



### Measurements on equipment with low power consumption

Low power

On a perfect electrical network, the voltage and current signals are sinusoidal. As a result, the power factor is the same as the cosine  $\phi$  (*displacement power factor*).

In industry, there are usually machines or other electrical equipment generating reactive power which adversely affects the power factor. Power suppliers have set up special pricing schemes for high-power supplies. In such cases, the power factor is monitored and the reactive power generated is billed. Industrial companies therefore need to raise the power factor by implementing solutions based around capacitors.

In the residential sector, power suppliers do not monitor the power factor. Only professionals subject to these special pricing schemes are concerned.

We are going to study the power consumed by an appliance connected to the mains and requiring a very low current, and then analyse the decomposition of that power.

**Power decomposition**

**Low current**

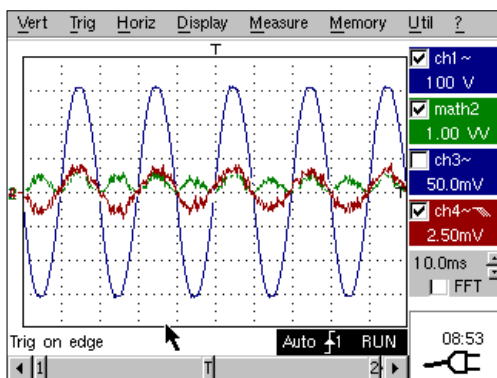
**Automatic measurements**

## THEORETICAL ANALYSIS

A simple way of finding out the current is to measure it with a current clamp (e.g. a K2 clamp (1 mA/10 mV)). The clamp is hooked up to the voltage input of a Scopix®, with the 5 kHz bandwidth limiter active. The minimum calibre authorized on the Scopix® is 2.5 mV/DIV.

The 230 V voltage can be measured directly with test probes (600 V CAT III), either on the terminals of a power socket or on the terminals of the appliance (*if a socket is used, it should be close to the appliance, as the mains network fluctuates throughout the day and the voltage and frequency vary as a function of time*).

The Math function can be used to obtain the product of the voltage multiplied by the current in order to view the apparent power, but not its power factor. By selecting the lowest vertical calibre, the amplitude of the trace is large enough for calculation of the power factor.



### The power factor depends on the active power P and the apparent power S : $\frac{P}{S}$

The apparent power S can be obtained by multiplying the RMS current value by the RMS voltage value. These values are available in the automatic measurements on each channel. The average value "Vavg" in the automatic I and U measurements associated with the MATH UxI calculation for the channel can be used to obtain the active power.

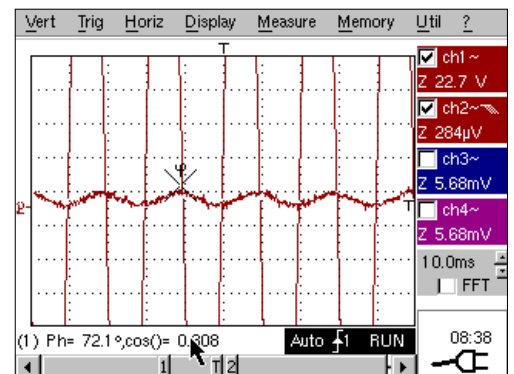
Note: if the two signals are sinusoidal, it is possible to deduce the phase shift of the power factor  $\phi$ .

#### Tip

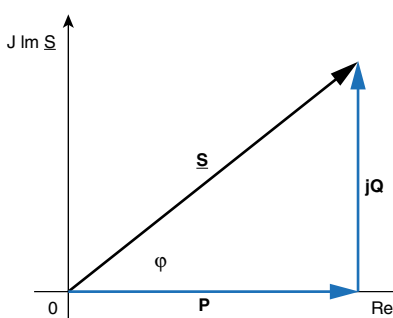
You are advised to wind the phase conductor N times around the jaw of the clamp and to divide by N the current value obtained; this ensures more accurate measurement.

In such cases, manual phase measurement is possible for greater accuracy. Measurement accuracy is an important factor to be taken into consideration.

With an application like this, we are close to the instrument's limits. Automatic phase measurement is not available in this case because the current amplitude is too low to be detected.



### Important formulae



By definition, the apparent power is the product of the RMS current value multiplied by the RMS voltage value:  $S = UI$

The active power is the mean value of the product of the current and voltage, i.e. the mean power value:  $P = \langle u(t)i(t) \rangle$

If the signal is sinusoidal, we can conclude:

$$PF = \cos \phi$$

$$\phi = \cos^{-1}(\text{power factor})$$

## MEASUREMENTS

In this specific case, the low power measurements performed are for analysis of the power factor. The current flowing in the conductor is low (100  $\mu$ A) and the voltage on the terminals is the 230 V mains voltage at 50 Hz.

A quick glance at the measurements in Scope mode by the Scopix® portable oscilloscope shows that it is possible to measure a power value (even a very low one) with a current close to 1 mA. These measurements allow us to calculate the power factor on the installation. In addition, as the current and voltage are sinusoidal, it is possible to deduce the phase shift (angle between I and V).

The figure below shows the traces of the power, voltage and current in Oscilloscope mode (Fig. 1):

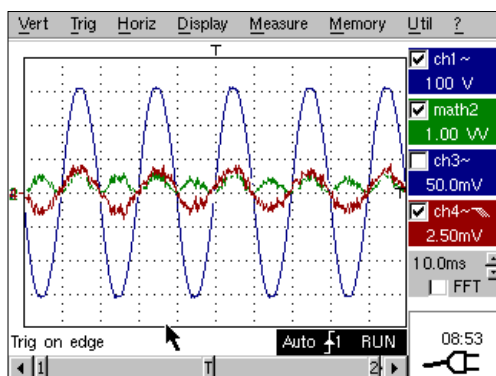


Fig. 1

As the amplitude of the current is so low that it is difficult to detect, measurements with the Scopix® in Meter mode are not suitable, which is why we have chosen to perform them in Scope mode..

However, the oscilloscope takes into account the Probix® inserted on channel 2 (Fig. 2).

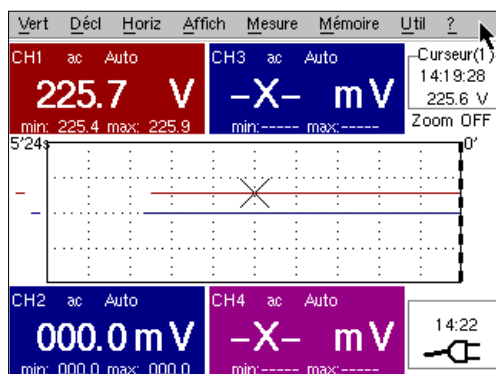
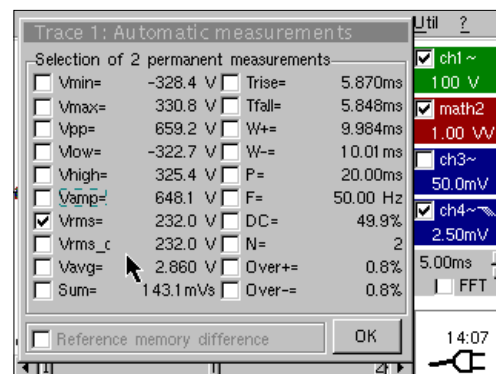
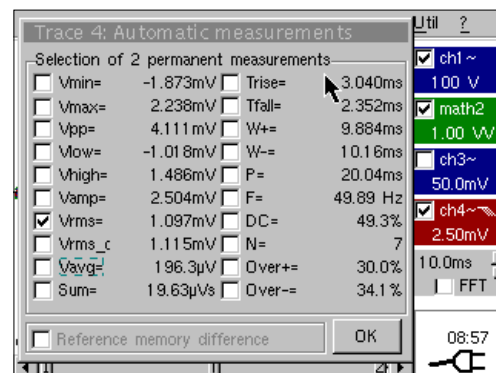


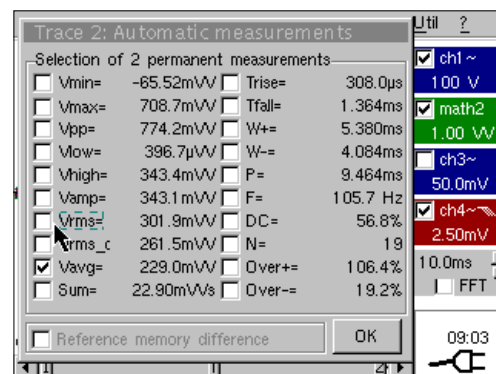
Fig. 2



Automatic measurement of the RMS voltage value



Automatic measurement of the RMS current value which must be divided by 10 because the K2 clamp has a ratio of 1 mA/10 mV



Automatic measurement of the MATH 2 = CH1 x CH2 calculation shows Vavg corresponding to Pavg = 220 mW

## ANALYSIS OF THE MEASUREMENTS

After performing the measurements, we need to analyse them. The formulae indicated in the box on the previous page are used for this and remain valid. First of all, it is possible to find the power factor because the active and apparent values are provided by the previous measurements.

$$\text{Power factor} = \frac{P_{\text{avg}}}{V_{\text{rms}} \times I_{\text{rms}}} = \frac{220.1 \times 10^{-3}}{232 \times 1.087 \times 10^{-3}} = 0.873$$

The signals observed during measurement were sinusoidal, so  $\text{PF} = \cos \varphi$ .

$$\varphi = \cos^{-1}(0.873)$$

$$\varphi = 29 \text{ degrees}$$

The power factor is simple to calculate if a suitable measuring instrument is used, even if the current present is very low. For this type of calculation, the Scopix® oscilloscope is recommended because the power can be viewed, even when low, and the automatic measurements can be performed sufficiently accurately.

## HOW TO PERFORM THE MEASUREMENTS

This instrument guarantees accuracy for this application, as the automatic measurements are particularly useful for obtaining a power factor value quickly.

**The Scopix® operating mode is simplified, as it is possible to enter a coefficient directly on the current sensor so that you can have an image of the current indicated in Volts (clamp transformation ratio) without opening the power-supply circuit, so without cutting off the mains.**



The oscilloscope in the Scopix III portable range from Metrix® is capable of measuring low power values while maintaining satisfactory accuracy. It is possible to carry out experiments of this sort by combining a current sensor (K1, K2, E3N, PAC 12 or PAC 22) from Chauvin Arnoux® and test probes for direct voltage measurements (600 V CAT III) in Oscilloscope mode.



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