Understanding Power Factor Correction and Harmonics

Designers and Manufacturers of Power Factor Correction Equipment and Harmonic Filters

1016 34 AV SE
Calgary, AB T2G 1V4
Canada

Tel: 403 287 2200
1 800 404 9114
Fax: 403 287 3808

contact@electrotekltd. com
www.electrotekltd.com

ELECTROTEKLTD

Introduction to Power Factor Correction Equipment

Electrical machines must be supplied with energy in order to work. In the case of electric motors, more energy must be supplied than what is actually required to turn the motor's shaft, since a certain amount of energy is required just to maintain the necessary magnetic field of the motor. This energy is known as reactive (or magnetizing) power. Utility companies will provide a limited amount of reactive power at no cost, however, customers with high reactive power loads are charged for the additional power. They call this additional charge a power factor penalty (or power factor surcharge).

What is Power Factor?

Power factor (pf) is the ratio of the active (or useable) power measured in kilowatts (kW), to the total (active and reactive) power measured in kilovolt amperes (kVA), and is calculated as kW / kVA = pf. Power factor is commonly referred to in percent, with 100% being a perfect power factor, also called unity. At unity power factor, the kVA = kW, therefor the utility company does not supply any reactive power.

What is Power Factor Correction Equipment?

PFC equipment provides the means of reducing the reactive power being supplied by the utility. Reducing the reactive power supplied by the utility results in a cost reduction to electrical bills, since the kVA demand is also reduced.

PFC capacitors are the main component in PFC equipment, with their size most often referred to in kVAr. Diagram 1 illustrates how a PFC capacitor works when installed on the line side of a motor.

How does it work?

PFC capacitors act as a "reactive power generator," providing the magnetizing power a motor requires to operate - rather than the motor having to draw it from the utility. Improving your power factor will reduce the amperage draw from the utility generator. The reduced amperage is a measurable value.

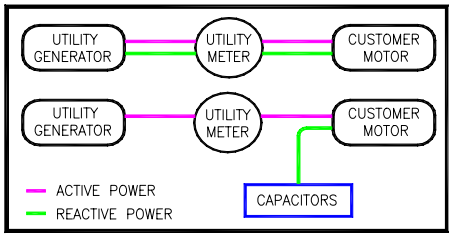

Diagram 1

The example in diagram 1 makes the application of PFC equipment look simple - and sometimes it is. However, in situations where an entire electrical distribution (or multiple electrical distributions) requires correction, finding the best solution (technically and economically) is more challenging.

What is the target power factor and how is it determined?

The "target power factor" is the power factor a consumer must obtain to avoid paying a power factor penalty. Utility companies set the target power factor(s) for their consumers. They vary anywhere from 90% to 100%, depending on the utility company, and specific rate structure within a given utility company.

Even if your target power factor is 100%, it is not always in your best interest to obtain a unity power factor; because increasing the power factor is not a linear relationship with the corresponding savings. It is the responsibility of your PFC equipment designer to ensure you receive the optimal combination.

How much money can be saved through Power Factor Correction?

The amount of annual savings which can be achieved is based on a number of factors:

- the existing power factor,
- the target power factor,
- the existing kVA demand, and
- the utility and rate structure.

Since there is a vast difference between the costs of consumer's electrical bills, talking about dollars saved through PFC can be misleading; so instead, we talk about payback periods. On average, the supply of PFC equipment has a payback period of 18 to 24 months.

To find out if your facility could benefit from power factor correction equipment, please see 'Preliminary Evaluation' on page 4.

Below are two examples to show you how PFC equipment saves money for two customers in different situations:

Customer "A" Forest Products		**Customer "B" Senior Citizens Complex**	
number of distributions:	3	number of distributions:	1
recommendation for correction:	1,750 kVAr	recommendation for correction:	140 kVAr
cost of PFC equipment:	$160,000.00	cost of PFC equipment:	$13,000.00
annual savings achieved:	$192,000.00	annual savings achieved:	$ 9,600.00
payback period:	10 months	payback period:	16 months

Although the differences in kVA demand for Customers "A" and "B" are enormous, each benefited from the installation of PFC equipment with payback periods under 18 months. The savings which can be achieved through PFC equipment is relative to the cost of a customer's electricity bills.

The two customers in our example did have one important factor in common: both of them suffered from significant harmonic distortion on their electrical distributions, and both received filtered PFC equipment to correct the problem.

Harmonics

"Harmonics" has been made out to be a *mystical problem*...leaving most people convinced they will never understand what they are, what they can do to electrical distributions, why they occur, and how to conquer them. We want to change that.

Harmonics come in different shapes and sizes; because they are all relative to your base frequency (being 60Hz in North America), the harmonics which affect your electrical distribution are all multiples of the base frequency.

For example: a measured frequency of 120Hz on your electrical system would be called a 2nd order harmonic (120 / 60 = 2), while a measured frequency of 300Hz would be your 5th order harmonic (300 / 60 = 5).

What are Harmonics?

Harmonics is a steady state distortion of the electrical sine wave. Most often called the THD (total harmonic distortion), it is referred to in percent. THD is also broken down into an ITHD (for current) and VTHD (for voltage). Diagram 2 illustrates the difference between a harmonic contaminated sine wave (upper) and a normal sine wave (lower).

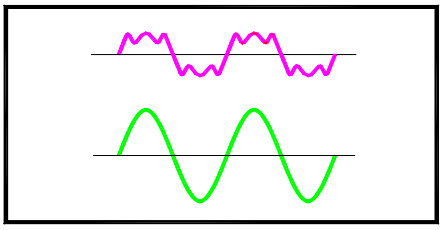

Diagram 2

What generates Harmonics?

Harmonics are generated by non-linear load on your electrical distribution. Variable frequency / speed drives are common culprits. Arc welders, DC rectifiers and soft start motors (on start up only) are also contributors. To make matters more complicated, harmonics can also be imported into your electrical distribution from your utility...the welding shop down the road from you could be the cause of your motor's early retirement!

When should Harmonics become a concern?

If the non-linear load on your electrical system exceeds 15% of the total load, you are likely to suffer from a harmonic contaminated network. Across North America, utilities are starting to implement guidelines as to the levels of harmonic distortion which a consumer is allowed to export; because just as your welding shop neighbour is sharing his harmonic distortion with you, you may also be exporting harmonics into his (or another) facility!

What are the risks of operating with a harmonic contaminated network?

Harmonics can cause serious damage to an electrical distribution because they increase the operating current and voltage on the system. Not only can motors and other components on the system be overloaded, the increase to the current and voltage also results in the generation of huge amounts of heat. Heat losses transpose into using and paying for more kWh than required.

Therefor, operating with a harmonic contaminated network quickly shortens the life expectancy of your electrical equipment and costs money.

How to eliminate significant Harmonic Distortion

Significant levels of harmonic distortion are easily and effectively reduced / eliminated with harmonic filters. A harmonic filter is a capacitor and reactor working together.

The *manufacturing* of a harmonic filter is not a difficult task, and this is probably why a number of companies have entered this market over the last few years...the harmonic bandwagon. The *design* and *proper application* of a harmonic filter is the difficult part, and this is what we do best!

Summary

Would you like to know how much your facility could stand to save through PFC equipment? If so, Electrotek Ltd. can conduct a **Preliminary Evaluation** for you. This is a no charge / no obligation service. In order for us to execute the evaluation, we require your last 12 months power bills. Calculations can be done with fewer bills, if the last 12 are not available.

This evaluation will provide you with an estimated annual savings, along with an estimated equipment cost. We will also let you know whether a power factor study and harmonic analysis is required to finalize a design.

Electrotek Ltd. can provide you with all your PFC and harmonic filtering needs: preliminary evaluations, power factor studies and harmonics analyses, guaranteed designs, engineered products (designed to meet the requirements of your electrical distribution), and after sale support.

An Electrotek Ltd. solution. Your solution.

Lease-to-Own Program

- Use the savings your PFC equipment is generating to pay for your PFC equipment!
- Obtain your PFC equipment without affecting your cash flow!
- Program can be set up for supply only, or supply and install!

1016 34 AV SE Calgary, AB T2G 1V4 Canada
Tel: 403 287 2200 Toll free: 1 800 404 9114
Fax: 403 287 3808
contact@electrotekltd.com
www.electrotekltd.com

ELECTROTEKLTD