Application Note

PQS

Dynamic PFC: Power Quality at the Docks (China State Shipbuilding Corporation)

Power Quality Solutions

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Foreword

Conventional PFC systems – consisting of capacitors, controllers and electromechanical capacitor contactors – are suitable and sufficient for industrial applications with slow changing loads. By contrast, power networks with fast-changing loads such as those present where welding equipment is used, require “real-time reaction” in order to make PFC effective and powerful. This is a task that can be accomplished with dynamic PFC.

The China State Shipbuilding Corporation (CSSC) aims to become the world´s largest shipbuilder by 2015. One step toward achieve this target is the implementation of dynamic PFC in their shipbuilding base on the sourthern shore of Changxing Island. The first systems have already been implemented – making the CSSC a dynamic PFC pioneer in China.

The Author
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EPCOS Senior Sales Manager with 10 years of sales and marketing experience in electronics field. Responsible for the PFC/PEC business development in Greater China region, located in Shanghai.

Content

Power Factor Correction

Dynamic PFC: Power Quality at the Docks

China's largest shipyard relies on EPCOS products for dynamic power factor correction. They allow energy quality and costs to be significantly improved.

1. The company

The **China State Shipbuilding Corporation** (CSSC) plans to become the world's largest shipbuilder by the year 2015. To achieve this lofty aim, its shipbuilding capacity will rise from the current figure of 4 million gross tons (GT) to 14 million GT by 2015. Its range of high-tech products will be extended to include vessels, not least luxury liners, powered by liquefied gas. Offshore installations for research, conveying and development operations will consequently also be built.

The CSSC was founded on July 1, 1999 as a state-authorized investment company under the direct control of the Chinese central government. A total of 60 major and associated companies are united under the umbrella of the CSSC, among them large shipbuilding and ship repair yards, research and development institutes, manufacturers of equipment for the maritime sector as well as trade companies in China.

The **CSSC Changxing Shipbuilding Base is located on the southern shore of the island of Changxing** in the immediate vicinity of Shanghai, where the Yangtse flows into the sea.

This is an ideal location for the shipbuilding industry with its eight kilometers of coast and water depths of between 12 and 16 meters. Seven docks with a capacity of 8 million GT are scheduled for completion by 2015. The total investment volume will be over a billion euros. At the present extension stage, the maximum capacity is 3 million GT.

2. The problem of nonlinear loads

Like all shipyards, CSSC also faces the problem of **nonlinear loads caused by the use of welding equipment**. Its large transformers and clocked power supplies produce enormous inductive reactive powers. This problem is aggravated by the fact that the welding equipment is always being switched on and off. As a result, the supply network is continuously stressed by alternating power factors, transients and harmonics.

Reactive power is a particularly undesirable phenomenon in power networks because it stresses generators, power lines and transformers, thus causing additional losses. It is usual practice to use capacitors for power factor correction (PFC) to compensate the phase shift between voltage and current. PFC capacitors improve not only the power factor but also the overall quality of the available power supply. So a reduction of the harmonic component, for instance, also stabilizes the voltage and thus reduces electrical losses.

Conventional PFC systems consist of a power factor controller and PFC capacitors which are connected to the power line via mechanical capacitor contactors. The reaction time between the individual switching operations is more than 60 seconds due to the discharge time of the capacitors – a process that in turn impacts the response time of the entire system. Part 1 of the IEC60831 standard for low-voltage PFC capacitors stipulates that they should not exceed 5000 switching operations annually. Conventional PFC systems are thus designed for slowly changing load conditions where only few switching operations take place per day. Typical examples are large machine tools or drives with high duty ratios.

3. Rapid reaction thanks to dynamic PFC

Loads that are continuously switched on and off, such as welding equipment, are in particular need of dynamic PFC in "real time." Such systems use electronic switches instead of electromechanical ones. The thyristor modules allow an unlimited number of switching operations, but also assure a short reaction time to load changes. Extremely short reaction times of 5 ms can be achieved, depending on their design. The use of thyristor switches prevents high inrush currents because the thyristors switch at the zero crossing (Fig. 1). No inrush currents are produced, thus avoiding destructive power-line reactions and solving one of the greatest problems occurring in the conventional switching of capacitors.

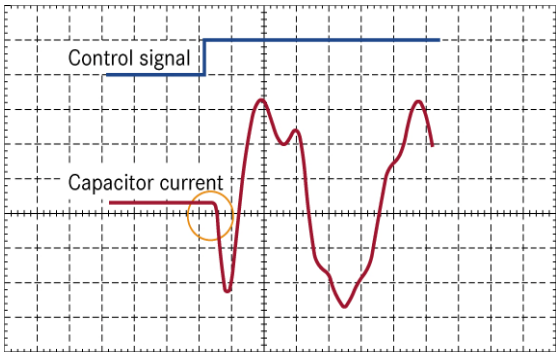

Fig. 1: Oscilloscope image of dynamic switching

No inrush current surges occur, so there is not impairment of the quality of the supply voltage such as voltage fluctuation and transients.

4. Characteristics of Dynamic PFC

Dynamic PFC is characterized by the following benefits:

- The **reactive power** drawn from the line is **eliminated**. Power costs are reduced even with rapidly fluctuating loads. Load cycles of only a few hundred milliseconds may be achieved.
- High load cycles allow **fast switching** without the delays caused by discharging.
- **Significant cost savings** can be made: Investments in new equipment are avoided because peak loads are reduced.
- **Flickering** is avoided.
- The **line voltage** is stabilized. This leads to qualitative improvement of the welding process, for instance, while simultaneously accelerating it.
- Avoiding powerline reactions: **smooth switching** ensures that no voltage or current transients occur.
- Contactless switching both at the switching element and the capacitors **prolongs operating life.**
- Improved **reliability**.
- The **reaction time** is very short at 5-40 ms.

5. Reference Installation

For the first stage of expansion of the CSSC shipyard, EPCOS will supply PFC systems with a total (dynamic) PFC output of 6920 kvar (Fig. 2). All systems are designed for 400 V at 50 Hz and are 7 percent detuned in order to avoid resonance phenomena due to harmonics and minimize the degree of distortion (THD-V). Donald Tang, Marketing Manager Power Capacitors in Shanghai, is proud to have implemented this project in the challenging Chinese market. "Our solution for CSSC's complex power grid clearly demonstrates the benefits of dynamic PFC in all manufacturing industries," said Tang. "This is an important step toward power quality solutions."

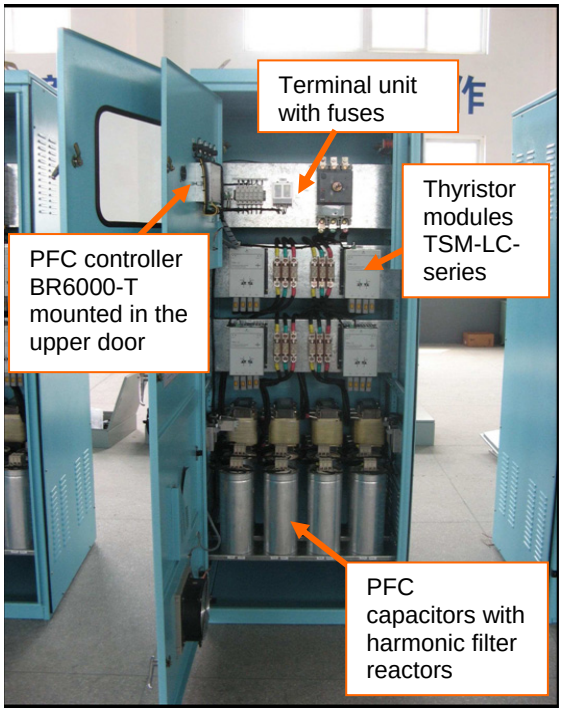

Fig. 2: Dynamic PFC installation for CSSC

- 50 kvar: 5 Systems
- 100 kvar: 14 Systems
- 150 kvar: 1 System
- 200 kvar: 20 Systems
- 250 kvar: 2 Systems
- 300 kvar: 1 System
- 320 kvar: 1 System

6. Conclusions

With the first dynamic PFC project in China, CSSC hast taken an important step toward improving power quality, stabilizing the power supply, cutting costs and – extremely important nowadays – saving natural resources.

Benefits of dynamic PFC

- Elimination of reactive power for slow and fast fluctuating loads.
- Investment reduction due to cutting-off of peak loads (distribution equipment, cable cross section, etc).
- Power Quality: avoiding of transients and voltage drops.
- Fast switching without delay time for discharging (< 20 ms), thus enabling high duty cycles.
- Stabilizing of grid voltage (avoiding of voltage drops), therefore improvement of production processes in terms of quality and time.
- Increase of life time and long term performance the PFC-system.

Power Quality Solutions by EPCOS
Key components for dynamic PFC:

- PFC capacitors
- PFC controller BR6000T
- Thyristor modules
  - TSM-LC10
  - TSM-LC25
  - TSM-LC50
  - TSM-LC200
  - TSM-HV50
- Discharge reactors
- Harmonic filter reactors

Thyristor modules of the TSM series:
Product range

7. Standards

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

- 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 Std. 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´ datasheets should be adhered to in any case.

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