

## POWER FACTOR CORRECTION CAPACITORS



### Reduce your Utility Bills with Baldor's Power Factor Correction Capacitor Products

You have already reduced the energy consumed by upgrading to Baldor Super-E premium efficient motors and drives, now its time to go to the next level and correct the power factor to further lower the overall utility bill.

Baldor's CC Series power factor correction capacitors are designed to reduce your utility's power factor penalty charges on a motor by motor basis. The CC series products are self contained, UL and cUL recognized and incorporate high quality three phase vacuum impregnated cells within a NEMA 3R, 16 gauge steel housing. The dielectric fluid is non-toxic, biodegradable and has a Class III combustible rating. There is a 5-year warranty on capacitor cells.

### What is power factor (PF)?

Power Factor (PF) is a ratio measurement of the efficient use of power. By definition  $PF = \text{Real Power} / \text{Total Power} = \text{kW} / \text{kVA}$  and is expressed as a percent.

Total power (kVA) is a combination of real power (kW) and reactive power (kVAR). Reactive power is the magnetizing power used by induction motors, transformers and other electrical devices that produce a lagging electrical load.

Inductive loads such as electric motors operate by producing magnetic fields. During operation these inductive devices combine real power and reactive magnetizing power to produce work. This combination is called apparent power.

To illustrate the two types of power think of a 19th century canal boat pulled by a horse. If the horse could swim and pull the boat his efforts would go 100% to pulling the boat less his efficiency losses while swimming. But, in reality the horse pulls from shore along the bank and in front of the boat. The boat still moves forward, but it takes more energy because there is a sideways component to the pulling. As the horse moves aft toward a position perpendicular to the boat it takes even more energy than if he pulled from in front leading the boat. To maximize efficiency we want to reduce the pulling angle between the boat and the horse. The sideways pull is similar to the reactive component of electrical power.

For a modern example, think of an airplane flying due East at 100 miles per hour. If the wind is blowing south at 40 miles per hour, the actual distance traveled can be calculated by using trigonometry or the Pythagorean Theorem assuming a right angle and a one hour flight.

Using trigonometry, the tangent of the angle is  $40/100 = 0.40$  and the angle is 22 degrees.

Therefore the cosine of 22 degrees = 100 miles / unknown distance (d). Or  $.93 = 100/d$  and  $d = 108$  miles.

If we use the Pythagorean Theorem then the distance is square root of  $(100^2 + 40^2) =$

Square root of  $(10,000 + 1,600) = 108$  miles.

Similar calculations can be used with electrical power. Solving apparent power problems takes advantage of Pythagoras' right triangle theorem  $A^2 = B^2 + C^2$  where A is the apparent power, B is the measured power and C is the reactive (or side pulling) component.

Apparent power  $kVA = (\text{sqrt}(\text{kW}^2 + \text{kVAR}^2))$ . The kW comes from the utility and the kVAR from the facilities inductive loading. Apparent power is the vector sum of the real power and reactive power loads. Reducing the angle brings the power factor ratio toward unity. K=kilo, W = watts, V = volts, A = amperes, R= reactive.

The goal in PF correction is to reduce the "pulling angle" to obtain a lower PF measurement. I.e. move the horse so he is pulling from the front more than from the side or "crab" the airplane to arrive at the original destination. A unity power factor of 1.0 is not practical therefore the utility looks for a power factor in the mid 90% range thus reducing the load on the utility.

Reactive power loads force the utility to build excess capacity and can even increase the transmission cable size. Therefore, utilities charge customers with low power factors a stiff fee as an incentive to become more efficient. Each utility has its own method of calculation, but two common methods are the kVA demand charge and the power factor multiplier charge method.

Facilities from commercial buildings to industrial plants can often benefit from location wide power factor correction and/or unit specific power factor correction, both help reduce utility bills.

Commercial buildings such as a hospitals and breweries have typical uncorrected power factors of 75-80% and a machine shops would have a typical uncorrected PF of 60-65%.

The utility would like to see the load PF between 85-95% and often charge \$5 to \$15 per kW or KVA as a demand load charge. The following are two examples of typical utility power factor penalty charge calculations.

# Power Factor Correction Capacitors

## Example #1: KVA Demand Charge

The utility wants to see a 95% power factor and has a demand charge of \$10 per kW for each percent or fraction below the 95% requirement. The customer has a monthly demand of 1000kW and an average PF of 87%. This is 8 percentage points below the required 95%.

The adjusted electricity usage becomes:  
 $1000kW + 8\% * 1000kW = 1080kW$ .

The penalty is  $(1080kW - 1000kW) * \$10/kW = \$800$  per month or \$9,600 per year.

Correcting to a 95% power factor would save \$9,600 per year.

## Example #2: Power Factor Multiplier Charge

The utility uses a power factor multiplier to estimate and charge for the reactive power component. The customer's electric rate is 10¢ per kWh, he has an overall power factor of 80% and this month's energy used was 500,000 kWh. According to the utility's rate table a PF of 80% results in a 1.15 multiplier of the energy usage.

The adjusted electricity usage becomes:  
 $500,000kWh * 1.15 = 575,000kWh$

The penalty is  $75,000 kWh * 10¢/kWh = \$7,500$  per month or \$90,000 annually. Correcting to a 95% power factor would save \$90,000 per year.

As you can see from the first two examples the power factor penalty can be substantial.

Now let's look at a motor example to determine the necessary kVAR capacitor bank needed to improve the power factor.

## Example #3: Determine the kVAR required for an ECP84410T-4

Although this 125 HP 460V motor is 95% efficient the power factor is only 87.9%. To correct to an overall 98% power factor would require a 30kVAR capacitor bank.

The actual calculations return a minimum required 29.71 kVAR capacitor bank to compensate to 98% power factor. 30kVAR is the closest stock size; therefore the customer would choose the CC4030 capacitor bank or if using an inverter would choose the CC4030NL.

The kVAR minimum calculations are made easy with the free downloadable kVAR calculator.

At present Baldor offers quality power factor correction capacitor products for our premium efficient motor lines. Baldor makes the capacitor product selection easy.

Step 1: Decide on the optimal PF required i.e. 95%

Step 2: Determine the VAR requirement for correction at the motor

There is a handy electronic kVAR calculator available for download.

Step 3: Select the motor's optimal capacitor bank from the table to the right.

Stocked capacitor banks are now available. Be sure to choose the correct capacitor product for your motor load, normal or high harmonic content.

480V Power Factor Correction Capacitors		
Suitable for 208V and 240V Systems		
kVAR	Linear Loads Catalog #	Heavy Duty High Harmonic Content Catalog #
0.40	CC4000.4	N/A
0.50	CC4000.5	N/A
0.60	CC4000.6	N/A
0.75	CC4000.75	N/A
1.00	CC4001	N/A
1.25	CC4001.25	N/A
1.50	CC4001.5	N/A
2.00	CC4002	N/A
2.50	CC4002.5	N/A
3.00	CC4003	N/A
3.50	CC4003.5	N/A
4.00	CC4004	N/A
5.00	CC4005	N/A
6.00	CC4006	N/A
7.50	CC4007.5	CC4007.5NL
10.00	CC4010	CC4010NL
12.50	CC4012.5	CC4012.5NL
15.00	CC4015	CC4015NL
17.50	CC4015.5	CC4017.5NL
20.00	CC4020	CC4020NL
22.50	CC4022.5	CC4022.5NL
25.00	CC4025	CC4025NL
30.00	CC4030	CC4030NL
32.50	CC4032.5	CC4032.5NL
35.00	CC4035	CC4035NL
40.00	CC4040	CC4040NL
50.00	CC4050	CC4050NL
60.00	CC4060	CC4060NL
75.00	N/A	CC4075NL
80.00	CC4080	CC4080NL

For further information, please contact your Baldor District office or sales team.



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