⬙TDK

EPCOS Product Profile (India) 2013

Power Factor Correction

Power Quality Solutions

Preview

Linear loads:
voltage was followed
by current.

Non linear load produce
non sinusoidal currents when
connected to sinusoidal voltage.
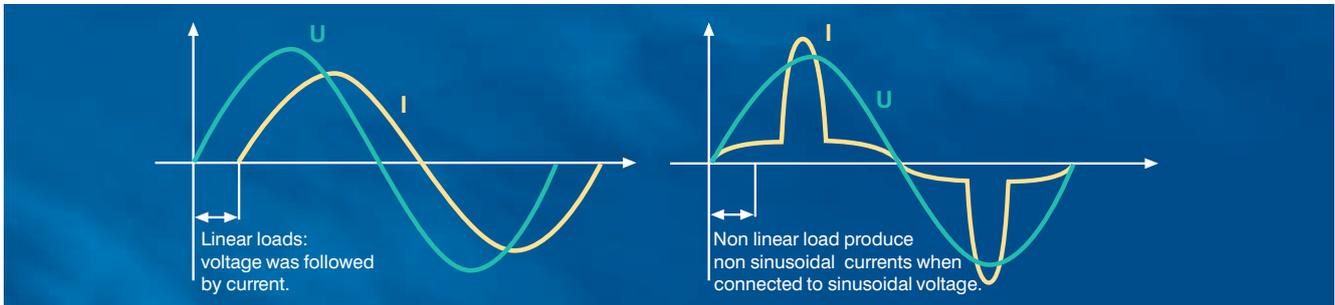
General

The increasing demand of electrical power and the awareness of the necessity of energy saving is very up to date these days. Also the awareness of power quality is increasing, and power factor correction (PFC) and harmonic filtering will be implemented on a growing scale. Enhancing power quality – improvement of power factor – saves costs and ensures a fast return on investment. In power distribution, in low- and medium-voltage networks, PFC focuses on the power flow (cos $\varnothing$) and the optimization of voltage stability by generating reactive power – to improve voltage quality and reliability at distribution level.

How reactive power is generated

Every electric load that works with magnetic fields (motors, chokes, transformers, inductive heating, arc welding, generators) produces a varying degree of electrical lag, which is called inductance. This lag of inductive loads maintains the current sense (e.g. positive) for a time even though the negative-going voltage tries to reverse it. This phase shift between current and voltage is maintained, current and voltage having opposite signs. During this time, negative power or energy is produced and fed back into the network. When current and voltage have the same sign again, the same amount of energy is again needed to build up the magnetic fields in inductive loads. This magnetic reversal energy is called reactive power.

In AC networks (50/60 Hz) such a process is repeated 50 or 60 times a second. So an obvious solution is to briefly store the magnetic reversal energy in capacitors and relieve the network (supply line) of this reactive energy. For this reason, automatic reactive power compensation systems (detuned/conventional) are installed for larger loads like industrial machinery. Such systems consist of a group of capacitor units that can be cut in and cut out and which are driven and switched by a power factor controller.

Apparent power $S = \sqrt{P^2 + Q^2}$
Active power $P = S * \cos \varphi$
Reactive power $Q = S * \sin \varphi$

With power factor correction the apparent power S can be decreased by reducing the reactive power Q.

Reactive Power [KVAr]
$Q^2 = S^2 - P^2$

Apparent Power [kVA]
$S^2 = P^2 + Q^2$

Active Power [kW]
$P^2 = S^2 - Q^2$
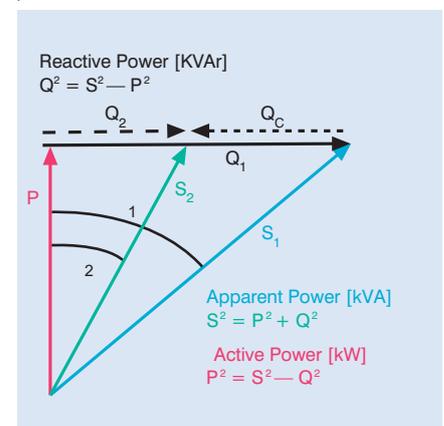
Power factor
Low power factor (cos φ)

Low cos φ results in

- Higher energy consumption and costs,
- Less power distributed via the network,
- Power loss in the network,
- Higher transformer losses,
- Increased voltage drop in power distribution networks.

Power factor improvement

Power factor improvement can be achieved by

- Compensation of reactive power with capacitors,
- Active compensation – using semiconductors,
- Overexcited synchronous machine (motor/generator).

Types of PFC
(detuned or conventional)

- individual or fixed compensation (each reactive power producer is individually compensated),
- group compensation (reactive power producers connected as a group and compensated as a whole),
- central or automatic compensation (by a PFC system at a central point),
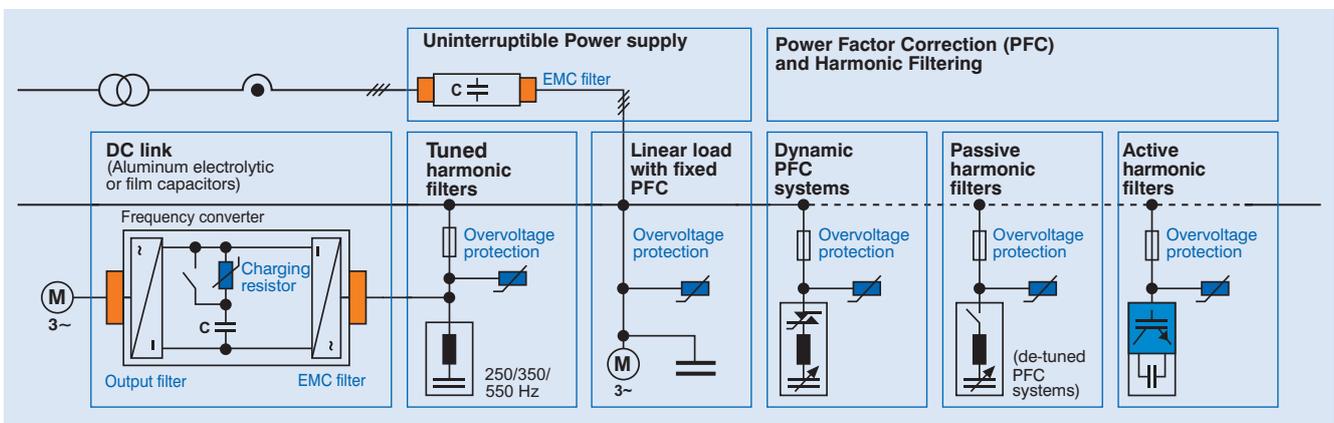- mixed compensation.

Preview

Power Quality Solution strategy

Along with the emerging demand for power quality and a growing awareness of the need for environmental protection, the complexity in the energy market is increasing: users and decision-makers are consequently finding it increasingly difficult to locate the best product on the market and to make objective decisions. It is in most cases not fruitful to compare catalogs and data sheets, as many of their parameters are identical in line with the relevant standards. Thus operating times are specified on the basis of

tests under laboratory conditions that may differ significantly from the reality in the field. In addition, load structures have changed from being mainly linear in the past to non-linear today. All this produces a clear trend: the market is calling increasingly for customized solutions rather than off-the-shelf products. This is where Power Quality Solutions come into the picture. It offers all key components for an effective PFC system from a single source, together with:

- Application know-how
- Technical skills
- Extensive experience in the field of power quality improvement
- A worldwide network of partners
- Continuous development
- Sharing of information

These are the cornerstones on which Power Quality Solutions are built. On the basis of this strategy, EPCOS is not only the leading manufacturer of power capacitors for PFC applications but also a PQS supplier with a century of field experience, reputation and reliability.

PQS Key Components Overview

Switching devices and detuned filters			
Parameter	**Capacitor contactors**	**Thyristor modules**	**Reactors - Antiresonance harmonic filter**
	With Pre-closing resistor	Thyristor switch for dynamic PFC systems	For detuning application with high linearity
Voltage	230...690 V	TSM-LC: 3 × 440 V TSM-HV: 3 × 690 V	230...1000 V
Output range	12.5...100 KVAr for B...J230 7...60 KVAr for B...C240	TSM-LC: 10...50 KVAr TSM-HV: 50 KVAr	5...100 KVAr
Frequency	50/60 Hz	50/60 Hz	50 or 60 Hz
Detuning	Suitable for detuned and conventional systems	Suitable for detuned and conventional systems	Factor: 5.67%, 7%, 14%
Ordering code	B44066S...J230 for all PFC systems B44066S...C240 for all PFC systems	TSM-LC: B44066T...R440 TSM-HV: B44066T...R690	B44066D...
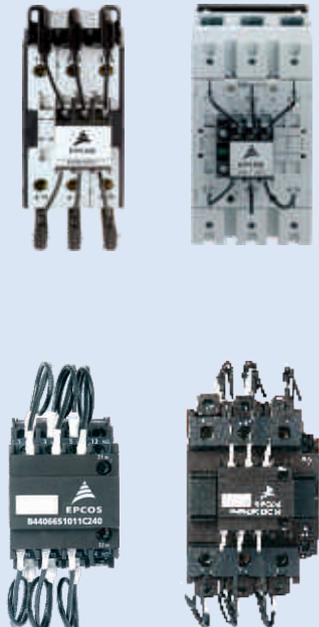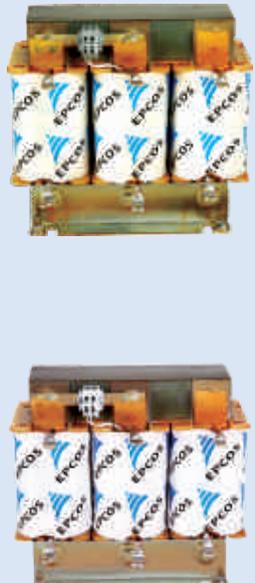
Important Notes

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1. Some parts of this publication contain **statements about the suitability of our products for certain areas of application**. These statements are based on our knowledge of typical requirements that are often placed on our products in the areas of application concerned. We nevertheless expressly point out **that such statements cannot be regarded as binding statements about the suitability of our products for a particular customer application.** As a rule, EPCOS is either unfamiliar with individual customer applications or less familiar with them than the customers themselves. For these reasons, it is always ultimately incumbent on the customer to check and decide whether an EPCOS product with the properties described in the product specification is suitable for use in a particular customer application.

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Reactors - Antiresonance Harmonic Filter

Type tested at CPRI ● 'H' Class insulation ● Thermal Micro Switch ● Linearity 173%

EPCOS

General

The increasing use of modern power electronic apparatus (drives, uninterruptible power supplies, etc.) produces nonlinear current and thus influences and loads the network with harmonics (line pollution).

The power factor correction or capacitance of the power capacitor forms a resonant circuit in conjunction with the feeding transformer. Experience shows that the self-resonant frequency of this circuit is typically between 250 and 500 Hz, i.e. in the region of the 5th and 7th harmonics.

Such a resonance although can lead to the following undesirable effects:
– overloading of capacitors,
– overloading of transformers and transmission equipment,
– interference with metering and control systems, computers and electrical gear,
– resonance elevation, i.e. amplification of harmonics,
– voltage distortion.

These resonance phenomena can be avoided by connecting capacitors in series with filter reactors in the PFC system. These so called "detuned" PFC systems are scaled in a way that the self-resonant frequency is below the lowest line harmonic. The detuned PFC system is purely inductive seen by harmonics above this frequency. For the base line frequency (50 or 60 Hz usually), the detuned system on the other hand acts purely capacitive, thus correcting the reactive power.
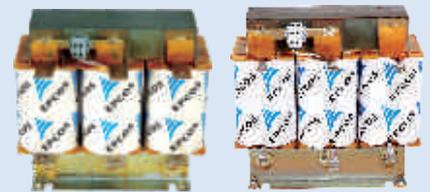
Applications

• Avoidance of resonance conditions
• Tuned and detuned harmonic filters
• Reduction of harmonic distortion (network clearing)
• Reduction of power losses

Features

• High harmonic loading capability
• Very low losses
• High linearity to avoid choke tilt
• Low noise
• Convenient mounting
• Long expected life time
• Temperature protection (NC contact)

Technical data and limit values	
Filter reactors	
Harmonics*	$V_3 = 0.5\% \, V_R$ (duty cycle = 100%)
	$V_5 = 6.0\% \, V_R$ (duty cycle = 100%)
	$V_7 = 5.0\% \, V_R$ (duty cycle = 100%)
	$V_{11} = 3.5\% \, V_R$ (duty cycle = 100%)
	$V_{13} = 3.0\% \, V_R$ (duty cycle = 100%)
Effective current	$Irms = \overline{(I_1^2 + I_3^2 \ldots I_{13}^2)}$
Fundamental current	$I_1 = 1.06 \cdot I_R$ (50 Hz or 60 Hz current of capacitor)
Temperature protection	microswitch (NC)
Dimensional drawings and terminals	see page 62 and 63

Three-phase filter reactors to EN 60289	
Frequency	50 Hz or 60 Hz
Voltage	230, 380, 400, 415, 440, 690, 750, 800, 1000
Output	5 … 100 KVAr
Detuning	5.67%, 7%, 14%
Cooling	natural
Ambient temperature	40 °C
Class of insulation	H
Enclosure	IP00

* According to DIN ENV VV61000-2-2

Reactors - Antiresonance Harmonic Filter

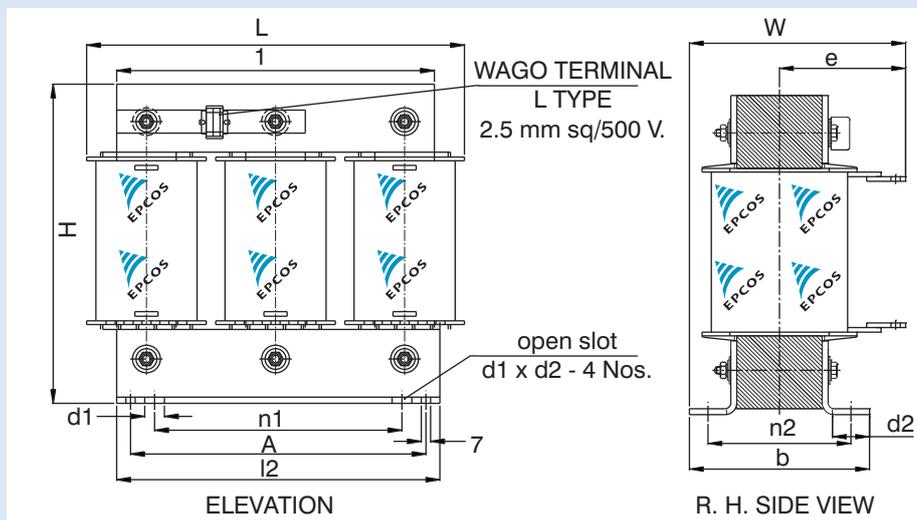Type tested at CPRI ● 'H' Class insulation ● Thermal Micro Switch ● Linearity   173%

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Rated voltage - 440 V 7% aluminum wound reactors

Electrical Parameters and Terminations

KVAr	Material Code	Rated Current (A)	I rms (A)	Inductance (mH)	Terminations
5	B44066D7005K440N1	6.6	7.45	9.28	CU. 6/6 Sq. mm
10	B44066D7010K440N1	13.2	14.9	4.65	CU. 6/6 Sq. mm
12.5	B44066D7012K440N1	16.5	18.7	3.71	CU. 6/6 Sq. mm
15	B44066D7015K440N1	19.65	22.35	3.1	AL. 8/35 Sq. mm
20	B44066D7020K440N1	26.24	29.78	2.32	AL. 8/35 Sq. mm
25	B44066D7025K440N1	32.8	37.2	1.86	AL. 8/35 Sq. mm
30	B44066D7030K440N1	39.36	44.7	1.55	AL. 8/50 Sq. mm
40	B44066D7040K440N1	52.49	59.6	1.16	AL. 8/50 Sq. mm
50	B44066D7050K440N1	65.61	74.5	0.93	AL. 8/50 Sq. mm
75	B44066D7075E440N1	98.41	111.68	0.62	20X3 CU BUSBAR
100	B44066D7100E440N1	131.22	148.91	0.46	25X3 CU BUSBAR

Rated voltage - 415 V 7% aluminum wound reactors

Electrical Parameters and Terminations

KVAr	Material Code	Rated Current (A)	I rms (A)	Inductance (mH)	Terminations
5	B44066D7005K415N1	6.96	7.89	8.257	CU. 6/6 Sq. mm
10	B44066D7010K415N1	13.91	15.79	4.128	CU. 6/6 Sq. mm
12.5	B44066D7012K415N1	17.39	19.73	3.303	CU. 6/6 Sq. mm
15	B44066D7015K415N1	20.87	23.68	2.752	AL. 8/35 Sq. mm
20	B44066D7020K415N1	27.82	31.58	2.064	AL. 8/35 Sq. mm
25	B44066D7025K415N1	34.78	39.47	1.651	AL. 8/35 Sq. mm
30	B44066D7030K415N1	41.74	47.36	1.376	AL. 8/50 Sq. mm
40	B44066D7040K415N1	55.65	63.15	1.032	AL. 8/50 Sq. mm
50	B44066D7050K415N1	69.56	78.94	0.826	AL. 8/50 Sq. mm
75	B44066D7075E415N1	104.34	118.41	0.55	20x3 CU BUSBAR
100	B44066D7100E415N1	139.12	157.88	0.413	25x3 CU BUSBAR

Reactor dimensional details

ELEVATION   R. H. SIDE VIEW

Reactors - Antiresonance Harmonic Filter

Type tested at CPRI ●'H' Class insulation ● Thermal Micro Switch ● Linearity   173%

EPCOS

Rated voltage - 440 V 7% aluminum wound reactors

Dimensions

KVAr	Material Code	L	W	H	l1	l2	n1	n2	b	e	d1	d2	A	B
5	B44066D7005K440N1	175	95 ± 5	158	150	150	100	56 ± 3	73	60 ± 5	10.8	15.5	125	56
10	B44066D7010K440N1	175	124 ± 5	160	150	150	100	78 ± 3	95	75 ± 5	10.8	15.5	125	78
12.5	B44066D7012K440N1	175	124 ± 5	160	150	150	100	78 ± 3	95	75 ± 5	10.8	15.5	125	78
15	B44066D7015K440N1	225	150 ± 5	230	190	190	150	73 ± 3	93	105 ± 5	10.8	15.5	180	73
20	B44066D7020K440N1	225	165 ± 5	205	190	190	150	95 ± 3	114	115 ± 5	10.8	15.5	180	95
25	B44066D7025K440N1	225	165 ± 5	205	190	190	150	95 ± 3	114	115 ± 5	10.8	15.5	180	95
30	B44066D7030K440N1	260	225 ± 5	240	220	220	150	165 ± 3	185	127 ± 5	10.8	15.5	175	165
40	B44066D7040K440N1	260	225 ± 5	240	220	220	150	165 ± 3	185	127 ± 5	10.8	15.5	175	165
50	B44066D7050K440N1	260	225 ± 5	240	220	220	150	165 ± 3	185	127 ± 5	10.8	15.5	175	165
75	B44066D7075E440N1	310	180 ± 5	270	265	265	150	132 ± 3	150	97 ± 5	10.8	15.5	175	132
100	B44066D7100E440N1	330	180 ± 5	270	285	285	150	132 ± 3	155	97 ± 5	10.8	15.5	175	132

* All dimensions are in mm.

Rated voltage - 415V 7% aluminum wound reactors

Dimensions

KVAr	Material code	L	W	H	l1	l2	n1	n2	b	e	d1	d2	A	B
5	B44066D7005K415N1	175	95 ± 5	158	150	150	100	56 ± 3	73	60 ± 5	10.8	15.5	125	56
10	B44066D7010K415N1	175	124 ± 5	160	150	150	100	78 ± 3	95	75 ± 5	10.8	15.5	125	78
12.5	B44066D7012K415N1	175	124 ± 5	160	150	150	100	78 ± 3	95	75 ± 5	10.8	15.5	125	78
15	B44066D7015K415N1	225	150 ± 5	230	190	190	150	73 ± 3	93	105 ± 5	10.8	15.5	180	73
20	B44066D7020K415N1	225	165 ± 5	205	190	190	150	95 ± 3	114	115 ± 5	10.8	15.5	180	95
25	B44066D7025K415N1	225	165 ± 5	205	190	190	150	95 ± 3	114	115 ± 5	10.8	15.5	180	95
30	B44066D7030K415N1	260	225 ± 5	240	220	220	150	165 ± 3	185	127 ± 5	10.8	15.5	175	165
40	B44066D7040K415N1	260	225 ± 5	240	220	220	150	165 ± 3	185	127 ± 5	10.8	15.5	175	165
50	B44066D7050K415N1	260	225 ± 5	240	220	220	150	165 ± 3	185	127 ± 5	10.8	15.5	175	165
75	B44066D7075E415N1	310	180 ± 5	270	265	265	150	132 ± 3	150	97 ± 5	10.8	15.5	175	132
100	44066BD7100E415N1	330	180 ± 5	270	285	285	150	132 ± 3	155	97 ± 5	10.8	15.5	175	132

* All dimensions are in mm.

Reactor dimensional details

MOUNTING PLAN