Antenna Tuners for Long Distance Communications

By Gordon West

The shipboard antenna system is critically important for good range with marine single-sideband and ham radio. The antenna radiates the transmitted energy from your 100-watt transmitter. This same antenna system also picks up radio frequency energy from other transmitters and couples it to your receiver.

In order for the antenna system to operate at optimum capabilities in transmitting and receiving radio energy, the antenna must be an exact length, in feet and inches, for the radio frequency you are operating on. The exact length is directly related to the length of the radio waves, with higher frequency waves being shorter and lower frequency waves being longer. For the more technical mariner, this matching of lengths is called resonance, with the antenna being one-half wavelength or one-quarter wavelength long for each frequency band you operate in.

The optimum antenna system must also exhibit a constant "back-pressure" called impedance (abbreviated z) in order for your solid-state ham or marine sideband set to operate properly. Again, for you technical folks, the load impedance should be 50 ohms resistive (50 Ω z).

The following table gives the frequencies and antenna lengths for the bands used on board cruising boats:

Band	Frequency	Antenna Length (all need ground)
10 meters ham	28.4 MHz	8.0'
22 MHz marine	22.124 MHz	10.5'
15 meters ham	21.404 MHz	10.75'
16 MHz marine	16.5861 MHz	14.0'
20 meters ham	14.313 MHz	16.25'
12 MHz marine	12.4292 MHz	18.75'
8 MHz marine	8.2911 MHz	28.25'
40 meters ham	7.250 MHz	32.25'
6 MHz marine	6.2186 MHz	37.75'
4 MHz marine	4.125 MHz	56.75'
75 meters ham	3.950 MHz	59.25'
2 MHz marine	2.182 MHz	107.25'

A lower frequency requires a longer antenna. Lower frequencies also require a bigger ground system.

It would obviously be impractical to change the physical length of your antenna for each frequency. Instead, we use an antenna tuner in order to electronically lengthen or shorten your fixed "antenna wire," to create an electrical resonance for each one of these frequencies. In effect, the tuner makes your antenna operate as though it were a different length than it actually is.

With a good tuner, your antenna can be a fixed length insulated backstay, a random wire run up to a spreader, ungrounded lifelines (in an emergency), a 20' non-resonant sideband whip, or any other length of wire above the waterline. The tuner can make any of these wires operate as though they were variable lengths, so they will resonate with any of the different broadcast and receive frequencies.

Manual tuners are best-suited to inveterate tinkerers.

The tuner will also balance the ship's ground system that acts as a counterpoise to the antenna wire. In order for the radio frequency (RF) to exit the wire and head for the ionosphere, it needs a ground "counterpoise" to get a good push-off, just like a swimmer pushing off from the side of a pool, or a diver springing off a board—without something to push off, the energy won't go anywhere.

The antenna tuner also compensates for the right impedance at the feedpoint of the transmitter—exactly 50 ohms for your transmitter to put out its 100 watts.

Inside an antenna tuner there are coils and capacitors. The coils are selected to electrically "lengthen" your antenna wire or whip that may be too short for the lower frequencies. The capacitors electrically "shorten" a wire or whip that may be too long for the higher frequencies. The right combination of coils and capacitors will allow your transmitter to see a perfect electrical length antenna system, including the ground, and perfect impedance at 50 ohms.

When everything is set on the nose, maximum power flows from your worldwide SSB set and into the wire, whip, or insulated stay that you are using as the antenna.

Although the tuner can tune up almost any piece of wire, the longer that piece of wire, the better performance (technically, the higher radiation resistance) you will generally get from your antenna system. Thus, on a sailboat, an insulated backstay will usually make the best antenna.

Manual vs Automatic Tuners

A manual tuner is a tuner that you adjust yourself at the radio equipment. Cost is generally under $100. Models 941 and 949 from MFJ Enterprises are the most popular manual tuners for marine applications because of their small size.

Automatic antenna tuners are remotely mounted, away from the transmitter and usually close to the base of the antenna. On a powerboat, they are usually mounted somewhere on the flying bridge, and on a sailboat they're usually located aft, in the lazarette. Automatic tuners self-adjust for any band and will tune up any length of wire, whip, or insulated backstay. They are expensive—from $500 to $1000 or five to ten times as much as the manual tuners.

Manual Tuner Considerations

If you are a ham radio operator and love to play with a bunch of knobs and switches every time you change bands, the manual tuner is an inexpensive way to go. MFJ Corporation has the largest selection of manual tuners. The tuner sits beside the radio and is connected to it with RG-8X coax. The output of the tuner is also coax, even though the manual tuner may have a terminal for a "long wire."

Attempting to connect a ship's antenna system to the "long-wire" output at the tuner will result in radio frequency (RF) radiation inside the cabin. No, the RF won't hurt you, but it will cause many things to become RF hot. It will also cause you to lose most of your signal inside the cabin, rather than putting it into the antenna where it belongs. If you buy the inexpensive manual tuner, **don't use the single wire output.**

Rather, connect quality RG-213 weatherproof coax to the coaxial-cable antenna output. Run the coax from the manual tuner aft to wherever your antenna system begins.

If you are feeding an insulated backstay, the center wire of the coax goes to the insulated section of the stay, just above the bottom insulator. (The bottom insulator should be approximately at eye level above the deck.) The outside braid of the coax must be grounded. Ground the braid to the bottom portion of the stay (below the backstay insulator) that runs down to the deck chainplate. Weatherproof this "Y" connection with Coax Seal or anything else that will absolutely repel moisture.

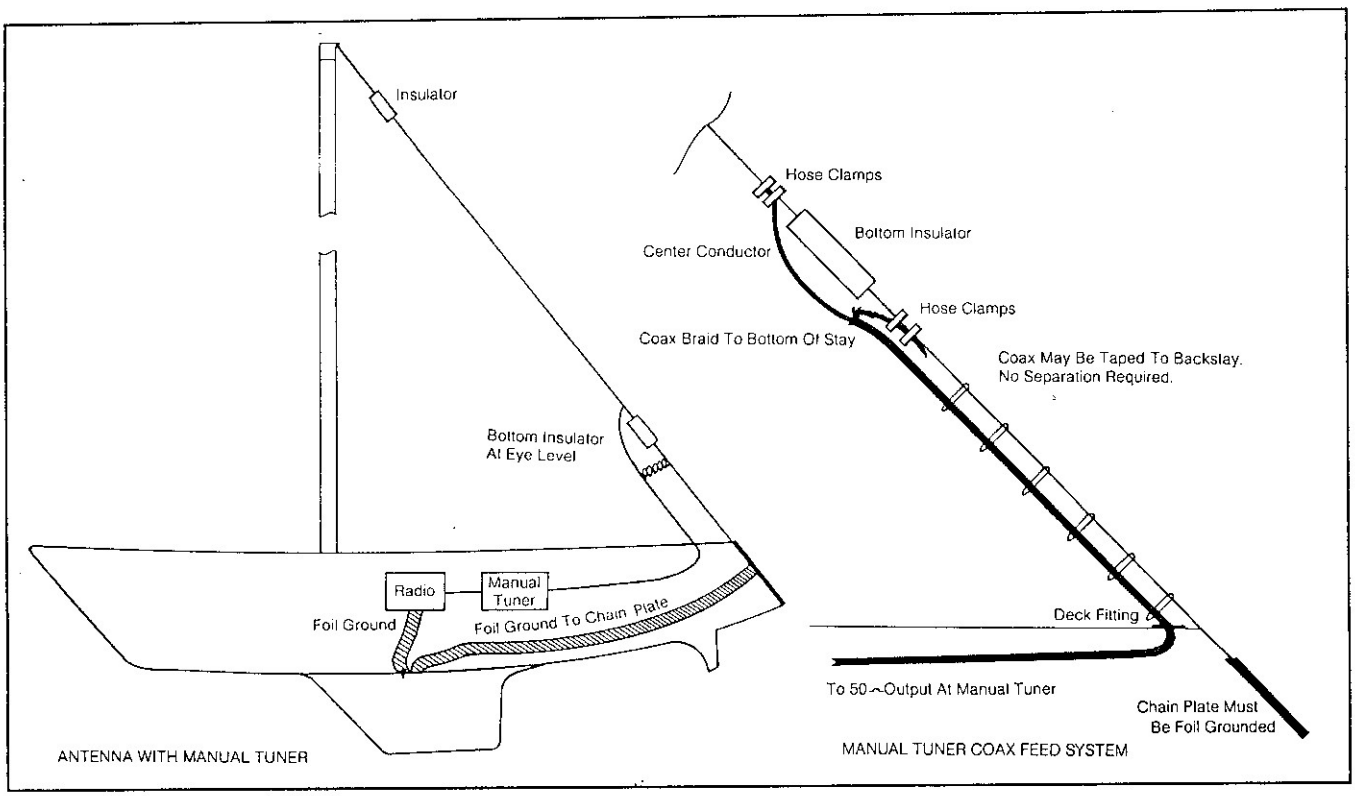
The bottom of the stay and chainplate must be copper-foil grounded to your external metal keel, main bonding system, or a ground plate to act as the counterpoise. If you don't have a good ground on the braid of the coax at the feedpoint, you won't have a good signal.

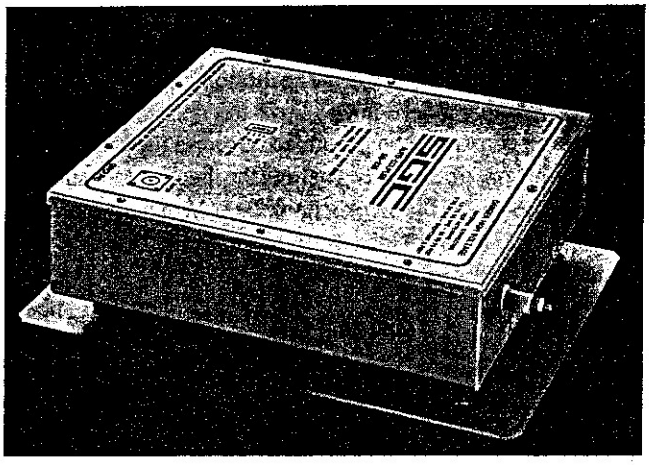
It usually takes a fellow ham familiar with manual tuners to preset the tuner on your first tune-up. This is a lengthy job, similar to picking a safe. You can't unlock the 100 watts of power out of your transmitter until you have a perfect match. This requires adjusting three or four dials to the perfect combination. Once the tuner is tuned, write down the settings—they won't change much after they have been preset for perfect resonance.

If the manual tuner won't tune, find another ham "expert." It just takes a bit of experience to know about where they tune up, and a delicate touch to find the exact resonant point. Your goal is maximum forward power, and minimum reflected power (minimum SWR).

Automatic Tuners

The marine SSB automatic tuner will work quite nicely on ham frequencies, too. The marine automatic tuner is the best way to go if you want a quick tune-up without ever having to fiddle with knobs and switches. Just select the





An automatic tuner will tune up an antenna of any length for any frequency.

frequency on your radio, say a few words into the mike or push an "auto-tune" button, and the tuner automatically does its thing in less than three seconds. Marine automatic tuners are reliable, and they seldom die of natural causes. Many are completely weather-tight, so they work well in that damp hanging locker or wet lazarette.

The automatic tuner is interconnected with RG-213 or RG-8MX coax, and is placed out of sight near the antenna feedpoint. It needs a small amount of 12-volt power (about 1 amp) that you can take from almost anywhere. Some automatic tuners (ICOM AT-120, ICOM AH-1, Hull, Kenwood, and Yaesu) also require a four-conductor control line from the SSB or ham radio set.

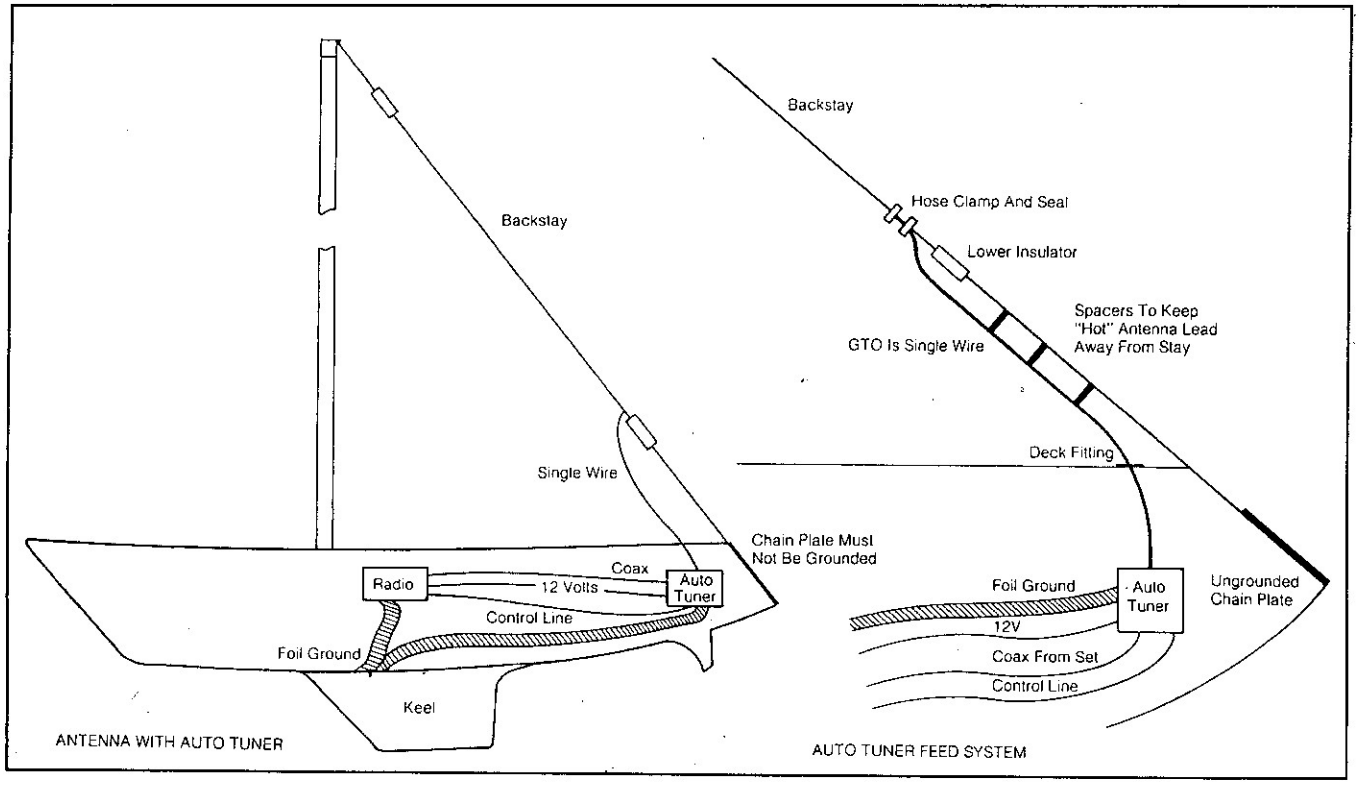
Some automatic tuners will work with any set without the need of a data line (Stephens 1612 and the new SGC). As soon as these more expensive tuners receive power from the transceiver, they self-adjust without the need of a four-conductor tune line.

The output from the tuner is a single wire post (low impedance reactance feed), sometimes called a "long-wire feed." A single wire rated for high voltage (such as GTO-15 or neon sign wire) is led from the tuner's output directly to the insulated backstay or non-resonant whip. In case of dismasting or whip failure, any length of wire longer than 20' will radiate a nice signal. Like the manual tuner, the automatic tuner must also be copper-foil grounded in order to work.

In home "amateur radio" automatic tuners, as opposed to "marine" auto tuners, the long-wire feed is not a common feature. The automatic tuners built into the Kenwood 440 and 940 series transceivers are really only "trimmers." They won't tune up a long wire. The same thing is true for most auxiliary "ham radio" automatic tuners—they are not intended for marine long-wire installations, but rather for home installations using an antenna system that is nearly resonant. This is why built-in automatic tuners in the Kenwood 440 as well as home-style automatic tuners normally do not work at all in marine installations with a single wire feed.

The "marine" tuners need large inductors (coils) and very large capacitors which together are physically too big to fit inside a ham set. So far only the ham manufacturer ICOM has a remote tuner that is specifically designed for a single wire feed (ICOM AH-2 or AT-120). We understand that Kenwood and Yaesu may follow shortly, but ICOM, Kenwood, and Yaesu automatic tuners only work with their own brand of equipment.

The Stephens 1612 and SGC Model 230 are designed to



work (without a control line) with any SSB set, or any ham set, on any frequency between 2 MHz to 28 MHz.

Grounding ALSO SEE 8/88 "MOTOR CRAFT"

You need at least 50 to 100 square feet of "ground" below the waterline for any type of tuner system to work properly on a quarterwave antenna system. **Wires are no good for grounding.** Wire looks "invisible" at radio frequencies (high inductive reactance). Three mil, 3" wide, copper foil is ideal. Run it everywhere below the waterline. If your metallic through hull fittings are bonded, go ahead and ground to them with hose clamps as well. Do not ground any metallic through hull that is not bonded to your ship's bonding system.

In a sailboat, try to attach the ground system to the metal keel. Even though the lead and foil are not actually contacting the sea water in an internally-ballasted boat, it will act as a terrific capacitive ground. The Guest Dynaplates are also a good investment—they are porous and they contact the sea water for a good ground (although I wouldn't necessarily agree with their computed surface area claims). The more ground you add below the waterline, the greater your counterpoise, the lower the take-off angle of your radiated wave, and the further you will talk and listen on marine/ham SSB.

Sure, a small amount of ground will let you operate up to 1,000 miles away with good results—but if you're cruising worldwide, you need a major ground system for that very low angle of radiation necessary for extremely long-range contacts. The more surface area ground below the waterline, the stronger the long distance signal on SSB.

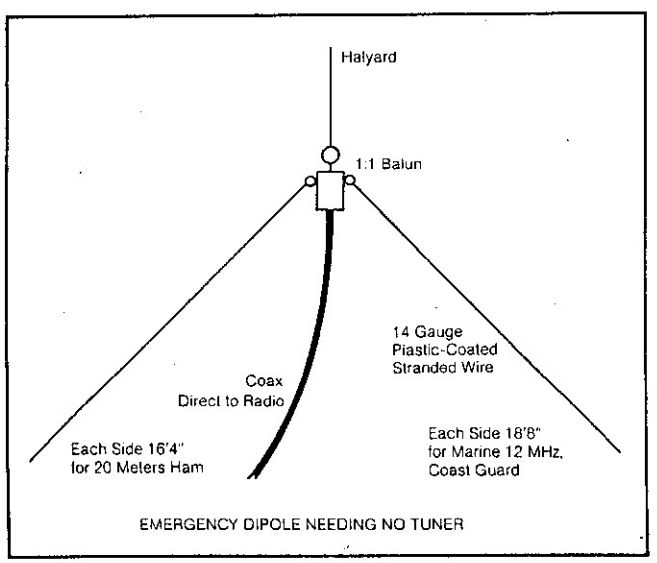
Summary

The reliability of fully automatic "marine" antenna tuners has been exceptional. Yes, they are electronic, and yes, they could get zapped by lightning. However, I haven't seen many fail even in the worst of conditions.

It is true that manual tuners, when properly adjusted, will put out the same amount of signal as a fully automatic tuner. The big problem is getting the adjustment just right on the manual tuner. Unless you are a knob-twirler or a died-in-the-wool ham radio operator, forget about the manual tuner because it will drive you crazy when you are trying to tune it up quickly or in an emergency.

Make absolutely sure that all feedpoint connections are kept absolutely bone dry. Black electrical tape won't do the trick. Coax Seal (Universal Radio, Reynoldsburg, Ohio) is gooey, but great. Marine silicone seal is fine, but impossible to remove. Water in the coax and corrosion at the feedpoint are the two greatest causes of little or no range on marine SSB. Everyone blames the radio and the tuner, when the problem is really the antenna connection.

You should also construct a simple dipole antenna for the ham radio 20-meter band, or the marine 12 MHz Coast Guard band, just for emergencies when your tuner system might fail and you need a simple antenna setup independent of anything else aloft. The dipole can be hoisted easily, and operated quite nicely in the inverted V configuration.



EMERGENCY DIPOLE NEEDING NO TUNER

*A detailed report on grounding methods is available from the author at no charge. Write Gordon West, c/o Radio School, Inc, 2414 College Drive, Costa Mesa, CA 92626. Include a self-addressed **triple-stamped** envelope for this multi-page report that details the exact techniques in developing a good RF ground system.*

Antenna Tuner Manufacturers

Manual Tuners

Nye
1614 30th Avenue NE
Bellevue, WA 98005

Palomar Engineering
Box 455
Escondido, CA 92025

Heathkit
Box 1288
Benton Harbor
MI 49022

MFJ Enterprises
921 Louisville Road
Starkville, MS 39759

Automatic Tuners

Hull Electronics
7563 Convoy Court
San Diego, CA 92111

RF Communications
1680 University Avenue
Rochester NY 14610

ICOM
2112-116th Avenue NE
Bellevue WA 98004

SGC
13737 SE 26th Street
Bellevue, WA 98005

Motorola
1301 E. Algonquin Road
Schaumburg, IL 60196

Stephens Engineering
7030-220th Street SE
Mount Lake Terrace
WA 98043