Understanding Noise
Cut Transformers

By Quality Transformer and Electronics
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Quality Transformer and Electronics first developed the Noise Cut Transformer (NCT) as an experimental product with the goal of providing high levels of noise attenuation for sensitive equipment in the Semiconductor Capital Equipment industry. However, we are beginning to see further demand and applications for these units where power quality is an issue. Many electronic systems incorporate sensitive components that require a reduction in the noise that can interfere with a tool’s operation. Quality Transformer and Electronics’ Noise Cut Transformers provide a solution to this problem. Our Noise Cut Transformers combat transient and common mode noise—noise coming from a plethora of sources. Our Noise Cut Transformers eliminate such noise and attenuate the spikes to negligible values, providing complete protection against these electrical disturbances.

Electromagnetic Interference

The increase of electronic devices of varying frequency ranges held within close proximity to one another has led to an increase in stray interference, or electrical noise. The types and sources of this electrical noise vary. For general purposes, we can call the noise found affecting circuits **electromagnetic interference**, which is the noise that affects an electrical circuit from either electromagnetic induction or electromagnetic radiation emitted from an external source—usually other electrical equipment on the line. The disturbance may interrupt or degrade the performance of the circuit. The interfering effect from a disturbing signal on an electronic circuit depends on three things: 1) the magnitude and type of interfering signal, 2) the attenuation of the signal between source and receiver, and 3) the susceptibility of the receiver. Furthermore,
depending on the impedance, magnetic or electric fields can also affect the circuit. For instance, time-varying electric fields greatly affect high-impedance circuits, while time-varying magnetic fields greatly affect low-impedance circuits.

An important topic that also needs addressing is the method by which noise can get onto a circuit as this will affect the type of solution required. Noise can get onto a circuit three ways: 1) conduction, 2) near-field induction, and/or 3) radiation (far field).

**Conduction** is the interference created when equipment with a common impedance is located between the interfering source and the interfered-with equipment. This is due to multiple pieces of equipment sharing a common power supply and a common ground path. Effectively, the resulting common impedance couples isolated circuits. For reasons of economy or space, it can become necessary for multiple pieces of equipment to share one power supply.

**Near-field induction** is either, or both, inductive and capacitive coupling between circuits and is commonly referred to as common mode interference. For simplicity, we will treat inductive coupling as mutual impedance, and capacitive coupling as mutual admittance. Inductive coupling, or mutual impedance, is the result of two conductors, usually wires, are configured in a way that the change in current flow through one wire induces a voltage across the edges of the other wire(s). This voltage across the other wire(s) is noise that can disrupt or interfere with the effectiveness of the equipment down the line of the circuit. Capacitive coupling, or mutual admittance, is the result of energy transfer within a circuit caused by capacitance between circuit noes. This energy transformer creates noise that can also affect electrical equipment. Generally, in most instances—instances involving large circuits with multiple pieces of equipment, the circuits are far too complex to specifically calculate the mutual inductance. However, an educated estimation is usually all that is needed to calculate an accurate measurement of the mutual inductance.
Far fields have frequencies of 3 MHz or greater, where the wavelength has decreased and the induction field is predominant out to 15 meters. The far field is commonly known as transverse mode interference. At these frequencies, we are usually concerning ourselves with sources outside of the equipment of interest. For example, broadcast or radio transmitters are usually transverse mode interference sources.

Ultimately, the distance between the source and receive and upon the frequency of the source are the most common and significant sources of the electromagnetic interferences that we are trying to mitigate.

Neutralizing EMI with a Noise Cut Transformer

The Noise Cut Transformer is designed to provide high levels of noise attenuation—essentially, it will help “clean” the power feeding into your tool. There are several parts to the design and construction of the Noise Cut Transformer that will help attenuate this noise, which include: coil shielding, wire/leads shielding, grounding techniques, the use of a noise attenuation filter, and the design of the housing or enclosure of the entire unit. Many parts of this process are designed to attenuate the noise, while other parts are designed to ensure noise is not added to the circuit after attenuation. A note must be made that we start with an Ultra-Shielded Isolation Transformer.

**Coil Shielding**

Shielding of the transformer coils is a vital step in the construction of the NCT. The technique used to shield the coil is commonly referred to as the box shielding technique, the wrapping of copper or aluminum foil so that the foil is folded to box in the sides of each coil. This method provides a very tight shield. Since the transformer is the place where the primary and secondary circuits come closest together, it is imperative that the shielding be as complete as possible. This means:
1. No pinholes in the shields.

2. Primary and secondary lead wires are shielded so that electrostatic coupling cannot take place between the leads.

3. No open spaces around leads where they emerge through the shields.

4. Extensive insulation so that leakage currents between coils is minimized.

5. Avoidance of shorted turns.

**Wire/Leads Shielding**

To help reduce coupling between wires, we will physically separate the wires carrying differing signals, such as voltage or current. This greatly reduces, if not eliminates, coupling between wires. Then, we will wrap the wires in a metallic mesh shielding to help reflect/attenuate any incoming interference and to limit crosstalk.

**The Use of a Noise Attenuation Filter**

Noise attenuation filters provide the simplest and most effective means to mitigate harmonics, reduce process-related voltage fluctuations, and improve equipment operating life and system capacity. The purpose of an EMI/RFI filter is twofold. First, it stops noise from entering and disrupting the operation of your electrical equipment—essentially protecting your own equipment. Secondly, it stops your electrical equipment from putting EMI/RFI noise onto the power lines—protecting equipment down the line.

The FCC, IEC and other regulatory agencies have rules and regulations concerning the amount of electrical noise your equipment will be allowed to place onto the AC Power line. These limits must be met before your equipment will be allowed to be connected to the AC Power line. The European limitations are much more stringent than the North American limits.
**Grounding Techniques**

Ground is any conducting material used to connect electrical circuits to a ground. Such a ground could be a metal chassis, a rack of equipment, a ground strip on a printed wire board, or the structural metal of a building. The circuit ground does not need to be at the same potential as earth ground. Grounding the transformer ensures the proper system operation and the prevention of coupling noise through the ground network.

The connection of electronic equipment to earth-ground can be made in two ways: the multipoint, or grid system, and the single-point, or tree system. The multipoint ground system requires an equipotential ground plane or grid for the system (i.e., the structural steel of a building, ground grid embedded in concrete, etc.) where electronic equipment can be connected to this ground at multiple points with lead lengths being as short as possible. “In a single-point ground system, all pieces of equipment are referenced to a single earth ground through a tree network in which there is only one unique path to ground from any point” (Buus, 1970). It is rare to find a system that is completely multipoint or single-point, as neither method by itself is cost effective. In most instances, a hybrid of the two methods is used to create the most cost effective solution.

**Transformer Shielding by means of Enclosure**

The use of a metal enclosure greatly reduces the electrical noise on the circuit. This is done in two ways: the reflection of the field from the metal, and the attenuation of the field in passing through the metal (Drummer, 1962).
Reflection occurs when an electromagnetic wave traveling through a medium of one impedance encounters another material having a different impedance. It follows that a shield, which inherently has a low impedance, will reflect a high-impedance field.

“A predominantly electric field can be well shielded by very thin sheet metal. Reflection is normally neglected in shielding design (except of microwave frequencies). Since its effect is always added to the attenuation of the field through the shield (by most measuring techniques), its neglect therefore provides a safety factor. Reflection is almost inversely proportional to frequency, so that its effect is greatest at low frequencies. The required thickness of the metal is determined from the minimum desired attenuation at the lowest frequency which the shielding is to exclude” (Drummer, 1962).

QTE designs and builds our enclosures to not only provide proper wire separation and terminal separation, but to provide shielding from external noise.
Works Cited

