

Power Factor Correction

Getting concrete: medium-voltage PFC successfully replaced by low-voltage PFC at Siam Industrial Wire Co., Thailand

Siam Industrial Wire is a member of NatSteel Holdings and a wholly owned subsidiary of the Tata Steel group. With annual production of 180,000 metric tons, SIW is one of ASEAN's largest manufacturers of pre-stressed concrete products. Its portfolio includes pre-stressed concrete stands, pre-stressed concrete wire, cold-drawn wire, hard-drawn wire and welded wire meshes, and it distributes these quality products throughout Europe, Oceania, the Middle East, America, Africa and Asia.



SIW for a better environment: Planting trees at Nong Plalai reservoir.

But SIW not only works with concrete – it also gets concrete! The company's vision is to fight against global warming. By running projects such as planting trees at Nong Plalai reservoir and dispensing with foam boxes and plastic bags, SIW has taken serious steps to save and protect the environment. And it has also decided to invest in power factor correction to significantly reduce the power consumption at its plants.

The idea to use PFC systems at SIW was not new. The company already had tuned capacitor banks – but two of them were damaged and did not operate as desired. The consequence was high electrical losses, kvar charges, energy costs and voltage variations.

In order to test the existing systems and application conditions, experts in power factor correction and power quality solutions were called in from the Thai company ITM. As the ordering party, SIW had very clear ideas about the targets to be achieved. Grid measurements already performed with the existing PFC systems showed a poor power factor and a high level of kVAr charges and TDI/TDH. So the message to ITM was clear:

Power Quality Improvement Targets

1. Improve the power factor from 0.7 to 0.96
2. Reduce losses by at least 40 kW.
3. Reduce losses and CO₂ emissions as a contribution to climate protection.
4. Stabilize the network voltage to avoid voltage sags.
5. Prolong the operating life of transformers, motors and other electrical equipment.
6. Reduce harmonics to further decrease power losses.
7. Increase motor torque.

In addition to these targets, the monthly energy costs called for a drastic reduction of energy consumption.

- Demand charge €12,750 per month
- Peak energy €54,750 per month
- Off-peak energy €87,250 per month
- Ft¹ charge €88,250 per month
- Kvar charge €1,025 per month

So an additional target set by Mr. Thumrongdej, ITM, and his staff was to reduce the current kvar charge of €12,300 per year.

As a first approach to a customized solution, ITM evaluated the existing PFC system:

SIW LOAD SUMMARY MAR 2008 VS AUG 2009

TR No.	TR Ratings KVA	KW	KVA	KVAR	PF	THDv	THDi	KW	KVA	KVAR	PF	THDv	THDi
Measured in March 2008													
Measured in Aug 2009													
SUB1													
11	3000	674	1,131	908	0.596	5.70%	24.00%	890	1290	890	0.69	4.13	19.32
12	3000	680	1,035	780	0.657	3.90%	21.20%	564	855	642	0.66	3.39	20.52
13	3500	1,049	1,351	851	0.777	10.30%	24.00%	1030	1260	670	0.81	4.91	23.38
14	1600	483	661	452	0.73	3.70%	20.00%	355	440	225	0.81	3.64	26.84
15	1600	569	734	463	0.776	5.80%	18.60%	505	640	365	0.79	5.96	21.2
16	3000	973	1,149	611	0.847	0.60%	1.40%	950	1090	530	0.87	0.85	1.16
17	3000	1,203	1,504	903	0.8			384	422	163	0.91	1.19	12.78
SUB2													
21	3000	313	470	350	0.667	1.70%	13.30%	450	730	470	0.62	1.49	6.45
22	3000	713	827	420	0.862	3.00%	12.60%	790	830	180	0.95	4.01	23.37
23	3000	241	617	568	0.391	2.80%	16.90%	230	440	370	0.53	1.44	9.88
24	3000	1,961	2,499	1550	0.785	3.90%	14.20%	540	620	280	0.87	2.65	15.6
25	1600	204	328	257	0.622	4.80%	42.60%	130	350	300	0.37	3.9	34.22
26	1600	30	149	146	0.202	1.50%	64.70%	159	220	139	0.73	1.41	1.5
28	1600	805	1,006	604	0.8			387	563	374	0.69	11.59	27.59

Table 1: Load summar

- 1 unit of 50 MVA, 115 11-kV transformers.
- 1 unit of 3.5 MVA, 8 units of 3.0 MVA and 5 units of 1.6 MVA, 11 0.4-kV transformers.
- 2 sets of 11-kV tuned capacitor banks.
- No 11-kV motors in the 11-kV systems.

The easiest solution would obviously have been to renovate the defective MV capacitor panels. But the easy way is not always the best. Mr. Thumrongdej pointed out the disadvantages of a tuned MV PFC system:

1. Harmonics outside the plant may overload the tuned capacitor banks.
2. Load variations may overload the tuned capacitors.
3. High maintenance costs.
4. No loss reduction at the 400 V systems, transformers, cables, busbars, etc.

Mr. Thumrongdej outlined a more effective alternative approach:

Installation of new detuned PFC systems:

- Detuned capacitor banks help protect capacitors.
- With regard to the fast-changing loads present at SIW, a dynamic solution is recommended where thyristor modules allow ultra-fast switching almost in real time.
- Low maintenance costs.
- Loss reduction at the 400 V systems, transformers, cables, busbars, etc.

Based on this recommendation, ITM offered the following specifications:

- 400 V: detuned conventional LV-PFC systems for slowly changing loads.
 - 900 kvar, 7 % detuned system for TR11, TR17.
 - 800 kvar, 7 % detuned system for TR12, TR13.
 - 400 kvar, 7 % detuned system for TR14, TR15, TR22.
 - 600 kvar, 7 % detuned system for TR16, TR23.
 - 500 kvar, 7 % detuned system for TR21.
 - 1,500 kvar, 7 % detuned system for TR24.
 - 300 kvar, 7 % detuned system for TR25.
- 550 V: detuned conventional LV-PFC systems for slowly changing load.
 - 600 kvar, 7 % detuned capacitor bank for TR28.
- 400 V: dynamic detuned LV-PFC systems for fast-changing loads.
 - 300 kvar, 7 % dynamic detuned PFC systems for TR26.

As a result, a total of 14 PFC systems will reach an output of 9,000 kvar.

SIW took the long route. In September 2009, ITM received the order to install the new detuned systems, a combination of conventional and dynamic units. In view of the high investment, the contract imposed the following guarantee conditions on ITM:

1. A power factor > 0.85 at the 115 kV point of coupling.
2. Saving of 40 KW losses.
3. Installation to be completed by December 2009.

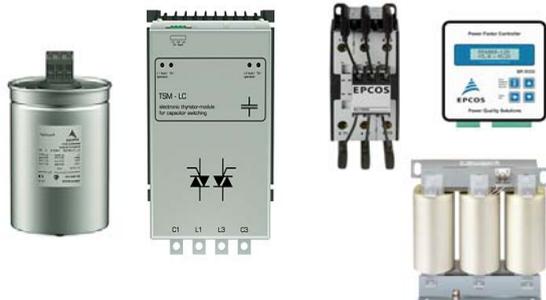
“Giving such a guarantee of course always involves a certain risk... no risk, no fun!”, says Mr. Thumrongdej Mungcharoen. “But to be serious: first of all we trust in our own skills and long technical experience. And on the other hand, we rely on the high quality standards of the key components that we receive from our business partner EPCOS”.



Thumrongdej Mungcharoen,
General Manager of ITM,
Thailand, an EPCOS-PQS
partner.

ITM ordered all parts for the 14 panels at EPCOS:

- PFC capacitors of the PhaseCap Premium series.
- Heavy duty capacitor contactors for switching conventional PFC systems.
- TSM thyristor modules for switching dynamic PFC systems.
- PF controller of the BR6000 series.



The various components were assembled into panels by ITM.



1,500 kvar, 400 V, 7% Detuned PFC-system for TR 24

300 kvar, 400 V, 7 % Dynamic detuned PFC-systems for TR 26



Needless to say, ITM met all the requirements set by SIW:

- The complete capacitor panels were delivered, erected and installed for commissioning in December 2009.
- The power factor at the 115 kV point of coupling was enhanced to 0.9.
- Savings of 40 KW losses can be achieved, as is already obvious after 6 months of operation.
- A lower current flows in the networks.
- Lower power losses in the networks.
- Savings in electrical energy (kWh, kvar charges, demand charges and Ft charges).
- The grid voltage has been stabilized.
- The customized solution extends the operating life of the transformers, motors and other electrical equipment.
- Reduction of harmonics and additional lower power losses.
- Increased motor torque.
- Fewer failures of electronic components, lower maintenance and downtime costs.

This project has clearly shown that it is possible to replace MV PFC systems by LV capacitor PFC systems. In the past, especially in the steel industry, MV PFC systems were mainly used because a PFC solution was not feasible for the fast-changing loads on the LV side. This is no longer a problem thanks to the TSM thyristor switches and the range of intelligent BR6000 controllers. Beside our BR6000 controllers for either contactor or thyristor switching, EPCOS also offers the BR6000-T6R6 hybrid controller: it has six transistor outputs for direct triggering of TSM thyristor modules for dynamic compensation and six relay outputs for direct triggering of contactors for conventional compensation.

As capacitors reduce the reactive power flow from the source, the ideal location is as near to the reactive load as possible – to ensure the greatest effect as regards reactive power compensation and reduction of network losses. It was consequently decided to install the new system on the low-voltage (LV) side in this project.

Some advantages of a power factor correction system on the LV side compared to MV are:

- The reactive power will already be reduced on the LV side: cables, transformers, etc. are subject to lower loads.
- The MV/LV transformer will be less loaded with reactive power, releasing additional capacity on the LV side.
- LV PFC is easier to maintain and as the LV creeping distances are lower, more compact PFC systems could be installed in the event of space constraints.
- LV components are usually more competitive and more easily available than MV components.
- Decreased voltage drops along the distribution lines.
- Increased equipment lifetimes of cables and transformers thanks to reduced temperatures resulting from lower loading.



Compared to other measures for reducing CO₂ emissions (such as renewable energy, use of frequency converters, ...), PFC is clearly one of the easiest and most effective ways of reducing energy consumption and improving energy efficiency.

The positive impact of reduced CO₂ emissions at SIW in Thailand is not apparent in the short term. The trees that the SIW staff have planted will not have an immediate impact on the environment either. But these efforts and investments will certainly pay off in future!

Standards

The recommendations and proposals stated in this Application Note are based (amongst others) on the following 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.

Published by:

EPCOS AG

Product Marketing PFC

P.O. Box 80 17 09

D-81617 Munich/Germany

ⁱ Ft = Thailand's automatic adjustment mechanism