House extensively shielded against cell towers and other microwave sources

This house was built from the ground up to provide as much shielding as possible at a reasonable cost. The shielding reduces wireless radiation by an amazing factor of 300,000 (55 dB).

Keywords: how to, shield, home, house, porch, cell tower, base station, Wi-Fi, smart meter, WLAN, microwave, RF, radio frequency, radiation, EMC, MCS, electrical sensitivity

The need for a shielded house

Jack (not his real name) is an engineer with severe electrical hypersensitivity (EHS). The radiation from cell towers (base stations), Wi-Fi, power lines and many other sources strongly affect him, even at very low radiation levels.

He bought a large piece of off-grid land in a remote part of the Arizona desert — far from neighbors, utility service and wireless towers. Cell phones did not work there at all.

He had an unheated outbuilding with a bathroom constructed in 2007. It was built between two small hills that could shield him against cell towers that might be built later.

Jack started living in the building for periods in the warm season and felt better there than at home. He started planning his future home on the site.

After some time, Jack noticed that he no longer felt so well there. He didn't know why until a guest discovered that his cell phone now worked. It turned out that a new cell tower had been erected five miles (8 km) away. Rural cell towers are often much more powerful than those in a city, as they need to serve a much larger area.

The new tower could not be seen from Jack's building site because of the surrounding hills. The hills dampened the radiation ten-fold (10 dB), but it was not enough.

Jack realized that even if he sold the place and moved even further away, the same would eventually happen again. He was unlikely to find anything better than what he already had. Since cell towers use a lot of electricity they are rarely erected in areas beyond the electrical grid. It was therefore unlikely that any tower would be erected closer to his home for a long time.

He decided to build his new house with as much shielding against microwave radiation as he could without spending a grand fortune.

Most shielded buildings are owned by large corporations or the military to protect against surveillance and electronic warfare. Jack did not have the budget of a large corporation and could not afford to hire any of the firms that build shielded rooms or buildings, or even hire a professional EMC engineer to design the house for him. There weren't any books available about how to do this, either. Jack had to figure it all out himself using more general information about shielding. It helped a lot that he was an electrical engineer, but he still had much studying to do.

To save money he invented a set of low-cost methods to shield his house. He hired a building contractor who had no experience with shielding, but was willing to work under Jack's close supervision. Jack's methods worked very well and will be described in detail in this article. He has lived in the finished house since spring 2011, i.e. five years as of this writing, and it continues to work very well, even though a second tower has since been built in the area.

House for chemical sensitivities

Jack also had multiple chemical sensitivity (MCS), which meant he had to build the house using less-toxic materials and building methods. The focus of this article is the shielding of the house, which worked very well with the less-toxic building methods he used.

Choosing the shielding materials

There are many kinds of shielding materials available. They all have their strengths and weaknesses and must be chosen carefully. Some materials are very cheap, while there are expensive exotic shielding materials that may not actually work any better in a particular case.

Jack focused on low-cost materials that were suitable for shielding microwaves, as that is what he had from the cell tower. Other sources of microwaves include Wi-Fi, wireless smart meters, DECT phones and all sorts of portable gadgets. The shielding will protect against those as well, if it ever becomes an issue.

Jack's house was in an area far from radio stations, power lines and ground currents. These are more difficult to shield, but Jack needed to be concerned only about the microwaves.

There are two general types of microwave shielding: reflective and absorbent. The absorbent materials turn some of the radiation into heat as it passes through, but they are not very effective. With the level of shielding Jack needed, the only choice was the reflective shielding materials, such as copper, aluminum and steel. Reflective shielding works by bouncing back the microwaves, just like a mirror reflects light. The only downside is that microwaves generated inside a shielded house will bounce around inside, but Jack did not intend to use any wireless gadgets inside anyway, so that was not a problem.

Double layer shielding

If Jack could wrap his entire house in metal, with no holes or edges, he would have a perfectly shielded house. Unfortunately, such a house would not be very comfortable to live in. People need windows, doors, corners, pipes and cables that all weaken the shield. Good shielding means a lot of work has to be done around these weak points, but they will still be the weakest parts of the shielding.

Like a chain, a shield is only as good as its weakest link. It is easier to build multiple layers of less-perfect shielding than one perfect layer. Professional shielding engineers commonly use multiple layers to shield a building or a room, and this house had two layers. The two shields are separated for most of the house, though they meet at the windows and the door. It is fine that they are connected to each other.

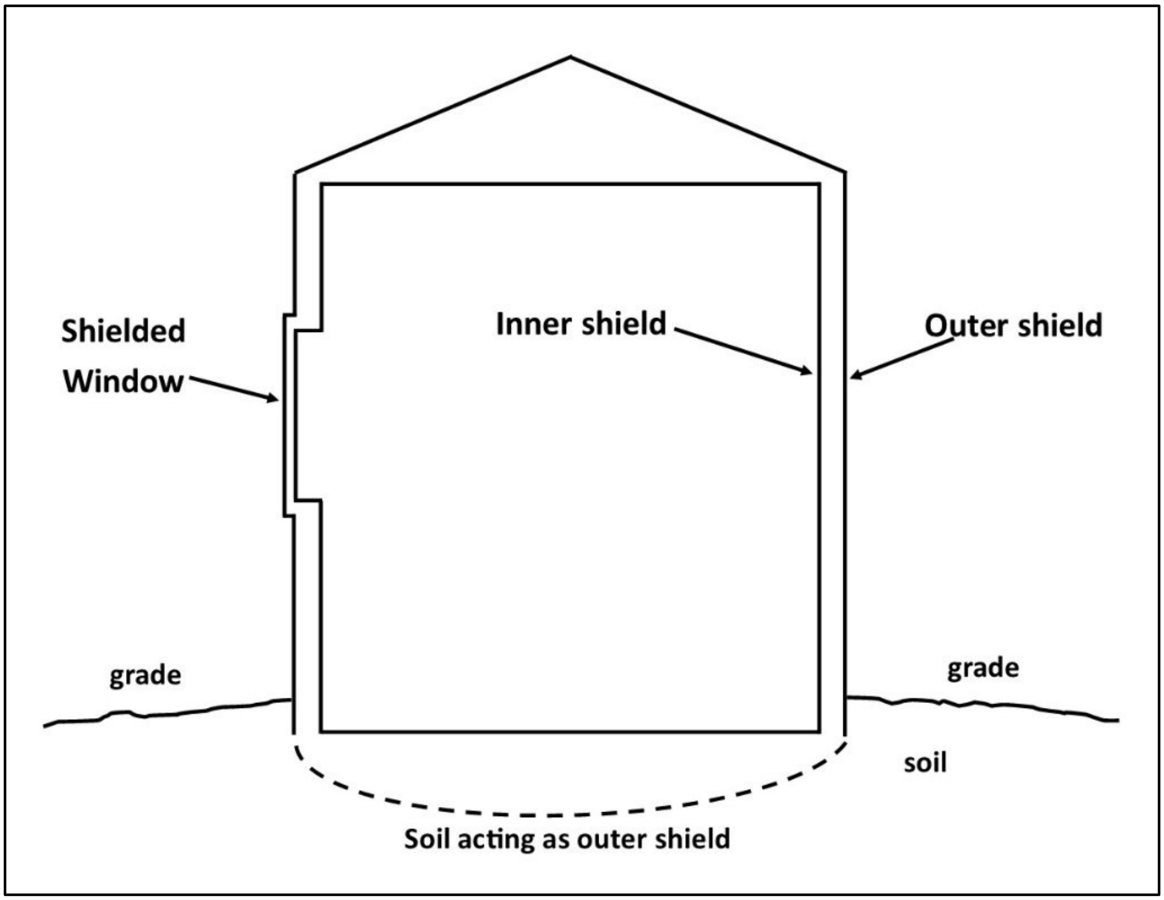


Figure A. The two layers of shielding.
The outer shield consists of the roof, siding and the soil below the house.
The inner shield is aluminum foil on walls, ceilings and under the floor.
The shielded window assembly is a part of both the outer and inner shield.

The grounded foundation

The house has a radiant floor heating system, where hot water circulates in plastic PEX tubes embedded in the concrete floor. This type of heating system is popular in environmental houses because it is very comfortable, does not pollute the indoor air and can be built so there is no noise or EMF inside the house. The downside is the extra cost of a fully insulated foundation.

This type of foundation works very well with the shielding.

The first part of the foundation was to build a stem wall around the perimeter of the house. It was built of concrete blocks that were filled with concrete and reinforced with steel rebar. These rebars were not a part of the shielding system and were not connected to the house grounding system.

The start of the stem walls, with steel rebar reinforcement.
These rebars were not connected to the grounding system.

The heated floor of the house required the stem wall to be fully insulated to avoid excessive heat loss. The stem wall was insulated on both the outside and the inside with foam boards that were glued to the concrete blocks.

The outside of the insulated stem wall was covered with galvanized steel plates, which both protect the insulation boards and are a part of the outer shield.

The outside of the stem wall is shielded with galvanized steel plates. They used recycled steel plates, some of which happened to be green.

About a dozen ground rods were pounded into the soil along the inside of the stem wall and spaced 7 to 11 feet (2.1 to 3.3 meters) apart.

The rods were pounded all the way into the soil, so they were not visible, but easily reachable in the dirt. The rods were 4 ft (1.3 meters) long because there was solid rock 5 ft below the surface.

A thick (#2, 6.5 mm) and two feet (60 cm) long copper grounding wire was then soldered to each ground rod and left for later use. The ground rod was cleaned before the ground wire was soldered to it to ensure a good connection. The soldered area was then spray painted to prevent corrosion.

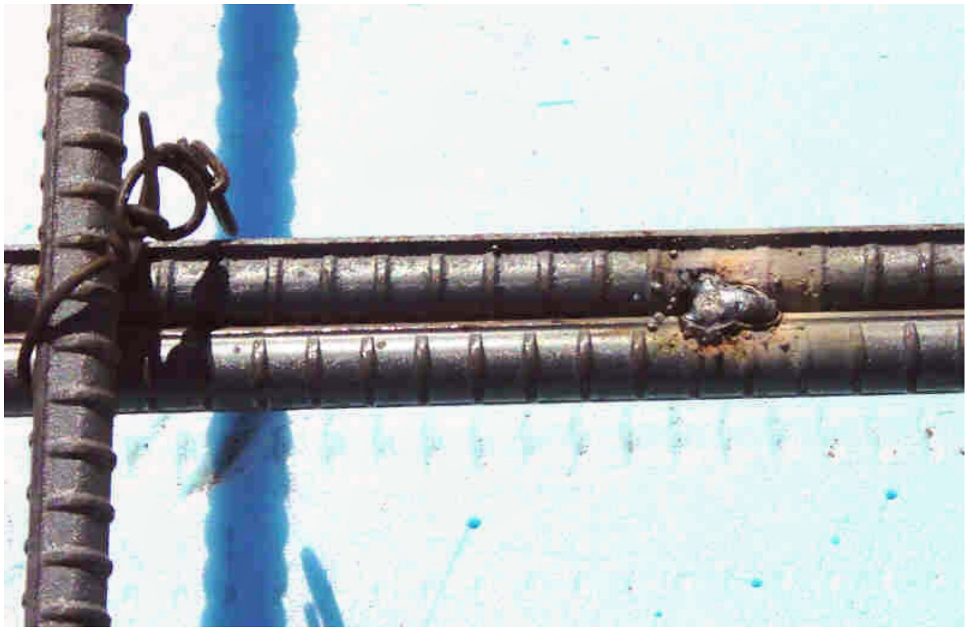
The area inside the stem wall perimeter was covered with tamped sand. Plastic-laminated aluminum foil was placed over the sand and up the inner sides of the stem wall (see picture). This foil became a part of the inner shield of the house.

On top of the foil came a 6 mil (0.15 mm) plastic moisture barrier and then two inches of insulating foam boards. The insulation was needed because of the heated floors.

Rebar was placed on top of the foam boards to provide reinforcement of the concrete floor. The rebar was thoroughly grounded to all the ground rods via the copper ground wires sticking up all along the stem walls (see picture). The ground wires were welded to the rebar nearest to each ground rod, to ensure the shortest path to ground.

The rebar was welded together in several places to make sure all rebars were well grounded.

The rebar connected to a hidden ground rod through a thick #2 (6.5 mm) copper wire. Another copper wire goes to the top of the stem wall, where it is later connected to the inner shield on the wall. The white plastic/aluminum laminate under the floor can be seen going up the inside of the stem wall, and folded over the inside insulation.



The rebar was welded together in several places to ensure good electrical contact.

Underground lines to the house

Underground lines bring water, electricity, communication and telephone into the house and bring out sewage. These all penetrate the outer shield and most also go through the inner shield.

Anything metallic that sticks out on both sides of a shield can bring radio waves into the shielded space. If a long nail was driven partly in through a shielded wall, the part of the nail on the outside could be a receiving antenna, while the part sticking into the room could re-radiate the microwaves.

The same principle applies to metallic pipes, conduits and cables passing through the shields.

This is not a problem in unshielded houses, since it simply allows microwaves to pass through, but does not amplify them.

The cables for electricity passed through a heavy-duty filter in the outbuilding and went on to the house in steel conduit. The steel conduit shields the cables so they do not pick up microwaves from the air and carry them into the house.

Heavy-duty filter on the electrical feed for the house.
Note the metal casing and conduits that prevent the wires from picking up microwaves from ambient radiation.
There is also a wide grounding strap.

The metal conduits and pipes were connected to ground rods just before they pass under the stem wall. Each pipe or conduit has its own dedicated ground rod to which it was connected with a short and thick (#2) copper wire that was soldered on. The soldered area was then painted to prevent corrosion.

The framing

Jack did not tolerate air conditioners and his off-grid solar system would not be able to power one anyway, so he built a super-insulated house with 12 inch (30 cm) walls. Since the house also had to be non-toxic, they could not use any sort of manufactured wood products, such as plywood or SIP panels. He decided to frame the house like a typical American wood-framed building, but with a double wall like it is commonly done in Canada.

The studs on the inner wall were set in an aluminum channel that was nailed to the concrete floor with a nail gun. Each of the nails was connected to the aluminum channel with copper tape, to ensure a good connection. The channel itself was connected to the ground rods below the wall, using the #2 copper wires that were installed before the concrete was poured, as mentioned earlier.

A similar method has later been used in another house with a single-wall design. They used six-inch wooden studs with no aluminum channel at the bottom (to avoid thermal bridging). The laminated aluminum foil under the foundation was pulled up on the inside of the wall and in direct contact with the foil on the drywall.

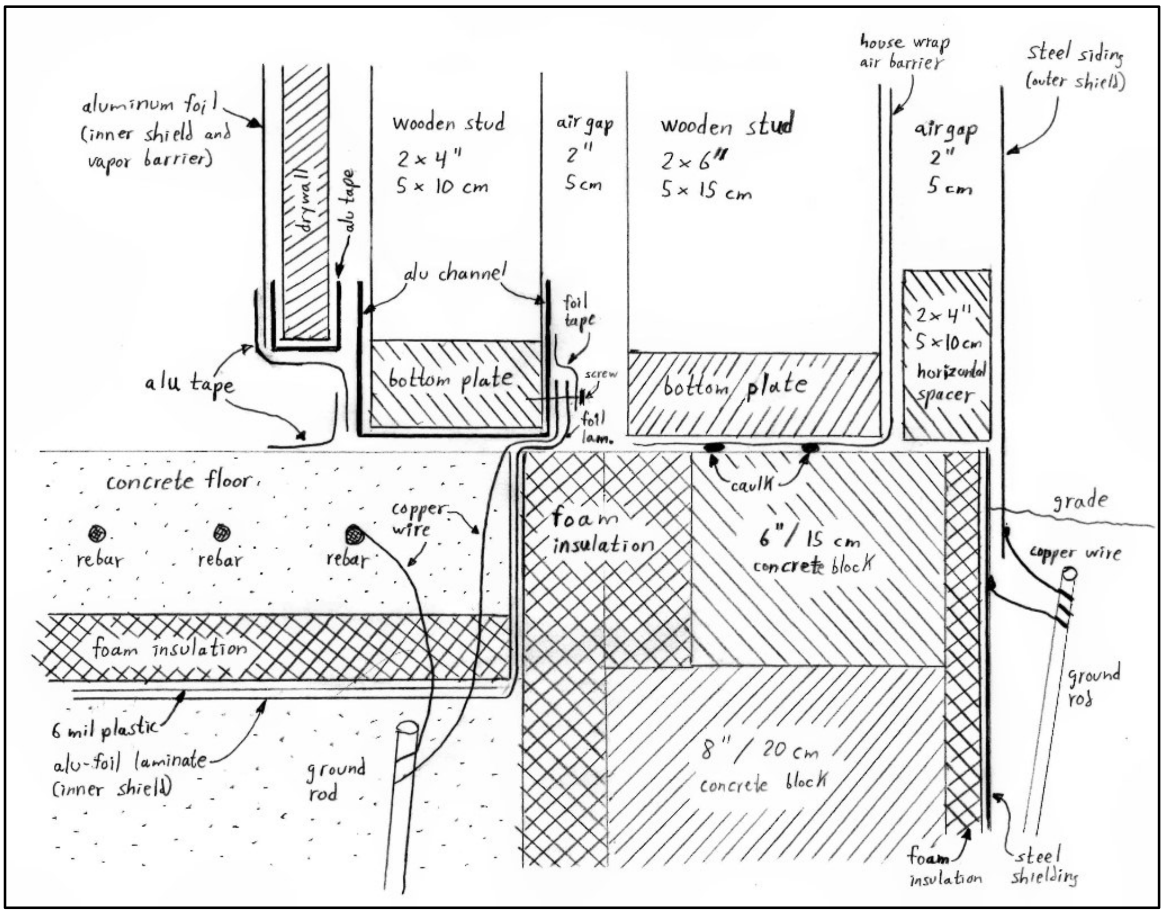


Figure B. Schematic of the wall design (not to scale). Note how the ground rod is connected to the aluminum foil on the walls through the channel and foil tape at the bottom of the wall. The house is super-insulated with double walls (two studs), though a similar design can also be used for single-walled houses.

An air barrier (also called "wind barrier" or "house wrap") was stapled to the outside of the studs to slow down air movement through the wall, while allowing water vapors to pass through. The inner shield (see later) became the house vapor barrier. This is important because a house can only have one vapor barrier, and it must be placed correctly in order to avoid mold growth in the walls due to condensation or trapped moisture.

Many people are not aware of the difference between an air barrier and a vapor barrier, as some products serve both purposes. Make sure you understand the difference before trying to build a shielded house.

Many regular American homes have plywood nailed to the outside of the studs to serve as a base for the siding. Plywood is toxic, so horizontal 2”x4” (5x10 cm) lumber was used instead.

The windows

The windows were the most complicated part of the project. Regular window glass is fully transparent to microwaves as are window frames of wood or plastic.

The first step was to use glass with a very thin metal film, and an aluminum window frame. These types of windows are widely available, as energy efficient “Low-E” windows use a metal film to reflect infrared heat. This coating can reduce microwaves by a factor of 100 (20 dB).

Producers of low-E windows are developing coatings that are non-metallic, so all low-E glass may not necessarily block microwaves in the future. (Most people *want* windows that let microwave signals pass through.)

Jack aimed higher than reducing microwaves by a factor of 100 in his house, but that meant he had to put in a lot more effort, including a second layer of shielding on the windows. He also had to do something about the narrow slits around the window frame, between the window frame and the glass frames, and between the two glass frames. He did that by building an outer shield around the whole window assembly, that is connected with the window frame and the inner shield.

Window with shielding outer frame, before siding was installed. The Tyvek brand air barrier can be seen covering the wall behind the horizontal 2x4 lumber that will later hold the siding. The wide aluminum grounding strap can be seen going down to the foundation and grounding rod.

Detail of the above picture, showing how the grounding strap is attached to the foundation shield with rivets. A thick (#2) copper wire connects the grounding strap to a ground rod.

Detail of outer shielding frame around window.

The finished window with stainless steel mesh screen, after the steel siding was installed.

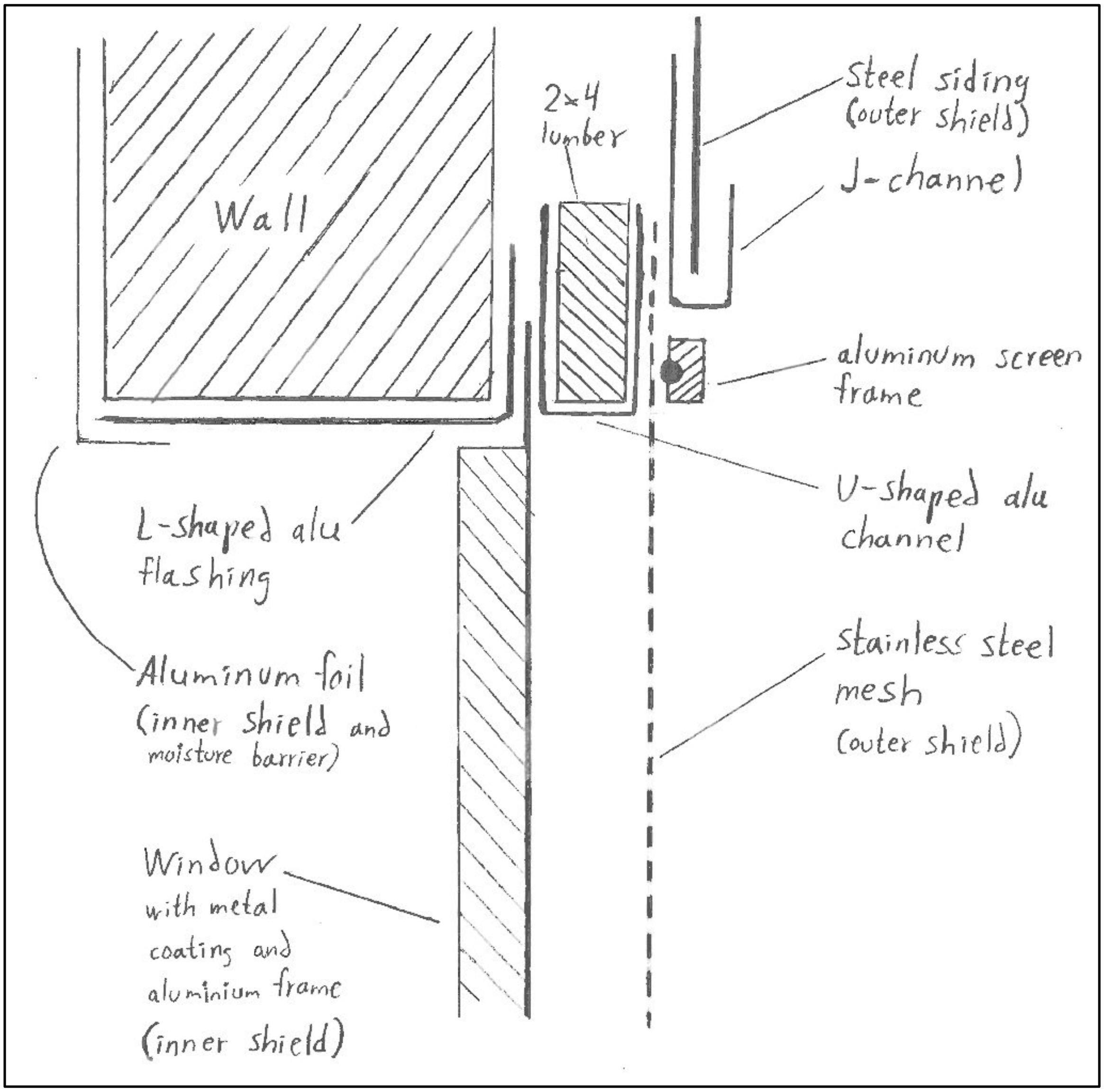


Figure C. Window assembly. Not to scale.

L-shaped aluminum flashing was mounted on the window sill and all around the window opening. This connects the inner shielding to the aluminum window frame.

A U-shaped aluminum channel wraps around the outer window frame, to continue the electrical contact out to the steel siding and the stainless steel mesh.

They made sure to have good electrical contact between the aluminum window frame, the flashing and the channels. This was accomplished by sanding the paint off the window frame and with the use of conductive silicone caulk where the various parts came into contact with each other. The conductive caulk was smeared on one metallic surface just before another metallic component was mounted over it. Screws or nails were used as fasteners.

The U-channel was also connected to the ground rod directly below the window, and the flashing (outer shield) on the foundation, as can be seen on the pictures. The ground connection is a wide strap made of aluminum flashing, as a wire would not work for such a distance.

Microwave energy behaves differently than regular electricity because of the much higher frequency. It has difficulty travelling along electrical wires due to the much higher resistance (impedance) at these frequencies. Using a wide strap greatly improves the flow of electrons. A hand rule is that the strap must be at least 1/5 as wide as it is long (according to EMC engineers Daryl Gerke and Bill Kimmel).

This type of multiple grounding points could cause an unintended ground loop if there are leakages from the electrical system. Jack wired his house very carefully, and used DC electricity, to avoid such problems.

He now doubts that having a ground rod below each window is really needed to obtain the shielding he has.

The windows slide to open. With the window open, air passes through the outer shield just as through mosquito netting. It would be very difficult to provide this level of shielding with casement windows because of the way they open.

The stainless steel mesh over the windows was a compromise between a mesh that was strong enough to withstand wind and hail, provide sufficient shielding and let enough light pass through. Jack was able to find a roll of it as surplus at a fraction of the regular cost. It has 50 threads per inch (20 threads per cm).

Jack used windows with a solid aluminum frame, which provides virtually no thermal insulation. The L-shaped flashing around the window opening also acts as a thermal bridge. He reports that the window area gets very cold in the winter with lots of condensation. If he had to build his house again, he would use aluminum-framed windows with a built-in thermal break and modify the frame so there is electrical contact across the thermal break (probably by sanding off the paint and attach conductive tape). He would also use aluminum foil instead of the L-shaped flashing, as it is thinner and less heat conductive. But the work has to be done much more carefully to prevent ripping the foil and thus breaking the shield.

The roof and siding

The roof and siding are a part of the outer house shield. Ordinary steel roofing material was used for both the roof and siding. In American house building the roof is usually attached to a layer of plywood, but Jack needed a non-toxic house, so they instead attached the steel panels to purlins made of 2x4 inch (5x10 cm) lumber. Purlins are commonly used for roofs in much of Europe, while they are uncommon in America.

The steel panels were attached with steel screws in matching color that came from the same company as the panels. Steel panels are available from several manufacturers.

The only special procedure for installing the siding was in the inside corners, such as where the soffit meets the siding. To prevent microwaves from entering through this slit, a corner shield was mounted before the siding was installed. The shield was made of metallized plastic that covered the corner with a generous overlap. Other materials, such as flashing, could also have been used, though the metallized plastic was cheaper and easier to install.

The soffits are a part of the outer shield and made of steel siding.
The slit between the soffit and the wall is shielded with metallized plastic
(hidden behind the soffit-siding connection.)

Closing the insides of the exterior walls and ceiling

The exterior walls were all framed, insulated, dry walled and covered with foil before any of the interior dividing walls were installed. This is not standard building practice, but was done to make the inner shield as seamless as possible. If the interior walls were installed sooner, then there would be gaps in the shield where the interior walls met the outer walls.

The exterior walls and the attic had the metal (EMT) conduits installed before the gypsum drywall was installed. The drywall sheets were taped around the bottom with aluminum tape, so when the sheets were mounted on the walls, the tape made contact with the aluminum channel under the wall studs (see figure B).

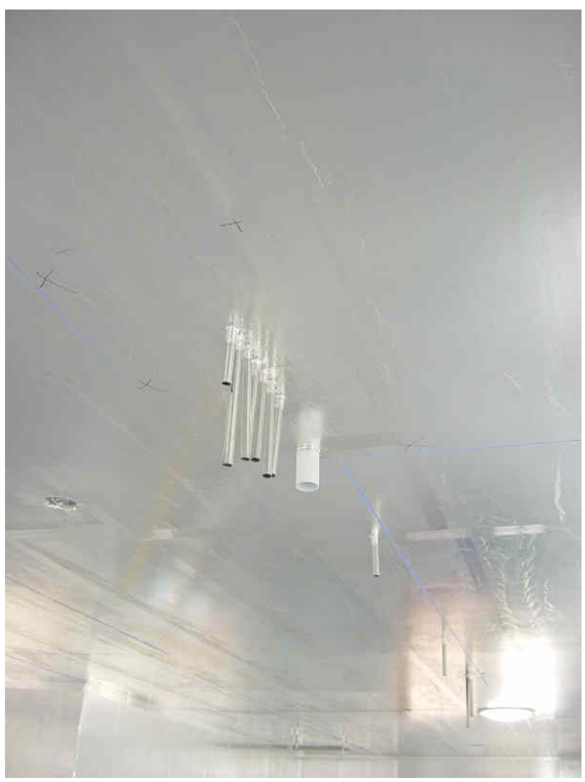
The ceiling was covered with drywall sheets as well.

Mounting the drywall was a bit complicated, since stubs of pipes and wiring conduit had to go through holes in the drywall sheets. These pipes would later be extended down into the interior walls, once they were framed.

The house was now one big room, with drywall on all the exterior walls and the entire ceiling.

The inner shield was then mounted on the walls and ceiling. It consisted of 1 mil (0.001 inch, 0.025 mm) thick aluminum foil, such as “heavy duty” aluminum foil from the grocery store. The foil was attached with a non-toxic glue. They used sodium silicate, while others have used wallpaper paste. Laminated foils (such as Denny Foil) are too stiff to be mounted as wallpaper.

The inside shield was applied to the finished exterior walls before any of the interior walls were framed.



Steel conduits sticking down from the ceiling.
They were later extended down into the interior wall placed there.
The plastic pipe is for the central vacuum.

The foil at the bottom of the walls connected to the aluminum tape around the bottom of the drywall. Since this tape was in contact with the aluminum channel under the studs, the whole wall was grounded to the foil and rods under the house (See Figure B).

The foil has three functions in this house:

- Microwave shielding
- Vapor barrier
- Seal fumes from the walls

Most houses need a vapor barrier to avoid condensation and possible mold growth inside the walls. In most climates, the vapor barrier is on the inside of the insulation, like in this house (but usually hidden behind the drywall).

In hot and humid climates, such as Florida, East Texas and tropical coastal areas, the vapor barrier should be on the outside of the insulation, or no vapor barrier used at all. In such climates, breathable shielding materials should be used, such as copper mesh or perforated aluminum foil.

Since Jack also had MCS, he needed the walls to be sealed by the foil to prevent fumes from the drywall materials, the insulation and the wooden studs from entering his living space.

Minimizing penetration problems

The various pipes that had to go through the inner shield create weaknesses in the shield. The number of penetrations were therefore minimized. One example was that both the kitchen drain and the bathroom drain share one vent stack up through the ceiling, and there are no outdoor hose bibs.

Most penetrations were of steel pipes and steel conduits, that are minor problems. Of more concern were the plastic tubes for the sewage vent stack and the whole house vacuum cleaner. Since the pipes are plastic, they create a hole in the shield as big as the diameter of the pipe. To mitigate that problem, these pipes were wrapped in aluminum tape from the ceiling penetration and about 10-12 inches (25-30 cm) up into the attic. Not down into the room below, except what it took to seal the hole between the pipe and the ceiling foil. This method is called "waveguide before cutoff." The shielding of the pipe could have been further improved upon by installing a "honeycomb vent" inside the pipe, but that would not have worked for the vacuum cleaner line, as it would soon clog up with dust.

The interior walls

The interior walls were put in after the outer walls were covered with drywall and foil.

Since these walls were entirely inside the inner shield, their construction was not important from a shielding perspective. Jack chose to use steel studs and drywall sealed with alu foil. People who do not have MCS would not need to foil the interior walls, unless they wish to have shielding between the rooms.

The interior walls were framed with steel studs after the exterior walls were walled in and covered with aluminum foil.

The studs were mounted in steel channels on the floor and ceiling. These were mounted with screws. To limit the screws' ability to transfer microwaves through the foil on the ceiling, the screws were installed from the attic side and the tip of the screw was then cut off flush with the channel (see figure D). The same procedure was not possible to do for the steel studs mounted up against an outer wall. What little radiation might slip through that imperfection is hopefully trapped inside the foiled interior wall.

When the bathroom shower stall was built, Jack needed to install cement boards to hold the tile. A small area of the exterior wall had to be covered with these boards, but Jack was able to glue the boards to the foiled wall instead of using screws.

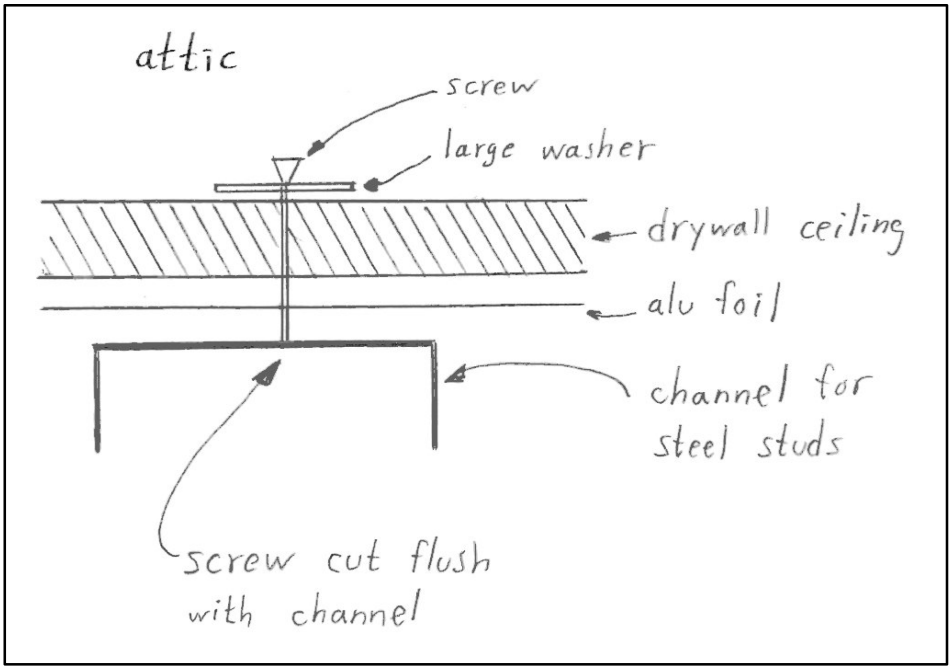


Figure D. The steel channels for the interior walls were mounted with screws from the attic side. The screw tips were then cut off.

To be on the safe side, the interior walls were grounded to the exterior walls. This was done with braided ¾ inch (20 mm) wide copper grounding straps. The straps were mounted between the bottom steel channels of the two walls where they meet. The straps were mounted with both screws and conductive caulk.

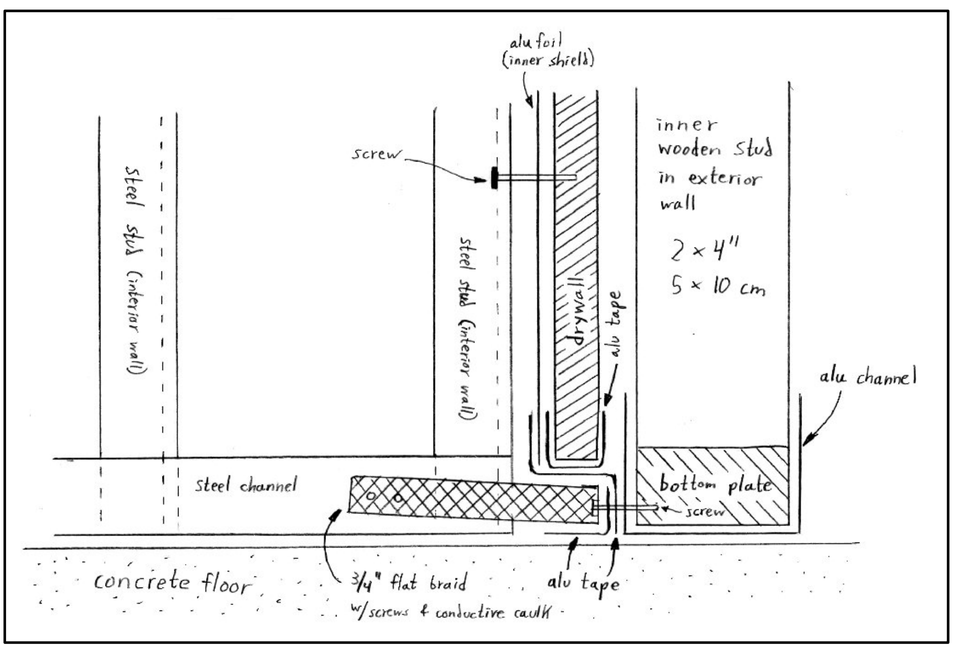
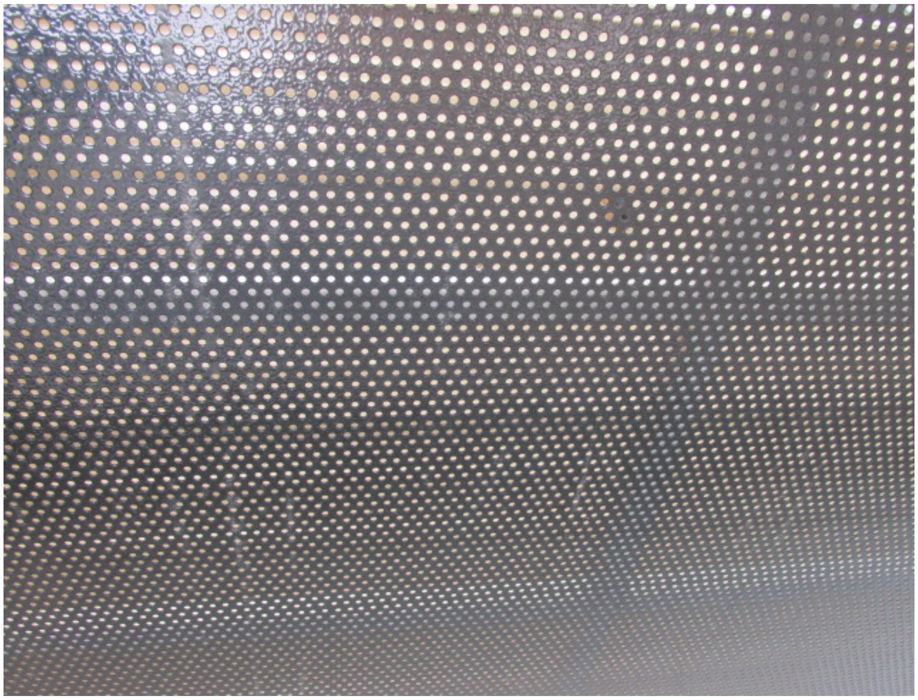


Figure E. The connection between interior and exterior walls.

The doors

Doors are a weak point in a shield, and this house has just one exterior door. A person entering the house has to pass three shielded doors in succession. There is first a sturdy screen door, with the densest metal screen available and set in a steel frame. There is good electrical contact between the door and the frame due to the installation of a conductive EMC gasket.

The front door is of steel, with a steel frame and a steel-mesh screen door.



The steel mesh on the screen door is similar to that used in the doors of microwave ovens.

The steel frame of the front door with conductive gaskets that seal the air gap between the door and the frame.

The front door is made of steel with a steel door frame. It opens into a small foyer, from which another steel-framed door leads into the rest of the house. The walls, ceiling and floor in the foyer were also shielded, so the walls and the doors provide multiple layers of shielding to compensate for the relatively "leaky" doors. It is a sort of "microwave airlock."

Household wiring

The wiring was shielded throughout the house by encasing it in steel conduit and steel boxes. The wires were also twisted. The conduit used was the EMT-type and it was connected with compression fittings. (The simpler slip-fittings do not provide good shielding.) The wires were pulled through the conduits after all the walls in the entire house were finished.

The wall boxes were a part of the inner house shield and had to be microwave tight. They were of steel with aluminum tape used to make a tight seal with the foil on the wall. All the knockouts on each box were sealed with aluminum tape to prevent leakage through the slits.

Electric box sealed to the foiled wall with aluminum tape.
The backside was also taped to seal the slits around each knockout.

The ceiling lights were mounted using regular steel boxes that were recessed in the ceiling. Since they were a break of the inner shield, they had to be taped like the wall boxes.

Recessed lighting was not used, as they get hot and are difficult to seal.

The house does not have any porch lights, since the light fixture and bulb could become a microwave antenna that dumps microwave energy onto the household wiring. The solution to the outdoor lighting problem was to install solar powered lights that turn on automatically at night. Jack also used battery-powered lanterns when outside at night.

There are no outdoor electrical outlets, to minimize penetrations of the outer shield.

Conductive glue and caulk

It is best to use conductive glues or caulks when two pieces of metal touch each other, to ensure a good connection.

Conductive glues are usually a problem for people with MCS and some of them take a very long time to offgas. They could not be used much in this house due to Jack's MCS. He mostly used a conductive caulk instead.

The aluminum tape he used did not have a conductive glue, so the connection between the foil tape and the surface will mostly rely on a capacitive coupling, which works acceptably at microwave frequencies, as long as there is a good overlap.

The places where it was essential, he used copper tape with the conductive glue and covered it with aluminum tape to seal in the fumes.

Other shield penetrations

The house has two large solar tubes that bring sunlight down into the house from a plastic dome on the roof. The light travels inside a reflective metal tube down to a plastic dome in the ceiling.

The aluminum tube was connected to the steel roof with lead flashing for a tight fit to the outer shield, but the vertical hole inside was no barrier, and also acted as a "waveguide" to bring microwaves into the house. The problem was solved by installing a very fine 100-thread copper mesh (100 wires per inch, 40 wires pr. cm) inside the aluminum tube and fasten it with copper tape with conductive glue. It made a measurable reduction in the microwave energy that entered the room below.

Nails that go through the foil can act as antennas to bring microwaves through the shield, if there are metal parts sticking out on both sides. There are no nails in the wall for hanging pictures or other decorations for this reason. Jack has several framed pictures and a big wall clock, but they are all attached with self-adhesive fasteners (3M Command strips).

Nails can transfer microwaves through the shielded walls.
Pictures are instead hung using self-adhesive fasteners.

Finishing the interior

The foiled walls were painted or covered with tiles to make Jack's house look nice. Because of his MCS, he used a home made clay paint and lots of tile. Aluminum foil can't be seen anywhere, except inside the walk-in closets.

The shielded porch

Jack built a shielded porch to allow him to enjoy the outdoors and still have some protection. The porch has only one layer of shielding and reduces the microwaves about a hundredfold (20 dB).

The porch is outside the house shielding, but still reduces the microwaves about a hundredfold (20 dB).

View from inside the shielded porch.

The porch is built into a corner of the house, but is outside the house shield (i.e. the wall and window between the porch and the house are fully shielded).

The porch is shielded by the house on two sides and by the roof. On the two exterior sides it is shielded by steel siding, steel mesh over the openings and by a screen door. The screen door is the same type as used in front of the entrance door.

Cost

Jack estimates that the extra cost for the shielding was about $12,000 in 2011. This includes installing the foil on the walls (also a part of making the house MCS safe), but not the cost of the steel siding and roof, as he would have used them anyway.

Jack saved a lot of money by using these low-cost shielding methods and not hiring any engineering help or a specially trained building crew.

Experiences

The house has worked very well since Jack moved there in 2011. Cell phones and FM radio receivers do not work inside the house. One very powerful AM radio station can be received inside, while other AM stations cannot.

The windows were measured to shield about 2 million times (63 dB) which is the level Jack will be exposed to in the rear bedroom, when he closes the door to the rest of the house.

The weakest part of the shielding are the front doors that when all closed shield by a factor of about 300,000 (55 dB).

The low hills surrounding the house reduce the microwaves from the cell towers by a factor of ten (10 dB). This means that Jack is exposed to less than $1/3{,}000{,}000^{th}$ (65 dB) of the cell tower radiation when he is inside his house compared to if he stood on a nearby open field in full view of the towers.

The shielding was tested by placing a powerful 2.5 GHz microwave transmitter outside the house and comparing the measured radiation at the same distance and direction with just air versus with a door/window/wall in between. The results will vary some with the frequency.

During these tests Jack found corrosion where an aluminum window frame touched the frame of the window screen. This corrosion reduced the shielding effect by 8 dB, which was restored when cleaned.

It would take a serious budget to shield a house any better than this one. Building a house like this one is a big effort. The shielding of a house is only as good as the weakest link in the chain, so anyone attempting to skip some of the details may find their house performing much more poorly.

It is much easier to build a more modestly shielded house, since many of the details described here would not be needed.

For more information

Additional articles about shielding are available at www.eiwellspring.org/shielding.html. Those articles provide introductory information about shielding that may make this article easier to read.

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