by Gordon West

COPPER FOIL GROUNDING FOR RADIO FREQUENCIES


Copper foil for radio grounds.

Hey, all you radio guys and girls, GOT GROUND? For a powerful marine and ham single-sideband transmission, and improved reception, good grounding techniques at the radio and at the automatic antenna tuner are extremely important. And for mariners planning on installing a differential GPS receiver for improved GPS positioning, GOOD GROUND is extremely important to improve the capabilities of your low-frequency DGPS system that feeds correction signals to your onboard GPS.

GOOD GROUNDING is also important to reduce the noise build-up interaction between various pieces of marine electronics aboard a boat. You may find that the inverter turned on that wipes out TV reception might be rendered almost noise-free by grounding the metal frame to a central ground plane aboard the boat. Same thing with automatic pilots and many voltage/amperage monitoring systems — their built-in central processing units (CPUs) can generate tremendous radio frequency interference from their squarewaves, and this interference can be contained within the device by good grounding techniques.

THE ULTIMATE GROUND

You are floating on it: sea water — the ultimate ground. The conductivity of salt water is the closest thing we can get to a traditional copper-screen land ground. Did you ever wonder why big military and commercial AM radio stations always plant the base of their antennas in marshes or at the edge of ocean bays? This is because the necessary ground is already in place to make up the essential "missing quarter" of their antenna system.

The brand new Yaesu ham radio FT-847 works better with a foil ground.

THE MISSING GROUND?

Halfwave antenna principles are based on a one-quarter wavelength antenna radiator, and a one-quarter wavelength OR GREATER mirror image of the radiator. This mirror image ground system is sometimes called a COUNTERPOISE. Without a good COUNTERPOISE, a one-quarter wavelength antenna cannot develop the antenna current to force your signal off of the wire and out to the ionosphere.

Low-frequency, medium-frequency, and high-frequency antenna systems all rely on sea water as making up the other half of the radiating antenna system. Electrically, your insulated backstay or big white fiberglass high-frequency whip is tuner resonated to be one-quarter electrical wavelength long. The tuner then looks for the ground connection to develop the COUNTERPOISE as the other mirror-image one-quarter wavelength. The greater the ground counterpoise potential, the higher the antenna radio frequency current that may be developed at the output of the automatic antenna tuner.

"The effect of a perfectly conducting ground can be simulated under the antenna by installing a metal screen or mesh, such as chicken wire or hardware cloth, near or on the surface of soil ground," comments the American Radio Relay League in their *Ham Radio Antenna Book*.

"The screen should extend at least a half wavelength in every direction from the antenna ... the screen will reduce losses in the ground near the antenna ..." As you decrease these ground losses, you increase radiation resistance and the amount of current that leaps off your insulated backstay or big non-resonant whip, and takes that first long-range bounce off the ionosphere.

Luckily for us mariners, we don't need screen. Salt water is a wonderful conductor; and when you're sitting in the middle of it, you certainly exceed the half wavelength necessary for strong antenna currents in the backstay or whip.

GETTING THERE IS THE BIG JOB

So how do you ground your marine and ham single-sideband transceiver to this water ground? And how do you ground the antenna coupler to the sea water ground? One big heavy ground cable should do the trick, right?

Wrong!

Despite the fact you grounded your radio and antenna coupler with massive four-gauge, stranded conductor, your brand new marine and ham single-sideband installation just isn't working right. Other mariners tell you your signal is garbled. The high seas marine operator indicates a very weak reception of your transmission, and on voice peaks your equipment goes into oscillation. Other boaters with SSB aboard all around you can talk regularly to the gang in Hawaii; and while you can hear them relatively well, they don't even know you are trying to transmit. Yet you have these huge four-gauge wires going from your antenna and tuner down to the world's biggest ground plate that's making sea water contact with a gold-plated connection.

What's worse, every time you transmit, all your bilge pumps click on, your autopilot goes whacko, your wind and speed equipment reads gale force conditions, and the propane stove automatic lighters begin to click with every syllable. And one of your guests indicates they will never use the head again when you're speaking over your marine SSB radio. Something about being in contact with the sea water and a burning sensation.

WHY WIRES WON'T WORK

You might have thought a big four-gauge wire off of your radio and tuner would be a great way to ground your long-range radio set-up to that massive underwater ground plate. You take out your fluke ohmmeter, and the combined run of 40 feet of #4-gauge wire registers only a fraction of a DC ohm resistance. With a maximum of two amperes of RF current from an antenna system from a 100-watt SSB transceiver, we definitely don't have a DC resis-

tance problem, here, do we?

We don't, but we do.

Chances are you spotted the green #8 stranded wire that may be part of your BONDING system for corrosion control. This WIRE is more than adequate to handle the few hundred miliamps that might be flowing from a sacrificial zinc anode to the protected underwater metals. This WIRE might also provide a low resistance path to bleed off a static discharge as you're sailing through the water, or getting close to thunderstorm activity.

Wires do an interesting thing at radio frequencies, including the unpredictable alternating currents of lightning.

That big #4 ground wire you installed as part of your ship radio station ground system is making up a minimum of half of your halfwave automatically tuned Marconi antenna system. Current not only flows in the part of the antenna you never want to touch on transmit, but there may also be current that gets mighty warm as part of your wire ground system. This is because the current flowing along your wire conductor in your ground system is a moving electromagnetic field. That big ground wire that may go directly from your tuner down to the underwater ground plate may develop the characteristics of a COIL of wire — after all, that wire is in the form of a cylinder, if you think about it.

Coils at different radio frequencies develop a very special type of RESISTANCE where the phase angle of voltage and current within the electromagnetic field TRAP the RF currents from making it from the automatic tuner all the way down to that big copper ground plate. It's not the slight resistance of the big wire that TRAPS the energy, but rather the fact that wire is round, and behaves like a radio coil at certain frequencies. And because you're using many different frequencies on ham and marine, and because your automatic antenna tuner develops its own internal inductive and capacitive reactance to develop resonance in the antenna circuit, there is no telling what length of wire, what frequency, or what wavelength won't see the nearby water as the great ground potential that it is.

Sure, you could move your tuner and put it right down there next to the big ground plate, and this would solve the problem nicely. But now you have the added problem of RF being transmitted from the water line up, off of that single GTO-15 high voltage wire, getting into all of the other electronics onboard. Better leave the automatic antenna tuner right where it is, in the lazarette or hanging locker aft in a sailboat, or up near the antenna in the flying bridge of a power boat. Or in a home installation, the automatic antenna tuner is up at roof level, keeping all of the radio frequency energy safely away from the operator down below.

Copper foil offers negligible reactance at maritime and ham radio medium-frequency and high-frequency wavelengths. Copper foil takes your sea water ground and brings it right up to the base of the tuner with almost no DC I2R losses, and virtually no trapping of the signal caused by wire reactance.

Copper foil from the tuner to a good sea water ground eliminates the need for one-quarter wavelength radials run below decks, and may also eliminate the need for that 100 square feet of ground which was what we originally had to do in the old days where antenna tuning was done at the radio, rather than automatically in the automatic antenna coupler.

"The outside one square foot ground plate will develop a terrific sea water ground potential if coupled to the automatic coupler using three-inch-wide copper foil," comments Jim Tindall of ICOM America. "But I always suggest that the more ground potential you can add to your marine and ham SSB system, the better," adds Tindall, indicating he might also ground to additional bonded underwater bronze through-hulls for additional sea water contact. It certainly wouldn't hurt.

In fact, the underwater bronze through-hulls that are part of your underwater bonding system make for great sea water pick-up points for your copper foil. Wire brush each bronze through-hull, wrap the foil around it and secure it with a stainless steel hose clamp, and then run the foil to other nearby bonded underwater bronze through-hulls. Since they are already bonded together with the corrosion control green wire, you are not changing your underwater galvanic balance.

During recent tests with three-inch-wide copper foil, I found that three or more bonded underwater bronze through-hulls gives me about the same performance as a dedicated underwater ground plate. Why bore a hole in the bottom of your boat for a ground plate if you don't have to? Got some bonded bronze through-hulls? Give them a try, first.

Shortwave reception improves with a foil ground.

If you are swapping out wire for copper foil, get the wire out of circuit. Use the wire for something else — maybe re-doing that corrosion control bonding system to meet American Boat & Yacht Council (ABYC) recommendations. ALWAYS adhere to ABYC recommendations.

For power boats, your job is getting from the automatic tuner in the flying bridge down below to those underwater through-hulls. It's perfectly acceptable to squash the foil into an irregular slim mass, now and then, to squeeze through tight areas. Just try to keep as much surface area exposed on the foil as possible.

For home installations, your job is to get the copper foil over to the chicken wire that holds the plaster on the side of your home. Or maybe run the foil down through a rain water downspout, and start burying it in the soil.

For home installations, keep in mind that soil is a lousy ground, and doesn't have near the conductivity as sea water. You must run over 100 feet of three-inch-wide copper foil buried under the ground to achieve good soil contact. You may notice your signal will get better after a big rainstorm, too!

See, mariners, what a good deal we have by running our station floating in the world's best ground plane?

Marine radio manufacturers ICOM America and Shakespeare Antenna both commissioned one-hour-long individual audio cassettes ALL ABOUT MARINE SSB INSTALLATIONS, and ALL ABOUT MARINE VHF RADIO AND INSTALLATIONS. You can get these two audio cassettes directly from me for a $20.00 bill by writing Radio School, 2414 College Drive, Costa Mesa, CA 92626. You can actually hear the difference between wire grounding and foil grounding systems.

The biggest provider of radio ground foil in bulk lengths of your choice is Metal & Cable Corporation, Twinsburg, OH; phone 330-425-8455, FAX 330-963-7246, or E-Mail David@metalcable.com. Besides their .0073-inch-thick x three-inch-wide pure copper foil, they also carry heavier .011-inch-thick x two-inch-wide copper strap with machine edges for safer handling. This is what I use for my home high-frequency radio installation where I don't need to fold it to sneak around tight corners as I would aboard a boat. This heavier strap is also a better way to convey nearby lightning surges directly to a good ground. I use this heavier copper foil off of my coaxial cable lead-in point on the side of my house directly down to a massive wet-soil ground system.

Aboard sailboats, I have seen this heavier foil added to the existing lightning wire ground system going from the base of the mast directly down to a keel bolt or underwater ground plate.

But if you should encounter a direct lightning strike, don't expect much of anything to work after the bolt other than your little handheld radio to call out for help. Lightning is unpredictable, and is a completely different subject than the need for a good radio frequency ground.

Finally, I suggest you also ground your stainless steel rails aft with the three-inch-wide copper foil. This will allow you a good sea water ground point for that new differential beacon receiver you're going to put back there for the reception of low-frequency RDF-type GPS correction signals broadcast by the United States Coast Guard. Soon the US Coast Guard will have access to hundreds of land transmitting stations originally intended for the emergency broadcast service. Copper foil grounding techniques will allow you to pull in differential GPS correction signals all over the country — inland or out on the water. Since these signals are down below the AM broadcast band (200 KHz-500 KHz), good copper foil grounding techniques will dramatically improve your receiving capabilities.

Also ground all of your other instruments aboard the boat — this will decrease the amount of noise coming out of those CPUs. For instruments, you can fold the three-inch foil in half, and this will suffice.

Got enough ground? That's easy to tell. Take that extra foil you ended up with, and toss one end into the sea water. Get someone to hold it near the antenna coupler. Make contact with a ham or marine shore station, and get an initial signal report. Now have your assistant touch the foil to the existing ground system, and see if your signal changes with this additional hunk of foil hanging in the sea water.

If the automatic tuner doesn't re-tune, and if the radio service says you sound the same, then you know that additional grounding is not necessary. See, I told you that just one or two good ground connections from your automatic coupler is all that is necessary if you use copper foil.

Copper foil — low reactance, good results. NV