How to wire a house for low EMF
Part 1: the basics

Electromagnetic (EMF) radiation from household wiring can be drastically reduced by good design and wiring practices. This is part 1 of a two-part how-to article.

Keywords: *EMF, EMR, radiation, wiring, electric field, magnetic field, electrical sensitivity*

Introduction

Research by epidemiologist Samuel Milham shows that as electrical service swept across rural America, in the 1920s to 1940s, the diseases of civilization (diabetes, depression, various cancers, heart disease, obesity and asthma) followed behind. This suggests that simply living with basic electrical service can have a health effect. In recent decades, electrical sensitivities have been added to the list of diseases that were rare or unknown before electricity was introduced.

This document covers basic information about radiation from household wiring and information needed for understanding how the wiring methods in this article lowers the radiation in a house.

Part 2 of this article covers the specific methods in detail. The methods can be used without understanding all the reasons but understanding them may prevent mistakes and self-defeating "short cuts."

Radiation from household wiring

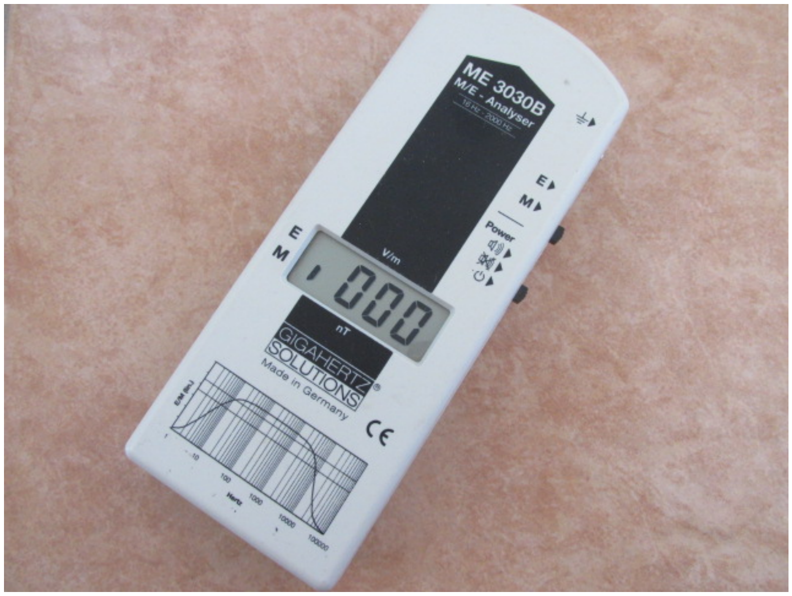
There are two basic types of radiation coming from household wiring:

- magnetic field
- electric field

The magnetic field depends on how much current is running through the wire. If there is no current in the wire, there is no magnetic field. The current runs when some appliance, such as a light bulb, is turned on. Two light bulbs will create twice as much current as one light bulb and thus twice the magnetic field.

The magnetic field can be measured by what is called a gauss meter in North America and a tesla meter in many other countries. The instruments measure the radiation as either milligauss or nanotesla.

A typical household will have an ambient magnetic field between 0.1 and 1.0 milligauss (10 to 100 nT).



Instrument that can measure both the electric and the magnetic fields from household wiring. This instrument is sensitive down to 0.01 milligauss (1 nanotesla). It is pictured inside an ultra-low EMF house where the magnetic field is less than 0.001 milligauss, so the instrument is unable to detect anything.

An electric field is always present around a live electrical wire, regardless of whether it is used to power anything or not. The electric field depends on the voltage on the wire.

Even if you plug an extension cord into an outlet and leave the other end unconnected, there will be an electric field around the cord (but no magnetic field). Likewise, there is an electric field around all the wires in the walls as long as the breakers are on (turning the breakers off should help, but may not fully eliminate the electric field).

An electric field meter is used to measure the electric field. The unit is volts-per-meter (V/m). Some of these instruments are designed for measuring high-tension power lines and will show zero in almost any house (they measure in kV/m, or thousands of volts per meter).

A typical home in North America will have readings around 10 to 50 V/m. It will be higher in countries with a higher household voltage, such as in Europe.

Electric field meters are more difficult to use correctly than a gauss meter. If not used correctly the readings can either be too high or too low.

The electricity in a household can also be "dirty." Dirty electricity is when there are high-frequency electrical spikes (transients) on the wiring. They are created by many types of electronics, such as:

- computers
- low-energy light bulbs (LED, compact fluorescents)
- dimmer switches
- computer networks using household wiring (PLC)
- solar power systems
- battery chargers
- entertainment electronics
- electrical motors (especially variable speed)

(Solar systems and LED lights do not always create dirty electricity, but all standard versions do.)

Dirty electricity affects both the magnetic and electric fields around household wiring, but will not show up on consumer-grade gauss meters or electric field meters. There are some special meters available to measure dirty electricity (such as the Stetzer meter and the Line EMI meter) but they measure only some of the dirty electricity.

Magnetic and electric fields travel through walls

Household wiring is usually hidden inside walls, above ceilings, below floors and inside baseboards. In older houses, the cables may be hidden inside panels, surface-mounted strips or conduits.

The magnetic and electric fields travel through wood, drywall, plastic and plywood as easily as sunlight goes through a glass window. A thick wall of brick or concrete will dampen the fields some (like a thin curtain can reduce sunlight through a window) but it will not block the radiation.

The only really effective ways of blocking the radiation is by using some sort of metal, which we will cover in Part 2 of this article. Shielding materials intended for blocking microwave radiation (such as from wireless networks and transmission towers) will usually NOT work as well for shielding household wiring. Shielding is not that simple.

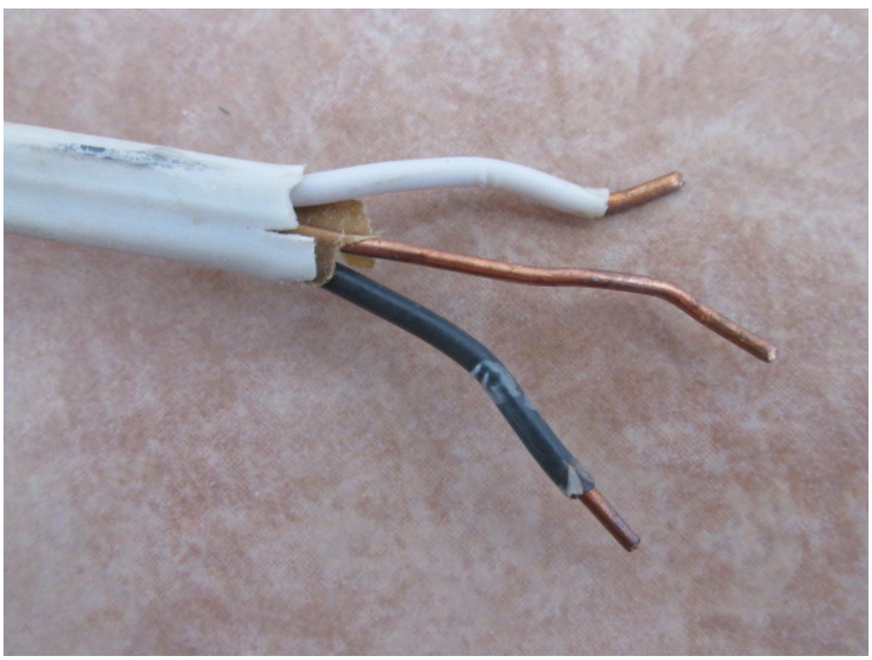
Household wiring

Household wiring is the electrical cables that go from the breaker panel to the electrical outlets, wall switches and built-in light fixtures. It also includes electric safety devices, such as breakers and grounding systems.

The cables used for most modern household wiring have three wires inside: hot, neutral and ground (also called Phase-Earth-Neutral, or PEN).

The hot and neutral wires are also called conductors, because they normally conduct electricity. The ground wire normally does not conduct much electricity and is not called a conductor by electricians.

If you go to a hardware store in the USA and ask for a roll of electrical household cable, you'll likely be handed something called "ROMEX 12/2." The 12/2 means it is 12-gauge and has 2 conductors, plus the ground wire.



Standard household electrical cable in the United States. The black wire is the "hot," the white wire is the "neutral" and the bare wire is the ground. Other countries may have different color coding and naming.

Unbalanced circuits

Cables used for regular household wiring have a "hot" and a "neutral" wire that runs next to each other. The current runs out on one wire and returns on the other.

Because the exact same amount of current runs in opposite directions and the wires are so close together, the magnetic field coming from the cable is much reduced (in physics terms: each wire induces a magnetic field of the same strength, but since they are in opposite directions, they largely cancel each other out).

If one cut open the cable and moved the hot and neutral wires away from each other, the magnetic field would become much stronger. This effect also happens if the current running on the two wires is not exactly the same. This is called an "unbalanced circuit," or "net current."

This can happen if some of the electricity runs where it is not supposed to, such as along metal water pipes or steel airducts. Or even in the soil around the house. It can also happen if the electrician did a sloppy job wiring up the house or when doing modifications later on. All these problems are quite common. Part 2 of this article shows how to avoid many of these problems.

The book *Tracing EMFs in Building Wiring and Grounding* by Karl Riley is an excellent source of information about how to find, fix and avoid unbalanced circuits. It is highly recommended.

Ground wires are not truly grounded

In principle, a ground wire should be as grounded as the soil outside the house. In praxis, that is almost never so.

A small current often runs on the ground wire from some types of lamps and electronics and back to the electrical panel. These are called leakage currents and they usually contain high-frequency waves, i.e. dirty electricity.

There are also other effects from the wiring itself, especially with longer runs of wires, where a low voltage is created on the ground wire simply because it runs next to the hot wire for a long stretch (the technical terms are inductive and capacitive coupling).

These problems become greater in larger buildings, especially apartments in tall buildings.

Grounding people

Some electrically sensitive people feel better if they are grounded (or "earthed"). They do that by sitting or lying on the ground, or even walking barefoot or with shoes with very thin soles. A less effective, but more practical method is to sit or sleep on a grounding pad that is connected to a ground rod with a cord. Some sleep with a copper bracelet on their ankle, that is also connected to a ground rod.

As described in the previous section the grounding wires in a house are not truly grounded. The grounding prong of an electrical outlet should not be used to ground people. It is much better to use a separate dedicated ground rod.

This also goes for connecting any shielding to the ground, such as a shielding bed canopy. Shielding is usually not enhanced by grounding it, anyway.

The earth is not a trash can for electricity

It is a common misunderstanding to think that the earth is some sort of "trash can" for electricity. The idea here is that adding better grounding can somehow "get rid" of electricity that is unwanted. For instance, if metal water pipes are found to have electricity running on them, the "solution" is sometimes thought to be connecting the pipes to the grounding system. This does prevent people from getting shocked, but it doesn't solve the problem with the radiation from the unbalanced circuits. In many cases, adding grounding will make things worse, as it can make it easier for the electricity to go along alternative paths instead of the household wiring, and thus further create imbalance and magnetic radiation.

A small company in Sweden sold very elaborate $75,000 "deep ground" systems based on the "earth is a trash can" idea. Their systems actually made things worse and the company was eventually shut down by a court.

It is much better to locate the actual problem (which Karl Riley's book can help with).

Electricity always runs in a loop. It always returns to the source. If electricity is directed to the earth under a house it will have to come back up somewhere else. There is no blind alley for electricity.

What does the ground rod actually do?

The ground rod has three purposes:

- lightning protection
- tying the neutral wire to the ground
- personal safety (somewhat)

If lightning strikes, the wires in a house can suddenly carry many thousands of volts. The ground rod can help siphon that into the earth and prevent fires and injury.

The ground rod is also used to tie the neutral wire to the earth (through the neutral-ground bonding in the main electrical panel). This ensures that the voltage of the neutral wire is so low it is not dangerous to touch it.

The ground rod is usually located right below the main electrical panel, with a wire connecting the two.

If a person touches a live "hot" wire, the ground rod *might* help trigger the breaker, but it may not. It is not really great at handling this situation.

If there is a short between the hot and neutral wires, the ground rod is not involved in triggering the breaker. The short burst of high current does not go through the soil and ground rod, it simply travels along the wires back to the breaker until the breaker is triggered. The same is the case if there is a short between the hot and the chassis on a piece of equipment. Then the current runs along the grounding wire back to the main panel where it jumps to the neutral wire (through the bonding) and trigger the breaker, again without involving the ground rod.

Using the ground rod for safety is a very old practice. Better technologies have been available for decades (such as GFCI/RCD) but utility standards are very conservative.

Unfortunately, the use of ground rods at every house, transformer and many other places creates wide-area unbalanced circuits. They do that by providing an alternative path for the electricity to run in the soil, from ground rod to ground rod, instead of it all running on the neutral wires along the street and back to the nearest substation.

That is the reason even large undeveloped pieces of land frequently have magnetic radiation of about 0.1 to 0.2 milligauss (10 to 20 nT). That radiation is created by electricity running in the soil itself, without wires. It is unrealistic to try to lower this ambient radiation when building a house on such a lot.

The more densely built an area, the greater the ambient magnetic radiation level, simply because of all the electricity passing through the soil between the many ground rods.

There is an alternative wiring practice that avoids this problem. It is called "delta," but it is used only by a few utilities.

Some people have built their homes more than a mile (1.6 km) beyond the nearest electrical service to avoid the electricity in the soil (and cell towers). This web site has several articles about such off-grid houses (see below).

More information

Part 2 of this article covers practical low-EMF wiring methods, and is available on www.eiwellspring.org/lowemfhousing.html. See also our main healthy housing menu on www.eiwellspring.org/saferhousing.html for other articles about low EMF and less toxic housing.

We highly recommend the book *Tracing EMFs in Building Wiring and Grounding*, by Karl Riley for detailed information about wiring problems and how to track them down.

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