

DIGITAL DC METER TESTING

Precise verification and calibration of digital DC energy meters with synchronized pulse capture, high-accuracy power analysis, and automated evaluation using the LMG600 series.

Products:

- ▶ LMG Power Analyzers ZES ZIMMER:
- ▶ LMG671
- ▶ LMG641
- ▶ LMG611
- ▶ LMG671-ATE
- ▶ Channels for your LMG600

Patrick Fuchs | 1GP161 | Version 1 | 05.2025

[LMG600 Series Power analyzer | Rohde & Schwarz](#)

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1 Overview

The advancing expansion of DC grids, the integration of DC microgrids, and the proliferation of DC charging stations for electric vehicles - where the DC energy transferred needs to be accurately measured for accounting purposes - are all driving the demand for DC meters. As soon as the meter readings become the base for billing, the consumers have a vested interest in the DC meter's reliability and precision. It becomes a matter of trust to ensure proper verification, calibration and certification of the DC meter used (e.g. Eichrecht conformity resp. E-VDE-AR-E 2418-3-100).

Figure 1 illustrates the connection of a DC charging station between the grid and the EV with the energy flow while charging. Figure 2 shows a DC microgrid and the use of DC meters for energy generators and consumers. A precise power measuring instrument like the LMG600 series power analyzer can be used for pre-compliance tests by meter manufacturers, it can serve as traceable standard for meter certification, and it is a tool of choice to verify the proper functioning of DC meters once doubts arise.

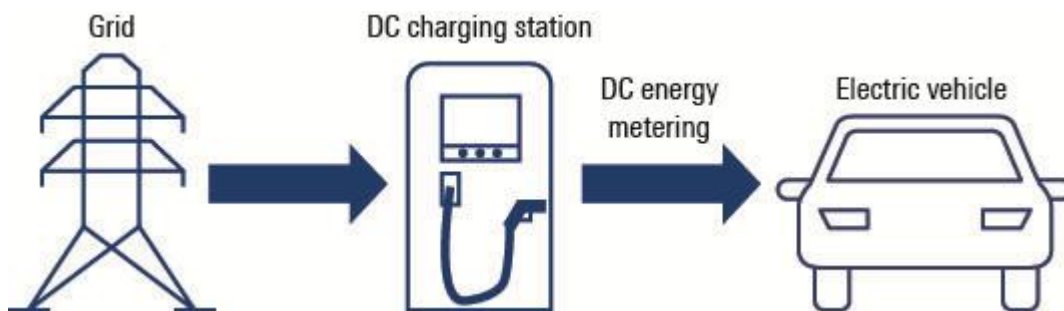


Figure 1: DC charging station

The LMG600 provides highly precise DC power and energy measurements. It can directly capture the pulse output of a digital DC meter and calculate its measured energy over a freely definable number of pulse intervals via the built-in script editor. The comparison between the evaluation of the pulses and the energy measured directly by the LMG600 can be visualized in a meaningful way using the powerful Custom Menu feature. Where other power analyzers struggle, the LMG600's unique timing features make sure pulses and measurement cycles remain perfectly in sync.

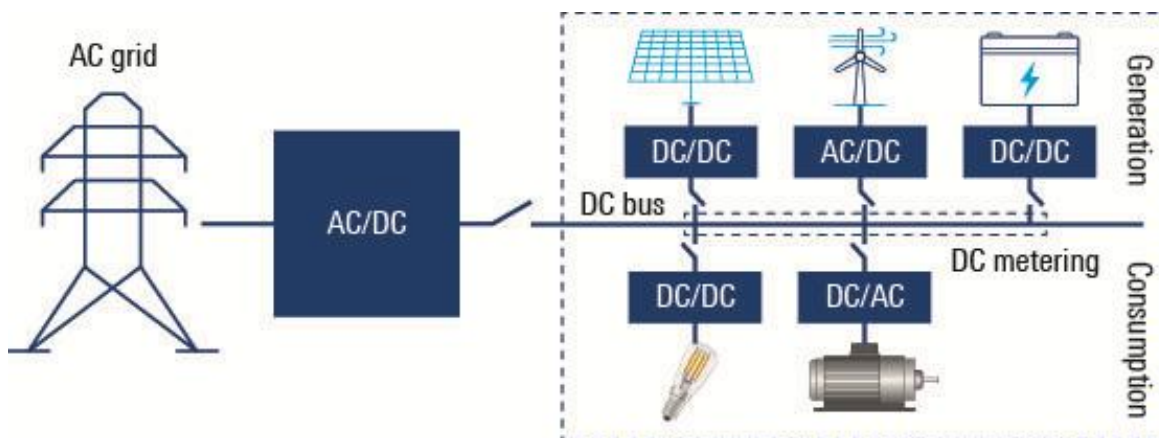


Figure 2: DC microgrid

2 Setup and measurement

To make sure the comparison is valid, the time intervals covered by energy meter and power analyzer need to be identical. This is where traditional power analyzers often struggle, and as a consequence test engineers need to introduce unreliable assumptions regarding the behavior of the energy flow over time. Precise measurements are replaced with guesswork, and the integrity of the meter verification is jeopardized.

The energy to be measured is generated by a precision power supply and fed both into the energy meter and the reference instrument, here an LMG600, parallel. In addition, the energy meter's pulse output is connected to the LMG600's external cycle input, allowing the analyzer to synchronize its measuring cycle for voltage, current, power, energy etc. to the meter's pulses. Since the external cycle input is sampled with more than 5 MHz, the pulses will be captured reliably and precisely. Figure 3 shows the basic measuring setup with an LMG641 power analyzer.

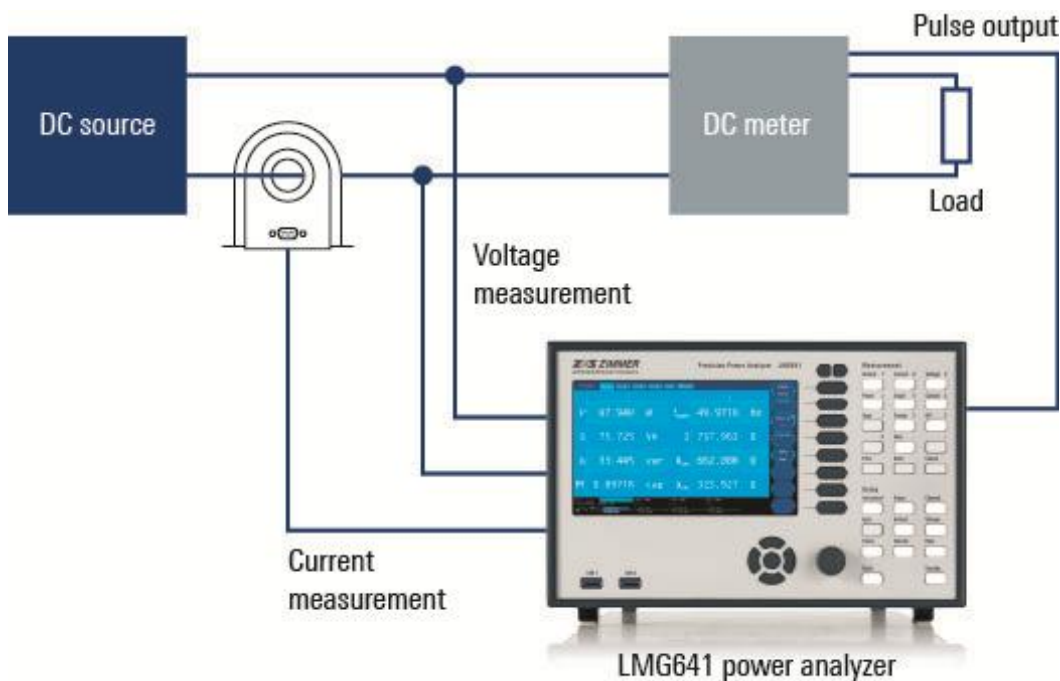


Figure 3: Measuring setup with the LMG641

Once the pulse intervals are synchronized to the measuring cycle of the power analyzer, their length can be recorded. In combination with the use of a highly stable and accurate DC source, this permits easy verification of the accuracy of the intervals and thus the energy counted.

The LMG600 series offers the possibility to customize the GUI so it mimics a specific application. This Custom GUI can be fed with values from the built-in Script Editor (both are available free of charge upon request), which allows to calculate values that are derived from diverse measurement inputs and typically lie outside the scope of run-of-the-mill power analyzers. Through the combination of both, all application-relevant parameters and only those can be displayed, such as:

- ▶ the energy measured by the LMG600
- ▶ the energy measured by the DC meter based on the pulses
- ▶ the duration of each pulse interval
- ▶ the absolute and relative error between LMG600 and DC meter measurements

In most of the DC meter verification and certification tests the energy will be measured over several pulses, i.e. a dose measurement. The user can set the desired number of pulses in the Custom GUI.

Example setting:

- ▶ DC meter with 1200 pulses per kWh output
- ▶ 100V / 100A applied
- ▶ Testing over 5 pulse intervals
- ▶ 300ms pulse interval

The Custom GUI offers a Start button to begin capturing the pulses from the DC meter and start the energy measurement, which will automatically terminate after the pre-configured 5 pulse intervals. The LMG600 displays, and in parallel logs, the readings and scripted variables of interest for each interval. Figure 4 shows the processing of the captured pulses.

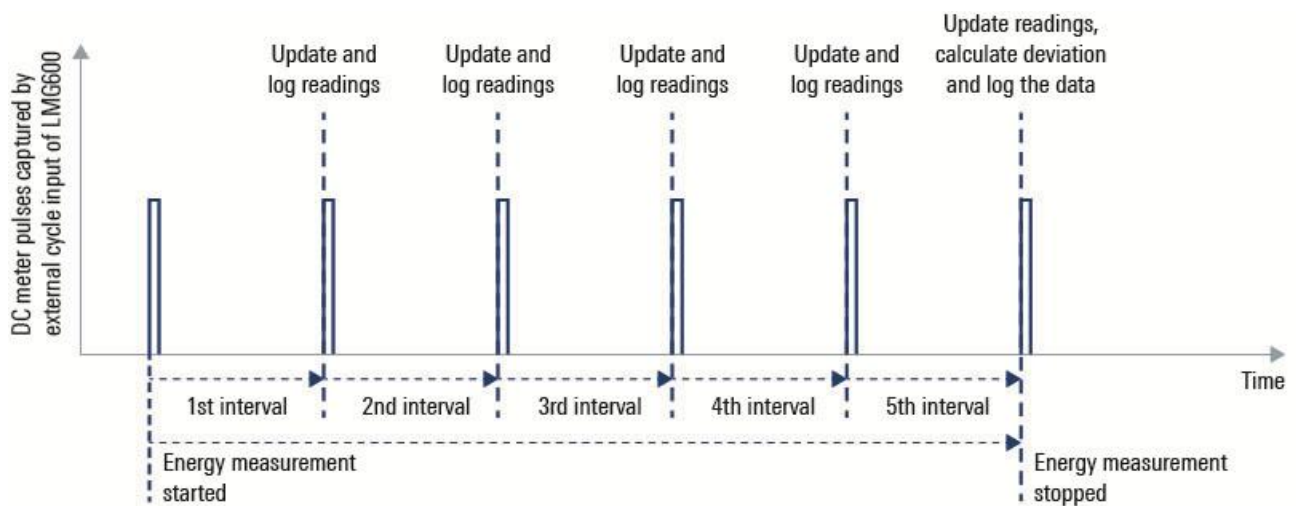


Figure 4: Captured DC meter's pulse intervals

Once the set number of pulses is reached, the script furthermore calculates the deviation between the energy measured by LMG600 and DC meter and displays it in the Custom GUI. This procedure can be carried out several times to verify the repeatability. The data can then be exported in CSV, Octave and/or Matlab format. Figure 5 and Figure 6 show the custom menu and the underlying script. Figure 7 shows the data getting logged in parallel.

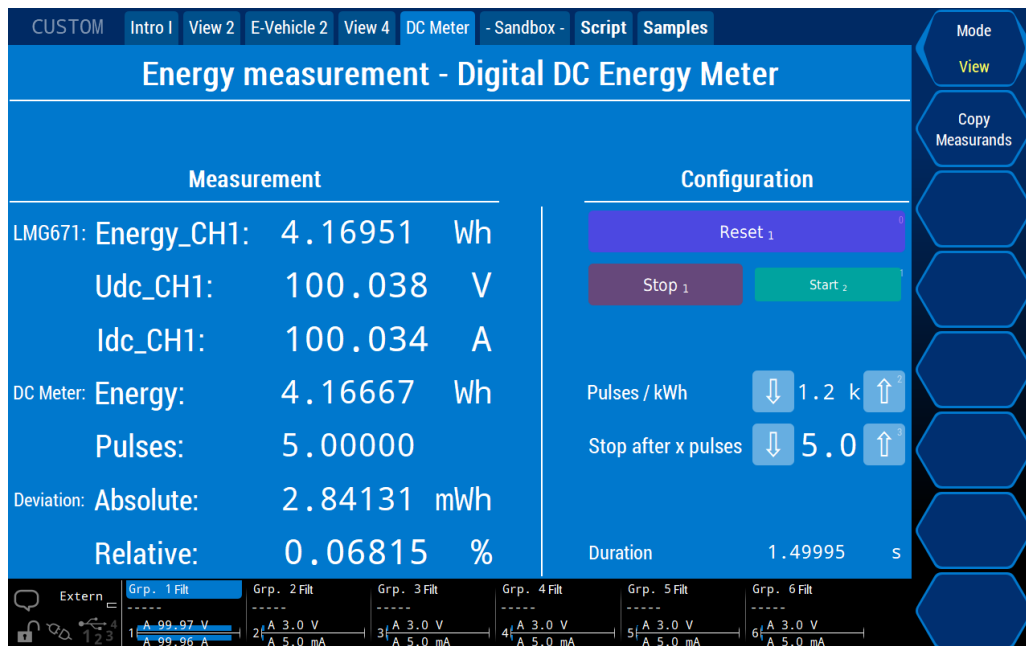


Figure 5: LMG600 custom menu

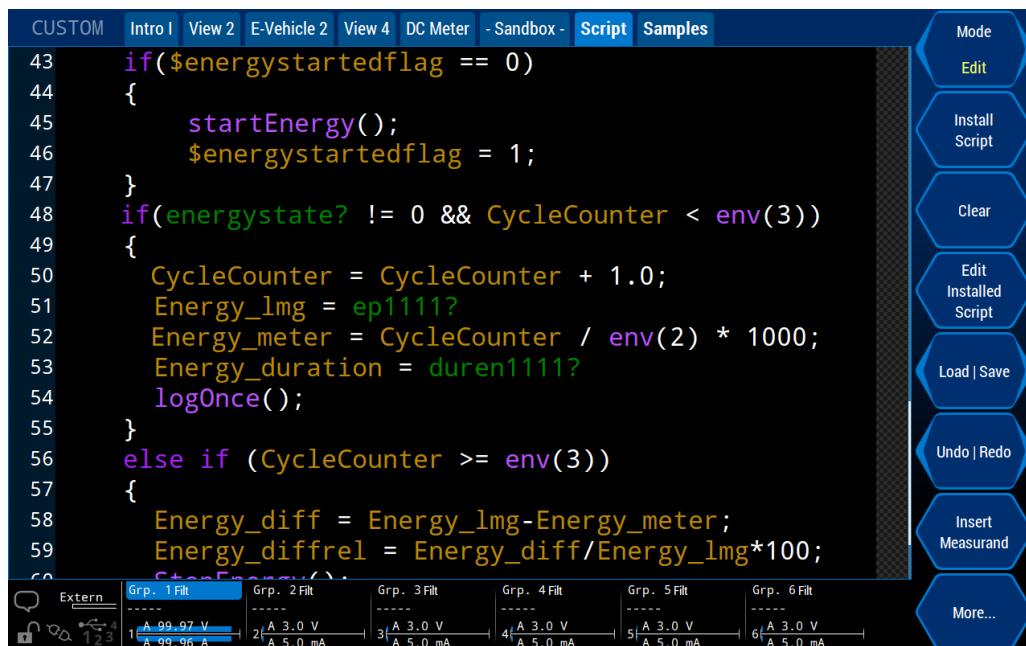


Figure 6: LMG600 dedicated built-in script

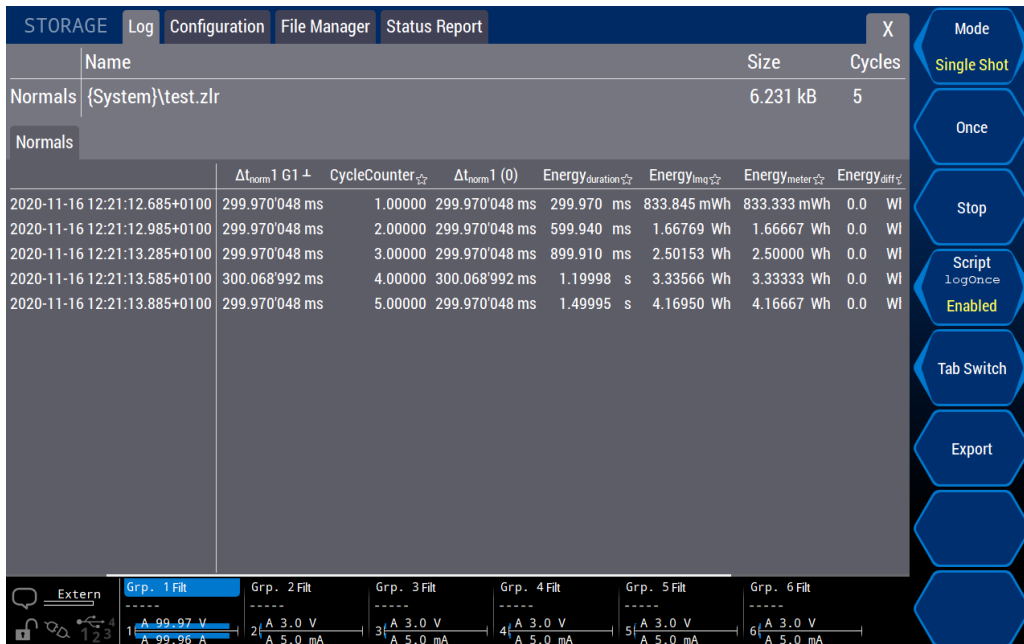


Figure 7: Data logging of the parameters of interest

The LMG600 series power analyzer offers an all-in-one solution for the verification/calibration of DC energy meters. The DUT gets connected directly to the reference instrument, and the measurement is carried out in a single pass. There is no need to stitch together data from different sources, no risk of incongruities, no gaps in the data, no manual reconciling of files, no additional error influences from additional pieces of equipment. The results are displayed immediately in a meaningful and concise manner, and they can easily be exported in various convenient formats, like CSV, MATLAB or TDMS.

3 Power channel specification

The LMG600 series provides accurate DC measurement with its high-end power channel type A. The device will be delivered with a calibration certificate traceable to the PTB or, upon request, a DAKKS-certified calibration.

- ▶ **Bandwidth:** DC, 0.05 Hz ... 10 MHz
- ▶ **DC power accuracy (best):** $\pm (0.032\% \text{ of reading} + 0.06\% \text{ of range})$
- ▶ **Time accuracy:** $\pm 50 \text{ ppm}$
- ▶ **Voltage input:** 300mV - 1000Vrms direct¹ (range extension with HST - high voltage dividers)
- ▶ **Current input:** 500 μ A - 32Arms direct (range extension with precise external sensors)

¹ Voltage range extension (L60-CH-S-VRE) to 1500 VDC optionally available

- ▶ 200Arms (300Apeak or DC)
- ▶ 600Arms (1000Apeak or DC)
- ▶ 1200Arms (1800Apeak or DC)
- ▶ 2000Arms (3000Apeak or DC)
- ▶ and even higher.

The measurement procedure described above uses the LMG600's built-in custom menu/script editor and runs on the analyzer itself. In order to replicate the same functionality in a remote-controlled test bench, we can make available a suitable python script interacting with the LMG600 via the Gigabit-Ethernet interface upon request. It comes with a ready-to-use and well documented python class including functions as open and close interface, write, read and many more.

	A	B	C	D	E	F	G	H
	run	timestamp	energy_ch1 [Wh]	pulse_dur [s]	cycle time [s]	energy_meter [Wh]	error_abs [Wh]	error_rel [%]
1	1	04.11.2020 15:04	2.760.496	9.939.997	9.939.997	2.777.778	-0.01782	-0.626039
2	3	04.11.2020 15:04	5.537.676	10.000.091	19.940.088	5.555.556	-0.01840	-0.328271
3	4	04.11.2020 15:05	8.314.860	9.999.991	29.940.079	8.333.333	-0.01873	-0.222173
4	5	04.11.2020 15:05	11.092.050	9.999.993	39.940.071	11.111.111	-0.019051	-0.171754
5	6	04.11.2020 15:05	13.869.310	10.000.097	49.940.169	13.888.889	-0.019579	-0.141167
6	2	04.11.2020 15:05	2.763.383	9.950.096	9.950.096	2.777.778	-0.014395	-0.520911
7	3	04.11.2020 15:05	5.540.633	9.999.992	19.950.088	5.555.556	-0.014923	-0.269329
8	4	04.11.2020 15:06	8.317.916	10.000.089	29.950.177	8.333.333	-0.015417	-0.185351
9	5	04.11.2020 15:06	11.095.210	9.999.987	39.950.164	11.111.111	-0.015901	-0.143315
10	6	04.11.2020 15:06	13.872.540	9.999.995	49.950.159	13.888.889	-0.016349	-0.117851
11	13							
12	4	04.11.2020 15:06	2.760.669	9.939.997	9.939.997	2.777.778	-0.017109	-0.619733
13	5	04.11.2020 15:06	5.538.043	10.000.091	19.940.088	5.555.556	-0.017513	-0.316223
14	16	04.11.2020 15:07	8.315.393	9.999.991	29.940.079	8.333.333	-0.017940	-0.215748
15	17	04.11.2020 15:07	11.092.750	9.999.993	39.940.071	11.111.111	-0.018361	-0.165524
16	18	04.11.2020 15:07	13.870.160	10.000.097	49.940.169	13.888.889	-0.018729	-0.135030

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