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What Are the Different Roles of Isolation Transformers and Surge Protective Devices (SPDs)?

There is often confusion between the roles of surge protection devices (SPDs) and isolation transformers. To protect sensitive electronics and equipment from transient events, various factors must be considered. Whether a transient originates **externally or internally, signal noise, common mode transients, differential mode transients and ground potential rise** can cause problems for poorly protected equipment. In this post, we clarify the applications of both isolation transformers and SPDs and how they stand up to various electrical events.

What is a Surge Protection Device?

Surge protective devices (SPDs) are non-linear voltage clamping devices. They are installed across lines for protection (in parallel with the equipment) and, thus, do not need to be rated to the line current. A SPD is normally a high impedance state under nominal supply voltage conditions. Under transient conditions, the transient voltage increases the line voltage to a point where the SPD clamping threshold is reached. The SPD then rapidly moves into a lower impedance state, diverting the excess transient energy (current) to ground, thus limiting the transient voltage to a safe level. After diverting the transient, the SPD automatically resets to a high impedance state.

What is a Surge Filtering SPD?

A surge filtering SPD improves on the standard SPD by adding a low pass and RFI/EMI filter. This secondary filtering stage is typically installed in series but, is also used in parallel panel applications. Series surge filters reduce the rapid rate of pre-clamped voltage rise, provides further attenuation to the clamped voltage, and reduces the small signal noise that may be below the SPD clamping voltage. Surge filters wired in series must be rated to the maximum circuit current.

What are Isolation Transformers?

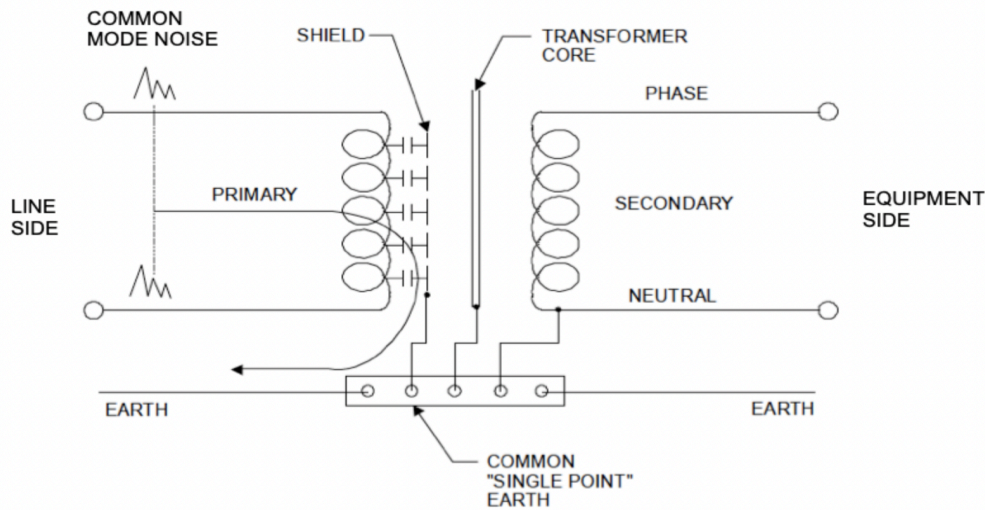
Isolation transformers are generally composed of two separate windings with a magnetic shield between the windings to offer noise control. The transformer carries the full load current, meaning it must be suitably sized. **Rather than employing non-linear clamping devices, the transformer operates by attenuation.** Attenuation is normally quoted in decibels (dB) for **small signal noise conditions**, which are minor transient conditions for which the transformer may offer considerably less attenuation. Each 20dB of attenuation equates to a reduction in noise voltage by a factor of 10. Therefore, 60dB of attenuation is a 1000% reduction in the noise voltage between input and output...

The two winding isolation transformer is a useful building block for power conditioning applications. It is not a power conditioner in its own right, but it is one of the most effective devices available for rejecting common mode noise. Isolation transformers have very little effect on attenuating differential mode noise, particularly at lower frequencies, since they are designed as a “pass” device at power frequencies.

When coupled with a suitable ground or shield, **isolation transformers can present an effective barrier to high frequency common mode noise and prevent propagation of this noise to the down stream equipment** through the power supply or ground system.

The main benefit offered by isolation transformers is the input-to-output isolation, where the output circuit can be re-grounded and isolated from the input or other ground noise sources. This isolation can also be useful where ground potential rise protection is not available by normal bonding procedures.

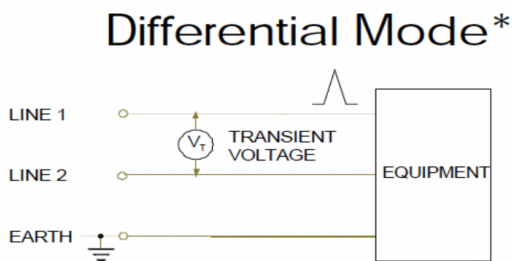
As shown below, a shielded isolation transformer provides a path for high frequency common mode noise to flow via capacitive coupling to the grounded screen and back along the ground. For the screening to be effective, the screen, transformer core and grounded conductors should be bonded together at a single point as shown.



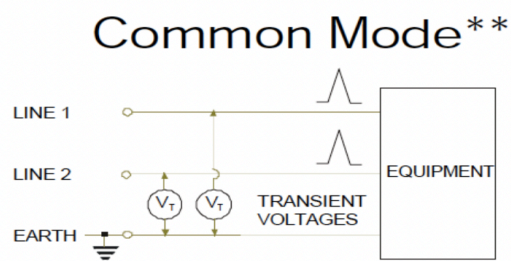
The shielded isolation transformer can be effective against common mode noise and low-level transients, but effectively provide no attenuation of differential mode noise and transients.

Isolation transformers have other power conditioning qualities, such as:

- Dampening three phase harmonics.
- “Capturing” **triplen harmonics** in the Delta of a Delta-Wye transformer.
- Enabling a stable ground reference to be established through a Neutral-Ground bond on the secondary side.



*Also known as Transverse, Normal or Metallic Modes



**Also known as Longitudinal Mode

Consider now a high voltage, high current transient introduced onto a power line by the direct and indirect (induced) effects of lightning activity or a switching surge. If these transients are differential mode, meaning they are induced onto a line with respect to neutral, then the isolation transformer will effectively pass these transients with little or no attenuation. This occurs because the isolation transformer is designed to “pass” power frequencies in the differential mode, and the frequency make up of a lightning transient means that most of the energy content is in frequency components below a few tens of a kilohertz, which is well within the pass band of most isolation transformers.

If, on the other hand, these signals are common mode, then a **suitable shielded isolation transformer will provide effective protection against such surges, as long as the peak voltage does not exceed the insulation rating of the transformer.** In some cases, the peak voltage magnitude that results from a direct strike to overhead, low voltage power feeds near the point of entry to a facility can exceed the insulation rating of a 1:1 isolation transformer, resulting in a flashover and potential damage to the down stream equipment.

Suitability of the Devices

The most common cause of industry power quality equipment reliability problems is generally differential mode voltage transients. Electronic equipment is far more susceptible to differential mode impulses than common mode.

Note that, although most lightning impulses are common mode at the point of coupling, these are converted to a differential mode at the service entrance by the presence of the neutral-ground bond. Thus, isolation transformers are ineffective at rejecting the most predominate type of transient.

A more effective transient protection device for sensitive equipment is a SPD with low pass series filter, which offers both effective common and differential mode transient and noise protection.

Isolation Transformers vs. SPDs

In conclusion, there is an overlap in the protection provided by isolation transformers and SPDs combined with low pass filters. However, **due to overall performance, size, weight and cost, the SPD is better for most industry protection applications.** The smaller and lighter SPD provides superior protection against differential mode transients and adequate protection for an estimated 85% to 90% of industries noise problems. This makes it the first low cost choice for most installers in the protection of sensitive electronic industrial equipment, such as a programmable logic controller (PLC).

Isolation transformers are still the best solution for the small number of sites that have electrically noisy grounds or where isolation is required. However, a SPD filter may still need to be added to give effective differential mode transient protection.

PROBLEMS	SOLUTIONS	
	ISOLATION TRANSFORMERS	SPD WITH LOW PASS FILTER
Solution Cost	\$\$\$	\$
Ground Potential Rise	✓✓✓	x
Noise	✓✓	✓
Common Mode Transients	✓✓	✓✓✓
Differential Mode Transients	x	✓✓✓

[x- no protection, ✓ - Good, ✓✓ - Better, ✓✓✓ - Best,]