Brass Tacks

An in-depth look at a radio-related topic

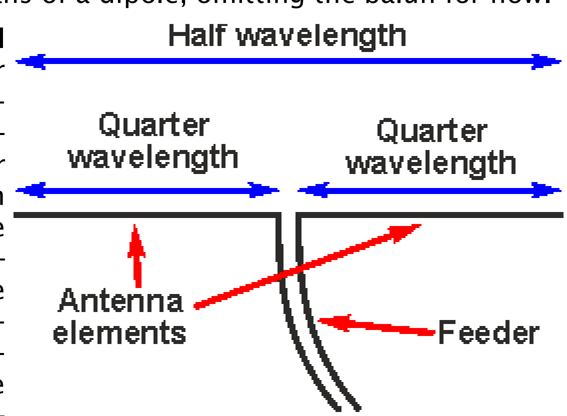
Ground planes

As many know, it can be difficult to get a good signal, especially with a handheld radio, out of the Orem City Council Chamber Room, where we hold our monthly club meetings. A couple of years ago at one of those meetings (see the Dec 2017 issue of the *UVARC Shack*, p. 1), I demonstrated how to drill a hole in your metal car body, but on a pizza tin. Kiara Johnson KI7RES then installed a 3/4-inch through-hole NMO mount onto the pizza tin, connected by RG-58 to a PL-259 connector. She also installed a pigtail adapter to her HT, transmitted her call sign, and at least two people came back indicating "full quieting into the repeater."

What made the difference? It's no mystery to many hams that mounting an external antenna on your car body can really get your signal out stronger, and so, clearer and farther, than with a standalone whip, and especially a rubber duck. But exactly why does that work so well?

The half-wave dipole antenna

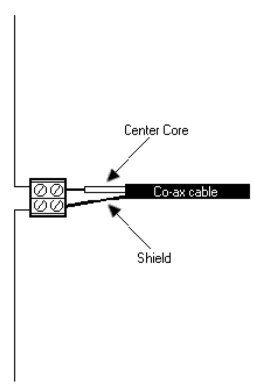
Imagine a horizontally oriented, half-wave dipole antenna, with one quarter-wave-long element connected to the coax (coaxial cable) center conductor, and the other quarter-wave-long element to the coax shield (outer braid), with the other end of the coax connected into your transceiver. Many of us are quite comfortable with how this dipole arrangement works, but here's a quick review of the travel of a signal by means of a dipole, omitting the balun for now.



Essentially, at any point during transmit, the signal is sent by the transceiver down the center conductor to one of the dipole elements, which through capacitive coupling with the other dipole element, converts the signal to electromagnetic radiation. After the signal reaches the other dipole element, it then races down the inside of the coax shield in reverse direction, back to the transceiver. In the next half-cycle, the signal starts all over again, but in reverse direction. In this scenario, we might say that the antenna has *poise*, or balance, due to the nearly constant equal and opposite travels of the signal. (The *nearly* equal and opposite current is due to unwanted *common-mode current*, which runs down the outside of the coax shield, and can be corrected by a properly constructed balun, whose discussion I'm going to postpone for another day.)

The vertical radiator

Now, imagine rotating the dipole to point the ends up and down, so that it's oriented vertically, with the element connected to the coax shield pointed downward, as shown:



Brass Tacks

continued

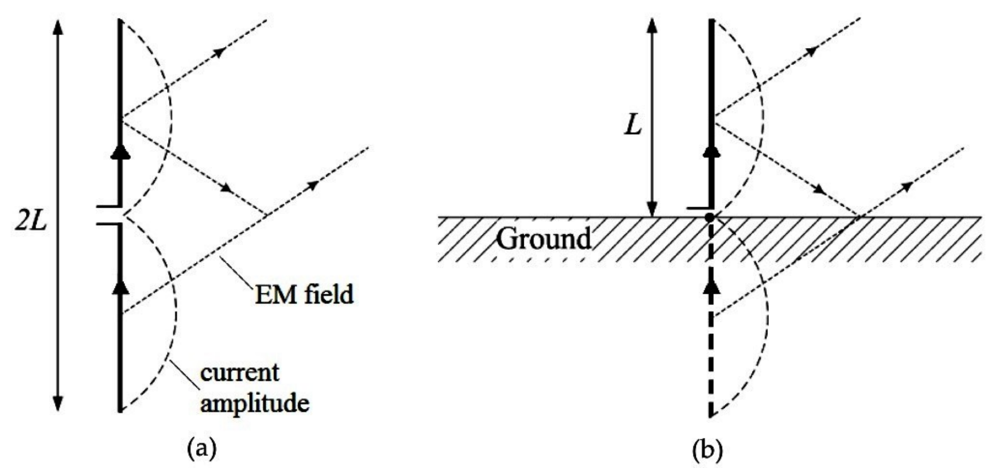
Furthermore, imagine that the downward-pointing element is split lengthwise into eight pieces whose ends are flared out from each other in the shape of a cone, like the legs of a tall, straight-legged spider, while the center conductor element remains pointing upward. This description is a construct of an actual antenna called a *discone*. (A true discone is accompanied by a *capacitance hat*, but again, that's outside the scope of this article.)

In this configuration, the antenna is still basically a dipole, but is now known as a *ground plane*, with the eight conically shaped legs known as a *counterpoise*, or counter-balance.

The monopole

It's probably not obvious at this point why the antenna is called a *ground plane*, so let's modify it further, by spreading the legs out flat, such that all eight of the legs are perpendicular to the center conductor element. This antenna now has the appearance of most tall AM radio station towers, known as *monopoles*, with one center element pointing straight up, and many wires originating near the tower and spreading out radially underground. Because half of the antenna is underground and lies in a plane, the reason for the name *ground plane* becomes more obvious.

But why does that flat, planar configuration work? If you picture how radio waves strike the full surface of the half-wave dipole (a), it makes sense that those received at a particular wavelength will result in the strongest collected signal. But if you also picture the same waves reflecting off the flat metallic surface of the ground plane, it's easy to see that the ground acts like a mirror (b), compensating for the *missing* bottom half. Waves arrive at the antenna directly and from its reflection, making it seem like the bottom portion of the dipole is still there, only in the mirror. The transmitted signal works in reciprocal fashion.



Brass Tacks

continued

The vehicle mounted vertical

Taking our imagination even further, turn this large disc-shaped spread of wires into a solid disc, but no longer underground, so now it looks like a big, circular pizza pan whose diameter is a half wavelength of the target frequency. In fact, the disc lies in a plane that's not even touching the ground. In a sense, we've created an *artificial ground* for the antenna, which can be moved from one location to another. And as long as we keep the diameter of the disc *at least a half wavelength*, the antenna will remain functional and effective.

This is why a single wire "monopole" antenna attached to the metal body of a vehicle works so well. Or a pizza tin. But wait, does the disc have to be metal? What about other conductors? It turns out that if you mount your antenna over water or marshy land, you can experience nearly the same effect. (Conversely, our poor soil conductivity is a big reason behind the poor performance of many vertical HF antennas in Utah.) And what would make water conduct even better? That's right...salt, a terrific ionizing agent. A vertical antenna constructed over salty water is one of the best-performing ground planes you can make. This is why so many *DXpeditions*, stationed on tiny, lonely islands far out in the Pacific, Atlantic, and Indian Oceans, are able to propagate their signals around the globe so well.

The missing HT ground plane

When I last picked up my HT, I looked at the antenna, and noticed right away that it has no ground plane, no pizza tin, and in fact no obvious counterpoise at all. So, I had to ask where the other side of my vertical dipole is. The answer is the metal chassis under its plastic body. The chassis is not a full quarter-wavelength in width or length, so I know that the antenna will not be a very effective radiator without that ground plane, and my signal will suffer as a result. Installing a quarter-wave (or longer) vertical radiating element will help, but it's still missing that other side.

It turns out that I can actually improve my HT signal above what a long whip can get me, by installing what's known as a *tiger tail*, which is nothing more than a counterpoise made from a quarter-wavelength-long wire electrically attached to the base (ground) of my HT. But if that works, then why not two tiger tails? Or three? Well, we can get carried away, or we can do what Kiara did, and remove the whip antenna altogether, and connect the HT by a pigtail adapter to an NMO antenna through-hole-mounted on a pizza tin. At any rate, I believe you get the point.

Brass Tacks

continued

It also turns out that many *HF* vertical antennas use the same tiger tail principle, by employing what's known as *radials*, which are nothing more than rods or wires that are at least a quarter-wavelength long, attached and emanating out from the base (ground connection) of the antenna. I sometime pity the hams that struggle over calculating the precise and *correct* lengths of their radials, when in fact, they only need to get them at least about a quarter-wavelength of their lowest frequency.

There are other ground planes and applications we can discuss, especially in the HF arena, but the point of this article is to explain what they are and why they work. The ubiquitous J-pole is an odd example of a VHF/UHF ground plane application whose explanation is way outside the scope of this article, yet uses similar principles of planar grounding.

Kiara making contact

My Hustler 5-BTV with balun and radials

Summary

A ground plane is nothing more than the lower (quarter-wave) grounded half of a vertically oriented dipole antenna. It works by reflecting the incoming or outgoing signal, to create the appearance of a mirror image of the *missing* lower half, resulting in antenna performance that's identical to that of a half-wave vertical dipole. Many antennas use this ground plane principle, such as AM radio towers, discones, vehicle verticals, tiger tails, and HF vertical radials. The ground plane can be made of metal, salty water, or any conductive, flat surface.

Noji Ratzlaff, KNØJI (kn0ji@arrl.net)