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Harmonic filter applications

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In recent years, Siemens has noticed increasing application of harmonic filters in a variety of industrial situations. Harmonic filters are primarily intended to deal with power quality issues arising from loads that create harmonics, such as drives.

Harmonic filters are also used extensively in installations involving electric arc furnaces.

Filter circuit applications are often called "capacitor switching" applications, but they are very different from capacitor switching applications. A filter circuit combines some aspects of inductance switching, and other aspects of capacitance switching. The result is an application that has characteristics unlike either of these.

To evaluate a potential filter application for suitability, specific information is required, including:

- The system one-line diagram. It should show any switching device for individual filter banks if the circuit breaker is to switch multiple filter banks simultaneously.
- If there are multiple filter banks, at least two switching configurations appear to be common.
 - Multiple filter banks, each with a dedicated filter switching device (typically, a contactor), are connected together, and the feeder to the filter banks is switched by a single circuit breaker.

All filter banks must be switched OFF (open) when the circuit breaker feeding the dedicated filter bank switching devices is to be closed. After the circuit breaker is closed, the filter banks must then be switched ON in sequence by the dedicated filter switching devices.

The filter bank system should be controlled so that the banks are switched ON from lowest order harmonic to highest order harmonic.

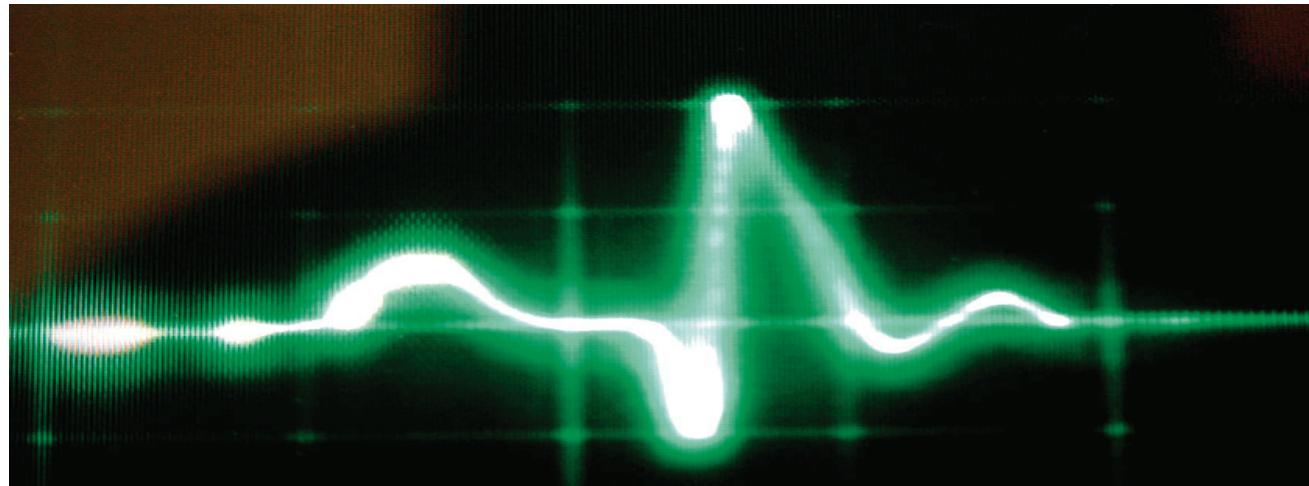
The filter bank system should be controlled so that the banks are switched OFF from highest order harmonic to lowest order harmonic.

In short, switch the circuit breaker ON first, then switch each filter bank ON from lowest to highest harmonic; switch each filter bank OFF from highest to lowest harmonic, and then switch the circuit breaker OFF.

- Multiple filter banks are connected directly to the switchgear, with an individual filter circuit breaker to switch each individual filter bank.

The filter bank system should be controlled so that the banks are switched ON from lowest order harmonic to highest order harmonic.

The filter bank system should be controlled so that the banks are switched OFF from highest order harmonic to lowest order harmonic.



- Confirmation that the switching sequence to be used conforms to the above. If not, the specific switching sequence must be fully defined.
- The size of filter bank at each harmonic, and the actual harmonic to which each filter is tuned. Most frequently, third, fifth and seventh harmonics are involved, although Siemens has also observed second, ninth and eleventh. This information is used to evaluate the inrush current and inrush frequency, so that these can be compared to the limits for the circuit breaker.
- The actual, nominal system voltage and the allowable short-term overvoltage for normal operation. This is necessary to allow evaluation of the voltages to which the circuit breaker will be exposed during switching. ANSI standard C84.1 generally is based on a maximum system voltage of the order of 105 percent to 106 percent of nominal system voltage.

Some additional comments that should be made, relating to the general application issues for Siemens' vacuum circuit breakers:

- Peak inrush current is limited to 10 kA.
- Filter voltage after switching OFF must not exceed the rated maximum voltage for the circuit breaker. (Filter voltage after switching OFF is higher by the ratio of [harmonic number squared]/[harmonic number squared minus 1.0]. Thus, the worst case is a second harmonic filter, which exposes the circuit breaker to 133 percent of the nominal voltage.)
- If the voltage exposure (considering system operation at the maximum of the normal voltage range, typically 105 percent to 106 percent of nominal system voltage) exceeds the rated maximum design voltage of the circuit breakers and switchgear, then equipment rated for the higher voltage must be used. Another possible solution is to use two circuit breakers in series, but the more normal solution would be to use higher voltage equipment.
- If the installation also involves an arc furnace, further consideration is needed, particularly with respect to voltage transients.

Due to their special nature, each harmonic filter application must be individually reviewed.

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