Electro Magnetic Fields (EMF)
WHAT ELECTRICIANS SHOULD KNOW ABOUT EMF

By: This Article by Karl Riley kriley3@earthlink.net who wrote the book.
Tracing EMFs in Building Wiring and Grounding.

Health concerns
The health concern which developed from research connecting childhood leukemia and brain tumors to nearby power lines lead to some unexpected findings about building wiring. When EMF consultants were called in to take magnetic field measurements in buildings it turned out that the wiring itself often produced higher magnetic field levels than nearby power lines. Further investigation showed that these elevated fields were not due to correct wiring but were caused by certain wiring errors - violations of NEC - which are seen all too often.

To backtrack: some readers may be wondering if there is anything to this health concern, particularly when there have been reports in the media that there is nothing to it. It should be understood that the financial concern with the outcome of this research makes the cigarette company's worries seem insignificant. When billions of dollars of retrofits are at stake, you are going to have "controversy". For the most authoritative review of the research yet conducted you can download the document from the internet. It is the NCRP report at http://www.microwavenews.com/ncrpl.html/ For a book written for the layman I recommend Electromagnetic Fields by Blake Levitt, Harcourt Brace Harvest Books, 1995, a paperback that sells for $12.

Recording Elevated Fields
But back to building wiring. As an EMF measurement consultant my job is to take magnetic field measurements at regular intervals throughout the building, record these measurements on a floor plan, and look for unusual field levels. The measurement unit used in the U. S. is milligauss (mG). The test instrument is called a gaussmeter. A correctly wired building that is not near a power line will usually show either 0.0 mG or a few tenths in most of the occupied areas of the building. The few tenths are usually due to fluorescent light ballasts, unless electronic ballasts have been installed, in which case you won't see anything on the meter. If there are wiring errors you will see milligauss measurements up to double digit readings in areas of rooms where the circuits run.

Identifying EMF Source (NEC Code Violations)
Once elevated field levels are recorded the second step is to identify the source. Appliance sources are very local and the fields weaken quickly. Power line sources can be identified easily by their presence in all areas and by the fact that they continue outside the building and get stronger nearer the power line. The most common sources, in my experience, are miswired circuits as well as fields due to grounded neutral current on water pipes, gas pipes, etc. What kind of miswirings am I talking about? Most commonly violations of NEC sections 300-3(b) and 310-4, which require, respectively, that all conductors of a circuit must run together, including the neutrals and equipment grounding conductors; and, that paralleled conductors are not allowed in conductors smaller than 1/0. A second type of error is addressed in 250-23(a) and 250-61(b) which prohibit connecting neutrals to ground on the load side of the service entrance.

To identify the circuits involved I go to the breaker boxes and use clamp-on ammeters to find the circuits carrying "net current". Net current means the portion of current not canceled out by an equal and opposing current in the circuit. Correctly wired circuits have zero net current, which means that if you clamp an ammeter around the circuit it will read zero. If there is net current the ammeter will read it and you will have found one circuit giving out a strong magnetic field. For a complete description of the whole process of measurement and source identification refer to my book, Tracing EMFs in Building Wiring and Grounding,.

After the circuits have been identified and found to have either a deficit or an excess of neutral current, other tracing techniques are used to follow the circuit out to find the junction box where the error was made. Typically this is the kind of error we find: sometimes at the end of the run of two branch circuits, the circuits share a junction box. One may feed, say, some outside lights. The other load served through the junction box may be, say, bedroom lights. One load is fed by one branch circuit; the other is fed by the other branch circuit. The hot conductors are wire nutted to their respective circuits, but when it comes to the neutrals, sometimes they are all twisted together with one big wire nut. What does this do? Suppose the bedroom lights are on. The neutral return current, since it is joined with the neutrals of both branch circuits, splits and returns to the panel through both neutrals. This creates two net currents: one by robbing the bedroom circuit of some of its balancing neutral current and the second by putting neutral current on the outdoor light circuit, which gives off an equal magnetic field.

Connecting neutrals in this way creates a parallel path and violates 310-4. Also, it makes the second neutral a part of the first circuit, but since the second neutral runs in another path, there is a violation of 300-3(b). Why does Code prohibit these net-current producing connections? Because it increases the impedance of the circuit and may lead to inductive heating, particularly if the circuits run in metal conduits or metal clad cable. Also the magnetic fields produced often cause problems in electronic equipment. Computer monitors will start to flicker at anywhere from 5-15 mG; usually around 12 mG. “Smart wiring” is sensitive to these net current fields since the small signals induced may be enough to give spurious commands to the system. If magnetic fields are eventually proven to be co-promoters for some cancers and Alzheimer’s, the liability of electricians creating these fields will get the attention of the lawyers who are at present suing power companies.

Connecting neutral to ground on the load side of the service entrance will cause similar net currents, but this time one of the net currents is on the circuit and the twin current is on a water pipe, sprinkler pipe, gas pipe, building steel, etc. This condition is caused when an electrician does not isolate the neutral as he should in a subpanel. There are other ways of misconnecting neutral to ground which I go into in Tracing EMFs.

Normally an electrical inspector will not detect these errors since his protocol does not include looking in junction boxes. Of course he should see grounded neutral busses in subpanels, but even there it may not be obvious and he may miss it. But anyone including a home owner can walk through the building with an inexpensive gaussmeter and immediately see that something is wrong (providing the lights are on). Eventually gaussmeters will be used routinely when inspecting buildings for sale, and by school officials and environmental consultants. These wiring errors will show up clearly. It would be very prudent for any electrician reading this article to think over his practices as well as the practices of the men he may hire to run the wiring and make sure that neutrals are correctly connected. Incorrectly wired 3-way switches also will produce high magnetic fields. Use 3-wire travelers and don’t try to get away with 2-wire (only switch legs can be 2-wire).

Magnetic fields due to net currents on grounded water pipes and consequently service drops are in a second category, since they are not due to wiring error. However the Code does address this situation in 250-21. Objectionable Current over Grounding Conductors. I refer the interested reader to my book for a thorough discussion of this problem and what can be done about it for a concerned client. This article is only meant to bring this new set of power quality concerns to the attention of electricians and contractors.