Application Notes

PQS

Dynamic Administration

Power Quality Solutions

Application Notes

The collection of “PQS Application Notes” is a library with in-depth information on PFC applications, case studies and reference projects. It also serves as a helpdesk for all topics relating to PFC and PQS, is suitable for training purposes and is designed to answer frequently asked questions.

Each issue will focus on a particular application topic, a specific solution or a topic of general interest. The aim is to share the extensive knowledge gained globally by EPCOS PFC experts with regional staff who deal with PFC and PQS. The authors of the PQS Application Notes have extensive experience in the field of PFC and PQS and a professional background as electrical/design engineers or product marketing managers throughout the world.

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Foreword

Conventional PFC-systems quickly reach their frontiers when they have to cope with fast changing loads. Especially administration buildings of today have a tremendous amount of electric consumers: elevators, lighting, chillers, office equipment put a heavy burden on the power supply by a number of switching operations that exceed the recommended value by far.

According to international standards IEC60831, capacitor contactors as used in conventional PFC-systems should not go beyond 5,000 switching operations per year – a value that is exceeded by far in huge administration buildings like the new “Murray House” in Hong Kong. To ensure a reliable power supply and increase the power quality, the facility management of the administration building in Hong Kong Central decided to invest into dynamic PFC.

This case study is a good example to show the improved values that are achieved by a tailor-made dynamic PFC-solution.

EPCOS offers all key components out of one source for dynamic PFC: different series of PFC-capacitors, PF-controllers, thyristor modules and harmonic filter reactors – all perfectly harmonized to each other.

The Author

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Dr. Goldstrass is part of the PFC product marketing team at EPCOS HQ/Munich. He is responsible for the definition of the global PFC product range and the product marketing for selected countries.

Professional experience in R&D, marketing and sales as well as his PhD in solid state physics help him to understand the requirements of both, basic development and final application to serve the needs of EPCOS’ customers in the optimal way.

Contents

Power Factor Correction

Dynamic Administration

The Central District of Hong Kong (known in Cantonese as Chung Wan) has been the center of the city's trade and financial activities from the earliest days. Nowadays, this area – with more than a million inhabitants – also serves as its administrative center with its many consulates and government buildings.

Fig. 1: Hong Kong – Skyline of the Central District

1. The location

One of the oldest government buildings in the Central District was **Murray House**. This Victorian edifice was dismantled in 1982 to make way for new buildings. It was then rebuilt and relocated to Stanley in 1998.

Instead of the original Murray House, a government administration building is now located at 22 Cotton Tree Drive, confusingly also known as Murray House!

Chillers, elevators, electronic office equipment – all these **different kinds of loads** with an exorbitantly high number of switching operations cause extreme stress to the power supply. Especially the chillers, which are a must during the Hong Kong summer, when temperatures reach more than 30 °C and humidity is high, may cause voltage sags and even blackouts. Although the new Murray House implemented PFC systems right from the beginning to **improve the power quality**, conventional technology very soon reached its limits.

2. Dynamic PFC

Whilst conventional systems for power factor correction (PFC) have found widespread use in standard applications operating under steady load conditions, they are not suited to fast fluctuating loads requiring reactions in real time. Industrial applications such as wind turbines, cranes, welding and pressing equipment and – as in the case of Murray House – elevators and chillers, demand very **fast switching**. Conventional PFC systems are switched by electromechanical capacitor contactors, making them far too slow for such processes. In a dynamic PFC system, the contactors are replaced by electronic **thyristor switches** that can switch within a few milliseconds and do not expose the capacitor to high inrush currents. This admits an almost infinite number of switchings per capacitor lifetime.

Fig. 2: Central District by night

3. Initial situation

To solve this power supply problem, the **Babel company** of Hong Kong was commissioned to perform measurements of the existing PFC system/situation, which comprised:

- **Two automatic PFC systems** of 210 kvar each
- A conventional system with reactors
- Two transformers, each on a large chiller (conventional induction motor, i.e. a linear load producing no major harmonics)
- Elevators with conventional induction motors

- A large number of **single-phase loads** with switched mode power supplies and other electronics, i.e. nonlinear loads producing typical harmonic distortions, especially of 3rd and 5th order
- **Load conditions:**
  - Full load conditions could not be tested in the winter season
  - One of the two chillers was out of operation due to servicing
- Measurements and harmonic analysis were carried out during main office hours from 9.30 a.m. to 4.00 p.m.

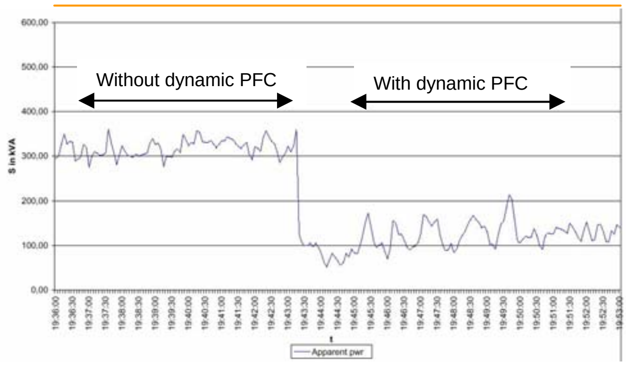

Fig. 3: Example: Time graph of power factor without and with dynamic PFC

4. Measurements and harmonic analysis transformer TX1

Measuring devices (harmonic analyzer and digital multimeter) showed the following **values** for the existing systems:

Without dynamic PFC

THD-V
(total harmonic voltage distortion) **2.2%**

THD-A
(total harmonic current distortion) **12%**

Actual power factor (average value during time of measurement) **0.85**

Actual apparent current (average value during time of measurement) **1,350 A**

Voltage: **374 V**

Putting into operation of individual stages:

Stages 1 and 2	**each 25 kvar**
Measured current:	**34 A**
Stages 3, 4, 5 and 6	**each 50 kvar**
Measured current:	**68 A**

Power Factor Controller Settings:

Delay time:	**1 second**
Target PF:	**0.98**
C/K value:	**0.05**

5. Measurements and harmonic analysis transformer TX2

Without dynamic PFC

THD-V
(total harmonic voltage distortion) **2.2%**

THD-A (total harmonic current distortion) **14%**

Actual power factor (average value during time of measurement) **0.83**

Actual apparent current (average value during time of measurement) **1,400 A**

Voltage: **376 V**

Putting into operation of individual stages:

Stages 1 and 2	**each 25 kvar**
Measured current:	**34 A**
Stages 3, 4, 5 and 6	**each 50 kvar**
Measured current:	**68 A**

Power Factor Controller Settings:

Delay time:	**640 milliseconds**
Target PF:	**0.98**
C/K value:	**0.05**

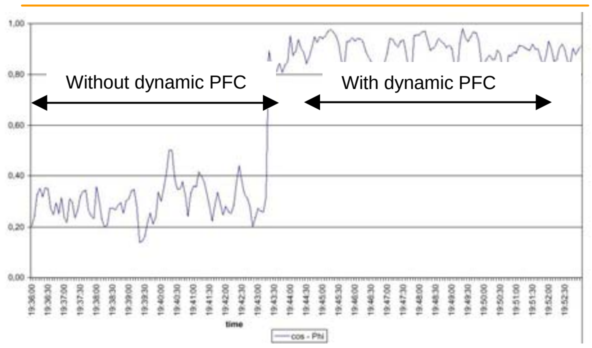

Fig. 4: Example: Time graph of apparent power without and with dynamic PFC

6. Customized design

Together with the facility management, Almen Ng and Carl Wong from the Babel company **defined the targets** for two dynamic PFC systems. In addition to stabilizing the power supply, the aim was also to improve the power factor in order to reduce:

- Consumption of reactive power
- Harmonic voltage distortion
- Harmonic current distortion

With these targets in mind, Babel designed and installed a customized solution for the new Murray House:

- 2 PFC systems each of 250 kvar
- Detuned, factor 7%, freq. 189 Hz

Key components:

- PFC capacitors PhaseCap
- Thyristor modules of the TSM series
- PFC controller of the BR6000 series
- Harmonic filter reactors

Fig. 5: Power Quality Solutions: Key components for dynamic PFC

7. Results

<u>Measurement and harmonic analysis with a new dynamic PFC system in operation on transformer TX1</u>

THD-V (total harmonic voltage distortion)	**1.5%**
THD-A (total harmonic current distortion)	**7%**
Actual power factor (average value during time of measurement)	**0.95**
Actual apparent current (average value during time of measurement)	**1,100 A**
Voltage:	**380 V**

<u>Final test result on transformer TX1</u>

The initial targets were met:

- The power factor improved from 0.85 to 0.95
- Harmonic voltage distortion was reduced by 32%
- Harmonic current distortion was reduced by 42%
- The apparent current was reduced by 250 A, which is equivalent to 18.5%

<u>Measurement and harmonic analysis with a new dynamic PFC system in operation on transformer TX2</u>

THD-V (total harmonic voltage distortion)	**1.6%**
THD-A (total harmonic current distortion)	**10%**
Actual power factor (average value during time of measurement)	**0.92**
Actual apparent current (average value during time of measurement)	**1,150 A**
Voltage:	**379 V**

<u>Final test result transformer TX2</u>

The initial targets were met:

- The power factor was improved from 0.83 to 0.92
  Harmonic voltage distortion was reduced by 28%
  Harmonic current distortion was reduced by 29%
- The apparent current was reduced by 250 A, which is equivalent to 18%

8. Conclusions

Although the initial targets of the facility management were fully realized, there is still room for improvement in the new Murray House: the measurements, installation and testing were performed during the winter when the chillers naturally do not operate at full power. Because the loads increase in summer, the two dynamic PFC systems were designed to allow simple extension according to actual needs. To maintain the improved power factors of 0.95 at transformer TX1 and 0.92 at transformer TX2, an extension of 100 – 250 kvar for both systems was recommended by Babel.

All key components for Power Quality Solutions from EPCOS are carefully harmonized with respect to each other. This allows simple and reliable upgrading of the dynamic PFC systems in Hong Kong's administration building.

9. Standards

The recommendations and proposals stated in this Application Note are based (amongst others) on several international standards for PFC capacitors, LV switchgear design and electrical systems:

- IEC60831: LV-PFC Capacitor Standard
- IEC61921: Power Capacitors LV PFC banks
- DIN EN61921: Leistungskondensatoren Kondensatorbatterien zur Korrektur des Niederspannungsleistungsfaktors
- EN 50160: Voltage Characteristics of Electricity Supplied by Public Distribution Systems
- Engineering Recommendation G5/4: Planning levels for harmonic voltage distortion and the connection of non-linear equipment to transmission systems and distribution networks in the United Kingdom
- IEEE Standard 519-1992: IEEE Recommended practices and requirements for harmonic control in electrical power systems
- IEC60439-1/2/3: Low-voltage switchgear and control gear assemblies

The specifications in the standards and manufacturers' data sheets should always be observed.

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