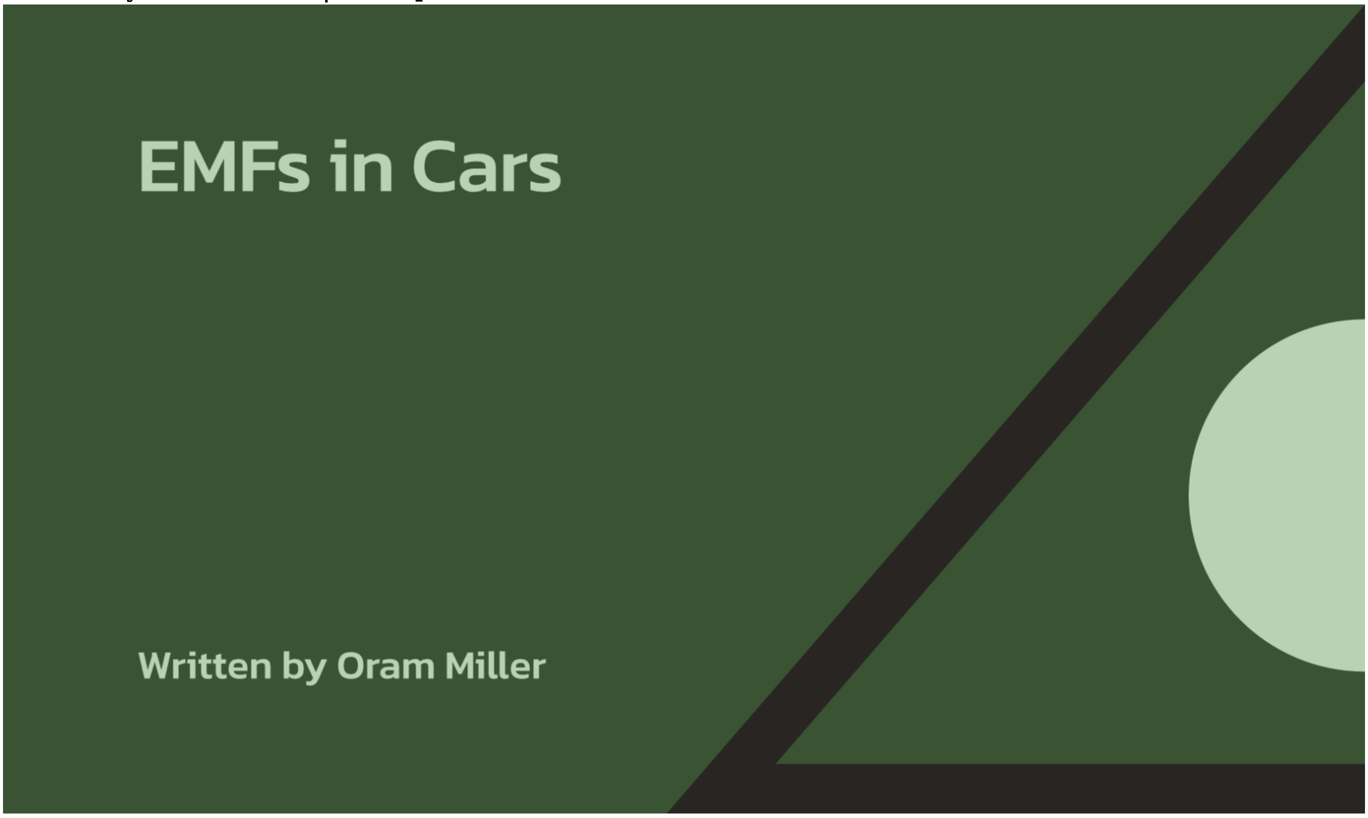
EMFs in Cars

written by Oram Miller | 17 September 2023



Introduction

We are often asked about EMFs in cars. Many people who are concerned about EMFs measure them in the car they drive or in a car they want to buy, whether they are electrically hypersensitive (EHS) or not.

Much of this concern comes from the assumption that electric cars and the batteries they contain must be filled with EMFs because they run on electricity, not gasoline. While that is true to a certain extent, it is also true that the gasoline-powered cars we have all driven for years have surprisingly high AC magnetic field EMF levels themselves, while all-electric or plug-in hybrid cars (when on battery) actually have lower AC magnetic field EMFs when compared to newer electric cars. Measure where you sit in the driver seat of your gasoline-powered car with any AC Gauss meter and see for yourself. More about that in a minute.

The Basics of EMFs in Cars

First, let's establish which types of EMFs we are dealing with in general in cars. The biggest type of EMF found in gasoline-powered cars over the decades has been and continues to be high AC magnetic fields in the driver and front passenger compartments, particularly at your feet and legs. This is from a number of sources, including: the alternator in the engine compartment, from the way the car is wired, from sparking of the distributor to spark plug wires, and within a foot or so of steel belted radial front and rear tires on either side as they are turning.

We also have significant dirty electricity in gas-powered cars from constantly changing voltages and currents. Plus, today's new gasoline-powered cars all have exceedingly high RF levels from WiFi, Bluetooth and radar.

The primary types of EMFs in all-electric and hybrid cars, on the other hand, are these higher frequencies of so-called "dirty electricity", along with the same RF issues with WiFi, Bluetooth and radar seen in gasoline-powered cars. Dirty electricity frequencies emanate into driver and passenger compartments from electricity running on the wiring of the car. Voltages and current levels on those wires are constantly changing, causing this dirty electricity. Higher frequency electric and magnetic fields, which is technically what dirty electricity is, are not steady on car wiring.

The 24 Volt Direct Current (DC) motor and batteries in all-electric cars and plug-in hybrid cars when running strictly on battery do not emit AC magnetic fields like you get from the alternator and single wire configurations in gasoline-powered cars — see below.

Yes, you have DC electricity and DC magnetic fields from low voltage wiring and batteries in electric and hybrid cars, just as you do in gasoline-powered cars. However, we cannot measure DC magnetic fields with our AC Gauss meters and we also do not consider them to be particularly harmful for otherwise healthy people. They are not the problem in electric cars.

One of the most important revelations in this debate about EMFs in cars is that the very gasoline-powered cars that we have driven for so many years, along with hybrids when they run on their gasoline engine, have AC electricity traveling through "hot" wires separated from return current paths, along with the alternator, causing high AC magnetic fields. That is what you are picking up with your AC Gauss meter in these cars, particularly with an older Trifield 100XE combination EMF meter set to magnetic fields.

That is especially true with the so-called "Frequency Weighted" Trifield model, which many of you have had over the years. As I explain in my EMF Meters and Instruments article in the AC Magnetic Fields section, the Frequency Weighted Trifield 100XE Meter shows a somewhat higher magnetic field reading due to the design of that analog meter. This Frequency Weighted value is considered by Alpha Labs, the maker of the Trifield meter, to represent the more "bio-active" EMF frequencies, which is true.

Alpha Lab's Flat Response 100XE model, on the other hand, has small earth magnets purposely placed inside the meter to dampen this effect and give you a reading that is closer to what you would measure with a digital Gauss meter, including their new TF2 combination EMF meter. You know you have a Flat Response model when it has the words "FLAT RESPONSE" printed at the bottom of the sticker on the back of the meter.

Alpha Labs now sells their great new digital combination EMF meter, model TF2. Turn the dial one click clockwise to measure AC magnetic fields in Standard Mode. Those readings are similar to what you find on their Flat Response 100XE model and very close to what we read on our more expensive digital Gauss meters, such as the Gigahertz Solutions NFA1000 combination EMF meter, costing over ten times more.

How Are Magnetic Fields Generated in Cars?

In gasoline-powered cars, which most people think have few EMFs, the wiring system is laid out differently than we find in homes. Wires in gas cars carry AC current from the alternator to electric loads at varying voltages, not consistently at 120 Volts like in houses.

However, what is most important is that whatever the voltage, the return current from electric loads in a car does not flow on a neutral wire right next to the hot wire as it does in building wiring, where magnetic fields of the same size rotating in opposite directions are literally on top of each other, canceling each other's magnetic field. Instead, return current in a car is carried not on a wire, but on the metal grounding system, finding its way eventually back to the alternator by flowing on the metal chassis all throughout the engine compartment.

You thus have no cancellation of magnetic fields as you do with current carried on hot and neutral wires inside building circuits. In homes, this results in lack of magnetic fields in occupied rooms when current flows on house circuits (assuming there are no wiring errors), as described in my Magnetic Field EMF article.

In gas-powered engines, large separation of hot electrical wires carrying AC current from the return path of that AC current flowing on metal parts (instead of wires) inside the engine compartment causes high AC magnetic fields that extend many feet into the driver and front passenger compartments, particularly if such wiring runs along the front of the firewall, inches from your feet and legs at the gas and brake pedals.

This is easily measured with any AC Gauss meter when the engine is running in idle or when driving. All Gauss meters measure magnetic fields at a range of frequencies and voltages, not just at 60 Hz. So, you will get an elevated reading even if the voltage is not 120 Volts, as we have with house wiring (in North and South America).

We also have measurement of this with a Gigahertz Solutions NFA1000 used to monitor magnetic fields at multiple frequencies, which is what you see in cars. This is presented in a fascinating study done by building biologist Arthur Kaliski, EMRS of EMF Reduction on Long Island, New York. Arthur's presentation of his study can be linked to here.

Arthur started by noticing that a hot wire carrying 3.2 Amps of current runs from his alternator in the center of his engine across to an unidentified electrical load on the other side of the engine. This causes a hefty magnetic field of 20-30 mG because the hot wire runs unopposed, with no neutral wire next to it carrying return current back to the alternator, like we have in a house circuit.

To remedy this, Arthur installed three "ground" wires right next to the hot wire, two 10-guage white wires and one 8-guage yellow wire, connected from the alternator to a ground point on the car chassis more than two feet away. These three ground wires simulate what a neutral wire would do if one were used in car wiring. See the power point presentation for photos and comparison graphs.

In the study, Arthur compares the magnetic field levels measured at four locations in the engine compartment, including right over the hot wire, as well as at seven locations in the driver's and front passenger's compartments, where your feet and legs would be. He compared readings before and after inserting the three ground wires. The alternator in his Forester is towards the front left of the engine, as viewed standing in front of the car looking to the rear. You will see Arthur label the Alternator Hot Wire in the second slide. This wire is not near the firewall where the driver and front passenger have their feet, but Arthur did measure a high total magnetic field of 20-30 mG at all frequencies right above the hot wire.

That magnetic field dropped to 5-8 mG right above the hot wire with insertion of the three ground wires, a 75% reduction. He also measured a total reduction of the average of 11.7 mG at all areas measured in the engine to an average of 6 mG at all areas after the three ground wires were installed, representing a 49% reduction of the averages.

The second comparison in the driver's and front passenger's compartments is not as dramatic a reduction due to the fact that the hot and ground wires were towards the front of the engine and not directly in front of the firewall, where your feet and legs would be. However, if you look closely at the before vs. the after tracings, you can definitely see fewer magnetic field pulses over time at each location at each frequency tested, with particularly less higher frequency magnetic fields at the third harmonic, 150/180 Hz (in light blue).

I believe this means other sources of magnetic fields still exist closer to the firewall that were not impacted by this wiring change. These sources would benefit from localized shielding on the driver's and passenger's sides of the firewall, under the accelerator and brake pedals. Those magnetic field sources near the firewall are also smaller, closer to 4-12 mG in intensity and not as strong as the 20-30 mG fields you get close to the single hot wire from the alternator carrying 3.2 Amps. However, if the alternator and its hot wire was closer to the firewall, I believe you would see higher magnetic fields at the feet and legs of the driver and front passenger.

Clearly this strategy of adding current-carrying paths so that return current can flow back to the alternator close to the hot wire should be the design in cars, along with shielding on the driver's and front passenger's side of the firewall, which you can do now.

Besides lack of cancellation of magnetic fields from AC current on the hot wire and metal grounding paths of the car chassis, you also have a large point-source of magnetic field from the alternator itself in a gasoline engine (and a plug-in hybrid with a gas engine), wherever it is mounted. This large magnetic field from the alternator can radiate into the driver and front passenger compartments if it is close. Hopefully your car's alternator is mounted far from where you sit at the driver seat, as is the case with the alternator in Arthur's Suburu Forester.

You will always measure some AC magnetic field EMFs in the driver's compartment, at least where your feet and legs are, in a gasoline-powered car. Try to choose a model with the lowest possible level. We often see AC magnetic field readings up to 5-20 mG or more at client's feet and legs in the driver's compartment, while our safe level is 1.0 mG or less.

Comparing AC Magnetic Fields in Gasoline-Powered Cars vs. All-Electric Cars

This revelation changes the misperception that non-electric, gasoline-powered cars are somehow okay, while electric cars are full of EMFs. That is not true, at least for AC magnetic field EMFs.

In fact, people are surprised to learn that AC magnetic fields are actually lower or nearly absent, at least in the driver's compartment in some all-electric cars and plug-in hybrids when running on battery. My Toyota Prius Plug-in Hybrid has *zero* AC magnetic fields where my feet and legs are when I drive the entire first 35 miles of every trip on battery (after having charged my car over the previous night).

I then measure a low 1.5 mG at my legs when the battery runs out and the gasoline engine kicks on, if my trip is longer than 35 miles. The magnetic field that comes into the driver compartment when the gas engine kicks on is due to separation of single current-carrying AC hot wires from the metal chassis carrying neutral return current back to the alternator, as well as from the alternator that my Prius also has, just like in any gasoline-powered car because my plug-in hybrid also runs on a gasoline engine.

Likewise, I have ridden in four Tesla (all-electric) cars with clients, where I measured low AC magnetic fields in the driver and front passenger compartments, at 1.0 mG or less. A Tesla sales rep even told my client and me that his company actually knows about EMFs and shields magnetic fields to confine them.

My Building Biology colleague, Larry Gust, EE, BBEC, EMRS of Gust Environmental, has two Chevy Volt plug-in hybrids, one older and one newer. He has measured up to 2-4 mG in these cars.

AC magnetic fields in gasoline-powered cars, on the other hand, can be as high as 5-20 mG or more, as noted above, at your feet and legs in the driver and front passenger seat.

One last point. Be sure to determine if an elevated magnetic field, measured above 1.0 mG, is actually coming from outside the car, specifically from under the pavement or from an overhead power line before assuming the field is completely coming from somewhere inside the car. Get out of the car and measure the AC magnetic field around the car. Then measure inside the car before turning it on. You can also drive away from that spot to an area known to have a lower magnetic field (because you previously measured it) and see if the reading goes down.

Avoiding AC Magnetic Fields in Cars

The location of the alternator varies, so you just have to see what the magnetic field levels are in the driver and front passenger compartment in every gas-powered car you test drive. You may be lucky and find a model that has relatively low magnetic field levels in the driver's seat and leg area.

The bottom line is you simply have to measure each gas-powered car for yourself. If you are electrically sensitive, you need to go by how you feel, regardless of what any Gauss meter reads.

Measure throughout the area that every part of your body will occupy as you drive as well as that of passengers, especially children. Generally, back seats have much lower magnetic fields, if any, than front seat compartments particularly in gas-powered cars, although some hybrids do have somewhat elevated AC magnetic field levels in spots at the rear seat in front of the battery. You need to measure.

In general, try to determine where the strongest sources are for the driver and all passengers, particularly when the car is in motion, and avoid them if you can. There will be many magnetic field sources, not just right in front of or beneath your feet and legs. You can test in neutral, or the car may need to be in motion. However, be careful, and have someone else drive while you move the Gauss meter about and take readings.

Shielding AC Magnetic Fields in Cars

Assuming you do find magnetic field readings above our generally accepted safe exposure levels for healthy people of 1.0 mG when the car is running, you then must figure out how to effectively shield against these fields.

Shielding AC magnetic fields is the most difficult and expensive form of EMF mitigation we encounter. The problem is, AC magnetic fields from electricity at such a low frequency as 60 Hz (cycles per seconds) bend around corners.

In reality, lines of magnetic field flux never disappear with shielding. They are only compressed and redirected, and only if the angle of the shielding plate or thick foil is correct. If the incident angle is a full ninety degrees to the magnetic field flux lines and the plate is essentially perpendicular to the lines of flux, flux fields will penetrate right through the shielding as if it wasn't there.

The shielding must be at a diagonal angle to the direction of the lines of magnetic flux to effectively compress and redirect those flux lines. You are essentially making the back side of the shielding, where the magnetic field source is, more attractive than the air on your side of the shielding, so those flux lines gather on the back surface of the shielding and get re-directed rather than passing through the shielding material to where your feet, legs and pelvis are.

Magnetic fields also appear to re-propagate from edges of shielding material if that material is not wide enough, thereby providing a new source of magnetic field that is closer to you.

Also, you can only use special materials to re-direct magnetic fields, such as nickel alloy found in MuMetal and G-Iron, rather than standard steel or aluminum, which do not block magnetic fields no matter what angle they are placed at. Fabric, shielding paint and metal mesh, on the other hand, which block radio frequencies and electric fields (when grounded), *DO NOT* block AC magnetic fields in any way.

Let me repeat that, because this is a great misunderstanding by many in the EMF community. RF-shielding fabric, canopies, paint and metal mesh only block radio frequencies from cell towers, smart meters, broadcast towers and neighbor's WiFi. They also block electric fields when grounded. Sadly, magnetic fields pass right through them. They are not the solution for AC magnetic fields.

Getting adequate magnetic field shielding in a house by simply putting up a large enough piece of G-Iron is possible if you are mounting the shield on a wall to protect against a "point source" of magnetic field exposure on the other side, such as an electric breaker panel. The closer the shielding is to the source, the better.

Trying to do the same in the convoluted confines of a car, however, between the engine compartment and your feet, legs and pelvis is another thing altogether. Car shielding usually only works partially. I have been successful at reducing AC magnetic fields at the feet of an electrically sensitive client in her gas-powered car by about 50% with G-iron laid fully on the floor and slid up behind the gas and brake pedals, making the sheet as wide as possible. This shielding is available as G-iron SuperFlex from LessEMF and as G-Iron ArmoFlex from Safe Living Technologies. If you cut G-iron with tin snips, be very careful as the edges are sharp. Carefully cover edges with several layers of thick duct tape.

Look at the FAQ page on LessEMF's website for their take on this process by clicking here and scrolling down to the question, "How Can I Shield Magnetic Fields in My Car?". LessEMF has varied success with this strategy for their customers, but they, or Safe Living Technologies in Canada and other retailers are the best resources as far as shielding magnetic fields in cars is concerned.

AC Electric Field EMFs in Cars

When we consider AC electric fields in cars, we have different voltages and different types of electricity to contend with, a mixture of Direct Current (AC) and Alternating Current (AC). Everything is different in cars compared to homes, where we only have 120 Volt (and 240 Volt) AC circuits for electricity (and low voltage DC current on data cables, such as Internet, telephone and coaxial TV cable lines).

It is hard to measure electric fields in cars. Generally, I only trust a three-axis, sensitive electric field meter when measuring electric fields in free-standing mode (without grounding the meter). That would be with the NFA1000 that we routinely use in the building biology profession. However, they are expensive (close to $2,000 USD). If you use a Gigahertz Solutions single-axis electric field meter, they are accurate but you need to measure electric fields in all three axes and see which axis has the highest reading. Do not hold your EMF meter when measuring electric fields, because your body artificially increases the electric field reading because your body, full of salty water, is an extension of the electric field antenna inside the EMF meter. Put it down and move 2-3 feet away, or mount your EMF meter on a stick or pole to take ground-free EMF readings.

The electric field setting on the TF2 and Cornet ED88t Plus Combination EMF meters is helpful as a screening tool, but not quite as sensitive as the Gigahertz Solutions meters, especially the NFA1000.

I actually prefer measuring AC electric fields in homes with my body voltage meter (using the NFA1000 or the Body Voltage kit from Safe Living Technologies, Electrahealth or LessEMF). If you do use a body voltage meter to measure electric fields in a car, you could ground directly to the earth outside the car.

I expect you will measure relatively low AC electric field EMFs in most cars because the wiring does not carry 120 Volt AC electricity as circuits in houses do — the voltage is less. I am not sure what the solution would be, either, if electric field readings were found to be high (above 2 to 3 Volts/meter). We shield AC circuits in walls and plastic AC power cords that we plug into in houses.

In cars, the parts of the car likely reduce what AC electric fields there may be because the metal parts are grounded. We generally do not hear that AC electric fields are a problem for EHS people in cars —- but they certainly are overlooked in homes! I call AC electric fields the "unknown EMF". See my AC Electric Field EMFs article for more information about electric fields in homes.

There are certainly AC electric fields in electric and hybrid cars at higher frequencies, which is our definition of dirty electricity, that do bother people. That is covered as a separate type of EMF below, after the next section.

Radio Frequency (RF) EMFs in Cars

Turning to the third type of EMFs, radio frequencies (RF), all new cars, whether gas-powered or electric, have high levels of RF from WiFi, Bluetooth and now, radar, most of which you cannot disable. This causes high levels of RF in car interiors, possibly affecting the ability of the driver to maintain full attention and concentration while driving. To see a video of an interesting study conducted at University Mainz in Germany measuring brain wave changes and cognitive experiences of the driver in a car when WiFi is enabled, click here. The video is in German with English subtitles.

WiFi and Bluetooth have been with us in cars for some years now, and RF signals tend to ricochet around the interior of the car, reflecting off the inside of metal doors, roof and other panels when your cell phone is transmitting (which is much of the time).

WiFi and Bluetooth are often brought into cars in the communication module installed when you select your car model at the showroom. Dealerships install the sound/music/media package you want, and WiFi and Bluetooth are often incorporated into that circuitry made by a third party, not by the car manufacturer.

In many new car models, the automaker also installs their own wireless transmitters or uses the transmitter in the sound system. Automakers now provide wireless monitoring of the car's systems, alerting you when maintenance is needed. Security systems monitor the geo-location of the car and connect you with a dispatcher in an emergency, such as a collision.

Some models let you disable WiFi and Bluetooth. However, that does not mean the RF signal is actually off. You must measure with your RF meter, being careful that the RF signal you may be measuring is not from your own cell phone or your friend's or partner's phone who is also in the car with you, or from a cell antenna outside the car. Check that your phones are off, then first measure RF outside the car before measuring RF inside with the engine off, then on. If ambient RF levels are high because of a nearby cell tower, drive to a new location and test the car's RF there. See if you can disable the WiFi and Bluetooth and re-check with your RF meter.

We recommend that you minimize your cell phone use in the car and keep your cell phone above the metal door panels. They block the RF signal, causing the phone to boost its transmitter power to emit a stronger signal to push through the metal barrier. If you put the phone on the dash, make sure it is secure and does not become a projectile in a sudden deceleration. Ideally, wait until you get home to make your phone calls.

Many GPS systems in cars engage RF transmitters and receivers either in the dashboard or on the outside of the car. RF signals are being transmitted when you use this system, although almost everyone uses it.

Satellite radio is actually received by the antenna on the top of the rear window from a network of terrestrial antennas, like cell towers, not from outer space. Some cell phones, however, are now able to receive certain satellite transmissions (but not easily inside a car or house).

Radar is now deployed in cars for many safety functions, including lane drift alerts and crash avoidance. Transmitters emit radar out the front, sides and back of your car, and you are also exposed to radar from passing, following and approaching cars.

We are measuring radar signals inside and outside cars in the 20-40 GHz range with the new Safe Living Technologies Safe & Sound millimeter Wave (mmWave) 5G RF meter. This is discussed in the mmWave Learning sessions linked to from the Safe Living Technologies website, particularly in the third session held on August 15, 2023. You can access a replay of an archived recording of that webinar by clicking here. To view a video of Safe Living Technologies proprietor, Rob Metzinger, BBEC, EMRS measuring radar on a 2020 car, click here. You can also see a presentation of radar from passing cars measured with a Safe & Sound mmWave 5G RF meter by Keith Cutter of EMF Remedy as part of the mmWave Learning Session held on August 15, 2023.

Reducing RF is almost impossible in new cars for EHS people who are RF-sensitive. They end up needing to buy an older model car that does not have WiFi, Bluetooth or Radar.

Dirty Electricity in Cars

The major type of EMFs you are exposed to in an electric or hybrid car, once again, is the higher frequencies created as electricity on wires changes from one voltage to another, known as dirty electricity. Some people are not bothered by dirty electricity (although their cells don't like it), while others who are electrically hypersensitive clearly do. I have clients who cannot drive or ride in an electric car or hybrid because they react to the dirty electricity.

If that is the case for you, an electric car or hybrid will not work for you. Get an older model car with a gas-powered engine and measure it’s AC magnetic fields with a digital Gauss meter, such as Alpha Lab’s TF2. Find the model of gas-powered car that has the lowest AC magnetic field reading at the feet, legs and pelvis of the driver’s seat (and passenger seat, if you are sensitive and someone else drives for you).

Hybrids cause high levels of dirty electricity, which we define as electric and magnetic fields at frequencies that are higher than the frequency of magnetic and electric fields from building electricity, which is at 60 Hertz (Hz). Dirty electricity, as noted above, is generated in hybrid cars from many sources. Many electrically hypersensitive (EHS) people are bothered by this.

Unfortunately, it is not easy to measure dirty electricity in cars because there is no 120 Volt AC electric outlet inside the car to plug a Greenwave or Stetzer Microsurge Electromagnetic Interference (EMI) meter into, like we have in a house. That eliminates the most common way of measuring dirty electricity used by most people.

You would have to bring an oscilloscope with a whip antenna into the car to measure DE, which is not practical for most people, and you cannot plug Stetzer or Greenwave EMI meters into a 120 Volt electric outlet, so you won’t know the DE level except by how you feel.

If the car you are looking at has a 120 Volt outlet, you can be sure the electricity you measure with a plug-in meter will be filled with dirty electricity, as the electricity comes from the alternator and likely has a square wave (like 120 Volt AC electricity from a portable battery) and unlike the smoother sine wave found on house circuits (in homes with low dirty electricity levels).

Controlling EMFs

Our philosophy is, control all EMFs that you can when in your own home, particularly where you sleep, so that when you are exposed to various EMFs during the day, particularly when you are away from home such as while driving, you have better able to withstand some degree of exposure.

Remember, we have all been exposed to elevated magnetic fields in our gas-powered cars for decades and not known it. That does not mean they are not harmful. I am just trying to put the issue into perspective and encourage otherwise healthy people to not worry unnecessarily about hybrid or electric-powered cars (unless you are EHS). Reduce and eliminate all the EMFs you have control over in your home and in your car, whichever type it is, as much as you can. That allows you to better tolerate those EMFs you are exposed to that you cannot control.

If you are sensitive, you will probably need to avoid electric and hybrid vehicles altogether and measure gas-powered cars for a model with the lowest magnetic readings. Generally speaking, the older the car, the simpler it is in terms of digital electronics and lack of wireless communication systems. The main criteria for older models is which car has the lowest magnetic field level in the driver’s compartment.

Summary

The bottom line is you just have to take your Gaussmeter and RF meter to the dealership and measure AC magnetic fields and radio frequencies in any car you want to buy or lease.

If you are electrically sensitive, you will likely not be able to find a new, late model car that you will be comfortable driving and riding in. Instead, plan on purchasing an older car with low magnetic fields, built before WiFi and Bluetooth were added.

Good luck. Happy car hunting.

Fellow Building Biologist Larry Gust, EE, BBEC, EMRS of Gust Environmental helped with background information for this article.