# Why Your Capacitor Bank Should be Left Ungrounded

**Introduction**

Should medium voltage capacitor banks on industrial and commercial power systems be grounded? This question often arises, and the answer is usually no for the following reasons:

- Grounded capacitor banks can interfere with a facilities ground fault protection system and cause the entire facility to lose power (main breaker trip).
- Harmonic currents in the ground path can cause harmonic interference with control and communication systems.
- Capacitor discharge currents may damage nearby surge arresters.

Interference with a facilities ground fault protection system is the primary reason for not grounding a capacitor bank or harmonic filter bank. Although this interference can be reduced or eliminated through system modification, it may require protective coordination analysis, relay changes and/or grounding resistor changes. This adds cost and complexity to the installation and may degrade the sensitivity of the existing ground fault protection system. This bulletin describes how a grounded capacitor bank can interfere with a facilities ground fault protection system and suggest that all banks applied on industrial and commercial power systems be left ungrounded.

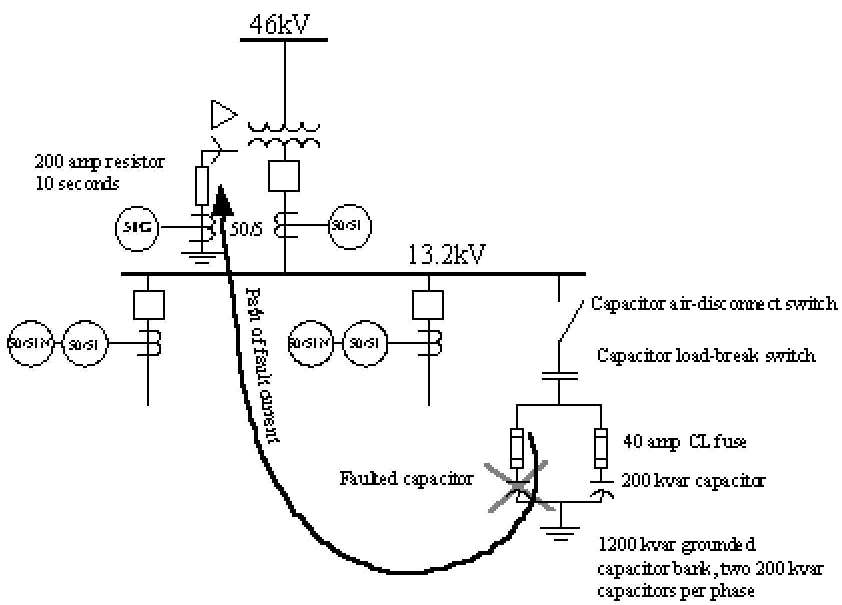


*Figure 1 - Typical industrial facility showing ground fault protection system, failed capacitor, and fault current path for a failed capacitor.*

## Background

In general, most industrial facilities with 2.4kV through 13.8 kV distribution are resistive grounded through a grounding resistor as shown in Figure 1. The systems are resistive grounded to reduce the fault current and arc damage during line to ground faults. This is particularly true for systems with directly connected motors. The resistor typically has a 10 second ampere rating (continuous and 60 second ratings are also available, but are not typical) that is approximately equal to the ground current that would flow if a line to ground fault should occur. The continuous current rating of a 10 second resistor is much less than the 10 second rating. For example, a 200 amp 10 second resistor may have a continuous rating of 50 amps. For this reason, the ground fault relay, device 51G, is typically set to pick up at approximately 10% of the resistor rating or 20 amps. This protects the resistor from un-cleared feeder faults and other system abnormalities that may damage the resistor.

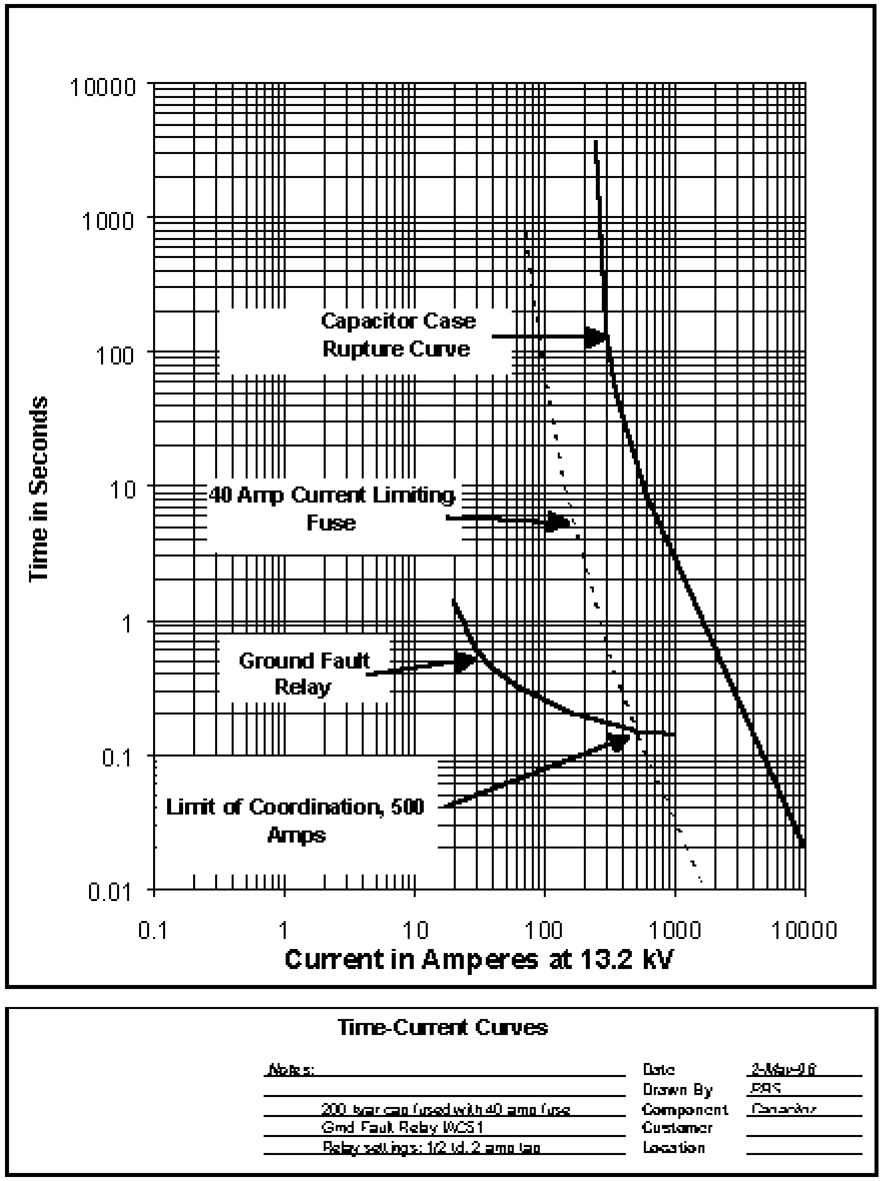


*Figure 2 - Time current coordination plot of system shown in Figure 1*

## Resistive Grounded Systems

Figure 1 is used to illustrate how a grounded capacitor bank can interfere with the ground fault protection system of a resistive grounded system. The main concern arises when a capacitor fails as shown in Figure 1 by the "X". Since medium voltage capacitors fail shorted, a faulted capacitor is like applying a line to ground fault on the facilities power system. Since the system is grounded through a 200 amp resistor, approximately 200 amps of fault current will flow though the resistor. This 200 amps of current in the ground resistor will be detected by the ground fault relay (51G) and will cause it to pickup since its pickup is set at approximately 10% of the resistor rating. This will cause the main breaker of the facility to trip, causing a plant shut down and possibly a major economic loss.

One might think the 40 amp current limiting capacitor fuse would blow before the main breaker, but this is not the case as shown in Figure 2. In fact, a resistor on the order of 500 amps would be required before coordination would be achieved between the 40 amp capacitor fuse and the facilities main ground fault protection relay. For larger capacitors with larger fuses, the limit of coordination (or resistor size) would be even higher, on the order of 1400 amps for a 500 kvar capacitor.

To make the situation worse, the cause of the main breaker tripping would not be known unless the bank is equipped with a fast enough unbalance detection scheme (main breaker trips and clears before the capacitor fuse blows) that has a mechanical flag or latching contact. Upon re-energization of the system, the main breaker would trip again. This would repeat itself until the capacitor fuse blew.

Even after the capacitor fuse blows, there is still a strong possibility that the system could not be brought on-line. This would be due to the unbalance on the capacitor bank. For the system in figure one, the unbalance current flow for a blown fuse would be approximately 26 amps, enough to trip the main ground fault relay.

If the bank is equipped with an unbalance detection scheme, the cause of the main breaker tripping may be discovered, but there may still be a problem of determining which capacitor has failed. This is because the main breaker trips before the fuse is allowed to melt and clear (see Figure 2). Therefore, blown fuse indicators would not be actuated, and an ohm meter or capacitance tester would be necessary. This would be a time and cost consuming task.

**Solidly Grounded Systems**

Although most commercial and industrial power systems are resistive grounded, there are situations where they may be solidly grounded. This may be due to the design engineers preference or because the facility is directly connected to the utility distribution system. The same possibility as describe above exist for systems that are connected to the utility through a solidly grounded step down transformer, but is less likely because the ground fault currents are much higher, and the current limiting fuse is much quicker at the higher current levels. This can be seen in Figure 2. Typically ground faults would be on the order of 7000 to 20,000 amps on these systems, and coordination could be achieved. Coordination, however should be checked, since a plant shut down can be quite costly.

**Systems Connected Directly To A Utility Distribution System**

Facilities that are fed directly from their utilities distribution system (no step down transformer) as shown in Figure 3 are grounded in accordance with the utilities grounding practices. Typically this would be a multi-grounded 4-Wire system.

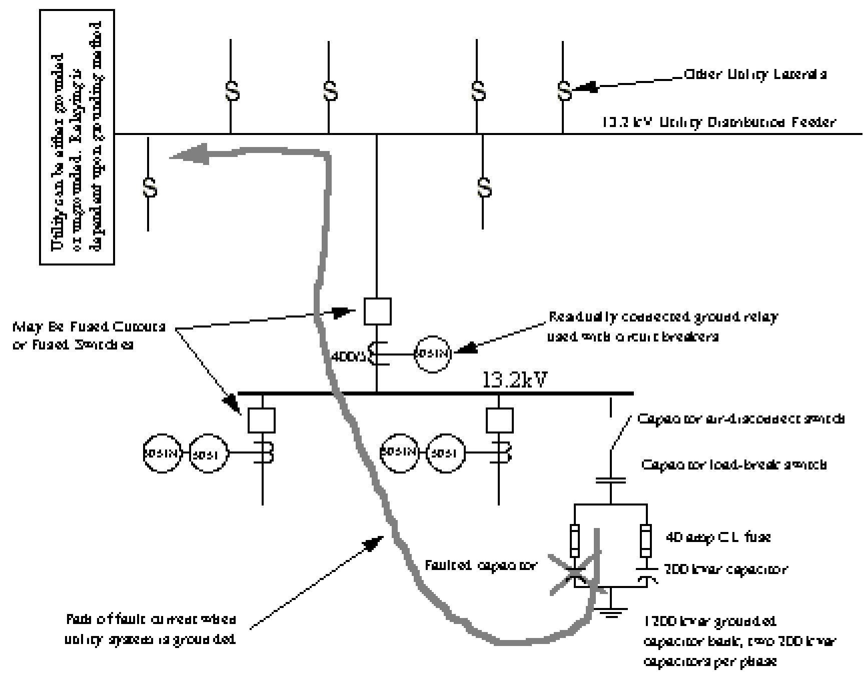


*Figure 3 - Ground fault current path when industrial is connected directly to utility distribution feeder.*

The facility may or may not have ground fault relays on the service entrance conductors. If relays are present, the ground fault relay would be a residually connected overcurrent relay or a 51N device. These relays are typically not set as low as the 51G device due to error currents in the phase relays. Facilities strive for minimum allowable pickup settings, and therefore coordination should still be checked as was done in Figure 2.

For utilities that utilize a uni-grounded system or an ungrounded system, the utility should be consulted to determine if the capacitor bank grounding will interfere with their system. Ground relays on a uni-grounded utility distribution system may be set low enough to pick up. Ungrounded systems raise an unrelated concern with over-voltages from un-cleared ground faults.

## Conclusion

With the forgoing discussion it should be clear that the installation of grounded capacitor banks to industrial and commercial power system can interfere with a facilities ground fault protection system. Proper engineering may be done to overcome these problems, but this adds to the cost and complexity of the installation.

The negative issue associated with ungrounded capacitor banks are as follows:

- Fuse coordination is difficult on smaller banks because a failed capacitor will only draw three times the banks nominal current rating.

- Overvoltage conditions can occur on the un-faulted capacitors on unbalance banks due to a fuse blowing. This condition can be eliminated by changing the number of capacitors, isolating neutral connections, and/or by adding a neutral unbalance detection scheme to the bank.

The above issues can be engineered out of the design by the manufacturer without any regard to the system for which it is being applied to. This puts the responsibility with the manufacturer and not the facilities engineer or design engineer working on the capacitor bank installation.

NEPSI's bulletin on Neutral Voltage Unbalance Protection provides further information on the above material. ***LINK HERE***

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