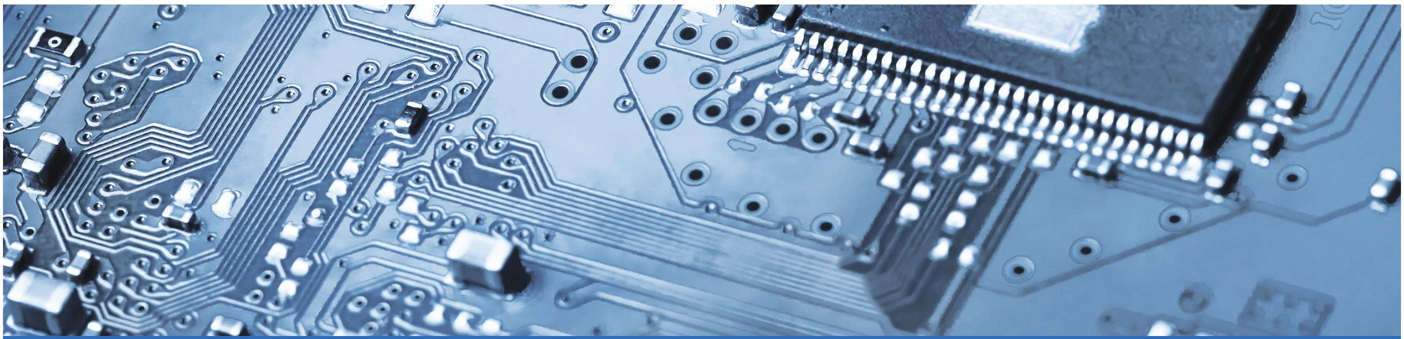
Power Electronic Capacitors



Electrical Energy Storage

1. Technical description

A. Physical principles

A Power Electronic Capacitor (PEC) is an energy storage system based on electrostatic effects that occur between two electrodes.

B. Important components

The main components are the following:

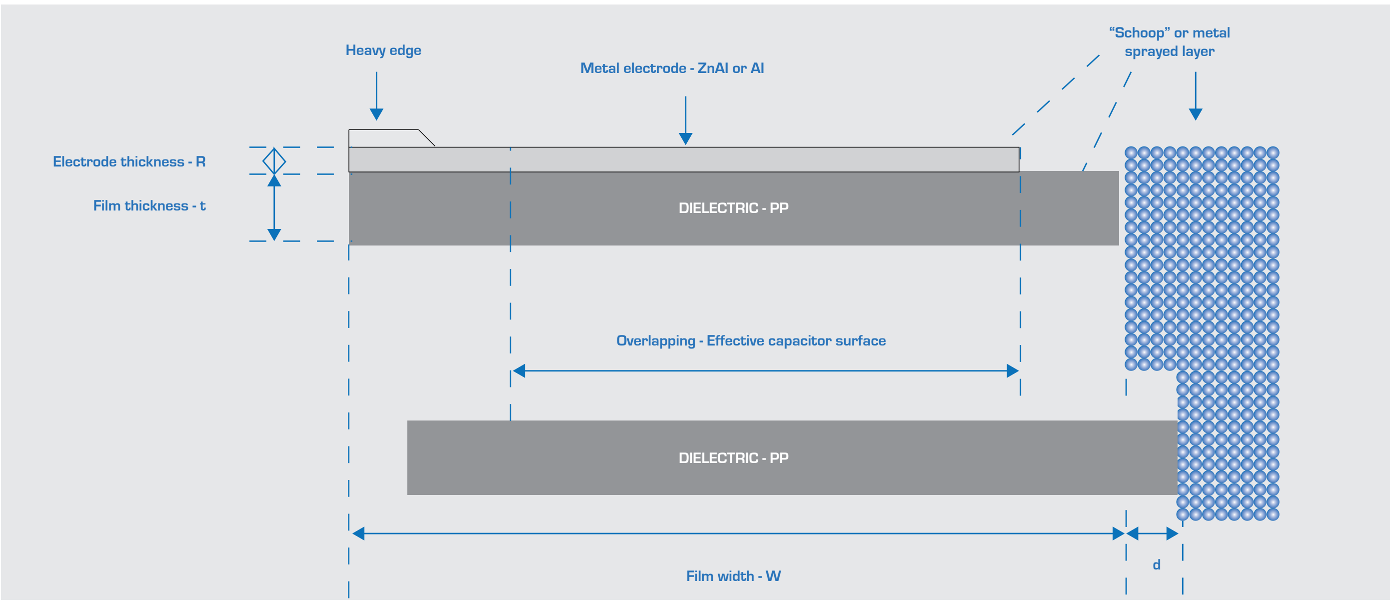
- Winding element: Two or more metallised films are wound in parallel to produce a capacitor element, or winding. The capacitor electrodes are made by depositing a metallisation layer (the electrode) on the dielectric film by evaporating the metal onto the film surface under vacuum. The dielectric film is typically High-Temperature Polypropylene Polymer (HTPP). The metal is usually pure aluminium or zinc-aluminium (ZnAl) alloys. The metal thickness is a key parameter for the self-healing capability of the capacitor. This capability consists of isolating any weak point and allows continued operation with minimal capacitance loss.
  The electrode profile on the film is designed in such a way that a number of internal series connections are included in the winding itself.

- Capacitor assembly: The winding elements are fitted inside the capacitor case, usually made of stainless steel. Different impregnation technologies may be used: gas and resin-filled, or oil-impregnation. The cases are hermetically welded. Different types of terminals are available for the connections.

C. Key performance data

Power range	200 kW to some MW
Energy range	0.007 kWh to some kWh
Discharge time	Some millisec to some sec
Cycle life	n.a.
Life duration	40 years
Reaction time	Some millisec
Efficiency	>95 %
Energy (power) density	0.07 Wh/liter
CAPEX: energy	n.a.
CAPEX: power	n.a.

Illustration: Charging principal of PEC



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D. Design variants (non exhaustive)

Different capacitor technologies are available in a wide variety of capacitance and nominal voltage values. The range corresponding to PECs varies from capacitances of the order of hundreds of nanofarads (nF) and voltages of up to 5,000V_R, to capacitor batteries of tens or hundreds of millifarads (mF) with voltage levels of below 1,000V_R.

2. State-of-the-art

The most relevant parameter describing the performance of a PEC is its energy density. This is equivalent to the field strength applied to the polypropylene dielectric. Currently, energy storage and Direct Current (DC) link capacitors are operated at a level of 180 to 220 V/µm. Depending on the requested current load and ambient temperature of the application, the applied field strength (and thus energy density) is expected to further increase.

3. Future developments

In recent years, PECs main application is in frequency converters, especially traction systems and industrial drives. Nowadays high-power electronic devices are beginning to play an important role in improving grid reliability, including through application in energy storage systems, Flexible Alternating Current Transmission Systems (FACTS), as well as Distributed Energy (DE) and High Voltage Direct Current (HVDC) systems.

Power levels will further increase through technological improvements, including more efficient heat dissipation.

4. Relevance in Europe

As an alternative solution to the construction of new Alternating Current (AC) transmission lines, FACTS technologies enhance the controllability and increase the power transfer capability of existing AC transmission lines. PECs are part of systems that improve power flow control, reliability and power quality.

In advanced multilevel Voltage Source Converters (VSC), the role of PECs is to smooth high voltages in the several thousands of volts range.

PECs are used in several projects in the North Sea (such as BorWin 2, HelWin 1 and SylWin) and have been applied in locations such as the German Bight and off the east coast of England.

5. Applications

Due to the relatively high specific energy combined with low internal resistance and the capability to withstand up to one million charge and discharge cycles without significant wear out, they are used in a large variety of applications:

- Uninterruptible power supplies (UPS) systems to back up short power failures and cover peak power demands
- Safety electronics as maintenance free power back-up
- Renewable energy for smoothing voltage sags and power boost