Automatic Power Factor Correction Panels

Installation and Maintenance instructions for APFC Panels

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Installation and maintenance instructions for APFC panels

Preliminary data

Installation and Maintenance Instructions

Read This First :

Read the following >> Installation and maintenance instructions << carefully before installing a APFC Panel into your application.

About this manual

The information stated in this manual applies to typical, approved usage. Please refer to our product specifications, or request our approval for your own individual specifications, before installing APFC panels

For your safety!

Disregarding the guidelines in this manual can result in operational failure bursting and fire. In case of doubt, contact your local EPCOS sales organization or distributor for assistance.

General safety notes for installation and operation

Ensure you are using the right APFC panel for your application, please refer to the EPCOS product catalogue and application notes for proper selection of APFC Panel and its configuration.

Maintain good and effective grounding for APFC panel

Provide the means to isolate any faulty units/ banks in the system

Follow proper engineering practices

Storage and operation Conditions

Donot use or keep APFC panel in corrosive atmosphere, especially where as, sulphide gas, acid, alkali, salt or similar substances are present. In a dusty environment, regular maintenance and cleaning, especially of the contacts, is required to avoid a conductive path between phases and /or phases and ground.

- The panel has to be stored with outer packing intact in a covered area under protection from rain. The panel should stand in vertical position as indicated in the packing crate.

Ambient temperature

: The ambient temperature category for most standard types is -40D. This means a max. temperature of 55DegC, an average temperature over 24 hours of 45DegC, and the average temperature in one year should not exceed 35 Deg C.

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Caution :

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Installation :

Mounting the APFC Panel : The place has to be identified where the panel has to be erected. It should be level and hard. The incoming cables should be brought depending upon the cable entry provisions of the panel. The cross section of the cable should be commensurate with the maximum kVAr rating of the panel.
The panel has to be shifted to the installation place. The incoming cables has to be connected to the incomer after fixing the appropriate cable lugs.
Earthing has to be provided at the designated place in the panel.
The panel has to be handled and unloaded carefully without damage.
Proper fork lift and rollers have to be employed. It should be never toppled as it is delicate.

Mounting Positions : APFC Panel should be always Verticle

Warning : Do not install the Panel in-case of

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Incomer Cable sizing : The incomer cable sizing should be commensurate with the kVAr rating of the panel. Allowances should be considered for increase in current due to presence of harmonics, overvoltage and kVAr tolerance. Following table gives the cable sizes to be used for different kVAr ratings.

Capacitor health checking : It is recommended to check the health of the capacitor in the APFC panel prior to commission the panel. It is also advisable to periodically check the capacitor health once in six months to detect any de-rating. The best way to check the capacitor condition is to measure the capacitance value after switching of the panel and completely discharging the capacitor. The capacitor value should be within the tolerance value.

The recommended values of capacitance for different kVAr @ different voltages are given in the following table.

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Pre-charging checks : Check the tightness of internal connections. This should include capacitor connection, bus bar joints and other connections.
Ensure that recommended ratings of fuses are put in the incomer and there are no loose connections.
Ensure the secondary of sensing CT are connected to the panel at t the designated terminal. The sensing CT has to be mounted such that both load and APFC panel current flows through it. It should be connected upstream of the APFC panel and load.
The APFC controller is pre-programmed in EPCOS factory. It should not be altered. If it has to be changed, it should be done only by authorized persons under instruction from EPCOS. The relevant controller manual should be referred for setting the parameters in the APFC controller. Wrong settings can adversely affect the panel performance and eventual failure of panel components.

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<u>Commissioning procedure :</u> Ensure that some minimum load say 10% of the connected load is on before switching on the APFC panel.

The APFC controller will display the power factor of the load prior to compensation. It should be inductive (Lagging). If it is showing as capacitive, then the control CT terminal has to be reversed.

The reversing of CT terminal has to be done carefully such that, the CT terminal is never open circuited. The shorting link has to be closed at the CT terminal point. The CT connection going to PF controller should now be reversed. Then the shorting link should be reversed. Now the PF indicated by the PF controller should read inductive.

After 90 seconds of switching on the APFC panel, the steps in the APFC panel should switch on one by one depending upon the quantum of load and its reactive power demand. If this does not happen , then check that the APFC controller is set to 'Auto' mode and if not set it to 'Auto' mode.

Important Notes :

The following applies to all products named in this publication:

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.

2. We also point out that **in individual cases, a malfunction of electronic components or failure before the end of their usual service life cannot be completely ruled out in the current state of the art, even if they are operated as specified.** In customer applications requiring a very high level of operational safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health (e.g. in accident prevention or life-saving systems), it must therefore be ensured by means of suitable design of the customer application or other action taken by the customer (e.g. installation of protective circuitry or redundancy) that no injury or damage is sustained by third parties in the event of malfunction or failure of an electronic component.

3. **The warnings, cautions and product-specific notes must be observed.**

4. In order to satisfy certain technical requirements, **some of the products described in this publication may contain substances subject to restrictions in certain jurisdictions (e.g. because they are classed as hazardous)**. Useful information on this will be found in our Material Data Sheets on the Internet (www.epcos.com/material). Should you have any more detailed questions, please contact our sales offices.

5. We constantly strive to improve our products. Consequently, **the products described in this publication may change from time to time**. The same is true of the corresponding product specifications. Please check therefore to what extent product descriptions and specifications contained in this publication are still applicable before or when you place an order.

We also **reserve the right to discontinue production and delivery of products**. Consequently, we cannot guarantee that all products named in this publication will always be available. The aforementioned does not apply in the case of individual agreements deviating from the foregoing for customer-specific products.

6. Unless otherwise agreed in individual contracts, **all orders are subject to the current version of the “General Terms of Delivery for Products and Services in the Electrical Industry” published by the German Electrical and Electronics Industry Association (ZVEI)**.

7. The trade names EPCOS, BAOKE, Alu-X, CeraDiode, CSSP, CTVS, DSSP, MiniBlue, MKK, MLSC, MotorCap, PCC, PhaseCap, PhaseMod, SIFERRIT, SIFI, SIKOREL, SilverCap, SIMDAD, SIMID, SineFormer, SIOV, SIP5D, SIP5K, ThermoFuse, WindCap are **trademarks registered or pending** in Europe and in other countries. Further information will be found on the Internet at www.epcos.com/trademarks.

Balanced 3 phase Delta connected Capacitors

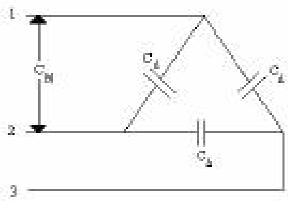


Fig (a)

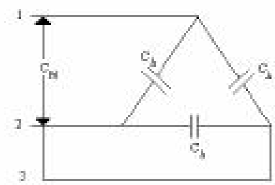


Fig (b)

C_M = measured capacitance in µF when isolated from other terminals
C_Δ = capacitance per phase in µF

Table 1: Voltage Rating – 415 V

kVAr	Line current in Amps	C_Δ (in µF)	Measured capacitance (C_M) across any two terminals with the other terminal kept open circuited (in µF) Refer Fig (a)	Measured capacitance (C_M) across any two terminals with the third terminal short circuited to any of the other two terminal (in µF) Refer Fig (b)
1	1.39	6.16	9.24	12.32
2	2.78	12.32	18.48	24.64
3	4.17	18.48	27.72	36.96
4	5.56	24.64	36.96	49.29
5	6.96	30.80	46.21	61.61
7.5	10.43	46.21	69.31	92.41
10	13.91	61.61	92.41	123.21
12.5	17.39	77.01	115.51	154.02
15	20.87	92.41	138.62	184.82
20	27.82	123.21	184.82	249.43
25	34.78	154.02	231.03	308.04

Table 2: Voltage Rating – 440 V

kVAr	Line current in Amps	C_Δ (in µF)	Measured capacitance (C_M) across any two terminals with the other terminal kept open circuited (in µF) Refer Fig (a)	Measured capacitance (C_M) across any two terminals with the third terminal short circuited to any of the other two terminal (in µF) Refer Fig (b)
1	1.31	5.48	8.22	10.96
2	2.62	10.96	16.44	21.92
3	3.94	16.44	24.66	32.88
4	5.25	21.92	32.88	43.84
5	6.56	27.40	41.10	54.81
7.5	9.84	41.10	61.66	82.21
10	13.12	54.81	82.21	109.61
12.5	16.40	68.51	102.76	137.01
15	19.68	82.21	123.31	164.42
20	26.24	109.61	164.42	219.22
25	32.80	137.01	205.52	274.03

Introduction

All electrical equipment needs reactive power apart from active power for their operation. The need for reactive power arises because the current and voltage waveform are not in phase with each other. In Inductive loads, the current lags the voltage and in capacitive loads the current leads the voltage. The power factor is defined as the cosine of the angle between current and voltage vector. When the current and voltage vector are perfectly in phase as in the case of a purely resistive load, the phase angle between voltage and current is zero and the power factor is unity. This power factor is called the displacement power factor as it relates to displacement of current vector with respect to voltage vector. The displacement power factor is lagging in case of inductive load and leading in case of capacitive load.

If inductors and capacitors are connected in parallel, then the inductive current which is 90 degrees lagging with respect to applied voltage is exactly opposite in direction to capacitive current which is 90 degrees leading to applied voltage. Thus the capacitive current can neutralise the inductive current and vice versa thereby reducing the reactive current considerably in the circuit. This is the essence of reactive power compensation.

Since the predominant loads are inductive in nature capacitors are used for reactive power compensation. If the loads are steady, then we can consider fixed compensation by using fixed capacitors. But usually the loads are fluctuating requiring varying reactive power requirement and to compensate such a load the capacitors need to be switched. The following types of switching devices are available for switching the capacitors.

1. Ordinary Contactors

They are most cost effective solutions available. They can be used when the variation in reactive power with respect to time is slow and capacitor switching interval greater than 60 seconds. More rapid switching rate is not possible with contactors as it will damage the contacts. More over minimum time of 60 seconds is to be allowed before reconnecting a disconnected capacitor to allow the capacitor to completely discharge before reconnection to avoid premature capacitor failure. This makes contactor switched systems suitable for only slow varying loads.

Another serious issue with use of ordinary contactors is the inrush current associated while switching capacitors. Capacitors tend to draw very large transient currents of 75 to 150 times their steady state currents at the time of switching. This is because the rate of change of voltage (dv/dt) across the capacitor terminals is very large at the time of switching. The current through the capacitor being proportional to dv/dt is also very large. The duration of this large current although is very small, typically less than 1 msec, can cause capacitors to fail and contacts of the contactor to weld. The inrush current is oscillating in nature and can cause failure of sensitive loads in the network. Thus a serious power quality issue arises by the use ordinary contactors in switching capacitors.

To overcome these difficulties inrush limiting air core coils are used in series with capacitors. These coils are used only on two of the three phases of the capacitor. The coils are made out of the connecting wires to the capacitor with 8 to 10 turns and diameter of approximately 10 cms. Alternatively a capacitor duty contactor can be used to limit the inrush current as mentioned below.

2. Capacitor duty contactors

Capacitor duty contactors have additional auxiliary contacts with current limiting resistors (also called pre charging resistors) in series with it. The inrush current is limited by these auxiliary contacts coming on first and then the main contacts takes over the steady state current of the capacitors.

3. Thyristor modules

Thyristor modules are very effective in eliminating the inrush current of capacitors. They are controlled switching devices which can be made to switch on when the voltage across the Thyristor is zero, thereby eliminating the inrush current. Additionally, Thyristor are used when the load variation is rapid like cranes, lifts, spot welding, plastic extrusion etc.

Harmonic environment

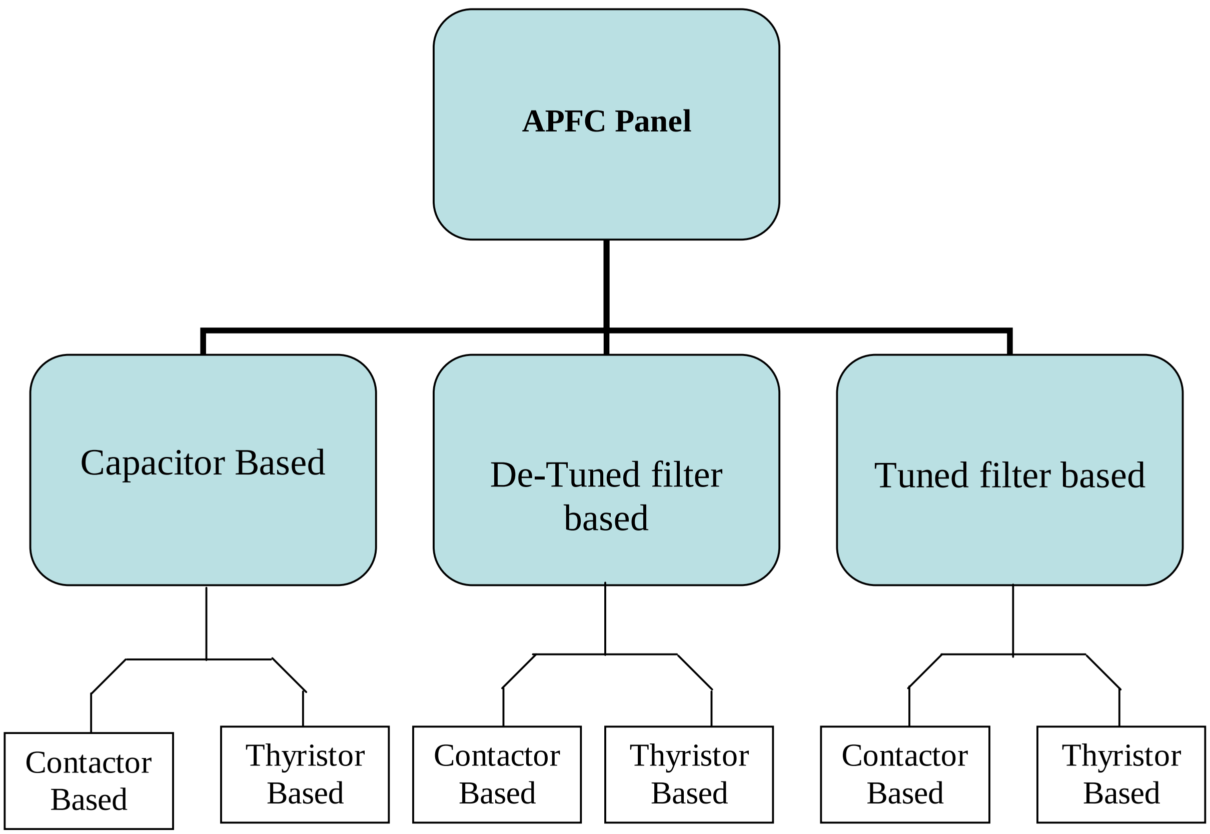
Harmonic environment is said to exist when non-linear loads are extensively used in a network. Non-linear loads are power electronic loads which draws non sinusoidal current waveform when fed from sinusoidal voltage waveforms. Examples of such loads are AC/DC drives, UPS, converter/inverter, computers, CFL Lamps etc.

In the presence of harmonic environment, power factor correction should not be done by conventional power capacitors as it will cause unhealthy harmonic amplification due to parallel resonance between power factor correction capacitors and transformer/system impedance.

In such an environment the power factor correction capacitors have to be replaced by Harmonic filters (Tuned or De-tuned).

Classification of APFC panels

APFC panels can thus be classified as follows.



Panel sizing calculation (kVAr.)

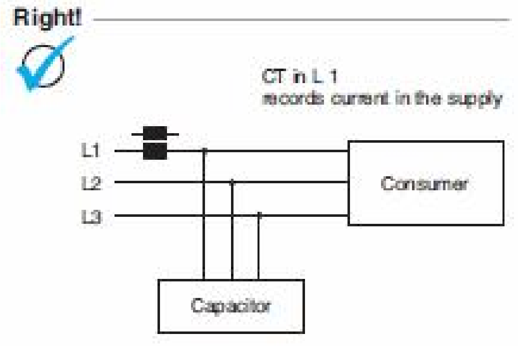
Estimating the panel rating in kVAr has to be done knowing the present uncompensated power factor (initial PF) and the desired PF after compensation (final PF) and the peak kW loading of the load. Following table gives the multiplying factor to be used in estimating the panel kVAr.

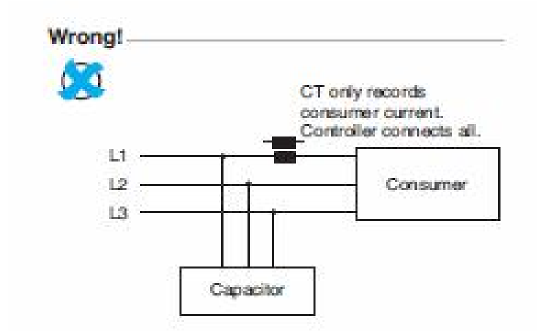
Panel kVAr rating = multiplying factor X kW of the load

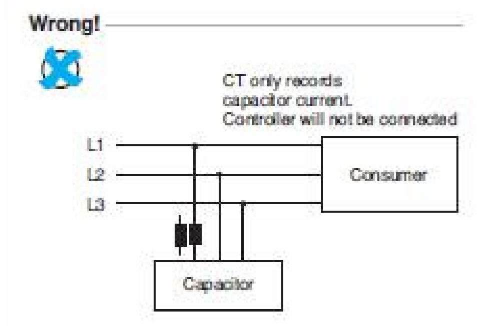
Initial PF ⇩	Final PF								
	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1.00
0.6	0.907	0.938	0.970	1.005	1.042	1.083	1.130	1.191	1.333
0.62	0.839	0.870	0.903	0.937	0.974	1.015	1.062	1.123	1.265
0.64	0.775	0.805	0.838	0.872	0.909	0.950	0.998	1.058	1.201
0.66	0.712	0.743	0775	0.810	0.847	0.888	0.935	0.996	1.138
0.68	0.652	0.683	0.715	0.750	0.787	0.828	0.875	0.936	1.078
0.7	0.594	0.625	0.657	0.692	0.729	0.770	0.817	0.878	1.020
0.72	0.538	0.569	0.601	0.635	0.672	0.713	0.761	0.821	0.964
0.74	0.483	0.514	0.546	0.580	0.617	0.658	0.706	0.766	0.909
0.76	0.429	0.460	0.492	0.526	0.563	0.605	0.652	0.713	0.855
0.78	0.376	0.407	0.439	0.474	0.511	0.552	0.599	0.660	0.802
0.8	0.324	0.355	0.387	0.421	0.458	0.499	0.547	0.608	0.750
0.81	0.298	0.329	0.361	0.395	0.432	0.473	0.521	0.581	0.724
0.82	0.272	0.303	0.335	0.369	0.406	0.447	0.495	0.556	0.698
0.83	0.246	0.277	0.309	0.343	0.380	0.421	0.469	0.530	0.672
0.84	0.220	0.251	0.283	0.317	0.354	0.395	0.443	0.503	0.646
0.85	0.194	0.225	0.257	0.291	0.328	0.369	0.417	0.477	0.620
0.86	0.167	0.198	0.230	0.265	0.302	0.343	0.390	0.451	0.593
0.87	0.141	0.172	0.204	0.238	0.275	0.316	0.364	0.424	0.567
0.88	0.114	0.145	0.177	0.211	0.248	0.289	0.337	0.397	0.540
0.89	0.086	0.117	0.149	0.184	0.221	0.262	0.309	0.370	0.512
0.90	0.058	0.089	0.121	0.156	0.193	0.234	0.281	0.342	0.484
0.91	0.030	0.060	0.093	0.127	0.164	0.205	0.253	0.313	0.456
0.92		0.031	0.063	0.097	0.134	0.175	0.223	0.284	0.426
0.93			0.032	0.067	0.104	0.145	0.192	0.253	0.395
0.94				0.034	0.071	0.112	0.160	0.220	0.363
0.95					0.037	0.078	0.126	0.186	0.329

Location of sensing CT

The location of sensing CT which senses the corrected power factor is very important for proper functioning of the APFC panel. The following diagram shows the correct position of the sensing CT. Also indicated are commonly used wrong positions of CT, which should not be used. The APFC panel will not work properly in these cases.







Total capacitor current (1.6 x In)	Cu. Cable Sq.mm (minimum)	Al. Cable Sq. mm (minimum)	Incomer	
			Rating, A	Device
50	16	25	125	MCCB (Preferred) or Switch fuse unit
75	25	50		
100	50	70		
125	70	95		
150	95	120	250	
175	120	185		
200	150	240		
250	185	240		
300	240	300	400	MCCB
400	400	2 x 240		
600	2 x 300	3 x 240	630	
800	2 x 400	3 x 300	800	ACB
1250	3 x 400	4 x 400	1250	
2400	Bus duct	Bus duct	2500	
3200	Bus duct	Bus duct	3200	

Note : - Short circuit rating of incomer to be the same as that of the system,
typically 25 KA or 40 KA or 50 KA.