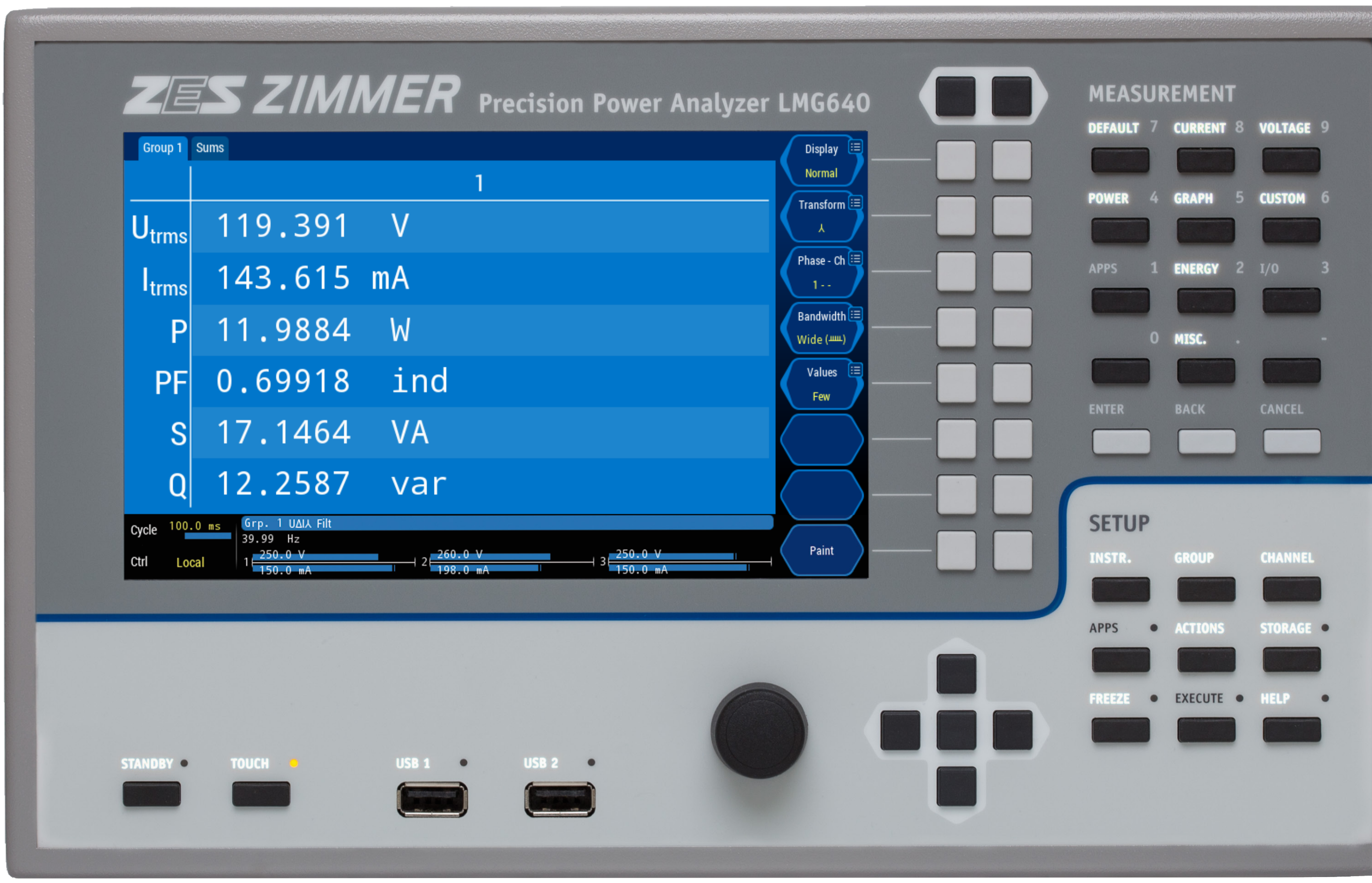
ZES ZIMMER

# LMG640

## Precision Power Analyzer

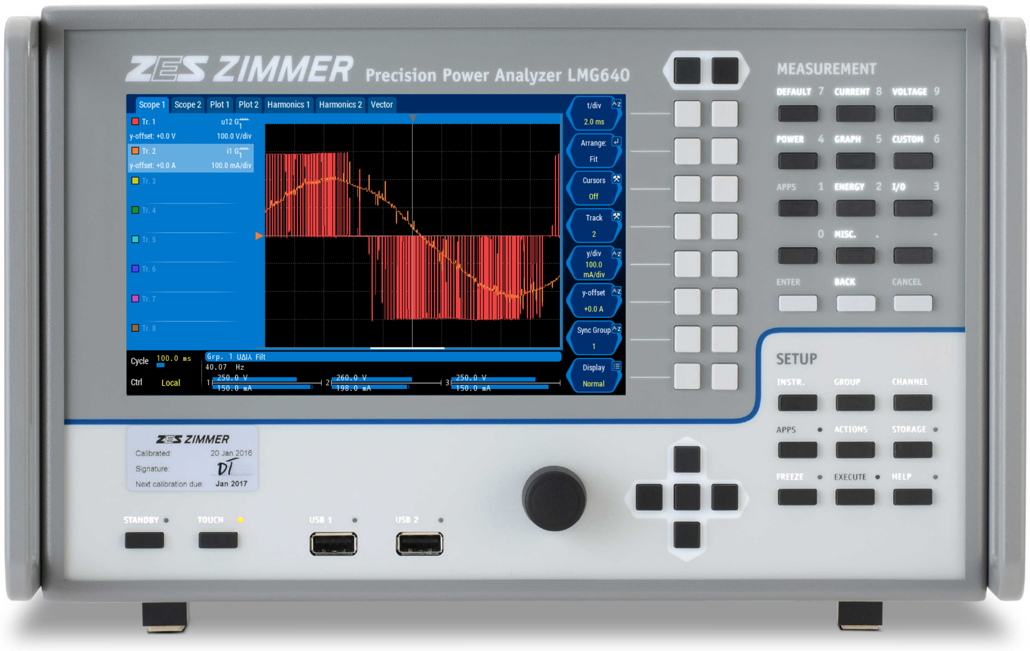



# [Power Analysis]$^2$ with Dual Path

## Two Bandwidths Simultaneously

Single-shot results for narrowband, broadband & harmonics measurements

# LMG640 – powerful, convenient, flexible




## Features

| | |
|---|---|
| **Harmonics** | · Harmonics and interharmonics up to 2000th order, in compliance with EN61000-4-7 |
| **Process Signals** | · (Optional) speed/torque sensor inputs freely configurable for all signal types (analog, frequency as RS422, TTL or HTL) |
| **Script Editor** | · Flexible scripting tool for special applications<br>· Convenient calculation of all derived variables in the power analyzer |
| **Simultaneity** | · Simultaneous measurement of I, U and P-variables and harmonics<br>· Presentation in tabular or graphical form |
| **Flexible Filters** | · Signal filters freely configurable by frequency, type and characteristics |
| **Plug 'n' Measure** | · Connected current transducers are automatically configured and supplied with power<br>· Convenient commissioning with zero risk of misconfiguration |
| **Synchronization** | · Synchronization to up to 4 different frequencies simultaneously |
| **Flicker** | · Interactions between grid and consumers according to EN61000-4-15 |
| **Sample Values** | · Direct access to high-resolution sample values and harmonics via interfaces |
| **Star-to-Delta** | · Conversion from line-to-line voltages to phase voltages and determination of active power |

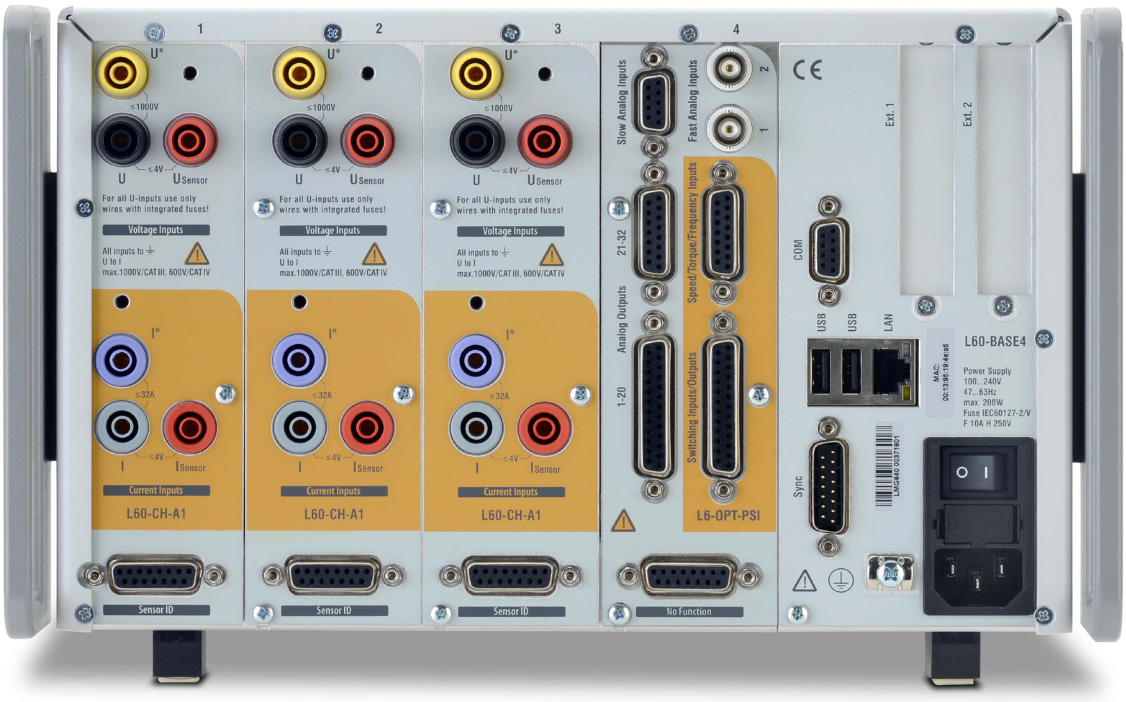
## GUI

| | |
|---|---|
| **Touchscreen** | · Large 800x480 display for rapid access to all important menu items<br>· DVI/VGA output for external monitor or projector |
| **Remote Control** | · Real-time display of all device functions, remote operation and data visualization<br>· No rethinking required, thanks to the new unified GUI |

## Storage & Periphery

| | |
|---|---|
| **Memory** | · Internal storage even of long-term measurements with the shortest cycle time, thanks to high-capacity mass-storage device |
| **Interfaces** | · Excellent connectivity provided by USB 2.0, Gigabit Ethernet, RS232, DVI/VGA and CAN |

# Modular with up to four power channels




## Measurement Channels

| | |
|---|---|
| **DualPath** | · Narrowband-, wideband RMS values and harmonics in a single measurement, simultaneously and free from aliasing |
| **Sampling Rate** | · High sampling rate of up to 1.2 MS/s |
| **Resolution** | · Generation of RMS values with a minimum cycle time of 10 ms |
| **Accuracy** | · Extremely high measurement accuracy of 0.015 % of the measured value + 0.01 % of the measuring range limit |
| **Dynamic Range** | · Full dynamic range continuously available from 500 µA to 32 A and 3 mV to 1000 V<br>· Power measurement from standby to full load (max. 32 A) possible without mechanical changes |
| **Bandwidth** | · Analog frequency range from DC up to 10 MHz<br>· Analysis of 1000 harmonics in the GUI and 2000 via interface |
| **Flexibility** | · Configuration with 1 to 4 power measurement channels (resp. 3 channels and process signal interface)<br>· Retrofitting of channels possible |
| **Continuity** | · Gapless sampling at 18 bit A/D converter resolution and a cycle time of 10 ms<br>· No discontinuities in recorded measurements and complete capturing of all relevant events |
| **U-I-Synchronicity** | · Time offset between current and voltage input adjustable in steps < 3 ns<br>· Very precise measurements at small power factors (PF) and/or high frequencies |
| **Immunity** | · Reliable even in areas with difficult electromagnetic conditions |
| **A/B/C Channels** | · The right channel type for any task — Channel A: 0.025 % accuracy, up to 10 MHz<br>Channel B: 0.07 % accuracy, up to 500 kHz<br>Channel C: 0.04 % accuracy, up to 10 kHz |
| **Ground Capacitance** | · Particularly low earth capacitance of < 90 pF avoids interference by leakage currents |

## Misc.

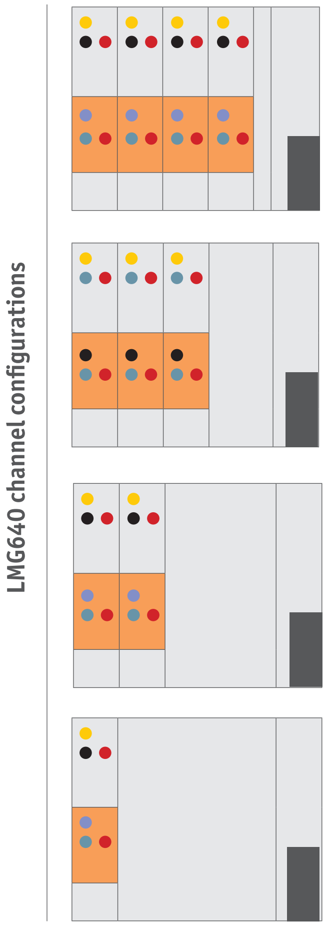
| | |
|---|---|
| **Calibration** | · 12-month calibration interval guarantees low maintenance costs and optimum device availability<br>· Includes calibration certificate upon delivery, free of charge |
| **Warranty** | · 24 months |

# Setting the bar in power analysis

For more than three decades, ZES ZIMMER has been focused solely on high-precision power measurement technology – so we know there is more to it than simply measuring current and voltage. Anyone who has tried to use generic data acquisition systems for power measurement will have rapidly run up against their limitations. What is the situation with common-mode rejection? Is the result still reliable for power factors in the range of 0.01? Is the earth capacitance low enough to avoid interference by leakage currents? In which frequency ranges does the manufacturer guarantee the stated measuring accuracy? It quickly becomes clear that only a device designed specifically for power measurement can really satisfy these high requirements. The LMG600 from ZES ZIMMER stands out in the market for its extreme reliability, best-in-class accuracy, and maximum frequency range – the ideal prerequisites for excellent results.

# The right channel combination for every application

Power analyzers are available in different accuracy classes, to allow the user to choose the right tool for the job at hand. After all, not all applications require maximum precision; often lower resolution and frequency range are sufficient. Unfortunately, not all measuring applications exhibit this distinction. It is very well possible, for instance, to have need for different frequency ranges and accuracy levels at different points in the same measurement configuration. This is why the LMG600 offers three different channel types, which can be combined in the same chassis without problems to ensure that you always have a measuring device tailored to your needs for your particular application, without having to accept trade-offs in accuracy or take a sledgehammer to crack a nut, if a lower priced solution could have served your purposes equally well.




*Drive measurements*
*1-phase input*
*3-phase output*

*Power measurements*
*on 3-phase-motors*

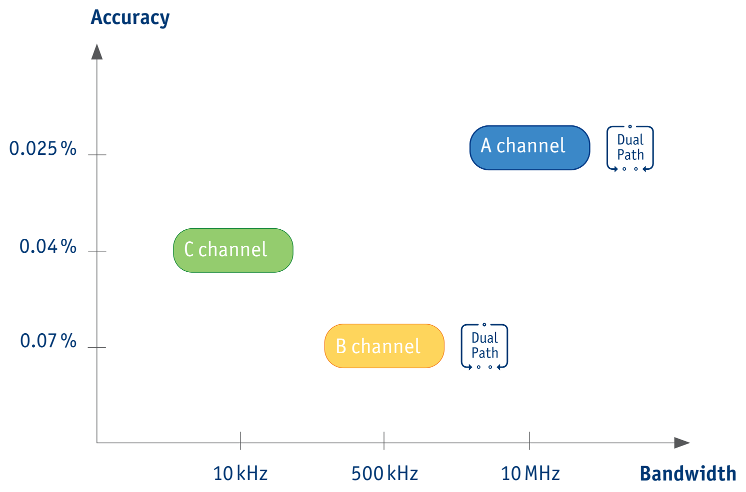
*Efficiency*
*measurements*
*on power supplies*

*Analysis of core losses*

**A channel** – *High-precision measurements at high bandwidth, e.g. high-frequency bearing currents, ballasts, high-frequency ferrite core losses, inductive heating, ultrasonics*

**B channel** – *Cost-effective broadband measurements e.g. as universal laboratory tool, measurements on power tools*

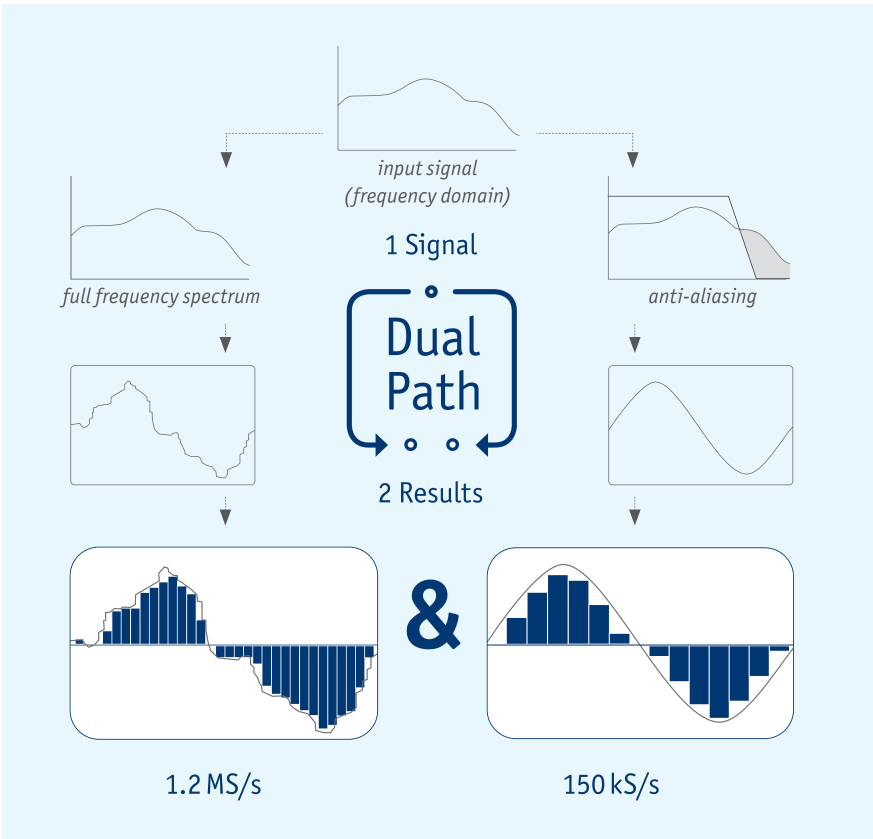
**C channel** – *Precise measurements on 50/60 Hz applications, e.g. standby power measurements, energy efficiency, core losses, impedance measurements on transformers, grid quality, power transformers, domestic appliances*



# Measuring in two bandwidths at the same time, thanks to DualPath - no compromises, no doubts

On conventional power analyzers, a signal first undergoes analog conditioning, followed by optional anti-aliasing filters, to then be fed into an A/D converter. The resulting signal can afterwards be used for the calculation of cycle-based RMS values. Alternatively it can serve as the base for an FFT or further digital filtering. Due to the limitation to a single A/D converter, there are inherently some downsides to be factored in with conventional devices. If measurements are carried out with filters active, in order to avoid aliasing with FFTs, then the wide-band values are lost. With the filters switched off, strictly speaking, FFTs should not be used. If, in spite of this, FFTs are used without an anti-aliasing filter for measurements across the full frequency range, then the quality of the calculated values is questionable. An aliasing error of 50 %, for instance, is easily detected, however a deviation of 0.5 % could go unnoticed. Ultimately, when you alternate filtered and non-filtered measurements, the validity of the results is equally in question, as this involves the assumption that the signal does not change over time, which is in practice hardly ever the case. In addition, this procedure is especially time consuming.


In the end, all of the measurement methods presented are merely unsatisfactory compromises. This is why ZES ZIMMER has fundamentally redesigned signal processing and developed the DualPath architecture. The analog side is the same as in conventional measuring devices, however the subsequent digital processing has been revolutionized. The LMG600 is the first power analyzer to have two A/D converters in two independent signal paths for each current and voltage channel. One, for the filterless measurement of the wideband signal, and another, for the narrowband signal at the output of the anti-aliasing filter. The parallel processing of the digitized sample values gives the user access to both measurements of the same signal, without risking aliasing effects. This unique procedure avoids all of the downsides of previous approaches and guarantees the most precise result in the shortest time possible.



# Gapless measurement

In the course of stricter monitoring of the consumption and efficiency of electrical devices, new standards and procedures are continuously being introduced (e.g. SPECpower_ssj2008, IEC 62301, EN 50564), in order to enable an impartial comparison of products from different manufacturers. Be it an office computer, server or household appliance, the same principle applies: the procedure always requires long term analysis of the power consumption, taking into account all relevant operating conditions. The differences between minimum load - e.g. in standby - and full load can be of a significant magnitude, which makes precise measurement very challenging (see also application report no. 102 „Measurement of standby power and energy efficiency" at www.zes.com). Some of the measurements required must be performed over several hours, yet without gaps. By selecting a sufficiently wide measurement range, changing ranges and the inevitably associated losses in data can be avoided. The high basic accuracy of the LMG600 ensures precise measurement results, even near the lower limit of a range.

# Precise measurements thanks to minimal delay differences

The fast-switching semiconductors used in modern frequency converters to improve efficiency produce extremely steep voltage edges. The resulting capacitive currents put strain on the bearings and the insulation of the motors – this can lead to premature failure.

Motor filters (e.g. dU/dt filters) attenuate the steep voltage gradient, although they generate power losses themselves due to the transient oscillation with the filter's own frequencies (typically > 100 kHz).

The broad frequency range and the minimal delay between current and voltage on LMG600's allow extremely precise power loss measurements on the filters at these frequencies, including longitudinal measurements at low power factors. This also applies to power measurements with high frequency ranges of up to 10 MHz, which require the current and voltage channels to be designed for the smallest delay differences. On the LMG600 the offset is less than 3 ns, corresponding to a phase error <1 µrad at 50 Hz. This makes the devices best suited to measure the power losses at low phase angles for transformers, chokes, capacitors and ultrasonic generators. No additional options or adjustments are required; the LMG600 is already fully capable of this measurement task with the standard factory settings. Usually current and voltage transducers are used for measurements on high-power circuits. The phase angle of these transducers can be corrected to improve measurement accuracy.

# Range extension with sensors? Plug 'n' Measure!

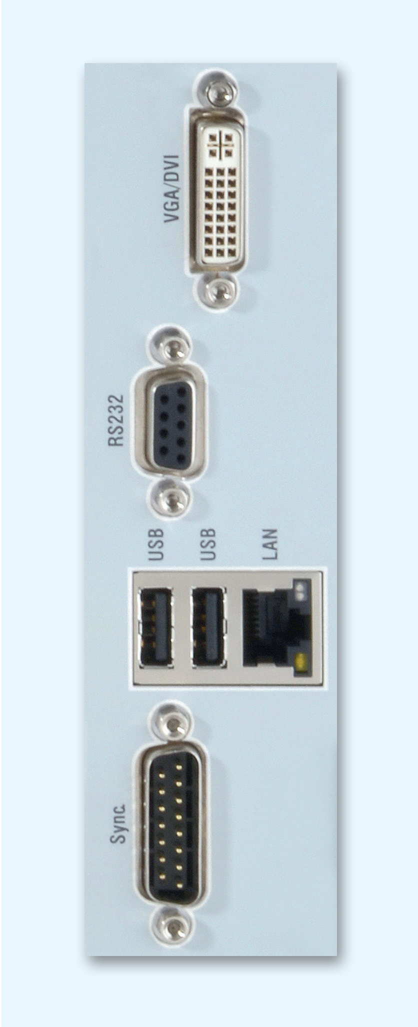
Although the LMG600 offers unmatched dynamic range, both for voltage and current, there are always applications with extraordinary requirements in terms of measurement ranges. Whether you are dealing with currents of several hundred amps or voltages of several kilovolts, ZES ZIMMER has the right solution at the ready. We offer a wide range of current and voltage sensors, which work perfectly in unison with the LMG600 precision power analyzer and extend the measurement ranges of the device by the required amount. The sensors of our Plug 'n' Measure series are equipped with a bus system, which enables automatic configuration of the LMG600. This allows for all of the important parameters, such as the precise scaling factor, the delay compensation variable, the last calibration date, and the sensor type, to be read and used automatically by the power analyzer. Moreover, the sensors are actively supplied with power by the LMG600, separate power supplies are no longer required.

With Plug 'n' Measure there is no need for fine tuning by the user to improve the results. There is no difference between direct and sensor-supported measurements. Of course, other commercially available sensors can also be used with the LMG600.


*Sensor Type PCT*

# Powerful interfaces

In addition to the GUI and the connection to the device under test itself, the exchange of data with the existing computer and software environment is of primary importance in determining how well the instrument is able to perform its intended task. Only with seamless integration into the overall system can the full power of the instrument be harnessed by the user. The high sampling rate of the LMG600 inevitably creates a large amount of data. Therefore we have ensured, by using the right system architecture, that the measured data can be transmitted via the interfaces at a high through put rate. Even high-resolution measurements of all important parameters such as current, voltage, active power, et cetera over a period of several minutes can be rapidly transferred to a connected computer. In order to cope with the requirements of a wide array of different applications, a range of ports is available. In addition to a serial port and Gigabit Ethernet, a slot is available for USB 2.0; the device can also optionally be equipped with a VGA/DVI output for connecting an external monitor or projector. Two more slots can be retrofitted for future interface standards. By using the integrated sync interface, it is possible to precisely synchronize multiple LMG600's with one another. This makes it possible to have a common time base for measurements involving multiple LMG600's on the same system, or the mutual connection and control of an LMG600 by oscilloscopes or waveform generators. Thanks to its internal HDD, the LMG600 provides the option to store measured values, settings, user-defined measurement variables, or graphs for later use, even without having a PC connected. When it comes to storage capacity, the customer has several options available. The firmware of the LMG600 can be quickly and easily brought up to date via USB.



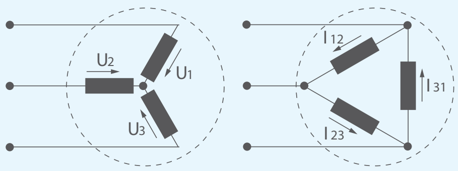

# Process signal interface

It is often necessary to take further measurements in addition to electrical parameters to be able to make a meaningful overall statement on the performance and efficiency of the device being tested. Hence, it is vital to be able to perfectly synchronize these measured values with the RMS values calculated by the LMG600, in order to establish reliable timing between electrical and mechanical events. A typical application is the analysis of electrical drive systems, where torque and speed must be measured and reconciled with the electrical parameters. Conversely, it may also be necessary for the power analyzer to output results for further processing in analog form, or to trigger switching operations depending on measured variables or derived values. In order to be equipped for all of these potential requirements, the LMG600 offers a multitude of different input/output features for analog and digital signals.

| |
|---|
| 2 fast, synchronized analog inputs (ca. 150 kS/s) |
| 8 analog inputs |
| 8 switching inputs (ca. 150 kS/s) |
| 2 torque-/speed-/ frequency inputs |
| 32 analog outputs |
| 8 switching outputs |

# Star-to-delta conversion

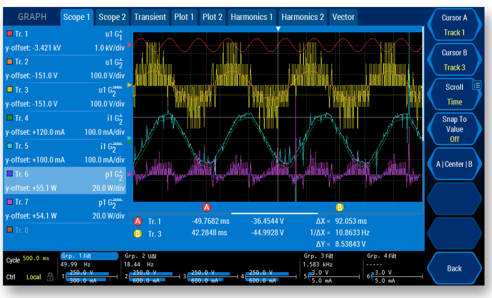
In three-phase three-line systems, only the line-to-line voltages $U_{12}$, $U_{23}$, $U_{31}$ and the line currents $I_1$, $I_2$, $I_3$ are accessible for measurement. With the star-to-delta conversion option, the line-to-line voltages can be converted to non-accessible phase voltages and the related active power can be determined. Likewise the line currents can be converted into „linked" currents. From these calculated values it is possible to derive all other variables, such as harmonics. Distortions and imbalances of the grid or consumers are properly taken into account. This makes the use of an external, artificial neutral point superfluous; although one could use one at any time, provided that the associated disadvantages (e.g. increased power losses) are taken into account.



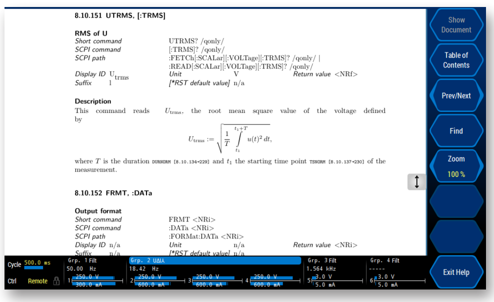

*3-phase 3-wire system: measuring phase-to-phase voltage and line currents*

# Easy to use – with or without touchscreen

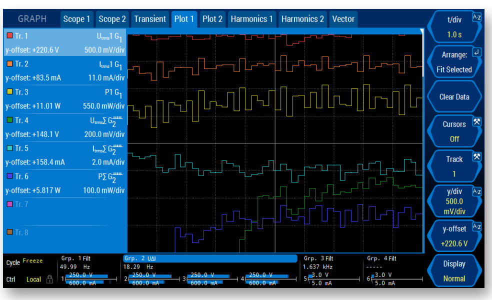
To ensure that the LMG600 can be used in all conditions, particular attention has been paid to universal usability. All display modes and setting options can be operated both by the touchscreen or the keypad, without exception. The optimized design consistently links the keypad to the associated views and setting options on the screen. To use the instrument effectively requires almost no familiarization. The graphical user interface directs the user without detours to the required values. Be it RMS of voltage or current, associated harmonics or cumulative values, these are usually only a single press of a button away. In addition, user-defined views allow to group individually measured values, so that all the parameters are always available at a glance. This ergonomic way of operation and the associated time savings contribute directly to the productive use of the LMG600. The eight context-specific double softkeys to the right of the display, whose function always corresponds to their on-screen counterparts on the right-hand side, are especially important for ease-of-use. One can determine the function assigned to a given softkey at a glance. The double softkey design enables the respective parameter to be rapidly configurable; switching through views that are not relevant is no longer necessary. Should there be questions as to function and control while operating the device, the relevant sections of the manual can be displayed at any time.



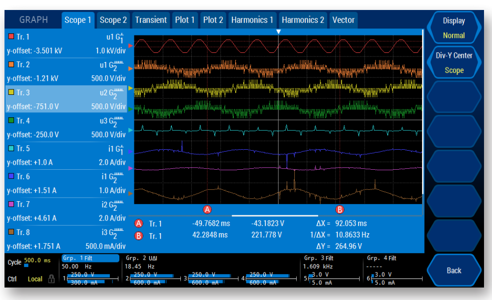
*Simultaneous measurement of narrow and broadband values*



*Superimposed help text from manual*

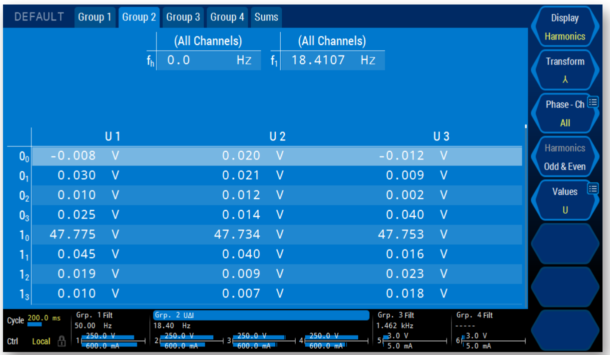


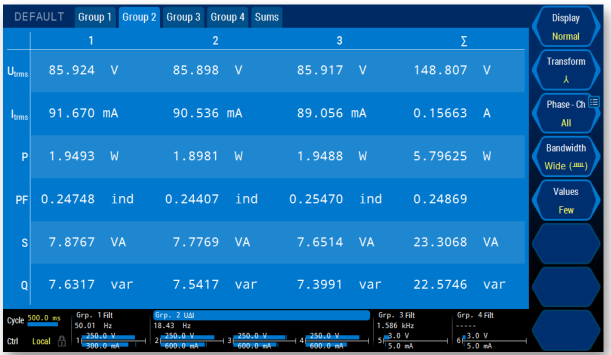
*Display of measured RMS values*



*Display of sampling values of 8 signals in two scopes*

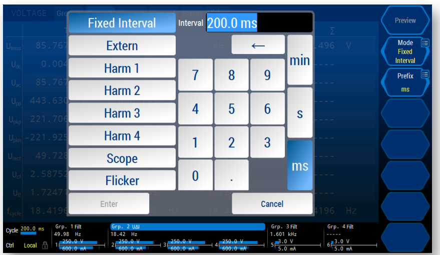
# Everything important just a click away





*Click on the <Phase-Ch> softkey: measured values for all channels or linked values in a group*

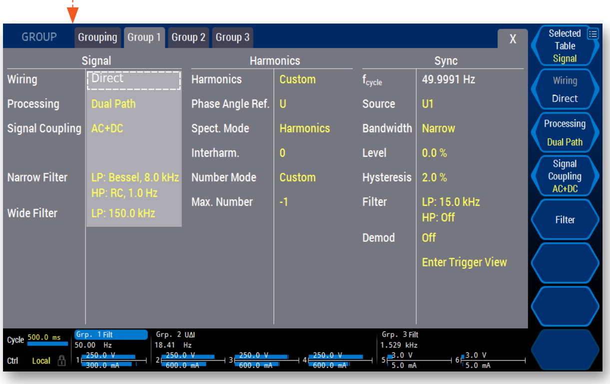
*Click on softkey <Display>: toggling between RMS values and harmonics*

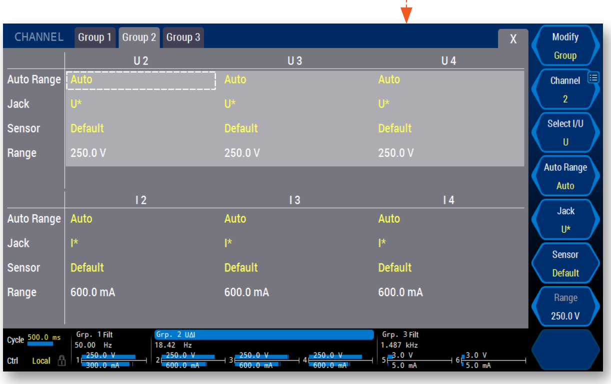



*Click on Cycle: Configuration of cycle time or reference*

*Click on the group: configuration of activation, synchronization, filters, etc.*

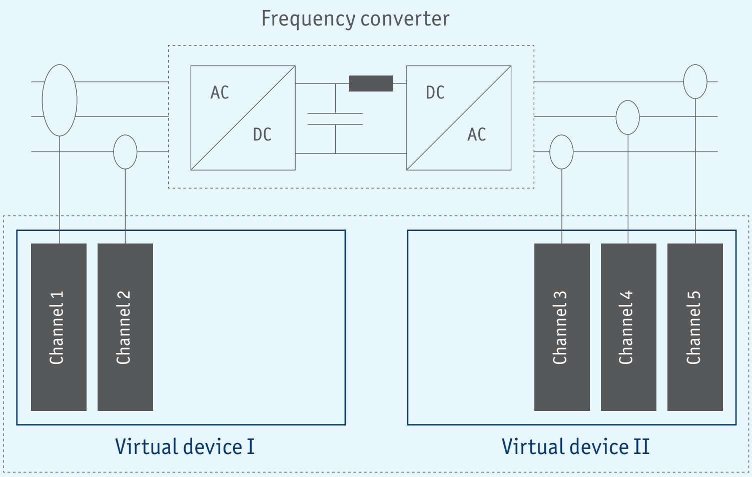
*Click on the level indicator: configuration of channel-specific measurement ranges and sensor settings*





# Clear visualization of measurements thanks to groups

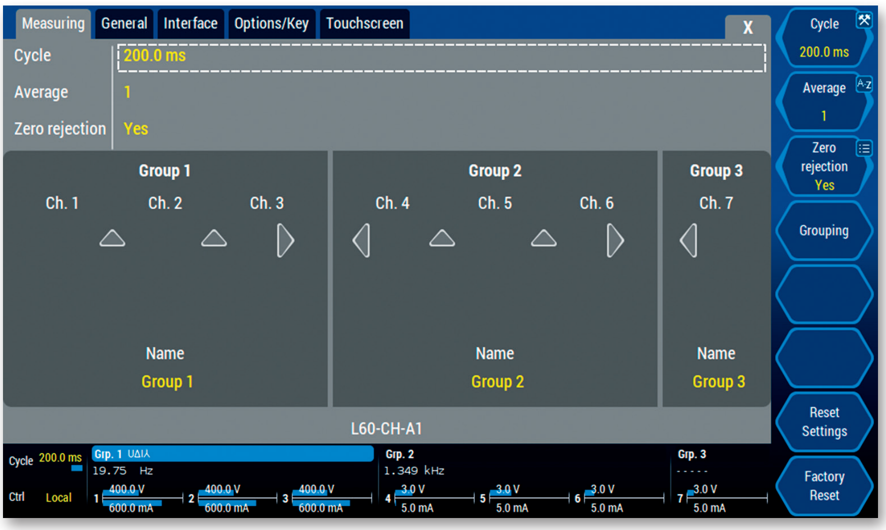
In order to properly illustrate the functional relations between physical measurement channels, the power measurement channels (P-channels) can be organized into so-called groups, which appear almost as virtual measurement channels or virtual devices in addition to the physical channels. The logical grouping of the P-channels is dependent on the number of wires and phases of the electrical system being analyzed. Thanks to the flexibility of the LMG600, it is possible to model even unusual and rarely seen configurations, such as split-phase systems and four-phase or multiphase systems, both simply and reliably. The only requirement is that all of the channels within a group have the same basic frequency and are of the same type (A, B, C). This will avoid subtle errors, which arise due to the different technical properties of the different channel types. One benefit of creating groups is that it makes configuring the device easier, since filter settings (for example) affecting all channels in the group only have to be configured once. In addition, derived values, such as active, apparent or idle power are calculated across all channels in the group. While grouping specifies how the channels are combined logically, the wiring dictates how the inputs of the measuring device are connected to the measuring circuit, i.e. whether it is a star-to-delta circuit or whether there are neutral wires, etc. The wiring defines how the measured signals are interpreted by the device.




*Example: measurement on frequency converter*

*Group I measures the input power in an Aron circuit. C-channels are usually sufficient.*

*To determine the output power, Group II measures the voltages on the delta side and the currents on the star side. A-channels are recommended for this. Using another single-channel group, the DC intermediate circuit can also be measured. A-channels would also be indicated here.*

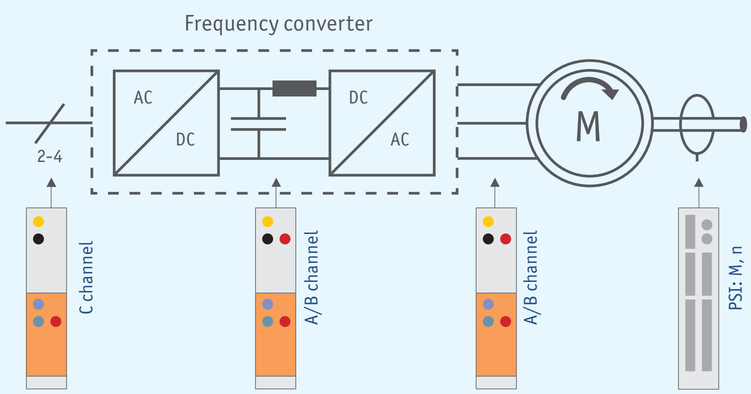



*Logical grouping of channels for different points of measurement in the LMG600 configuration menu*

Application

# Electrical drive systems

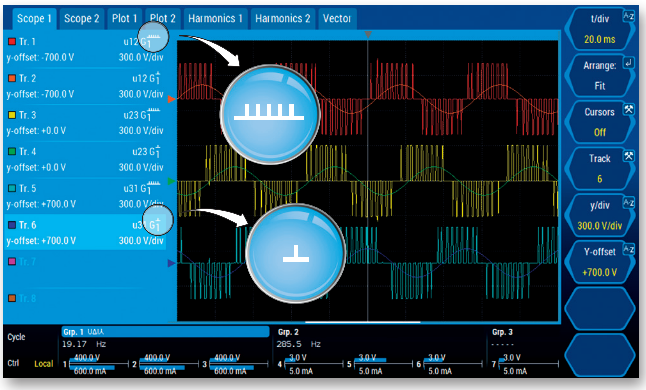
More than half of the electrical energy generated worldwide is converted to mechanical motion, and the importance of electric powertrains for transport of goods and people is growing steadily. While outdated speed controllers are afflicted with losses of up to 40 %, modern, frequency-controlled systems can achieve efficiency levels of over 95 %. These frequency converters use pulse width modulation to control the speed of the motor with hardly any losses. The objective is to optimally adjust the converter and motor to one another, in order to achieve the best overall efficiency. Measuring the input power, the intermediate circuit, and the output power of the converter as well as the mechanical power of the motor simultaneously is anything but trivial. In addition to the integration of sensor technology (wideband sensors for high currents, high-voltage dividers, precise speed and torque transmitters), the instrument must meet the challenge of measuring the very steep-flanked signals at the converter output. This environment is often described as harsh, not merely from an EMC point of view.




*Determining the efficiency of an electric drive system*

*C channels are usually sufficient for the input of the converter. Depending on the required level of precision, A or B channels are required for the DC intermediate circuit, as it exhibits significant residual ripple under certain circumstances.*

*For the converter output only A or B channels are to be used, also dependig on the required level of precision. Via a process interface mechanical quantities are measured synchronously to the other channels.*




Dual Path

*Scope display of the voltages at the converter output. The wideband values (⊓⊓⊓⊓) show the PWM signal, the narrowband values (⊥) are sinusoidal.*

Of course the key question in the analysis of electrical drive systems is: which part of the electrical energy at the converter output relates to the torque-relevant fundamental frequency of the motor, and which part to the remaining frequency range, particularly the harmonic spectrum? To give an accurate answer, it has long been necessary to perform two separate measurements: one without filters to establish the wideband power, and another one on a filtered signal to determine the power at certain frequencies, resp. a subsequent FFT analysis to measure the harmonic spectrum. This procedure is very time-consuming, yet it cannot guarantee that the conditions present during the initial measurement still prevail during the repetition.

The innovative DualPath architecture of the LMG600 provides all of the required results simultaneously in a single measurement, with maximum precision, and the widest frequency range on the market – free from aliasing effects.

**CHALLENGES**

- Synchronous measurement of speed and torque
- Highly accurate measurement of the fundamental oscillation relevant to torque
- Simultaneous aliasing-free measurement of losses across maximum frequency range
- Range expansion for high current and medium voltage applications
- Fast data export to third-party devices and applications

✓ DualPath
✓ A/B/C Channels
✓ Harmonics
✓ Star-to-Delta
✓ Accuracy
✓ Immunity
✓ Interfaces
✓ Plug 'n' Measure

Application

# Switched-mode power supplies

Already years ago, advances in power electronics have caused relatively large and heavy transformer power supplies to be replaced by smaller, lighter and more efficient switched mode power supplies. Today those can be found in practically all grid-powered electrical devices. While avoiding many of the downsides of their predecessors, they also bring new challenges: for one, the conducted emissions due to harmonics are not insignificant and must be limited by standards (EN61000-3-2, EN61000-3-12). Secondly, the high switching frequencies of up to several hundred kilohertz can lead to problems with electromagnetic compatibility, both on the grid side and on the consumers' part. The role of power measurement technology is to support the manufacturer in optimizing their products.

**CHALLENGES**

- Gapless, standards-compliant measurement of harmonics
- High frequency range for analysis of conditions at pulse frequencies >300 kHz
- Quick and gapless sampling for measuring steep switching flanks
- Reliable measurement even at power factors $\lambda < 0.01$

**LMG600**

High Bandwidth | Continuity | Flexible Filters | High Sampling Rate | U-I-Synchronicity | Harmonics

Application

# Solid & laminated magnetic cores

Under the influence of changing fields, the ferromagnetic components of an electrical machine are subject to losses due to continuous remagnetization and eddy currents, which are ultimately converted into heat or vibrations.

The total losses are frequency-dependent and should be minimized as far as possible, as they have a significant effect (for example) on the range of the batteries in electric vehicles. The core power loss can be calculated directly from the excitation current of a test winding and the magnetization voltage of a sensor winding. The magnetic flux density in the core material can be derived from the rectified value of the voltage induced in the sensor winding. The magnetic field strength is proportional to the current flowing in the test winding.

While the high-frequency currents in solid cores can be measured directly, the high amp values occuring in laminated cores usually demand high-precision transducers.

**CHALLENGES**

- Precise determination of the active power, even at lowest power factors ($\lambda < 0.01$) and very low voltages
- Calculation of a multitude of derived variables such as peak value of field strength ($H_{pk}$), magnetic flux density ($B_{pk}$), and amplitude permeability ($\mu_a$)
- Convenient integration of transducers for high currents

**LMG600**

High Bandwidth | Accuracy | Script Editor | Plug 'n' Measure | U-I-Synchronicity

Application

# Conformance testing for the aerospace industry

Particularly in the aerospace industry, electromagnetic compatibility between installed systems is of existential importance. For this reason, industry directives such as ABD0100.1.8 set limits on harmonic currents up to the range of 150 kHz. These harmonics can be analyzed using the LMG600. This can either be accomplished using the built-in harmonics analysis, or alternatively in any level of detail via off-line analysis of sample values using external software.

*to be continued on top of following page*

**CHALLENGES**

- High accuracy even at high frequencies
- Aliasing-free harmonic analysis up to 150 kHz
- Powerful FFT with up to 2000 harmonic components

**LMG600**

High Bandwidth | Accuracy | Harmonics | High Sampling Rate

# Application Lighting technology

In an effort to reduce energy consumption, light bulbs are being replaced with ever more efficient light sources all around the world. While on the consumer end all that is required is to insert a new product into the existing fitting, the differences on the electrical level are considerable – in contrast to conventional bulbs, LED lights and compact fluorescent lights ("low-energy light-bulbs") are controlled by special electronic ballasts. Some of these ballasts work with switching frequencies of up to 200 kHz and produce signal distortions at frequencies of up to 1 MHz. The manufacturers are required first and foremost to prevent damaging circuit feedback, and secondly, to ensure optimum service life for their products. To achieve the aforementioned objectives, often a controlled warm start is performed, whose proper execution has to be verified by making appropriate measurements.

**CHALLENGES**

- Broad frequency range of the measurement, hand-in-hand with a high level of precision
- Verification of standby power of ballasts even for $\lambda < 0.01$
- Minimal earth capacitance to avoid leakage currents during the measurement

**LMG600**

High Bandwidth | Accuracy | Flexible Filters | Ground Capacitance | U-I-Synchronicity

# Application CE compliance testing for harmonics and flicker

Electrical equipment, systems and devices must satisfy the directives and ordinances of the EU on the permitted level of electromagnetic emissions and immunity to electromagnetic effects, if they are put on the market inside the European Union (EU). Two different types of grid emissions are tested: harmonics and flicker. Any electrical device with a non-linear load characteristic produces current harmonics. Due to the impedance of the grid, these cause drops in voltage and resulting distortions. In addition, certain devices (e.g. continuous-flow heaters, heating furnaces, et cetera) control their power consumption by abruptly switching on and off, which destabilizes the voltage level due to the grid impedance. This produces fluctuations in voltage, which trigger variations in brightness in the electric lighting ("flicker"). In combination with a suitable AC source and reference impedance, the LMG600 is the tool of choice for the qualified assessment of harmonics and flicker. The LMG Test Suite (see accessories) is providing a user-friendly software solution for this, which turns performing conformity tests for electromagnetic compatibility into child's play.

**CHALLENGES**

- Verification of absence of distortions and voltage stability of the source
- Measurement of signals at significantly different levels
- Clearly organized management of a multitude of measured values

**LMG600**

C Channels | Accuracy | Harmonics | Flicker | Dynamic Range | Test Suite

# Accuracy specification

| **A channel** Accuracy | ± (% of measured value + % of maximum peak value) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | DC | DC [e)] | 0.05 Hz … 45 Hz 65 Hz … 3 kHz | 45 Hz … 65 Hz | 3 kHz … 10 kHz | 10 kHz … 50 kHz | 50 kHz … 100 kHz | 100 kHz … 500 kHz | 500 kHz…1 MHz | 1 MHz … 2 MHz | 2 MHz … 10 MHz |
| Voltage U* | 0.02+0.08 | 0.02+0.06 [e)] | 0.015+0.03 | 0.01+0.02 | 0.03+0.06 | 0.2+0.4 | | 0.5+1.0 | 0.5+1.0 | f/1 MHz*1.5 + f/1 MHz*1.5 | |
| Voltage $U_{SENSOR}$ | 0.02+0.08 | 0.02+0.06 [e)] | 0.015+0.03 | 0.01+0.02 | 0.03+0.06 | 0.2+0.4 | | 0.4+0.8 | 0.4+0.8 | f/1 MHz*0.7 + f/1 MHz*1.5 | |
| Current I* 5 mA…5 A | 0.02+0.1 | 0.02+0.06 [e)] | 0.015+0.03 | 0.01+0.02 | 0.03+0.06 | 0.2+0.4 | | 0.5+1.0 | 0.5+1.0 | f/1 MHz*1.0 + f/1 MHz*2.0 | - |
| Current I* 10 A…32 A | 0.02+0.1[1)] | - | 0.015+0.03[3)] | 0.01+0.02[3)] | 0.1+0.2[3)] | 0.3+0.6[3)] | f/100 kHz*0.8 + f/100 kHz*1.2[3)] | | - | - | - |
| Current $I_{SENSOR}$ | 0.02+0.08 | 0.02+0.06 [e)] | 0.015+0.03 | 0.01+0.02 | 0.03+0.06 | 0.2+0.4 | | 0.4+0.8 | 0.4+0.8 | f/1 MHz*0.7 + f/1 MHz*1.5 | |
| Power U*/ I* 5 mA…5 A | 0.032+0.09 | 0.032+0.06 [e)] | 0.024+0.03 | 0.015+0.01 | 0.048+0.06 | 0.32+0.4 | | 0.8+1.0 | 0.8+1.0 | f/1 MHz*2.0 + f/1 MHz*1.8 | - |
| Power U*/ I* 10 A…32 A | 0.032+0.09[2)] | - | 0.024+0.03[4)] | 0.015+0.01[4)] | 0.104+0.13[4)] | 0.4+0.5[4)] | | f/100 kHz*1.0 + f/100 kHz*1.1[4)] | - | - | - |
| Power U*/ $I_{SENSOR}$ | 0.032+0.08 | 0.032+0.06 [e)] | 0.024+0.03 | 0.015+0.01 | 0.048+0.06 | 0.32+0.4 | | 0.72+0.9 | 0.72+0.9 | f/1 MHz*1.8 + f/1 MHz*1.5 | |
| Power $U_{SENSOR}$ / I* 5 mA…5 A | 0.032+0.09 | 0.032+0.06 [e)] | 0.024+0.03 | 0.015+0.01 | 0.048+0.06 | 0.32+0.4 | | 0.72+0.9 | 0.72+0.9 | f/1 MHz*1.4 + f/1 MHz*1.8 | - |
| Power $U_{SENSOR}$ / I* 10 A…32 A | 0.032+0.09[2)] | - | 0.024+0.03[4)] | 0.015+0.01[4)] | 0.104+0.13[4)] | 0.4+0.5[4)] | | f/100 kHz*1.0 + f/100 kHz*1.0[4)] | - | - | - |
| Power $U_{SENSOR}$ / $I_{SENSOR}$ | 0.032+0.08 | 0.032+0.06 [e)] | 0.024+0.03 | 0.015+0.01 | 0.048+0.06 | 0.32+0.4 | | 0.64+0.8 | 0.64+0.8 | f/1 MHz*1.1 + f/1 MHz*1.5 | |

| **B channel** Accuracy | ± (% of measured value + % of maximum peak value) | | | | | | |
|---|---|---|---|---|---|---|---|
| | DC | 0,05 Hz … 45 Hz 65 Hz … 1 kHz | 45 Hz … 65 Hz | 1 kHz … 5 kHz | 5 kHz … 20 kHz | 20 kHz … 100 kHz | 100 kHz … 500 kHz |
| Voltage U* | 0.1+0.1 | 0.1+0.1 | 0.03+0.03 | 0.2+0.2 | 0.3+0.4 | 0.4+0.8 | f/100 kHz*0.8 + f/100 kHz*1.2 |
| Current I* 5 mA…5 A Current $I_{SENSOR}$ | 0.1+0.1 | 0.1+0.1 | 0.03+0.03 | 0.2+0.2 | 0.3+0.4 | 0.4+0.8 | f/100 kHz*0.8 + f/100 kHz*1.2 |
| Current I* 10 A…32 A | 0.1+0.1[1)] | 0.1+0.1[3)] | 0.03+0.03[3)] | 0.2+0.2[3)] | 0.6+1.2[3)] | 1.5+1.5[3)] | f/100 kHz*2.0 + f/100 kHz*2.0[3)] |
| Power U*/ I* 5 mA…5 A Power U*/ $I_{SENSOR}$ | 0.16+0.1 | 0.16+0.1 | 0.05+0.02 | 0.32+0.2 | 0.48+0.4 | 0.64+0.8 | f/100 kHz*1.28 + f/100 kHz*1.2 |
| Power U*/ I* 10 A…32 A | 0.16+0.1[2)] | 0.16+0.1[4)] | 0.05+0.02[4)] | 0.32+0.2[4)] | 0.72+0.8[4)] | 1.52+1.15[4)] | f/100 kHz*2.24 + f/100 kHz*1.6[4)] |

| **C channel** Accuracy | ± (% of measured value + % of maximum peak value) | | | | | | |
|---|---|---|---|---|---|---|---|
| | DC | 0,05 Hz … 45 Hz 65 Hz … 200 Hz | 45 Hz … 65 Hz | 200 Hz … 500 Hz | 500 Hz … 1 kHz | 1 kHz … 2 kHz | 2 kHz … 10 kHz |
| Voltage U* | 0.1+0.1 | 0.02+0.05 | 0.02+0.02 | 0.05+0.05 | 0.2+0.1 | 1.0+0.5 | f/1 kHz*1.0 + f/1 kHz*1.0 |
| Current I* | 0.1+0.1[1)] | 0.02+0.05[3)] | 0.02+0.02[3)] | 0.05+0.05[3)] | 0.2+0.1[3)] | 1.0+0.5[3)] | f/1 kHz*1.0 + f/1 kHz*1.0[3)] |
| Current $I_{SENSOR}$ | 0.1+0.1 | 0.02+0.05 | 0.02+0.02 | 0.05+0.05 | 0.2+0.1 | 1.0+0.5 | f/1 kHz*1.0 + f/1 kHz*1.0 |
| Power | 0.16+0.1[2)] | 0.032+0.05[4)] | 0.03+0.01[4)] | 0.08+0.05[4)] | 0.32+0.1[4)] | 1.6+0.5[4)] | f/1 kHz*1.6 + f/1 kHz*1.0[4)] |

| | | |
|---|---|---|
| Accuracies valid for: | 1. Sinusoidal voltages and currents<br>2. Ambient temperature (23±3) °C<br>3. Warm-up time 1 h<br>4. The maximum peak value for power is the product of the maximum peak value for voltage and the maximum peak value for current. | 5. 0 ≤ \|λ\| ≤ 1 (power factor)<br>6. Current and voltage 10 % … 110 % of nominal value<br>7. Adjustment carried out at 23 °C<br>8. Calibration interval 12 months |
| Other values | All other values are calculated from current, voltage and power. Accuracy resp. error limits are derived according to context (e.g. S = I * U, ΔS / S = ΔI / I + ΔU / U). | |

[1) 2) 3) 4)] only valid in range 10 … 32 A:

[1)] additional uncertainty ± $\frac{80\,\mu A}{A^2} * I_{trms}^2$   [2)] additional uncertainty ± $\frac{80\,\mu A}{A^2} * I_{trms}^2 * U_{trms}$   [3)] additional uncertainty ± $\frac{80\,\mu A}{A^2} * I_{trms}^2$   [4)] additional uncertainty ± $\frac{80\,\mu A}{A^2} * I_{trms}^2 * U_{trms}$

[e)] Accuracy specification after non persistent zero adjustment, temperature change after zero adjustment max. ±1 °C

| **Voltage measuring ranges U*** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Nominal value (V) | 3 | 6 | 12.5 | 25 | 60 | 130 | 250 | 400 | 600 | 1000 |
| Max. trms value (V) | 3.3 | 6.6 | 13.8 | 27.5 | 66 | 136 | 270 | 440 | 660 | 1000 |
| Max. peak value (V) | 6 | 12 | 25 | 50 | 100 | 200 | 400 | 800 | 1600 | 3200 |
| Overload protection | 1000 V + 10 % permanently, 1500 V for 1 s, 2500V for 20ms | | | | | | | | | |
| Input impedance | 4.59 MΩ, 3 pF | | | | | | | | | |
| Earth capacitance | < 90 pF | | | | | | | | | |

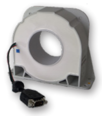
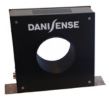
| **Current measuring ranges I*** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nominal value (A) | 0.005 | 0.01 | 0.02 | 0.04 | 0.08 | 0.15 | 0.3 | 0.6 | 1.2 | 2.5 | 5 | 10 | 20 | 32 |
| Max. trms value (A) | 0.0055 | 0.011 | 0.022 | 0.044 | 0.088 | 0.165 | 0.33 | 0.66 | 1.32 | 2.75 | 5.5 | 11 | 22 | 32 |
| Max. peak value (A) | 0.014 | 0.028 | 0.056 | 0.112 | 0.224 | 0.469 | 0.938 | 1.875 | 3.75 | 7.5 | 15 | 30 | 60 | 120 |
| Input impedance | ca. 2.2 Ω | | ca. 600 mΩ | | | ca. 80 mΩ | | | ca. 20 mΩ | | | ca. 10 mΩ | | |
| Overload protection permanent (A) | LMG in operation 10 A | | | | | | | | LMG in operation 32 A | | | | | |
| Overload protection short-time (A) | 150 A for 10 ms | | | | | | | | | | | | | |
| Earth capacitance | < 90 pF | | | | | | | | | | | | | |

| **Sensor inputs $U_{SENSOR}$, $I_{SENSOR}$** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nominal value (V) | 0.03 | 0.06 | 0.12 | 0.25 | 0.5 | 1 | 2 | 4 |
| Max. trms value (V) | 0.033 | 0.066 | 0.132 | 0.275 | 0.55 | 1.1 | 2.2 | 4.4 |
| Max. peak value (V) | 0.0977 | 0.1953 | 0.3906 | 0.7813 | 1.563 | 3.125 | 6.25 | 12.5 |
| Overload protection | 100 V permanently, 250 V for 1 s | | | | | | | |
| Input impedance | 100 kΩ, 34 pF | | | | | | | |
| Earth capacitance | < 90 pF | | | | | | | |

| | |
|---|---|
| **Isolation** | All current and voltage inputs are isolated against each other, against remaining electronics and against earth.<br>Max. 1000 V / CAT III resp. 600 V / CAT IV |
| **Synchronization** | Measurements are synchronized on the signal period. The period is determined based on „line“, „external“, u(t) or i(t), in combination with configurable filters. Therefore readings are very stable, especially with PWM controlled frequency converters and amplitude modulated electronic loads. |
| **Scope function** | Graphical display of sample values over time in two scopes with 8 signals each |
| **Plot function** | Two time (trend-) diagrams of max. 8 parameters, max. resolution 10 ms |
| **External graphics interface (L6-OPT-DVI)** | VGA/DVI interface for external screen output |
| **Process signal interface (L6-OPT-PSI)** | 2 fast analog inputs (150 kS/s, 16 bit, BNC)<br>8 analog inputs (100 S/s, 16 bit, D-Sub:DE-09)<br>32 analog outputs (output per cycle, 14 bit, D-Sub: DA-15 & DB-25)<br>8 switching outputs (6 switches with 2 connections each and 2 switching outputs with common negative, D-Sub: DB-25)<br>8 switching inputs (150 kS / s, in two groups 4 inputs each with common ground, D-Sub: DB-25)<br>Speed-/torque-/frequency inputs (150 kS/s, D-Sub: DA-15) |
| **Star-delta conversion (L6-OPT-SDC)** | Conversion of line voltages to phase voltages and computation of resulting active power |
| **Harmonics at device level (L6-OPT-HRM)** | Harmonics and interharmonics up to 2,000th order, independent and simultaneously for each group |
| **Flicker (L6-OPT-FLK)** | According to EN 61000-4-15 |
| **LMG Remote** | LMG600 expansion software, basic module for remote configuration and operation via PC |
| **L60-TEST-CE61K** | LMG600 software for conformity tests according to EN61000 for harmonics and flicker |
| **Miscellaneous** | |
| Dimensions | LMG640: Table-top version: (WxHxD) 284 mm x 177 mm x 590 mm, 19" version: (WxHxD) 84 HP x 4 RU x 590 mm |
| Weight | Depending on installed options: max. 15.5 kg |
| Protection class | EN 61010 (IEC 61010, VDE 0411), protection class I / IP20 in accordance with EN 60529 |
| Electromagnetic compatibility | EN 61326 |
| Temperature | 0 ... 40 °C (operation) / -20 ... 50 °C (storage) |
| Climatic category | Normal environmental conditions according to EN 61010 |
| Line input | 100 ... 230 V, 47 ... 63 Hz, max. 200 W |

# Accessories program (excerpt)

## Current sensors

| Type | Ring-type transducers | | | | | Current clamps | | Shunt |
|---|---|---|---|---|---|---|---|---|
| |  |  |  |  |  |  |  |  |
| Name | PCT | Hallxxx-L6 | DS | WCT | LMG-Z5XX | L60-Z406, L60-Z60/66 | L60-Z68 | LMG-SH (-P) |
| Signal type | AC+DC | | | AC | | AC | AC+DC | AC+DC |
| Current ranges | $200 \ldots 2000\,A_{rms}$ | $100 \ldots 2000\,A_{rms}$ | $50 \ldots 7000\,A_{rms}$ | $100 \ldots 1000\,A_{rms}$ | $750\,A_{rms} \ldots 10\,kA_{rms}$ | $40 \ldots 3\,kA_{rms}$ | $1\,kA_{rms}$ | $22mA_{rms} \ldots 1\,A_{rms}$ |
| Best accuracy | 0.01 % | 0.5 % | 0.01 % | 0.25 % | 0.02 % | 0.2 % | 2.0 % | 0.15 % |
| Max. bandwidth | DC…1 MHz | DC…100 kHz | DC…1 MHz | 30 Hz…1 MHz | 15 Hz…5 kHz | 5 Hz…50 kHz | DC…2 kHz | DC…100 kHz |
| Power supply by LMG600 | PCT200/600 | Yes | No | Not required | | Yes | | Not required |
| Plug 'n' measure | PCT200/600 | Yes | No | No | | Yes | | No |

## High-voltage dividers

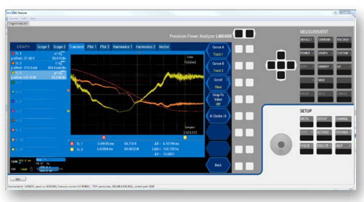
| Name | HST-3 | HST-6 | HST-9 | HST-12 |
|---|---|---|---|---|
| Signal type | AC+DC | | | |
| Max. voltage | $3.15\,kV_{eff}$ | $6.3\,kV_{eff}$ | $9.45\,kV_{eff}$ | $12.6\,kV_{eff}$ |
| Best accuracy | 0.05 % | | | |
| Max. bandwidth | 0 Hz…300 kHz | | | |
| # of phases | 1 to 3 | | | |
| Plug 'n' Measure | No | | | |

## Breakout box

| |  | |  | |
|---|---|---|---|---|
| Name | LMG-MAS | LMG-MAK1 | BOB-CEE3-16 | BOB-CEE3-32 |
| Nominal voltage | 250 V | 300 V | 230 / 400 V | |
| Category | CAT III | | CAT II | |
| Safety standard | IEC / EN61010-1 | | IEC / EN61010-1 | |
| Socket for load connection | 16 A 250 V CEE 7/4 | 10 A 250 V IEC 60320-C14 | 16 A 400 V 3L+N+PE, 6 h IEC 60309 | 32 A 400 V 3L+N+PE, 6 h IEC 60309 |

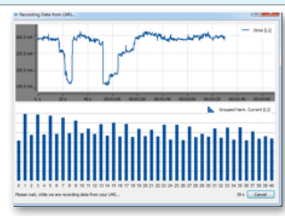
The Breakout Boxes enable access to the individual lines in a connector for measurement, and provides an easy and elegant way to take measurements on single and three-phase consumers.

## LMG Remote



The LMG Remote PC software allows to easily control the LMG600 remotely from a Windows PC. Since this software mimicks the measuring device itself down to the last detail, the LMG600 can be operated as usual, even from the PC - no rethinking required, no familiarization time.

## LMG Test Suite



The tests performed by LMG Test Suite are in accordance with the currently valid edition of EN 61000-3-2/-12 or EN 61000-3/-11, and measurements according to ECE R-10.4 Annex 11 (electromagnetic compatibility of vehicles), for example, are also possible.



ZES ZIMMER

**Germany (headquarters)**
ZES ZIMMER Electronic Systems GmbH
Pfeiffstraße 12 • D-61440 Oberursel
info@zes.com • +49 6171 88832-0
www.zes.com