`Seawater Grounding for High-Frequency Radios

by Gordon West

Communications **No Need to turn your boat into a copper mine. Just tap into the ultimate ground---the sea of salt water that surrounds you**

I can still remember that Saturday morning in 1957 when the Federal Communications Commission (FCC) engineer boarded our water taxi in San Pedro, California, carrying a World War II frequency counter, a Simpson 260 mirrored multi-meter, a thermocouple RF ammeter, and a big tape measure. He also carried a copy of the FCC Rules, parts 81 and 83, and was ready to inspect our installation of a big 100-watt Bendix AM transmitter. I had just passed my Second Class radiotelephone license (a rarity for a teenage) and had everything pretty well figured out, except for the tape measure.

After the FCC inspector confirmed that all of our crystals were netted within 20 Hz of the assigned carrier frequency, and that output-antenna current looked good, and that the secondary backup battery was indeed getting a full charge, the next step was to pull the engine covers and confirm with the tape measure that we had the required 100 square feet of ground plane. In the end, we passed the commercial ship station inspection with flying colors, and our logbook was properly signed off.

Any marine electronics technician today would probably insist that a modern marine SSB installation needs at least 100 square feet of ground plane below the waterline. Most marine SSB manufacturers, too, will parrot the need for 100 square feet of ground counterpoise. There are still boat manufacturers who run a big copper ribbon all around the inside of their boats to meet this requirement. And I regularly see boat yards punching big holes in otherwise clean hulls to affix three or four porous ground plates connected via copper foil to every living piece of metal inside the boat.

But if you press the point and ask about the whys and wherefores of this "requirement," the answers you get may be more emotional than technical. You will not hear much about capacitive in-hull grounds versus ground plates, nor much about the inductive reactance of cc foil ground systems at 2 MHz versus 14 MHz, and nothing at all about where this 100-square-foot commandment originally came from.

In fact, it came from the old FCC commercial boat rules and is not found in the amended marine-radio rules. Grounding requirements for high-frequency receivers changed considerably when Motorola first introduced a transmitter/automatic tuning unit (ATU) box that can be mounted in a remote location away from a radio's operating position. And as ATUs were further improved, electrical loading of vertical antenna systems counterpoised off marine ground *systems* changed dramatically.

With the introduction of microprocessor-based relay switching for automatic antenna couplers, yielding thousands of variations on inductance and capacitance, plus high-impedance and low-impedance output to a single wire, the world of grounding changed even more. Although the, principle of grounding by providing a mirror image of at least one-quarter the wavelength of the band you are operating on will never change, the modern processor-based tuner now allows the user to experiment with different types of ground planes. A thermocouple micro ammeter, plus distant station signal reports of transmitted energy, can be used to prove some interesting points.

My latest test of a marine-radio ground system took place last May in Long Beach, California. I brought an old friend, Art Godson, aboard a sailboat with a brand new 100-square-foot capacitive ground system to verify my results. Although Art has been out of marine electronics for years, he is one of the most active amateur radio operators in the country and designs and builds unique mobile marine-antenna systems that put out monstrous signals.

The Test

Our 40-foot sailboat was professionally outfitted with an ICOM marine SSB/ham transceiver .The automatic antenna tuner was an ICOM AT 130, and the ground system was a professionally installed copper-foil strip that went nearly all the way around the boat, capacitively picking up metal fuel tanks along the way.

Our comparison grounds were made up of 3-inch-wide, 3-mil-thick copper-foil strips. We soldered four copper-foil "tags" onto a modified antenna switch, which allowed us to switch between each ground system rapidly to minimize up and down band conditions while conducting our skyway test.

The boat's capacitive ground system, estimated to exceed 100 square feet, was connected to switch position 1. Switch position 2 was connected to copper foil running to a single un-bonded underwater through-hull 4 feet from the automatic antenna tuner in the lazarette. Position 3 connected to a copper-foil strip temporarily run over the side and immersed in seawater to a depth of only 6 inches. Position 4 was connected to a large fully immersed foil strip.

Our tests were with sky wave stations as far away as Hawaii and as close as San Francisco; all were asked which system sounded best. We also monitored for onboard electrical interference and judged our reception by listening to WWV at 10 MHz .We monitored antenna output current with an MFJ-854 RF ammeter with an inductive pickup loop, and we observed RF output at the antenna feed point on the tuner with a 4-foot fluorescent tube.

Art Godson was fascinated to see some of the new technology, but he kept his attention acutely focused on the RF output meter on the insulated backstay, the signal reports received over the air, and the light output from the fluorescent tube down below.

We were careful to retune the antenna tuner each time we switched ground systems, and the results were as anticipated. While the capacitive ground did indeed give us a signal out on the airwaves, the seawater ground improved antenna power output, decreased the noise floor while receiving on board, increased sky wave signal strength, and caused the entire 4 foot fluorescent tube to glow brightly with modulation peaks.

We saw only half as much signal strength with the capacitive ground. The fluorescent tube barely glowed, and only at one end. Using any of the seawater grounds, the output-antenna current meter jumped up, sky wave stations reported a much stronger signal, and the fluorescent tube lit up from one end to the other on modulation peaks.

When tuning we could also see a difference in how hard the antenna tuner was working when we switched from a capacitive ground to a seawater ground. With the capacitive ground it would take as much as a couple of seconds to recycle through the different Land C combinations. But when we switched between the three seawater grounds, the tuner would immediately start and stop tuning, staying with the same settings through the three seawater connections.

Keep in mind that two of the three seawater connections were single-point contacts between the foil and the water. Further tests on other days with big submerged copper-screen panels, copper pipes, and large copper-printed circuit board sheets showed signal reports that were comparable to those achieved with just a small bronze underwater through- hull.

Conclusions

If you are installing your own marine SSB or ham radio system and are looking for an easy way to ground it, start by grounding to a convenient underwater bronze through-hull near where the tuner is mounted in the lazarette. Just clamp the foil to the through-hull, being sure to first clean up the contact area on the fitting with a wire brush. Its a good idea to fold the foil under the clamp several times to insure the connection won't break down easily: Keep the foil (which has sharp cutting edges) clear of any hose attached to the through-hull and keep it away from any sloshing bilge water.

I also recommend grounding to a single through-hull. There is no need to run foil all over the bilge tying in additional through-hulls, tanks, rudderposts, and whatnot, as this will not appreciably raise the antenna current output or your signal strength to a distant station. The best through-hull to use will be plumbed with non-conducting rubber hose and, of course, should stay in the water at all angles of heel.

True, a large ground plate is a better choice than a corroded through-hull fitting. Big bronze ground plates have gold-plated studs for a good foil connection, and they also have more surface area than a small through-hull. There is no question that increased surface contact with the water helps lower onboard noise sources, and getting noises out of your radio system can be just as important as pumping out every last milliamp of antenna current. But my tests have confirmed that the porosity of ground plates does not effectively improve contact with the water, and I have found that a single plate the length and width of a common brick is all that is needed to develop a substantial amount of antenna current.

The longest distance between your antenna coupler and your seawater ground, be it a through-hull or a ground plate, should not exceed 15 feet. The shorter the run, the less the likelihood of developing inductive reactance. And never use wire to make the connection; always be sure to use copper foil, as this offers the least resistance to radio-wave AC currents.

It's also a good idea to provide a low reactive ground system (again, use copper foil, not wire) for your marine electronic at the nav station. Instrument noise on marine SSB may dramatically reduce reception of voice, PACTOR text, and weather-facsimile transmissions. I have found the largest noisemakers are electronic tachometers, shore side battery chargers, solar-panel voltage regulators, water-purification systems, refrigerators, radiated energy from battery monitors, and any microprocessor clock circuit. Connecting instruments to a good seawater ground will minimize all this errant noise radiation. Capacitive grounding may only reradiate these interfering signals somewhere else aboard the boat. In fact, short capacitive-ground systems may actually invert the antenna/ground signals, radiating more signals below deck than through the antenna above deck.

Finally, it is best to develop an entirely separate grounding system for lightning protection. For recommendations on the best lightning ground, refer to American Boat and Yacht Council (ABYC) specifications.

Remember, when it comes to you high-frequency radio, your best ground is the element you're floating in, plain old seawater. If you aren't taking advantage of it, you may be losing valuable antenna current. Run a low-reactive copper-foil ground to seawater, and your transmit and receive signals will dramatically intensify over long and short signal paths.

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