System Planner

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HF-SSB MARINE SYSTEMS

Long Distance Marine Communications

MOTOROLA

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INTRODUCTION

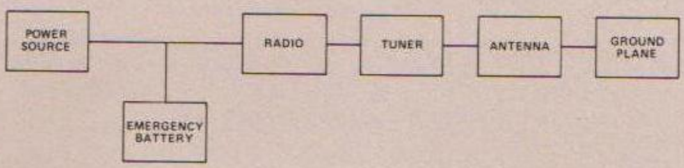
The main purpose for marine HF-SSB stations is to provide long distance communications in times of emergency. The safety of the crew and their chances for survival are greatly improved when the vessel is equipped with HF-SSB radio. On a daily basis, the equipment is used to coordinate the activity of the vessels and to increase their efficiency.

Motorola manufactures HF-SSB equipment that is ideal for marine applications. This system planner is designed to assist in the selection and installation of this equipment.

SECTION 1—EQUIPMENT SELECTION

Many factors influence the selection of equipment for marine systems. The wide range of vessels, their construction and usage often require that compromises be made from the ideal system design. This section will provide information on the basic system components and will aid in selecting the right equipment for a given application.

The diagram below shows the basic equipment that comprise a typical HF-SSB marine system.



1.1 POWER SOURCE

Motorola HF-SSB radios require 12 VDC at 35 amps maximum and a negative ground electrical system.

Every vessel will require a primary electrical power source and should carry a 12 VDC battery and connecting cables as a backup power supply for use in emergencies.

1.1.1 Vessels with 12 VDC Battery as Primary Power

Vessels that have a 12 VDC battery as the primary power source generally require no additional power supply accessories. The power cables supplied with the radio can be connected directly to the battery terminals. This will reduce wire losses and grounding problems.

1.1.2 Vessels with 20 to 45 VDC Primary Power

Vessels with 20 to 45 VDC primary power must use a DC to DC converter to provide a 12 VDC output at the appropriate current levels for the radio.

1.1.3 Vessels with 110 to 240 VAC Primary Power

Vessels that have an AC voltage as primary power must use an AC power supply to provide a constant 12 VDC output at the appropriate current levels for the radio.

Please refer to the price pages for the correct AC power supply to use with the selected radio model.

1.1.4 Vessels with Other Types of Primary Power

If the vessel does not have a primary power source in one of the three categories covered above, use a 12 VDC battery with a battery charger designed to operate with the vessel's primary electrical power.

1.1.5 Emergency Back-Up Power Source

Every vessel should carry a 12 VDC battery and a means to connect it to the radio for use in emergency situations. The battery should be mounted as high as practical above the water line to allow the maximum time possible to call for help should the vessel begin to sink. Equipment for mounting the battery securely must be provided. The emergency battery should be connected in parallel to the primary power leads. Some type of isolating device must be used to effectively disconnect the vessel's primary power system from the radio and emergency battery.

1.2 HF-SSB RADIO

Any standard Motorola HF-SSB radio can be used for marine systems. Selection will depend on customer requirements for frequency range, number of channels, and modes of operation. Typical systems require a large number of channels with some operating in a half-duplex mode. (Half-duplex operation uses different frequencies for transmit and receive.) Radio models that offer a large number of channels and half-duplex operation as a standard feature are recommended.

1.3 ANTENNA TUNER

Motorola's fully Automatic Antenna Tuner is the only model recommended for marine systems.

The purpose of the tuner is to match the 50 ohm output of the radio's transmitter to the antenna for the maximum power transfer and radiation. Antenna impedance will vary with the frequency and the surrounding environment. The Automatic Antenna Tuner is the only model that can adjust to the constantly changing conditions in marine applications without requiring the services of a technician to do the retuning.

RF and control cables are needed to connect the radio and tuner. Refer to the price pages for the available lengths.

1.4 ANTENNA

Selection of the proper antenna depends on the mounting space available and the desired propagation characteristics. It is not within the scope of this document to discuss the differing radiation patterns offered by the available antennas and their installation. However, effective coverage can be had with any antenna by providing a high quality installation and using the appropriate frequency for the distance desired. Selection of the antenna therefore depends mostly on which type can be installed for the highest effective radiated power. It is very important to read the section in this document on antenna installation before making the antenna selection.

1.4.1 Long-Wire Antenna

In general, long-wire antennas are preferred over whip antennas. They are less expensive and usually provide more efficient performance. For vessels with some type of mast, they are also easier to install.

The propagation characteristics of a long-wire antenna depend on the manner in which it is installed. The best overall coverage is provided by an inverted "L" configuration. A long-wire antenna installed as an inverted "L" is the most highly recommended antenna configuration due to its reliable performance.

1.4.2 Whip Antennas

Whip antennas are the most common HF-SSB antennas found on vessels. This is because they can more easily be installed where they will not interfere with the operation of the moving parts of the vessel. Whip antennas are more expensive than long wires and are often less efficient radiators. They require that the structure to which they are mounted be strong enough to withstand the stresses placed on the antenna by the wind and seas.

In general, the longer the whip antenna, the better the performance. Motorola's 23-foot and 35-foot whips are recommended. The 32-foot whip is sectional and will not withstand the stresses of a marine application. The 8-foot whip with matching harness is inefficient at low frequencies and requires a very large ground plane to operate at maximum efficiency. The 8-foot whip is to be used only when the vessel is constructed of metal and clearances prevent use of a longer whip or long wire antenna.

1.5 GROUND PLANE

The ground plane is one of the most important, and most often neglected, components of a marine HF-SSB system. Ground plane requirements depend on the construction materials of the vessel. As with antennas, it would be useful to read the installation section of this document before ordering the equipment. The diagrams and text in that section will help to estimate the quantity of grounding material that will be needed.

1.5.1 Ground Plane for Metal Vessels

Vessels constructed of aluminum or steel do not need a separate ground plane. The vessel itself becomes the ground plane. The only additional materials required will be some 12-gauge or heavier bronze or copper strap or wire to ground the antenna tuner to the vessel.

1.5.2 Ground Plane for Non-Metal Vessels

Vessels constructed of wood or fiberglass must have a ground plane added. It is essential to make use of all of the available metal structures on the vessel and to add enough ground screen material to provide a sufficient plane. At least 100 square feet of copper or bronze screen must be ordered and enough copper strap to connect all of the available metal structures on the vessel to the ground plane.

1.6 MISCELLANEOUS

In addition to the major system components described in the previous sections, several miscellaneous items will be required. These will differ with each application but will certainly include various fasteners for mounting the equipment and routing the cables.

Solder will be needed to bond together the various components of the ground plane and some type of fiberglassing or tar material will be needed to install the ground screen.

When the antenna tuner is mounted inside on metal vessels (which is preferred), an RF Feed Through Insulator is required to pass the RF through the wall or ceiling.

If a long wire antenna is selected, inspect the mounting points for existing hardware. If no suitable attachment hardware is present, it will have to be acquired.

SECTION 2—INSTALLATION

2.1 GENERAL

This section focuses on where and how to install HF-SSB equipment on board boats and ships. The Motorola HF-SSB equipment is designed to be mounted almost anywhere and any way the customer desires. There are some important aspects in installing the equipment which will be noted in the appropriate sections.

2.2 POWER SUPPLY LOCATION AND INSTALLATION

2.2.1 General

Vessels that have 12 VDC as the primary electrical power will not require any power supply for the HF-SSB equipment. Insure that the power leads for the radio are as short as possible. Where practical, also install an emergency power backup system.

2.2.2 Location

The power supply or converter is usually located in the same compartment as the radio. The supply or converter should be mounted in an area that is accessible but out of the way. Typical places are under desks, in cabinets, on equipment shelves or racks, or in the bottom of a console.

2.2.3 Installation

The power supply or converter will require 3-5 inches clearance on all sides and top for proper heat dissipation and service access. Securely mount the unit in place. This will prevent damage to the unit, adjacent equipment or personnel by the unit moving around when the vessel is at sea. The power leads to the radio must be as short as possible. This will reduce the voltage drop at high current levels and reduce the possibilities of grounding problems.

2.3 RADIO LOCATION AND INSTALLATION

2.3.1 Site Selection

There are generally three places on vessels that are considered for the radio location.

The first and most common is the pilot house (wheel house or bridge). When only one person is normally working in the pilot house, the unit should be located so that the microphone and radio controls are within easy reach of the helm. Typically, the unit will be mounted in an overhead console, custom installed in an equipment bay, or mounted on a wall (bulkhead). When two or more persons man the pilot house, the unit will typically be mounted in a communications equipment bay or console.

The second location is near the chart table which is typically in an adjoining space to the pilot house or helm. Usually the unit is mounted in an equipment rack or mounted on the ceiling or wall.

The third possible location is an equipment rack in a radio room.

When custom or rack mounting is desired, drop ship or locally supplied materials will be required.

2.3.2 Installation

The radio, when mounted on the overhead or bulkhead, will require a mounting tray and a reverse escutcheon so that the words for the controls will be legible.

There should be at least 3-1/2 inches of open space behind the heatsink to permit access to and clearance for the cable connectors. In all cases, the radio must be securely mounted to prevent the unit from moving around when the vessel is at sea.

2.4 TUNER LOCATION AND INSTALLATION

2.4.1 Location

The tuner housing is designed to be mounted both inside and outside. Where practical, install the tuner inside to reduce exposure to the elements. When the antenna site will not permit inside mounting, position the tuner as high as possible above the water line and as shielded from the elements as possible. For example, many vessels have overhangs around all or part of the pilot house. Mounting the tuner under the overhang on the bulkhead or actually mounted to the overhang itself is recommended (see Figure 2).

When mounting the tuner on a mast, there are often platforms or yardarms which can provide substantial protection to the tuner (see Figures 1 and 4). Mounting the tuner to the mast is suggested *only* when absolutely necessary.

The antenna feed line must be insulated to prevent accidental direct contact by personnel, riggings, or booms.

When the tuner is mounted inside metal vessels, the feed line must pass through the bulkhead or deck via a feed-thru insulator (see Figures 3, 5, and 6). In small to medium metal pilot houses, the tuner should be located as far as possible from the radio. This is to reduce the possibility of interaction between the tuner and radio.

2.4.2 Installation

The tuner is easy to mount and connect. Usually only four bolts or screws are required to mount the unit. There are two drain holes that are plugged with screws on the tuner. One is on the bottom and the other is next to the control line studs. The bottom drain hole should be open if there is a possibility of damage due to condensation.

When connecting the groundplane to the tuner, keep the lead as short as possible. Use copper strap whenever possible. ***Do not use braid.***

2.5 ANTENNA LOCATION AND INSTALLATION

2.5.1 Longwire Antennas

2.5.1.1 Longwire Location

There are three basic sites to choose from for longwire antennas: bow-to-mast, mast-to-mast, or mast-to-stern. The first step in site selection is to have all booms and riggings on the vessel moved through their full operating range and configurations. Select an area that is free of involvement for installing the antenna.

The preferred installation is mast-to-mast. The longwire can then be configured as an inverted "L" which has the best propagation characteristics.

2.5.1.2 Bow-to-Mast Longwire Installations

The bow-to-mast configuration has some special considerations. In heavy seas, the bow portion of the antenna will intermittently be subjected to direct contact to the water. This will change the tuning of the antenna and will drastically alter the antenna efficiency.

To minimize this effect, the bow end should be attached to the top of a separate stanchion. This will reduce the amount of time that water can come in contact with the antenna and also reduce the hazard of potential contact by the crew. Whenever possible, the antenna should be made of insulated wire or cable.

Figures 1 and 2 show good examples of bow-to-mast installations:

In Figure 1 is an example of a bow-to-mast longwire that is end fed from the mast end. This configuration is recommended for metal vessels only. Note the stanchion on the bow end of the antenna. As you can see, the bow is very high above the water line; but in heavy seas, the bow is very likely to go under water often. The stanchion will have to be constructed so that it can withstand the enormous stress of the water on it.

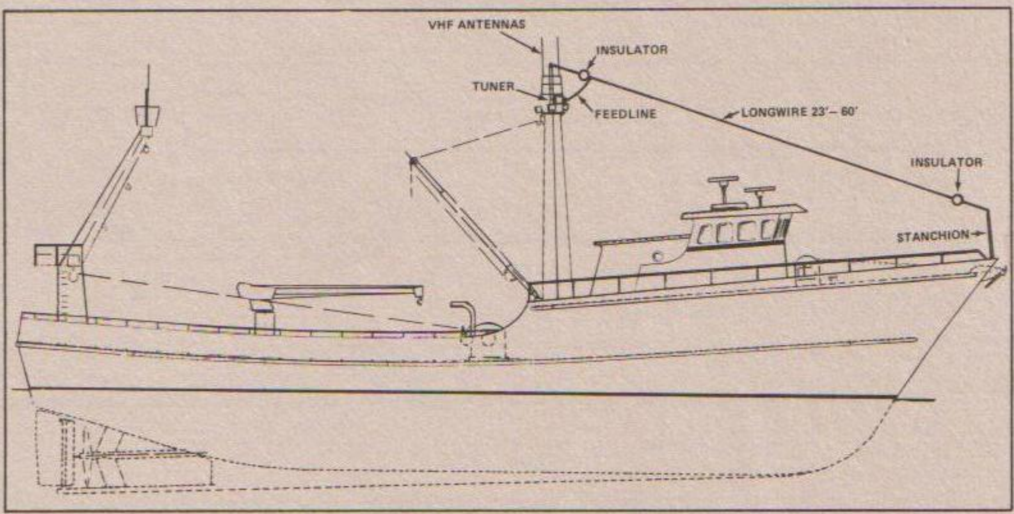


Figure 1 Bow-to-Mast

In Figure 2 is an example of a bow-to-mast longwire that is fed from the bow end. This is a more flexible arrangement for vessels constructed of all types of materials. On vessels constructed of wood or fiberglass, the ground plane should be installed on the roof of the pilot house as well as the deck.

2.5.1.3 Mast-to-Mast Longwire Installations

Many vessels with more than one mast can utilize a mast-to-mast configuration. Some vessels even have an existing cable that is used to help support and maintain the proper positioning of the masts. These existing cables can be insulated and fed from either end or can be used as an inverted "L" type antenna with a down lead. The inverted "L" type is the recommended configuration.

Figures 3 to 5 show typical mast-to-mast installations:

Figure 3 shows a typical motorized river barge. Most river vessels have some height restrictions on the antenna systems. The longwire antenna shown highlights the adaptability of a longwire to such restrictions. The antenna wire and feed line should be insulated.

Figure 4 shows a possible configuration of an end-fed longwire. This arrangement is not recommended for wood or fiberglass vessels because this places the tuner too high above ground. Note that the tuner is mounted under the deck of the platform on the mast. This provides some protection to the tuner from the elements.

Figure 5 shows an inverted "L" configuration longwire. The down lead is one-half the length of the horizontal lead. This arrangement is well suited for vessels constructed of all types of materials.

2.5.1.4 Mast-to-Stern Longwire Installations

The third configuration is the mast-to-stern arrangement. This configuration is most often used on sailboats but can be used on many types of power vessels.

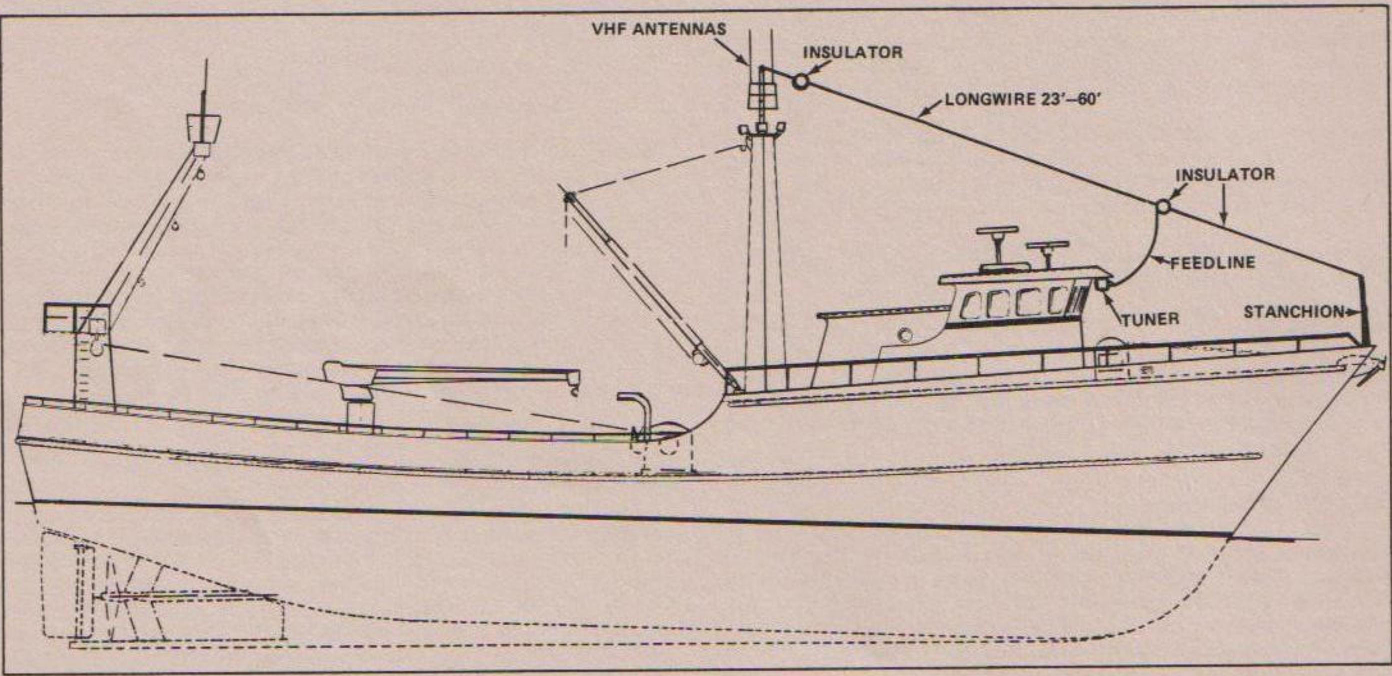


Figure 2 Bow-to-Mast

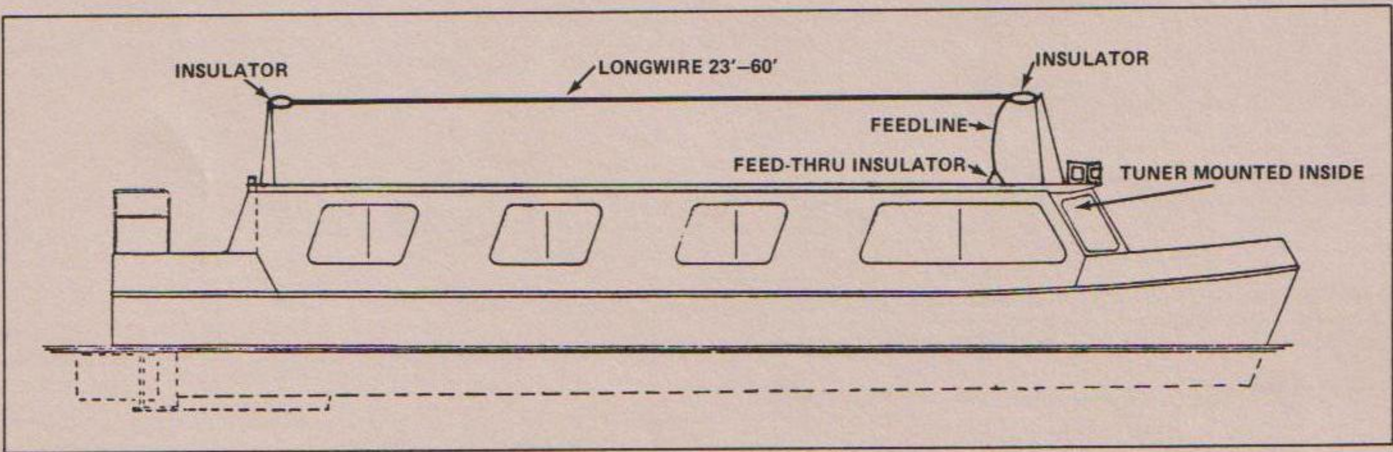


Figure 3 Mast-to-Mast

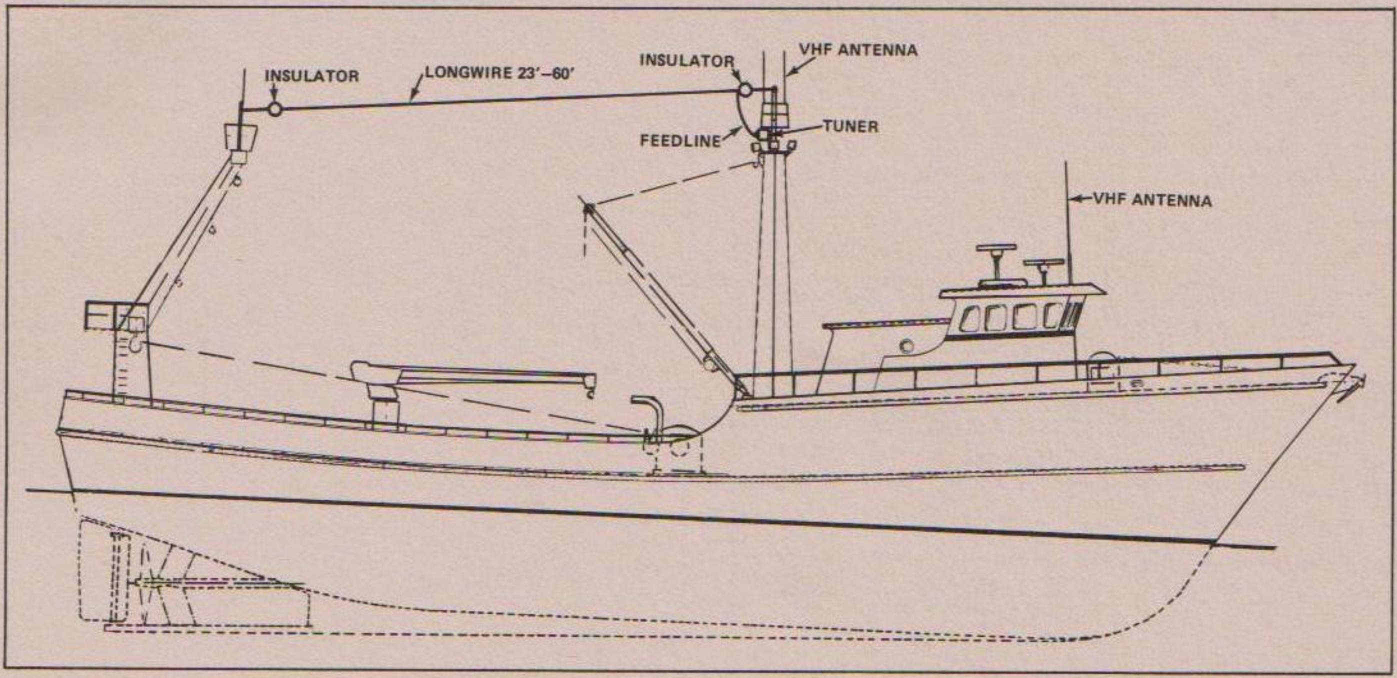


Figure 4 Mast-to-Mast

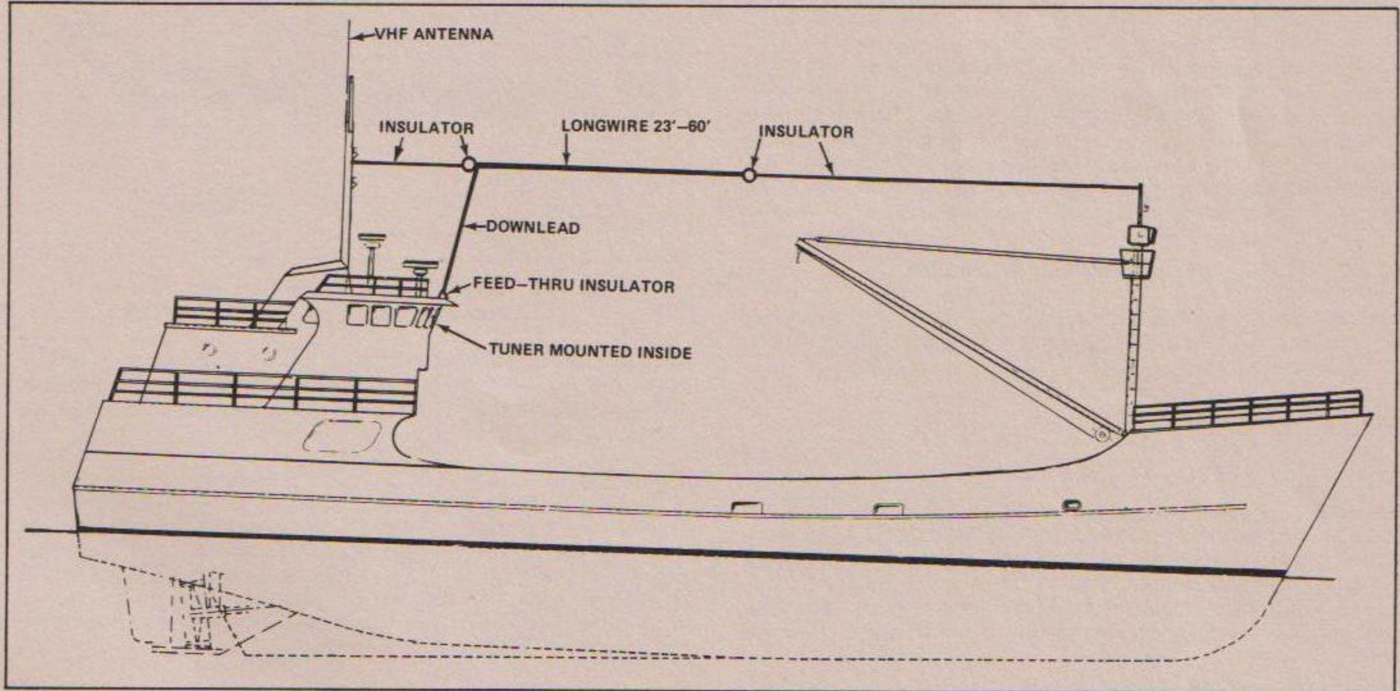


Figure 5 Mast-to-Mast Inverted "L"

Figure 6 shows a coastal freighter with a mast-to-stern arrangement. Note the stanchion that was added to support the stern end of the antenna. The purpose for this stanchion is to allow mounting of the antenna as far above the water line as possible and to be clear from contact by the crew.

Figure 7 shows a sailboat with a mast-to-stern configured antenna. This is the most common HF-SSB antenna used on sailboats.

There are two important facts about this antenna. The first is the personnel hazard that the antenna and feedline presents to the crew in the cockpit. The second is the stress that the insulators are subjected to due to the load which this antenna must carry. The forward motion of the vessel is dependent on transforming the wind pressure upon the sails to the motion of the hull in the water. Part of transforming that pressure to the hull requires that the mast be held upright against the wind. The stress, therefore,

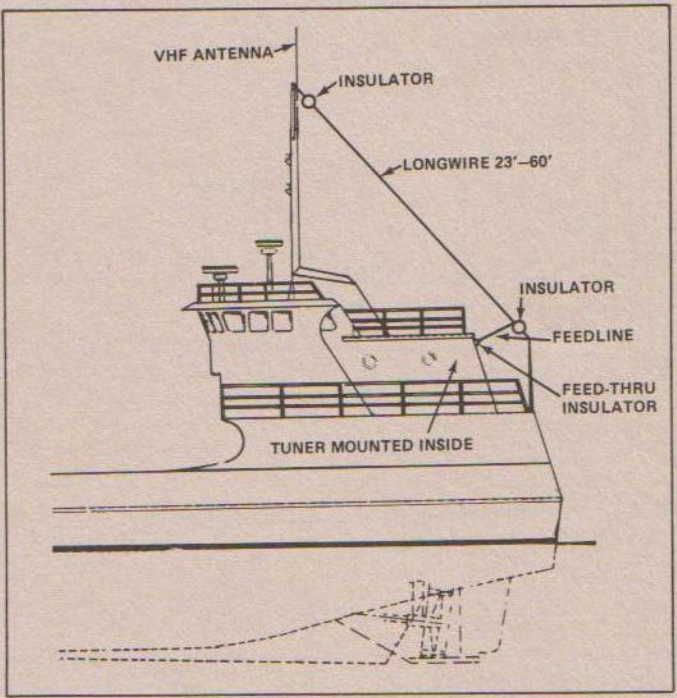


Figure 6 Mast-to-Stern Sloping Longwire

can and often is several tons of force. This stresses the insulators at both ends. Oftentimes this will cause cracks to develop in the ceramic insulators. Cracks allow salt water and other impurities to contaminate the insulator and reduce or negate its insulating properties. This, then, causes the antenna system to become non-functional. Therefore, it is recommended that the insulators be inspected three or four times a year for cracks and replaced yearly.

2.5.1.5 Longwire Post Installation Procedures

After the antenna is installed, have the booms and riggings moved through their full operating ranges to ensure that they do not interfere with the antenna.

2.5.2 Whip Antennas

2.5.2.1 Location

Whip antennas require a mounting site that is structurally sound enough to support the antenna in high winds and high seas. Have all booms and riggings moved through their full operating ranges and note the areas that are clear of involvement. Inspect those areas for sufficient structural support for the antenna. The area must be able to support the antenna under wind loads of up to 100 mph.

Figures 8 to 11 show good examples of whip antenna site location and installation:

Figure 8 shows an 8-foot whip antenna being used on a river barge where clearances are critical. The antenna must be mounted as close to the center of the ground plane as possible. This is due to the low efficiency of a short antenna even under ideal circumstances.

Figure 9 shows an intermediate sized fishing vessel. The antenna depicted here is a 23-foot whip. A 35-foot whip could not be adequately supported. Please note the booms and riggings. This vessel is used as a purse seiner and requires that the entire stern

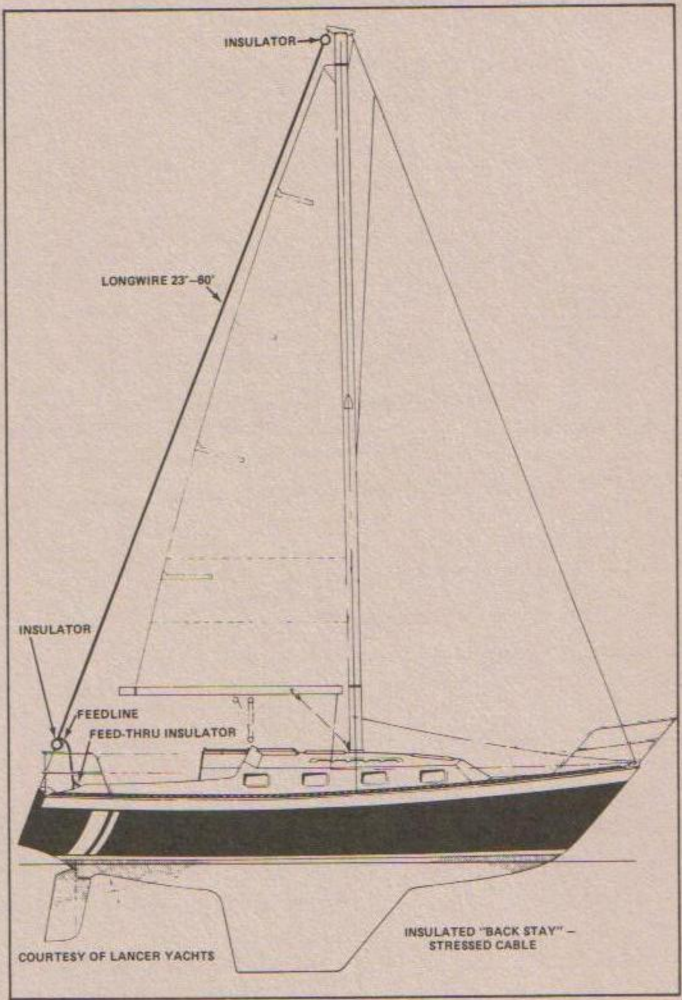


Figure 7 Mast-to-Stern Sloping Longwire Insulated "Back Stav"—Stressed Cable

area be clear of obstructions for net nandling operations. The HF-SSB antenna is mounted inside the cowling of the flying bridge. This provides protection to the tuner and the base of the antenna in heavy seas.

Figure 10 shows a coastal freighter. The antenna depicted here is a 23-foot whip but a 35-foot whip could just as easily be mounted. Please note that the antenna is mounted as far away as possible from the mast and out in the open. This is important for proper radiation. The mast will still absorb some radiated signal but it will not appreciatively affect long-range communications. Due to the corrosive nature of the engine exhaust, place the antenna off the center line as much as practical.

Figure 11 shows a sailboat with an insulated sidestay (mast support cable) as the antenna. This antenna operates the same as a whip. The bottom 1/3 to 1/2 should be insulated to reduce the high voltage hazard to personnel present during transmit.

2.5.2.2 Whip Antenna Installation

Motorola supplied whip antennas are designed to be mounted almost anywhere. The only limiting factor on mounting is that it be able to withstand the winds and seas. Normal mountings are base mount/self supporting, base mount/side support, and side mount. Suitable base mount/self supporting antennas are listed in the Motorola price book.

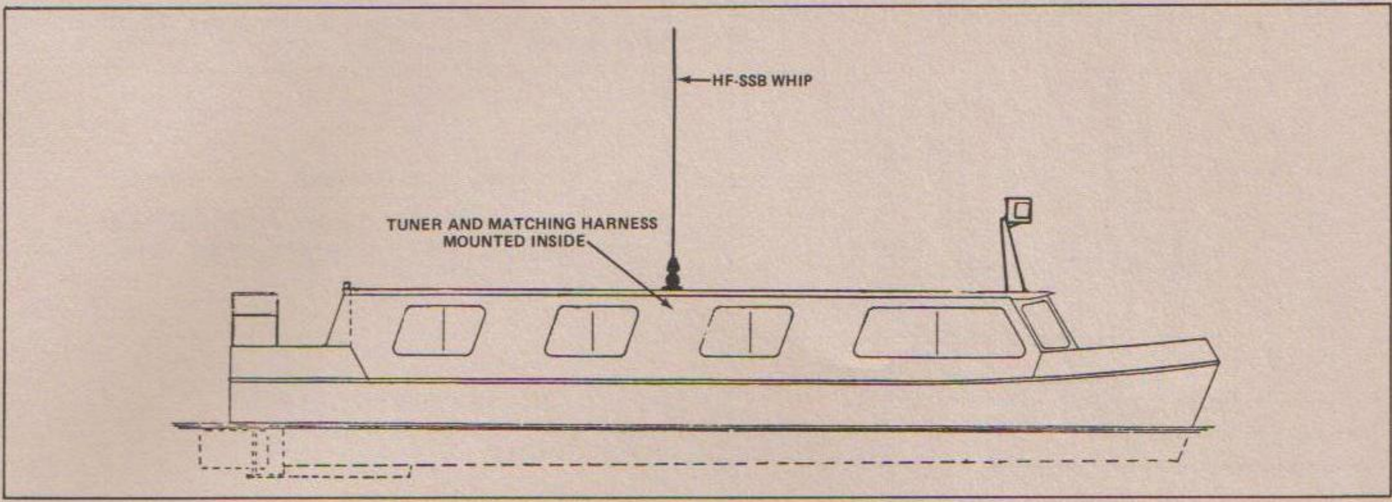


Figure 8 Mobile Whip

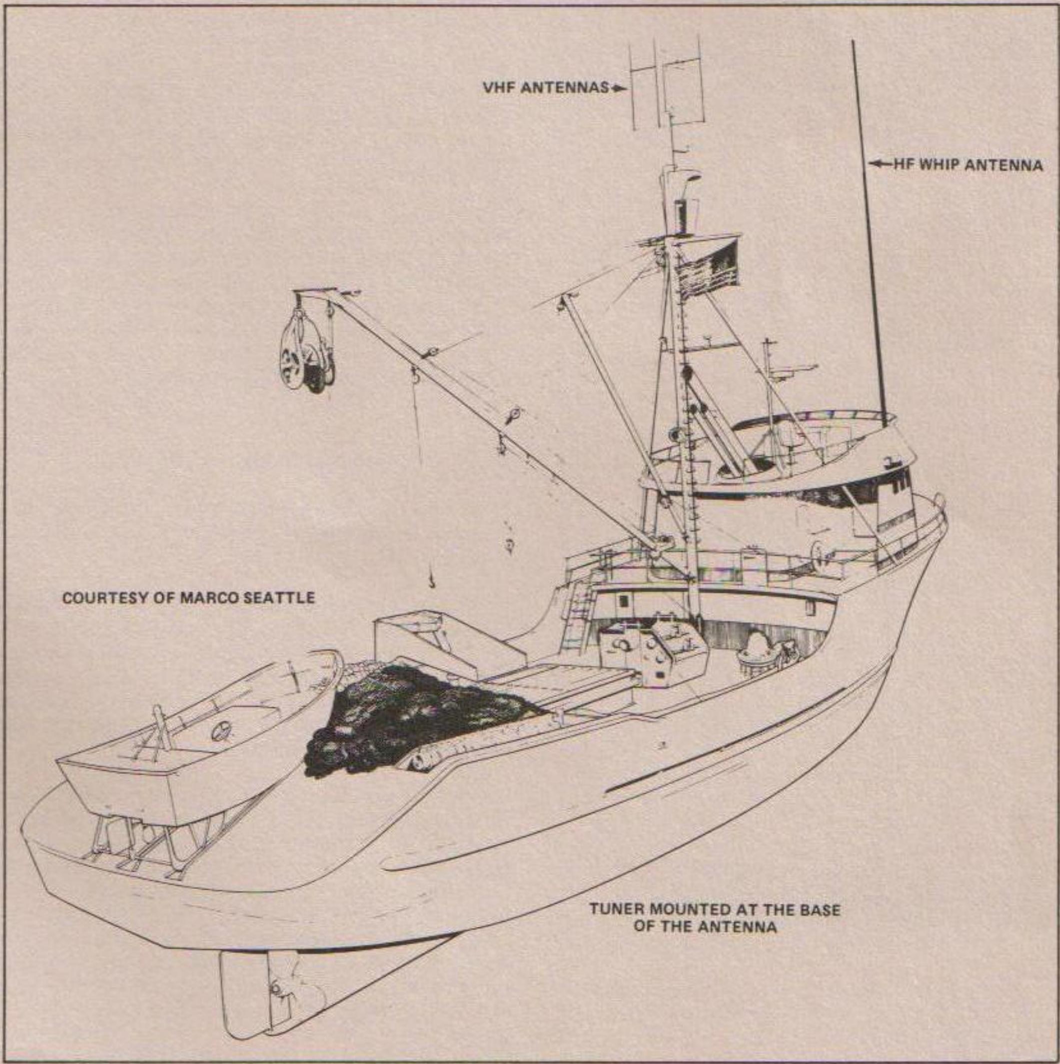


Figure 9 Whip Antenna

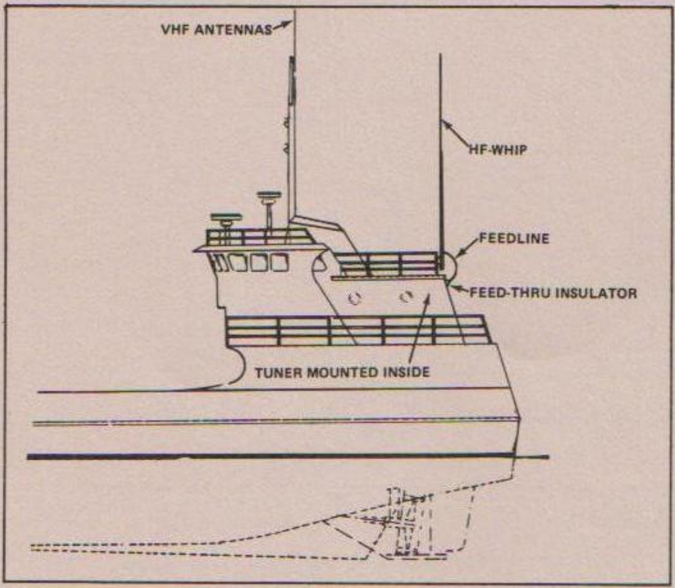


Figure 10

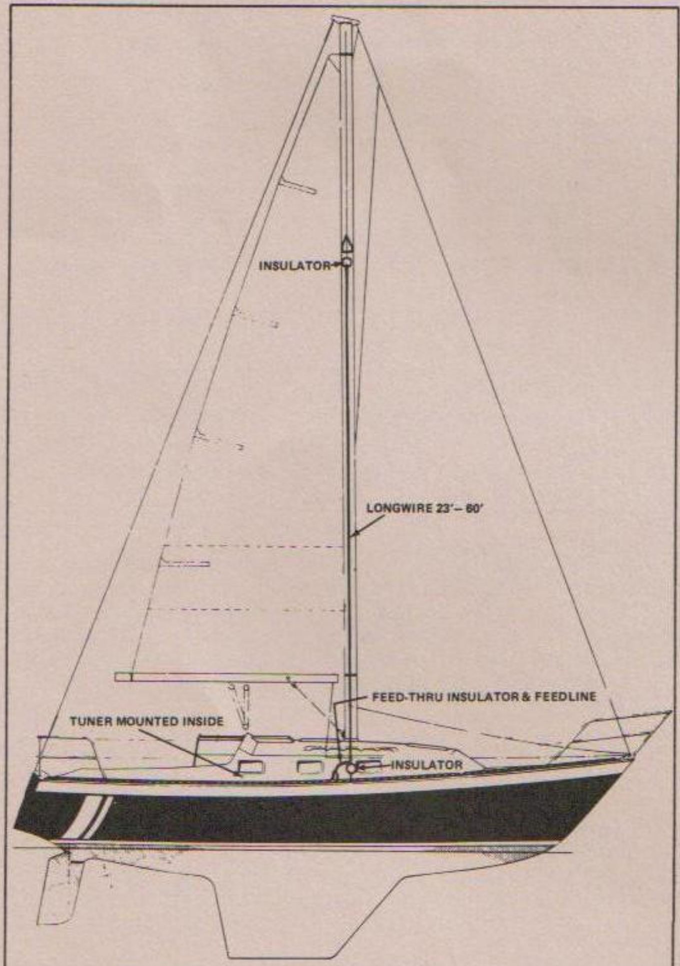


Figure 11 Vertical "Side Stay" Antenna

The feed lines are often close to manned areas. *During transmit, the antenna is energized with RF voltage of 5 kV. Therefore, exposed feed lines and antennas must be insulated to reduce the shock hazard to personnel.*

2.5.2.3 Post Installation Procedure

After the antenna is mounted securely, have the booms and rigging moved through their full operating ranges to check for interference with the antenna.

2.6 GROUND PLANE INSTALLATION

2.6.1 General

The larger the ground plane area, the more efficient the antenna system. The ground plane acts as the bottom half of the antenna. Often radios or tuners are blamed for poor system performance when, in fact, an inadequate ground plane is responsible.

2.6.2 Steel or Aluminum Hull Vessels

Metal vessels are the easiest on which to install an efficient antenna system. The vessel itself becomes the ground plane. It is very important to keep all ground leads to the radio, tuner and power supply as short as possible. All grounding points to the vessel must be free of paint, oil, etc., for good electrical contact.

Vessels with aluminum superstructures or cabins and steel hulls and decks must have bonding straps between the superstructure and hull. When two dissimilar metals are exposed to salt water, oxidation and corrosion will alter the original electrical contact. The straps should be placed every 10 feet around the inside perimeter, where it will not be exposed, to ensure an adequate ground plane. The additional grounding straps will then maintain good connections between the two metals.

2.6.3 Wood or Fiberglass Vessels

Both wood and fiberglass are very poor electrical conductors, and do not provide any ground plane for an antenna. A ground plane must be added to the vessel.

There are two basic sections to the ground plane. First, all the metal fixtures, plumbing, riggings, machinery and hardware must be bonded together (see Figure 12). Motorola supplies a kit of 75 feet of 2-inch wide copper strap for this purpose. Many vessels also are outfitted with grounding plates to provide a good connection for lightning protection. This plate must also be bonded to the rest of the metal hardware.

Second, a ground screen must be added. Figure 13 depicts a fiberglass vessel with a longwire. Note that both the roof of the forward cabin and the deck of the flying bridge is covered with screen. The screen can be mounted on the ceiling inside if preferred. The edges of the screen should be soldered to make good electrical contact within itself and to prevent unraveling. These screens are then connected to each other via 2-inch wide copper straps soldered to the screens. In this installation the antenna tuner is physically located on top of the upper screen. A ground strap is soldered to the screen and connected to the ground lug on the tuner.

Finally, the ground screens and the bonded hardware must be connected together with 2-inch wide copper strap.

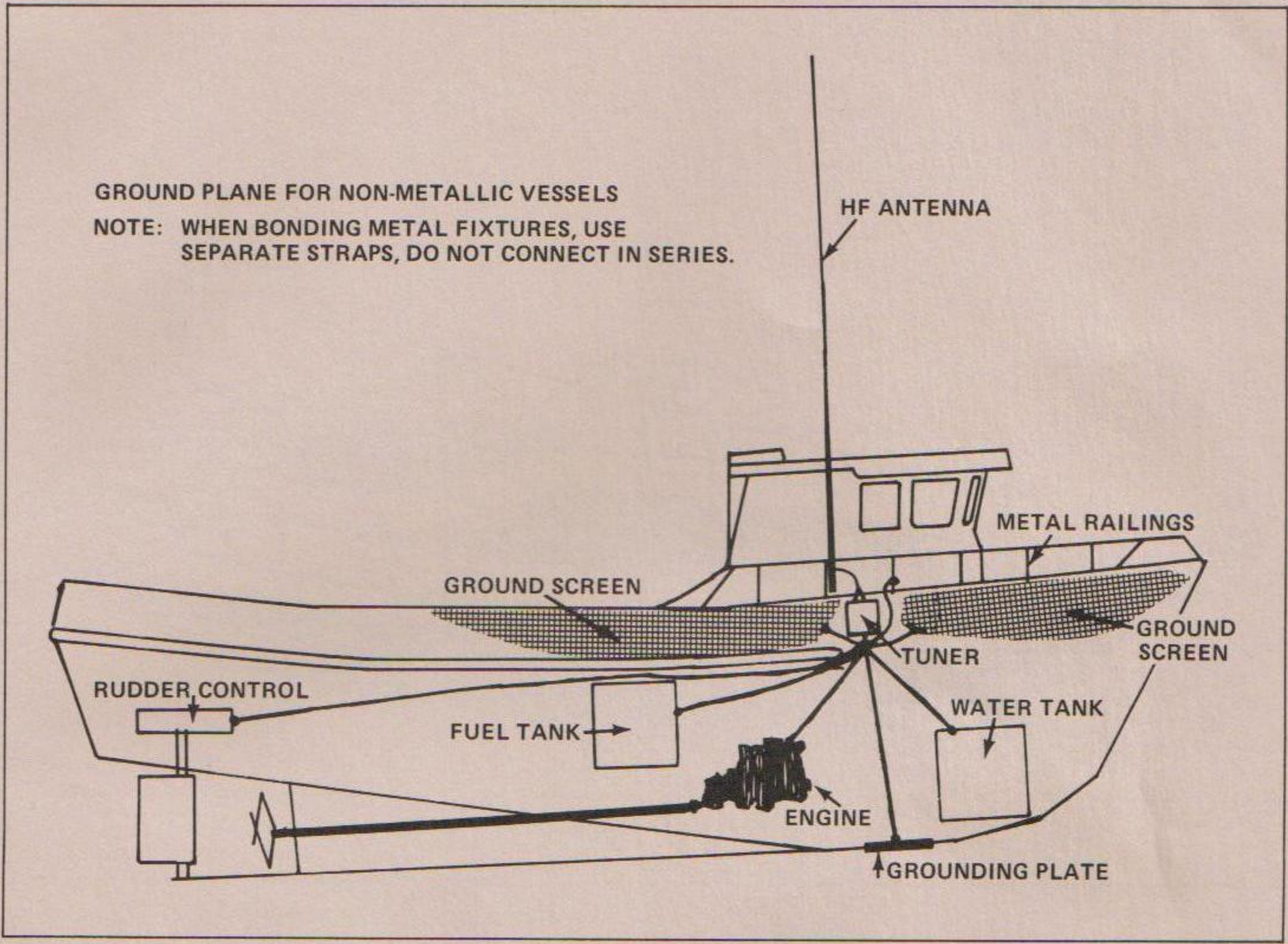


Figure 12

In Figure 14, a whip antenna is mounted on a fiberglass vessel. The location was chosen to provide adequate support for the antenna. Note that the ground screen on the forward cabin roof is the same as in Figure 13. The second screen is mounted on the deck of the cabin. This places the ground plane at the bottom of the antenna where it will give the best performance. The same installation procedures are incorporated here as was previously described for Figure 13. The tuner is mounted inside the cabin and connected to the ground.

On small vessels, there normally is not room to spread out 100 square feet of ground screen on the deck or mount in the ceiling of the cabin. The best way to install the screen is to glue 1/2 of the screen to the outside of each side of the hull with fiberglass, or inside with fiberglass, paint or tar. Connect the two halves together with 2-inch strap and bond to the rest of the grounding system. The tuner should be mounted at the base of the antenna and as close to the center line as possible.

2.7 CABLE ROUTING

Connecting of all the pieces of the system normally requires some routing of cables. There are some important considerations to keep in mind when planning and installing these interconnect cables.

The RF and control cables carry important information and their placement and routing should be such that they are out of the way. Their routing should eliminate the possibility of nails or screws from piercing the cables and shorting out the conductors.

When routing requires that the cable pass through a wall or bulkhead, stuffing tubes should be used to provide watertight integrity.

Many vessels comply to some standard of construction. Most of these standards require that cables that carry more than 5 VDC be armored cable. RF coaxial cables are often specified for either semi-rigid or rigid helix. When these requirements are encountered, please contact Drop Ship.

RF feedline between the antenna tuner and the antenna must be installed to maximize the distance between the cable and ground. When the tuner is mounted inside a metal superstructure or under a metal deck, and the RF cable must pass through the deck or bulkhead, a feed-thru insulator must be used. It is also recommended that a feed-thru be used on wooden vessels as well.

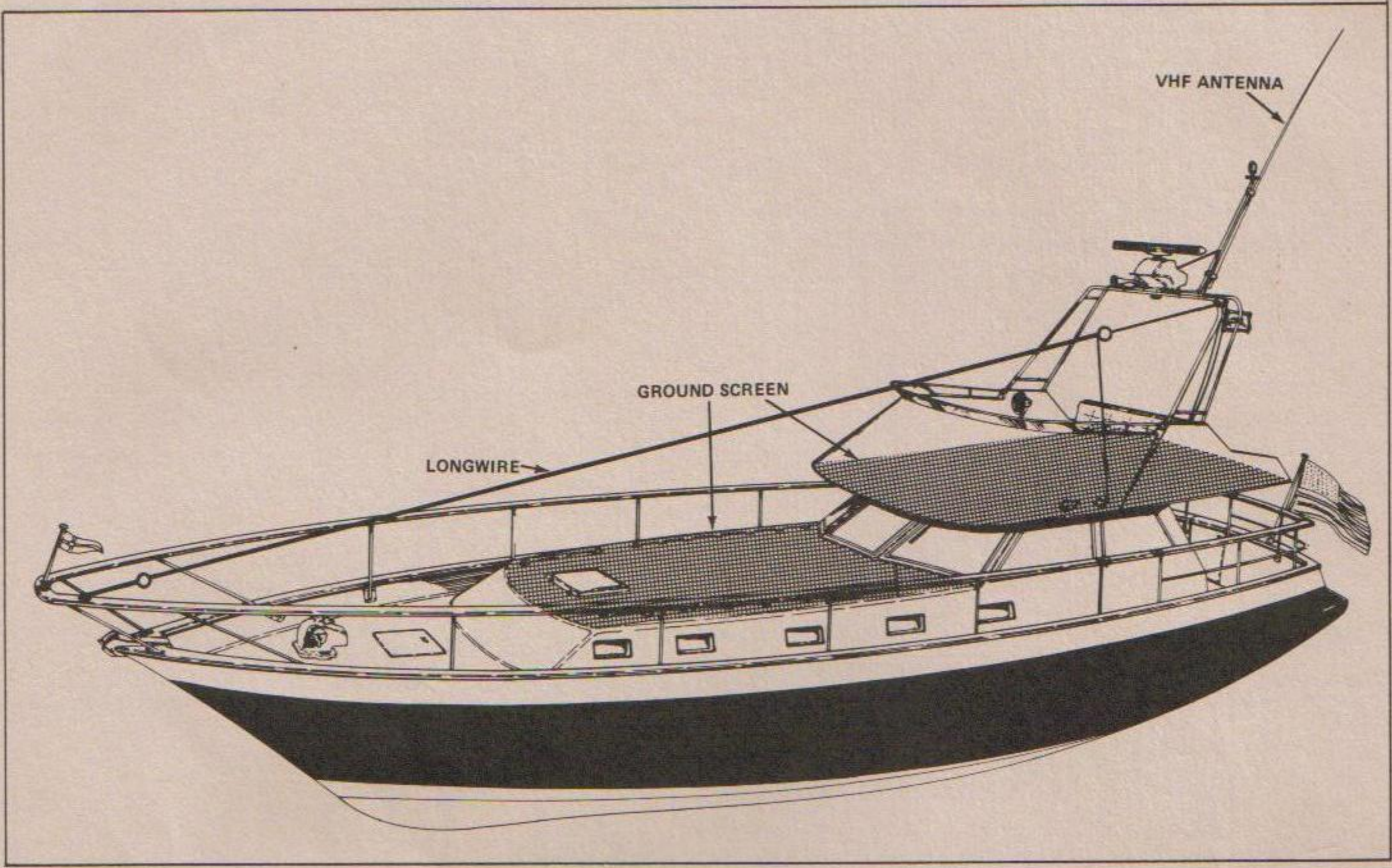


Figure 13 Fiberglass Hull

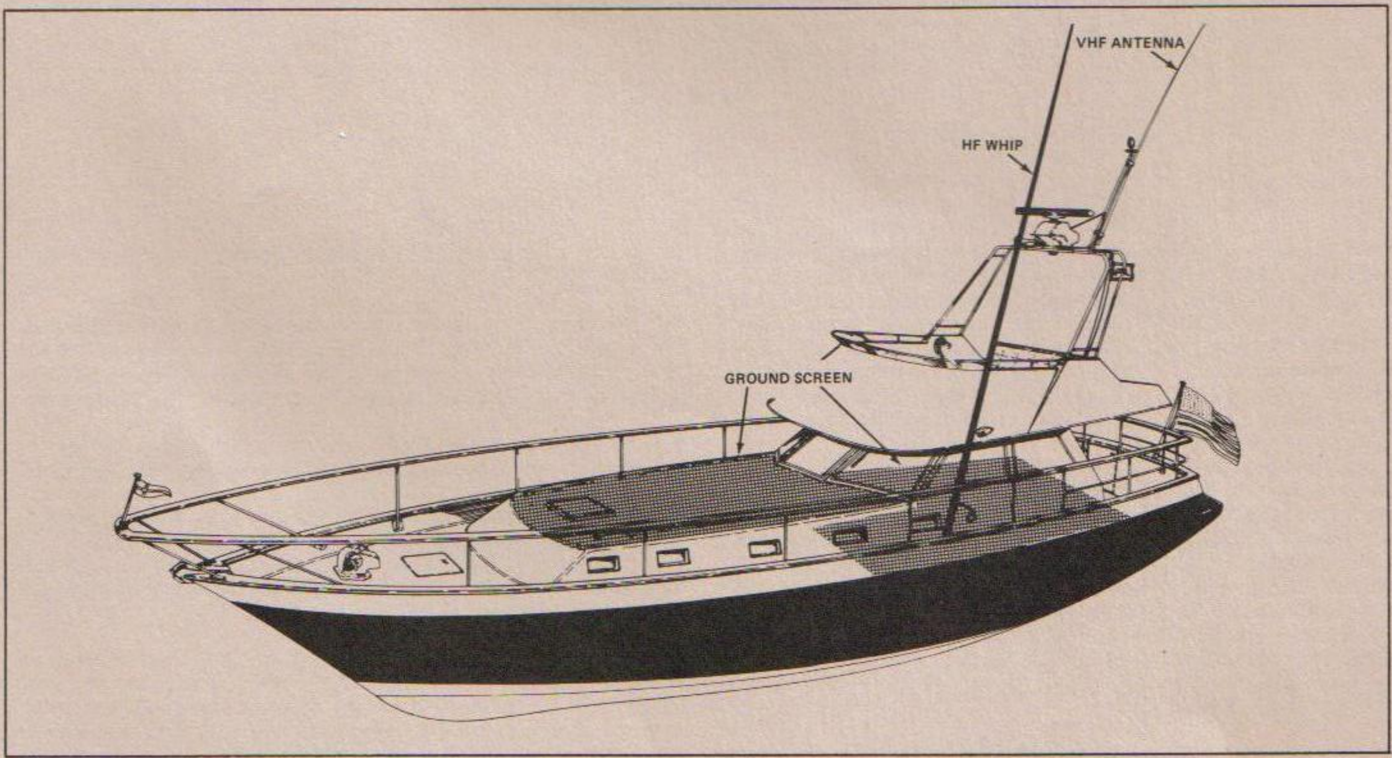


Figure 14 Fiberglass Hull

Artwork courtesy of Marco Seattle, Inc. and Lancer Yacht, Inc.

