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TECHNICAL NEWS

Issue 24 February 1998

Please circulate to

Quarterly Technical Newsletter of Australia's leading supplier of low-voltage motor control and switchgear.

IN THIS ISSUE

Power Factor, What is it?

By Albert Massoud
Product Manager

NHP Electrical Engineering Products Pty Ltd

Where open electricity markets have been introduced, the supply of electrical energy becomes competitive between the supply utilities. Although private distribution companies are obligated to run a profitable and successful business, they are also committed to maintain the quality of supply at a high level. Competition in an open electricity market creates new opportunities for even better quality of supply of electricity.

One very important aspect of improving quality of supply is the control of power factor; low power factor means poor electrical efficiency. The lower the power factor, the higher the apparent power drawn from the distribution network. This means that the supply company must install larger generation capacity, larger size transmission lines and cables, transformers and other distribution system devices, which otherwise would not be necessary. This results in a much higher capital expenditures and operating costs for the Electricity Supply Company, which is then passed on to the consumer in the form of higher tariff rates.

This is the main reason behind why the Electricity Supply Companies in modern economies demand reduction of the reactive load in their networks via improvement of the power factor. In most cases, special reactive current tariffs penalise consumers for poor power factors.

European countries have a minimum power factor of 0.9, this is also the case in NSW. The Regulator General has approved a penalty tariff for the Victorian consumers starting on the 1st July, 1998.

Electrical Load Types

Loads on an electrical distribution system can be categorised as:

Resistive

Inductive

Capacitive

Under normal operating conditions certain electrical loads (e.g. transformers, induction motors, welding equipment, arc furnaces and fluorescent lighting) draw not only active power

(Continued from Page 1 Electrical Load Types)

(kW) from the supply, but also inductive reactive power (KVAr). All inductive loads require active power (KW) to actually perform the work, and reactive power (KVAr) to maintain the electromagnetic field.

This reactive power is necessary for the equipment to operate correctly but it could be interpreted as an undesirable burden on the supply.

The power factor of a load is defined as the ratio of active power to apparent power, i.e. KW : KVA and in mathematic terms is referred to as cosØ. The closer cosØ is to unity, the less reactive power is drawn from the supply.

Power Factor (cosØ) = Active Power (KW) / Apparent Power (KVA)

Factors that could degrade electricity supply quality

Harmonics

The presence of harmonics in the waveform of the network voltage can be attributed to various causes such as rectifiers, thyristors, saturated transformers, arc furnaces, etc.

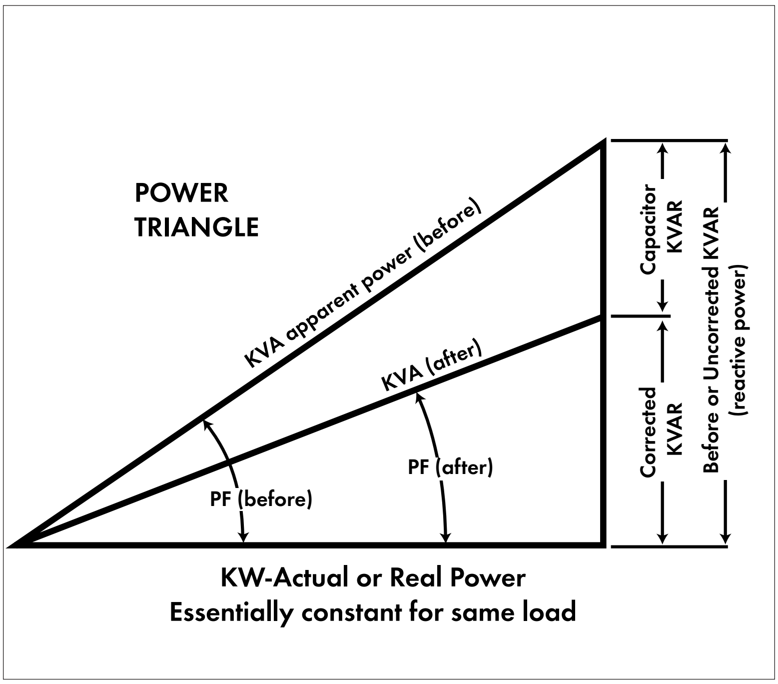
The main problems caused by harmonics are:

Interferences in tele-communications systems and equipment

Distortion of the Electricity Supply Voltage

Erratic operation of control and protection relays

Failures in transformers and motors due to overheating caused by core losses.



If the harmonic power is significant, i.e. greater than 5 or 10%, this may result in overvoltages and overloads and may lead to destruction of the capacitors, circuit breakers, contactors etc.

Resonance

Amplification of both voltage and current at the same time will occur if the resonant frequency is close or equal to one of the harmonic frequencies present in the distribution system.

The power feeder (overhead line or underground cable) have an inductive impedance. By putting a capacitor in parallel with the load (for power factor correction) it is possible to obtain resonance.

Cable losses

As the power factor of a three phase system decreases, the current rises. The heat dissipation in the system rises proportionately by a factor equivalent to the square of the current rise.

Solutions

Power Factor Correction Capacitors

A poor power factor can be improved by adding power factor correction capacitors to the plant's distribution system. Correction capacitors provide needed reactive power (KVAr) to the load. Therefore, the Electricity Supply Company is freed from having to supply it.

Power factor correction capacitors reduce the total current supplied by the Electricity Supply Company to the load and as a result the distribution system capacity is increased.

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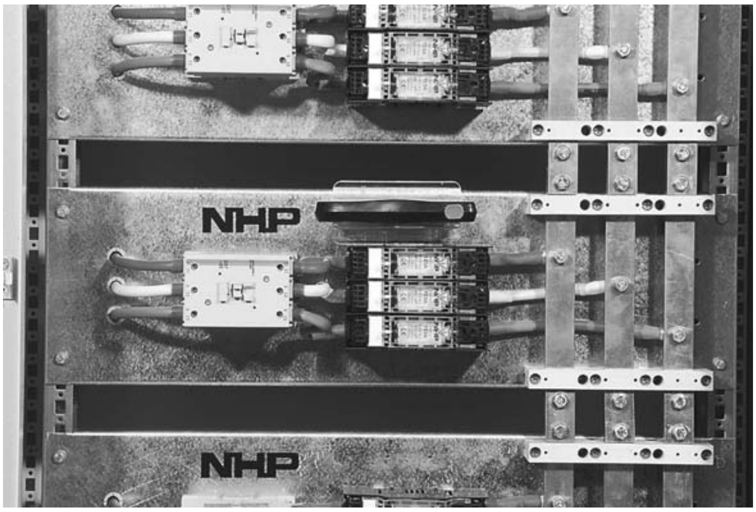


Modular design to suit customer requirements.

Capacitor Ratings

Power factor correction capacitors are rated in electrical units called 'vars'. One var is equivalent to one volt-ampere of reactive power. Vars then are units of measurement for indicating just how much reactive power the capacitor will supply.

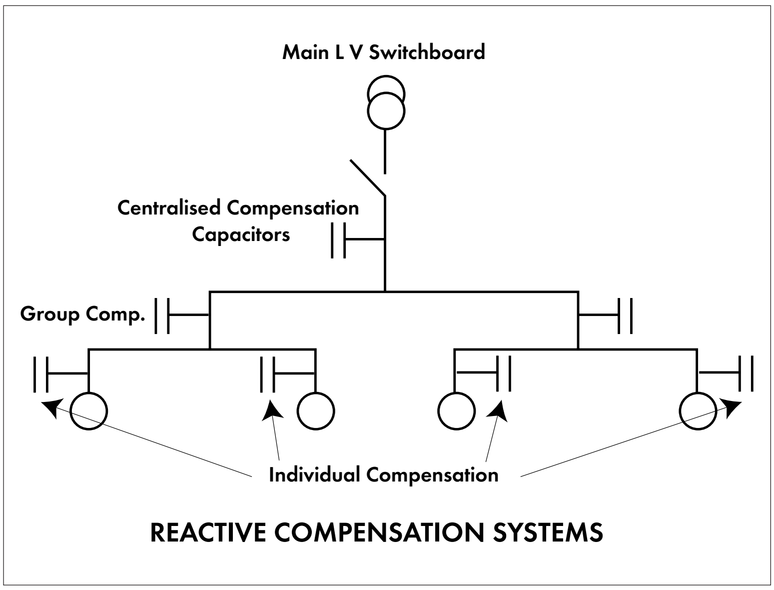
Filter Reactors

In most cases it is necessary to reduce the effects of the harmonic currents. One way of reducing harmonic currents is to install an inductance (filter reactor) in series with the capacitor.

The filter reactors protect the electrical installations and equipment but it does not eliminate the harmonics.

This reactor value should be calculated and designed in order to reduce the resonance frequency of the circuit to a value lower than that of the lowest harmonic in the system.

A capacitor equipped with a filter reactor is protected from harmonics regardless of the layout of the network to which it is connected. Except in some cases when switching in steps the inductance and capacitance values could add up to equal one of the harmonic frequencies in the system. This depends on the short circuit withstand capability of the system.



Power Loss Reduction

Distribution system losses are also reduced through power factor correction by reducing the total load current in the system.

Voltage Improvement

Power factor capacitors decrease distribution system voltage drops and fluctuations during the start of large inductive loads.

Where should the Power Factor Correction equipment be installed

After determining the required size capacitor in KVAr, the next step is to decide on the location for installation of the capacitor bank.

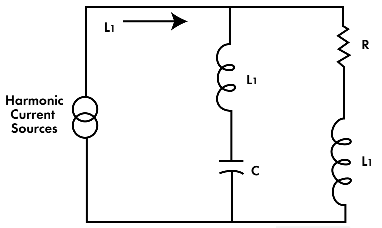
It is difficult to set definite guidelines for location of capacitor installation. However, the following general rule should be kept in mind:

As close as possible to the load to be compensated.

Reactive Compensation Systems

Centralised Compensation

Centralised compensation by means of an automatic capacitor bank with automatic regulation offers the most simple and economical solution.



RESONANCE

Tuning the capacitor bank to lower than the lowest harmonic, usually the 5th. This is done by introducing an inductor in series with the capacitor.

The reactive power is subdivided in a number of capacitor steps that can be connected independently. A reactive power controller continuously measures the needs of the installation and connects or disconnects the capacitors until the target power factor is achieved.

The advantage of this system is that the total capacitor power is smaller than the sum needed for individual compensation, that means less cost.

Group Compensation

Several inductive loads can be grouped together and equipped with a common capacitor.

This system usually applies for users that have their own installations with distribution transformers and high voltage power lines/cables.

The reactive power that is consumed by the transformers is compensated by the permanently connected capacitors to the secondary side of the transformers.

Individual Compensation

This type of compensation is applied to motors, transformers, and in general to loads with a high time of operation .

Capacitors are directly connected in parallel to the terminals of the loads.

This system minimises the reactive current circulating through the installation, enabling the use smaller switchgear and power lines or cables, which means a lower capital expenditure for new installations.

In the case of existing installations, utilising capacitors for power factor correction will increase the maximum apparent power that can be supplied to the installation.

Power Factor Correction Control Relay

When selecting a power factor correction relay the following main functions should be considered:

Measurement of the required reactive power and control the capacitor switching according to the power factor desired or pre-set value.

Indication of Power Factor, preset parameters and specified installation data.

Disconnect the capacitors when a system voltage drop occurs, this will prevent significant overvoltages in the installation and the subsequent damage to switchgear insulation.

Allow manual control.

Provision for a visual display of signal lamps for monitoring the number of capacitor steps switched into the system

Maintenance of capacitor banks

Maintenance of a capacitor bank is virtually NIL. It consists only of the following inspections:

- Clean terminals especially for dusty environments;
- Check fuses, protection and auxiliary devices;
- Power factor correction is an investment that helps to improve company's profit performance.

PFC Capacitor - 50 KVAr with terminal cover.

PFC Capacitor - 50 KVAr without terminal cover.

(Continued from page 4 Reactive Compensation Systems)

NSW and WA have existing penalty structures in place for customers that operate on a poor power factor. Victoria will impose such a penalty as from the 1st July, 1998.

Here is an example to illustrate the savings by installing power factor correction equipment.

Let us assume that the penalty is 37.57 cents per day per KVAr, for the KVAr necessary to improve the power factor above 0.8 lag.

1000 kWatt load at P.F. of 0.54 = 1558 KVAr

1000 kWatt load at P.F. of 0.80 = 750 KVAr

The extra KVAr drawn from supply = 1558 - 750 = 808 KVAr

808 x 37.57 cents = $ 303.56 penalty per day

Assume Automatic Power Factor Correction unit will cost installed about $ 60.00 per KVAr

Therefore 850 KVAr x $60.00 = $ 51,000.00

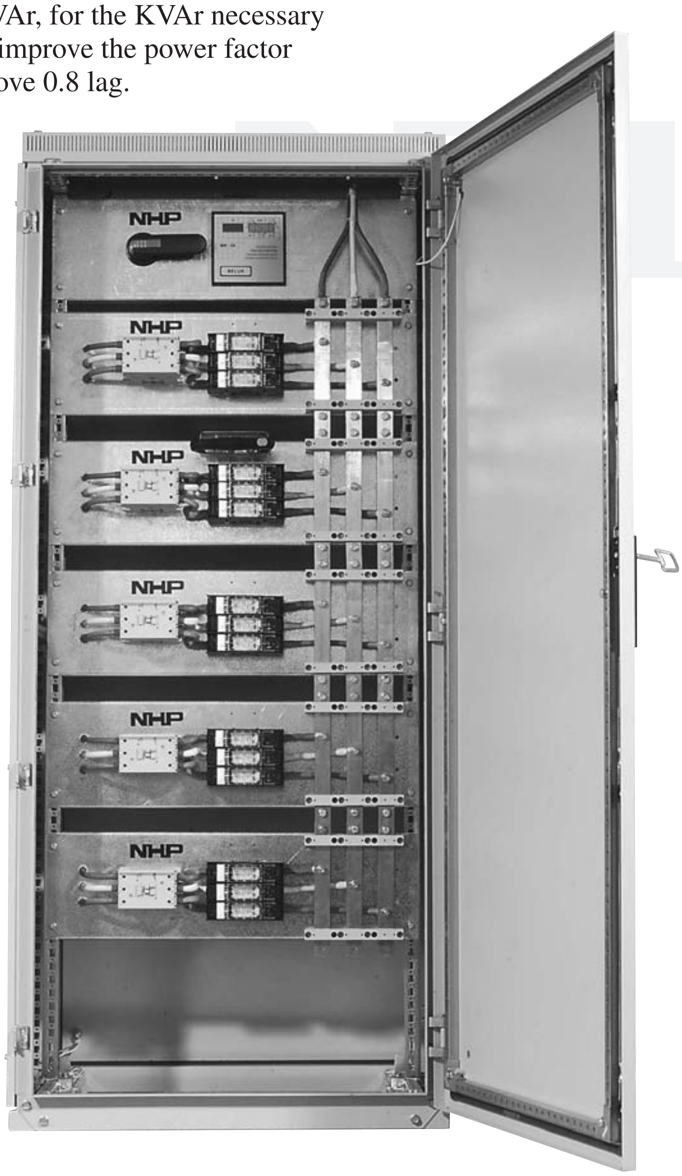
Payback period = $51,000.00 divided by $303.56 = 168 days about 6 months.

In about 6 months the cost for power factor correction is recovered and any further penalties are avoided for the life of the electrical installation.

Any further savings then become profits that add to company’s bottom line.

Note:
This example is for illustration purpose only. Actual savings can vary from installation to installation.

For further information on NHP's range of power factor products and your copy of our power factor catalogue, please fill in the reader response form at the back of this issue.



Reactive Compensation System fully assembled ready to connect.

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Editorial content: - Please address all enquiries to 'The Editor - 'NHP Technical News'
PO Box 199, Richmond Victoria 3121.

NHP Electrical Engineering Products Pty Ltd A.C.N. 004 304 812

Melbourne
43 - 67 River Street,
Richmond VIC. 3121
Phone: (03) 9429 2999
Fax: (03) 9429 1075

Sydney
30 - 34 Day Street North,
Silverwater N.S.W. 2128
Phone: (02) 9748 3444
Fax: (02) 9648 4353

Brisbane
25 Turbo Drive,
Coorparoo QLD. 4151
Phone: (07) 3891 6008
Fax: (07) 3891 6139

Adelaide
50 Croydon Road,
Keswick S.A. 5035
Phone: (08) 8297 9055
Fax: (08) 8371 0962

Perth
38 - 42 Railway Parade,
Bayswater W.A. 6053
Phone: (09) 271 8666
Fax: (09) 272 3906

Newcastle
575 Maitland Road,
Mayfield West N.S.W. 2304
Phone: (02) 4960 2220
Fax: (02) 4960 2203

Townsville
62 Leyland Street,
Garbutt QLD. 4814
Phone: (07) 4779 0700
Fax: (07) 4775 1457

Rockhampton
208 Denison Street,
Rockhampton QLD. 4700
Phone: (07) 4927 2277
Fax: (07) 4922 2947

Toowoomba
Cnr Carroll Street &
Struan Court,
Toowoomba QLD. 4350
Phone: (07) 4634 4799
Fax: (07) 4633 1796

Cairns
14/128 Lyons Street,
Bungalow QLD. 4870
Phone: (07) 4035 6888
Fax: (07) 4035 6999

Darwin
3 Steele Street,
Winnellie N.T. 0820
Phone: (08) 8947 2666
Fax: (08) 8947 2049

Agents

Hobart
H. M. Bamford (Hobart)
199 Harrington Street,
Hobart TAS. 7000
Phone: (03) 6234 9299
Fax: (03) 6231 1693

Launceston
H. M. Bamford (Launceston)
59 Garfield Street,
Launceston TAS. 7250
Phone: (03) 6344 8811
Fax: (03) 6344 4069

Burnie
H. M. Bamford (Burnie)
6 Wellington Street,
Burnie TAS. 7320
Phone: (03) 6432 2588
Fax: (03) 6432 2580

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