

Power Factor & Power Quality Specialists



PRODUCT INFORMATION

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Introduction

For many years now most of us involved with electrical distribution and power systems in industrial/commercial environments have been aware of, suffered from or made corrections to poor power factor conditions, which can result in penalty payments on utility bills.

At the same time, electrical people (engineers, technicians, etc.) have been aware of another phenomenon in electrical distribution systems called "Harmonics".

The rapid increase over the past few years in the use of non-linear loads (electronic) in electrical systems has created the potential of generating dangerous, damaging "Harmonics".

Typical examples of non-linear loads (harmonic sources) are:

Office area

Computers
Printers
Fax Machines
Electronic Equipment
Controlled Equipment

Lighting

Fluorescent
Mercury Vapor
Sodium
Neon

Plant areas

Arc Furnaces
Robotics
DC Drives
SCR

The most unfortunate aspects of this potential hazard is the seemingly unrelated events, i.e. breakdown or problems that occur for no apparent reason. In the majority of cases, the tendency is to put them down to faulty equipment, poor quality or just plain bad luck.

Examples of these situations would be:

- Electrical component failures & nuisance fuse failures
- Computer lock-up or "Crash"
- Erratic operation of electronically controlled equipment
- Unusually high lighting failures
- Occasional transformer shut down
- Escalating electrical maintenance costs

If any of these conditions exist in your facility an analysis of your system will pinpoint the problem.

With today's non-linear loads it is extremely difficult to correct for poor Power Factor without increasing existing harmonic distortion thereby trading one problem for another. The simple answer is to treat both problems simultaneously. Depending on your utility and geographic area, a Power Factor less than 90% in your facility will be penalized, and although there are no penalties paid for the level of harmonics, their presence in the system can be far more costly than the Power Factor penalties.

Total Harmonic Distortion (THD) of more than 5% is potentially dangerous to your equipment's health (and your pocketbook). Random Power Factor correction alone could severely increase this potential. When implementing Power Factor Correction be sure to consider the current and voltage THD as well as the Power Factor.

Harmonics can be corrected but the correction needs to be designed for each individual environment. Hence a good reason to do an analysis of your system.

The Power Utility provides "clean" usable power for the distribution system. Most harmonic problems (99.9%) are generated within the facility but can in extreme cases be imported or exported by a facility. Harmonics can be likened to a noxious chemical dumped into the river, it contaminates everything in its path "downstream". In fact, the time may come when harmonic pollution will not be allowed.

An analysis of the electrical distribution system will determine the presence, the level and the source of harmonics.

Should you have concerns about these potential hazards, we are here to help. In some cases, for as little as the cost of replacing a couple of blown fuses, we can quickly analyze your system to see exactly what is happening. Then if required, we can design, build and if you wish, arrange installation of suitable mitigation equipment to improve and correct your system.

The cost of poor Power Quality may be much greater than simply the penalties involved.

"Cos Phi Inc. is a solution company."

Facts About Power Factor Correction

Principle of Power Factor Correction

The Total Electrical Power (Kilo Volt Amperes or KVA) used by the industrial or commercial facility has two components:

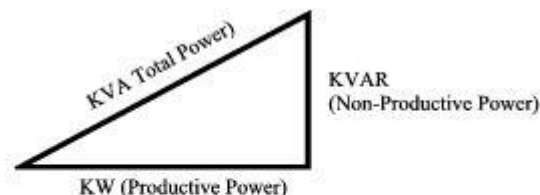
- **Productive Power** (Kilowatts or KW) which produces work
- **Reactive Power** (Kilovar or KVAR) which generates the magnetic fields required in inductive electrical equipment (AC motors, transformers, inductive furnaces, ovens, etc.)

Reactive Power produces no productive work

Because the inductive electrical equipment employing magnetic fields requires this Reactive Power, which produces no productive work, the Total Power (KVA) provided by the generating source must be greater than the Productive Power.

Power Factor is a measure of system electrical efficiency

The ratio of Productive Power (KW) to Total Power (KVA) is Power Factor. It is a measure of system electrical efficiency in an alternating current circuit, and is represented as a % or a decimal.



$$\text{Power Factor} = \frac{\text{KW (Productive Power)}}{\text{KVA (Total Power)}}$$

The Relationship between KVA, KW and KVAR is non-linear and is expressed:

$$\text{KVA}^2 = \text{KW}^2 + \text{KVAR}^2.$$

Why Improve Power Factor

➤ Reduce Utility Power Bill

Removing system KVAR improves the Power Factor and reduces the Utility Power Bill. Most utility bills are influenced by KVAR usage.

➤ Increase System Capacity

Improving the Power Factor releases system capacity and permits additional loads (motors, lighting, etc.) to be added without overloading the system. In a typical system with a .80 P.F., only 800 KW of productive power is available out of 1000 KVA installed. By correcting the system to unity (1.0 P.F.), the KW = KVA. Now the corrected system will support 1000 KW, versus the 800 KW at the .80 P.F. uncorrected condition; an increase of 200 KW of productive power.

➤ Improved system operating characteristics

A good power factor (.95) provides a "stiffer" voltage, typically a 1-2% voltage rise can be expected when power factor is brought to +\-.95.

Improving power factor will lower losses in the distribution system of the facility since losses are proportional to the square of the current.

Methods

➤ Static or fixed Power Factor Correction

Compensation on the load side of the AC motor starter (motor switched or "at the load"). A good application for essential or constant loads over 40HP.

➤ Central Power Factor Correction

Compensation for electrical systems with fluctuating loads. Usually installed at the main power distribution.

The capacitors are controlled by a microprocessor-based relay, which continuously monitors the reactive power requirements. The relay then connects or disconnects capacitors to supply capacitance as needed.

When harmonic distortion is a concern systems are built based on the principles explained under Harmonic Distortion and power factor correction.

Harmonic Distortion & Power Factor Correction

In recent years the way electricity is used has changed significantly. Developments in semi-conductor technology have created a major increase in thyristor and converter - fed loads. Electronic equipment, particularly that using solid state devices, can have a detrimental effect on the electrical power system in a facility to the point where operation of electrical and electronic equipment is disrupted. Solid state devices generate Harmonics into the electrical system, i.e. they generate frequencies that are integer multiples of the fundamental line frequency of 60Hz. The harmonics lead to a higher capacitor current, because the higher frequencies are attracted to the capacitor. The impedance of the capacitor decreases as the frequency increases.

Harmonic Distortion can result if any or all of the following:

- Premature failure of capacitors
- Nuisance tripping of circuit breakers and other protective devices
- Failure or malfunctioning of computers, motor drives, lighting circuits and other sensitive loads

The rising capacitor current can be accommodated by design improvements of the capacitor. However, resonating circuits may occur between the power factor correction capacitors and the inductance of the feeding transformer as well as the main feeders. If the frequency of such a resonating circuit is close enough to a harmonic frequency, the resulting circuit amplifies the oscillation and leads to immense over-currents and over-voltages.

Detuned Capacitor Banks

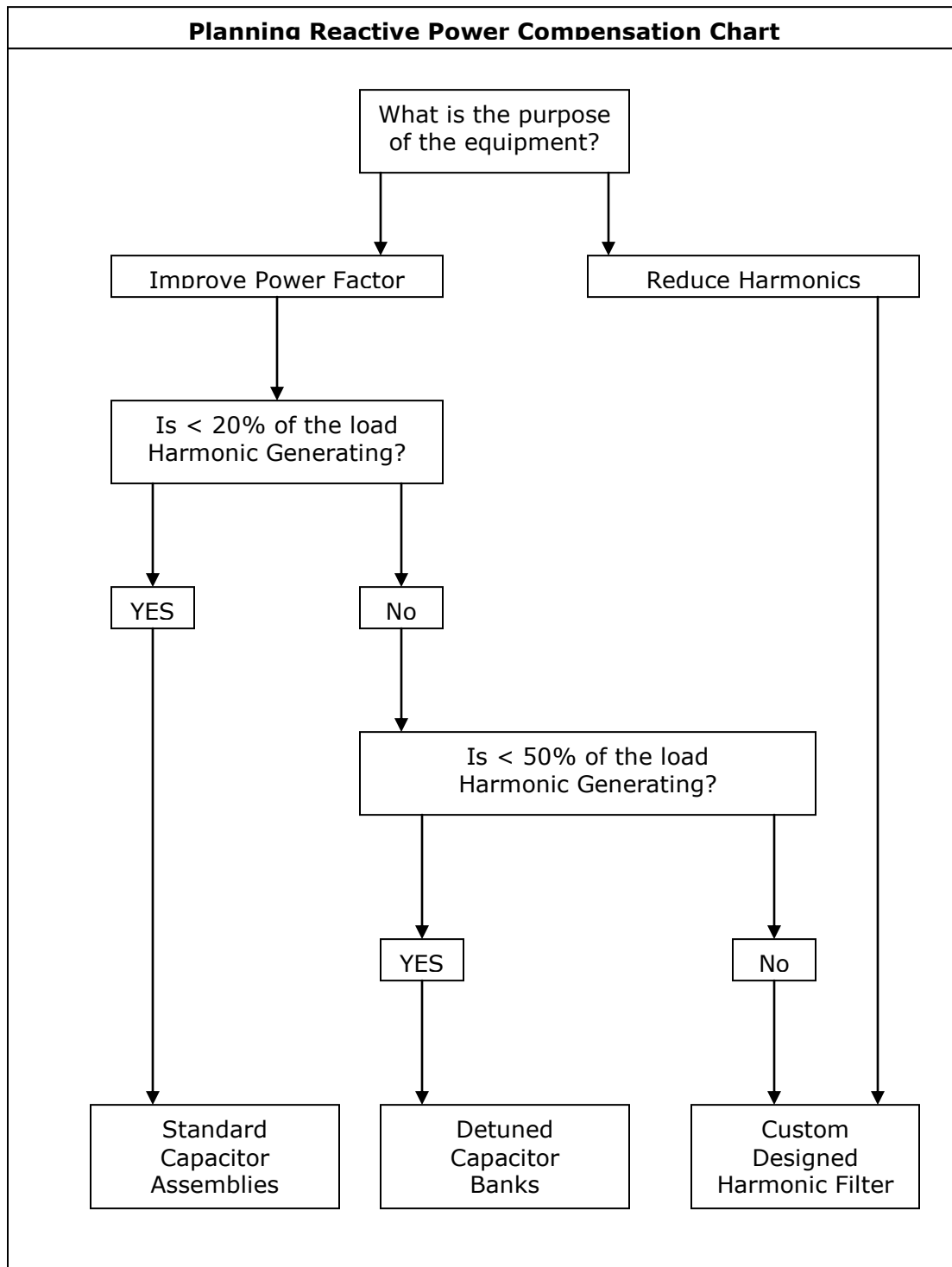
The installation of de-tuned (reactor-connected) capacitors is designed to force the resonant frequency of the network below the frequency of the lowest harmonic present. This ensures that no resonant circuit and no amplification of harmonic currents exist. Such an installation also has a partial filtering effect, reducing the level of voltage distortion on the supply, and is recommended for all cases where the share of harmonic-generating loads is more than 20% of overall load to be compensated.

Tuned or Filtered Capacitor Banks Or Harmonic Filters

A filter circuit presents a very low impedance to the individual harmonic current, diverting the majority of the current into the filter bank rather the supply. The resonance frequency of a de-tuned capacitor is always below the frequency of the fifth harmonic.

Reactive Power Compensation can be properly planned with the aid of the diagram shown at the left.

Planning Reactive Power Compensation



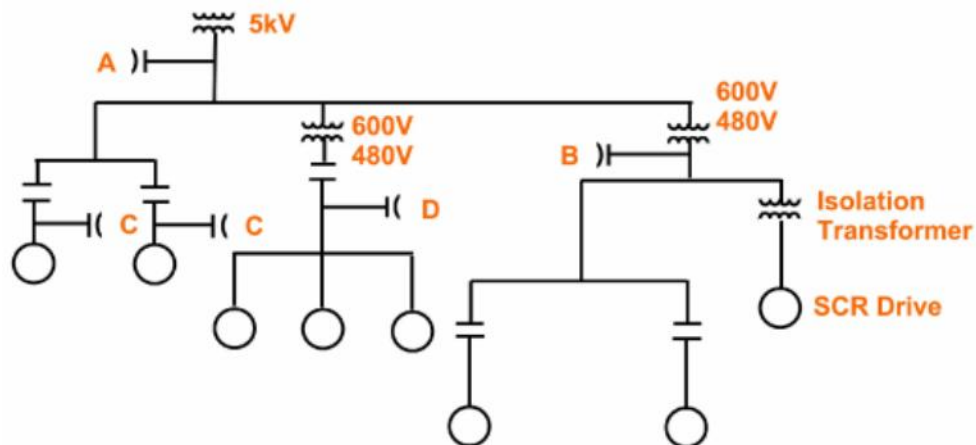
Typical Locations for Power Capacitors

Before power capacitors can be placed in the Facility system, the following factors must be addressed:

Meter Location: The physical location of the utility meter should be determined since all Power Capacitors must be installed "Downstream" of the meter

There are four basic locations for Power Capacitors

1. Load side of the utility transformer on the distribution bus
2. Bank installation at Feeders, Sub-stations, or Transformers
3. Load side of the AC motor, commonly referred to as "at the load" or "motor switched"
4. Small motors operating from a common starter



A Typical Facility System Line Diagram

Formulas and Calculation Examples Relating to Power Factor Correction

Determine Reactive Power (kVAR)

480V and 1200A are measured at the load side of the facilities transformer and the facility load is 800 KW.

A, What is the Power Factor?

B. How much Reactive Power (kVAR) is in the system?

Solutions.

- A. To calculate the Power Factor, we must first calculate the kVA in the system.

$$\mathbf{kVA} = \frac{V \times A \times \sqrt{3}}{1000} = \frac{480 \times 1200 \times \sqrt{3}}{1000} = \mathbf{1000kVA}$$

Next we substitute the kVA into the Power Factor Formula

$$\mathbf{P.F.} = \frac{KW}{kVA} = \frac{800}{1000} = \mathbf{.80 \text{ or } 80\% \text{ P.F.}}$$

- B. To calculate the Reactive Power (kVAR) in the system, requires re-arranging the formula $kVA^2 = KW^2 + kVAR^2$ and solving for kVAR.

$$\mathbf{kVAR} = \sqrt{kVA^2 - KW^2} = \sqrt{1000^2 - 800^2} = \mathbf{600kVAR}$$

How to Determine Potential Demand Savings

Known information taken from Hydro billing about electrical system:

kVA = 1000, KW = 800, kVAR = 600, P.F. = .80

Typical Billing Structure Examples:

A. 90% Billing Structure - Where demand billed is based on 90% of the kVA or 100% of the KW - Whichever is greater. Because the facility has a power factor of .80 they will pay demand rates on 90% of the kVA $1000 \times .90 = 900$ kVA because it is the larger number ($900 \text{ kVA} > 800 \text{ KW}$). Thus the facility is paying a penalty on 100 kVA of unproductive power. Correcting the facility's Power Factor to 90% + will eliminate this penalty cost.

B. 100% kVA + 100% KW Billing Structure - Where one rate is applied to 100% of the KVA and another rate is applied to 100% of the KW. Both are then added together to determine the total demand charged on the bill. If we correct the power factor to unity (kVA = KW or 800 kVA = 800 KW) we can recover costs paid on 200 kVA at *kVA rates. **Assuming an equal rate is being paid for kVA and KW** - Rather than pay Demand costs on 1000 kVA + 800 KW = 1800 if the Power Factor = Unity we will pay Demand costs on 800 kVA + 800 KW = 1600. Savings = 1800 - 1600 = 200.

*Note: Generally the cost per kVA is greater than the cost for KW. Thus the savings would be greater by correcting the power factor to unity.

Increase System Capacity

Known values for electrical system:

kVA = 1000, KW = 800, kVAR = 600, P.F. = .80

The uncorrected system can only support 800 KW of Productive Power at a P.F. of .80.

Increasing the system P.F. to 1.0 (unity), kVA = KW. The corrected system is now capable of supporting 1000 KW of productive power.

The system capacity has been increased by 200 KW.

Lower Losses

Assume Facility system wide losses = 5%

Increase P.F. from .80 to 1.0

% Reduction in (I²R) losses =

$$100 - 100(\text{Original P.F.}/\text{Corrected P.F.})^2 = 100 - 100(.64) = 36\%$$

The original facility system losses of 5% are reduced by $.36 \times 5 = 1.8\%$

As a result the monthly kWh billing is reduced by 1.8%, an additional savings.

Calculating kVAR Required for System Correction

1000 kVA and 800 KW are measured in the system.

How much Power Capacitor kVAR is required to operate the system at a P.F. of .95 while providing the same productive power of 800 KW.

1. Determine system kVAR and P.F. before correction

$$\mathbf{kVAR} = \sqrt{\text{kVA}^2 - \text{KW}^2} = \sqrt{1000^2 - 800^2} = \mathbf{600\text{kVAR}}$$

$$\mathbf{P.F.} = \frac{\text{KW}}{\text{kVA}} = \frac{800}{1000} = \mathbf{.80 \text{ or } 80\% \text{ P.F.}}$$

2. Determine system kVAR after correction

$$\mathbf{kVA} = \frac{\text{KW}}{\text{PF}} = \frac{800}{.95} = \mathbf{843}$$

$$\mathbf{kVAR} = \sqrt{\text{kVA}^2 - \text{KW}^2} = \sqrt{843^2 - 800^2} = \mathbf{265\text{kVAR}}$$

3. Determine Power Capacitor kVAR Rating

$$\begin{aligned} \mathbf{\text{Power Capacitor kVAR}} &= \text{kVAR(uncorrected)} - \text{kVAR(corrected)} \\ &= 600 - 265 = \mathbf{335} \end{aligned}$$

If the KW load, Uncorrected Power Factor and the Desired Power Factor are know, using the KW Multiplier Table on the next page is an alternative method for calculating Required kVAR.

Improved System Operating Characteristics

Provides a "stiffer" voltage, typically a 1-2% voltage rise.

$$\% \text{ voltage increase} = (\text{kVAR added} \times \text{transformer \% impedance}) / \text{transformer kVA}$$

KW Multipliers Table

Desired Power Factor

Original Power Factor	Desired Power Factor																				
	.80	.81	.82	.83	.84	.85	.86	.87	.88	.89	.90	.91	.92	.93	.94	.95	.96	.97	.98	.99	1.0
.51	.937	.962	.989	1.015	1.041	1.067	1.094	1.120	1.147	1.175	1.203	1.231	1.261	1.292	1.324	1.358	1.395	1.436	1.484	1.544	1.687
.52	.893	.919	.945	.971	.997	1.023	1.050	1.076	1.103	1.131	1.159	1.187	1.217	1.248	1.280	1.314	1.351	1.392	1.440	1.500	1.643
.53	.850	.876	.902	.928	.954	.980	1.007	1.033	1.060	1.088	1.116	1.144	1.174	1.205	1.237	1.271	1.308	1.349	1.397	1.457	1.600
.54	.809	.835	.861	.887	.913	.939	.966	.992	1.019	1.047	1.075	1.103	1.133	1.164	1.196	1.230	1.267	1.308	1.356	1.416	1.559
.55	.769	.795	.821	.847	.873	.899	.926	.952	.979	1.007	1.035	1.063	1.090	1.124	1.156	1.190	1.228	1.268	1.316	1.377	1.519
.56	.730	.756	.782	.808	.834	.860	.887	.913	.940	.968	.996	1.024	1.054	1.085	1.117	1.151	1.189	1.229	1.277	1.338	1.480
.57	.692	.718	.744	.770	.796	.822	.849	.875	.902	.930	.958	.986	1.016	1.047	1.079	1.113	1.151	1.191	1.239	1.300	1.442
.58	.655	.681	.707	.733	.759	.785	.812	.838	.865	.893	.921	.949	.979	1.010	1.042	1.076	1.114	1.154	1.202	1.263	1.405
.59	.618	.644	.670	.696	.722	.748	.775	.801	.828	.856	.884	.912	.943	.973	1.005	1.039	1.077	1.117	1.165	1.226	1.368
.60	.584	.610	.636	.662	.688	.714	.741	.767	.794	.822	.850	.878	.907	.939	.971	1.005	1.041	1.083	1.131	1.190	1.334
.61	.549	.575	.601	.627	.653	.679	.706	.732	.759	.787	.815	.843	.873	.904	.936	.970	1.008	1.048	1.096	1.157	1.299
.62	.515	.541	.567	.593	.619	.645	.672	.698	.725	.753	.781	.809	.840	.870	.902	.936	.974	1.014	1.062	1.123	1.265
.63	.483	.509	.535	.561	.587	.613	.640	.666	.693	.721	.749	.777	.807	.838	.870	.904	.942	.982	1.030	1.091	1.233
.64	.450	.474	.502	.528	.554	.580	.607	.633	.660	.688	.716	.744	.775	.805	.837	.871	.909	.949	.997	1.068	1.200
.65	.419	.445	.471	.497	.523	.549	.576	.602	.629	.657	.685	.713	.743	.774	.806	.840	.878	.918	.966	1.027	1.169
.66	.388	.414	.440	.466	.492	.518	.545	.571	.598	.626	.654	.682	.712	.743	.775	.809	.847	.887	.935	.996	1.138
.67	.358	.384	.410	.436	.462	.488	.515	.541	.568	.596	.624	.652	.682	.713	.745	.779	.817	.857	.905	.966	1.108
.68	.329	.355	.381	.407	.433	.459	.486	.512	.539	.567	.595	.623	.652	.684	.716	.750	.788	.828	.876	.935	1.079
.69	.299	.325	.351	.377	.403	.429	.456	.482	.509	.537	.565	.593	.623	.654	.686	.720	.758	.798	.846	.907	1.049
.70	.270	.296	.322	.348	.374	.400	.427	.453	.480	.508	.536	.564	.594	.625	.657	.691	.729	.769	.817	.878	1.020
.71	.242	.268	.294	.320	.346	.372	.399	.425	.452	.480	.508	.536	.566	.597	.629	.663	.701	.741	.789	.850	.992
.72	.213	.239	.265	.291	.317	.343	.370	.396	.423	.451	.479	.507	.538	.568	.600	.634	.672	.712	.761	.821	.963
.73	.186	.212	.238	.264	.290	.316	.343	.369	.396	.424	.452	.480	.510	.541	.573	.607	.645	.685	.733	.794	.936
.74	.159	.185	.211	.237	.263	.289	.316	.342	.369	.397	.425	.453	.483	.514	.546	.580	.618	.658	.706	.767	.909
.75	.132	.158	.184	.210	.236	.262	.289	.315	.342	.370	.398	.426	.456	.487	.519	.553	.591	.631	.679	.740	.882
.76	.105	.131	.157	.183	.209	.235	.262	.288	.315	.343	.371	.399	.429	.460	.492	.526	.564	.604	.652	.713	.855
.77	.079	.105	.131	.157	.183	.209	.236	.262	.289	.317	.345	.373	.403	.434	.466	.500	.538	.578	.620	.687	.829
.78	.053	.079	.105	.131	.157	.183	.210	.236	.263	.291	.319	.347	.376	.408	.440	.474	.510	.552	.594	.661	.803
.79	.026	.052	.078	.104	.130	.156	.183	.209	.236	.264	.292	.320	.350	.381	.413	.447	.485	.525	.567	.634	.776
.80	.000	.026	.052	.078	.104	.130	.157	.183	.210	.238	.266	.294	.324	.355	.387	.421	.459	.499	.541	.608	.750
.81	-	.000	.026	.052	.078	.104	.131	.157	.184	.212	.240	.268	.298	.329	.361	.395	.433	.473	.515	.582	.724
.82	-	-	.000	.026	.052	.078	.105	.131	.158	.186	.214	.242	.272	.303	.335	.369	.407	.447	.495	.556	.698
.83	-	-	-	.000	.026	.052	.079	.105	.132	.160	.188	.216	.246	.277	.309	.343	.381	.421	.469	.530	.672
.84	-	-	-	-	.000	.026	.053	.079	.106	.134	.162	.190	.220	.251	.283	.317	.355	.395	.443	.504	.645
.85	-	-	-	-	-	.000	.026	.053	.080	.108	.136	.164	.194	.225	.257	.291	.329	.369	.417	.478	.620
.86	-	-	-	-	-	-	.026	.053	.081	.109	.137	.167	.198	.230	.265	.301	.343	.390	.451	.513	.655
.87	-	-	-	-	-	-	-	.026	.055	.082	.111	.141	.172	.204	.238	.275	.317	.364	.425	.487	.629
.88	-	-	-	-	-	-	-	-	.026	.056	.084	.114	.145	.177	.211	.248	.290	.337	.398	.460	.602
.89	-	-	-	-	-	-	-	-	-	.028	.056	.086	.117	.149	.183	.220	.262	.309	.370	.432	.574
.90	-	-	-	-	-	-	-	-	-	-	.028	.058	.089	.121	.155	.192	.234	.281	.342	.404	.546
.91	-	-	-	-	-	-	-	-	-	-	-	.030	.061	.093	.127	.164	.206	.253	.314	.376	.518
.92	-	-	-	-	-	-	-	-	-	-	-	-	.031	.063	.097	.134	.176	.223	.284	.346	.488
.93	-	-	-	-	-	-	-	-	-	-	-	-	-	.032	.066	.103	.145	.192	.253	.315	.457
.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.034	.071	.113	.160	.221	.283	.425
.95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.037	.079	.126	.187	.249	.391

How To Determine kVAR Required Using Table Above

1. Determine KW and Original Power Factor.
2. Locate Original Power Factor on Table, move across table to Desired Power Factor. The number represented is your multiplier number.
3. Multiply KW by the multiplier of the Desired Power Factor.
4. The result is the amount of kVAR required to bring system to the Desired Power Factor.

Suggested Wire Sizes and Unimproved Power Factor by Industry

Suggested Minimum Wire Sizes

Size* AWG mm	90°C** wire ampacity	Maximum kVAR		
		240 Volt 3-phase	480 Volt 3-phase	600 Volt 3-phase
14	15	14	8	10
12	20	12	10	12.5
10	30	10	17.5	20
8	50	8	30	35
6	70	6	40	50
4	90	4	50	60
3	105	3	60	75
2	120	2	70	87
1	140	1	75	100
1/0	155	1/0	90	110
2/0	185	2/0	100	140
4/0	235	4/0	125	180
250	270	250	160	200
300	300	300	175	230
350	330	350	215	245
400	360	400	220	275
500	405	500	265	330

* 1. Wire sizes shown are THHN or equivalent sizes based upon 135% rated current for KVAR rating.

**2. Ampacity of not more than 3 single insulated conductors in a raceway with 30° ambient.

Guide Lines

1. *Capacitor rated current: 3PH, 60HZ*
To determine, multiply the kVAR x the factor for the given line voltage.

Line Voltage	240V	480V	600V
Factor (f)	2.4	1.2	.96

Example: 100kVAR, 600V, Capacitor (f) = .96
Amperes = 100 x .96 = 96A

2. *Minimum Current rating of wire*
For a given Capacitor, it is its current (Step 1.) x 135%

Example: 100kVAR, 600V, capacitor current = 96A (Step 1.) Min. wire size = 96 x 135% = 130A. From the suggested wire size chart # 1 AWG wire is proper.

3. *Capacitor Fuses*
To prevent "nuisance" clearing, fuses should be a min. of 200% capacitor rated amperes.

4. *Over Current Protection and Disconnecting Means*

	% capacitor rated Amps
safety switches:	fuses: 165%
circuit breakers:	165%*

*NOTE: If harmonics are present consult Cos Phi Inc.

Typical Unimproved Power Factor Values, by Industry

Industry	Power Factor
Auto Parts	75-80
Brewery	75-80
Cement	80-85
Chemical	65-75
Coal Mine	65-80
Clothing	35-60
Electroplating	65-70
Foundry	75-80
Forge	70-80
Hospital	75-80
Machine Manufacturing	60-65
Metalworking	65-70
Office Building	80-90
Oil-field Pumping	40-60
Paint Manufacturing	65-66
Plastic	75-80
Stamping	60-70
Steel Works	65-80
Too, Die, Jig	65-75

Typical Unimproved Power Factor Values, by Industry

Industry	Power Factor
Air Compressor	
External Motors	75-80
Hermetic Motors	50-80
Metalworking	
Arc Welding	
with commercially	
furnished capacitors	70-80
Machining	40-65
Melting	
Arc Furnace	75-90
Induction Furnace, 60HZ	100
Stamping	
Standard	60-70
High Speed	45-60
Spraying	60-65
Welding	
Arc	35-60
Resistance	40-60

Suggested Capacitor Ratings for T-Frame NEMA Class B Motors

Induction Motor Horsepower Rating	3600 RPM		1800 RPM		1200 RPM		900 RPM		720 RPM		600 RPM	
	kVAR	Current Reduction %	kVAR	Current Reduction %	kVAR	Current Reduction %	kVAR	Current Reduction %	kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %
2	1	14	1	24	1.5	30	2	42	2	40	3	50
3	1.5	14	1.5	23	2	28	3	38	3	40	4	49
5	2	14	2.5	22	3	26	4	31	4	40	5	49
7.5	2.5	14	3	20	4	21	5	28	5	38	6	45
10	4	14	4	18	5	21	6	27	7.5	36	8	38
15	5	12	5	18	6	20	7.5	24	8	32	10	34
20	6	12	6	17	7.5	19	9	23	10	29	12.5	30
25	7.5	12	7.5	17	8	19	10	23	12.5	25	17.5	30
30	8	11	8	16	10	19	15	22	15	24	20	30
40	12.5	12	15	16	15	19	17.5	21	20	24	25	30
50	15	12	17.5	15	20	19	22.5	21	22.5	24	30	30
60	17.5	12	20	15	22.5	17	25	20	30	22	35	28
75	20	12	25	14	25	15	30	17	35	21	40	19
100	22.5	11	30	14	30	12	35	16	40	15	45	17
120	25	10	35	12	35	12	40	14	45	15	50	17
150	30	10	40	12	40	12	50	14	50	13	60	17
200	35	10	50	11	50	11	70	14	70	13	90	17
250	40	11	60	10	60	10	80	13	90	13	100	17
300	45	11	70	10	75	12	100	14	100	13	120	17
350	50	12	75	8	90	12	120	13	120	13	135	15
400	75	10	80	8	100	12	130	13	140	13	150	15
450	80	8	90	8	120	10	140	12	160	14	160	15
500	100	8	120	9	150	12	160	12	180	13	180	15

Suggested Capacitor Ratings for High Efficiency motors and older design (pre "T-Frame") Motors

Induction Motor Horsepower Rating	2-3600 RPM		4-1800 RPM		6-1200 RPM		8-900 RPM		10-720 RPM		12-600 RPM	
	kVAR	Current Reduction %	kVAR	Current Reduction %	kVAR	Current Reduction %	kVAR	Current Reduction %	kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %
3	1.5	14	1.5	15	1.5	20	2	27	2.5	35	3	41
5	2	12	2	13	2	17	3	25	4	32	4	37
7.5	2.5	11	2.5	12	3	15	4	22	5	30	6	34
10	4	10	3	11	3	14	5	21	6	27	7.5	31
15	5	9	4	10	5	13	6	18	8	23	9	27
20	6	9	5	10	6	12	7.5	16	9	21	12.5	25
25	7	9	6	10	7.5	11	9	15	10	20	15	23
30	9	8	7	9	9	11	10	14	12.5	18	17.5	22
40	12.5	8	9	9	10	10	12.5	13	15	16	20	20
50	15	8	10	9	12.5	10	13	12	20	15	25	19
60	17.5	8	15	8	15	10	17.5	11	22.5	15	27.5	19
75	22.5	8	17.5	8	17.5	10	20	10	25	14	35	18
100	27.5	8	20	8	20	9	27.5	10	35	13	40	17
120	30	8	25	8	30	9	30	10	40	13	50	16
150	35	8	30	8	35	9	37.5	10	50	12	50	15
200	40	8	37.5	8	40	8	50	10	60	12	60	14
250	50	8	45	7	50	8	60	9	70	11	75	13
300	60	8	50	7	60	8	60	9	80	11	90	12
350	60	8	60	7	75	8	75	9	90	10	95	11
400	75	8	60	6	75	8	85	9	95	10	100	11
450	75	8	75	6	80	8	90	9	100	9	110	11
500	75	8	75	6	85	8	100	9	100	9	120	10

Static Capacitor Banks

480V, 3 phase, Delta, 60Hz

Part #	Capacitance		Dimensions in mm			Encl.	Weight
	kVAR	µF	W	D	H	Fig #	(kg)
MPP3/480D6BK1	3	3 x 11.5	260	170	406	1	5.5
MPP5/480D6BK1	5	3 x 19.2	260	170	406	1	5.6
MPP7.5/480D6BK1	7.5	3 x 9	260	170	406	1	5.6
MPP10/480D6BK1	10	3 x 38.4	260	170	406	1	6.4
MPP12.5/480D6BK1	12.5	3 x 48	260	170	406	1	6.6
MPP15/480D6BK1	15	3 x 57.6	260	170	406	1	6.7
MPP17.5/480D6BK1	17.5	3 x 67.2	260	170	406	1	8.1
MPP20/480D6BK1	20	3 x 76.8	260	170	406	1	8.2
MPP25/480D6BK1	25	3 x 96	260	170	406	1	8.4
MPP30/480D6BK2	30	3 x 115.2	387	170	527	2	13.4
MPP35/480D6BK2	35	3 x 134.4	387	170	527	2	14.9
MPP40/480D6BK2	40	3 x 153.6	387	170	527	2	16.4
MPP45/480D6BK2	45	3 x 172.8	387	170	527	2	16.6
MPP50/480D6BK2	50	3 x 192	387	170	527	2	16.8
MPP55/480D6BK3	55	3 x 211.2	387	170	959	3	23.1
MPP60/480D6BK3	60	3 x 230.4	387	170	959	3	24.6
MPP65/480D6BK3	65	3 x 249.6	387	170	959	3	24.8
MPP70/480D6BK3	70	3 x 268.8	387	170	959	3	25
MPP75/480D6BK3	75	3 x 288	387	170	959	3	25.2
MPP80/480D6BK3	80	3 x 307.2	387	170	959	3	28.8
MPP85/480D6BK3	85	3 x 326.4	387	170	959	3	29
MPP90/480D6BK3	90	3 x 345.6	387	170	959	3	29.2
MPP95/480D6BK3	95	3 x 364.8	387	170	959	3	29.4
MPP100/480D6BK3	100	3 x 384	387	170	959	3	29.6
MPP120/480D6BK3-2	120	3 x 460.8	387	390	959	3	45.8
MPP125/480D6BK3-2	125	3 x 480	387	390	959	3	46
MPP140/480D6BK3-2	140	3 x 537.6	387	390	959	3	48.7
MPP150/480D6BK3-2	150	3 x 576	387	390	959	3	50.4
MPP160/480D6BK3-2	160	3 x 614.4	387	390	959	3	52.8
MPP180/480D6BK3-2	180	3 x 691.2	387	390	959	3	56.4
MPP200/480D6BK3-2	200	3 x 768	387	390	959	3	59.2

Understanding your part #

Example: Cos Phi Part #: MPP75/480D6BK3

MPP – Capacitor Type

75 – kVAR size

480 – Nominal voltage

D – Delta connected

6 – 60Hz

BK3 – Enclosure Type

600V, 3 phase, Delta, 60Hz

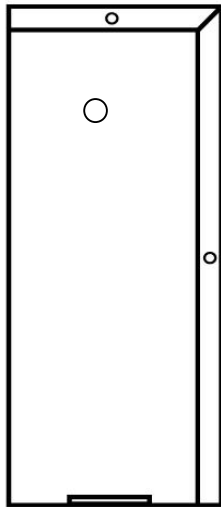
Part #	Capacitance		Dimensions in mm			Encl.	Weight
	kVAR	µF	W	D	H	Fig #	(kg)
MPP3/600D6BK1	3	3 x 7.4	260	170	406	1	5.3
MPP5/600D6BK1	5	3 x 12.3	260	170	406	1	5.4
MPP7.5/600D6BK1	7.5	3 x 18.5	260	170	406	1	5.6
MPP10/600D6BK1	10	3 x 24.6	260	170	406	1	6.4
MPP12.5/600D6BK1	12.5	3 x 30.8	260	170	406	1	6.6
MPP15/600D6BK1	15	3 x 36.9	260	170	406	1	6.7
MPP17.5/600D6BK1	17.5	3 x 43	260	170	406	1	8.1
MPP20/600D6BK1	20	3 x 49.2	260	170	406	1	8.2
MPP25/600D6BK1	25	3 x 61.5	260	170	406	1	8.4
MPP30/600D6BK2	30	3 x 73.8	387	170	527	2	13.4
MPP35/600D6BK2	35	3 x 86.1	387	170	527	2	14.9
MPP40/600D6BK2	40	3 x 98.4	387	170	527	2	16.4
MPP45/600D6BK2	45	3 x 110.7	387	170	527	2	16.6
MPP50/600D6BK2	50	3 x 123	387	170	527	2	16.8
MPP55/600D6BK3	55	3 x 135.3	387	170	959	3	19.1
MPP60/600D6BK3	60	3 x 147.6	387	170	959	3	20.6
MPP65/600D6BK3	65	3 x 159.9	387	170	959	3	20.8
MPP70/600D6BK3	70	3 x 172.2	387	170	959	3	21
MPP75/600D6BK3	75	3 x 184.5	387	170	959	3	21.2
MPP80/600D6BK3	80	3 x 196.8	387	170	959	3	22
MPP85/600D6BK3	85	3 x 209.1	387	170	959	3	23.6
MPP90/600D6BK3	90	3 x 221.4	387	170	959	3	23.9
MPP95/600D6BK3	95	3 x 233.7	387	170	959	3	25.4
MPP100/600D6BK3	100	3 x 246	387	170	959	3	25.6
MPP120/600D6BK3-2	120	3 x 295.2	387	390	959	3	33.8
MPP125/600D6BK3-2	125	3 x 307.5	387	390	959	3	34
MPP140/600D6BK3-2	140	3 x 344.4	387	390	959	3	36.7
MPP150/600D6BK3-2	150	3 x 369	387	390	959	3	38.4
MPP160/600D6BK3-2	160	3 x 393.6	387	390	959	3	40.8
MPP180/600D6BK3-2	180	3 x 442.8	387	390	959	3	44.2
MPP200/600D6BK3-2	200	3 x 492	387	390	959	3	47.2

(Other static capacitor banks available: 208V, 416V.)

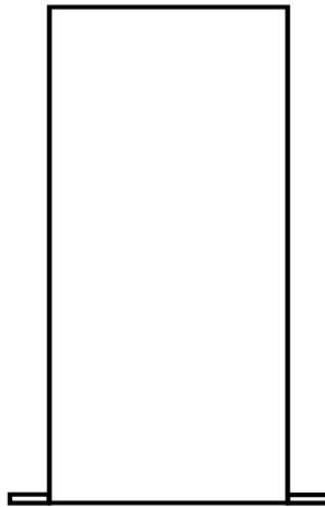
Add-on/Upgrade Options

Current Limiting Magnetic Contactor(s)
LED indicators (indicate red or green)

Static Bank Enclosures



Side View



Front/Back View



Top/Bottom View

Enclosure Dimensions:

Depth: 170mm

Width: 260mm (without mounting pads: 197mm)

Height: 406mm

Mounting pads: 32mm x 76mm

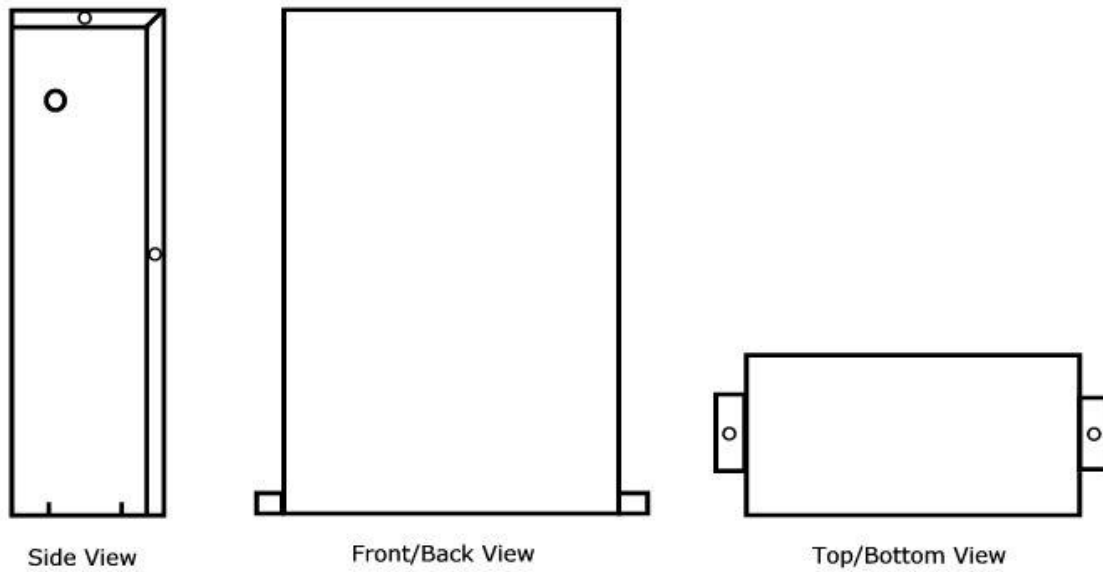
Colour: RAL1014 Husky Beige (special request for other colours)

Constructed from 18 gauge cold roll steel

Weight: 4 kg

NEMA 1, 12 (must specify)

BK1 Type Enclosure
Fig. 1

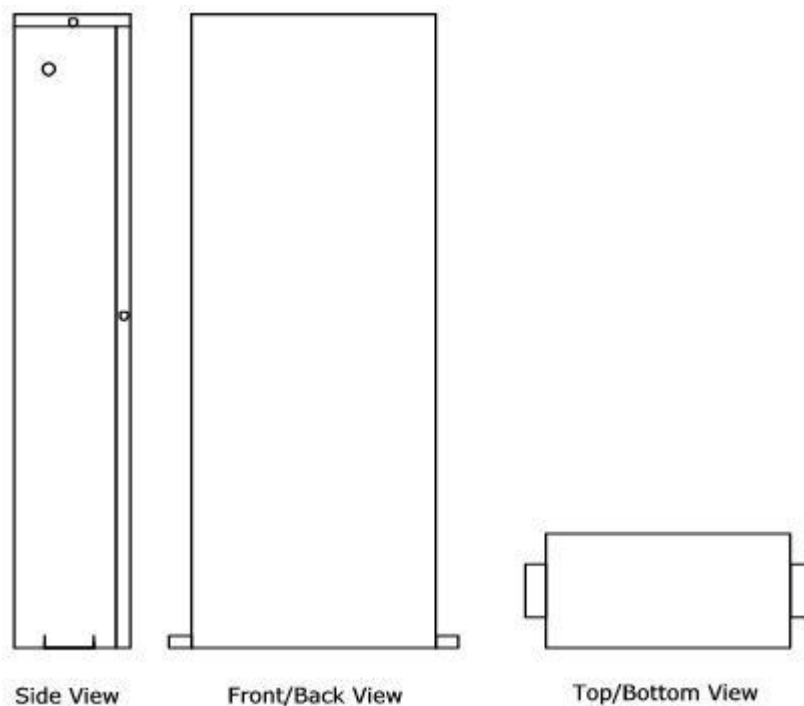


Enclosure Dimensions:

Depth: 170mm
Width: 387mm (without mounting pad: 350mm)
Height: 527mm
Mounting pads: 32mm x 76mm

Colour: Beige (special request for other colours)
Constructed from 18 gauge cold roll steel
Weight: 8 kg
NEMA 1, 12 (must specify)

BK2 Type Enclosure
Fig. 2



Enclosure Dimensions:

Depth: 170mm
Width: 387mm (without mounting pads: 350mm)
Height: 959mm
Mounting pads: 32mm x 76mm

Colour: Beige (special request for other colours)
Constructed from 18 gauge cold roll steel
Weight: 12 kg
NEMA 1, 12 (must specify)

NOTE: A BK3-2 consists of 2 x BK3 with connecting hardware, mounted on uni-strut.

BK3 Type Enclosure
Fig. 3

Specifications for Static Capacitor Banks

1.0 Enclosures

- 1.1 NEMA 1, beige color
- 1.2 Connection terminal block included
- 1.3 Utilizing capacitor cells as defined below (see 2.0)
- 1.4 All banks shall have grounding lug provided.
- 1.5 All electrical ratings shall be shown on the label of the bank enclosure of the bank, including connections.
- 1.6 Optional wall mounting brackets shall be available.

2.0 Capacitor Cells

- 2.1 Individual capacitors shall be oil-impregnated 3 phase cells, manufactured with metalized paper and polypropylene dielectric and Delta connected. Wye connected capacitors are not acceptable. Metalized polypropylene dielectric is not acceptable.
- 2.2 Each three-phase capacitor shall be furnished with UL listed pressure sensitive interrupter. The interrupter shall disconnect all three phases at the same time to maintain a balanced circuit.
- 2.3 Each element shall contain a 100kA HRC fuse as part of the pressure interrupting circuit.
- 2.4 Electrical losses including contribution of discharge resistors shall be $<0.25\text{W/kVAR}$.
- 2.5 Terminal bushing shall withstand 10kV AC to ground and be rated to 35BIL or greater and shall be totally enclosed, touch safe housing discharge resistors
- 2.6 Nominal design life of individual capacitor cells shall be 20 year
- 2.7 Individual capacitor cells shall be covered by a 3-year warranty.
- 2.8 All capacitor cells shall have a terminal block, lug type terminal, four-wire connection
- 2.9 No capacitor shall exceed 25kVAR.

- 2.10 Capacitor cells shall be designed to handle the increase in voltage from the reactor.
- 2.11 All three phase capacitor banks shall be UL/ULC listed
- 2.12 Over-current rating according to standards, 1.5 or more (I_N)
- 2.13 Maximum permissible rate of change in switching operation $(DV/DT)_{max}$ shall be a minimum of $30V/\mu s$ or greater
- 2.14 The capacitor shall be rated for continuous duty at 45 degree C ambient
- 2.14 A +/- 10% variation in the line voltage shall not affect the life of the capacitor.

3.0 Testing and Installation

- 3.1 All capacitor cells shall be traceable through construction and testing.

4.0 General

- 4.1 Acceptable manufacturer: Cos Phi Inc.
- 4.2 All capacitor banks shall be calculated for natural series resonant point in order to avoid resonance
- 4.3 All capacitor banks for non-linear loads up to 15% of the total load shall be standard.
- 4.4 All capacitor banks for non-linear loads of 15-50% of the total load shall be de-rated and/or detuned (i.e. have filter reactors).
- 4.5 Reactors shall have a gap between the iron core and the winding of no less than 5mm all the way around the iron core.
- 4.6 All banks for non-linear loads of more than 50% of the total load shall be of a harmonic filter design (i.e. sharply tuned)
- 4.7 The following standard type tests shall be performed and passed:
 - 4.7.1 Resistance check
 - 4.7.2 Capacitance check
 - 4.7.3 Controller operation manual
 - 4.7.4 Controller operation automatic

- 4.7.5 Hi-pot test
- 4.8 All capacitor banks shall be sized and detuned/designed to cope with non-linear loads.
- 4.9 All protective devices for the capacitor banks or steps shall be no less than 100kA interrupting capacity.
- 4.10 In filtered units, capacitors shall be de-rated at 600V from 690V, at 480V from 600V, at 208V from 230V.
- 4.11 All detuning reactors shall be built as such that the thermal currents can escape easily and located in the bank in such manner that the heat will not affect the capacitors (reactors away from or above capacitors).

Power Factor Correction Systems

Automatic switching Central Power Factor corrector

- ⊗ nominal voltages, 230V, 480V, 600V
- ⊗ de-rated, filtered or detuned configurations

Features

Microprocessor based “intelligent” controller

- Automatic self adjustment to any Capacitor step value
- Digital indication of Power Factor, preset parameters and specified installation data
- No-Volt release feature to immediately disconnect all Capacitors in the even of a Power failure.
- TTL-Interface for data acquisition
- Plug-in terminal connection
- Digital setting of individual parameters including Target Power Factor, Switching Time Delay, Step Limit etc.
- Indication and elimination of defect capacitor steps
- Inquiry of switching per step
- Visual display of Control Alarm ($\cos \varphi$)
- Visual display of Harmonic Overload Alarm (du/dt)

Modular Construction

- 2 steps per module
- easy maintenance
- expandable
- drawer type assembly

Pre-insertion limiting reactors

- reduced I²R losses
- eliminates current inrush or ring waves when switching

Capacitors

- phase delta connection
- oil impregnated
- self-healing

Options available:

- main breaker or switch installed
- NEMA 1 or 12 enclosure
- custom designed & special construction available



All units are CSA approved

Standard Power Factor Correction Systems Sizes

kVAR	480 Volts			Derated kVAR
	D	W	H	
150	600	600	2200	150
200	600	600	2200	200
250	600	600	2200	250
300	600	600	2200	-
350	600	600	2200	-
400	600	600	2200	-
450	600	1200	2200	-
500	600	1200	2200	-
550	600	1200	2200	300
600	600	1200	2200	350
650	600	1200	2200	400
700	600	1200	2200	450
750	600	1200	2200	-
800	600	1200	2200	-

kVAR	600 Volts			Derated KVAR
	D	W	H	
180	600	600	2200	120
240	600	600	2200	180
300	600	600	2200	240
360	600	600	2200	300
420	600	600	2200	-
480	600	600	2200	-
540	600	1200	2200	-
600	600	1200	2200	-
660	600	1200	2200	360
720	600	1200	2200	420
780	600	1200	2200	480
840	600	1200	2200	540
900	600	1200	2200	-
960	600	1200	2200	-

Specifications for Power Factor Correction Systems

1.0 Capacitor Cells

- 1.1 Individual capacitors shall be oil-impregnated 3 phase cells, manufactured with metalized paper and polypropylene dielectric and Delta connected. Wye connected capacitors are not acceptable. Metalized polypropylene dielectric is not acceptable.
- 1.2 Each three-phase capacitor shall be furnished with UL listed pressure sensitive interrupter. The interrupter shall disconnect all three phases at the same time to maintain a balanced circuit.
- 1.3 Each element shall contain a 100kA HRC fuse as part of the pressure interrupting circuit.
- 1.4 Electrical losses including contribution of discharge resistors shall be <math><0.25\text{W/kVAR}</math>.
- 1.5 Terminal bushing shall withstand 10kV AC to ground and be rated to 35BIL or greater and shall be totally enclosed, touch safe housing discharge resistors
- 1.6 Nominal design life of individual capacitor cells shall be 20 year
- 1.7 Individual capacitor cells shall be covered by a 3-year warranty.
- 1.8 All capacitor cells shall have a terminal block, lug type terminal, four wire connection
- 1.9 No capacitor shall exceed 25kVAR.

- 1.10 Capacitor cells shall be designed to handle the increase in voltage from the reactor.
- 1.11 All three phase capacitor banks shall be UL/ULC listed
- 1.12 Over-current rating according to standards, 1.5 or more (I_N)
- 1.13 Maximum permissible rate of change in switching operation $(DV/DT)_{max}$ shall be a minimum of 30V/ μ s or greater
- 1.14 The capacitor shall be rated for continuous duty at 45 degree C ambient
- 1.15 A +/- 10% variation in the line voltage shall not affect the life of the capacitor.

2.0 Testing and Installation

- 2.1 All capacitor cells shall be traceable through construction and testing.

3.0 Power Factor Control Relay

- 3.1 Automatic self-adjustment to any Capacitor step value
 - 3.2 Digital indication of Power Factor, Present Parameters and specified installation data
 - 3.3 No-Volt release feature to immediately disconnect all capacitors in the event of power failure.
 - 3.4 TTL-interface for data acquisition
 - 3.5 Plug-in terminal connection
 - 3.6 Digital setting of individual parameters including target power factor, switching time delay, step limit, etc.
 - 3.7 Current path 5A or 1 A selectable
 - 3.8 Indication and elimination of defective capacitor steps (e.g. welded contactors)
 - 3.9 Historical inquiry of switching per step
 - 3.10 Inquiry of step sizes (proportional)
 - 3.11 Visual display of control alarm ($\cos \varphi$)
- Visual display of harmonic overload (du/dt)

4.0 Optional Features

- 4.1 Fault signaling contact to indicate control alarm.
- 4.2 Available in 3, 6, 12 and 14 step programmable (i.e. from 1-3 steps, from 1-6 steps etc.)

5.0 Controls

- 5.1 All controls in enclosure shall be mounted for ease of inspection and service.
- 5.2 All live electrical parts and components shall have a dead front preventing accidental contact by service and maintenance personnel.
- 5.3 A mechanical door interlock shall be provided to disconnect when the enclosure door is open.
- 5.4 All steps shall be no larger than 60kVAR at 600V, 50kVAR at 480V and 12.5kVAR at 230/208V.
- 5.5 All capacitors shall have appropriately sized contactors rated for the size of the capacitor being switched, with pre-timed inrush reactor to provide a controlled inrush current.
- 5.6 All capacitor steps shall be tuned away from a natural series resonance with a supply impedance.
- 5.7 All power wiring shall have thermal plastic insulation rated for 125C at 600V.
- 5.8 System wiring connections shall be made to a copper bus bar, braced for 65kA or greater.
- 5.9 The unit shall have a thermostatically controlled fan.
- 5.10 CT terminal connection shall be provided with a Flexi-Link shorting device for protection of excessive voltages being developed in the case of required maintenance.

6.0 Enclosure

- 6.1 Enclosure shall be able to accommodate future expansion.
- 6.2 The capacitor banks shall be of modular construction.
- 6.3 Enclosure shall be of NEMA 1, fabricated from 12-gauge cold rolled steel or better.
- 6.4 Internal grounding lug shall be provided.
- 6.5 Baked enamel textured finish in the RAL7032 beige powder coat.
- 6.6 Enclosure shall have removable lifting eyes
- 6.7 Enclosure shall have three a point latch with a key locking handle.
- 6.8 Enclosure shall be appropriately ventilated to evacuate heat produced by capacitors and reactors.
- 6.9 Cable entry shall be specified (top, bottom, left, right)
- 6.10 Each capacitor stage shall consist of hermetically sealed three-phase capacitor cell on a modular assembly with soft charge contactor and three-phase fusing.

7.0 General

- 7.1 Acceptable manufacturer: Cos Phi Inc.
- 7.2 All capacitor banks shall be calculated for natural series resonant point in order to avoid resonance
- 7.3 All capacitor banks for non-lineal loads up to 15% of the total load shall be standard.
- 7.4 All capacitor banks for non-lineal loads of 15-50% of the total load shall be de-rated and/or detuned (i.e. have filter reactors).
- 7.5 Reactors shall have a gap between the iron core and the winding of no less than 5mm all the way around the iron core.
- 7.6 All banks for non-lineal loads of more than 50% of the total load shall be of a harmonic filter design (i.e. sharply tuned)
- 7.7 All connections must provide documentation in package including certification for test done for appropriate torque of wire connections and power connections.

- 7.8 The following standard type tests shall be performed and passed:
 - 7.8.1 Resistance check
 - 7.8.2 Capacitance check
 - 7.8.3 Controller operation manual
 - 7.8.4 Controller operation automatic
 - 7.8.5 Hi-pot test
- 7.9 All capacitor banks shall be sized and detuned/designed to cope with non-linear loads.
- 7.10 All protective devices for the capacitor banks or steps shall be no less than 100kA interrupting capacity.
- 7.11 In filtered units, capacitors shall be de-rated at 600V from 690V, at 480V from 600V, at 208V from 230V.
- 7.12 All detuning reactors shall be built as such that the thermal currents can escape easily and located in the bank in such manner that the heat will not affect the capacitors (reactors away from or above capacitors).

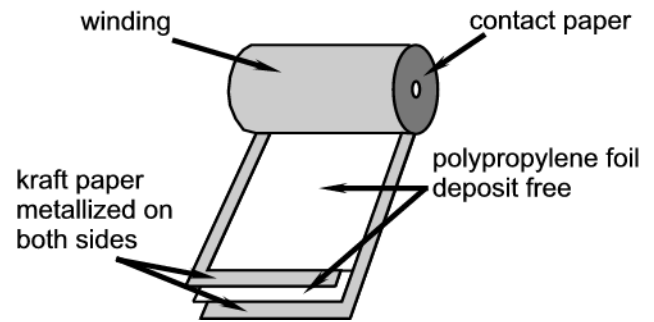
Capacitors for Power Factor Correction

MPP Capacitors for Power Factor correction

MPP-type capacitors are made of low-loss polypropylene foil interlayered with metalized Kraft paper. The MPP capacitor cells are inserted in their case, dried under high vacuum and then impregnated with a mineral oil in a sealed vat for several days. The metalized paper sheets serve as electrodes, while the oil acts as a coolant and provides instant self-healing.

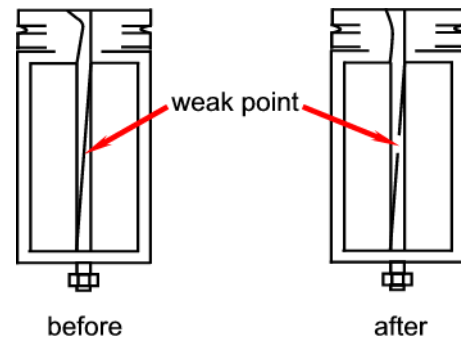
Advantages of MPP Technology

- long life-expectancy and extremely stable electrical characteristics
- very high resistance to impulse charges
- improved self-healing qualities
- may be operated at high ambient and case temperatures up to 70°C
- are particularly suited for de-tuned capacitor equipment



Protection

MPP capacitors are fitted with a "Break Action Mechanism". This prevents the capacitor from bursting in the event of severe over-voltage or aging at the end of its useful life.



**IEC 83 1-1, IEC 83 1-2, VDE 0560-41
CSA standard C 22.2, UL standard 810**

MPP Types

Rated Voltages:	400, 415, 440, 525, 580, 600, 690, 760V
Rated frequencies:	50 / 60 Hz
Tolerance of capacitance:	-5 / +10%
Temperature class:	-40°C / + 55°C
Maximum permissible current:	see table below, higher values on request

Maximum permissible rate of change of voltage in switching operations $(dv/dt)_{max}$:

Height (Case)	$(dv/dt)_{max}$ Rated Voltage			I_{max}
	400...440 V	525...580V	690...760V	
148 mm	15 V/ μ s	20 V/ μ s	30 V/ μ s	1.5 x I_N
176 mm	30 V/ μ s	40 V/ μ s	60 V/ μ s	1.8 x I_N
245 mm	25 V/ μ s	35 V/ μ s	50 V/ μ s	1.6 x I_N
320 mm	15 V/ μ s	20 V/ μ s	30 V/ μ s	1.5 x I_N

Losses

Dielectric:

cca 0.25 W / kVAR (without discharge resistors)

Capacitor:

cca 0.5 W / kVAR (with discharge resistors)

Life expectancy:

> 130,000 hours

Ambient Temperature Category:

-25 / D

(Dmax = 55°C, Highest Mean over any period of:
24 h = 45°C, 1 Year = 35°C)**480 Volt, 3 Phase Delta**

KVAR	Capacitance	Rated I	d	h	Weight (kg)
3	3 x 11.5	3 x 3.6	85	220	1.5
5	3 x 19.2	3 x 6	85	220	1.6
7.5	3 x 28.8	3 x 9.8	85	220	1.6
10	3 x 38.4	3 x 12	110	220	2.4
12.5	3 x 48	3 x 15	110	220	2.6
15	3 x 57.6	3 x 18	110	220	2.7
17.5	3 x 67.2	3 x 21	146	220	4.1
20	3 x 76.8	3 x 24	146	220	4.2
25	3 x 96	3 x 30	146	220	4.4

600 Volt, 3 Phase Delta

KVAR	Capacitance	Rated I	d	h	Weight (kg)
3	3 x 7.4	3 x 2.9	85	175	1.3
5	3 x 12.3	3 x 4.8	85	175	1.4
7.5	3 x 18.5	3 x 7.2	85	220	1.6
10	3 x 24.6	3 x 9.6	110	220	2.4
12.5	3 x 30.8	3 x 12	110	220	2.6
15	3 x 36.9	3 x 14.4	110	220	2.7
17.5	3 x 43	3 x 16.6	146	220	4.1
20	3 x 49.2	3 x 19.2	146	220	4.2
25	3 x 61.5	3 x 24	146	220	4.4

D = Diameter in mm

H = Height in mm

690 Volt, 3 Phase Delta

KVAR	Capacitance	Rated I	d	h	Weight (kG)
3	3 x 5.6	3 x 2.5	85	175	1.3
5	3 x 9.3	3 x 4.2	85	175	1.4
7.5	3 x 14	3 x 6.3	85	220	1.5
10	3 x 18.6	3 x 8.4	85	220	1.6
12.5	3 x 23.3	3 x 10.5	85	220	1.6
15	3 x 27.9	3 x 12.5	110	220	2.4
17.5	3 x 32.6	3 x 14.6	110	220	2.6
20	3 x 37.2	3 x 16.7	110	220	2.7
25	3 x 46.5	3 x 21	146	220	4.1

D = Diameter in mm

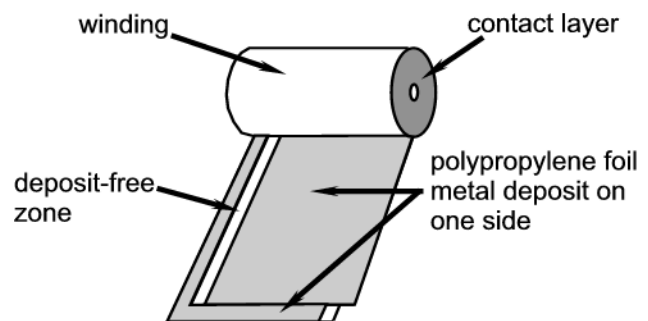
H = Height in mm

MKP Capacitors for Power Factor Correction

MKP-type capacitors are made of pure polypropylene foil, metalized on one side with a thin self-healing zinc and aluminum mixture. The capacitor elements are dried in a vacuum. The capacitor cells are inserted in their case, which is then filled with a patented viscous polypropylene resin.

Advantages of MKP Technology

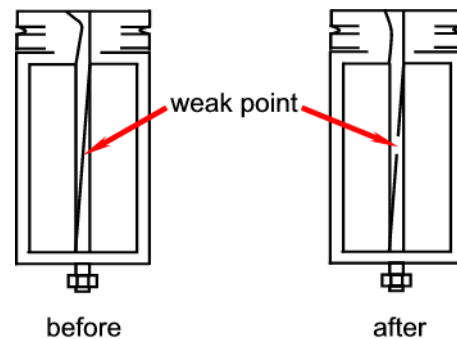
- competitive price
- usually smaller dimensions than MPP
- high specific capacitance and high A.C. load capacity



Protection

Both MPP and MKP capacitors are fitted with a "Break Action Mechanism". This prevents the capacitor from bursting in the event of severe over-voltage or aging at the end of its useful life.

**IEC 83 1-1, IEC 83 1-2, VDE 0560-41
CSA standard C 22.2, UL standard 810**



MKP Types

Rated Voltages:	230, 400, 415, 440, 480, 525 V
Rated frequencies:	50 / 60 Hz
Tolerance of capacitance:	-5 / +10
Temperature class:	-25°C / + 50°C
Maximum permissible current:	see table below

Maximum permissible rate of change of voltage in switching operations $(dv/dt)_{max}$:

Height (Case)	$(dv/dt)_{max}$ Rated Voltage			I_{max}
	400...440 V	525...580V	690...760V	
148 mm	10 V/ μ s	12.5 V/ μ s	15 V/ μ s	1.5 x I_N
176 mm	15 V/ μ s	20 V/ μ s	25 V/ μ s	1.5 x I_N
245...280 mm	10 V/ μ s	12.5 V/ μ s	15 V/ μ s	1.5 x I_N

Losses

Dielectric:	cca 0.25 W / kVAR (without discharge resistors)
Life expectancy:	> 130,000 hours
Ambient Temperature Category:	-25 / D
	(Dmax = 55°C, Highest Mean over any period of: 24 h = 45°C, 1 Year = 35°C)

230 Volt, 3 Phase Delta

KVAR	Capacitance	Rated I	d	h	Weight (kG)
3	3 x 7.4	3 x 2.9	85	175	1.3
5	3 x 12.3	3 x 4.8	85	175	1.4
7.5	3 x 18.5	3 x 7.2	85	220	1.6
10	3 x 24.6	3 x 9.6	110	220	2.4
12.5	3 x 30.8	3 x 12	110	220	2.4

D = Diameter in mm

H = Height in mm

Other Products



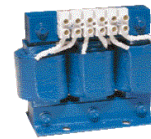
Beluk

Relay Controllers



*MCG Surge
Suppression*

**Harmonic
Filters**



**Line/Load
Reactors**

**Detuning
Reactors**

And More...



Contact Cos Phi Inc. for more details

Services

Power Factor

- Cos Phi Inc. will provide an overview of harmonics and Power Quality and an explanation of Power Factor for you and your staff.
- 12 month billing analysis is done upon request showing Power Factor correction calculations and estimated pay back calculations.
- Supply of custom designed corrective equipment. We build and/or source according to the individual facility requirements.
- We will provide instruction to your staff or contractor on installation of equipment and personally commission the equipment if requested.

Power Quality / Harmonics

- Cos Phi Inc. will provide monitoring and analysis where Power Quality may be a concern. This service applies to all areas of industry, i.e. mining, pulp and paper, fabricating, refineries etc.
- Power Quality surveys are available at all voltage levels from 120V to 36kV and include:
 - Demand measurements
 - power consumption (negative or positive)
 - negative sequence currents
 - current (current sequence)
 - voltage and current disturbances (i.e. sags, surges, swells, dips and transients, etc.)
 - voltage
 - kVAR
 - kVA
 - harmonic spectrum
 - power factor
 - waveform analysis
 - Detailed report with diagrams, measurement printouts, executive summary, observations and recommendations for correction.
 - Presentation of report to committees or management in person. Advice on corrective measures and quotations for corrective equipment.
 - The survey is done during normal plant operations without interrupting operations.
- Cos Phi Inc. will supply custom designed corrective equipment. We build and/or source according to the individual facility requirements.
- Cos Phi Inc. has the capabilities to design, model and build Harmonic filters at all voltage levels.
- We will provide instruction to your staff or contractor on installation of equipment and personally commission the equipment if requested.

Engineering Services

Modeling of Power Systems and Engineering Studies:

- Short Circuit Analysis
- Protection Co-ordination
- Transient analysis
- Load Flow analysis
- Harmonic analysis
- Power Factor analysis
- Motor-Starting analysis
- Robotic welding analysis
- Load Forecasting

Design of Substations and Power Systems

- Transformer evaluation

Grounding Surveys

- Ensure that electrical systems meet local code requirements
- Recommend alterations for optimal performance of electrical systems
- Ground-mat analysis

Engineering Drawings

- Single line diagram
- Control

Test and Measurement Services

Other Services Offered

High Voltage

- High Voltage Power Factor and Harmonic correction
- Calculations and specification of High Voltage Harmonic Filters
- Systems studies and modeling

Education

- Individual or group training on Power Factor, Harmonics, and Power Quality can be designed for your operations at a reasonable rate

Other Services

- Troubleshooting electrical distribution problems
- Substation evaluation
- Transformer evaluation
- Thermo-graphic scanning
- Single Line diagrams on hard copy and/or computer disk

Customer Reference List

United Plastic Components Inc.

Contact: K Taylor Lambert

143 Thames Rd. E.
Exeter, Ontario
N0M 1S3
Ph: 519-235-2867
Fax: 519-235-2497

PepsiCo Foods Canada Inc.

Contact: Ron Waite

34 Hunter Street West
Peterborough, Ontario
K9J 7B2
Ph: 705-743-6330
Fax: 705-876-4114

Bluewater Power Distribution Corporation

Contact: Ron LaPier

P.O. Box 2140
855 Confederation Street
Sarnia, Ontario
N7T 7L6
Ph: 519-344-9941 x235

Big 'O' Group

Contact: Bill Bengough - Armtec Ltd.

149A Thames Rd West
Exeter, Ontario
N0M 1S3
Ph: 519-235-0870
Fax: 519-235-2144

SAF Drive Systems Ltd.

Contact Sylvester Tyc

88 Ardel Ave.
Kitchener, Ontario
N2C 2C9
Phone: 519-743-5491

Autoliv Canada Inc.

Contact: Charles Haycock

20 Autoliv Drive
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Ph: 519-380-6546
Fax: 519-682-3767

Beavers Dental

Contact: Maurice Currier

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Ph: 613-543-3791
Fax: 613-543-2525

W.G. Thompson & Sons Ltd.

Contact: Peter Bisback

96 Nelson St.
Box 339, Hensall, Ontario
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AMCOR Twinpak – North America Inc.

Contact: Eric Wilson

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Fax: 905-275-3007

Culliton Brothers Ltd.

Contact: John Williams

473 Douro Street, P.O. Box 850
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Ph: 519-349-2850