

Isolation Transformers and Surge Protection

There is often confusion between the roles of Surge Protection Devices and Isolation Transformers. This Technical Note attempts to clarify the applications that each is best suited to.

Surge Protection Devices:

Surge Protection Devices (SPDs), also known as Transient Voltage Surge Suppressors (TVSSs) are non-linear voltage clamping devices. They are installed across the lines to be protected (in parallel with the equipment) and thus do not need to be rated to the line current. The SPD is normally in a high impedance state under nominal supply voltage conditions. Under transient conditions the line voltage is increased by the transient 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/source and thus limiting the transient voltage to a safe level. The SPD automatically resets after the transient.

Series Filtering SPD:

A Series Filtering SPD is an improvement on the standard SPD where a low pass and RFI/EMI filter is added. This secondary filtering stage reduces the rapid rate of pre clamped voltage raise, plus provides further attenuation to the clamped voltage as well as small signal noise that may be below the SPD clamping voltage. The Surge Filter is series connected devices and must be rated to the maximum circuit current.

Isolation Transformers:

Isolation Transformers are generally composed of two separate windings with a magnetic shield between these windings to offer noise control. The transformer carries the full load current, and thus must be suitably sized. Rather than employing non-linear clamping devices, the transformer operates by attenuation. Attenuation is normally quoted in dB (decibels) for small signal noise conditions (not large transient conditions to which the Transformer may offer considerably less attenuation). Each quoted 20dB of attenuation equates to a reduction in noise voltage by a factor of 10. Hence 60dB attenuation is a 1000% reduction in the noise voltage between input and output.

The main benefit offered by Isolation Transformers is the input-to-output isolation, where the output circuit can be re-grounded and isolated from input or other ground noise sources. This isolation can also be useful where Ground Potential Rise protection can not be afforded by normal bonding procedures.

Transformer Operation:

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 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 as they are designed as a "pass" device at power frequencies. When coupled with a suitably grounded or shielded, Isolation Transformers can present an effective barrier to high frequency common mode noise and prevent propagation of this noise to the downstream equipment via the power supply or ground system.

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 thus back along the ground. For this screening to be effective, the screen, transformer core and grounded conductors should be bonded together at a single point as shown.

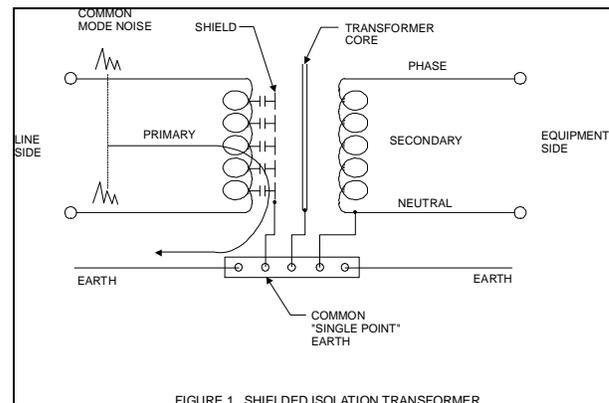
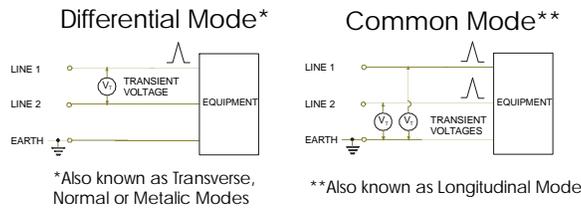


FIGURE 1. SHIELDED ISOLATION TRANSFORMER

The shielded Isolation Transformer can thus be seen to 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 and enabling a stable ground reference to be established via a Neutral - Ground bond on the secondary side.



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 (i.e. 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 is such that most of the energy content is in frequency components below a few tens of kilohertz (i.e. 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 **provided the peak voltage does not exceed the insulation rating of the transformer.** In some cases, the peak voltage magnitude resulting 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:

The most common causes 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 will be 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. This offers both effective common and differential mode transient and noise protection.

In conclusion, there is an overlap in the protection provided by Isolation Transformers and SPDs combined with Low Pass Filters, but 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 low cost first choice for most installers in the protection of sensitive electronic industrial equipment such as PLCs.

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 also 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,]

