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# TechTopics No. 32

## Capacitor switching applications

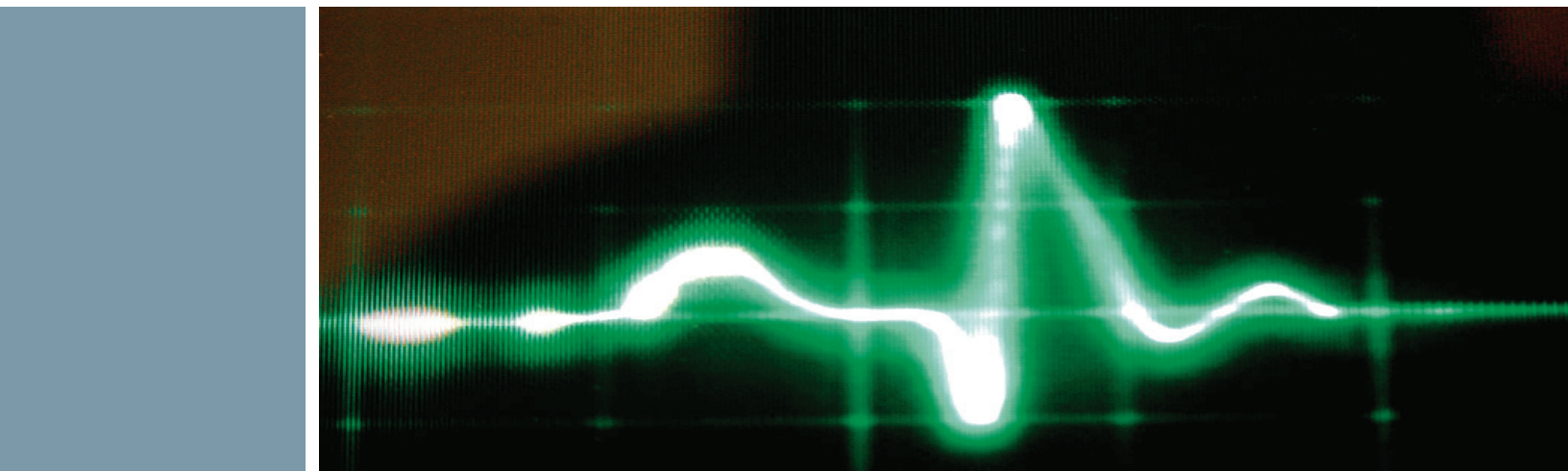
Capacitor switching is an application for which vacuum circuit breakers are well suited. In fact, it was the first practical application of vacuum switching devices in the late 1950s. The reason that vacuum is well suited as a switching technology for capacitive circuits is because the rate of increase of the dielectric capability of the contact gap following interruption is extremely high.

The major challenge for any circuit breaker in capacitor switching relates to initial energization of capacitor banks. While energizing one bank (isolated bank switching) is severe, paralleling of capacitor banks, commonly referred to as back-to-back switching, is far more onerous. If two capacitor banks are located in close proximity, high inrush currents can occur when one capacitor is already energized and the second capacitor bank is switched in. To compound the situation, these inrush currents can be of very high frequency.

The worst situation occurs when the inductance between the two capacitor banks is very low, and the second bank is connected to the bus when the system voltage (and the voltage on the first capacitor bank) is at an instantaneous maximum. Under this situation, the natural frequency of the LC circuit is extremely high.

For these reasons, the inrush current peak and the inrush current frequency for back-to-back capacitor bank switching must be limited. The applicable limits for the peak current and the inrush current frequency are shown as follows:

- Peak inrush current must be limited to 10 kA or less.
- Inrush current frequency should not exceed 4,240 Hz.



The capacitive current switching capability of the circuit breaker must account for the increase of current over nameplate capacitor bank ratings. ANSI/IEEE C37.012-2005, clause 6.10.1, discusses this in some detail. The required current switching capability and the continuous current rating of the conductors used to feed the capacitor bank must be increased to account for the following:

- The manufacturing tolerance for kVAR of capacitors is -0 percent, +15 percent.<sup>1</sup>
- The capacitors can be continuously energized at up to 10 percent overvoltage, which increases the capacitive current by the same amount.
- Capacitors will carry harmonic currents as a result of the capacitor connections, and because capacitors present a low-impedance path for the flow of harmonic currents. Depending on the manner of connection, these currents may be as high as 10 percent.

To account for these factors, the capacitor current calculated based on nameplate ratings must be increased by a factor of 1.35 to determine the capacitive current switching capacity required of the switching device, and to determine the continuous current carrying capacity required of the connections to the capacitor bank. This factor is required by C37.012, as well as by the National Electrical Code® (see 460-24).

**Footnote:**

<sup>1</sup> Note that C37.012-2005 states tolerance on kVAR as -0% to +15%, while IEEE 18-2002 revised the tolerance to -0% to +10%. Other codes (particularly the NEC®) have not reduced the adjustment factor from 1.35.

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