HAMEG
Programmable Measuring Instruments

Attention! LOAD!

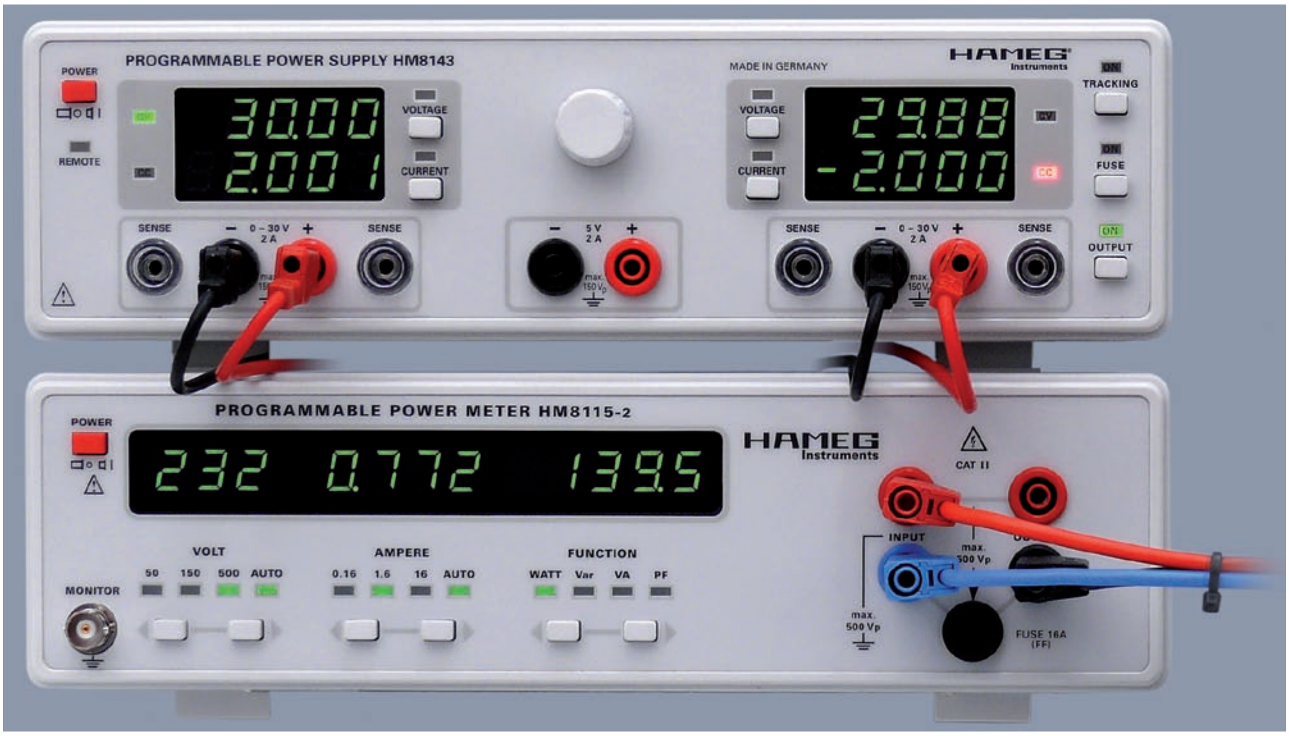


Fig. 1: The power analyzer HM8115-2 measures the power consumption of the Four-Quadrant Power Supply HM8143, for the connection to the mains the HZ815 is used.

Purpose and value of power measurements in the industrial field

In the past 20 years, traditional power supplies consisting of mains frequency transformers, rectifiers, filter elements and linear regulators were increasingly replaced by switch-mode power supplies (SMPS) offering a multitude of advantages like global (wide-range) operability, much higher efficiency, lower bulk and weight and often lower cost.

SMPS circuitry is considerably more complex (high voltage components, feedback circuits, auxiliary start-up circuits etc.). Higher integration, including single-chip solutions as well as the revolutionary improvements of the power semiconductors, decreased the component count considerably. However, while with traditional supplies production failures like wrong components or functional problems led at least to a non-functioning power supply, SMPS pose a whole batch of possibly severe safety risks (massive over voltage, overheating, risk of fire etc.) Consequently, conventional test methods may not detect hidden faults in SMPS even if a supply seems to function normally.

Utilising the Programmable 8 KW HM8115-2 Power Analyzer during design and final production testing will reveal hidden faults better and more reliably than any other method, quite simply, and at moderate cost. Due to its DC to 1 KHz frequency range, it can be used not only in classical 50/60 Hz but also in 16 2/3 Hz railway and 400 Hz airplane systems. The instrument features continuous displays of voltage (U), current (I), apparent power (S), active power (P), reactive power (Q) as well as the power factor PF. In the application the HM8115-2 is either directly connected or by using the optional HZ815. Quite analogous to the use of high precision weighing scales by specialized logistics companies in order to detect packing faults (missing or wrong accessories), this power analyzer will indicate hidden faults in the power supply or in internal loads. Further fault analysis will be performed by qualified personnel.

Characterization of (AC) loads.

There are quite a few power analyzers on the market, many of which feature astonishingly high accuracy at low prices and are marketed as "energy detectives". Typically, such instruments cover the range of 1.5 to 3,500 W, but they can not be integrated in a remotely controlled measuring system nor do they offer the full range of S, P, Q parameter measurements or PF. The HM8115-2 allows precision power measurements in the voltage ranges 50, 150, 500 V and the current ranges 0.16, 1.6, 16 A up to 8 KW with a resolution of up to 1 mW.

For most SMPS of medium power levels the 80 W range (500 V, 0.16 A) is appropriate. In this range a resolution of 10 mW, 10 mVA, 10 mVAr is still achieved which, in the final test, allows the above mentioned detection of deviations of one or more of the power parameters S, P, Q, PF from their respective reference values. Quite often, the products tested (e.g. POS credit card terminals) have various modes like standby, mains, or battery operation with associated changes in the power management such that in each operating mode the four power parameters will be different.

In addition to the display of the parameter values for quantitative analyses, an analog monitor output (1 V AC at full range) is provided which is isolated from the measuring terminals and interfaces which allows e.g. to display the momentary power as a function of time on an oscilloscope. Fig. 2 shows the typical line power of a SMPS (of a HM8118). The analysis of the instantaneous power is important for SMPS designers and for test engineers when searching for faults.

Interpretation of measurement results.

It applies to all types of power supplies that power is drawn from the mains during both half cycles because power is the product of voltage times current, the power frequency is thus 100 (120) Hz. This doubling of line frequency, known from ac theory, is demonstrated quite clearly by the monitor output signal.

In this example, the test object's (HM8118) line current is 66 mA, the PF equals 0.57, this leads to an active power P = 8.98 W, a reactive power Q = 13.2 VAr and an apparent power S = 15.8 VA. These numbers represent a "signature" of a reference instrument. From the standpoint of product safety it does not suffice to just measure P, at least one of the parameters Q or PF is required in addition.

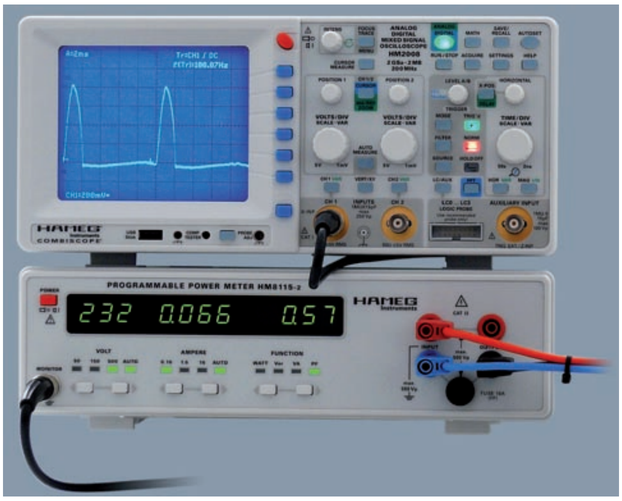


Fig. 2: Display of the instantaneous power of a SMPS available at the HM8115-2 monitor output.

Fig. 1 shows the current flowing out of the first channel of a HM8143 Four-Quadrant Power Supply (classical concept with mains transformer, linear regulator etc.) into the second channel acting as a current sink where it is converted to heat. The power consumed is P(in) = 139.5 W, Q = 112 VAr, S = 179.1 VA which corresponds with an unspectacular PF = 0.78.

The importance of the Power Factor PF.

The European Standard EN 61000-3-2, applying to products › 75 W destined for the general public, defines maximum limits of line current harmonics for the power ranges 75 to 600 W, › 600 W. The purpose of this norm is to limit the line current harmonics caused by pulsating line currents.

A variety of methods are used in order to create a line current as close to a sine wave as possible and to minimize the phase difference between voltage and current even at high power levels. There are various passive and active power factor correction (PFC) circuits in use.

The HM8115-2 allows you to display both parameters (momentary power and PF) without any problems.

Measurements in industrial applications: time is money.

The measurement of a DUT's power parameters is performed simultaneously with the current system test because the power analyzer is also connected to the DUT, no additional time is required other than that

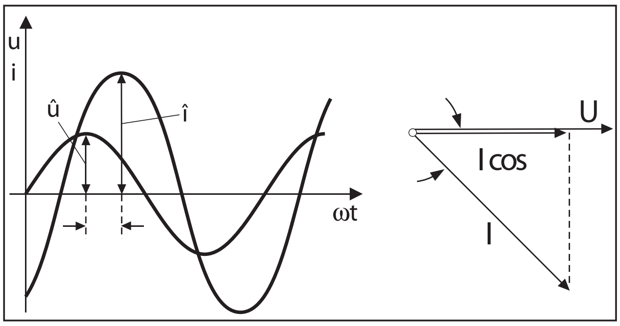


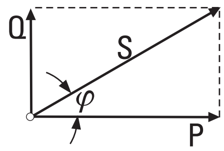
Fig. 3: left: Phase difference between u(t) and i(t).
right: Phasor diagram of an inductive load.

needed to transfer measurement results of U, I, P, Q, S, PF via the interface. The HM 8115-2 is equipped with a RS-232 interface. An optional (factory-installed) dual RS-232/USB or GPIB may be ordered. All interfaces are isolated and guarantee a connection to the ATE which is free from any interference. For professional applications a 2 unit 19" rack-mount kit is available.

Conclusion.

The SMPS contained in many products offer various advantages like higher efficiency and wide-range operation (85 …264 V). However, they do not use transformers but diverse passive high voltage components and power semiconductors, hence preventive quality assurance requires a more comprehensive test procedure. The power analyzer HM8115-2 is highly qualified for this task because it can not only measure the power consumed separated in active, reactive and apparent power and also the power factor by pressing a button, but it features an analog monitor output for the instantaneous power as a function of time – and all this at the fair net price of ‹ 500 €.

S = Apparent power
P = Active power
Q = Reactive power



Power factor

$$PF = \frac{P}{S}$$

Apparent power

$$S = \sqrt{P^2 + Q^2}$$

Fig. 4: top: Phasor diagram of P, Q, S showing the phase difference
bottom: Definition of the power factor PF.

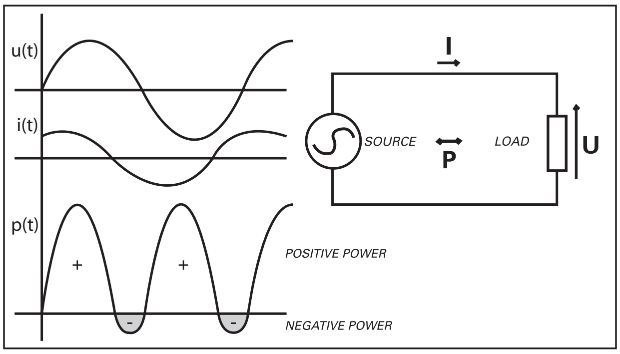


Fig. 5: Instantaneous power p(t) as the product of u(t) and i(t). Positive power is consumed, negative power oscillates back and forth, causing undesirable instability and requiring greater conductor cross sections.

The available (ac) measurement parameters of the HM 8115-2	
Active power P:	Unit watts (W). Only the active power can be transformed into any other form of power like mechanical, thermal or chemical power.
Reactive power Q:	Unit reactive VAr. Loads with inductive or capacitive components cause a phase difference between voltage and current (see Fig. 3). Energy is stored and discharged: the additional current caused thereby fluctuates between mains and load, contributing nothing to the actual power, only creating additional losses.
Apparent power S:	See Fig. 4: The apparent power is calculated equal to the geometric sum of active and reactive powers.
Power Factor PF:	Quotient of active/apparent powers.

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