Desert Moon House:
Wiring for Lower EMF

by Andrew Eriksen

This article describes the simple low-EMF features of a less-toxic house constructed in northeastern Arizona. The focus here is on the 110 volt AC system. The house also has a solar electric DC system, which is covered in a separate article.

Many people with severe MCS develop some level of electromagnetic hypersensitivity (EHS) later. Sometimes many years later. It seems prudent to consider designing a new house for low EMF, while it is being built, as that can be done at a low cost. It is much more costly to do it after the house has been built.

Layout of the house

One of the important criteria for the layout of the house was to put all electrical appliances in one area, away from where the occupant will spend most of his time.

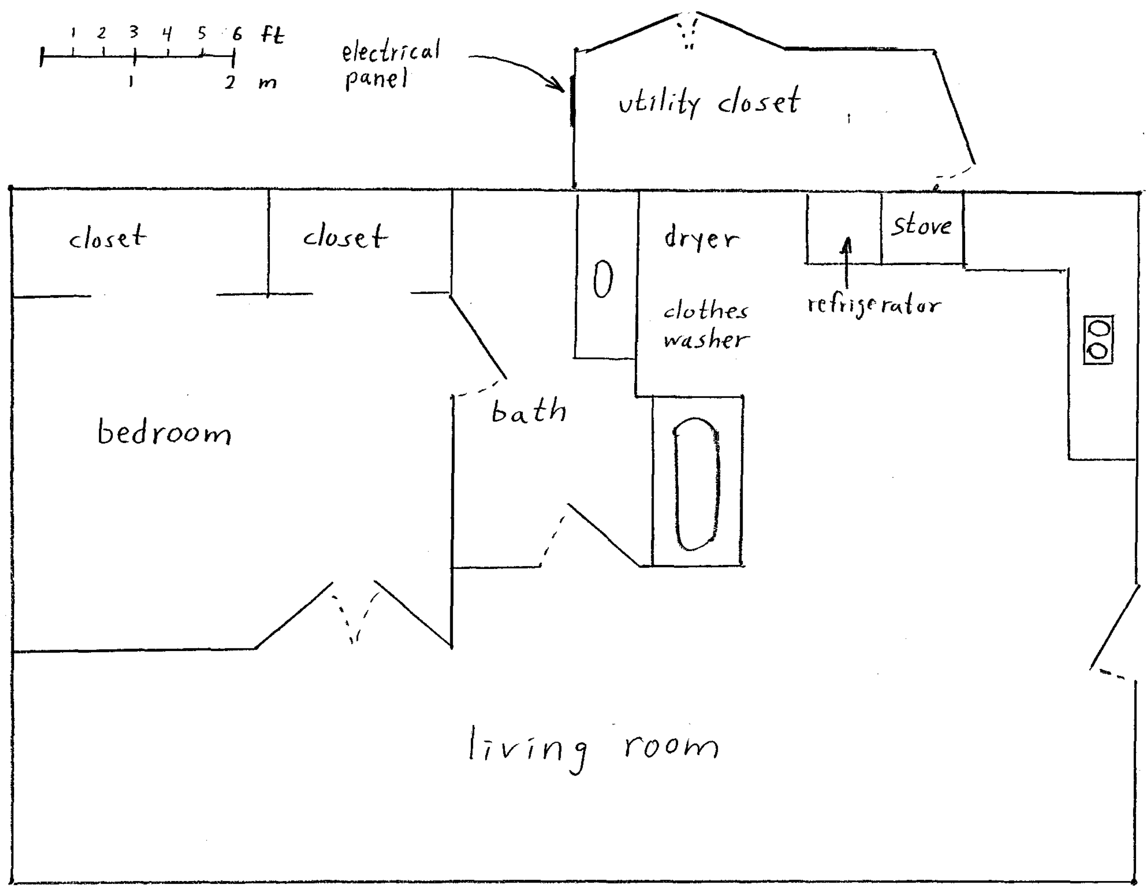
The stove and refrigerator in the kitchen are placed in the north-east corner of the house up against the utility closet. The utility closet houses the water heater and the breaker panel. There is space for a washer and dryer in a pantry next to the kitchen.

The bathroom provides some distance to the bedroom, and the length of the kitchen provides distance to the dining area and living room.

The house has no air conditioning, which is not really needed in this mountain climate of temperate summers, especially since the house is designed for passive cooling. Otherwise, it would be put in the utility closet.

The bedroom is at the end of the house, so no electrical cables need pass through it to other rooms.

This is a small house (830 sq ft/86 sq m). The distances which can be achieved in such a small area are limited.



The house is designed with all appliances and the breaker box in one area, away from bedroom and living room.

The breaker panel

The breaker panel is mounted on the outside wall of the utility closet, away from occupied areas. All AC electricity to the house runs through this little box.

The panel is of the "sub-panel" type, that does not have a meter on it, and where the neutral bus bar is insulated from the chassis. This allows the panel to NOT have the "bonding" between the ground and the neutral wires. This bonding should preferably only be at the master panel, but your inspector may specify you need the bonding both places. True sub-panels are often not available at building supply stores, as they are not used much in residential houses. They can either be special ordered, or are available from electrical supply houses. They can all be configured with and without the bonding.

When this house one day is connected to the electrical grid, a separate master panel will be placed in the yard, well away from the house. This master panel will house the electrical meter and a master breaker that feeds electricity to the sub-panel on the house. Another breaker will also serve the outbuilding. The master panel can be mounted on a pole, a pedestal or perhaps on the outbuilding.

The benefit of using a standalone master panel (and no bonding on the sub-panel on the house) is that it will reduce ground currents at the house and also keep the utility meter away. All electrical meters radiate EMF and the new generation of "smart meters" sends out radio signals as well. These smart meters allow the electrical company to charge a variable rate for their electricity over the day, and save money by laying off their meter readers. But this all requires direct communication with the utility company, which happens with radio frequency links, such as cell phones, Wi-Fi or Broadband over Power Lines. These meters will probably eventually be installed on every house in the country.

It can be a problem to mount an electrical panel directly in contact with steel studs and/or steel siding. Stray currents may travel from the chassis of the electrical panel and across the siding or studs to another grounded unit, such as a steel wall box or a water pipe.

This problem is more likely to happen if the panel is "bonded", i.e. there is a connection between the neutral and the ground in that panel (which is the norm). Stray currents can still happen without the bonding, as the house's ground wires often do carry small amounts of electricity.

If the electrical panel is isolated from the siding and studs, stray electricity cannot happen there. One way to isolate a breaker panel is to put a board of wood or plywood behind it. The board is attached to the wall with screws, and the electrical panel is attached to the board with a separate set of screws. It is important to use two sets of screws, so electricity cannot travel along the screws.

Make sure to seal the plywood on all sides, before mounting, to protect it against moisture.

If steel conduit is used, be careful it does not touch the steel studs/siding.

A multimeter should be used to verify that there is no connection between the chassis of the panel and the siding and/or studs. This is done with the meter on the ohm/resistance setting, which is often symbolized with the Greek letter omega (Ω).

This house has steel siding, but no metal studs. The sub-panel mounted on the outside wall came with both the neutral and the ground bus bars isolated from the chassis, so there was already no possibility of stray currents, unless the bonding screw is installed. Most panels sold do not have the bus bars isolated.

Arc-detecting breakers

The National Electric Code recently introduced the requirement that the breaker for the bedroom circuit is a special arc-detecting braker, called an AFCI (Arc-Fault Circuit Interrupter). An AFCI has electronic circuitry which monitors the line, to detect sparks generated by faulty wiring, which is a fire hazard.

Unfortunately, such sophisticated electronics generate EMF. The model purchased by the author emitted a high level of EMF. Hopefully other models are better designed, but probably not. This is another reason to locate the breaker panel away from frequently occupied areas.

The wiring used

The cables used were standard ROMEX cables, but they were twisted. Twisting the wires reduced the EMF radiation from them by about 90% in an experiment done by the author. (A 90% reduction is not as impressive as it sounds, but it helps). It is a very cheap way to reduce EMF, and really ought to become common practice. It is very simple to do. The electrician simply sticks the end of the cable into the chuck of a power drill and then slowly turns it, twisting the cable. It only takes a minute. One twist per 1 to 4 inches (2.5 cm to 10 cm) is fine. The cable is just as easy to use afterwards, in fact our electrician thought it was easier to pull it.

Twisted wires are standard practice in telephone cables and computer networks, because the wires do not disturb each other as much on long runs.

Twisting ROMEX cable, using a power drill

Twisting the cable does not change them significantly. The surface area is largely the same, so there should not be an issue of dissipating heat from a cable carrying a high current, for instance.

It is still possible that a building inspector would be concerned, simply because he has never seen it done before. An alternative is to buy cables that happen to be twisted already by the manufacturer. If you ask for twisted ROMEX at the hardware store, you are very likely to draw blank stares. The trick is to closely inspect the available cables. Those that have twisted wires inside the sleeve can be spotted when looking carefully.

One commonly available already-twisted cable is one that has three conductors and ground inside the sleeve (they are colored red, black, white and bare copper). These are commonly used for 220 volt AC wall units and three-way hallway lighting. They cost a little extra, but no inspector should raise an eyebrow. Simply cut off the extra red wire at each end, and otherwise use as you would normally.

If one wants to have even better EMF reduction, the next step up is to twist loose wires, and then pull them through steel conduit (called EMT and IMC in the USA). This is much more costly, because of the labor involved in installing the steel conduit.

In our experiments, the flexible metal clad (MC) cables did not offer better EMF reduction than twisted ROMEX cable.

Routing of the cables

The cables were pulled through the attic and down the walls. They were not pulled horizontally along the walls, except for short stretches. This keeps the cables further away from the people, especially when sitting or lying down. It also avoids the coil-effect, where cables circling a room in effect create a coil.

The wiring was done carefully, to ensure that the neutral (white) wires from two circuits are never tied together. This can cause unbalanced circuits, with higher EMF levels the result. The best way to avoid this common error is to have only one circuit connected to each wall box.

Wall boxes

The wall boxes were of plastic. Using steel might be better for MCS, but the building code requires that steel boxes are connected to the ground wire. With the walls of this house covered with aluminum foil, the aluminum tape covering the cracks between the wall board and the wall box, there would be electrical contact between the walls and the grounding wires, and between the grounding wires from different circuits. This could cause various types of problems. One possibility is stray currents traveling across the foil, or that high frequency signals on the ground wires can use the foiled walls as large antennas. There could also be some interaction between the signals that travel on the different circuit's ground wires. It is not predictable what could happen, if anything. In houses that do not have any form of electronics hooked up to the electrical system (such as computers, clocks, stereos, etc.), there is much less of a chance for these troubles. The problem with these devices is that their power supplies leak electricity onto the grounding wire, and they emit high frequency signals that travels on all wiring.

If one decides to use steel wall boxes, it is advised to electrically isolate them from the foil on the walls.

In houses without foiled walls, there could still be problems with steel wall boxes and conduit, but rarely. There have been some case reports from Sweden, where people changed their existing wiring to be in steel conduit, and felt worse from it.

Kill switches

All outlets in the bedroom are fed through a kill switch, which is an ordinary double-poled switch that disconnects both the "hot" and the "neutral" wires. Disconnecting both conductors limits the high frequency signals that can travel on a wire, and radiate from it. These signals, called "dirty power", are generated by many sources, such as computers, fluorescent lights, and other types of electronics. They can also come to the house from the outside, caused by old wiring in the street, or activities next door.

The adjacent bathroom and adjacent section of the living room also have kill switches, so the whole west end of the house can be made completely free of electricity.

An even more effective kill switch would be to install a four-poled switch to also disconnect the ground for the area. The ground wires can act as a conduit for dirty power as well, though less likely. Any sort of switch on the building ground wires will not pass inspection, and should be considered very carefully. This sort of disconnect is not used in this house.

GFCI

The National Electric Code requires the use of special GFCI outlets in kitchens, bathrooms, outdoors and any other location where water may be present. A GFCI (Ground Fault Circuit Interrupter) monitors the current passing through an outlet.

If the current becomes unbalanced, such as when a person receives an electrical shock, the GFCI breaks the circuit. The electronics inside a GFCI emit EMF. The amount varies dramatically between brands. This author tested several brands and found that the Cooper brand has the lowest emissions, and it apparently has been the best for several years.

To further reduce emissions from the GFCIs in the house, they were all put on switches, so they only have power to them when needed. This includes the four outdoor GFCIs, each of which have a switch inside the house. The outlets in the bathroom are all controlled by a single GFCI, which is turned off by a double-poled kill switch.

Switched GFCI outlet in kitchen. The right outlet is for DC electricity (see separate article).

Other details

This house has

- no dimmer switches
- no fluorescent light fixtures
- no electronic thermostats

To deter future use of wireless gadgets, it has

- many phone outlets
- several computer network outlets
- multiple television antenna outlets

Actual use of house wiring

Presently, there is no 110 volt AC power in the house. All the circuits described in this article are dormant, i.e. without power. There are no electrical appliances in the house at all. Instead, the house is served by a separate 12 volt DC system that is powered by solar panels. The 110 volt AC circuits were installed for possible future use, either by the author or by a future owner. They were also required by the building code.

More information

Making a house truly low EMF is a large subject, and the measures vary with the situation. An excellent book about house wiring is *Tracing EMFs in Building Wiring and Grounding* by Karl Riley. It is written for electricians and assumes the reader has a good understanding of wiring practices.

Disclaimer

This article describes the electrical system of a particular house. All houses are different and what is described here may not apply.

It is the reader's sole responsibility to ensure that their own house is in compliance with all applicable codes, rules and regulations, as well as common sense.

The author assumes no responsibility for any results from the use of this information.