

ICOM

INSTRUCTION MANUAL

**GROUNDING
AND ANTENNA
CONSIDERATIONS**

For **IC-M700**
IC-M700TY

Icom Inc.

FOREWORD

Congratulations on your purchase of the ICOM IC-M700 marine single sideband transceiver. You have chosen one of the finest sideband sets available.

This special insert into your marine single sideband instruction and installation manual will assist you in choosing the right antenna and getting the best range out of a good grounded single sideband installation. Good antennas and good grounding are absolutely essential for good single sideband range, and this is why this special report is included with your single sideband transceiver.

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ANTENNAS & TUNERS. If the IC-M700 is going aboard a sailboat, you may either use an insulated backstay, an insulated sidestay, or a nonresonant white fiberglass whip antenna off the stern to make up your antenna system. Your best range will be from an insulated backstay because of the long length of the antenna "radiator" which is that portion within the top and bottom insulators. Have your rigger put the top insulator about one foot down from the tip of the mast. Have your rigger install the bottom insulator at about eye-level when you're standing back aft. (This length between insulators should not exceed 120' or be less than 30'.) If you decide to go for the non-resonant whip antenna, such as the Shakespeare 390 or the Morad WH28, the antenna usually goes at the extreme stern and mounts either vertically or raked back at about a 45-degree angle.

These non-resonant antennas may be tuned by the ICOM AT-120 automatic antenna tuner that matches the IC-M700 transceiver. The tuner goes back aft, in the lazarett. It's completely weather-protected and can easily take the punishment of being aft and below deck where you're probably also going to store wet life preservers, foul weather gear, and the like. The AT-120 easily interconnects with the ICOM IC-M700. Full details are in the AT-120 instruction/installation manual. We suggest you use "GTO-15" high voltage lead-in wire from the single wire output of the AT-120 to your insulated backstay or to your non-resonant whip. This high voltage wire won't break down in wet weather or sunlight. Use stainless steel hose clamps to attach the wire to the insulated backstay. If you decide to use a non-resonant whip, attach the single wire with a lug to the feedpoint at the base of the whip.

More about the importance of grounding in a moment.

For those of you with a powerboat, a whip antenna approximately 20 feet long is what you'll be using with your new ICOM IC-M700. The most common and preferred set-up consists of the white fiberglass 21-foot, non-resonant whip antenna that is automatically tuned with the ICOM AT-120 automatic antenna tuner. Similar to sailboat installations, the tuner is hidden out of the way in the flying bridge area or below deck near the base of the whip. GTO-15 wire interconnects the whip to the automatic tuner. The tuner is fed with coax and a control line from the back of the IC-M700 to wherever you plan to hide the auto-tuner. Remember, the AT-120 ICOM automatic tuner is fully automatic, so you can put it completely out of sight!

Another antenna system for powerboat operation is the pre-tuned trap, 23-foot, aluminum whip from Morad, Inc., Model MB4, 6, 8, 12, 16, at 1125 N.W. 46th Street, Seattle, Washington. This \$400 antenna requires no automatic tuner---simply feed it with coax out of the back of your IC-M700, and it works nicely on all of the pre-set marine frequencies. This antenna system must usually be tuned up by a technician, and it usually is not as popular as the non-resonant, white fiberglass whip used in conjunction with the AT-120 tuner. Although both are good performers, the AT-120 and the white fiberglass non-resonant whip is usually the easier way to go.

We suggest you check with the dealer that sold your transceiver if you would like to purchase the AT-120 automatic tuner as well as a resonant or non-resonant whip antenna assembly. Dealers that sell ICOM equipment usually have these accessories on hand.

THE IMPORTANCE OF GROUNDING. Please read this! If you are looking for "super range" with your new ICOM IC-M700, we have some tricks that will give you the same kind of range as globe-circling cruise ships, super tankers, solo sailors, the Navy, and the Coast Guard. Surface area to the sea water and the use of copper foil exclusively throughout your ground system is the combination that gives you commercial-type "super range." The sea water acts like a diving board or side of a pool for a diver and a swimmer---it gives your signal a solid surface to push off from. This is technically called a "counterpoise." and it's the absolute necessary other-half of your antenna system that must be achieved for your overall single sideband system to work well.

It's not that hard to develop your own sideband ground system in just about a day's time, and you may even find that most of the ground system is already installed so you have little to do but to tie everything together with copper foil. Read on, please, and let us show you how easy it is.

NON-TECHNICALLY SPEAKING. If you plan to have a technician or a technical friend install your sideband system, have him skip this part and begin reading at "Antenna Ground Principles---Technically Speaking." If you plan to do the installation yourself, and this is the first one you've done, read on!

The water that your boat sits in is the ultimate ground counterpoise. There's none better. Commercial AM broadcast stations on the coast usually put their giant antenna system smack dab in the mud flats of a local bay for good range.

Some boat suppliers put ground foil and ground screen in the cabin overhead. This is true on expensive powerboats, and is sometimes found in a few sailboats. While this type of overhead ground system is better than nothing, it still lacks the capability of coupling with the ocean or lake as the ultimate water ground system. A far better ground system would be the following:

- | | |
|--------------------------------|-----------------------------|
| Lead keel | Metal oil-catch pans |
| Metal water tanks | Interconnected through-hull |
| Steering system hydraulics | Foil radials |
| External ground plate | Engine block |
| 100 feet foil below water line | |

That's right, we list the engine block as last as a good underwater counterpoise. The reason is because it does not have an extremely large amount of surface area that is flat and close to the water your boat is sitting in. The whole idea is surface area--and this is why a keel bolt, underwater tanks, through hulls, and anything else flat and next to the water does such a good job. Now we know your next question--But doesn't a good ground actually have to be in contact with the water? Not at all! At radio frequencies (RF), your underwater ground counterpoise sees the water in a capacitive way, which gives just as good a ground effect as if it were actually touching the water!

Now here's another very important point--no ground wires for ground! Even if you use welding wire the size of your thumb, you cannot achieve a good ground counterpoise with round wire. In our "Technically Speaking" section, we'll tel you why--but in non-technical terms, round wires tend to cancel out at radio frequencies, and they look invisible as a ground counterpoise interconnect. This is why copper foil must be used between the chassis of your transceiver to your ship's ground, and the chassis of the automatic antenna tuner to ship's ground. Round wires won't work--only copper foil will!

Your better marine electronic stores that sell ICOM equipment will also sell three-inch wide, super-thin, copper foil for grounding. In a pinch, you can use one-inch wide copper plumber's tape. Three-inch is better.

It's going to take you about a day to work this foil below decks and below the water line picking up anything and everything of ground potential. If you can get at your keel bolt, or tap a screw into the keel, your grounding is done. Lead encapsulated keels are the ultimate in grounds, and you need nothing further.

In powerboats, since there's no keel, you're going to need to come up with at least 100 square feet of ground surface below the water line. This means you must pick up as many ground potentials below the water line as possible. We usually use a stainless steel hose clamp to grab each underwater metal source. If your vessel is bonded with a small green wire going to each underwater through hull, run your foil along with the green wire and pick up each and every through hull just like the green wire does. You cannot rely on the round green wire as an effective ground pick-up. You must double up on it.

Now let's take a look at grounding from a slightly more technical point of view. Don't worry, we won't get over-technical, and it's easy to read and understand. If you're letting a technical friend or a technician put in your equipment, make sure they read over this section several times. The facts here are based on hundreds of hours of doing, and undoing, different types of ground systems. In all cases, following these techniques will give you the results that you want--and that's long range and the loudest signal on the band.

ANTENNA GROUND PRINCIPLES--TECHNICALL SPEAKING. The marine antenna system for low, medium, and high frequency applications will utilize both the seawater as well as that shiny white fiberglass antenna radiator for its entire operation. Like two kids on a teeter-totter, the system works well if there is a balance between the antenna radiator and the seawater ground. This balanced antenna system may electrically be compared to a dipole antenna system--one-half wavelength long on the frequency band of operation with voltage and current loops equally distributed throughout the half-wave length system. In marine applications where a vertical antenna is used, this system is more precisely referred to as a Hertz antenna set-up. The white fiberglass whip is tuned to an electrical one-quarter wavelength and the ground system will make up the other one-quarter wavelength. We technically call the ground system a "counterpoise," and the antenna the "radiator."

If either a one-quarter wavelength antenna or ground system is missing or inadequate, radio reception and transmission range will be severely reduced. How good was your car radio reception when someone broke off your whip antenna? The same degradation of range also takes place when there is little or no ground system for the whip to work against in a marine installation.

Imagine a swimmer making a flip turn, but not having the side of the pool to push off from. The same thing happens with radio wave transmissions on single sideband. The most powerful antenna will not radiate a signal if it has no counterpoise to push off the signal from.

On Loran receiving antennas, an inadequate ground will allow the noise generated by onboard electrical forces to escalate, completely making weak Loran signals.

In technical terms, the less ground, the higher the radiation resistance of the antenna system. This radiation resistance will lead to substantial power loss and single sideband equipment will not only perform poorly, but also get quite hot in the transmitter section. An inadequate single sideband ground will also lead to "hot mikes" where the operator actually receives a radio frequency burn each time the mike is held next to his mouth. Poor grounding will also lead to erratic movement of analogue dial instruments, bizarre behavior of automatic pilots while transmitting on the sideband set, and may even cause burn-outs of tiny integrated circuits in companion marine electronic gear aboard. Enough said?

SURFACE AREA. For marine radio and Loran applications, a good radio frequency ground system will consist of a minimum of 100 square feet of metal below the waterline. Now we know you're going to jump out of your chairs when you read this, but don't be overwhelmed. There are plenty of underwater metals that we might attach to in order to obtain this amount of counterpoise below the waterline. Lead keels encapsulated within fiberglass will make excellent surface area grounds in sailboat applications. The tough part will be getting to the lead keel or the exposed keel bolt.

In other marine installations, stainless steel tanks, copper hydraulic lines, through hulls, and grounding plates will help make up the ground counterpoise system.

Boat manufacturers have the capabilities of adding a terrific ground system when the hull is being laid up. Lightweight copper screen is one of the best ways to provide a good surface area ground. Copper screen could be laminated inside the fiberglass layers as the hull is under construction. Thin sheets of copper foil could also be used in the manufacturing process of the hull. Even the conducting mesh that holds together cement hulls can be used quite nicely as a ground counterpoise system.

Copper foil and grounding screen is available from most marine electronic distributors as well as marine electronic dealers. Thickness of the screen and foil is not important--the most common foil is generally one to four mils thick and comes in three-inch wide rolls--just about any length you want. Copper window screen (if you can find it) is usable--again, thickness is not important. Radio frequency energy travels on the outside of this conducting surface called skin effect, eliminating the need for thick grounding materials.

Since grounding foil and screen is relatively expensive, most boat builders will simply leave out this grounding process and expect the customer to provide their own ground once the boat is finished. This is a shame--it's so easy to build in when the hull is under construction, and far more difficult to add after the vessel is fully completed.

The copper foil and screen does not actually need to contact seawater in order to create the ground system. Radio frequency energy passes quite nicely through fiberglass, so an encapsulated ground system works just as well as one that is actually exposed to the seawater. Incapsulated lead keels with a half-inch of resin also work well. Any ground system that is capacitively coupled to the seawater is enhanced by the seawater itself.

Developing the ground system for radio frequency applications (as opposed to DC circuits) requires that all ground connections be interlaced using copper foil. Round ground wires are out! Wires actually look like inductive trap circuits at certain radio frequencies, and will appear invisible as an effective way of coupling your set to your ground system. That's right, copper foil must be run from below the waterline ground system and attach directly to each piece of low and high frequency radio gear. While this may also seem to be an insurmountable problem in running foil, rather than wire, foil handles quite nicely, even in tight places. The foil is easily soldered to the below waterline ground system, and then routed up the side of the hull into the area of the NAV station. It may be glassed into the hull, painted over, glued in, or even left resting on the side of the hull. The foil may be bent in order to accomplish a 90-degree turn. If the foil must absolutely pass through a small hole, it may be rolled up in a not-so-tight configuration and squeezed through the orifice. Avoid a concentric type run that tends to cancel oscillating radio frequencies. Flat is best.

There are several sticky marine compounds that will allow the foil to adhere to the underside of a hatch, or to the side of a hull. Almost anything will work, and there is little danger of any substantial amounts of voltage developing on your ground foil run. The ground foil and your complete ground system, which run inside the hull, also will not substantially change your corrosion exposure to the seawater. Galvanic corrosion problems occur when dissimilar metals are immersed in seawater. The ground system is not actually immersed, its coupling is only capacitive.

Electrolysis is another form of corrosion where stray currents may begin to eat up underwater metals. Good wiring techniques for your 12-volt system independent of your ground system will eliminate electrolysis.

Now let's get back to finding a spot to terminate that three-inch wide copper foil that emanates from the below waterline ground system. Most manufacturers of Loran, FAX, and marine single sideband sets don't provide an easy way of adding ground foil to the stern end of their electronics! The best method is to run the foil up to the back of the equipment and use existing sheet metal screws to make a firm connection. Where a ground post stud with nuts and a washer are provided, all the better--run the foil up to the stud, double it back on itself several times for strength, punch a hole in it, and then make the connection. Never negate all your hard work of running the foil by using a small jumper wire to interconnect the foil to the radio set-up. You will be putting a "weak link" in your ground system at radio frequencies.

We usually accordion up the excess foil in back of the equipment so that we might remove the equipment for servicing with the foil attached. If you put the bends in the right spot, the foil will resume its natural collapsed state when the equipment is put back in place. Watch out for the sharp corners on the ground foil--they are capable of piercing through the plastic protective covering on electrical wires. Make sure that red and black voltage carrying wires are not allowed to rub up against the side of the ground foil.

We usually ground everything with foil at the navigation station. This would include the casing of the wind and speed equipment, pilot control box, Omega, Loran, sideband, radar, VHF, and just about everything else that lights up. The more grounding you provide for your central electronics, the less problems you will have with stray RF.

The ground foil must also run to remote tuners. This includes the tuner on your Loran antenna set-up as well as the AT-120 single sideband tuner that's usually several feet away from the equipment. These tuners may be all the way back aft, adding another dimension to your ground foil run. It's best to run the foil from the ground source directly to your tuner, rather than stringing everything out in series like Christmas tree lights. Now picture one ground foil run from the keel bolt to the electronics, and a second ground foil run from the keel bolt back aft to the sideband tuner and your stern-mounted Loran whip. These tuner ground circuits are mandatory for any type of reliable operation. If you try to run an IC-M700 sideband set with an AT-120 remote tuner that is ungrounded, you stand the chance of not only burning up your equipment, but also damaging other electronics onboard with stray RF. If it's not easy to run ground foil from your central below the waterline ground source back aft, then try to figure out another way to do it. It has to be done!

You can also pick up additional ground counterpoise surface area by adding substantial metals along the way in your copper foil run. Stainless steel hose clamps make it easy to pick up through-hull bronze fittings, water tanks, copper hydraulic lines, bilge pump valves and copper lines, small underwater grounding lightning plates, and anything else that may give you some additional underwater surface area.

The engine is also a small percentage of your below the waterline ground system. You will probably require a wiper brush if you plan to use the shaft and prop as additional ground plane counterpoise. Since the gear box is filled with oil, and oil is not a good conductor, the wiper brush for grounding and corrosion control is another way to go. There's some good surface area obtained on some of those big "wheels" aboard powerboats.

It's also universally recommended to pick up all through bolts that anchor your standard rigging. By grounding your rigging you can create a zone of protection inside the rigging in case of a nearby or direct lightning hit. While lightning strikes are totally unpredictable, good grounding techniques may provide some additional safety to those inside the zone of protection. Lightning strikes on ungrounded rigging may result in discharges between stays as well as miniature lightning zaps between close proximity metals. Good grounding will usually lead the major portion of the lightning bolt into the seawater satisfying its quest for earth.

Installers of ground systems in areas of high lightning activity should consult local marine lightning experts who have developed special exit "buttons" that will pass tremendous amounts of energy under the sea water safely, without blowing out a through hull or popping holes in a lead keel.

Mariners with sailboats with poured encapsulated lead keels as well as metal hull vessels have the easiest time in obtaining a good ground counterpoise. If the keel is visible, a second nut on the exposed thread will anchor on the ground foil. We usually seal this connection to prevent deterioration from the bilge water. It may also be recommended by local experts to tie in the aluminum mast to this close proximity keel bolt for lightning protection. The run from the mast to the keel bolt must be smooth, direct, and without sharp turns in order to pass lightning energy effectively into the underwater lead. Again, consult local lightning experts.

Steel-hulled vessels are easily attached to with foil by scraping away any protective coating from the hull, and making a low resistant good surface area contact. Again, seal this connection well. Non-metal jull or keel boats require yards and yards of foil to be run below the waterline, anywhere you can, and picking up any other large below the waterline tanks and tubes.

SUMMARY. If you follow these steps, you will have an outstanding single sideband signal that can be heard around the world. The difference between a good and bad ground is easily noticed on transmission as well as reception. Since your ground counterpoise is actually a part of your complete antenna system, pay just as much attention to grounding as you did to putting up that white fiberglass whip or going to your insulated backstay.