Lab Notes - Mobile Installations and Electromagnetic Compatibility

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Mobile Installations and Electromagnetic Compatibility

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Q: I read your QST article on mobile electromagnetic compatibility (EMC),[1] but it left a lot of questions unanswered. It didn't tell me how to install a radio in my car, or even which cars are compatible with Amateur Radio equipment. Can you help?

A: The article was not intended to be a technical discussion. We summarized the manufacturers' policies so that hams could make a decision about which vehicles were compatible with their Amateur Radio interests. As you might have noticed in the article, I was frustrated by some of the incomplete or evasive answers, too.

The manufacturer of a vehicle is still the best expert on how that vehicle performs, including its electromagnetic compatibility. If possible, select a manufacturer and dealer who offers technical support if you run into difficulty. In this regard, there were some clear winners (and losers) in the article.

Q: Where do I start?

A: Start with your dealer. Ask about service bulletins. Unfortunately, this process doesn't always work. Several members called *me* to get the correct Technical Service Bulletin numbers that the dealers and factory customer-service staff said didn't exist!

Also, ask your dealer about *fleet vehicles*. Some manufacturers have special modifications for vehicles intended for sale to police, taxi companies and other users who will be installing radios in the cars.

Q: I was quite impressed with the auto manufacturers who had booths at the Dayton HamVention. Does this mean that I can't go wrong if I buy one of their cars?

A: Oh, if only it were that simple. Unfortunately, each manufacturer has a number of different models, all of which have different options. The possible combinations can result in unexpected problems. If problems do occur, it is often not possible to engineer changes after the design is complete. What I'm saying is that even the good guys can make mistakes—and the help they can offer is sometimes limited.

Q: How can I tell which car is compatible? Does the ARRL maintain a database?

A: No, we don't have a database. There are hundreds of different models in each model year and we have reports on only a handful. Most hams don't write the ARRL to report problems, and almost none write to tell us they are *not* having an interference problem.

Q: But I still need to buy a new car. Is there anything I can do?

A: Yes—you can test the cars before you buy them!

EMC problems with vehicles come in two flavors—interference *from* the vehicle and interference *to* the vehicle. The easiest thing to check is interference *from* the vehicle. When you go to a dealership, bring a battery operated receiver that covers the frequency ranges you want to use. You can use a built-in whip antenna, but a mag-mount antenna will yield more reliable results.

Start the vehicle and turn on the receiver. Tune across the entire frequency range. You are looking for two types of signals: broadband noise and discrete spurious signals. Turn on all the accessories (wipers, turn signals, air conditioning, and so on) one at a time or in combination. Have the dealer drive the car for a mile or so, just to see if there are any problems apparent while the vehicle is in normal use.

Q: I hear a little noise and I found a few spurious signals. Does this mean I should not buy the car?

A: Maybe not. Amateur Radio applications are only *part* of your decision. You may be able to live with *some* noise to get an otherwise fine car. Compare the amount of noise against your intended use of the radio. If you are going to use it to talk through a powerful, local repeater, the repeater will probably be strong enough to mask the noise. If the spurious signals fall on frequencies not used in your area, you may not care.

Q: Okay, I can live with the receive problems. What about transmitting?

A: This is a bit harder. The only way to conduct a test is to actually transmit. You will need to talk this over with the dealer. The dealer will *not* allow you to do a permanent installation, but you should be able to use a mag-mount antenna and external battery (I use a deep-discharge marine battery) for your tests. You may run into other snags when you hardwire the installation, but they can usually be fixed.

Q: The dealer said "no way" when I asked if I could transmit. Is this common?

A: Well, it isn't rare. This answer should tell you something, though. If they're not willing to work with you when you're in their showroom with a pocketful of money, they may be even less congenial if you have EMC problems later on. If you can obtain a copy of the car manufacturer's transceiver installation guidelines (if there are any), they may help you convince the dealer.

Q: The dealer finally allowed me to try a transmit test. When I keyed the rig on 2 meters, the windshield wipers came on! Is this serious?

A: It is a good thing you didn't try it using high-speed Morse code! Actually, compatibility problems come in a wide range of severity, from nuisances (like what you discovered) to more serious glitches. The manufacturers usually take care of the serious problems, but if minor malfunctions are found late in the design cycle, they may not be corrected.

Q: Well, is it time to try another car?

A: I would first experiment with the placement of the mag-mount antenna. You may find that it works well in a different place, especially toward the rear of the vehicle.

Q: Bingo! During my test I had the antenna on the hood. When I moved it to the center of the roof, the windshield wipers stopped misbehaving. Does this mean I can buy this car?

A: It will probably be okay. Just make sure you follow the car manufacturer's guidelines when you install the radio.

Q: Some of the things in the installation guidelines are a real pain. Why can't I just follow "good engineering practice" in my installation?

A: Manufacturers have worked out the proper installation procedures in great detail, even citing the locations close to the electronic control module (ECM) and wiring that should be avoided. Perhaps even more important, especially for vehicles that are still under warranty, you *must* follow the manufacturer's guidelines if you expect to obtain *any* support from a manufacturer or dealer. Even if what you do is technically correct, the manufacturer may choose not to support an installation that was not done their way.

Q: Should I avoid cars that don't have published installation guidelines?

A: Not necessarily. Even though some of the customer-service people I contacted didn't know it, all cars are subjected to EMC testing. After all, the manufacturers don't want their cars to fail when they're driven past a high-power transmitter site.

Transceivers can be installed in *most* cars. Even so, you may want to avoid manufacturers who state that it's *not* acceptable to put radios in their cars.

Q: When I'm installing the radio, where should I connect the dc power leads?

A: The positive and negative leads from the transceiver should connect directly to the

[1]Notes appear on page 75.

battery with fuses in *both* leads. Route them *away* from any other wiring in the vehicle. This usually means drilling a small hole in the firewall between the engine and the passenger compartment and running the wires through a rubber grommet (to protect their insulation from sharp edges). If the wiring or antenna lead *must* pass near vehicle wiring, route it at right angles to the wiring. It is best to run the power and antenna leads as close to the vehicle chassis as possible.

Q: Why can't I find power inside the car?

A: It's often difficult, especially in modern cars, to know which power sources in the passenger compartment can safely carry the high-current loads of a transceiver. If you choose a source that also powers one of the microprocessors, the transmit current could cause problems. In addition, some transmitters are not well bypassed and some RF energy can appear on the power leads. This is bad news for microprocessors.

Even grounding isn't as simple as it seems. With all of the plastics used in modern vehicles, not everything that looks like ground is really ground. It could be "floating" or even be part of the wiring for one of the vehicle's sensors. Even if you do tie into the chassis, it is possible that the section you've chosen forms part of the return path for one of the control modules. Generally, you're better off running the wires to the battery, especially for high-power installations.

Q: I understand. I've been curious, though; why do I need two fuses at the battery? The radio has a fuse. Isn't that enough to protect the radio?

A: The fuses at the battery are not just to protect the radio; they also protect the car. If a short circuit were to develop in the wiring, the radio fuse would not blow and the wiring could start a fire. Fusing the radio's hot lead at the battery could prevent this.

I've received a lot of questions about the fuse in the negative lead. In most cars, there is a heavy conductor between the negative battery post and the engine block. This conductor is used to carry (among other things) the high current drawn by the engine's electric starter motor. If this negative lead were to fail (corrosion around a battery can take its toll), the starter current would flow through the transmitter's negative power lead! This wire is not rated to carry the high current of the starter. Fusing the radio's negative lead will prevent the wire from overheating and protect the transmitter installation. (I sure wish I had put this explanation in the original article; it would have saved me hours on the telephone!)

Q: Where should I put the antenna?

A: First, use only high-quality coaxial cable for the antenna feed line. This feed line should be as short as possible and located away from other wiring in the car. Most manufacturers' guidelines also say that the antenna should be operated with an SWR of 1.5:1 or less. This is not usually critical, although if the feed line is not well shielded, the leakage from the line will increase with SWR. (The most important reason to honor *all* conditions of the installation guidelines is that you may need to do so to obtain the support of the manufacturer.)

Most of the installation guidelines specify that the antenna be located on the roof, or at the rear of the car. Be prepared to experiment with the location. The mag-mount antenna you obtained earlier will help you do this, even if you plan to use a different mount for a permanent antenna.

The transceiver should be located away from vehicle electronics and wiring. Make sure that it will not interfere with the operation of the vehicle. One space often overlooked is the deployment area of the air bags! Don't put *anything* where they will interfere with the car's safety features. If you're not *sure* where aftermarket equipment can be safely installed, ask the dealer.

Q: My VHF installation works perfectly. However, I followed similar guidelines for HF and found that I had some pretty strong noise on receive. Some of this noise goes away when I connect the radio to the test battery I used earlier. Any ideas?

A: It sounds like some of the noise is coming down the power leads. To cure this, first try ferrite chokes on the positive and negative leads. Obtain two FT-140-43 ferrite cores[2] and wrap about 10 turns of each wire onto the core. (Fewer turns may not work, and if you substitute a different ferrite, make sure it's suitable for HF—unknown materials usually don't work!) You can also try installing 0.01-µF capacitors from the positive lead to the negative lead, or from the positive lead to chassis ground (or both). The capacitors may work best with or without one or both of the ferrites.

Q: That did improve things, but I still hear noise when I connect the antenna.

A: Some of this may be coming from *outside* the car. First, see if the problem goes away when the car is turned off. If it does, it's being radiated by something in the car. Once it is radiated, it can't be filtered at the receiver, so you'll have to locate the source and correct it there.

There are a number of possible noise sources in a car. Listening to the nature of the sound may give you a valuable clue. It may sound similar to the digital noise you often receive near a home computer system or video game. If so, one of the vehicle's ECMs may be radiating. It may have the characteristic whine of electric motor noise. Determining which motor is operating may be fairly easy. For example, an electric fuel pump can be noisy. If the whine occurs all the time and varies with engine rpm, it's probably the alternator.

It's also possible that an electric motor is defective, especially if the vehicle passed the noise tests you gave the demonstrator model in the lot. If so, the dealer can change the motor.

If you hear a fast pop-pop or buzzy sound that increases to a whine with the car's engine, you may have ignition noise problems. These are usually more noticeable on HF, although severe cases can bother VHF FM. If your receiver has a noise blanker, this may be effective at reducing or eliminating ignition noise.

If you didn't hear ignition noise when you checked the car at the dealership, it may have developed an ignition problem. First, check to see that both the wires and the plugs are "resistor" types. (In some cars, using both at the same time may reduce engine power slightly; check with your dealer.) You may also have a bad plug or ignition wire. This is fairly easy to check by substitution. Problems such as worn rotors, a cracked ignition cap, and so on can create ignition noise. In severe cases, it may be possible to add bypassing to the distributor components or try shielded wires. In modern high-voltage, computer-controlled ignition systems, these types of cures can cause more problems than they create and should be done only by qualified service personnel.

Q: How much RF power can I run in my car without endangering the vehicle electronics?

A: There is no clear-cut answer to this one. You should be able to do a successful installation with 100-W transmitters on HF, 25 W on VHF and 10 W on UHF and above. At VHF and UHF, you may be able to get away with power levels as high as 50 W. *Most of the time*, these power levels do not cause permanent damage to the vehicle. I recommend that you think long and hard before wiring in a high-powered mobile amplifier; it may do permanent damage to sensitive vehicle electronics.

Q: Thanks for your advice. Should I run outside and "fix" my car now?

A: If the car is under warranty, leave the repairs to the dealer. If you have an older car and usually do your own repair work (you should see some of my beaters!), obtain a copy of the ARRL book, *Radio Frequency Interference: How to Find It and Fix It*.[3] The chapters on automotive, electrical and computer interference may all prove useful.

We welcome your suggestions for topics to be discussed in *Lab Notes*, but we are unable to answer individual questions. Please send your comments or suggestions to: Lab Notes, ARRL, 225 Main St, Newington, CT 06111.

Notes

[1]E. Hare, KA1CV, "Automotive Interference Problems: What the Manufacturers Say," September 1994 *QST*, page 51.

[2]These are available from distributors such as Amidon, FairRite and Palomar. Check *QST* advertisers or the parts distributors listed in the *1995 ARRL Handbook*.

[3]Available from your favorite Amateur Radio dealer, or directly from the ARRL. See the *Publications Catalog* elsewhere in this issue.

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