

# Harmonic Filter Bank Protection

## Introduction

The protection of a harmonic filter is different than that of a shunt capacitor bank. Typically shunt capacitor banks are protected for case rupture by expulsion or current limiting fuses. For metal-enclosed capacitor banks, full-range current limiting fuses are used since they expel no gas during interruption and they limit fault damage. In addition to case rupture protection, ungrounded capacitor banks are typically protected by a sensitive unbalance protection system that protects the remaining good capacitors from overvoltages (due to neutral voltage shift) that result when a capacitor fuse blows. The above capacitor protection concerns also apply to harmonic filters, but filters have additional overcurrent protection concerns for the tuning reactor(s). The following discussion provides background information on harmonic filter bank protection

The figure below shows a comprehensive harmonic filter bank protection system. The figure shows a filter bank feeder breaker connected to an ungrounded-wye connected harmonic filter bank. Several different relays are shown with their ANSI number designation. Current transformers provide the current signal required for these relays. A main disconnect switch and main fuses are shown just ahead of a set of vacuum switches that are used to automatically switch the bank on and off. In some cases the feeder breaker may form an integral part of the metal-enclosed harmonic filter bank. In which case, the main-fuses and disconnect switch may become unnecessary.

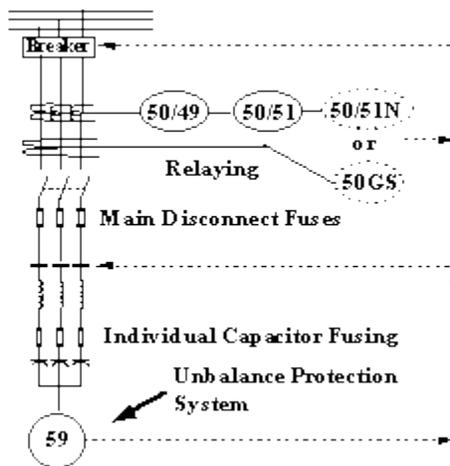


Figure 1 - Typical harmonic filter protection system

The following points can be made in regards to figure 1.

- Resistive grounded systems may have low ground fault current levels and may not be detected by standard phase overcurrent relays or the main disconnect fuses. Therefore 50/51N or 50GS relays may be necessary.

- An upstream feeder breaker or an integral roll-out vacuum circuit breaker within the metal-enclosed filter bank will provide current interruption for faults on the line side of the capacitors and may eliminate the requirement for the main-disconnect fuses and switch.

The protection of a filter bank can be divided into two parts, capacitor protection, and reactor protection.

### **Reactor Protection**

The tuning reactor should be protected for both faults and overloads. Overloads may occur for any of the following reasons:

- The addition of harmonic producing devices on the industrial system or nearby utility distribution system.
- An increase in the ambient harmonic voltage distortion.
- The malfunctioning of a non-linear load.
- A change in tuning point due to a blown capacitor fuse.
- An over voltage condition.

The overload protection is best achieved by a thermal overcurrent relay (Device 49) mounted in each phase of the filter bank. This relay is sensitive to RMS current and ambient temperature and can be set to trip at RMS current values that will cause damage to the reactor. This sensitive protection is not achievable with fuses and is more sensitive than a regular 51 relay. The thermal relay(s) should be wired to trip the filter bank by either the internal filter bank vacuum switches (for multi-stage banks with independent stage protection) or the upstream circuit breaker.

In addition to overload protection, the reactors should also be protected for phase and ground faults. Protection against phase faults can be achieved with current limiting fuses on the main disconnect switch or by 50/51 relays on the filter bank supply. If relays are to be used, they should be wired to trip the feeder breaker or the next upstream device since most filter bank capacitor switches (either oil switches, vacuum breakers, and vacuum contactors) are not rated to interrupt fault currents.

If the reactor is iron-core (enclosed filter banks usually are), consideration should be given to installing the current limiting fuses on the main disconnect even if a feeder breaker or integral breaker exist. The primary concern is the bracing of the iron-core reactor. During a load side reactor fault, full voltage is applied across the iron-core reactor, and it saturates to its low, air-core reactance. If this saturation effect is not accounted for in the original design (usually it is not due to cost), current limiting fuses should be considered.

Ground fault protection is not required on solidly grounded systems since they can be detected by the phase fault protective devices. For resistive grounded systems, however, a 50/51N or 50GS device is usually required. These devices can detect low level ground faults and can be wired to trip either the upstream breaker or the filter bank switches if the resistor rating is low enough.

### Capacitor protection

The filter capacitors should be protected against case rupture (due to internal capacitor faults) and overvoltages from blown capacitor fuses. In addition, the filter bank capacitors should be taken off line if one of the main disconnect fuses blow. This protection function is achieved with single ungrounded wye-connected capacitor banks with neutral unbalance protection systems. The figure below shows the details of a typical neutral unbalance protection system. The figure shows "individual capacitor fusing" (versus "group fusing") and an unbalance detection system.

"Individual capacitor fusing" is almost always necessary in ungrounded filter banks since a failed capacitor only draws three times the banks rating. In addition, high rated full-range current limiting fuses are expensive. The fuses should have a voltage rating equal to the line-line voltage unless they are tested for voltages that exceed their normal rating. These capacitor fuses should be coordinated with the upstream disconnect fuses, thermal relays, and over current relays.

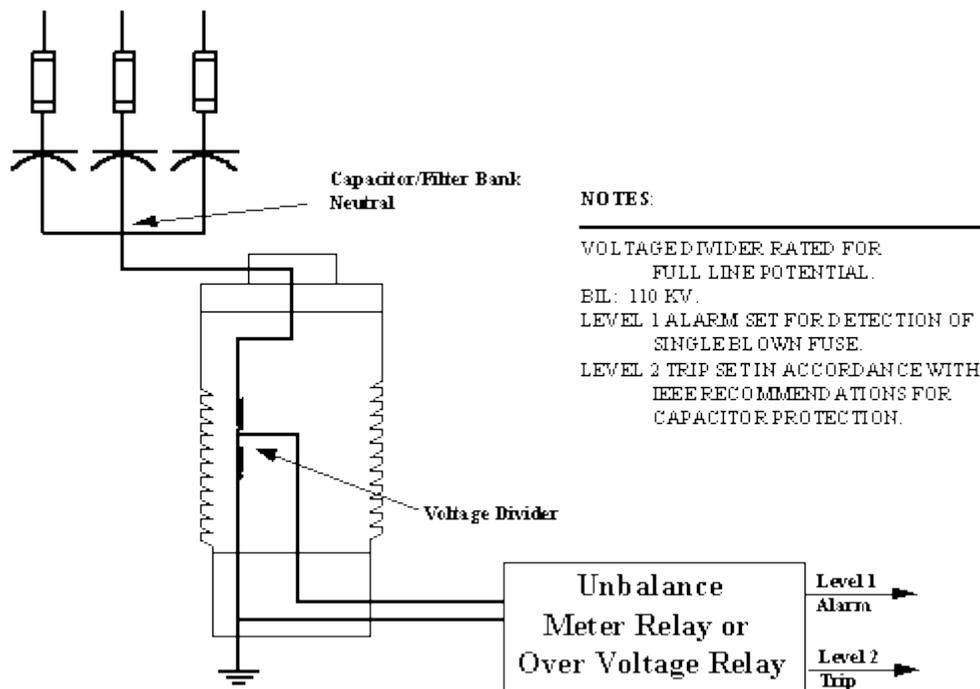


Figure 2 - Unbalance protection system by neutral voltage sensing

The unbalance protection system consists of a neutral voltage sensing device as shown in figure 2. This device is rated for full line potential since it may be subjected to full line-voltage during abnormal system conditions or when capacitor fuses open. The neutral voltage sensor has a very high impedance since it is desirable to keep the filter bank ungrounded. The relay (device 59) is normally set to trip the bank off-line for neutral voltages (resulting from blown capacitor fuses) that can cause damage to the remaining healthy capacitors due to detuning or neutral voltage shift. NEPSI's standard protection system has two tripping points. The "level 1" trip will alarm plant personnel of a blown fuse while the "level 2" trip will trip either the filter bank switches or the upstream breaker. It is important that this relay be coordinate with the upstream ground fault relays so that it does not trip during upstream ground faults.

In addition to the above protection system, it may be desirable to have overvoltage protection on the filter bank if the electrical system is not equipped with one. The main concern here is over voltages that can occur during light load and ground fault conditions.

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