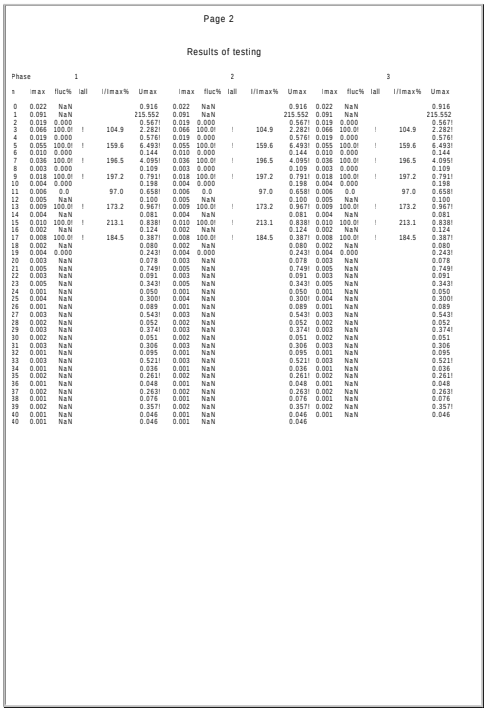
Phase	1	2	3
All voltage harmonics lim	fail	fail	fail
Voltage +/-2% of nominal value	fail	fail	fail
Frequency within +/-0.5%	ok	ok	ok
All current harmonics<limit	fail	fail	fail
All fluctuating harmonics<limit	fail	fail	fail

Values at 00:00:00 before end of measuring

Phase	1	2	3
U=	213.711 V	213.581 V	207.600 V
I=	0.129 A	0.129 A	0.123 A
P=	18.204 W	18.186 W	16.886 W
S=	27.59 VA	27.57 VA	25.59 VA
Q=	20.73 VAr	20.72 VAr	19.23 VAr
PF=	0.660	0.660	0.660
f=	49.963 Hz	49.963 Hz	49.963 Hz

Maximum usage of the limits, %

Phase 1 Phase 2 Phase 3



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Results of testing

Phase	1					2					3				
n	Imax	fluc%	Iall	I/Imax%	Umax	Imax	fluc%	Iall	I/Imax%	Umax	Imax	fluc%	Iall	I/Imax%	Umax
0	0.022	NaN			0.916	0.022	NaN			0.916	0.022	NaN			0.916
1	0.091	NaN			215.552	0.091	NaN			215.552	0.091	NaN			215.552
2	0.019	0.000			0.567!	0.019	0.000			0.567!	0.019	0.000			0.567!
3	0.066	100.0!	!	104.9	2.282!	0.066	100.0!	!	104.9	2.282!	0.066	100.0!	!	104.9	2.282!
4	0.019	0.000			0.576!	0.019	0.000			0.576!	0.019	0.000			0.576!
5	0.055	100.0!	!	159.6	6.493!	0.055	100.0!	!	159.6	6.493!	0.055	100.0!	!	159.6	6.493!
6	0.010	0.000			0.144	0.010	0.000			0.144	0.010	0.000			0.144
7	0.036	100.0!	!	196.5	4.095!	0.036	100.0!	!	196.5	4.095!	0.036	100.0!	!	196.5	4.095!
8	0.003	0.000			0.109	0.003	0.000			0.109	0.003	0.000			0.109
9	0.018	100.0!	!	197.2	0.791!	0.018	100.0!	!	197.2	0.791!	0.018	100.0!	!	197.2	0.791!
10	0.004	0.000			0.198	0.004	0.000			0.198	0.004	0.000			0.198
11	0.006	0.0		97.0	0.658!	0.006	0.0		97.0	0.658!	0.006	0.0		97.0	0.658!
12	0.005	NaN			0.100	0.005	NaN			0.100	0.005	NaN			0.100
13	0.009	100.0!	!	173.2	0.967!	0.009	100.0!	!	173.2	0.967!	0.009	100.0!	!	173.2	0.967!
14	0.004	NaN			0.081	0.004	NaN			0.081	0.004	NaN			0.081
15	0.010	100.0!	!	213.1	0.838!	0.010	100.0!	!	213.1	0.838!	0.010	100.0!	!	213.1	0.838!
16	0.002	NaN			0.124	0.002	NaN			0.124	0.002	NaN			0.124
17	0.008	100.0!	!	184.5	0.387!	0.008	100.0!	!	184.5	0.387!	0.008	100.0!	!	184.5	0.387!
18	0.002	NaN			0.080	0.002	NaN			0.080	0.002	NaN			0.080
19	0.004	0.000			0.243!	0.004	0.000			0.243!	0.004	0.000			0.243!
20	0.003	NaN			0.078	0.003	NaN			0.078	0.003	NaN			0.078
21	0.005	NaN			0.749!	0.005	NaN			0.749!	0.005	NaN			0.749!
22	0.003	NaN			0.091	0.003	NaN			0.091	0.003	NaN			0.091
23	0.005	NaN			0.343!	0.005	NaN			0.343!	0.005	NaN			0.343!
24	0.001	NaN			0.050	0.001	NaN			0.050	0.001	NaN			0.050
25	0.004	NaN			0.300!	0.004	NaN			0.300!	0.004	NaN			0.300!
26	0.001	NaN			0.089	0.001	NaN			0.089	0.001	NaN			0.089
27	0.003	NaN			0.543!	0.003	NaN			0.543!	0.003	NaN			0.543!
28	0.002	NaN			0.052	0.002	NaN			0.052	0.002	NaN			0.052
29	0.003	NaN			0.374!	0.003	NaN			0.374!	0.003	NaN			0.374!
30	0.002	NaN			0.051	0.002	NaN			0.051	0.002	NaN			0.051
31	0.003	NaN			0.306	0.003	NaN			0.306	0.003	NaN			0.306
32	0.001	NaN			0.095	0.001	NaN			0.095	0.001	NaN			0.095
33	0.003	NaN			0.521!	0.003	NaN			0.521!	0.003	NaN			0.521!
34	0.001	NaN			0.036	0.001	NaN			0.036	0.001	NaN			0.036
35	0.002	NaN			0.261!	0.002	NaN			0.261!	0.002	NaN			0.261!
36	0.001	NaN			0.048	0.001	NaN			0.048	0.001	NaN			0.048
37	0.002	NaN			0.263!	0.002	NaN			0.263!	0.002	NaN			0.263!
38	0.001	NaN			0.076	0.001	NaN			0.076	0.001	NaN			0.076
39	0.002	NaN			0.357!	0.002	NaN			0.357!	0.002	NaN			0.357!
40	0.001	NaN			0.046	0.001	NaN			0.046	0.001	NaN			0.046

Analysis/diagnostics software for the SYS61K

A conformity test with the software described above confirms the quality of the device. It provides documentation that the CE-tested device produces current harmonics and flicker only within the limits permitted in the standards. For the developer and device manufacturer, this good/bad statement offers not enough support for the further development and improvement of his product. During the development process he must carry out pre-compliance tests in order to determine the level of harmonics and/or flicker at each respective stage of development of the product. In addition, he requires a tool with which he can easily display dependence on harmonics and/or flicker and thus detect their causes.

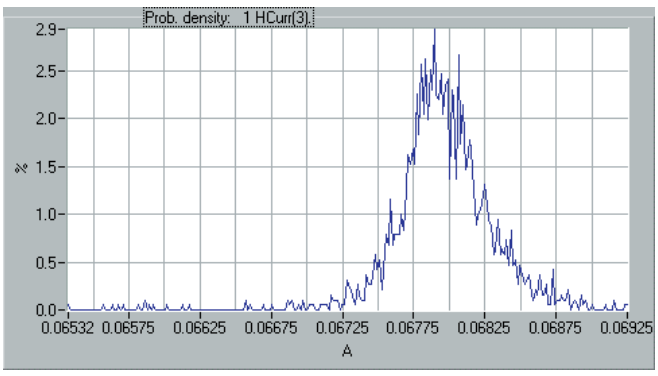
Statistical and regression methods which are provided in the analysis and diagnostics software for the SYS61K are often used for this. If dependence and causes are known, it is then possible to initiate specific countermeasures that are also efficient in terms of time. Modern devices which are connected to low-voltage mains often represent a combined consumer that consists of various types of load. A typical example is the washing machine, which represents a combination of thermal and motor loads. Here, harmonics and flicker often depend on several parameters (active power and reactive power, power fluctuations, current etc.).

The execution of EMC tests on such appliances during the development phase requires simultaneous measurement of these variables. An elaborate subsequent analysis of influencing factors and their effects is necessary.

The implementation of statistical and regression analysis in the evaluation software allows a fast, detailed and easy-to-understand investigation of harmonics and flicker as well as their dependence on current, voltage, reactive power and active power and on changes in these variables. This is very helpful in the development phase. When a washing machine is being tested, the influence of the thermal and motor parts, for example, can be viewed separately. This allows a statement about which block is responsible for the increase in harmonics.

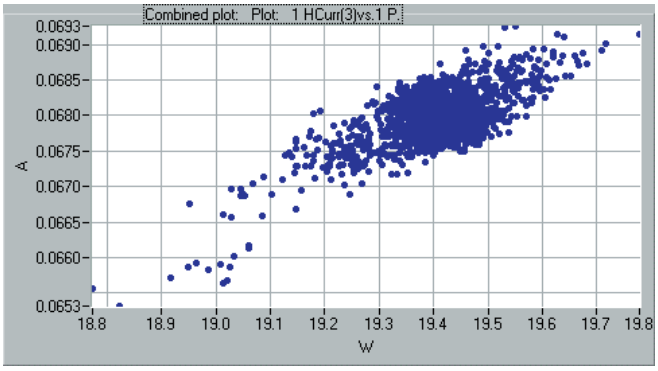
In the flicker test of a copier, for example, it can quickly be determined that flicker is caused by changes in the active power. Power conditions are determined by various parameters (trigger angle, impedance etc.).

In this situation, the software allows a rapid comparative analysis of the different variants.



Normal distribution

The “process signal interface” in the LMG devices makes it possible to monitor additional influencing variables (rotating speed, temperature etc.) in order to analyse the effect on harmonics and flicker in different operating phases of a test sample.
The “Normal distribution” graph shows the third current harmonic of phase 1.
The device developer will display several different relationships and will thus quickly get to know important dependence conditions, and so will be able to obtain hints for improvement. The “Regression” graph



Regression

shows the dependence of the third current harmonic of phase 1 on the active power received. A power consumption of 19.4W results in an average value of 68mA for the third harmonic. It is also clear that the third harmonic shows linear dependence on power.

Ready-to-use systems and components

ZES ZIMMER supplies ready-to-use systems, 1-phase or 3-phase. The AC power sources are selected to the customer’s test requirements. Thanks to the modular, open system architecture, power sources that are already available to the customer can be integrated. Upgrading from a 1-phase to a 3-phase system just by adding two other LMG95 and two power sources is possible.
In each analysis window of 10, 12 or 16 periods, the LMG series of high-precision power meters/analysers checks to find out whether the source in use is sufficiently voltage-stable and distortion-free for the conformity test.
For pre-compliance and only to support development the system can be used without AC-sources by using special active filters at the mains.
Besides complete ready-to-use systems, ZES ZIMMER can of course also supply its customers with the individual hardware and software components used in the systems.
The table shows the available **AC-sources for various testing performances**.
The AC-sources of i-series can optionally be equipped with a controller for arbitrary wave forms. Tests can be performed on device immunity comparable to the standards as mentioned below:

- voltage variation **(EN61000-4-11)**
- harmonics **(EN61000-4-13)**
- over-/undervoltage **(EN61000-4-14)**
- frequency variation **(EN61000-4-28)**

Modell	Phasen-zahl	Umax	Imax	Ipk	Smax
801RP	1	270V	3A	13,8A	0,8kVA
1251RP-400	1	270V	4,6A	13,8A	1,25kVA
2001RP	1	270V	6,7A	22,2A	2kVA
2003RP	3	270V	2,5A/ϕ	7,5A/ϕ	2kVA
3001i	1	270V	11A	55A	3kVA
5001i-400	1	270V	18,5A	92,5A	5kVA
10001i-400	1	270V	37A	185A	10kVA
15001i-400	1	270V	55,5A	277A	15kVA
15003i-400	3	270V	18,5A/ϕ	92,5A/ϕ	15kVA

AC sources for various testing performances

In the RP series, arbitrary curve shapes can be set to a limited extent using the PC port.
The NI2415 **reference impedance** is available as 1-phase and 3-phase versions. It is designed for a current level of 16 A per phase.
The reference impedance can be remote-controlled via the digital outputs of the “process signal interface” of the LMG devices.
For measurements of harmonics currents, it is bridged by the built-in switch. It is switched in again for measuring flicker.
The **software for the SYS61K** (order no. SYS61K-Soft) can also be obtained separately. However, it can only run with the LMG95 and LMG450 analysers.


1-phase version of the SYS61K


3-phase version of the SYS61K with 3 x LMG95 power measuring device and source 3 x 5 kVA

ZES ZIMMER Electronic Systems

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