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BLOCK WHITE PAPER

EXPERT REPORT

SELECTIVE CAPACITOR DISCONNECTION FOR PASSIVE HARMONIC FILTERS

SELECTIVE CAPACITOR DISCONNECTION FOR PASSIVE HARMONIC FILTERS

White Paper on effective elimination of capacitive reactive power in a low-load or idling scenario where the system as a whole is connected to the network.

„The use of passive harmonic filters is the subject of ongoing debate: Is there an effective way to eliminate capacitive reactive power in a low-load or idling scenario without disconnecting the system as a whole from the network? The obvious answer is simply to disconnect the capacitors used in filters – but this is often easier said than done."

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SELECTIVE CAPACITOR DISCONNECTION FOR PASSIVE HARMONIC FILTERS

Capacitors must be easily accessible in order for customers or equipment manufacturers to implement a suitable switching device. When capacitors are connected, this can lead to extremely high starting currents. And once they have been connected and disconnected a number of times, switching contacts tend to become worn or welded. This presents the system operator with certain challenges.
When planning a system, it is important therefore to ensure the contactor chosen is appropriate for the switching of capacitive loads. The right kind of design is based on resistors in parallel to the switching contacts, and the manufacturer will designate this as the contactor for capacitors. However, the information provided by the manufacturer regarding the anticipated capacitor current is often insufficient. One option is to calculate the apparent current from the capacitance and network voltage, although this takes no account of the greater current flow that occurs during operation due to the harmonic load. Even during full-load operation, the contactor should always be able to conduct or safely interrupt the capacitor current. Depending on the filter‵s design, about 30 to 40% of the rated current should be used as an approximate value for dimensioning purposes.

DETERMINING CURRENT AND POWER FOR CAPACITOR CONNECTION

Once the components have been determined, it is necessary to define the current or power level at which the capacitors are connected and therefore the filter is fully activated. It is a case here of balancing reactive power against what is acceptable by way of any potential impact on the network – as a function of rated power in percentage terms. This means the filter, without an active capacitance circuit, only acts as a reactor and any impact on the network is higher accordingly. In this arrangement, capacitive reactive power is considerably reduced as the capacitive component associated with, say, the frequency inverter downstream is offset by the remaining (filter) reactor. By contrast, however, the harmonics are also considerably greater than for regular filter operation. One quality criterion that applies in this context is the total harmonic distortion (THD) associated with the current. It should be noted that the value given, namely THD-I, corresponds to the fundamental oscillation amplitude.

The following calculation makes this connection clear:

$$THD - I = \sqrt{\sum_{n=2}^{n=50} \left(\frac{I_n}{I_1}\right)^2}$$

As one of the world's leading manufacturers of inductive winding goods, BLOCK began working on the EMC of frequency inverter-controlled drive systems at an early stage.

CONNECTION BETWEEN RATED POWER AND REACTIVE POWER

It is possible therefore for a small fundamental oscillation amplitude I1 (i.e. low power) to have a high THD-I value. Values of 150 to 180% are certainly possible, without additional measures. These may not, however, be factored into the valuation process as any impact on the supply voltage is negligible due to the low amplitudes involved.

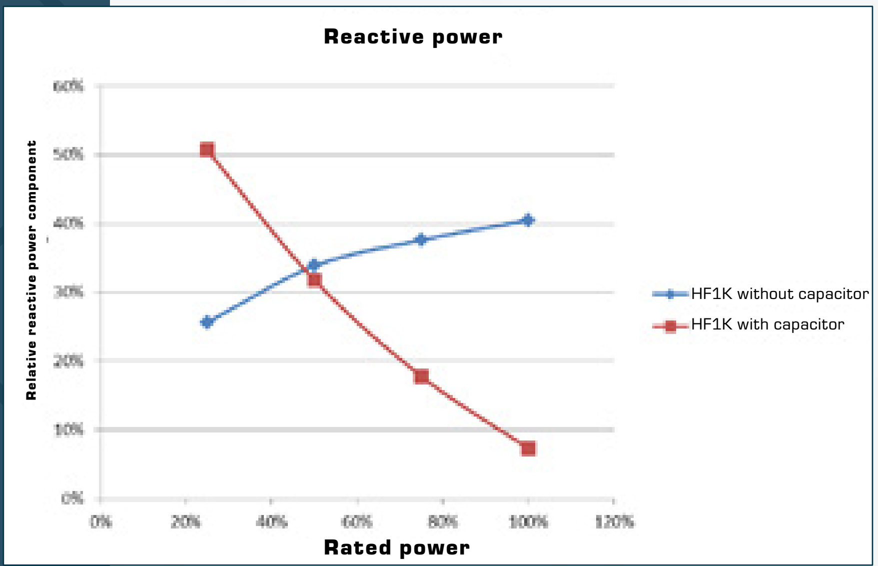

Fig. 1: Reactive power. Rated power. THD-I. Relative reactive power component. HF1K without capacitor. HF1K with capacitor. Comparison based on drawing of reactive power for a connected and disconnected capacitor – as a function of rated power with and without a filter circuit

This makes it important to consider reactive power for this particular load case. So if the power increases with the capacitor disconnected, the capacitive reactive power will increase automatically. At the same time, THD-I decreases due to the fundamental oscillation increasing as per the equation shown. With the capacitor connected, the reactive power component decreases as the power increases. So disconnection or connection should occur no later than the intersection in the graph. Here, the associated hysteresis prevents the contactor „wobbling" as a result of potential fluctuations in power about the point. Depending on the design of the filter, this intersection can typically be found at around 45 to 50% of rated power. Solely as a result of the reactor becoming effective, it becomes possible to achieve a THD-I as low as 20% at 50% of rated power at the most. According to standards such as EN 61000-3-12 or IEEE 519, thresholds for current harmonics may be exceeded up to twice the permissible limit within various time frames.

DEVISING FILTER APPLICATIONS

A further point worth considering is selection and dimensioning in respect of the average load associated with the final application.

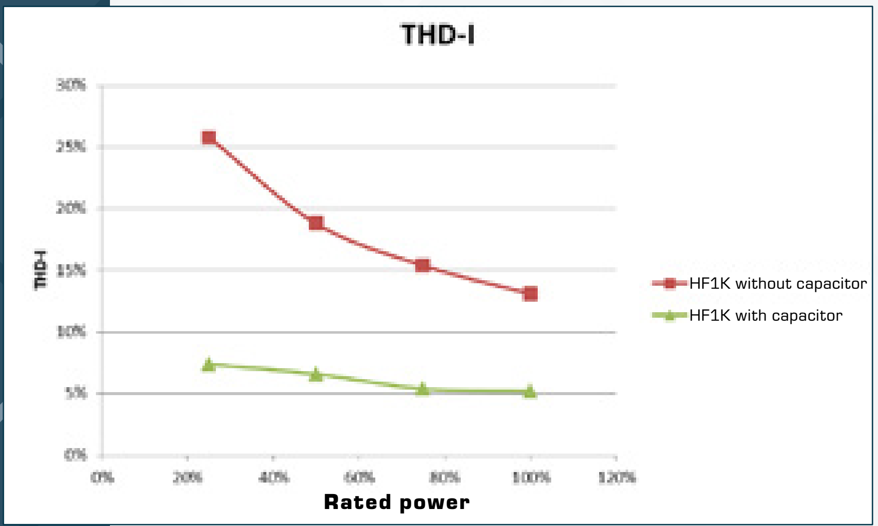

Fig. 2: THD-I as a function of rated power with and without a capacitor connected.

It is a case of weighing things up accordingly before devising an application – based on 100% – where the components will predominantly operate in the partial load range (around 30 to 70%). Power reserves involve certain costs too. A passive harmonic filter can only really accommodate and combine the twin concepts of harmonics reduction and reactive power from a rated power level of around 50%. It is critical not to overlook this point at the planning stage.

As regards practical implementation of capacitance disconnection, the harmonic filters from BLOCK's HF1K and HFM ranges offer this kind of easy access to the relevant capacitor. This provides a way of effectively counteracting the predominantly capacitive load case associated with an idling or low-load scenario.

With their great technical expertise, our experts can help you implement an additional disconnection arrangement. For further contact details, please visit:

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