Multimeters as Power, Transient and Energy Recorders

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The multimeter has been and remains the most frequently used tool in the electronics and electrical engineering professions. The **METRAHit® 29S** professional multimeter has surpassed all previous performance limitations: Amongst other functions it can record power, acquire one-time-only events with ingenious trigger techniques like a storage oscilloscope, and provide users with important information for the reduction of energy costs.

Compact design and battery operation give rise to innumerable advantages for laboratory and on-site use of hand-held multimeters. Problems caused by PC links and mains borne interference are all but eliminated. These devices are thus not only suited for simple tasks, but rather for difficult troubleshooting, maintenance work and calibration as well.

Figure 1 The METRAHit® 29S is setting high performance standards for hand-held multimeters with 3 x ± 300,000 digits and power and mains disturbance recording with the integrated data logger.

Calibration with “DKD calibration certificate” is provided as a standard feature, predestining the instruments for demanding on-site balancing, adjustment, inspection and maintenance tasks. Calibration values for the new METRAHit29S are acquired during the manufacturing process with an on-site DKD calibration bench. Data logging and documentation is fully automated and thus does not generate any additional manufacturing costs. Each instrument can thus be furnished with a DKD calibration certificate free of charge.

Comprehensive Multimeter and Data Logger Functions

This precision instrument offers extraordinary performance and accuracy. With its triple display, each with a range of ±300,000 digits, as well as 0.02% basic accuracy, excellent long-term stability thanks to digital balancing and a price tag of 50% less than benchtop instruments, this multimeter fulfills all requirements in the areas of quality assurance, R&D, service and training.

In addition to high resolution, the triple digital display provides the operator with additional information such as the point in time at which extreme values are acquired. The sampling rate which can be adjusted within a broad range is entirely unique for a hand-held multimeter: With stepped resolution, it can be varied from 10 minutes to ½ millisecond depending upon application and measuring function.

The **METRAHit® 29S** (figure 1) includes all of the functions expected of a high quality multimeter: Suitable for alternating, direct and pulsating voltage measurements, it is equipped with a TRMS converter which assures reliable measuring results thanks to its excellent dynamics (up to 10 ms) and low noise factor. Precision measurements for direct voltage and direct current (intrinsic error to 0.02%) are standard as well, as are a signal band width of up to 100 kHz, measurement of current, level, frequency, capacitance and resistance, and logging of extreme values with reference to real-time.

Measuring results can be recorded over lengthy periods of time and uploaded to a PC later with METRAwin®10 software for visualization, arithmetic processing and analysis thanks to the integrated, battery-backed 128 kB memory with quartz movement and ingenious storage techniques (“delta sampling”, -/1/-). Easy data export to MS EXCEL®, WORD® and other Windows applications is accomplished with the clipboard function, allowing for data analysis and processing with other programs.

Versatile Power Measurement

In addition to the above mentioned multimeter and data logger functions, the instrument offers a wide variety of measuring and recording functions for single-phase power measurement. Whereas many power meters reach their limits during measurement of only a few watts, this instrument allows for precision measurements ranging from milliwatts to kilowatts (see figure 2). Measurements can be performed in single-phase alternating **and direct** current circuits. Measuring results are displayed as active power, apparent power, reactive power and power factor. The triple display is quite advantageous in this respect, because it allows for the unambiguous display of several measurement values.

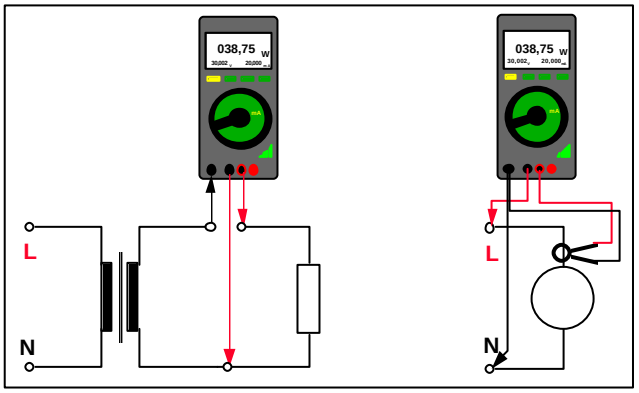

Figure 2: Active power measurement from milliwatts to kilowatts. Current and voltage are displayed simultaneously and recorded to internal memory.

These values can be displayed at the high-contrast LCD and simultaneously recorded to the integrated memory

with reference to real-time. The METRAHit29S thus not only replaces traditional power meters: Linked to a PC, it functions as a power recorder as well. In addition to recording **active power**, it also acquires **current** and **voltage**. After transmitting in-process data (online) or stored data (offline) to the PC, multi-channel characteristic curves for reactive power, apparent power and power factor based upon these basic data can be display at the monitor, documented and exported to other Windows programs. With two or three interconnected instruments (two-wattmeter circuit /3a, 3b/), analyses can also be conducted at 3-phase systems with unbalanced load, which can be recorded to a maximum of 10 channels with optional METRAwin10 software, and processed and evaluated.

Power measurement and the inspection of power meters are extremely important for electrical power utilities. Measurement within the secondary circuit k-l (figure 3) of permanently connected current transformers is especially critical: Permanently installed measuring transducers with a nominal output current of 5 A at outputs “k” and “l” may not be
interrupted during inspection measurements because interruption of load independent current at the secondary side would result in extremely high open-circuit voltage, and would thus lead to coil flashover or destruction and downtime.

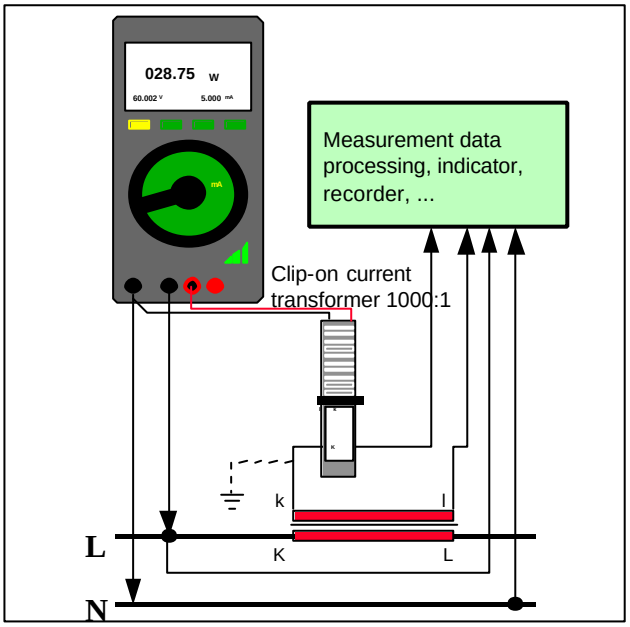

Figure 3: Hazard-free power measurement and recording at transformer circuit k-l for scrutinizing power measurement at electrical power utilities

Precision active power measurement is performed on-site by the METRAHit29S multimeter with the help of the WZ11D miniature clip-on current transformer in a hazard-free fashion. Power characteristics, as well as current and voltage, can be simultaneously recorded, and can be displayed, presented and analyzed later at the PC as actual measured quantities (reactive, active or apparent power) after entering the transformation ratios.

Cost-Effective Energy Control

Mid-sized companies frequently ask themselves if consumed energy is being used economically. The optimization of energy consumption always necessitates initial logging of peak power values – with the greatest possible level of accuracy. The METRAHit29S can be successfully taken advantage of for energy optimization in systems and sub-systems: for the measurement if energy, the display of peak values and for the recording of quarter hour mean values to its non-volatile 128 kB memory.

Energy is recorded universally by means of three different possible methods:

- Analog, single-phase (as shown in figures 2 and 3) via a clip-on current transformer and the voltage circuit. Mean power values are incorporated via the internal integrator over a period of 15 minutes (the period is freely selectable), and are saved to memory.
- Digital pulses from a 3-phase energy meter, for example the U368X /3b/, are evaluated and recorded as described above.
- Digital pulses are acquired from a standard 3-phase Ferraris electric meter with an adapter which is available as an accessory, and are recorded as described above.

The calculated 15 minute mean values are stored to memory, and can be graphically represented and analyzed with optional METRAwin 10 software. Based upon the resulting characteristic curve, significant energy savings can usually be achieved by means of organizational measures, or with minor investment sums.

Recording Mains Failures and Power Disturbances /2/

High performance monitoring of mains voltage and mains failures, as well as rapid logging of peak pulses, are essential for troubleshooting in electrical systems, CNC machine tools and electrical networks, and provide power utilities and consumers with valuable troubleshooting and analysis assistance. However, multimeters were previously incapable of mains voltage and mains failure monitoring because their digitization rates were too slow – despite the relatively high conversion rate offered by the older METRAHit instruments. The new instrument is many times faster and includes extensive trigger criteria for acquiring transient events.

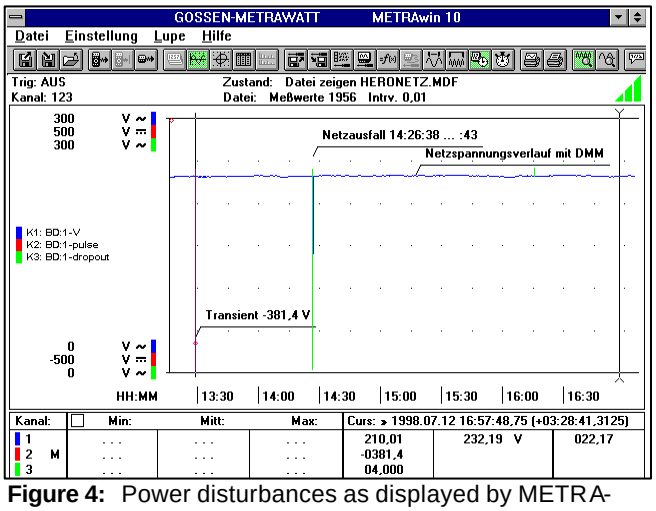

Figure 4: Power disturbances as displayed by METRAHit®29S / METRAwin®10. The data file contains approximately 2000 significant measuring points from 1,400,000 samples.

However, the high speed sampling rate, which is very fast for a multimeter, and the integrated 128 kB memory would not be adequate for the logging of short, high energy transients and other disturbances over long periods of time. Power disturbance recording has thus been distributed over three channels within the instrument:

- Channel 1 is used for continuous line voltage recording with an adjustable sampling rate. It acquires line voltage tendency and characteristics over long periods of time. Its dynamics are approximately equivalent to those of a conventional continuous-line recorder.
- Channel 2 acquires rapid transients with peaks of up to 1000 V and changing polarity ("+ pulse" / "- pulse") within a range of ½ to 5 microseconds. These are recorded simultaneously along with time of occurrence and amplitude by means of a sample & hold circuit, and are displayed in the METRAwin10 line diagram (figures 4 and 5) as a red rhombus (corresponds to the point in time at which the peak occurred).
- Channel 3 records overvoltages, undervoltages (dips and drops) and mains failures at a sampling rate of one millisecond with high dynamics.

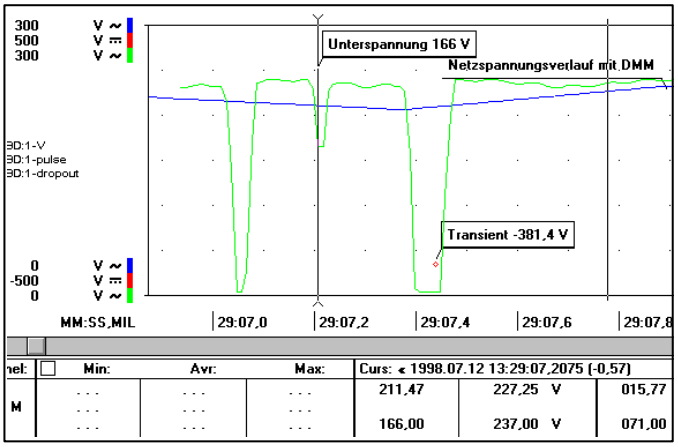

Figure 5: Undervoltage, line voltage interruptions and a rapid spike recorded at 13:29:07 o'clock. Recorders of traditional design respond as indicated by the blue DMM channel. (Detail of the 1st disturbance shown in figure 4)

The recording function of **channel 1** (blue in figures 4 and 5) is supported by the "delta sampling" signal dependent sampling process. Although the signal is sampled at a constant interval of, for example, 0.5 s, measured values are only saved to memory after a predefined degree of change is detected. This has been accomplished in our example with a previously selected signal hysteresis of 0.5 V. This method results in a significant reduction of data volume without any loss of information.

Power disturbance analyses necessitate long battery service life which presents a problem for the power consumption characteristics associated with high speed measuring electronics. Generally speaking, a new battery is sufficient for a recording period of approximately 4 days. Lithium batteries, or a mains power pack which is available as an accessory, are thus advisable for long-term recordings which extend over a period of several days.

Channel 3 utilizes a constant sampling frequency of 1 kHz (green curve in figures 4 through 6). One TRMS value is generated from 10 sampled values. This means that one TRMS measurement value is recorded to memory at a sampling rate of 10 ms. If a pre-selected minimum value of, for example, 190 V is fallen short of, 100 measurement values are written to toroidal-core memory during a recording period of 1 s, 90 of which are recorded after the event. Toroidal-core memory is enabled for a new event after 1 second. The occurrence of disturbances and their characteristics can thus be recorded, and displayed with adequate resolution (see figure 5).

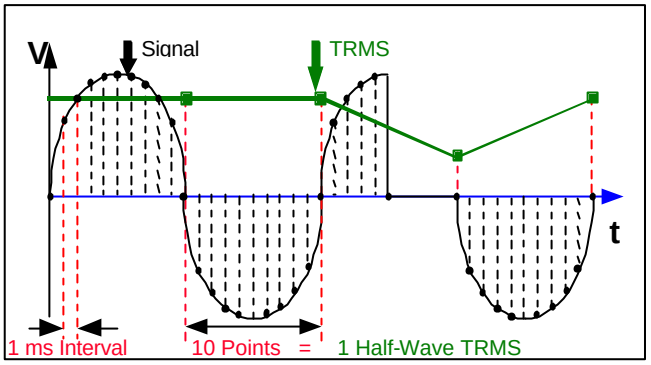

Figure 6 Rapid sampling of an alternating voltage signal at channel 2 and conversion to TRMS values

Memory depth and maximum recording duration are frequent matters of concern where transient recording systems are involved. Although memory capacity for the METRAHit29S is limited to 128 kB, it is used very efficiently: In the example shown in figure 4, only about 4% of available memory capacity was utilized during a recording period of just under 4 hours! This translates into a maximum recording time of approximately 4 days with uniform ripple content and disturbance levels, and continuously high information content. This monitoring period can be extended by optimizing the trigger setting, the sampling period and the signal difference.

The METRAHit29S is a full-fledged system measuring instrument. It can be operated as a stand-alone, or as a system in combination with several instruments and METRAwin10 software. The instrument can be controlled with METRAwin10 windows software via the RS 232C interface which is provided as standard equipment, and can be automatically calibrated with METRAwin90 software. Operating costs and downtime are both reduced as a result. The extraordinary range of instrument features is rounded out with inexpensive recalibration performed at the factory including DKD certificate.

A highly versatile measuring instrument, a multifunctional power meter, a power disturbance measuring instrument and a 3-channel data logger are all included with the new METRAHit29S in its time-tested enclosure. As is also the case with other instruments included in the METRAHit series, it provides users with the proven levels of safety offered by the patented "Automatic Blocking System" (ABS), as well as exceptional operating reliability. It reduces downtime and maintenance costs. Online and offline PC links are made possible by the patented "infrared interface" and the integrated data logger, and a scope of applications ranging from measuring instrument to universal multi-channel recording system is assured. The DKD cali-

bration certificate, which is provided as a standard feature, further expands the range of applications by transforming the instrument into a calibration standard which is accepted throughout all of Europe /4/.

References

/1/ Willi Thomas, Elektronik Industrie, 9/1993
Flexibles Messen und Registrieren per PC
(Flexible Measuring and Recording via PC)

/2/ Willi Thomas, Sonderdruck GMC-Instruments
Kompaktes Hochleistungswerkzeug - Digital-Multimeter METRAHit29S
(The METRAHit29S Digital Multimeter – a Compact High-Performance Tool)

/3a/ Pflier/Jahn, Springer-Verlag, Berlin/Heidelberg
Elektrische Meßgeräte und Meßverfahren
(Electrical Measuring Instruments and Measuring Methods)

/3b/ Klaus-Peter Richter, Sonderdruck GMC-I, 11/97
Elektrische Energiezähler, Grundlagen und Applikationen , BN 3-337-059-01
(Electrical Power Meters, Basic Principles and Applications)

/4/ Willi Thomas, ElektronikPraxis 2/1997
Vom Standard-Multimeter zum Kalibrierstandard
(From Standard Multimeter to Calibration Standard)