

# Reduction of ELF Magnetic Fields Emanating from Circuits with Net-Current Conditions by Cancellation Techniques

Jon W. Munderloh, Kenneth L. Griffing, Michael L. Hiles, Kirby C. Holte.

<sup>1,2</sup>Field Management Services Corp., Los Angeles, CA 90048, Grid Technology Associates, Walnut, CA 91789

## INTRODUCTION:

Elevated levels of power frequency magnetic fields in commercial buildings are often caused by "net-current" conditions present on conduits, bus ducts and other distribution circuits. In multi-grounded, four-wire industrial and commercial building wiring systems, some portion of the neutral current may return to the source transformer via building grounds. In other cases, neutrals of different circuits may be tied together thus allowing current from one neutral to return to the transformer via an alternate neutral conductor. In any of these instances, the vector sum of the currents for any given circuit may not add up to zero. When the vector sum of the phase, neutral, and parallel ground wire (if present) for a given circuit does not equal zero, a net-current condition is present. This circuit condition creates net-current magnetic fields that decay at a 1/D rate versus the 1/D rate normally associated with magnetic fields emanating from such distribution circuits.

Reconfiguration of conductors is usually not effective at reducing net-current magnetic fields; however some reduction may be possible by arranging conductors in such a way to cause the displacement magnetic field to partially cancel the net-current field. The best mitigation measure for magnetic fields caused by a net-current condition is to correct wiring problems (improper neutral connections, missing neutrals, improper grounding, etc.) so as to minimize or eliminate the alternative current paths that are creating the net-current circuit conditions.

Most often, it is logistically and economically prohibitive to consider reduction of elevated magnetic field from net-current circuits with magnetic field shielding. Elevated magnetic fields from net-current circuits can best be reduced by corrections or changes to wiring systems. However, in some commercial and industrial buildings, such corrections to wiring systems are not practical.

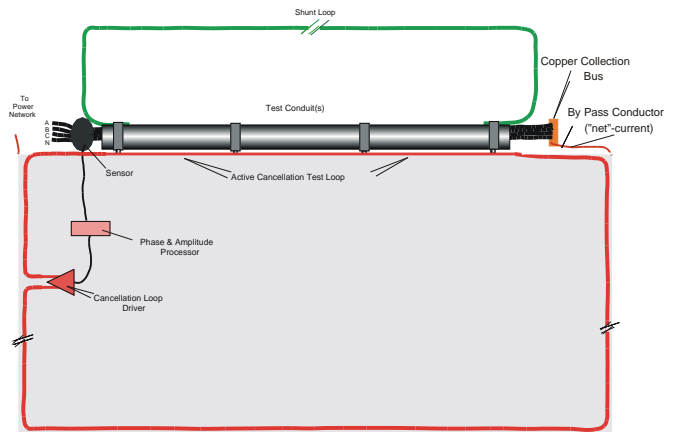
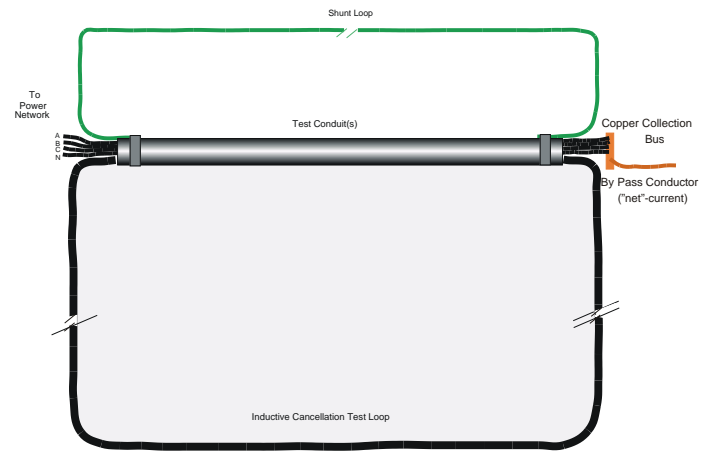
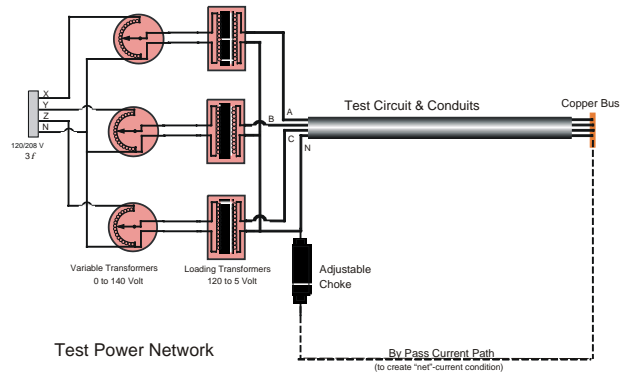
## OBJECTIVE:

This study was intended to investigate the effectiveness and commercial viability of using magnetic field cancellation techniques to reduce magnetic fields in commercial buildings with net-current magnetic field conditions present.

The objective of this study was to (1) develop and evaluate magnetic field cancellation schemes, in a laboratory setting, utilizing both passive and active cancellation techniques to effectively reduce magnetic fields produced by net-current circuit conditions, and (2) to investigate the viability and practicality of using such techniques in real world commercial and industrial buildings that have net-current magnetic field conditions present.

## METHOD:

Utilizing three 10-foot-high by 10-foot-wide by 10-foot-long non-metallic test structures, a series of single-phase and three-phase conductors in a variety of conduits typical of commercial buildings, were suspended above an x and y measurement grid on the floor of a laboratory to simulate an office beneath the test circuits and conduit(s). Three variable transformers were connected to a 208 volt, three-phase, four-wire commercial electric service. The output of the three variable transformers provided an adjustable 0 to 140 volt source to three loading transformers, each configured for 120 volt input and 5 volt output. The output of each loading transformer was connected directly to one of the phase conductors in the test circuit conduit. The three individual phase conductors plus neutral conductor were connected together utilizing a short length of copper bus located at the exit of the conduit. This test power network thus allowed either



three-phase or single-phase current to circulate in values ranging from 100 to 800 amps in the test conductors. Real world circuit imbalance conditions were controlled by different phase current settings and use of different wire sizes for the neutral conductor. Net-current conditions were controlled by connecting a separate external wire loop from the neutral point of the loading transformers to the copper collection bus at the end of the conduit. This external by-pass loop was fastened to the perimeter walls of the laboratory to create distance from the magnetic field measurement area. An adjustable choke used in the by-pass circuit allowed for further adjustment of circulating current. This arrangement allowed net-current conditions from 1 to 50 amps to be created in the test circuit conduit. Metallic (non-ferromagnetic and ferromagnetic) and non-metallic conduits were included in the test program.