

Application Note

PQS



PoleCap: Power Factor Correction on Site

P o w e r Q u a l i t y S o l u t i o n s

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PoleCap: Power Factor Correction on Site

Exposing a standard PFC capacitor to the influence of direct sunlight, weathering and rain means an enormous stress to the device. This is why outdoor PFC applications have been a very sensitive and difficult topic.

With the development of the PoleCap series, EPCOS has introduced a PFC-capacitor for outdoor usage. It is designed for direct mounting on the masts of overhead power lines in rural areas or regions with commercial or industrial activities. The PoleCap series enable power distribution companies to stabilize the power supply, while simultaneously reducing power consumption and voltage drops.

Also, PoleCap capacitors are suitable for applications under adverse conditions, for example in sawmills or cement works where one will find high dust or moisture concentrations, or in places where the ambient temperature is very high.

This Application Note gives some technical information on the PoleCap. Also, it contains an in-depth case study for the first outdoor application in India with approximately 14,000 PoleCap units installed on poles.



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Power Factor Correction

PoleCap: Power Factor Correction on Site

Recent years have repeatedly seen spectacular power outages that paralyzed major cities and even entire regions. Grid overload can be prevented by using power factor correction (PFC) equipment in the immediate vicinity of loads. Power quality improves at the same time. PoleCaps are the right tool for this purpose.

The number of great blackouts is increasing all over the world, leaving large areas without electricity for hours or even for days – effecting millions of people and causing billions of dollars of damage.

Such incidents with serious consequences lead to ever louder demands on power companies: consumers insist on stable grids with a reliable supply of energy and high power quality. For this purpose, power capacitors have been used for many years for power factor correction in industrial power distribution, in UPS systems, in wind parks and drive systems. PFC equipment of appropriate design reduces the share of reactive current in the entire grid, simultaneously reducing power consumption and voltage drops, and stabilizing the power supply. Lower energy costs are a further benefit.

1. Capacitors for outdoor use

To obtain the same effect in rural areas with mainly domestic or agricultural loads or in regions with little commercial or industrial activity, considerable capital expenditure would be needed to expand the distribution network. An alternative is to install PFC capacitors close to the source of reactive current – in this case by mounting them right on the masts of the overhead power lines.

2. Requirements for outdoor capacitors

Because of their **exposed position**, power capacitors used for this purpose must satisfy several requirements.

Several **properties** are mandatory for the design of capacitors for outdoor usage. They must be

- watertight
- dustproof
- impact-resistant
- resistant to weathering and UV light
- of high dielectric strength
- resistant to high temperatures caused by sunlight
- capable of remote operational monitoring.

With the PFC-capacitors series PoleCap EPCOS satisfies these requirements. Based on proven metalized plastic film technology, PoleCaps are a logical development of the PhiCap and PhaseCap® series.

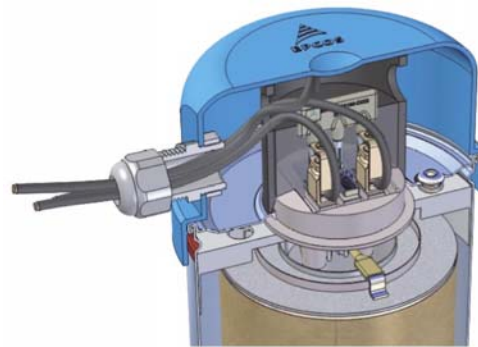


Fig. 1: Cross section of a PoleCap

3. Suitable for adverse conditions

However, it would be wrong to use the PoleCap outdoors only. Thanks to their high **impermeability**, they are also suitable wherever high levels of dust or moisture can impair operation of conventional capacitors – such as in cement works and sawmills. Here PoleCap capacitors can be used either inside or outside a switch cabinet. Further advantages are their **compact design and low weight**.

The PoleCap can be directly mounted outdoors on a power mast. They are supplied with connecting cables already fitted, leading to considerable **savings in time** and thus cost. In addition, the M12 threaded stud permits fast and **simple mounting**.

4. Safety features

The PoleCap series also offers a host of safety features.

- All live parts are protected; cable
- connections are protected against **shock hazards** to IP 54
- Integrated **overpressure disconnect**
- **Self-healing** design
- **Dry technology** thanks to gas impregnation
- Pre-mounted **discharge module** on ceramic basis

5. Visible fault control

Capacitors mounted on masts must permit operational monitoring from the ground.

The PoleCap series are equipped with a red strip that becomes visible as soon as the overpressure disconnecter has triggered in response to a malfunction.

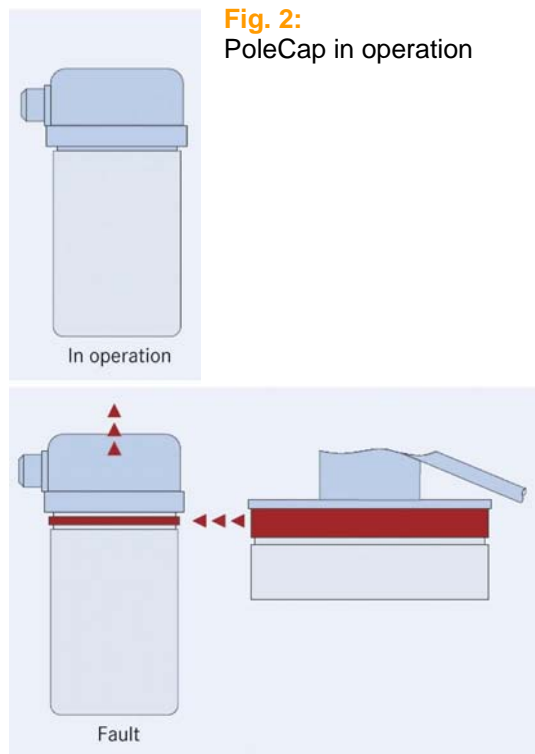


Fig. 3: Red strip visible after triggering of overpressure disconnecter

6. Superior thermal response

What makes PoleCaps unique is their thermal response. The conventional solution for capacitors designed for outdoor use or mast mounting is to fit an additional protective casing. Capacitor losses lead to **self-heating** that heats up the space between inner can and outer casing. This accumulated heat then surrounds the capacitor, which is heated up already, like an electric blanket. Insufficient cooling then makes premature aging of the capacitor inevitable.

The PoleCap, on the other hand, is designed to prevent this extra heat reservoir from forming. Tests have shown that PoleCaps with their **single-can design** operate at a significantly lower temperature than conventional capacitors with additional steel casings. The PoleCap uses convection alone for inner cooling. This property gives it a longer operating life and higher reliability.

In order to accurately compare the thermal behavior of two capacitors with and without additional protective casings, **tests were carried out in Malaysia** under extremely harsh climatic conditions. A voltage of 440 V was applied to both capacitors, which were exposed to direct sunlight. Evaluation of the temperatures measured with thermistors shows that the can and core temperatures of the capacitor with the extra casing are significantly higher than for the PoleCap.

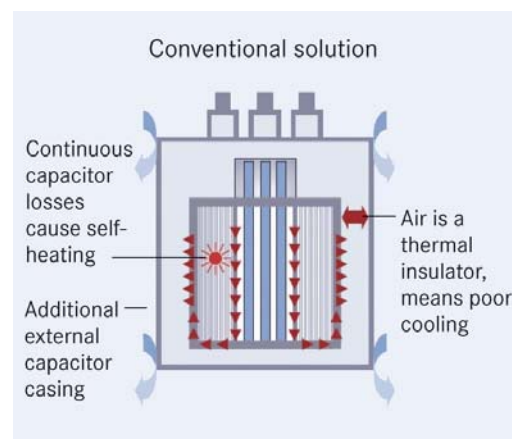


Fig. 4: Conventional PFC capacitor with external casing

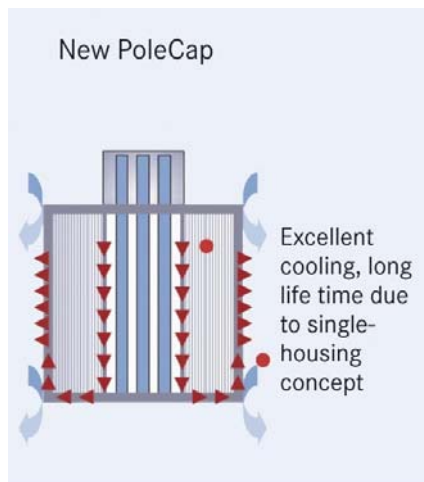


Fig. 5: New PoleCap design with excellent cooling features

The PoleCap without extra casing attains a **hot-spot temperature** 7°C lower than in conventional solutions. This is a significant advantage, as experience shows that a temperature reduction of this size roughly doubles the operating life of the capacitor.

7. Case Study

The **city of Jaipur** in Rajasthan, India, was one of the pioneers for PFC on site with the objective targets

- Reduction of kvar consumption
- Reduction of line losses
- Improvement and stabilization of power quality

Apart from these objectives, the utility board of Jaipur Vidyut Vitran Nigam Ltd. has required some features for the design of the PFC capacitor:

- Protection degree IP 54
- Protection against influence of water, sun and dust
- High degree of temperature resistance
- Fault identification from the ground

Company Jaipur Vidyut Vitran Nigam Ltd. has received the official order to evaluate a tailor-made solution to fulfill all requirements. The necessary evaluation was performed together with PFC-specialists from EPCOS India.

8. Jaipur power grid

Jaipur city has an installed **capacity of 4600 transformers** of 11 KV / 0.433 KV of various ratings:

- 25 kVA
- 40 kVA
- 63 kVA
- 100 kVA
- 250 kVA
- 315 kVA
- 500 kVA

These transformers are dedicated to feed the distribution network.

Total capacity of installed transformers is approx. 1000 MVA. An **analysis** was performed and showed an average **power factor** of LT lines of 0.85 (Fig. 6).

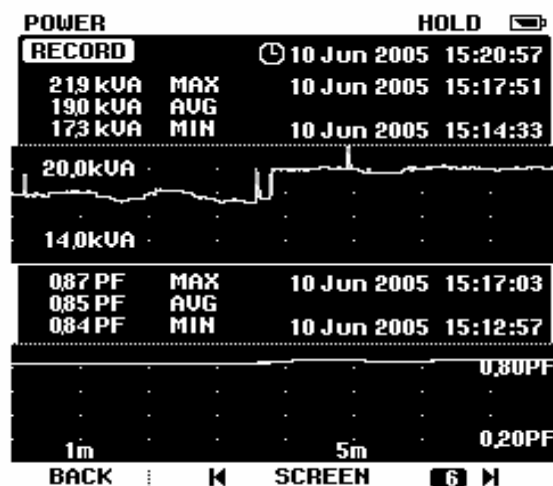


Fig. 6: Analysis of average power factor

Average loading on each transformer is 50 %.

Summer Season Demand: 430 MW (506 MVA)

Winter season demand: 300 MW (353 MVA)

Total losses of Jaipur City: 17%

9. Methodology adopted for selection of kvar

Minimum loading on transformers
(average 20% of kVA rating)

Power Factor: 0.85

Capacitor selected:
for 100 kVA transformer:
 $20 \times 0.85 \times \text{M.F.}^*)$
 $= 20 \times 0.85 \times 0.619 = 10.5 \text{ kvar}$

So **selection of capacitors** has been done on basis of 10% of kVA rating of the transformers (in multiples of 5 kvar).

Example:

For 100 kVA transformer: 10 kvar (= 2 x 5 kvar capacitors) and these two capacitors installed at the tail end or place where the higher concentration of load exists, of distribution lines and on poles.

Selection of kvar steps, rated voltage 440 V:

13,000 PoleCap of 5 kvar
250 PoleCap of 10 kvar
125 PoleCap of 20 kvar
13,375 PoleCap capacitors

After installation of PoleCap, further readings of grid parameter taken at various places (Fig. 6). Now the analysis shows an improvement of power factor correction from 0.85 to 0.95.

10. Analysis on loss reductions

Installed capacity of transformers: 1000 MVA
Power factor at peak demand: 0.85
During summer: 430 MW or 506 MVA
During winters: 300MW or 353 MVA

After installation of 70,000 kvar, Power Factor improves to 0.91

Result for peak demands :

During summer: 472 MVA
During winter: 330 MVA

Reduction in Resistive Transmission Losses

$$\frac{(MVA1^2 \times MVA2^2)}{MVA1^2} \times 100 \% = 13 \% \text{ saving in terms of line losses}$$

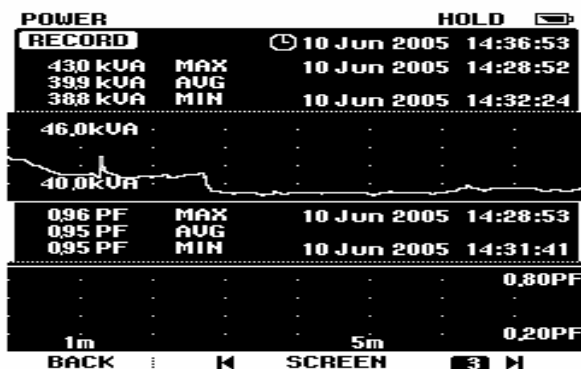


Fig. 7: Analysis after installation of PoleCap

*) M.F. = weighting factor, see PFC Product Profile, current version, page 71

11. Conclusion

Jaipur city is the first city in India that invested in power quality. This pilot project and the analysis performed impressively documented the achievements of power factor correction by PoleCap:

Reduction of losses

- Improvement of power factor
- Stabilization of power supply

With its unique design and optimized thermal behavior, the PoleCap is not only the perfect capacitor for outdoor applications, but also under tight surrounding conditions: wherever one has to consider the presence of dust, water or UV-impact, the PoleCap will allow power factor correction at site.

Datasheets for the particular types are available in the EPCOS Internet, www.epcos.com/pfc or contact your local sales office.



12. Standards

The recommendations and proposals stated in this Application Note are (among 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 obeyed in any case.

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