What is Ground ?

A **ground** is defined as *a low-impedance electrical connection to earth.* Also a *common reference point in electronic circuits*. All transmitting antenna systems need a properly functioning ground system to provide for proper operator safety and efficient radiation of the maximum amount of RF energy into the air.
There are three principle forms of ground, the last two more appropriate to operating in the mobile environment:

- **Power Line Ground:** is the ground you see at the power box where your home's electrical service is connected. It is required by law and serves to provide general, overall electrical safety for your building and property. Commonly known as the M.E.N System. (Multiple Earthed Neutral System.
- **DC Ground:** *(Also called "Safety Ground")* is familiar to the amateur as the strap or wire placed from equipment to a convenient cold water pipe or ground rod to eliminate the hazard of electrical shock. In your car it is the wire you connect from the ground stud on the rear of the radio to the negative terminal of the battery, or ideally the engine block.
- **RF Ground:** is a low-impedance path for RF to reach earth and which is designed to *dissipate* rather than *radiate* RF energy. Generally, though not in all cases, the DC Ground and the RF Ground are served by a common connection. Again, in an automobile this point is usually the car frame or chassis, the car body or engine block.

RF Ground and The Ground Plane
In the environment of the mobile antenna system many factors contribute to the radiation of an excellent RF signal, but none more than the quality of the RF ground. The RF ground represents the "unseen half" of your antenna system. The visible half is the whip or other radiating element. Failure to construct a good RF ground inhibits the efficiency of the system's radiation and can present danger to the operator through RF feedback.
In mobile installations, the chassis or body represents a *ground plane*: a common circuit return or reference point for your signal. The signal radiates outward from the radiating element and flows back to the radio via the ground plane. Then the polarity switches and this process reverses, back and forth, in synchronization with the transmitted sine wave.
You can understand, then, that if the car itself represents half of the antenna. It follows that the connections to it be made solidly and properly.
In constructing an efficient antenna system for your vehicle always make sure that your frame or car body are at RF ground by connecting them electrically and physically with the engine block. The engine block acts like a terminal strip or "bus" for your car's electrical system: the negative terminal of the battery and all other electrical grounds are connected to it as the central meeting point. The engine, in turn, is bound to the vehicle chassis through the engine mounting bolts, *though not necessarily grounded!* In today's modern vehicles insulating elements, i.e., rubber motor mounts, are used to cushion vibration. At DC, a solid path to ground exists, and even if this path should somehow fail, the car's body ground can act as a reserve. At *RF frequencies* however, an acceptable DC ground can sometimes present such a high impedance to your antenna system that it is, in effect, no ground at all! Most Commercially made antennas are DC Grounded simply to provide a Direct path for unwanted static and lightning, but are so designed that at RF Frequencies the impedance his so high it appears an open circuit.

To ensure your mobile antenna environment is at RF ground, simply bond the block to the chassis with tinned copper braid. Use short runs so as to avoid introducing any inductive reactance which will impede the flow of the RF current to ground. Coiling any earth lead is definitely not a good idea, as you are effectively adding
Impedance.

How Can I Tell if I Have A Good Ground ?
Actually, it's usually a lot easier to tell when you don't! Here are some of the signs that the quality of your mobile's RF ground may be lacking:

- Difficulty or inability to tune to an acceptable SWR match with your manual or automatic antenna tuner. (Assumes you have confirmed in advance that the antenna is already resonant "off the system".)
- Noticing a waving up and down of the SWR reading on the meter when transmitting while the vehicle is in motion.
- Noticing that the radio is "kicking", (cutting out and turning itself off) during transmission, an indication of significant RF feedback.
- Getting an RF "bite" or “burn” on the radio equipment or code key during transmission, an

indication that excessive RF energy is feeding back from the antenna system or that the system is floating above ground potential..

Remedies require a review of how your antenna system is mounted to the car, specifically:

- Is there a good physical and electrical connection between your antenna's ground and the vehicle frame/body?
- If utilizing the body as the ground plane is there isolation from RF ground which may be causing the RF return path to float above ground potential?
- Do you have faulty shield connections along your transmission line?
- Are ground loops present in your system?

Based upon your assessment of the above, take action as necessary to clean up any weak points you uncover.

Ground Loops.

Ground loops can be inadvertently created when ground connections on several pieces of equipment are connected in *series*, rather than to one single, centralized ground point. As an example, visualize a station consisting of three pieces of equipment: a radio, amplifier and antenna tuner. Loops could very easily be created by connecting the ground connections of the radio to the amplifier, then the amplifier to the antenna tuner, and finally the antenna tuner to the ground stake. These series connections promote miniature loops (circuits) between each individual piece of equipment, allowing RF current to circulate at differing intensities, which are another source of radiated RF noise. As the ground circuits "float" above zero potential they never actually draw down to true ground (where, theoretically, zero RF current flows). A dangerous shock hazard to the operator can result, but is easy to avoid through good design practices.

To avoid ground loops, each of the three pieces of equipment should be tied to the *same* ground point. In this design, a run of flat tinned copper braid should be run from the ground terminal of *each individual piece of equipment* directly to the station's DC/RF ground. In the case of your home, this might represent your ground stake buried outside with, again, as short a run of flat tinned copper braid as is practical .

Domestic Earth and Shack Earth.

Some interesting things can happen when looking at your House Main Power Supply earth and your shack earth. In earlier days it was pretty much impossible to provide an earth better than the one attached at your Main Switch Board. In fact there was a time that they were effectively all bonded via the same galvanised Water Main. This is no longer the case. Every Power Installation is now only required to have a 2 Mtr galvanised rod in the ground that is then bonded to any metal pipes etc within your home or anything else that has the potential of becoming live.

Now Consider this... Remembering that Neutral is effectively bonded to Earth at the Switch board. and your Rig is possibly or in many cases required to be earthed via the Mains Plug. Meaning your Equipment has two earths. One to handle RF and one to protect yourself from Electrical Shock. If your earth in your shack is better than the 2 Mtr Galvanised rod out the front of your house…, we would all say great, that's what I want to happen… Right? Sure that's where your you want your Stray RF to go. But what about every other earthed appliance in your home? What is the shortest path for any faults it may have or develop? It is worth looking at… Measure the current and voltage at your shack earth. If you feel there is a possibility that there is a problem **fix it**. Your Shack Earth is not wired efficiently enough to provide a grounding for your whole electrical installation. You could have a defective House Earth. Get it fixed by a Registered Electrician. I have seen the result of fault currents taking the incorrect but shortest path. And it's not pretty. Imagine the scenario if you had a broken neutral at your mains point of entry… That piece of flex going from your power point to the rig may get rather warm!

Ground Loops in The Mobile Environment.

In your vehicle ground loops are often unknowingly created as a consequence of frantic attempts to ground out noise sources by braiding "everything" one can think of to the nearest metal available. This is most likely when working under the hood to suppress noise in the antenna and power supply systems, but can also occur when your antenna is inadequately mounted to the frame/chassis. In reading the nature of the formation of ground loops above, you can see how, in braiding to the nearest available metal, series connections could very well have crept into your design.

Remember: if you are not at ground potential, RF currents may still be circulating within your ground system which may then be re-radiated as RF noise that can be received by the antenna system.

To eliminate any loops in your ground, the concept of applying a centralized ground point, as

described earlier for a home station, applies to the mobile configuration as well. In adopting a single point for your vehicle, use the frame/chassis as your "ground stake", if you will. It is the common metal to all other metal points of your vehicle (though additional bonding techniques may ultimately be required), and provides an excellent ground plane for your vertical antenna to work against.