How to Protect Capacitor Banks?

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Introduction

Capacitor banks are used to ***compensate for reactive energy*** absorbed by electrical system loads, and sometimes to make up filters to reduce harmonic voltage.

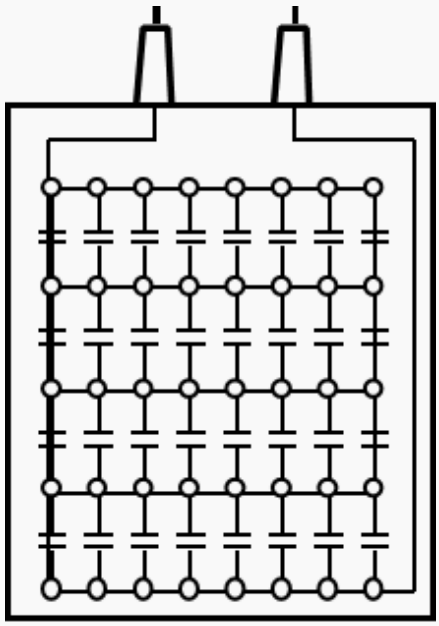
Their role is to ***improve the quality*** of the electrical system. They may be connected in star, delta and double star arrangements, depending on the level of voltage and the system load.

A capacitor comes in the form of a case with insulating terminals on top. It comprises individual capacitances which have limited maximum permissible voltages (***e.g. 2250 V***) and are series-mounted in groups to obtain the required voltage withstand and parallel-mounted to obtained the desired power rating.

There are two types of capacitors:

1. Those with no internal protection,

2. Those with internal protection: a fuse is combined with each individual capacitance.



Capacitor bank

Types of faults

The main faults which are liable to affect capacitor banks are:

1. Overload,
2. Short-circuit,
3. Frame fault,
4. Capacitor component short-circuit

1. Overload

An overload is due to ***temporary*** or continuous overcurrent:

Continuous overcurrent linked to:

- Raising of the power supply voltage,
- The flow of harmonic current due to the presence of non-linear loads such as static converters (*rectifiers, variable speed drives*), arc furnaces, etc.,

Temporary overcurrent linked to the energizing of a capacitor bank step. Overloads result in overheating which has an adverse effect on dielectric withstand and leads to premature capacitor aging.

2. Short Circuit

A short-circuitis an internal or external fault between live conductors, phase-to-phase or phase-to-neutral depending on whether the capacitors are ***delta*** or ***star-connected***.

The appearance of gas in the gas-tight chamber of the capacitor creates overpressure which may lead to the opening of the case and leakage of the dielectric.

3. Frame fault

A ***frame fault*** is an internal fault between a live capacitor component and the frame created by the metal chamber.

Similar to internal short-circuits, the appearance of gas in the gas-tight chamber of the capacitor creates overpressure which may lead to the opening of the case and leakage of the dielectric.

4. Capacitor component short-circuit

A capacitor component short-circuit is due to the flashover of an individual capacitance.

With no internal protection: The parallel-wired individual capacitances are shunted by the faulty unit:

- The capacitor impedance is modified
- The applied voltage is distributed to one less group in the series

- Each group is submitted to greater stress, which may result in further, cascading flashovers, up to a full short-circuit.

With internal protection: the melting of the related internal fuse eliminates the faulty individual capacitance: the capacitor remains fault-free, its impedance is modified accordingly.

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Protection devices

Capacitors should not be energized unless they have been discharged. Re-energizing must be time-delayed in order to avoid transient overvoltage. A 10-minute time delay allows sufficient natural discharging.

Fast discharging reactors may be used to reduce discharging time.

Overloads

Overcurrent of long duration due to the ***raising of the power supply voltage*** may be avoided by overvoltage protection that monitors the electrical system voltage. This type of protection may be assigned to the capacitor itself, but it is generally a type of overall electrical system protection.

Given that the capacitor can generally accommodate a voltage of ***110% of its rated voltage*** for 12 hours a day, this type of protection is not always necessary.

Overcurrent of long duration due to the flow of harmonic current is detected by an overload protection of one the following types:

- Thermal overload
- Time-delayed overcurrent

provided it takes harmonic frequencies into account.

The amplitude of overcurrent of short duration due to the energizing of capacitor bank steps is limited by series-mounting impulse reactors with each step.

Short circuits

Short-circuits are detected by a ***time-delayed overcurrent protection device***. Current and time delay settings make it possible to operate with the maximum permissible load current and to close and switch steps.

Frame faults

Protection depends on the grounding system. If the neutral is grounded, a time-delayed earth fault protection device is used.

Capacitor component short-circuits: Detection is based on the change in impedance created by the short-circuiting of the component for capacitors with no internal protection by the elimination of the faulty individual capacitance for capacitors with internal fuses.

When the capacitor bank is ***double star-connected***, the unbalance created by the change in impedance in one of the stars causes current to flow in the connection between the netural points. This unbalance is detected by a ***sensitive overcurrent protection device***.

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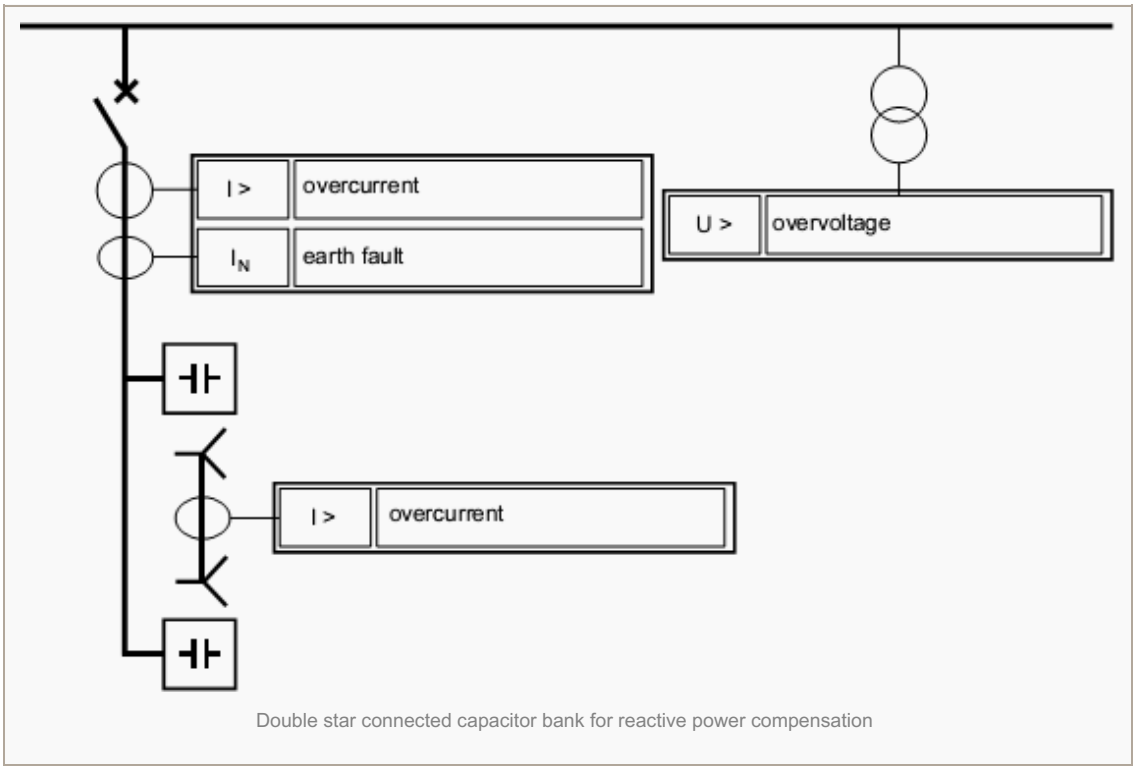
Examples of capacitor bank protection

Double star connected capacitor bank for reactive power compensation



Double star connected capacitor bank for reactive power compensation

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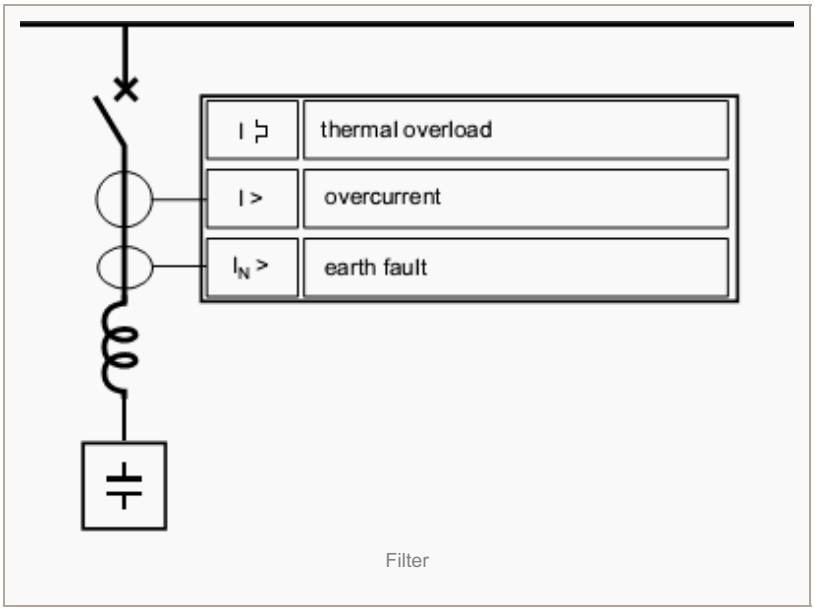

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Setting information

Type of fault	Setting
Overload	***Overvoltage setting:*** ≤110% Vn ***Thermal overload:*** setting ≤1.3 In or overcurrent setting ≤1.3 In direct time or IDMT time delay 10 sec
Short-circuit	***Overcurrent direct time setting:*** approximately 10 In time delay approximately 0.1 sec

Frame fault	***Earth fault direct time setting:*** ≤20% maximum earth fault current and ≥10% CT rating if suppied by 3 CTs time delay approximately 0.1 sec
Capacitor component short circuit	***Overcurrent direct time setting:*** < 1 ampere time delay approximately 1 sec

Resource: *Protection Guide – Schneider Electric*