

Info Letter No. 22

Definitions

"Power factor" and "current-distortion reactive power"

Power factor and $\cos\varphi$:

In power supply facilities, a high power factor is strived for in order to avoid transmission losses. In an ideal case it is 1.0. Power supply companies often specify a power factor of at least 0.9 for their customers. If it is below this value, the related reactive work is billed separately.

In connection with the subject of line harmonics in electronic circuits, the power factor plays a special role.

The power factor, active power factor, or also work factor refer to the ratio of the active power P to the apparent power S.

Active power:

$$P = U \cdot I \cos \varphi$$

Apparent power:

$$S = U \cdot I$$

The apparent power (S) corresponds to the product of the effective voltage value (U) with the effective current value (I).

Power factor:

$$\lambda = \frac{|P|}{S \text{ (Power Faktor PF)}}$$

Instead of the power factor ($\frac{|P|}{S}$), the " $\cos\varphi$ " measurement value traditionally used resulted primarily from the previously used measurement techniques. In conventional measurement transformers, the much easier-to-implement measurement of the phase shift between the current and voltage is used.

The corresponding converters usually produce a linear output signal with an angle φ (e. g. -20 mA ... 0 ... 20 mA). The desired cosine function is realized on the scales of the subsequent switching devices by a corresponding non-linear scale (scale range proportional to the cosine curve e.g. 0.5 capacitive ... 0 ... 0.5 inductive).

Only with exactly sinusoidal currents and voltages is the power factor equal to the cosine of the phase angle φ .

The power factor can be between 0 and 1.

Under the above conditions the following also applies:

$$\lambda = \cos \varphi$$

Current-distortion power factor

The distortion power factor, also called the harmonic reactive power, describes a special form of reactive power. In alternating and three-phase systems, the distortion power factor is produced by non-linear consumers such as rectifiers, inverters or magnetic components with saturation phenomena. The non-sinusoidal current can be represented as a sum of harmonic currents. These current harmonics in combination with the line voltage result in reactive power components, which are called the distortion reactive power.

The product of the voltage with all the harmonic currents forms the current distortion power D:

$$D = U \cdot \sqrt{\sum_{v=2}^{\infty} I_v^2}$$

Note:

The definition is based on the assumption that there are no voltage harmonics that, with a harmonic current (same frequency), can produce an effective power.

The current distortion power (D) is:

$$D = \sqrt{S^2 - P^2 - Q_{50}^2}$$

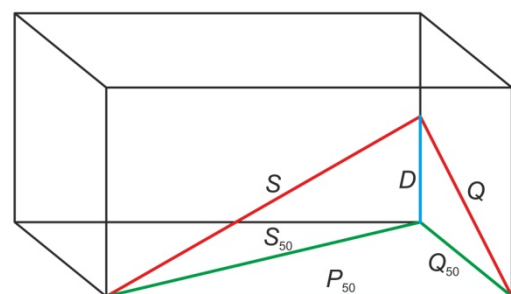


Figure 1

The active power P is that power which is consumed by a consumer as a power. The fundamental reactive power Q_{50} is a power component that due to the storage of energy in the inductive or capacitive components of the consumer periodically shifts back and forth between producers and consumers.

With current harmonics in the network, a third component is added, the current distortion power D, which represents the reactive power of the current harmonics.

We take care of it.

The product of two pure sine waves of different order is a null period, despite changes over time!

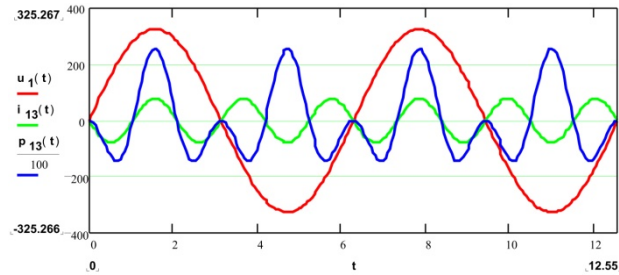


Figure 2

red = 50 Hz voltage;
green = Current 150 Hz;
blue = Power from Product U 50 Hz
and I 150 Hz

Voltage and current harmonics result in a different frequency during a period of no average power, therefore no active power.

The work power is formed only from the current and voltage components of the same frequency, in this case only with the current fundamental frequency

Active power:

$$P = U \cdot I_1 \cos \varphi_1$$

This produces for the

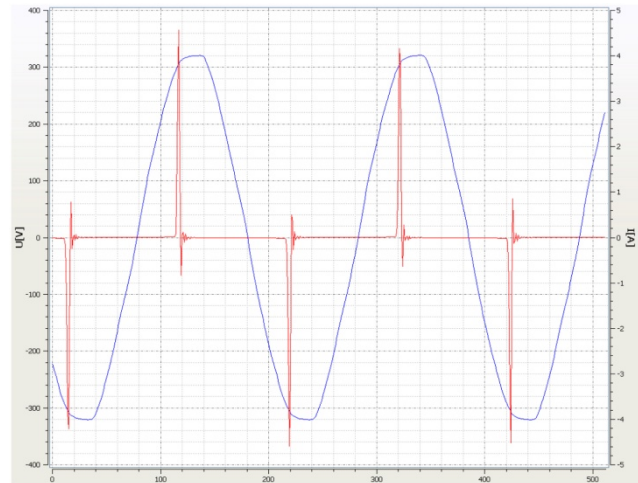
Power factor:

$$\lambda = \frac{|U \cdot I_1 \cdot \cos \varphi_1|}{S}$$

For example, energy-saving lamps

Current L1	=	580 mA
Voltage L1-N	=	232 V
Active power P	=	28 W
Apparent power S	=	134.6 VA
Reactive power Q	=	131.6 VAR
Current-distortion power factor D	=	112 VAR

Due to the large number of current harmonics (THD $I = 375\%$) for this consumer the power factor $\lambda = 0.20$, while the $\cos \varphi$ is 0.93.



Many electronic consumers such as bridge rectifier circuits or switching power supplies have a high $\cos \varphi$ that is close to 1, but a bad power factor.

Here the use of compensation equipment would not produce a reduction in the reactive power or result in an improvement of the power factor.

The series will be continued.

We will gladly supply missing Info Letters at any time!

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