# ISOLATION TRANSFORMERS

(For Noise Suppression)

Ordinary isolation transformers isolate one circuit from another while magnetically coupling wanted energy from one to the other. Such a transformer is adequate for use with low-gain circuits or insensitive instruments. However, if the transformer must work into a high-gain load or sensitive instrumentation, noise potentials between the primary circuit and ground must be prevented from affecting the secondary circuits due to capacitive and resistive coupling between the transformer's windings.

Traditional techniques for keeping noise from reaching the transformer secondary, e.g., the standard Faraday shield (a grounded single turn of conducting foil between the windings) will divert much of the primary noise current to ground. But noise still can be coupled into the secondary because of the electrostatic field around the Faraday shield and will cause serious problems in the secondary circuits.

Unique box-shielding techniques employed in Topa Ultra-Isolation Transformers (See pages 74 to 75) effectively overcome this problem. The impedances between windings are among the highest commercially obtainable.

Isolation transformers should be conservatively rated so that they remain cool under full load conditions and have good regulation. They should be especially designed for these five important applications:

1. For isolating sensitive instrumentation from noisy power lines.
2. For maximum common-mode noise rejection.
3. For isolating noisy equipment from noise-sensitive equipment, both of which share the same power line.
4. For minimizing transverse noise (noise across winding) resulting from common-mode noise (noise between winding and ground).
5. For complete electrostatic guarding. When the complete electrostatic shield surrounding the transformer secondary is extended around the equipment being electrostatically guarded, shielding is maximized.

FIG. 1

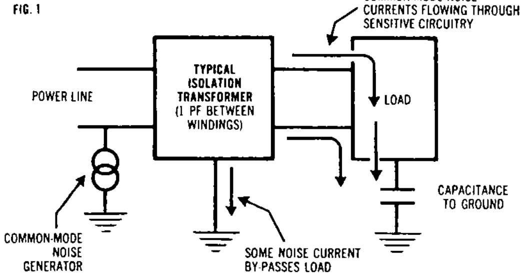
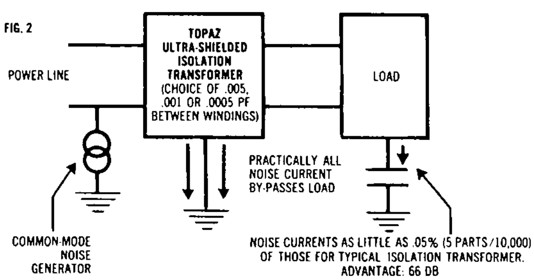



FIG. 2




## Common-Mode Noise Rejection

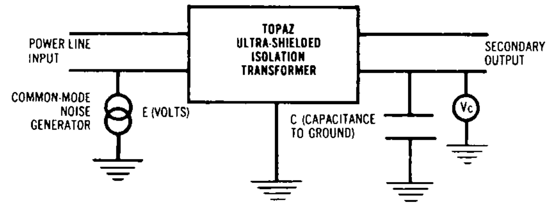
Box-shielding techniques employed in the construction of Isolation Transformers should achieve maximum impedance between windings while offering a very low impedance path for common-mode noise to ground. To accomplish this, the leakage resistance should be kept at a high level (10,000 megohms) and the effective interwinding capacitance maintained at the guaranteed low values stated below. This provides a significant advantage over the typical isolation transformer using traditional shielding methods (Fig 1-2).

Three basic categories of shielding excellance that are commercially available are:

1. .005 picofarads (.005x10-12picofarads)
2. .001 picofarads (.001x10-12picofarads)
3. .0005 picofarads (.0005x10-12picofarads)

Common-mode noise voltage ($V_C$) in dB is measured relative to input noise voltage (E), as in Figure 3. Measurements are over the audio frequency band.

FIG. 3




For each category of interwinding capacitance, the common-mode noise rejection, stated in dB relative to input noise E, is shown in the following table. $V_C$ is measured across C, a .01 $\mu$f capacitor to ground.

| $C_X$ (picofarads) | $V_C$* |
|---|---|
| .005 | -126 dB |
| .001 | -140 dB |
| .0005 | -146 dB |

*For noise across capacitances to ground other than C=.01 $\mu$f, add -20 dB to above numbers for each factor of 10 *increase* in C, or add +20 dB for each factor of 10 *decrease* in C.

## Suppression of Transverse Noise Generated by Common-Mode Noise Input

The Shielding should minimize transverse noise caused by a common-mode noise source. Figures 4 and 5 illustrate how the ultra-shielding techniques achieve a reduction of transverse noise voltage greater than 40 dB below the value attainable by the normally best box shielding methods.

Stated and illustrated in other terms, the ordinary shielded isolation transformer (including a box-shielded type) will itself generate a transverse noise voltage between either primary or secondary terminals due to a common-mode noise voltage appearing between any of these terminals and ground.

FIG. 4

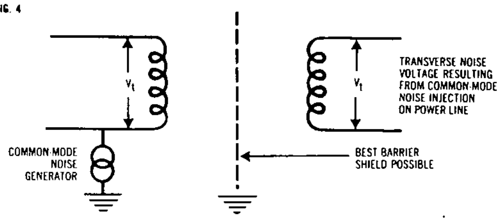
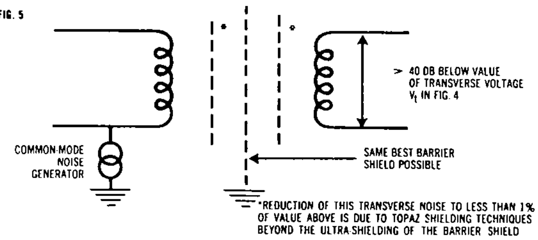



FIG. 5




In Figure 4, transverse noise appears as a voltage ($V_t$) across both primary and secondary windings of an isolation transformer when a common-mode noise signal causes current to flow in the primary winding and from there to ground via capacitance to a grounded shield. Similarly, common-mode noise generated by noisy equipment in the secondary environment can be transformed into transverse noise which not only appears across the secondary but is also magnetically coupled to the primary, thereby contaminating the power lien. A good isolation transformer can reduce this transverse noise to less than 5/1000 of the amount encountered in standard box-shielded isolation transformers.

## Electromagnetic Noise Suppression

Often the instrumentation in the secondary circuits is sensitive enough to be affected by electromagnetic noise fields emanating from the isolation transformer itself. Precautions are taken in Ultra-Isolation Transformers to keep these stray fields to a minimum. A typical level at a distance of 18 inches from the geometric center of the transformer is 0.1 gauss. The noise will roughly obey an inverse cube law.

That is, at double the distance, the noise level will be 1/8 of this value; at 4 times the distance, 1/64 the value. Typical noise fields around a loaded 5 KVA Topaz transformer are depicted in Figures 7 through 9. Both the radial field (component of magnetic lines of force emerging from geometrical center of transformer) and the field at a right angle to the radial field are depicted in the figures.

**NOISE FIELD — DB RELATIVE TO 1 GAUSS AT DISTANCE OF 18″ FROM CENTER OF TOPAZ 5KVA STANDARD ULTRA-SHIELDED TRANSFORMER**

NOISE FIELD ALONG RADIUS ———— NOISE FIELD PERPENDICULAR TO RADIUS - - - - - -

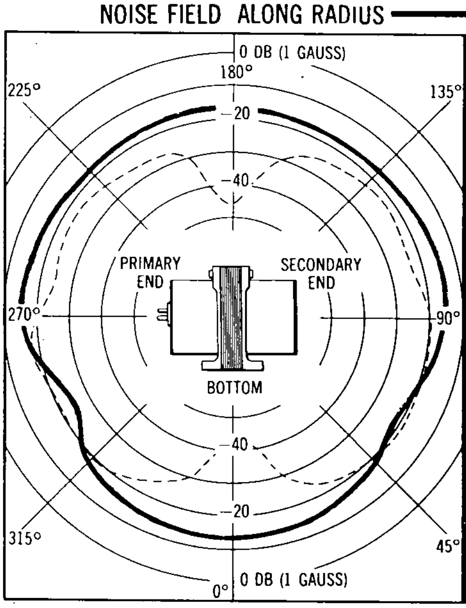



**FIG. 7**

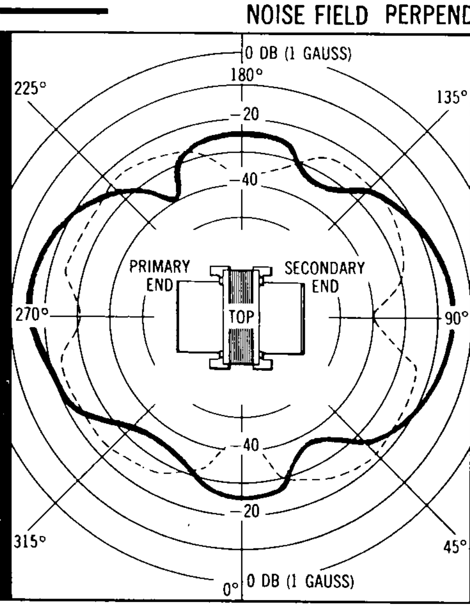



**FIG. 8**

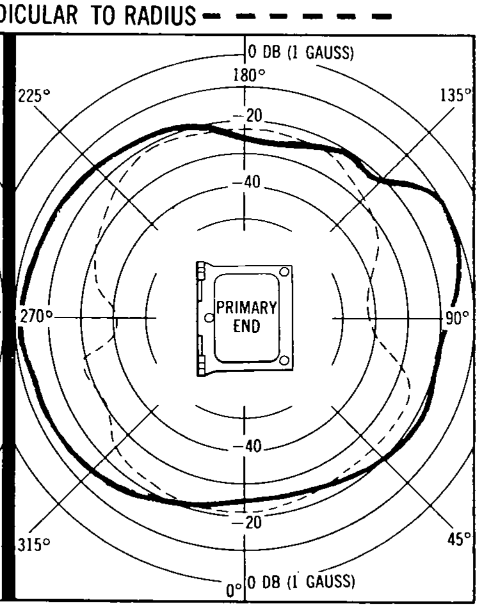



**FIG. 9**