CIRCUTOR

S (kVA)
Apparent power

P (kW)
Active power

φ

Q (kvar)
Reactive power

HANDBOOK
Basic formulas
for power
factor correction

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Basic formulas for power factor correction

This handbook of basic formulas aims to provide a quick reference tool for most of the calculations relating to power factor correction, also including certain aspects of compensation in networks with harmonic distortion by means of capacitor banks with detuned filters.

Please contact the **CIRCUTOR** Technical Department for any explanations or queries regarding power factor correction and/or harmonic correction.

BASIC CONCEPTS

Main magnitudes (unit and name in brackets):

U	Voltage (V / volt)
I	Electric current intensity (A / ampere)
P	Active power (W / watt)
Q	Reactive power (var / volt-ampere reactive)
Q_L	Inductive reactive power (var L / volt-ampere reactive-inductive)
Q_C	Capacitive reactive power (var C / volt-ampere reactive-capacitive)
S	Apparent power (VA / volt-ampere)
C	Capacity ($F = 10^6$ µF / farad = 10^6 microfarads)
L	Inductance ($H = 10^3$ mH / henry = 10^3 millihenries)

f	Frequency
	(Hz / hertz)
φ	Angle of phase difference
	(rad / radian)
λ	Power factor
	(commonly expressed as PF)
$\cos \varphi_1$	Displacement factor
	(commonly expressed as $\cos \varphi$)

Fundamental formulas (considering perfectly sinusoidal, balanced networks):

Three-phase active power, *(P)*:

$$P = \sqrt{3} \cdot U \cdot I \cdot \cos\varphi$$

(U = Phase-phase voltage (between phases))

Three-phase reactive power, *(Q)*:

$$Q = \sqrt{3} \cdot U \cdot I \cdot \sin\varphi$$

(U = Phase-phase voltage (between phases))

Three-phase apparent power, *(S)*:

$$S = \sqrt{3} \cdot U \cdot I$$

(U = Phase-phase voltage (between phases))

Power factor, (λ *(PF))*:

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

Ratio of active power to reactive power, (tan φ):

$$\tan\varphi = \frac{Q}{P}$$

Displacement factor, $(\cos\varphi)$:

$$\cos\varphi = \cos\left(\tan^{-1}\left(\frac{Q}{P}\right)\right)$$

Capacitive reactive power (Q_C) required to compensate from an initial cosine $(\cos\varphi_I)$ to a final one $(\cos\varphi_F)$:

$$Q_C = P\cdot\left(\tan\left(\cos^{-1}\left(\cos\varphi_I\right)\right) - \tan\left(\cos^{-1}\left(\cos\varphi_F\right)\right)\right)$$

Total capacity of a capacitor in µF with known power Q_C in kvar, *(C)*:

$$C = \frac{Q_C}{2\cdot\pi\cdot f\cdot 10^{-9}\cdot U^2}$$

(U = Phase-phase voltage, f = Mains frequency)

Power of a capacitor in kvar with known total capacity in µF, *(Q_C)*:

$$Q_C = 2\cdot\pi\cdot f\cdot C\cdot 10^{-9}\cdot U^2$$

(C = Total capacity in µF, U = Phase-phase voltage, f = Mains frequency)

Nominal current, in amperes, per phase of a three-phase capacitor with power Q_c in kvar, (I_c):

$$I_c = \frac{Q_c \cdot 1000}{\sqrt{3} \cdot U}$$

(U = Phase-phase voltage)

Power of a capacitor with nominal voltage U_n, for a network voltage U_R, (Q_{U_R}):

$$Q_{U_R} = Q_{U_n} \cdot \left(\frac{U_R}{U_n} \right)^2$$

(Q_{U_n} = Power of the capacitor with voltage U_n, $U_n > U_R$)

POWER FACTOR CORRECTION IN NETWORKS DISTORTED BY CAPACITOR BANKS WITH REJECTION FILTERS (OR DETUNED FILTERS)

Fundamental formulas:

Resonance frequency of a detuned filter, (f_{res} / Hz):

$$f_{res} = \frac{1}{2 \cdot \pi \cdot \sqrt{L \cdot C}}$$

(C = Total capacity in F)

(L = Inductance per reactor phase in H)

Overvoltage factor of a detuned filter, (p %):

$$p = 100 \cdot \left(\frac{f}{f_{res}} \right)^2$$

(f = Mains frequency in Hz)

Resonance frequency of a detuned filter with known p (%), (f_{res} / Hz):

$$f_{res} = f \cdot \sqrt{\frac{100}{p}}$$

(f = Mains frequency in Hz)

Voltage applied to the capacitor, (U_c / V):

$$U_c = \frac{U}{1 - (p/100)}$$

(U = Phase-phase voltage of the mains)

Parallel resonance frequency of an electrical network (f_{res} / Hz):

$$f_{res} = f \cdot \sqrt{\frac{S_{sc}}{Q_c}}$$

(f = Mains frequency in Hz)

(S_{sc} = Short-circuit power of the transformer in kVA)

(Q_c = Power of the capacitor bank in kvar)

or

$$f_{res} = f \cdot \sqrt{\frac{100 \cdot S}{u_{sc} \cdot Q_c}}$$

(f = Mains frequency in Hz)
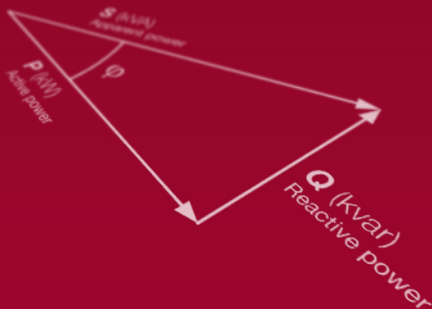
(S = Nominal power of the transformer in kVA)

(u_{sc} = Short-circuit voltage of the transformer in %)

(Q_c = Power of the capacitor bank in kvar)

Leaders in power factor correction

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