Wide Band Power Analyzer System

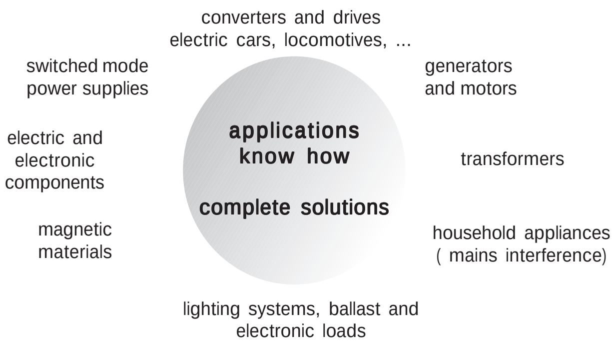
NORMA D 6000

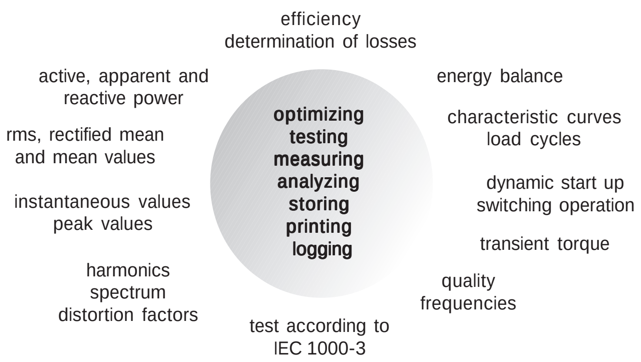
- **Complete system for high end power analysis, flexible and modular**
- **Single to six phase models (1 to 12 channels)**
- **Highest precision (0.05% for current and voltage measurements, < 0.1% for power measurements)**
- **Frequency range DC to 1 MHz**
- **Calibration certificates valid for 24 months !**
- **Harmonic analysis DFT and FFT, integrated memory for measured values, graphic display**
- **Optimal versions for motor- and transformer-measurements**

APPLICATIONS

For highest demands on precision

In many fields like developing laboratories and testing facilities, in quality assurance and also at commissioning on-site there are many demanding measuring problems to be solved. High precision, wide bandwidth and immunity to interference are advantages of the Power Analyzer NORMA D 6000 of LEM Instruments.





For Highest Demands on Flexibility

The system series D6000 is designed to be completely modular. There are basic instruments for six or twelve plug-in units, various current and voltage channels, interfaces and additional options. Resulting from that there are complete sets, optimized for standard, motor or transformer analysis, each in single-, three or six phase versions.

D 6000 S : Standard configuration
The standard configuration covers a wide field of applications. Extensions can be made quickly on-site by simply adding plug-in units.

D 6000 M : Motor and generator analysis.
The version M is extremely suitable for measurements on motors and generators. DC- , asynchronous, and synchronous motors, and special machines.
Torque, speed, mechanic shaft output, slip, efficiency and of course all the electrical parameters are measured precisely and simultaneously. High accuracy guarantees the exact determination of losses. Furthermore special dynamic measurements of torque can be made.
The viewing of torque in time domain shows torque harmonics.
Up to twelve channels can work together simultaneously. It is possible to completly analyze converter drives.
All partial efficiencies and the total efficiency are calculated.
Frequency spectrum, distortion factor, rectification factor, inversion factor, ripple of the intermediate circuit and other specific parameters can be determined.

D 6000 T: Transformer test
This version is designed specially for testing tranformers. It offers an even higher measuring accuracy at very small power factors. Accuracies of power measurements are better than 0.1% for power factors of 1 to 0.1 and 0.4% for power factors of 0.01. This allows exact analysis.
The no-load power losses are corrected automatically in accordance with the form factor.
The single phase version of the D 6000 T is often used for measuring high quality capacitors and reactors.

LEM

D 6000 - THE POWER ANALYZING SYSTEM

For highest demands on analysis.

Flexible measuring conditions
By means of multiple modes of synchronization, filtering, triggering and averaging an optimal adaption to particular measuring tasks is possible.The shortest average time to get all measured values continuously is 14ms.

Detailed analysis of distorted wave formes
Harmonics can be analized by means of Discrete Fourier Transformation DFT (up to the 99th harmonic) or spectral lines by means of Fast Fourier Transformation (FFT) of currents, voltages and also power. The results can be presented numerically or graphically.

Formula editor
This function provides an online processing of measured values. In this way also partial efficiencies or fundamental efficiencies can be determined in addition to the standard total efficiency in real time.

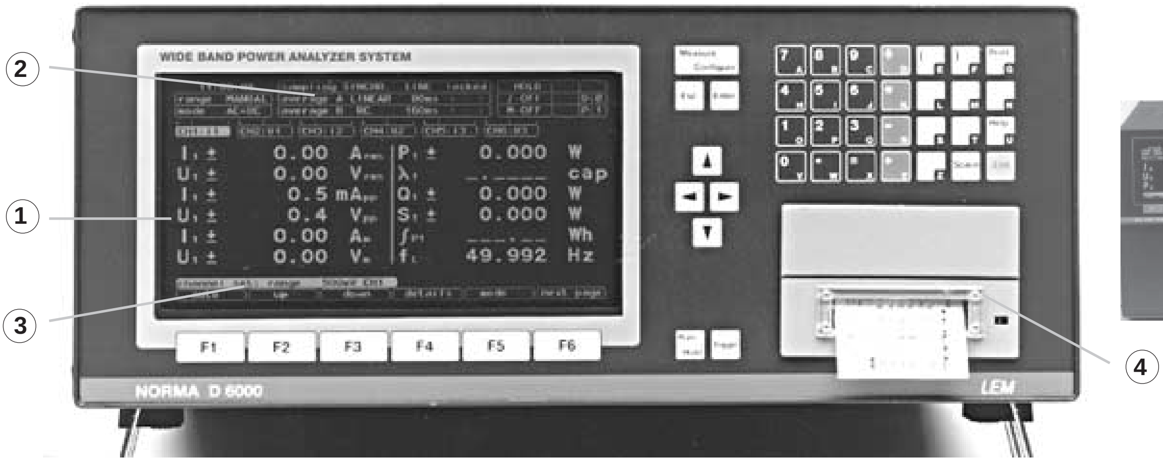
Recording
An internal memory supports the recording of sampled or average values. Various trigger conditions are supported.

Graphic wave forms
Wave forms, transient dynamic events and trend analysis or even x(y)-diagrams are shown on the display.

Load and energy management
6 parameters can be user selected for simultaneous and continuous integration (ΣWh, -Wh, VAh, varh, Ah ...). The recording shows e.g. the 24-hour-profile for maximum demand analysis. Via measuring of the power factor compensation equipment can be checked. 6 freely programmable control outputs can be used for automatic switching of loads. The trigger can be set on user selected values.

Tests in conformance with standard IEC 1000 -3
In prescribed tests of current harmonics and flicker according to appropriate standards the D 6000 offers full functionality and certified accuracy.

Tests of electric three-phase-machines
In addition to the electrical and mechanical parameters the determination of the airgap torque from the sampled values of current and voltages is possible in the D 6000 . In this case no mechanic measuring shaft is necessary. An extended field of applications and dynamic failure preventing analysis are enabled.



① Graphics display
The electroluminescent monitor (512 x 256 pixels) offers many possibilities of numeric and graphic analysis. The λ/4 antiglare glass filter provides a large viewing area during all lighting conditions.

② Settings
The major settings of the instrument are visible at first glance. So you are constantly informed about range selection, input level, operating modes, sampling and averaging, as well as integrators and memory function.

③ User guided operation
Context relevant menu strips and control or entering keys make your individual settings easier. A user help text is available in several languages. In addition to 3 standard configurations 11 further individual configurations can be stored in order to be prepared for various applications. The recently used configuration is stored automatically.

④ Thermal printer 61 P2
The graphics compatible printer (200 dpi) rapidly produces screen copies (25 m of paper per roll).

General data, Quality and Safety

Dimensions of basic instruments (W x H x D)
4 HU : 450 x 190 x 550 mm (19", 4 HU)
8 HU : 450 x 370 x 550 mm (19", 8 HU)
Mass: Complete instrument
three-phase (6 plug-in units): approx. 16.5 kg
six-phase (12 plug-in units): approx. 29.0 kg
Temperature ranges: nominal temperature range: 18... 28°C
working temperature range: 0... 40°C
storage temperature range: -20... +50°C
Protection type: IP 30
Protective class: I
Climatic class: KYG as per DIN VDE 40040, humidity max. 85%, no dewing
Safety: IEC 61010-1, EN 61010-1
max. voltage against earth 1kV CATIII
Verschmutzungsgrad 2

Test voltages
of the input-channels: HI - LO/G - PE: 6 kV_{RMS} / 50 Hz / 1 min
Voltage plug-in 61U1: HI - LO: test pulse 8 kV / 1.2 / 50µs
Voltage plug-in 61U2: HI - LO: test pulse 1.5 kV / 1.2 / 50µs
Current plug-in 61I1, 61I2: HI - LO: 250 V_{RMS} / 50Hz
Current plug-in 61I3: HI - LO: 150 V_{RMS} / 50Hz
Transient influence: mains input : standard test pulse 3kV, 1.2 / 50µs
Test voltage: mains - PE: 1.5 kV_{RMS} / 50 Hz
CE: Certificate of conformity according to the guide lines for emission and immission standards
Mechanical strength:
DIN VDE 57411 page 1 / DIN VDE 0411 part 1, chapter 11
Vibration test : test in normal position in all three directions with 0.35 mm amplitude and 10... 100Hz.
approx. 14g.

D 6000 - THE POWER ANALYZER SYSTEM

For highest demands on the technology of instruments

Essential for highest precision are the linear frequency response and the computation of measured quantities independent of waveshape . Moreover there are exact simultaneous sampling and minimal angular errors relevant for accurate measurement of power. The D 6000 achieves a continuous frequency range from DC to 1 MHz (bandwidth 2 MHz) with high linearity and small amplitude-errors down to 0.05%. Simultaneous sampling of up to 12 channels results in angular errors as small as a few millidegrees . Because of that you get results of highest accuracy, also in measuring of mixed quantities, distorted waveforms, high frequencies and small power factors.
In developing this analyzer considerable attention was paid to high immunity to interference. Because of sophisticated double screening and additional GUARD-inputs a common mode rejection of up to 135 dB at 100 kHz is achieved. Even with extremely variable floating potentials your measurements are accurate. This excellent common mode rejection is of great benefit for applications of frequency converters and electronic lighting equipment.

The system D 6000 meets the demands of flexibility, accuracy and immunity to interference also by using cylindrically designed and screened triaxial shunts.

Calibration
The power analyzers have been designed, produced and tested as per ISO 9001 and as standard are delivered with a calibration certificate. Via our calibration laboratory the measured quantities are traceable to international standards.

We exclusively use high-quality components and therefore we can extend the validity of the specifications to **24 months**. Thus you save a lot of time and money for recalibration.

Reliable measuring results are guaranteed.

5 Flexibility
Owing to the modular design the D 6000 can be supplied with user selected voltage and current channels. All channels are calibrated on their own; no recalibration is necessary after changing channels. The inputs are floating and galvanically isolated from each other. The voltage channels are designed for measurements from 50 mV_{RMS} to 2500 V_{PEAK} . The current channels are useable in connection with wide band triaxial shunts from 3 μA_{RMS} to 1500 A_{RMS}.The calibrated shunt factor is automatically taken into account . For current measurements we also supply precision clamp-on transformers and solid core current transformers. Additional scale factors can be entered. The D 6000 even enables online correction for measuring transformer errors.

6 PC - Interfaces - Automation
Various options include IEEE 488 and RS 232 for remote control, Centronics for direct transfer to a printer, up to 12 analog outputs and 6 relay outputs as well as additional inputs for torque and speed. The D 6000 system matches the requirements of integration into an automatic testing station. All analysis can be made on the D6000 system itself or easily transmitted to and displayed on a PC with the software Power Win 6000 in order to obtain test reports rapidly.

7 Power Supply power consumption 110 VA
The supply takes place via fuses and can be switched either to 115V (90 - 135V) or to 230V (187 - 264 V), at 45 to 65 Hz. The power supply unit also contains an external trigger socket and an external synchronization socket.

Interface 61D1

IEEE-488 interface and 6 analog outputs (userdefined, with free assignment and scaling)

Analog outputs

Output voltage:	max. ± 10.5 V ; max. load 2 mA , short-circuit-proof , common LO at protective earth potential
Output rate:	corresponding to the actual averaging period
Permissible ext. overload:	max. 50 V_{RMS} at the HI input
Additional error:	± (0.15 % of rdg + 5 mV)
Resolution:	± 5000 digits for ± 10 V
Rise time:	approx. 10 ms for 10 ... 90 %

Interface 61D3

RS 232 and Centronics (for operation with an external printer)

Interface 61D2 Motor

IEEE-488, RS 232 and Centronics, 12 analog outputs and 6 relay outputs (controlling of the ext. relay box 61R1), inputs for torque and speed measurement.

Analog outputs:	see interface 61D1
Torque input:	**analog**
Measuring range:	-10 V ... 0 V ... +10 V (DC)
Sampling rate:	1.6 kHz
Accuracy:	± (0.1 % of rdg + 0.05 % of rng)
Input resistance:	approx. 200 kΩ
Overvoltage:	max. 50 V_{RMS}
Speed inputs:	**digital,** 90° shifted
Frequency range:	1 Hz ... 200 kHz
Input voltage:	max. 50 V_{RMS}
Accuracy:	± 0.01 % of rdg
Input resistance:	approx. 200 kΩ

Input n: speed measurement, Input d: direction of rotation

SPECIFICATIONS - Voltage Channels

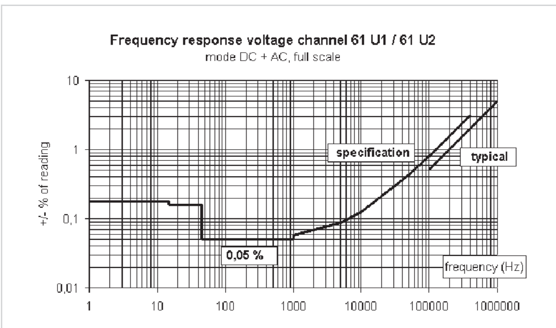
Voltage channel 61U1 with HI, LO and Guard inputs

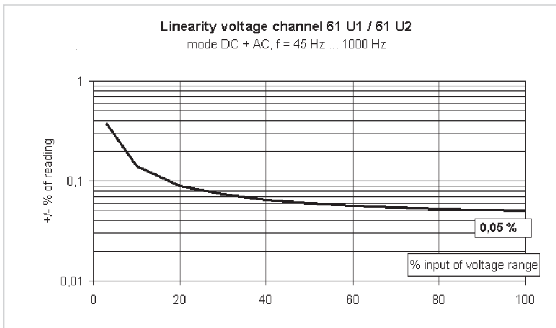
Voltage channel 61U1 Standard voltage channel with double screening and 3 safety inputs for HI , LO and GUARD.			**Voltage channel 61U2** Like voltage channel 61U1 but with lower measuring ranges for measuring of low voltages or voltage drops. It is used for example for measuring of chokes, coils, varistors, PTC´s and so on.		
Measuring range	Max. input DC, square	Max. input sine	Measuring range	Max. input DC, square	Max. input sine
25 V_{PEAK}	25 V_{RMS}	17 V_{RMS}	2.5 V_{PEAK}	2.5 V_{RMS}	1.7 V_{RMS}
45 V_{PEAK}	45 V_{RMS}	32 V_{RMS}	4.5 V_{PEAK}	4.5 V_{RMS}	3.2 V_{RMS}
90 V_{PEAK}	90 V_{RMS}	64 V_{RMS}	9 V_{PEAK}	9 V_{RMS}	6.4 V_{RMS}
180 V_{PEAK}	180 V_{RMS}	128 V_{RMS}	18 V_{PEAK}	18 V_{RMS}	12.8 V_{RMS}
340 V_{PEAK}	340 V_{RMS}	240 V_{RMS}	34 V_{PEAK}	34 V_{RMS}	24 V_{RMS}
670 V_{PEAK}	670 V_{RMS}	470 V_{RMS}	67 V_{PEAK}	67 V_{RMS}	47 V_{RMS}
1300 V_{PEAK}	1300 V_{RMS}	920 V_{RMS}	130 V_{PEAK}	130 V_{RMS}	92 V_{RMS}
2100 V_{PEAK}	2100 V_{RMS}	1500 V_{RMS}	210 V_{PEAK}	210 V_{RMS}	150 V_{RMS}

Accuracy	**Limits of error ± (% of rdg + % of rng)**			
Frequency range	AC + DC	AC	AC + DC	AC
0 Hz ... 15 Hz	± (0.15 + 0.03)	-	± (0.15 + 0.03)	-
15 Hz ... 45 Hz	± (0.15 + 0.01)		± (0.15 + 0.01)	
45 Hz ... 1 kHz	± (0.04 + 0.01)		± (0.04 + 0.01)	
1 kHz ... 400 kHz	± [(0.04+0.0045/kHz) + (0.01+0.003/kHz)]		± [(0.04+0.0045/kHz) + (0.01+0.003/kHz)]	
400 kHz ... 1 MHz	typical : - 0.5 % of rdg. / 100 kHz		typical : - 0.5 % of rdg. / 100 kHz	

Additional error for measuring of peak values	± 0.1% of rng	± 0.1% of rng
Input Impedance	10 MΩ // 12 pF	1 MΩ // 30 pF
Overload	1770 V_{RMS} / 2500 V_{PEAK} continuously (in all ranges)	500 V_{RMS} / 700 V_{PEAK} continuously (in all ranges)
Common mode rejection (CMR):	120 dB at 1000 V and 100 kHz	110 dB at 500 V and 100 kHz

Limits of error valid for 24 months after calibratrion
at inputs of 3 ... 100 % of measuring range and (23 ± 5) °C





SPECIFICATIONS - Current channels

Current channel 61I1 with triaxial socket for shunt identification

Current channel 61I1

Plug-in unit for the connection of a triaxial shunt, a shunt adapter (for external high current shunts), the clamp-on transformer 61C1, or the LEM transducer set IT. Via a 9pol socket the shunts or transformers are identified automatically.

Measuring range	Max. input DC, square	Max. input sine
50 mV_{PEAK}	50 mV_{RMS}	35 mV_{RMS}
158 mV_{PEAK}	158 mV_{RMS}	110 mV_{RMS}
500 mV_{PEAK}	500 mV_{RMS}	350 mV_{RMS}
1580 mV_{PEAK}	1580 mV_{RMS}	1100 mV_{RMS}

Current channel 61I2

Like current channel 61I1 but with even higher angular accuracy. This current channel is used in the transformer version and in all applications that depend on high accuracy at small power factors.

Measuring range	Max. input DC, square	Max. input sine
50 mV_{PEAK}	50 mV_{RMS}	35 mV_{RMS}
158 mV_{PEAK}	158 mV_{RMS}	110 mV_{RMS}
500 mV_{PEAK}	500 mV_{RMS}	350 mV_{RMS}
1580 mV_{PEAK}	1580mV_{RMS}	1100mV_{RMS}

Current channel 61I3

Like current channel 61I1 but with lower measuring ranges. Thus results a higher dynamic range at current measurements in connection with the triaxial shunts.

Measuring range	Max. input DC, square	Max. input sine
15.8 mV_{PEAK}	15.8 mV_{RMS}	11.0mV_{RMS}
50 mV_{PEAK}	50 mV_{RMS}	35 mV_{RMS}
158 mV_{PEAK}	158 mV_{RMS}	110 mV_{RMS}
500 mV_{PEAK}	500 mV_{RMS}	350 mV_{RMS}

Accuracy	Limits of error ± (% of rdg + % of rng)					
	Range 50 mV	Ranges 158...1580 mV	Range 50 mV	Ranges 158...1580 mV	Range 15.8 mV	Ranges 50 ... 500 mV
Frequency range	AC + DC		AC + DC		AC + DC	
0 Hz …15 Hz	± (0.15 + 0.05)	± (0.15 + 0.03)	± (0.15 + 0.05)	± (0.15 + 0.03)	± (0.15 + 0.05)	± (0.15 + 0.03)
	(AC + DC) and AC		(AC + DC) and AC		(AC + DC) and AC	
15 Hz …45 Hz	± (0.15 + 0.03)	± (0.15 + 0.01)	± (0.15 + 0.03)	± (0.15 + 0.01)	± (0.15 + 0.03)	± (0.15 + 0.01)
45 Hz …1 kHz	± (0.04 + 0.02)	± (0.04 + 0.01)	± (0.04 + 0.02)	± (0.04 + 0.01)	± (0.04 + 0.02)	± (0.04 + 0.01)
1 kHz…100 kHz	±[(0.04+0.0045/kHz) +(0.02+0.0045/kHz)]	± [(0.04 + 0.0045/kHz) +(0.01+ 0.003/kHz)]	±[(0.04+0.02/kHz) +(0.02+0.0045/kHz)]	±[(0.04+0.0045/kHz) +(0.01+0.003/kHz)]	±[(0.04+0.0045/kHz) +(0.02+0.0045/kHz)	±[(0.04+0.0045/kHz) +(0.01+0.003/kHz)
100 kHz…400 kHz					typical: -1.5 % of rdg / 100 kHz	
400 kHz…1 MHz	typical: -2 % of rdg/100 kHz	typical: -1 % of rdg / 100 kHz				

	61I1	61I2	61I3
Additional error for measuring of peak values	Range 50 mV: ± 0.5% of rng Range 158 mV: ± 0.3% of rng Range 500 mV, 1,58V: ± 0.1% of rng	Range 50 mV: ± 0.5% of rng Range 158 mV: ± 0.3% of rng Range 500 mV, 1,58V:± 0.1% of rng	Range 15.8 mV: ± 0.5%of rng Range 50 mV: ± 0.3% of rng Range 158 mV, 500mV:± 0.1% of rng
Input impedance:	101 kΩ // 30 pF	101 kΩ // 30 pF	31,9 kΩ // 81 pF
Overload	250 V_{RMS} / 350 V_{PEAK} continuously (in all ranges)	250 V_{RMS} / 350 V_{PEAK} continuously (in all ranges)	25 V_{RMS} / 35 V_{PEAK} continuously (in all ranges)
Common mode rejection (CMR):	135 dB at 1000 V and 100 kHz	135 dB at 1000 V and 100 kHz	135 dB at 1000 V and 100 kHz

Angular error

Phase angle between voltage and current , in both channels AC+DC - mode, without LP-filter

Between current channel 61 I 1 and voltage channels

Range	0...100Hz	100Hz...1kHz	Additional error
50mV	0.015°	0.020°	0.005°/kHz
158mV	0.005°	0.010°	0.005°/kHz
500mV	0.005°	0.005°	0.005°/kHz
1580mV	0.005°	0.005°	0.005°/kHz

Between current channel 61 I 2 and voltage channels

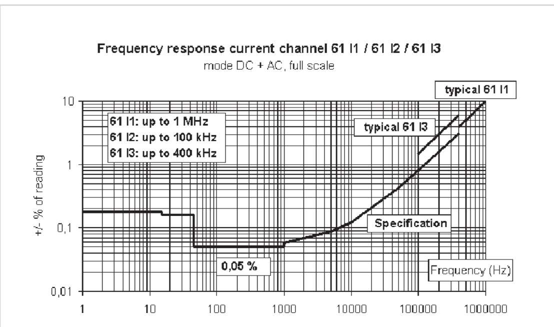
Range	0...45Hz 65...100Hz	45Hz... 65Hz 1)	100Hz... 1kHz	Additional error up to 10kHz
50mV	0.015°	0.002°	0.020°	0.005°/kHz
158mV	0.005°	0.002°	0.010°	0.005°/kHz
500mV	0.005°	0.002°	0.005°	0.005°/kHz
1580mV	0.005°	0.002°	0.005°	0.005°/kHz

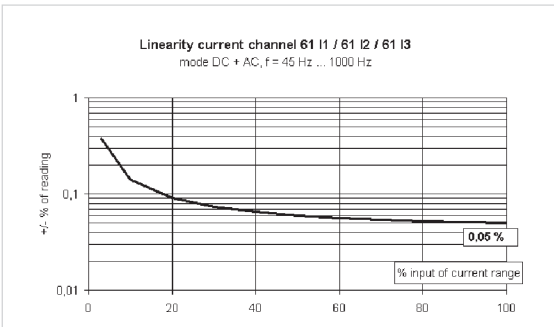
Between current channel 61 I 3 and voltage channels

Range	0...100Hz	100Hz... 1 kHz	Additional error
15.8mV	0.015°	0.020°	0.005°/kHz
50mV	0.005°	0.010°	0.005°/kHz
158mV	0.005°	0.005°	0.005°/kHz
500mV	0.005°	0.005°	0.005°/kHz

1) The specification for 45 Hz ... 65 Hz is valid for the voltage ranges 25 V_p ... 340 V_p (max. 240 V_{RMS})

Limits of error valid for 24 months after calibratrion
at inputs of 3 ... 100 % of measuring range and (23 ± 5) °C



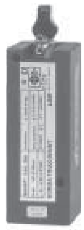


SPECIFICATIONS - Triaxial shunts

In the system D 6000 the high demands on accuracy are taken into account additionally by cylindrically designed and shielded triaxial shunts with GUARD connection. A continuous frequency range from DC to up to 1 MHz, amplitude error of 0.03 % and negligible phase errors of 0.1°/100 kHz secure accurate results also with mixed quantities, distorted wave forms, high frequencies and small power factors.
The calibration data are stored directly in the shunts and are recognized automatically by the D 6000 - you can measure at once. The ***certified accuracy data*** of these highly linear and stable components are also valid for ***24 months*** after calibration.

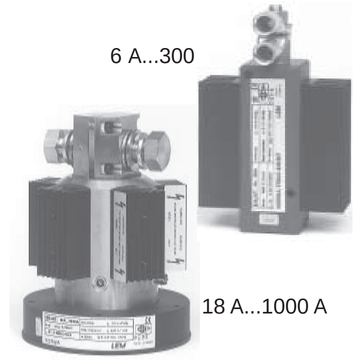
Triaxial plug-on shunts
0.3 mA...300 mA

3 mA...3 A



External triaxial shunts

6 A...300



18 A...1000 A

		Triaxial plug-on shunts 3 µA ... 100 A									External triaxial shunts 6 A ... 1500 A		
Continuous load range	**I_{min}**	**3 µA**	**30 µA**	**0,3 mA**	**1 mA**	**3 mA**	**30 mA**	**0.1 A**	**0.3 A**	**1 A**	**6 A**	**18 A**	**18 A**
	I_{max}	**3 mA**	**30 mA**	**300 mA**	**1 A**	**3 A**	**10 A**	**30 A**	**50 A**	**100 A**	**300 A**	**1000 A**	**1500 A**
Nominal current		**0.3 mA**	**3 mA**	**30 mA**	**0,1 A**	**0,3 A**	**3 A**	**10 A**	**16 A**	**30 A**	**100 A**	**300 A**	**500 A**
Nominal voltage drop		100 mV	100 mV	100 mV	100 mV	100 mV	100 mV	100 mV	50 mV	30 mV	20 mV	18 mV	30 mV
Nominal resistance		333 Ω	33 Ω	3 Ω	1 Ω	333 mΩ	33 mΩ	10 mΩ	3 mΩ	1 mΩ	0.2 mΩ	0.06 mΩ	0.06 mΩ
Short time overrange	5 s load 15 s interval	-	-	-	2 A	4 A	20 A	35 A	60 A	200 A	450 A	1500 A	2000 A
Overload protection up to		1 A			-	-	-	-	-	-	-	-	-
Overload W_{max}		-	-	-	20 Ws	25 Ws	60 Ws	90 Ws	180 Ws	200 Ws	2 kWs	7.5 kWs	10 kWs
Band width		2 MHz			2 MHz						1 MHz	500 kHz	200 kHz
Frequency range		0...100 kHz			0...1 MHz			0...500 kHz		0..200 kHz	0..100 kHz	0..20 kHz	0...20 kHz
Angular accuracy [°/ kHz]		± 0.003	± 0.002	± 0.001	± 0.001					± 0,002	± 0.002	± 0.025	± 0.025
Basic accuracy [%)		**± 0.2**	**± 0.1**	**± 0.1**	**± 0.03**						**± 0.1**		
Frequency influence [% / kHz]		± 0.002			± 0.0015						± 0.01	± 0.03	± 0.03
Load influence [% / A²]		-			$\pm 1 * 10^{-6}$						$\pm 0.1 * 10^{-6}$	$\pm 0.2 * 10^{-6}$	$\pm 0.5 * 10^{-6}$
Temperature coefficient [ppm/K]		≤ 20			≤ 15						≤ 10		
For current channels		61 I1 / 61 I2			61 I1 / 61 I2 / 61 I3						61 I1 / 61 I2 / 61 I3		
Mass		0.15 kg			0.6 kg			0.75 kg			1.2 kg	5.3 kg	6 kg

Clamp-on transformer 61C1

Continuous load range	(1 A...) 5 A...1000 A
Frequency range	10Hz...5kHz (...30kHz)
Overload	1200 A
Scale factor	1000 A / 1V
Max. conductor diameter	54 mm

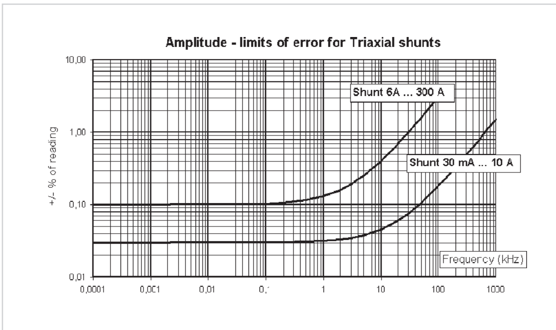
Limits of error % of rdg	**Current 1 A ... 5 A**	**Current 5 A ... 1000 A**	**Angle**
10 Hz … 20 Hz	± 0.4	± 0.2	1.5°
20 Hz … 45 Hz	± 0.4	± 0.2	0.8°
45 Hz … 65 Hz	± 0.3	± 0.2	0.3°
65 Hz … 1 kHz	± 0.4	± 0.2	0.3°
1 kHz ... 5 kHz	± 0.4	± 0.4	1°
5 kHz … 20 kHz	± 0.4	± 0.4	5°
20 kHz ... 30 kHz	± 1	± 1	5°

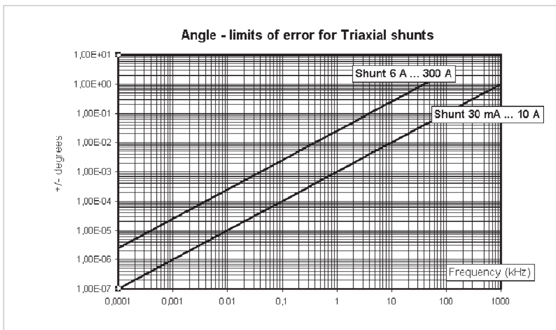
Stray field influence : <0,2 % at 5 A and 400 A/m

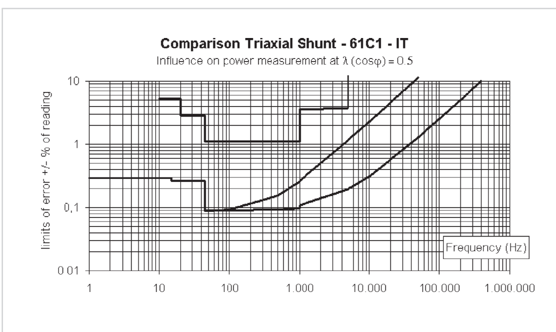
LEM transducer set IT

For all current channels the current measurement can also be made by means of precise active straight-through current transformers in connection with specially adjusted shunt adapters.

	Set IT 150-S	Set IT 600-S
Continuous load range	1 A ... 150 A	5 A ... 600 A
Overload	165 A	660 A
Bandwidth	100 kHz	
Frequency range	0 ... 30 kHz	
Basic accuracy [%] at nominal current	± 0.01	
Frequency influence [%/kHz]	± 0.1	
Angular accuracy [°/kHz]	± 0.05	
Scale factor	150 A / 400 mV	600 A / 400 mV
Max. conductor diameter	26 mm	
Mass	1 kg	







SPECIFICATION - Power Measurement

Limits of error valid for 24 months after calibratrion
at inputs of 3 ... 100 % of measuring range and (23 ± 5) °C

The limits of error F_P for active power consist of the limits of error of the voltage channel F_V , the current channel F_A, the shunt F_{Sh} and the angle F_W.
F_P is calculated according to international agreement:

$$F_p = \frac{2}{\sqrt{3}} * \sqrt{F_v^2 + F_A^2 + F_{Sh}^2 + F_W^2}$$

Voltage channel error F_V: from the specifications of voltage channels 61U1 or 61U2

Current channel error F_A: from the specifications of current channels 61 I 1 , 61 I 2 or 61 I 3

Shunt error F_{Sh}: from the specifications of the selected shunt

Angular error F_W: depends on the input of the power measuring range, the power factor (cos φ) and the sum of angular errors Δφ of the particular current channel F_{GW} and the shunt F_{SW} (or transformer) (F_{GW} and F_{SW} from the particular specifications)

$$F_W = \sqrt{\frac{I_N * U_N}{I * U}} * \frac{\cos(\varphi + \Delta\varphi) - \cos\varphi}{\cos\varphi} * 100$$

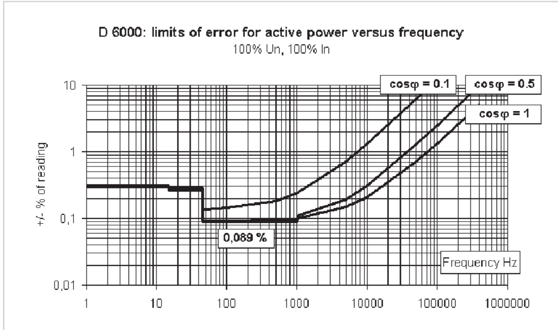
Results / important key results of these calculations:

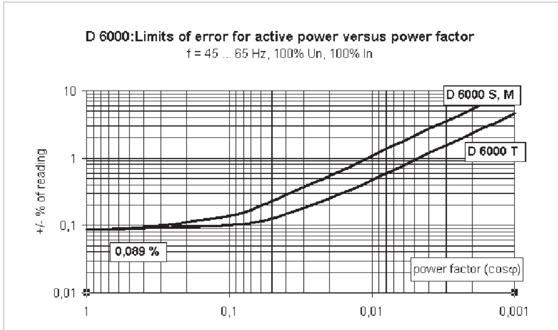
Limits of error for active power	± % of rdg for S and M		
Frequency	Power factor (cos φ)		
	1	0.5	0.1
1 Hz	0.296	0.296	0.313
50 Hz	0.089	0.091	0.138
1 kHz	0.089	0.097	0.238
10 kHz	0.211	0.31	1.32
100 kHz	1.32	2.5	
400 kHz	5.04		

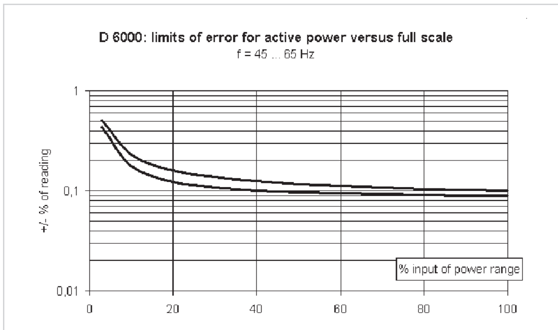
Limits of error for active power	± % of rdg at 50 Hz	
Power factor (cos φ)	D 6000 T	D 6000 S, M
1	0.089	0.089
0.1	0.1	0.138
0.01	0.472	1.07
0.001	4.64	

Limits of error for active power	± % of rdg at 50 Hz			
Input of power measuring range	D 6000 T		D 6000 S, M	
	Power factor (cos φ)			
	1	0.1	1	0.1
100 %	0.089	0.1	0.089	0.138
50 %	0.097	0.117	0.097	0.179
10 %	0.175	0.228	0.175	0.379

Assumption: worst case of an asymmetrical input (for instance input of power measuring range of 10 % results from 100 % input of voltage channel and 10 % input of current channel)







Frequency measurement

Each voltage and current channel, the line or an external input can be used for frequency measurement.

Range: 0.2 Hz .... 400 kHz

Accuracy: ± 0.01 % of reading

For measurements of highly distorted signals (e.g. of inverters) two filtering methods are available:

a) a switchable lowpass filter (RC, 1st order, f_C = 60 Hz) for synchronization with the fundamental

b) a switchable lowpass filter 0 ... 1kHz (switched capacitor filter) with 5 selectable filter steps 1.75 / 8 / 35/ 150 / 800 Hz which offers the following advantages:
- Improved frequency measurement of highly distorted signals in the range of 0.2 Hz ... 1 kHz
- Better synchronization (Phase Locked-Loop PLL) with highly distorted signals in the range of 8 Hz ... 1 kHz.

Remark: For functions that require synchronized sampling a software controlled synchronization for low frequencies down to 0.5 Hz is also available.

OPTION Data Memory and Analysis 61E1

This option has the following additional functions :

- Harmonic analysis (DFT or FFT)
- Evaluation of spectrum (Distortion Factor, Telephone Factor, ...)
- Data memory (sampled values, average values)
- Computation of rectified mean values of delta voltages

Harmonic analysis

Discrete Fourier Transformation (DFT)

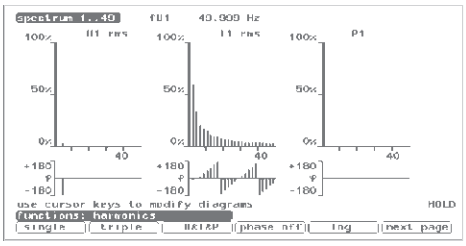
Principle: Discrete Fourier Transformation with synchronization with the fundamental and rectangular window, switchable anti-aliasing filter (Butterworth, 3rd order, f_c = 6 kHz). The representation can be selected between sin- and cos- series.

Computation: DC-component, fundamental and up to the 99th (D6200 : 49th) harmonic of voltage, current and power with the angle between the particular harmonics and their fundamental. The calculation of the harmonics is selectable between RMS-value, % of total RMS-value or % of fundamental.

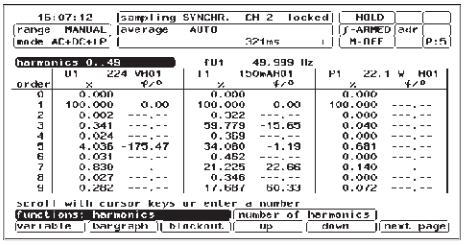
Visualisation, Output of DFT

a) complete spectrum as bargraph or as table on the display, at the thermoprinter or at an external printer.

b) fundamental, single harmonics or weighting factors can also be shown on the display.



Display of the spectrum as bargraph



Display of the spectrum as table

Fast Fourier Transformation (FFT)

Principle: Numeric FFT - algorithm for the calculation of the spectral lines of selectable input quantities. No synchronization is necessary with the measured signal. The FFT also enables the calculation of subharmonics and intermediate harmonics and the analysis of transient or non periodic events.

Computations, measured values: spectral lines of line voltages U_X, line currents I_X, delta voltages V_{XV} (displayed as RMS-values) and of active power can be calculated.

Visualisation, Output of FFT

a) **Graphical display** of complete range of frequency or of selectable frequency window. Also numerical display of the fundamental and the measured quantity under the moveable cursor.

b) **Numerical display** of the fundamental; frequency (f_{01}) and value (e.g. U_{H01}). These values can be displayed on the screen stored in memory and displayed graphically, or used for further calculations via *userdefined functions*.

Specifications of DFT:

Frequency range:	max. fundamental frequency: 6.5 kHz	
	H_{09} ... 5 kHz	H_{19} ... 1.25 kHz
	H_{49} ... 500 Hz	H_{99} ... 250 Hz
max. harmonic frequency:	without LP-filter:	20 ... 30 kHz
	(with LP-filter: 12 kHz)	

Accuracy of synchronization:

± 0.03% at 45...65 Hz (as per IEC 1000-3-2)

Locking range: PLL on: 10 Hz...6.5 kHz fundamental frequency
PLL off (software controlled synchronization): 0.6 Hz ... 5 kHz fundamental frequency

Setting time: approx. 200 ms

Limits of error:

Fundamental: according to the specified accuracies of relevant measured quantity

Harmonics:

without LP-filter: for U and I: ± (0.02% of H_{01} + 0.01% of H_{01}/kHz)
for P: sum of errors of U and I

with LP-filter: filter of 3rd order , frequency response of amplitude and phase corrected by software up to 13 kHz
for U and I: up to 6 kHz :
±(0.1% of H_{01}+ 0.2% of H_{01}/kHz)
above 6 kHz:
±1% of H_{01}+ 2% of H_{01}/(f - 6 kHz)
for P: sum of errors of U and I + 2 times phase error; the LP-filter must be ON in both channels.

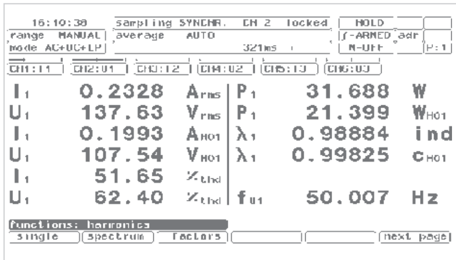
Phase angle : phase angle is displayed for harmonics with amplitude > 1 % .

without LP-filter: ± (0.1 ° + 0.05 ° / kHz)

with LP-filter: ± (0.1 ° + 0.2 ° / kHz)

Noise margin: > 80 dB

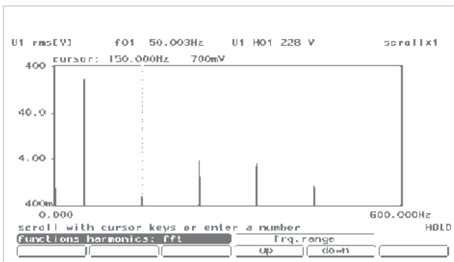
Intermodulation: < 0.05 % of H_{01}



Display of fundamental and THD

Specifications of FFT :

Sampling frequency:	65.536 kHz (fixed frequency)
Length:	4096 points
Frequency ranges:	8 frequency ranges, 0 ... 150 / 300 / 600 / 1200 / 2500 / 5000 / 10000 / 32000 Hz
Resolution:	0.125 / 0.25 / 0.5 / 1 / 2 / 4 / 8 / 16 Hz
Window function:	Hanning ($\cos^2$), with subsequent arithmetical smoothing
Limits of error:	based on the limits of error for voltage, current and power. Additional error for the calculated spectral values: ± (0.5 % of rdg + 0.1 % of rng)
Bandwith (-6 dB):	approx. 3.7 * resolution



Display of spectral lines

Weighting of the spectrum (single DFT)

According to international standards

- distortion factor K
- telephone harmonic factor THF
- telephone influence factor TIF
- harmonic voltage factor HVF

can be calculated instead of the spectrum.

Distortion factor (K or THD):

Calculation: K (in %) is calculated as per DIN VDE for voltage and current (for each channel). The distortion factor K is also refered to as Total Harmonic Distortion THD .

$$K\ (\%) = \frac{\sqrt{U_{rms}^2 - U_{H01}^2}}{U_{rms}} *100$$

Resolution: 1 digit (d) = 0.01 % THD

Limits of error: at THD > 0.2 %: + 1 d
THD 0.1 % .. 0.2 %: + 2 d

Telephone Harmonic Factor (THF)

Calculation: by weighting of all harmonics up to 5 kHz according to the weighting curve in DIN VDE 0530 part 1 ; IEC 34-1 ; ÖVE M 10 part 1 / 1987. Afterwards summation of the squares of the weighted harmonics according to the formula:

$$THF(\%) = \frac{1}{U}\sqrt{(U_{H01} * \lambda_{H01})^2 + (U_{H02} * \lambda_{H02})^2 + ... + (U_{Hn} * \lambda_{Hn})^2} *100$$

U ... RMS - value of the line voltage of the machine

U_{Hn} ... RMS - value of the n^{th} harmonic of the line voltage

λ_{Hn} ... weighting factor for the n^{th} harmonic according to table ÖVE M10

Telephone Influence Factor (TIF)

Calculation: similar to THF , but calculation and weighting acc. to IEEE Std. 115-1983 point 3.8 to 3.11 and ANSI C50.13-1977 and ANSI / IEEE Std. 100 / 1988

$$TIF = \frac{U_{TIF}}{U_{rms}}; U_{TIF} = \sqrt{\Sigma(T_{Hn}\ U_{Hn})^2}; Residual\ TIF = \frac{U_{TIF}}{3 * U_{rms}}$$

U_{TIF} ... weighted RMS value

U_{RMS} .. RMS value of voltage

U_{Hn} .. RMS value of harmonic

T_{Hn} ... weighting factor as per ANSI / IEEE std. 100 / 1988

Harmonic Voltage Factor (HVF)

Calculation: acc. to IEC publ. 34.1 / 83

$$HVF = \sqrt{\sum \frac{U_{Hn}^2}{n}}$$

U_{Hn} .. RMS value of n^{th} harmonic

n ... harmonic order

Rectified Mean Values U_{Δ}

Calculation: the rectified mean values of the delta voltages (line-to-line voltages) are calculated according to the formula:

$$\left|\overline{U_{xy}}\right| = \frac{1}{T}\int_0^T \left|u_x - u_y\right| dt$$

Data Memory

The function data memory of the option 61 E1 enables the storage of sampled values (for displaying waveforms or transient processes) or average values (display of sequential diagrams of voltages or load over time and x/y diagrams).

Memory: Standard size 512 kByte. Thus more than 230 000 sampled values or more than 65 000 average values can be stored.

Extension: using the memory options 61M2, 61M4 and 61M8 the memory can be extended up to 16 MB.

Variable: 12 variables selectable for simultaneous storage.

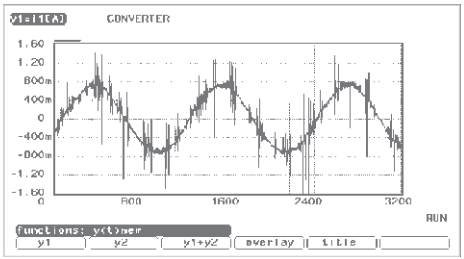
Aquisition rate: 14 µs ... 14 ms (for sampled values) (sample factor from 1 ... 512 selectable) 14 ms ... 67.9 h (for average values)

Trigger: manual or automatic trigger (level or slope), settable pretrigger , single or multiple trigger selectable .

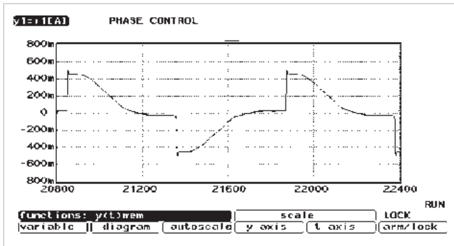
Limits of error: as for peak values (for sampled values) or average values.

Visualization and Output of the memory contents:

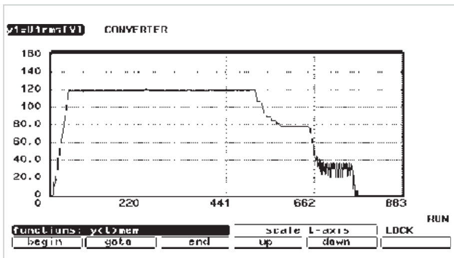
a) graphical with zoom and scroll function
b) table with scroll function
c) printout to an external printer.
d) transferring of the memory contents to an analog recorder



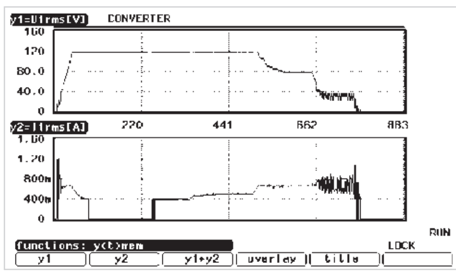
Current sampled values of a converter



Sampled values of a phase controlled current



Output voltage (RMS value) of a converter



Current and voltage at the output of a converter

Option IEC 1000 - 3

With this option the D 6000 becomes a standard measuring equipment for the testing of electrical appliances as per IEC 1000-3-2 (current harmonics) and IEC 1000-3-3 (voltage fluctuations and flicker). Electrical appliances that are supposed to be connected to the public low voltage distribution system have to fullfil these standards .
These standards are valid e.g. for household appliances . The compliance with the IEC 1000-3 standard is a requirement for **CE - certification**.

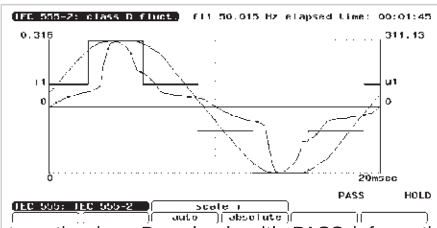
The compliance with the demands on accuracy of the D 6000 , according to the standards , has been testified by independent international certifying bodies .

IEC 1000-3-2 : definition of device classes
measurement of current harmonics
guideline for tolerable limits
IEC 1000-3-3 : measurement of flicker
measurement of voltage fluctuations
guideline for tolerable limits

IEC 1000-3-2

Before starting the measurement of current harmonics the device under test has to be assigned to one of the four device classes (A to D)

Class A: balanced three-phase equipment and all other equipment except those listed in one of the following classes.
Class B: portable electric tools
Class C: lighting equipment
Class D: equipment with “special wave shape“ that consumes active power of 75 W to 600 W and is not motor driven. This “special wave shape“ and the conditions for class D are exactly stated in the standard . The D 6000 performs an automatic Class D - check and gives a “PASS / FAIL“ information.



Automatic class D - check with PASS information

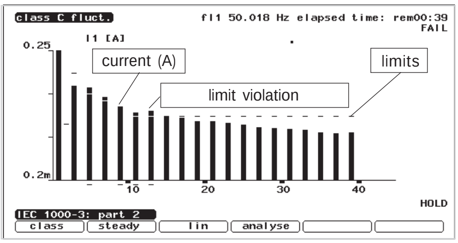
Principle of measurement and classification:
As per IEC 1000-3-2 a Discrete Fourier Transformation (DFT) is made up to the 40th harmonic synchronized with the fundamental within ± 0.3 %.
The rectangular window is gapless over 16 periods of the fundamental. Each harmonic is filtered by a RC - filter (1st order with 1.5 s).

Depending on the appliance a test for steady state harmonics or fluctuating harmonics has to be done, as there are different conditions for the transient (short time) operation.

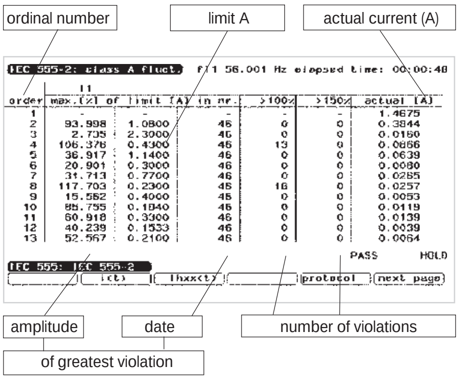
Steady state harmonics (settled stable operating state):
The harmonics (average of 16 periods) are compared with the limits of the standard and exceedings are indicated (PASS / FAIL information).

Fluctuating harmonics (altering operating state):
A sliding consideration window of 2.5 minutes is shifted further on for always 16 periods. Even harmonics of 2nd to 10th order and odd harmonics of 3rd to 19th order must not exceed 1.5 times the limit for “steady state“ during 10 % of any random observation time.

Visualization, Output:
For every single measurement the results with corresponding PASS / FAIL information can be visualized as bargraph or table on the graphic display or are printed out.



Visualisation of the spectrum as bargraph with limits, exceedings and FAIL information



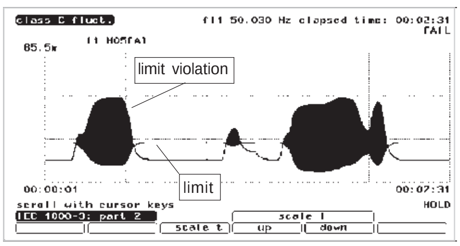
order	I1 max.[%] of	limit [A]	in nr.	>100%	>150%	actual [A]
1	-	-	-	-	-	1.4675
2	93.998	1.0800	46	0	0	0.3844
3	2.735	2.3000	46	0	0	0.0160
4	106.376	0.4300	46	13	0	0.0866
5	36.917	1.1400	46	0	0	0.0639
6	20.901	0.3000	46	0	0	0.0080
7	31.713	0.7700	46	0	0	0.0265
8	117.703	0.2300	46	16	0	0.0257
9	15.562	0.4000	46	0	0	0.0053
10	85.755	0.1840	46	0	0	0.0119
11	60.918	0.3300	46	0	0	0.0139
12	40.239	0.1533	46	0	0	0.0039
13	52.567	0.2100	46	0	0	0.0064

Spectrum as table with additional information

After the end of the test the complete result can be printed in form of a table on an external printer.

Test report according to class C / fluctuating FAIL information (see indications with *)

In case of a FAIL test the D 6000 offers practical help for finding the reason, by displaying the time sequence of the critical harmonics in combination with the limit (3-phase: 11, single-phase: 33 minutes per MB of memory).



Time sequence of the 5th harmonic with indicated violations

IEC 1000-3-3

This part of the standard concerns the measurement of the flicker and the registration of the **voltage fluctuations**. Load changes of electric equipment cause voltage fluctuations as a result of the line impedance. These must not exceed certain values (because of malfunction of other technical devices), they also must not occur with a certain rate (frequency), because in that case **flicker** (changes of illuminance) disturb the human eye. The sensitivity curve exactly states which changes of voltage are permissable at a certain changing frequency . This curve defines the flicker Ps = 1 and means that this flicker is just being sensed as disturbance by 50% of the people. Therefore a standard-conforming flickermeter must simulate the exact functional chain lamp - eye - brain.

Measuring of Flicker:

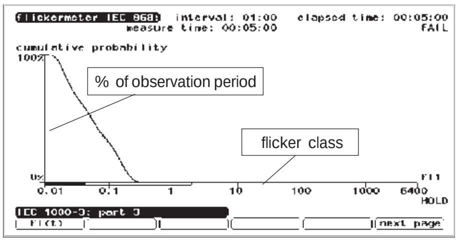
Principle: The used flickermeter is exactly defined in IEC 868. Stated demodulation, weighting filter and averaging by a low pass of 1st order secure the simulation of the above mentioned functional chain . According to this evaluation you get the so-called actual flicker (analog output 0 - 10 V).

Evaluation and Output:

The actual flicker is used for the calculation of the cumulative frequency distribution, short term flicker P_{ST} and long term flicker P_{LT}.

Cumulative Probability:

The actual flicker is statistically evaluated (1024 classes) and visualized. The cumulative probability states, for how many % of the observation period the flicker has exceeded one of the 1024 classes. Measurement times of 1, 5, 10 or 15 minutes are selectable.



Cumulative probability of the actual flicker with maximum pointer for indicating the highest value

Short Term Flicker P_{ST}:

Measuring times of 1, 5, 10 or 15 minutes are selectable. For the computation of P_{ST} a linear pre-smoothing is carried out:

$$P_{50S} = \frac{(P_{30} + P_{50} + P_{80})}{3}$$

$$P_{10S} = \frac{(P_{6} + P_{8} + P_{10} + P_{13} + P_{17})}{5}$$

$$P_{3S} = \frac{(P_{2,2} + P_{3} + P_{4})}{3}$$

$$P_{1S} = \frac{(P_{0,7} + P_{1} + P_{4})}{3}$$

With these values the P_{ST} is computed by means of a weighted five point alogorithm:

$$P_{ST} = \sqrt{(0.0314P_{0.1}+0.0525P_{1S}+0.0675P_{3S}+0.28P_{10S}+0.08P_{50S})}$$

Long Term Flicker P_{LT}:

For a selectable period the long term flicker is calculated according to a cubic smoothing:

$$P_{LT} = \sqrt[3]{\frac{\sum_{i=1}^{N} P_{sti}^{3}}{N}}$$

Selection of Limiting Values:

The input of the limiting values (P_{ST}, P_{LT}) is done by the tester. Default values of P_{ST} = 1.0 and P_{LT} = 0.65 are pre - set.

Output in form of Tables

During the selected measuring time you can observe on the display how the actual flicker, short term- and long term flicker (with their peak values) develop in all three phases. The key values for the evaluation of the voltage fluctuations are also displayed on this monitor.

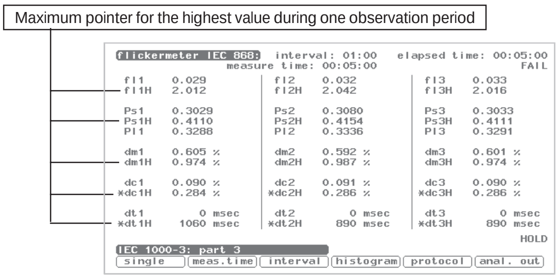
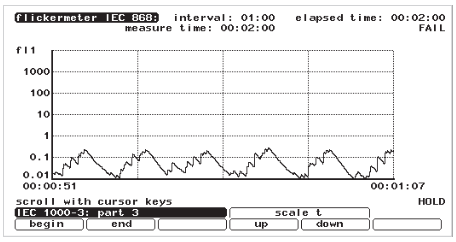


Table for flicker and voltage fluctuation in a three-phase system

PASS / FAIL decisions are automatically assigned to the results . In order to find the reasons for too high flicker values the actual flicker can be displayed over time (22 minutes per MByte of memory)

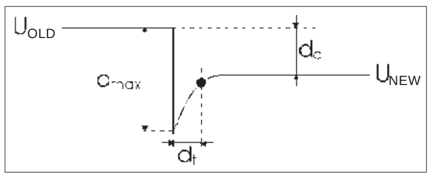


Actual flicker over time

Measurement of Voltage Fluctuations:

Voltage fluctuations are measured without the weighting filters used for flicker measurement. A voltage fluctuation is defined by the key values in the following diagram:

U_{OLD}	stable operating voltage
d_C	remaining voltage deviation
U_{NEW}	new stable operating voltage
d_t	time , until setting to U_{NEW}



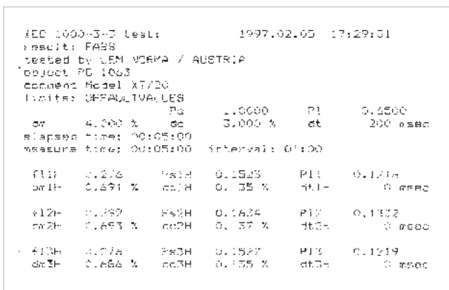
Key values of a voltage fluctuation

Selection of limiting values:

The input of the limiting values (d_{max}, d_C and d_t) is done by the tester. Default values of dm = 4.0 %, d_C = 3.0 % and d_t = 200 ms are pre - set.

Report:

The complete test acc. to IEC 1000-3-3 with its results can be logged on an external printer.



Testing report of a flicker measurement

ORDER REFERENCE NORMA D 6000 Wide Band Power Analyzer System

Set models	**Standard System**				**Motor System**				**Trafo System**	
Basic instruments	P 1 phase	1 phase	P 3 phase	3 phase	P 3 phase	3 phase	P 6 phase	6 phase	P 3 phase	3 phase
Measuring channels/interfaces	A 4603 30711	A 4603 30721	A 4603 30712	A 4603 30722	A 4603 30714	A 4603 30724	A 4603 30715	A 4603 30725	A 4603 30713	A 4603 30723
D 6100 Basic (4 HE) with display, keyboard and printer A 4603 30500	●		●		●				●	
D 6200 Basic (8 HE) with display, keyboard and printer A 4603 30501							●			
D 6100 Basic (4 HE) without printer A 4603 30540		●		●		●				●
D 6200 Basic (8 HE) without printer A 4603 30541								●		
Voltage channel 61U1 A 4603 30505	1	1	3	3	3	3	6	6	3	3
Voltage channel 61U2 A 4603 30515										
Current channel 61I1 A 4603 30506										
Current channel 61I2 A 4603 30516									3	3
Current channel 61I3 A 4603 30526	1	1	3	3	3	3	6	6		
Interface 61D1 A 4603 30507	●	●	●	●					●	●
Interface 61D2 A 4603 30508					●	●	●	●		
Interface 61D3 A 4603 30519										

Basic instruments (for purely remote control)

D 6300 Basic (4 HE) without display, keyboard, printer	A 4603 30504
D 6400 Basic (4 HE) without display, keyboard, printer	A 4603 30509

Options

Data memory and harmonic analysis 61E1	A 4603 30565
IEC 1000-3	A 4603 31000
Data memory extension 61M4 (4 MB)	A 4603 30572
Data memory extension 61M8 (8 MB)	A 4603 30573
Option Digital Torque Measurment 61T1	**A 4603 30574**

Triaxial Shunts (plug-on)

0.3 mA (3 µA ... 3 mA)	A 6414 00021
3 mA (30 µA ... 30 mA)	A 6414 00022
30 mA (300 µA ... 300 mA)	A 6414 00023
0.1 A (1 mA ... 1 A)	A 6414 00013
0.3 A (3 mA... 3 A)	A 6414 01001
3 A (30 mA ... 10 A)	A 6414 01010
10 A (0.1 A ... 30 A)	A 6414 01030
16 A: IEC 1000 (0.3 A... 50 A)	A 6414 01050
30 A (1 A ... 100 A)	A 6414 01100

Triaxial Shunts (external)

100 A (6 A ... 300 A)	with connection adapter	A 6414 01300
300 A (18 A ... 1000 A)	with connection adapter	A 6414 01340
450 A (10A ... 450 A)	with connection adapter	A 6414 01500
500 A (18 A ... 1500 A)	with connection adapter	A 6414 01350

Triaxial Switching Unit — A 6414 01016

Various additional connection adapters and extension cables are offered. Individual solutions are possible.
Please ask your local distributor.

Current clamp 61 C1 with connection adapter	A 4603 31013
LEM Transducer set IT 150-S single phase	A 6416 02033
LEM Transducer set IT 150-S three phase	A 6416 02034
LEM Transducer set IT 600-S single phase	A 6416 02035
LEM Transducer set IT 600-S three phase	A 6416 02036

● .... standard 1, 2, 3, 6.......... standard number of channels
Individual configuration: Your Power Analyzer can be configured according to your special requirements.

Accessories

Cable for D 6000 analog out	A 6002 81081
Cable for D 6000 torque / speed in	A 6002 81082
Cable for D 6000 EXT TRIGGER or SYNC IN	A 6002 81074
Ground lead	A 6002 81080
19" rack mounting kit for D 6000 (4 HU) (please use 2 kits for models 8 HE)	A 6499 00069
Star point adapter for voltage channels (61U1) (please us 3 pcs for forming an artificial star point)	A 6416 02016
High voltage divider 500:1, single phase, 5 kV_{rms}	A 6416 02018
Carrying case for D 6000 (4 HU)	A 6001 33005
Paper roll for D 6000 thermo printer 61 P2 (3 pcs.)	A 6202 96200
Operating instructions	A 4603 51GA5
External relay box 61 R1 with 6 built ins relays 250V / 2A	A 4603 30562

For details and additional accessories please ask your local distributor.

PC Software

PowerWin 6000	demo package	A 6899 00163
PowerWin 6000	1. licence	A 6899 00161
PowerWin 6000	add licence	A 6899 00162

Lab Windows driver for D 6000	A 6899 00151
Lab View driver for D 6000	A 6899 00200
Data - Transfer software for D 6000	A 6899 00160
Screen - Copy - software for D 6000	A 6899 00155

Hint: For use of the IEEE 488 interface we recommend National Instruments

Test Certificates
We offer various test certificates.
Please ask your local distributor.

LEM

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Publication A 98462 E