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HomeCap: Residential Power Factor Correction

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HomeCap: Residential Power Factor Correction

Power factor correction (PFC) has found widespread use in commercial applications, both withing industrial facilities, office complexes and in the power distribution grid in close proximity to commercial clients. Nowadays, in some regions of the world residential PFC is also becoming more and more popular.

Company Edelnor, electricity distributor in Peru, is a pioneer in residential PFC. Initial efforts to improve the power factor began with banks of medium voltage capacitors installed in the high-voltage and medium-voltage transformer substations. Once Edelnor attained the required power factor and the demand for electricity continued to grow, further investments in power factor correction for the distribution network began showing diminishing returns. Edelnor started to explore the benefits of deploying PFC in the low-voltage distribution networks as close to the consumer as possible.

EPCOS engineers have developed suitable capacitors to fulfill the requirements for residential PFC. HomeCap capacitors provide the smallest possible diameter, ready to connect and to install inside the metering cabinet.

This application note provides some details about the HomeCap series and describes the pilot project performed by Edelnor, Peru.

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Power Factor Correction

HomeCap: Residential Power Factor Correction

Power factor correction (PFC) has found widespread use in commercial applications, industrial facilities, office complexes (conventional and dynamic PFC systems) and in the power distribution grid in close proximity to commercial clients (e.g. PoleCap capacitors for outdoor usage). A new application developed shows that correcting the power factor at the household level in certain regions benefits utilities and users alike.

1. Pressure in the energy market

Power factor

Deregulation and restructuring of the energy market and steadily increasing costs in many countries have put enormous pressure on the margins of the utilities. In order to improve the efficiency of the electrical system and create further capacity, authorities began to implement incentives for power factor correction. Under these, electricity distributors must achieve minimum power factors or face penalties. Normally initial efforts to improve the power factor begin with banks of medium-voltage capacitors installed in the high-voltage and medium-voltage transformer substations.

New solutions

For this reason, a new solution is to explore the benefits of deploying PFC in the low-voltage distribution networks as close to the consumer as possible, in private residences, where access cannot be controlled.

2. Pilot project

Case study

A pioneer in residential PFC was a distributor of energy in Peru, company Edelnor (s. page 8). In order to improve the power factor, Edelnor began with banks of medium-voltage capacitors installed in the high-voltage and medium-voltage transformer substations. Once Edelnor obtained the required power factor and the demand for electricity continued to grow, further investments in PFC for the distribution network began to show diminishing returns.

Network analysis

This is why Edelnor started to explore the benefits of deploying PFC in the low-voltage distribution networks as close to the consumer as possible. In the year 2001, a pilot project started with the installation of 4800 kvar in 26,000 households in Infantas (northern Lima). The networks analyzed were those connected to 250 kVA, 10:0.22 kV transformers.

Requirements

The only obstacle for residential PFC was the lack of a suitable capacitor that was standardized for installation in confines of the metering cabinet. The requirements were

- Smallest possible diameter
- Ready to connect
- Easy installation
- Safe operation

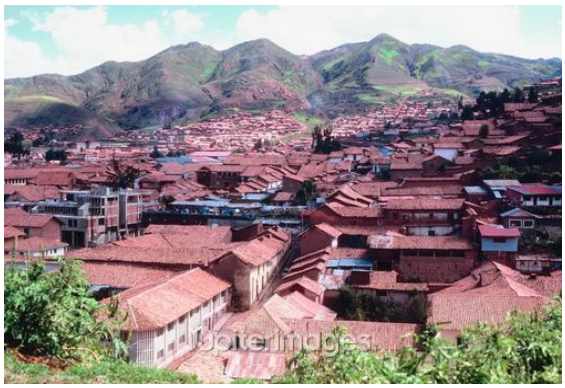


Fig. 1: Peru – Pioneer in residential PFC

3. New development: HomeCap

Features and characteristics

To meet these requirements, EPCOS-engineers have developed the HomeCap series of PFC -capacitors in private residences (**Fig. 2**), based on the well-established PhiCap (MKP technology). It does not only offer all the features required by Eldenor's specification, but also several additional safety features:

- Shrink sleeve for the aluminum can
- Top case to cover the terminals
- Internally insulated
- Strong cable with double insulation
- Internal safety device: overpressure disconnector
- Self-healing

Fig. 2: HomeCap capacitor – ready to connect

HomeCap values

The new ready-to-connect PFC capacitors are designed for single power networks. The current spectrum offers capacitance values ranges from 5 µF to 33 µF. This enables inductive reactive powers of 0.25 kVAr to 1.66 kVAr to be corrected. The permissible rated voltage in 50 Hz or 60 Hz grids ranges from 127 V to 400 V. A reinforced polypropylene film is employed as dielectric. HomeCap has a diameter of 40 mm and a height of 70 mm to 105 mm, depending on its capacitance.

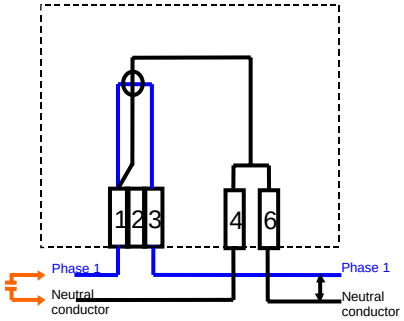
HomeCap at a glance:

Dielectric:	Polypropylene film (extra thick)
Rated voltage:	400 V (application voltage 127 V to 400 V)
Capacitance:	5 to 33 µF
Reactive power:	0.25 to 1.66 kvar
Frequency:	50 / 60 Hz
Diameter:	40 mm
Height:	70 to 105 mm

Measuring and connection examples

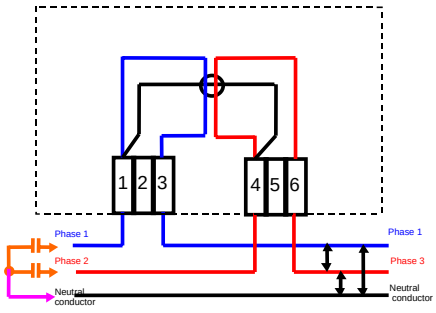
Figs. 3 and 4 show some measuring circuits with connection examples; **Fig. 5** gives an example for connection schematic.

Fig. 3: Two wires single phase



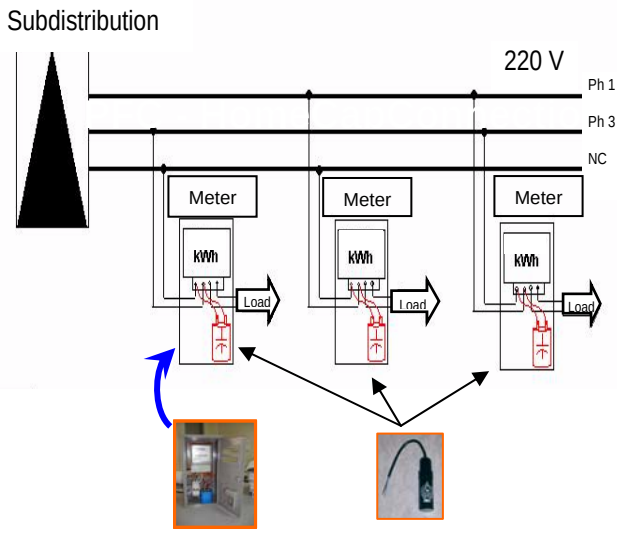
Single capacitor

Fig. 4: Three wires single phase



Double capacitors

Fig. 5: Connection Schematic



4. Customer benefits

Connection and installation

Apart from the diameters matching with the size of the cabinet, HomeCap offer a variety of customer benefits: The factory-mounted accessories allow easy connection to the AC power line (Fig. 6). Installation can simply be done by any technician and requires no special training. A top case to cover the terminals and a strong cable with double insulation keep a safe installation inside the metering cabinet where access cannot be controlled.

Pay-back of investment

HomeCap has a high life expectancy (up to 100,000 hours) which results in a very short pay-back-time of investment. In the case of Edelnor, for example, a total saving of around 19,300 MWh per year means a cost saving of close to US$ 900,000 – a savings not only for the company, but also for end customers.

It is important to mention that the advantages of residential PFC go far beyond the cost savings. Because PFC reduces the current loading of distribution equipment, electricity distributors are able to postpone investments to increase their power system and expand grid capacity. Moreover, PFC at all network levels helps to considerably improve the voltage in the network.

Priorities for the 21st century

Certainly, residential PFC based on the HomeCap is a model for countries and regions with large proportions of overhead lines and depends on the load structure. Of course, each distribution company must valuate its own needs based on the characteristics of its network. Advancements such as residential PFC will be of highest priority in the 21st century if the electricity distributors want to efficiently deliver the service quality levels demanded by customers. They will need to develop innovations and new products in order to compete in the electricity market.

Fig. 6:
HomeCap installation in the metering cabinet

5. Edelnor , Peru

Company profile

Edelnor S.A.A. is a distributor of electricity serving Peru. It is part of the Endesa Group from Spain, which is preliminary engaged in the generation, transmission and distribution of electricity in Chile, Argentina, Brazil, Colombia and Peru. Edelnor serves a 2400 square kilometer region north of Lima.

Carlos Arroyo

Managing director of quality and service at Edelnor:

"Further investments in PFC for the distribution network began showing diminishing returns. Therefore we started to explore the benefits of deploying PFC in the low-voltage distribution networks as close to the customer as possible."

6. Summary Edelnor

- Power factor improved in substations from 0.84 to 0.93.
- Voltage profiles in MV and LV distribution networks improved, without over voltages.
- Unbalance levels of voltages and currents kept in their previous levels as before the installation of the capacitors.
- Voltage harmonic distortion level on the low voltage side of the transformers increased in average by 1%, but is still below the regulation's limits.
- LV reactive compensation optimizes utilization (more kW can be connected) of LV transformers and distribution components.

7. Conclusions

The energy market is changing fast. New energy providers are coming in – the competition is growing. There is not only a demand for price decreases, but also for more power quality and efficiency. The achievement of a minimum power factor regulated by authorities in many countries is a further reason for providers to look for appropriate means.

With the development of the HomeCap-series EPCOS offers a standardized capacitor suited for installation in metering cabinets: smallest possible diameter, easy to install and safe operation in a residential environment. Based on the proven MKP technology – the PhiCap series – HomeCap capacitors have put the theory of residential PFC into reality. In order to compete in the electricity market, it is necessary to develop innovative products today to fulfil the requirements of tomorrow.

8. 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 adhered to in any case.

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