

Capacitor Switching in APFC Panels

The switching of capacitor banks is a special and challenging application in Automatic Power Factor Correction (APFC) panels. The selection of appropriate switching device for such applications is based on two criteria:

- Ability to carry rated capacitor current continuously
- Ability to make the peak-inrush current of capacitor

It is simple to calculate the capacitor rated current and select the switching device to be able to carry rated capacitor current (2.5 to 3 times the capacitor rated current to take care of overload, harmonics, supply voltage variation and capacitor value tolerance). However, it is a little difficult to select the switching device which is able to make the peak-inrush current. This is because the peak inrush current for capacitor switching application depends upon various factors such as:

- The inductance of the network (including cables, switchgears and transformer)
- The transformer power rating and % impedance
- Methods used for power factor correction:
 - fixed capacitor bank
 - multi-stage capacitor bank with steps of equal ratings
 - multi-stage capacitor bank with steps of unequal ratings
- In multi-stage capacitor bank, the nos. and rating of steps already switched on

In most of the installations, the multi-stage capacitor banks are used with steps of unequal ratings. The bigger steps of higher kVAr ratings being switched on initially and smaller steps are switched on periodically, for achieving the targeted power factor. In such cases, the value of inrush-current peak will be far higher and hence the smaller capacitors will be heavily stressed.

Capacitor switching can be done by various ways such as:

Power contactor:

- Normal power contactors will simply allow the inrush current to flow through them and because of this, contactors and capacitors are heavily stressed. Contactor selection should be such that

it withstands the heavy inrush current for which some amount of derating would be required.

- Power contactors should be used along with inrush current limiting reactors, which will increase the cost and size of the APFC panel.
- Instead of de-rating power contactors and using current limiting reactors, capacitor duty contactors shall be used.

Capacitor duty contactor:

- MO C range of capacitor duty contactors can be used to limit the inrush current to less than $10 \cdot I_N$.
- Capacitor duty contactors have pre-contacts with current limiting resistors (of 4Ω).
- Capacitor duty contactors are employed where the frequency of switching is less i.e., the load fluctuation is not often. The capacitor requires atleast 60 seconds to discharge to a nominal value (50 V). So capacitor duty contactors cannot be used when load fluctuation is heavy.
- MO C contactors can be used for switching capacitors upto 80 kVAr in each branch.

Thyristor switching module:

- TSM is used for dynamic power factor correction i.e., wherever the load fluctuation is heavy (welding, steel rolling, etc.)
- Rapid switching (5 ms) is possible with TSM along with Quick Discharge Resistor (QDR). Existing discharge resistor in capacitors shall be replaced with QDR.
- There will be no inrush current while using TSM (zero voltage switching and zero current switching). So frequent switching will not affect the life of capacitors and there may not be a need to use extra current limiting reactors.
- TSM has thermal cutoff, which will switch off when temperature exceeds beyond a certain limit. It will automatically switch on when optimum temperature is attained.
- Panel design becomes critical while using TSMs and adequate cooling arrangements need to be employed.