Neutral Voltage Unbalance Protection System

Introduction

Ungrounded-wye connected capacitor banks and harmonic filter banks applied at the medium voltage level should be equipped with a neutral voltage unbalance protection system. An unbalance protection system serves two primary functions:

- It provides over voltage protection to capacitors. These over voltages are primarily caused by blown fuses and can cause damage to the capacitors.

- It provides blown fuse indication.

The following discussion provides background information on setting and applying neutral voltage unbalance protection relays on ungrounded-wye connected capacitor banks and harmonic filter banks. It also serves as an introduction to NEPSI's unbalance protection system. Further information on this topic can be obtained from NEPSI's technical staff or in IEEE C37.99-1990, "IEEE Guide for the protection of Shunt Capacitor Banks".

Background

Shunt capacitor banks and harmonic filter banks are not typically grounded in industrial and commercial power systems for a variety of reasons. The main reason for keeping them ungrounded is to overcome the disadvantages associated with grounded wye capacitor banks. These disadvantages include:

- Grounded banks provide a low-impedance path to ground for 0-sequence (ground or unbalanced) harmonic currents. These harmonic currents have the potential of exciting resonances and may also cause communication interference and nuisance ground fault relay operation.

- Grounded banks may cause ground fault relay operation when unbalanced due to a blown capacitor fuse(s), capacitor tolerances, and/or system voltage unbalances.

- Grounded banks have high discharge currents during system ground faults. These discharge currents can cause nuisance fuse operation and surge arrester damage.

- Grounded banks on resistive grounded systems (very prevalent on industrial and commercial power systems) can be damaged during system ground faults.

Due to these disadvantages, many capacitor banks and harmonic filter banks are left ungrounded for industrial and commercial power systems up to 34.5kV. The primary disadvantage of ungrounded banks is the over voltage that occurs when the bank is unbalanced due to a capacitor fuse blowing as shown in the Figure 1 below. The over

voltage appears across the remaining capacitors on the phase in which the fuse has opened. The over voltage can be as high as 50%, depending upon bank configuration, and can reduce the life and permanently damage the remaining capacitors. In addition, the kvar output of the bank is reduced, and can cause the industrial or commercial customer to be hit with a power factor penalty. For this reason, neutral voltage unbalance protection should be considered.

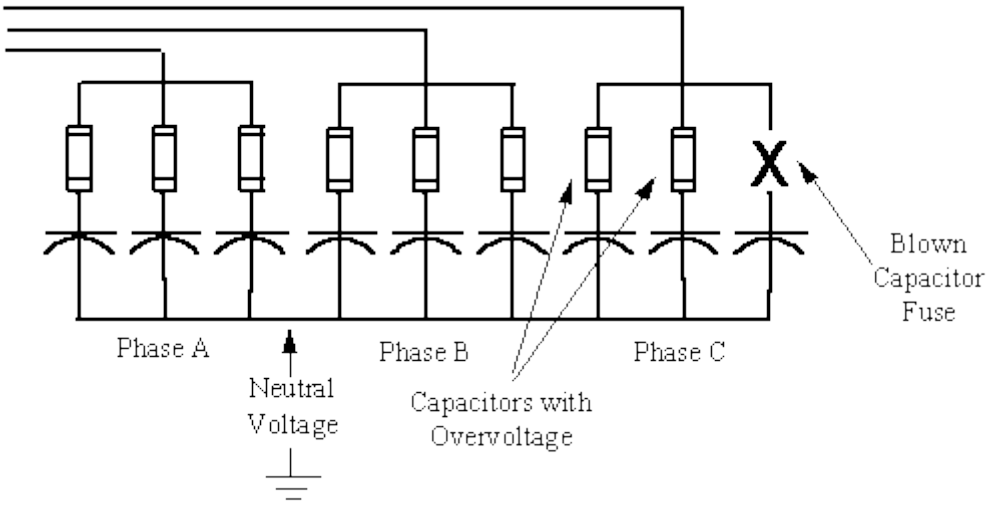

Figure 1 - Over voltage Caused by capacitor fuse blowing

Neutral Voltage Unbalance Protection Considerations

There are many technical considerations when setting and applying a neutral voltage unbalance protection system. The following bullets list the major considerations. They may not all be obtainable for every bank configuration.

- The unbalance protection system should coordinate with the individual capacitor unit fuses such that the fuses operate to isolate a defective capacitor unit before the bank is switched out of service, and thus provide a convenient visual means of locating the defective capacitor unit.

- Where possible, the unbalance protection system should be sensitive enough to alarm for the loss of one or more capacitors, but trip out for a loss of sufficient or additional capacitor units that will cause an over voltage in excess of 110% on the remaining capacitors.

- The unbalance protection system should have a time delay of at least 0.5 seconds to overcome false operations due to inrush, ground faults on the line, lightning, switching of nearby equipment, and other transient unbalance conditions.

- The unbalance protection system should have a lockout feature to prevent automatic reclosing of the capacitor bank switching device.

- If the capacitor bank is not equipped with an over voltage relay, the unbalance protection system should be set with consideration given to the maximum continuous system operating voltage.

- To allow for the effects of inherent unbalance, the unbalance protection system should be set to alarm at one-half the level of neutral displacement determined for the desired alarm condition.

- To allow for the effects of inherent unbalance, the unbalance protection system should be set to trip at a level of neutral displacement that will not cause a capacitor over voltage in excess of the manufacturer's recommended maximum continuous operating voltage.

Figure 2 below can help in meeting the above considerations. The figure shows that a 28% loss in phase kvar can result in a 10% over voltage. This is the ANSI/IEEE continuous over voltage limit for standard off-the-shelf shunt capacitors. Other limits are shown for setting the time-delay requirements on the relay.

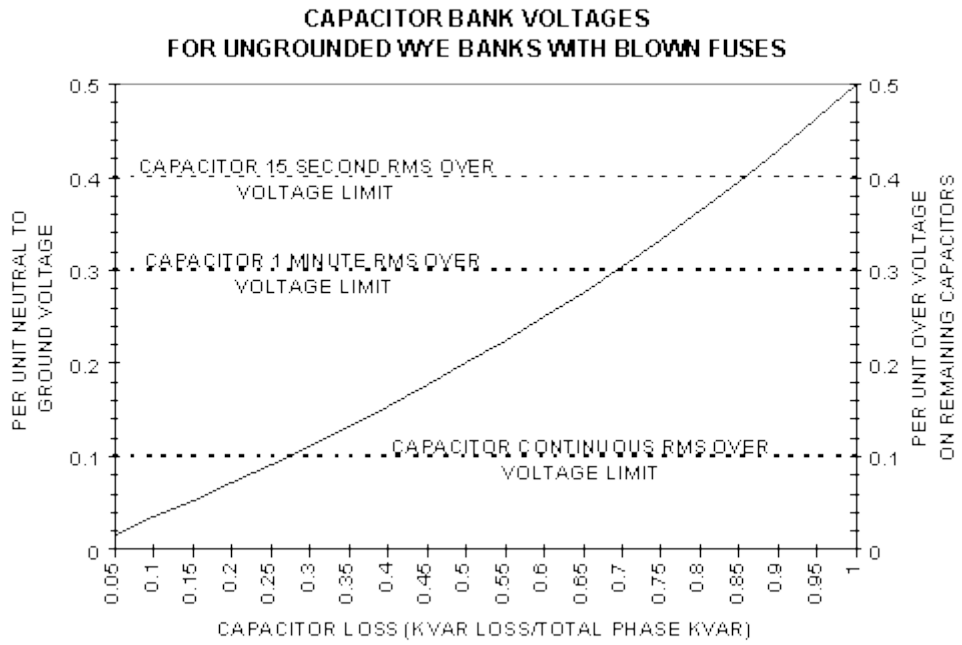

Figure 2 - Graph of Neutral-Ground Voltage and Per Unit Overvoltage for UngroundedCapacitor and Harmonic Filter Banks with Blown Fuses

NEPSI's Neutral Unbalance Protection System

The figure below shows NEPSI's neutral unbalance relay protection scheme designed for ungrounded-wye connected capacitor banks and harmonic filter banks. The protective scheme consists of a time delay over voltage relay or meter relay and a neutral to ground potential sensing device.

The neutral to ground potential sensing device is actually a resistive voltage divider and is selected for the lowest voltage ratio attainable, while still being able to withstand transient and continuous over voltage conditions in order to obtain the maximum unbalance detection sensitivity. The device is also rated for full line potential since it can see full line potential during energization.

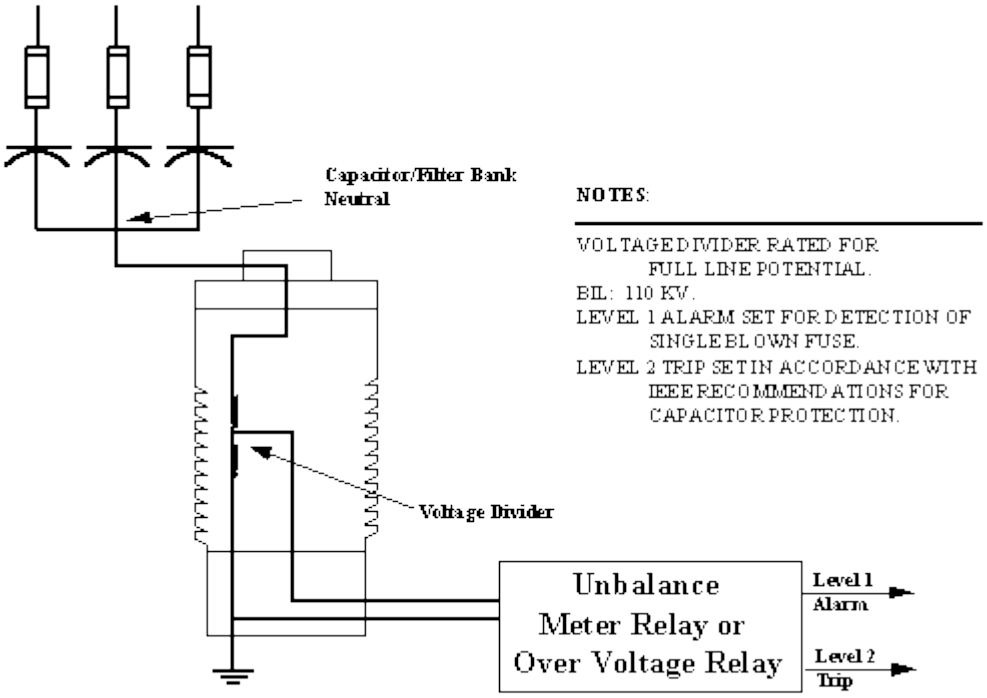

Figure 3 - Typical Neutral Voltage Unbalance Protection System for a 13.8kV Capacitor Bank

Either an over voltage relay or over voltage meter relay is available from NEPSI. Both relays serve the same function. The meter relay, however, allows the protection engineer the ability to monitor the "ambient" neutral voltage from inherent unbalances. This allows the relay to be set above the inherent neutral voltage and will help eliminate nuisance tripping and alarming. The over voltage meter relay is equipped with two independent relay outputs that can be set to trip at different levels. The first level can be set to alarm for a blown fuse, while the second level can be set to trip the bank off line for damaging over voltages.

For more information on the above protection system and other available from NEPSI, contact NEPSI or the nearest NEPSI sales representative.

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