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## Low Frequency AC Magnetic Fields

A Primer for the Electrical Contractor/Electrician

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In this day and age, one is quick to realize that the ever increasing application of new technologies in all areas of our daily lives, has dramatically increased the complexity of the so-called “traditional” power quality environment. The present day spectrum of this “electromagnetic environment” spans from OHz(DC) to frequencies in the GHz range and beyond. As our modern environment forces you to venture away from traditional power quality themes, your most likely first encounter with “non-traditional”, “radiated” power quality phenomena will be the discovery of Extremely Low Frequency(ELF) Electromagnetic Fields(EMF).

Extremely Low Frequency(ELF 20 - 2000Hz) Electromagnetic Fields(EMF) are alternating magnetic fields that can be found in all environments where alternating current is found. They are created by alternating current flowing through electrical conductors. Commonly recognized sources of ELF EMF’s are transformers, power lines, electrical panelboards, service feeders, electric motors, etc. At 60 cycles per second, the current changes direction 120 times per second, and the magnetic field created by the current spreads out and collapses at the same rate. Magnetic field

strength (magnetic flux density) is most commonly measured in Gauss(G). The SI unit is Tesla(T), where  $1T=10,000G$ .

In a single article, a complete description of all the causes, effects, and measurement techniques of ELF EMF's will not be possible. It is my intention to interest you by giving you a brief introduction to one of the most significant and overlooked causes of ELF EMF's in today's electrical environment. I am specifically referring to branch wiring faults(electrical code violations) involving the incorrect and/or inadvertent bonding of the neutral(grounded conductor) to ground, and the incorrect bonding of neutrals to neutrals. .

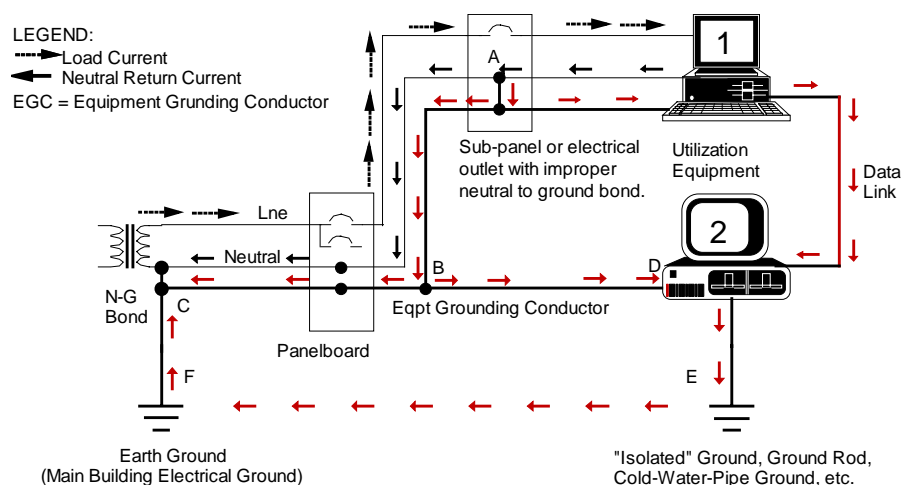
Computer systems and especially computer monitors can be severely effected by ELF EMF's and the wiring faults that cause them. Cathode Ray Tube(CRT) type computer monitors are the most ELF EMF sensitive piece of equipment that you will commonly find in the modern working environment. They can be adversely affected by ELF EMF levels as low as 4 mG depending on their characteristics(i.e. size, vert. Refresh rate, et.). Based on our experience, more than 75% of the time, higher than expected ELF EMF's are caused by faults and/or errors in electrical wiring. Increasing your awareness of these common errors will allow you to better diagnose and correct computer performance and/or ELF EMF related problems.

Ambient ELF EMF levels in most homes are usually below 2 mG, while ambient levels in typical office environments will normally be between 1 and 3 mG. Areas directly in the vicinity of electrical transformers, main service feeders, electrical panelboards, etc., will in most cases have levels between 20 and 200 mG. If you measure ambient levels greater than 3 mG in the absence of any known EMF sources, these levels are most probably due to ELF EMF's caused by electrical wiring faults and/or errors.

In order to better understand why wiring faults cause ELF EMF's let's take a look at a simple three wire 120 volt circuit(L-N-G). In a properly wired circuit pair(L and N), the currents in each conductor, are equal in magnitude, opposite in direction, and 180 degrees out of phase. They form a "current pair". Because these two conductors are side by side, the magnetic fields produced by the current in each conductor(L and N) will practically cancel each other out. However, if during the installation of the wiring, this effect

of magnetic field cancellation is compromised by either the introduction of a wiring fault, or separation of current pairs, high levels of ELF EMF's will result. It is important that you understand this concept of current pairs and magnetic field cancellation.

In the first case, we have found that the majority of neutral to ground faults, are usually created by either the poor installation of receptacles in metallic receptacle boxes, or by the inadvertent grounding of branch panelboard neutral buses. Either the cut and damaged neutral conductor or the neutral terminal screws themselves often accidentally make contact with the grounded metallic receptacle box thus creating an illegal neutral to ground bond. When the neutral return current from the various circuits is given access to these grounding paths, it splits and travels on both conductors according to the relative impedance's of the paths. Since the "return" current now has a choice of other paths to flow on, the net current on the circuit pair(line and neutral) will no longer be zero and the magnetic field created by the line conductor will not be completely canceled since the neutral conductor no longer carries the same amount of current. Radiated ELF EMF levels resulting from this error can easily be high enough to create distortion on computer monitors and resulting stray currents finding their way to sensitive computer communications cabling can also reap havoc by increasing intersystem noise levels.



In the second case, neutral to neutral bonds or better known as "paralleled" neutrals will also produce high ELF EMF levels. They are usually created when bonding neutrals from different branch circuits, or neutrals

from completely different sources. By connecting the neutral from one branch circuit(or source) to the neutral from a different branch circuit(or source), you make the neutral in the second circuit part of the first circuit, and vice versa. This will create the same sort of situation as described previously for the neutral to ground bond. The return current from the first neutral will have a choice of two paths to flow on, and the net current on the individual circuit pairs will no longer be balanced thus also creating high ELF EMF levels.

It is clear that the electrical profession is becoming more and more complex. I am certain that for many of you, the content of this article will seem simple in concept but unfamiliar in practice. There are many other types of wiring faults that can cause high levels of ELF EMF's. I hope that my introduction to a few of the most common has provided you with a new understanding of your important role in the modern electromagnetic environment. If you have any related questions and/or feedback, please email me at [marcb@powercet.com](mailto:marcb@powercet.com) or visit our web site at [www.bettertechnologies.com](http://www.bettertechnologies.com).