Mitigation of Voltage Swells I

3.2.1. Surge arresters and transient voltage surge suppressors

Arresters and TVSS devices protect equipment from transient over voltages by limiting the maximum voltage, and the terms are sometimes used interchangeably. However, TVSSs are generally associated with devices used at the load equipment. A TVSS will sometimes have more surge-limiting elements than an arrester, which most commonly consists solely of MOV blocks. An arrester may have more energy-handling capability.

The elements that make up these devices can be classified by two different modes of operation, *crowbar* and *clamping.*

Crowbar devices are normally open devices that conduct current during overvoltage transients. Once the device conducts, the line voltage will drop to nearly zero due to the short circuit imposed across the air or a special gas. The gap arcs over when a sufficiently high overvoltage transient appears. Once the gap arcs over, usually power frequency current, or ―follow current,‖ will continue to flow in the gap until the next current zero.

Thus, these devices have the disadvantage that the power frequency voltage drops to zero or to a very low value for at least one-half cycle. This will cause some loads to drop offline unnecessarily. Clamping devices for ac circuits are commonly non- linear resistors (varistors) that conduct very low amounts of current until an overvoltage occurs.

Then they start to conduct heavily, and their impedance drops rapidly with increasing voltage. These devices effectively conduct increasing amounts of current (and energy) to limit the voltage rise of a surge. They have an advantage over gap-type devices in that the voltage is not reduced below the conduction level when they begin to conduct the surge current. Zener diodes are also used in this application. Example characteristics of MOV arresters for load systems are shown in Figs. 3.12(a) and 3.12(b).

MOV arresters have two important ratings. The first is maximum continuous operating voltage (MCOV), which must be higher than the line voltage and will often be at least 125 percent of the system nominal voltage. The second rating is the energy dissipation rating (in joules). MOVs are available in a wide range of energy ratings. Figure 3.16 shows the typical energy-handling capability versus operating voltages.

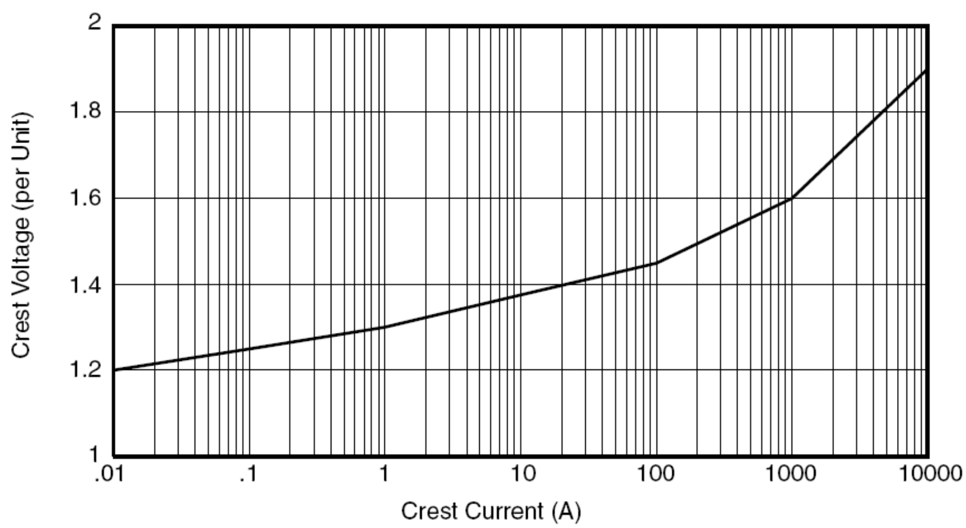

Figure 3.12(a) Crest voltage versus crest amps

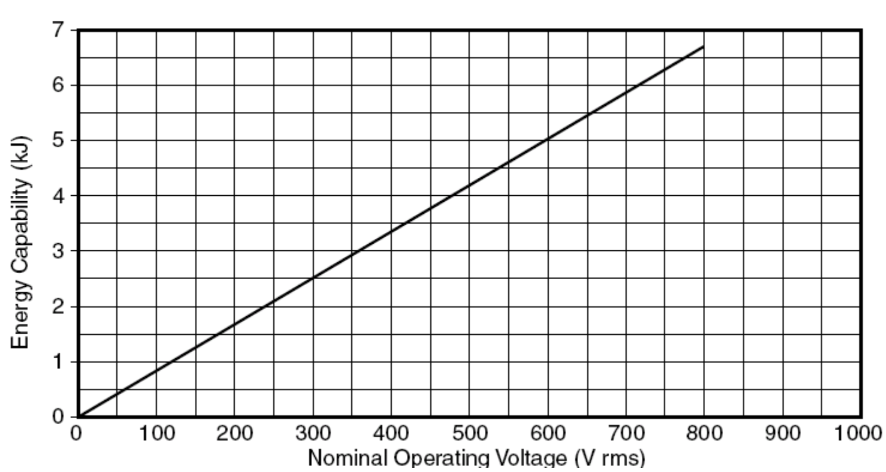

Figure 3.12(b) Energy capability versus operating voltage.

3.2.2 Isolation Transformers

Figure 3.13 shows a diagram of an isolation transformer used to attenuate high-frequency noise and transients as they attempt to pass from one side to the other. However, some common-mode and normal-mode noise can still reach the load. An electrostatic shield, as shown in Figure 3.13(a), is effective in eliminating common-mode noise. However, some normal-mode noise can still reach the load due to magnetic and capacitive coupling.

The chief characteristic of isolation transformers for electrically isolating the load from the system for transients is their leakage inductance. Therefore, high-frequency noise and transients are kept from reaching the load and any load-generated noise and transients are kept from reaching the rest of the power system.

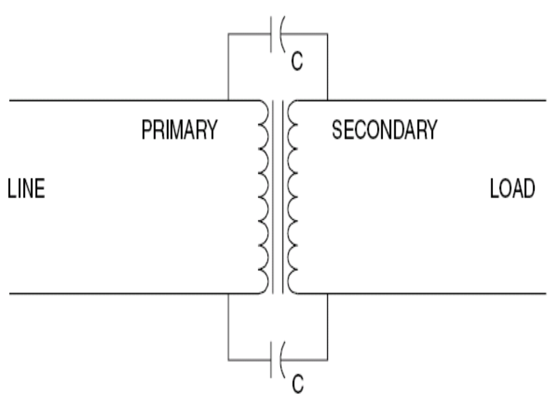

Figure .13 Isolation transformer

Voltage notching due to power electronic switching is one example of a problem that can be limited to the load side by an isolation transformer. Capacitor-switching and lightning transients coming from the utility system can be attenuated, thereby preventing nuisance tripping of adjustable-speed drives and other equipment.

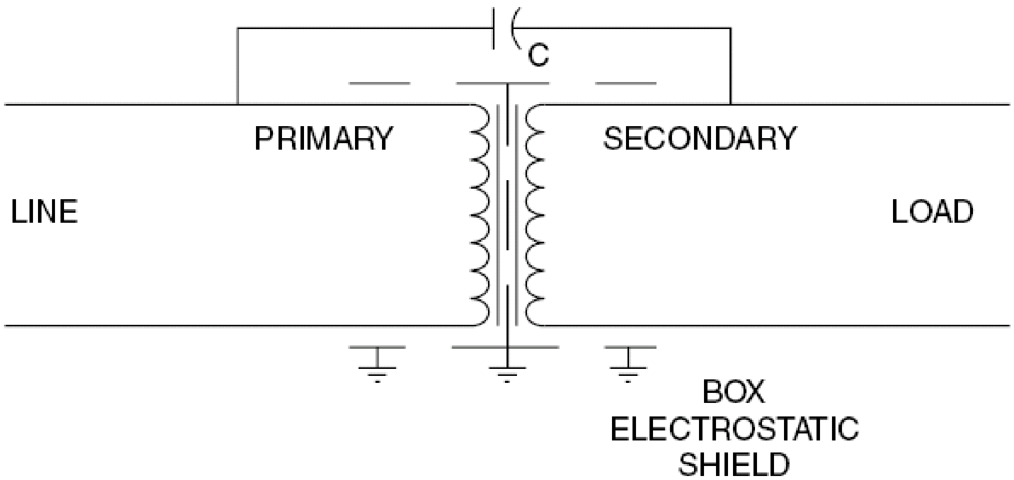

Figure 3.13 (a) Isolation transformer with electrostatic shield.

3.2.3 Low-Pass Filters

Low-pass filters use the pi-circuit principle illustrated in Fig. 3.14 to achieve even better protection for high-frequency transients. For general usage in electric circuits, low-pass filters are composed of series inductors and parallel capacitors. This *LC* combination provides a low impedance path to ground for selected resonant frequencies. In surge protection usage, voltage clamping devices are added in parallel to the capacitors. In some designs, there are no capacitors.

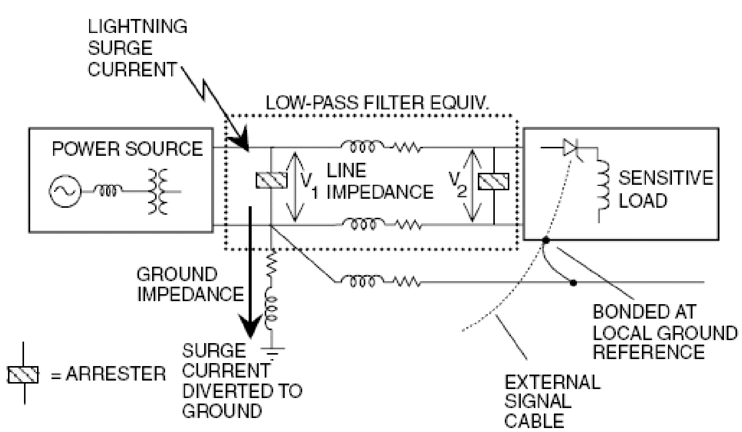

Figure 3.14 Demonstrating the principles of overvoltage protection

Figure 3.15 shows a common hybrid protector that combines two surge suppressors and a low-pass filter to provide maximum protection. It uses a gap-type protector on the front end to handle high-energy transients. The low-pass filter limits transfer of high-frequency transients. The inductor helps block high-frequency transients and forces them into the first suppressor. The capacitor limits the rate of rise, while the nonlinear resistor (MOV) clamps the voltage magnitude at the protected equipment.

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