Marine SSB and Offshore Communications

Practical techniques to make it all work

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What is SSB?

- SSB refers to a technology for communicating over long distances using radio transmissions in the 2 to 30 MegaHertz frequency range.
- The term "SSB" comes from "Single Sideband", a modulation technique which allows better utilization of available bandwidth. This is the norm for voice communications in the lower frequency bands.

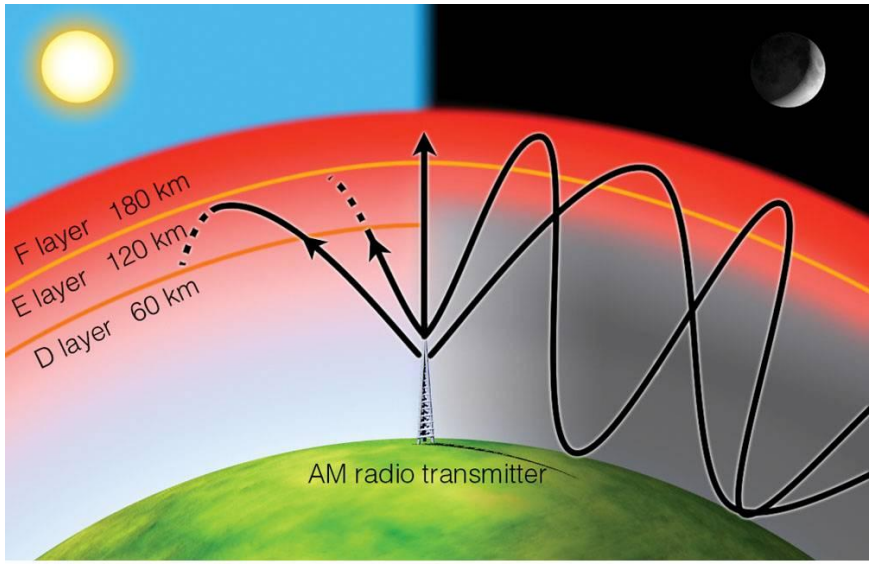
What is the difference between Marine SSB and Ham Radio?

- Marine SSB and Ham Radio use an essentially identical technology base in the 2-30 MHz spectrum. The main differences are in the frequency allocations, operating modes, and user interface.
- Ham radio allows the use of any frequency within a designated set of bands, and the radios are capable of continuous tuning within those bands. The radios are generally sophisticated and complex to operate, but allow the operator to optimize the connection.
- Marine SSB is a channelized service, similar in concept to the VHF marine radio. A marine SSB has very few controls, and is intended to communicate on only a discrete, well documented set of frequencies within the designated bands. Although intended to be simple to operate, the controls are often non-intuitive and annoying to use. Marine SSBs are usually somewhat hardened for use in a marine environment.

The Ionosphere

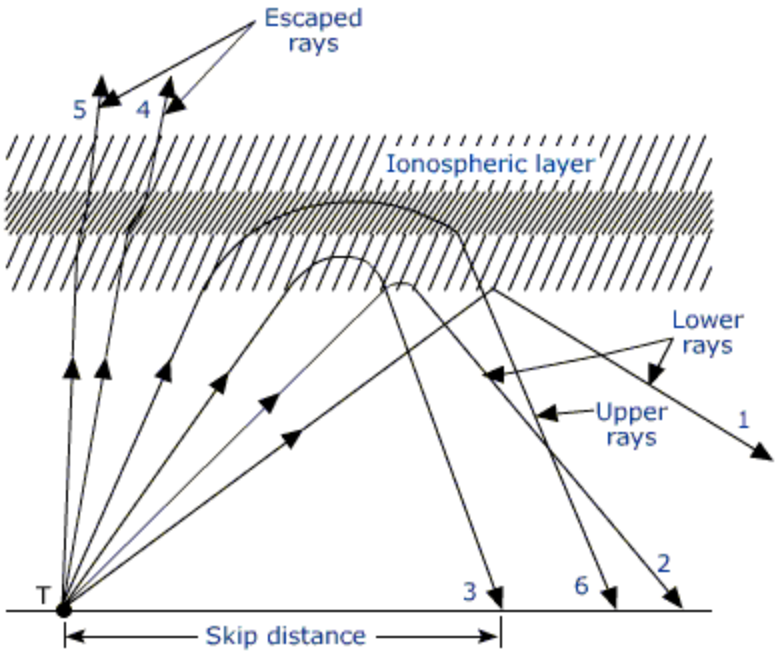
- High frequency radio waves (e.g. VHF) propagate in straight lines from the antenna. Due to curvature of the earth, the range is short, typically 20 to 200 miles).
- Radio waves in the HF range (2-30 MHz) can reflect off a layer of ionized particles in the upper atmosphere called the **ionosphere**, and bounce back to earth, dramatically increasing the distance traveled around the circumference of the earth. This effect depends on time of day, frequency, and the effects of the solar wind on the ionosphere. This is called "skip" propagation.
- Picking the right frequency band for a time of day and intended communication distance is a learned skill, but there are PC programs which can be helpful.
- An antenna with a high radiation angle (up from the horizon) will not bounce well from the ionosphere, limiting the communication range and signal power at the receiving site.

Ionosphere- Skip Propagation



The bending effect of the ionosphere Depends on the time of day and the Height of the layer (D,E, F) above Earth. Also on the solar wind from sunspots.

A high radiation angle from the antenna lets the transmitted radio waves escape into space instead of being refracted back to earth. This is an effect of a poor counterpoise or ground plane.



Marine SSB Frequencies

- Different frequencies can cover different ranges, at different times of the day. Here are some general characteristics of the Marine SSB Bands:
- 2 MHz 200-400 miles
  4 MHz 400-600 miles
  6 MHz 600-1,200 miles
  8 MHz 800-1,600 miles
  12 MHz 1,200-2,400 miles
  16 MHz 1,600-3,200 miles
  22 MHz 2,200-4,000 miles plus
  26 MHz unpredictable during our solar cycle minimum
- Generally the bands lower than 8 MHz propagate well at night, and those above 8 MHz propagate well in the daytime. This is a rough rule of thumb.
- The 4,6, and 8 MHz bands will be the ones primarily used

  in the SSS TransPac. 12 MHz may be useful for Wx FAX. Exact frequencies to be used in the race will be covered at the skipper's meeting.

From Latitude 38's "Idiots Guide to Marine SSB
http://www.latitude38.com/features/SSB.html#.Ux-JWc7vh1M

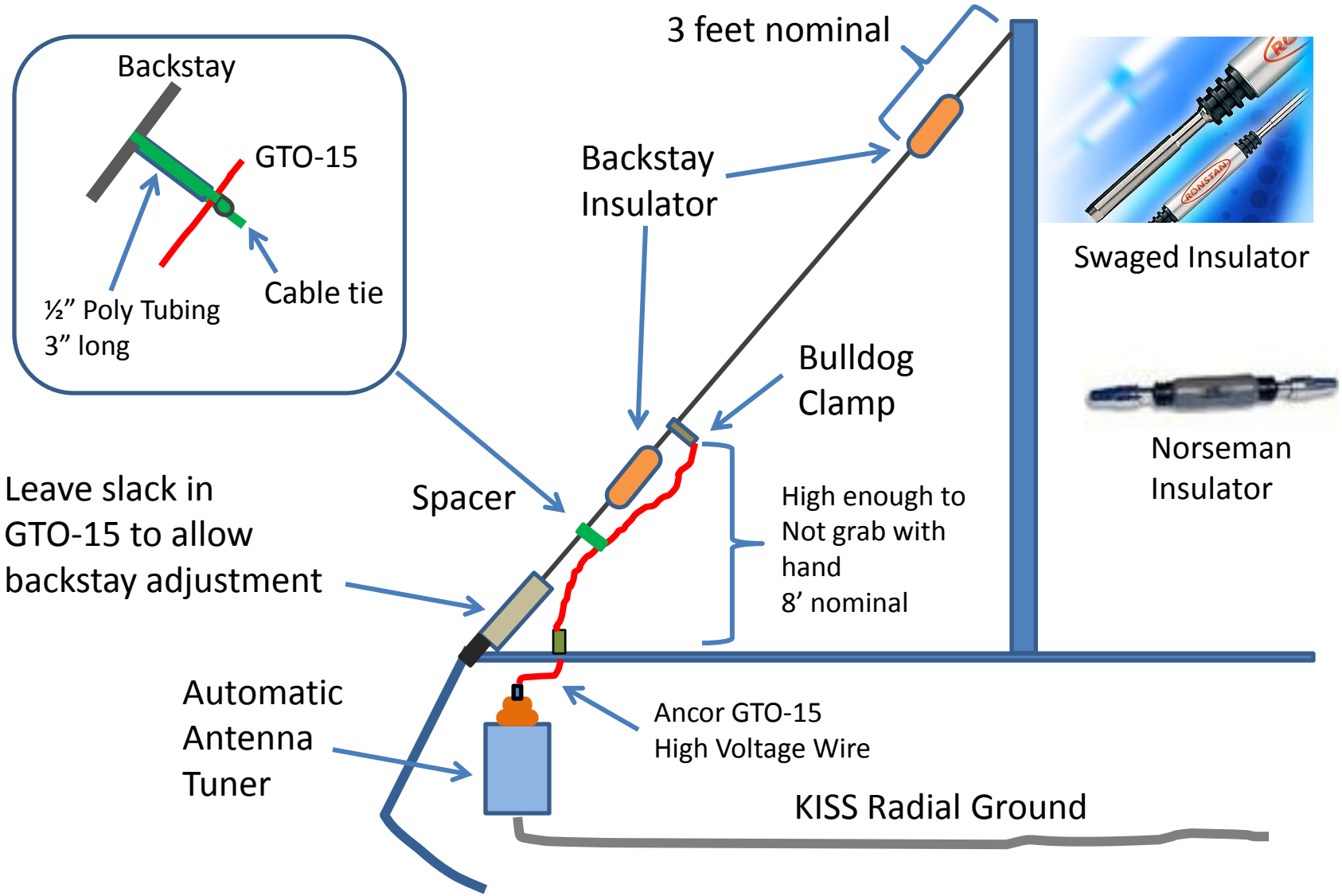
A Marine SSB System

- A good HAM or Marine SSB installation in a boat has the following parts:
  - An Antenna
  - An Antenna Tuner
  - A Ground System or “counterpoise”
  - A Line Isolator
  - A Lightning Arrestor
  - Coax Cable
  - An SWR Meter
  - A Transceiver
  - A Power Supply
  - Optionally, it may have a Pactor Modem, run by a computer

Antennas

- The Antenna converts the electrical signals generated in the Transceiver into travelling electromagnetic waves which then propagate through space to allow communication.
- Antennas must be resonant at the frequency of operation in order to generate radio waves of any significant amplitude. This is accomplished with an antenna tuner, unless the antenna is a specially designed narrow band one.
- Antennas on a boat are VERTICAL DIPOLE antennas, which necessitates a COUNTERPOISE or GROUNDING SYSTEM to simulate the missing half of the dipole. The quality of this grounding system determines antenna *efficiency* and *radiation angle*.
- Marine SSB antennas are usually non-resonant whips or insulated backstays, which generally need to be at least 23 feet long to allow the TUNER to make them resonant at all operating frequencies. Some antennas, such a short rail mount verticals, contain inductors and capacitors to make them resonant in a small set of frequency bands. They do not usually need a tuner, but suffer from poor efficiency and non-optimum radiation angle.

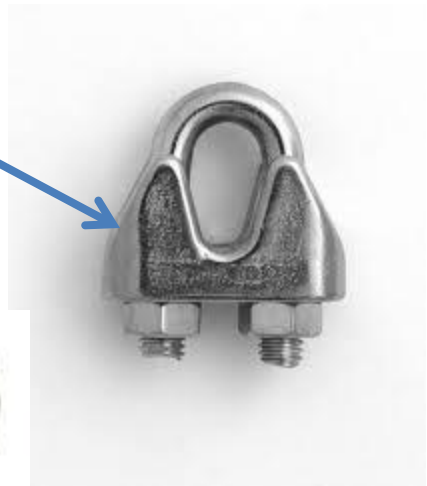
Insulated Backstay Antenna System

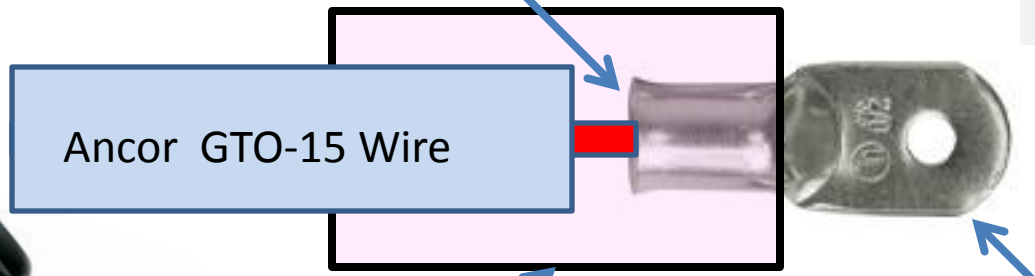


Antenna Connection

Solder GTO-15 to Ancor #8 Battery Lug with electronic grade solder. Fill the lug entirely with solder.

Use Stainless Steel Bulldog Clamp to attach to wire backstay.





Use Adhesive Lined Heat Shrink Tubing to seal

Use Lug with hole To match Bulldog Clamp

Use wire seal to bring GTO-15 through the deck.

Transceivers

- A Transceiver is the actual SSB radio.
- Some HAM transceivers can be modified to allow use on the Marine SSB frequency channels. It is technically illegal to operate like this, but if all you have is a HAM SSB, then it is a usable option. To avoid a nasty encounter with the FCC, be SURE (!!!) that the radio is tuned to EXACTLY the channel frequency and that you are using the appropriate sideband (upper or lower).Don’t be sloppy.

Transceivers

- There are a variety of Marine SSBs on the market. Although some are probably workable, massive experience by thousands of users has shown that ICOM Marine SSBs are the gold standard. Of these, there are 4 that Sailmail recommends: the old ICOM 700PRO, ICOM 710, ICOM 710RT, and the newer ICOM 802. These radios are very robust , reliable, powerful, and easy to get repaired (unlikely to be necessary).

ICOM Marine SSB

ICOM 700PRO

ICOM 710 RT

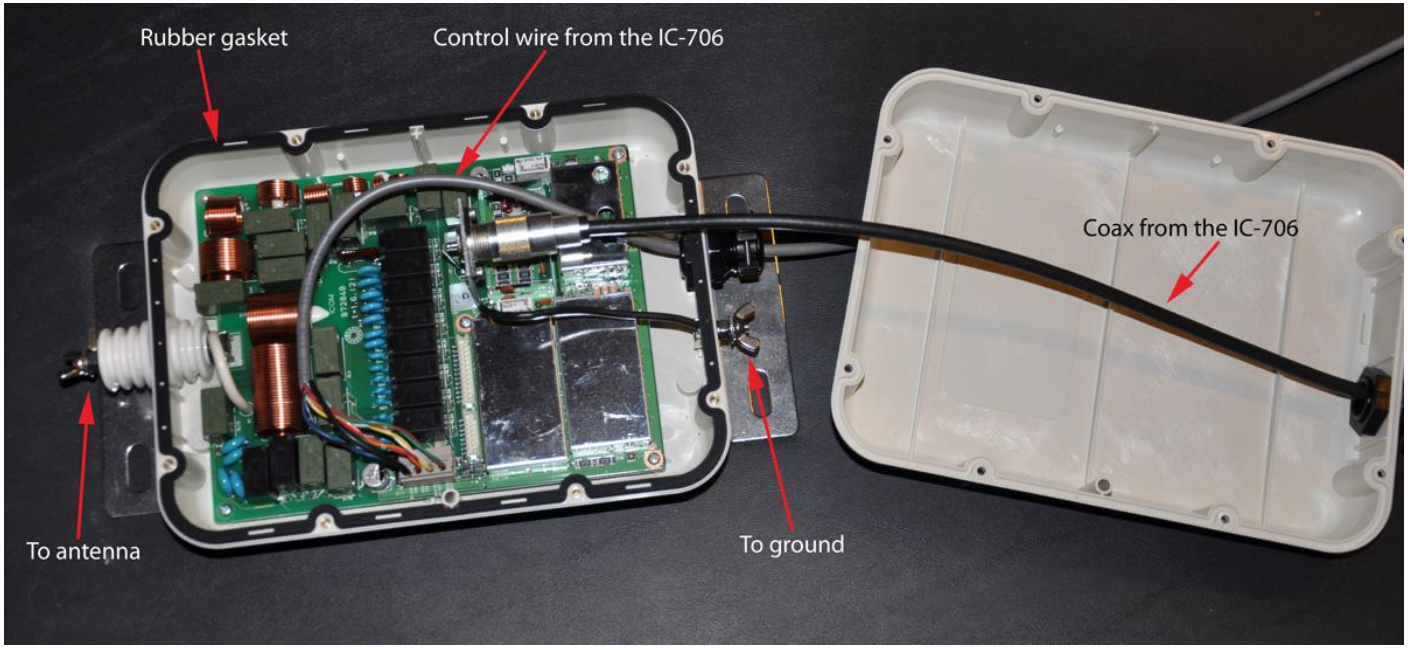
ICOM 710

ICOM 802

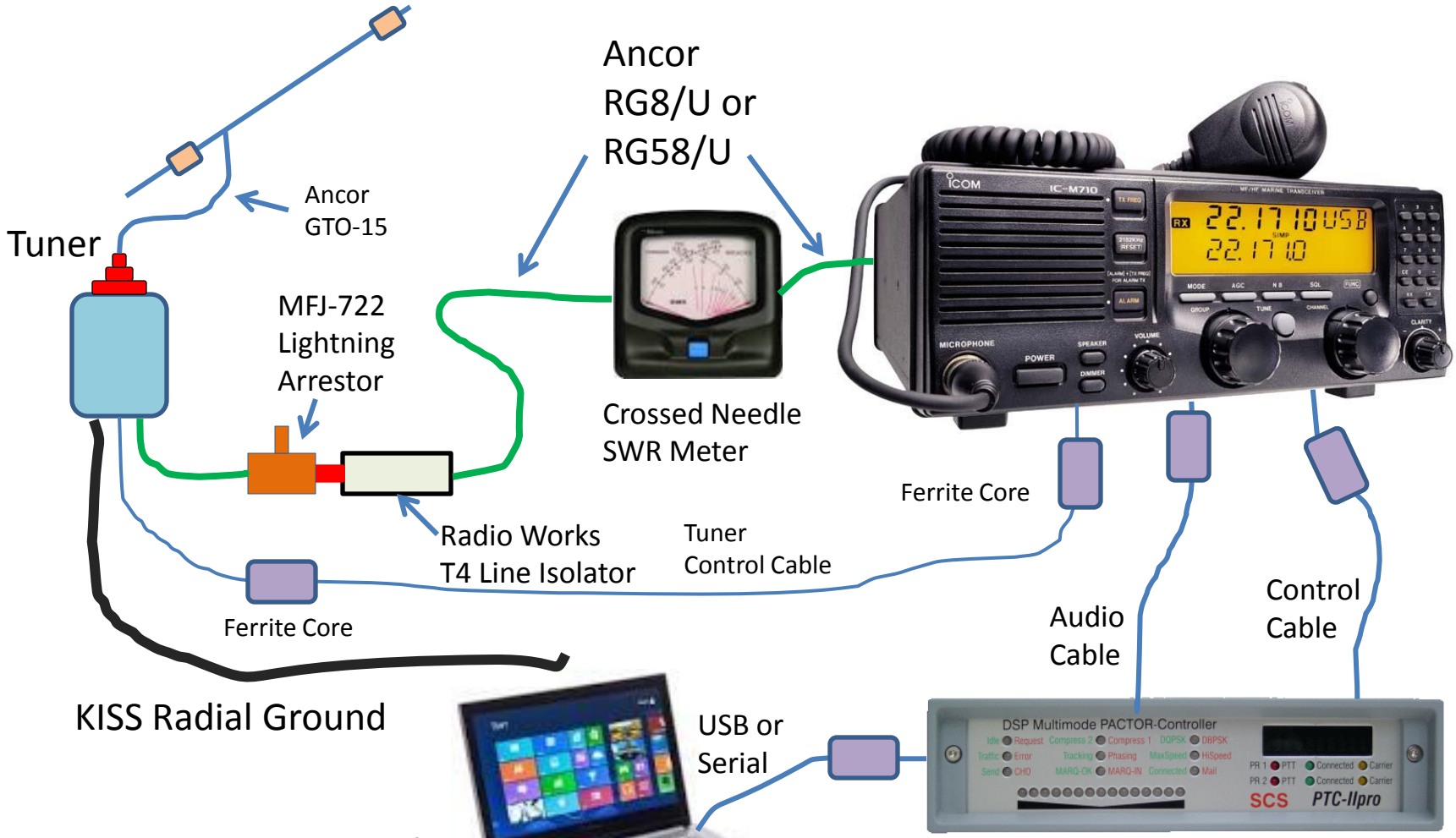
Antenna Tuner

The Automatic Antenna Tuner switches coils and capacitors in a network between the coax from the transceiver and the insulated backstay antenna to resonate it and to adjust the electrical impedance to be 50 ohms, maximizing power transfer and antenna efficiency.

It should be sited as close to the transom as practical, with a direct and, if possible, vertical lead to the antenna.



The Complete SSB System



PC running Airmail

http://siriuscyber.net/airmail/

Different Modem/SSB Models use different cables.
See Farallon Electronics at www.Farallon.us
Some SSB are direct to PC Serial Port for control.

Coax Cable

- Coax Cable is the "pipe" that is used to transfer RF energy from one place to another. Coaxial Cable has an inner wire strand surrounded by polyethylene insulator and an outer braided shield wire, all inside a tough insulating jacket. Due to the AC nature of RF, a balanced signal propagating in the coax does not (nominally) radiate radio waves outside the coax.
- A coax cable has a "characteristic impedance" which for this application will be 50 ohms. This number is an AC parameter, and relates the voltages and currents travelling in the coax at a point in space and time. It cannot be measured with an ohm-meter.
- An RF transmission line system MUST use appropriate connectors (UHF type for this application), properly attached to the cable. Random wires spliced onto a coax are a disaster, and can cause a system to behave poorly or not at all.
- Coax suitable for the Marine SSB includes RG8/U, RG58/U, RG213. I recommend that foam core RG8-X coax NOT be used, and NEVER use RG-59 (it is 75 ohm impedance). Ancor makes a very good line of coaxial cable for marine use, with tinned wires and a good jacket.

Coax Connectors

- There are a variety of connectors used to properly terminate and interconnect coaxial cables. Names of a few are: UHF, BNC, TNC, N, SMA, mini UHF. The standard for HF radio use is the venerable UHF connector. The male connector to be installed on a cable is designated as a PL259 connector.

There are screw-in adaptors to accommodate
Different coaxial cables:
Use only the shell and the center for RG8/U and RG213.
Use UG175 adaptor for RG-58 coax.
Use UG176 adaptor for RG-8X foam coax (not recommended)

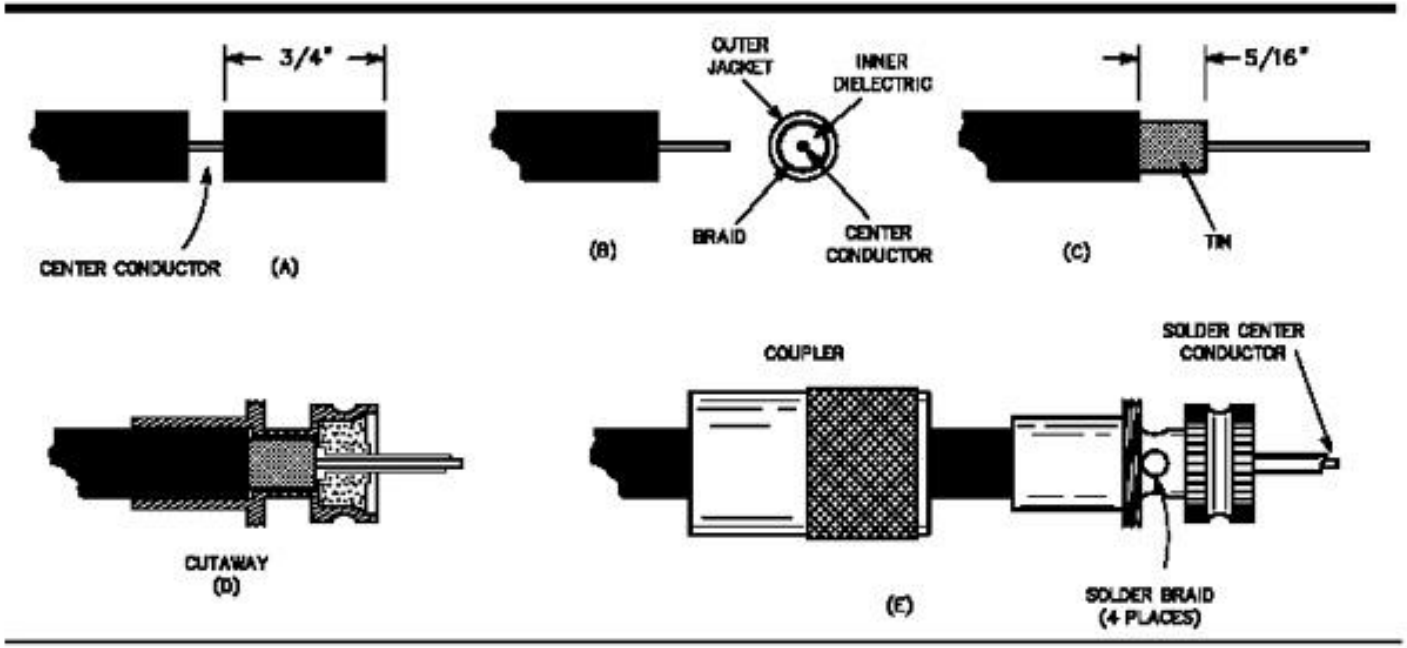
UG175

UG176

A good source of PL259 connectors and adaptors is Ham Radio Outlet.
Use gold or silver plated connectors with teflon insert such as # PL-259ST-HRO ($2.69).

Installing a PL259 Connector on RG-8 or RG-213

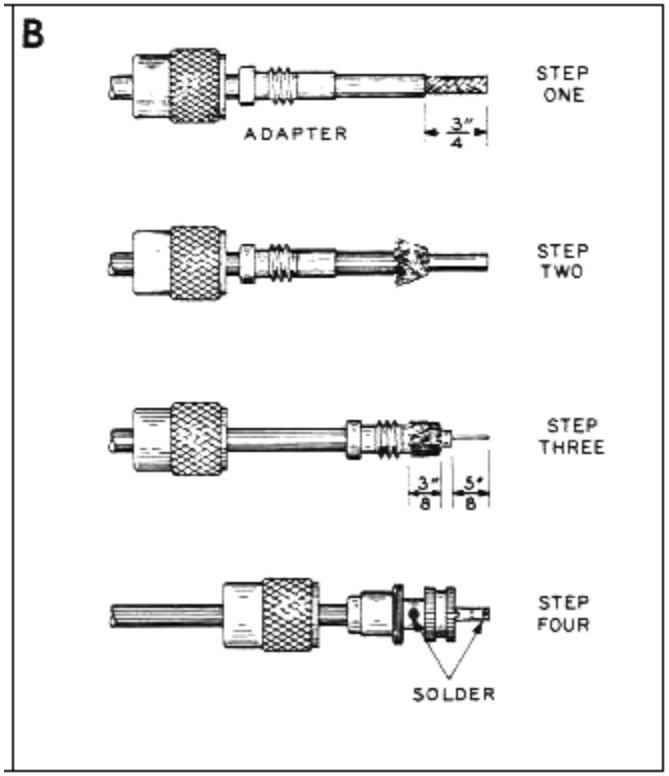
Before step D, tin the braid. Before soldering through the holes in step E, coat a small amount of radio solder flux on the braid and the hole walls.. Use a very hot, clean, tinned soldering iron to solder the braid in each of the holes to the shell. Do not move connector after soldering until cool. After the connector is cool, use Adhesive Lined Heat Shrink Tubing to seal the cable to the center part of the connector.

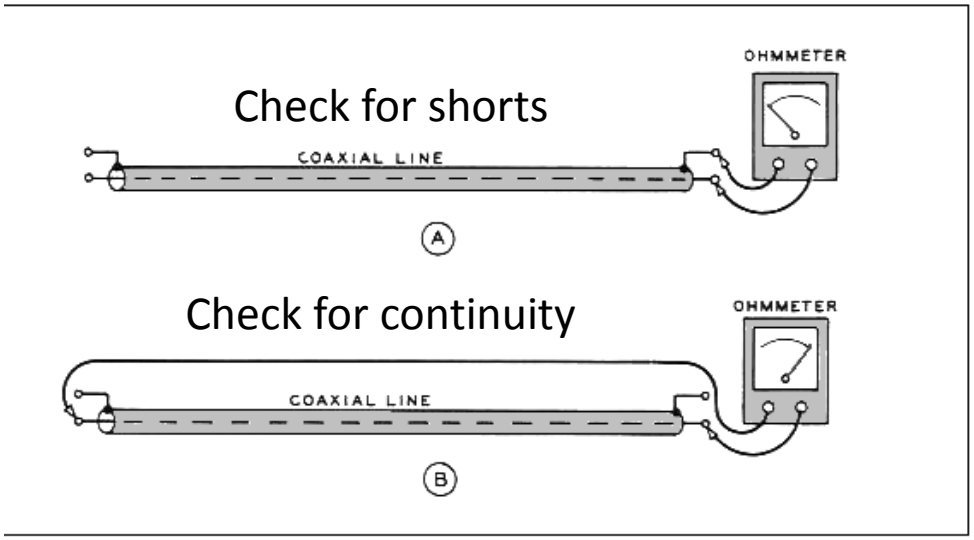


Heat Shrink

Installing a PL259 Connector on RG-58/U

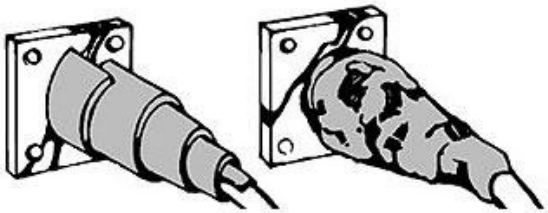
As before, in step 3 add a small amount of radio solder flux to the braid and the shell. Use a very hot, clean, tinned soldering iron to solder the braid to the shell through the holes and also the center pin. Do not move the assembly until cool! Use Adhesive Lined Heat Shrink Tubing to seal the coax to the connector. Check continuity of the assembled cable as shown below with an ohm-meter.



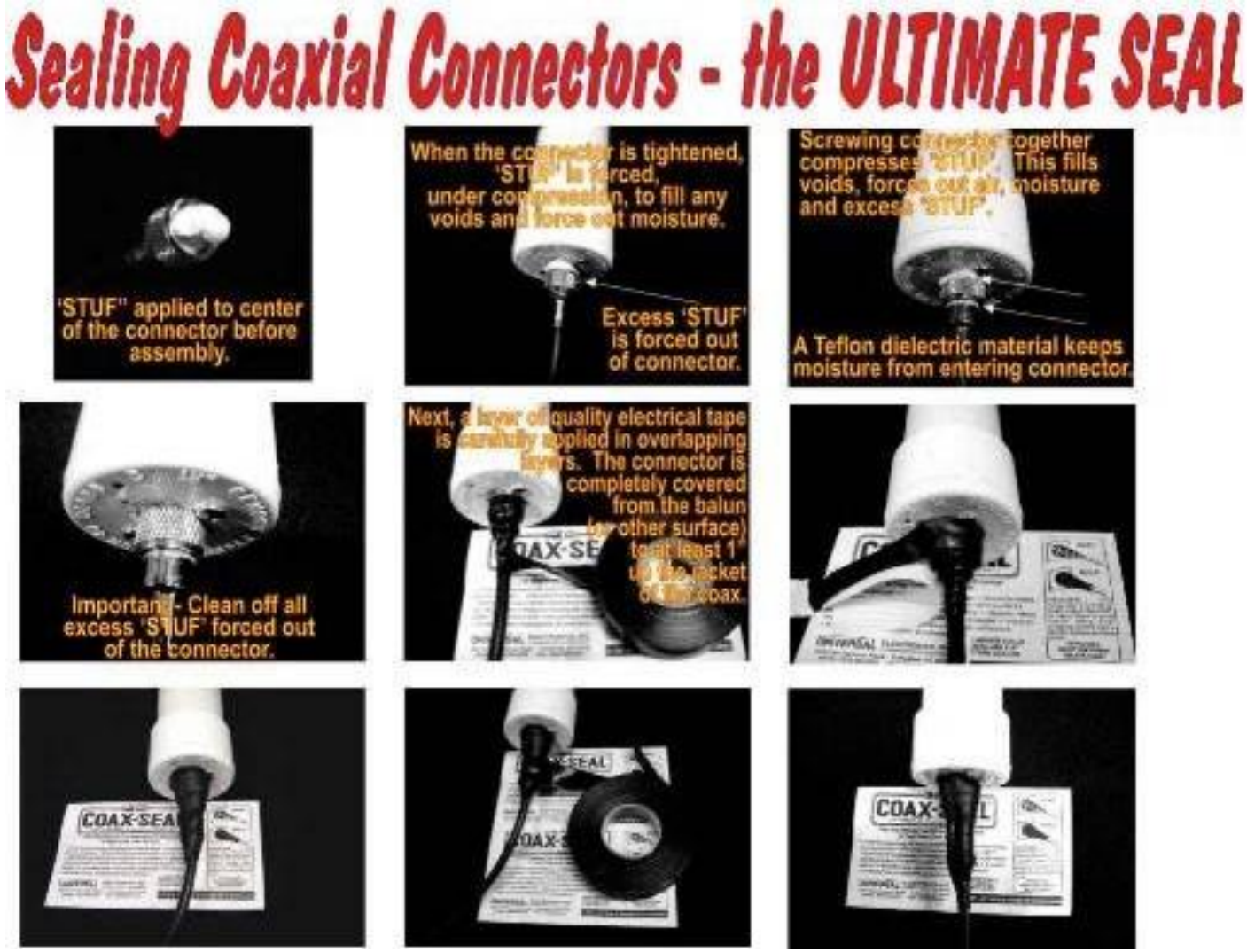


Waterproofing a Coax Connector

- Coax connectors in the wet parts of the boat must be sealed.
- Use “STUF” (Ham Radio Outlet, $11.95 /tube) to fill connector. Assemble connector to female fitting and wipe off excess STUF. Clean carefully.
- Wrap the connectors with a layer of electrical tape, and then a layer of clay-like Coax-Seal (HRO Universal Coax-Seal, $3.99). Mold to cover connectors. There should be nothing showing except metal outside the Coax Seal.
- Wrap assembly with self amalgamating rubber tape, overlapping remaining metal surfaces and work with fingers to make a smooth cover.



Waterproofing connectors- another look



From www.radioworks.com

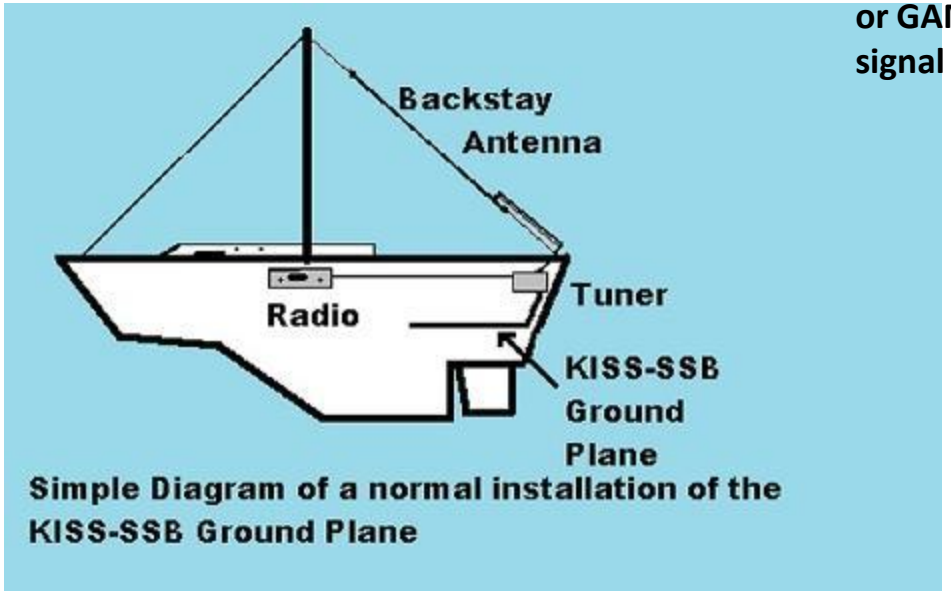
KISS Radial Ground System

- The part of an SSB system most people struggle with is the “ground” or “counterpoise”. This element primarily determines the ability of the SSB antenna to generate low radiation angle signals and for the tuner to provide a good match to the coax cable from the SSB. A bad ground system causes lots of RF in the boat, making the autopilot and other electronics go nuts.
- Rather than the masses of copper foil and arcane grounding schemes proposed in the past, the KISS Radial Ground system has been used to very good effect by racers in previous TransPacs. It is simple, easy to install, and relatively inexpensive. It should be tried first before adding lots of foil, etc, inside the boat. The current price is $189 from http://www.kiss-ssb.com/.

KISS Radial Ground System

It comprises of a four foot lead that attaches to the "ground / counterpoise lug" on your tuner and then you just stretch out the remaining 10 feet of 1" diameter tubing that encloses the array of specific lengths of radiating copper wires. It is just that simple, run it along the hull, behind a cushion, in the cabinets, in the lazarett, etc. If you can not run it straight it is just fine to make sweeping turns, even a sweeping U-Turn is OK. The perfectly measured lengths of copper and marine sealed coils act as an exact mirror image of your radiating backstay, whip, or GAM antenna, this is what bounces your radiated signal wave off your antenna.

From KISS website.



http://www.kiss-ssb.com/

Lightning Arrestor

- A Lightning Arrestor is a device which prevents high voltage pulses from nearby lightning strikes from blowing up your expensive SSB system. It is cheap insurance!! The MFJ-722 is a reasonable choice. There are many types available. Price is $35 at Ham Radio Outlet.

Install between tuner and line isolator. Male-Female connectors makes this easy. If a boat ground (keel, engine, thru-hulls, etc is available, connect the Ground terminal to that with a short piece of # 8 AWG wire.

Line Isolator

- A Line Isolator is an important component which prevents reflected power (indicating a mismatched antenna) from re-entering the coaxial cable to the SSB. This reflected power is primarily responsible for most of the troubles with autopilots and so on. The Isolator you need is the T4 model, sold by Radio Works (www.radioworks.com). $48.

SWR Meter

- An SWR Meter measures Transmitted and Reflected RF Power and also the Standing Wave Ratio, an excellent indicator of antenna and tuner proper operation. An SWR meter is an essential tool for insuring optimum performance and troubleshooting RF feedback and poor performance. The Crossed Needle SWR meter is probably the best for a boat. An SWR less than 2.0 to 1 is usually acceptable.

Palstar PM2000AM
$180
Has REMOTE Head

These are two suitable units I have used. Many more at Ham Radio outlet. Frequency range 1.8-30 MHz, Power to 300 Watts are minimum specs

MFJ-822
$60

Ham Radio Outlet (www.hamradio.com)
2210 Livingston Street, Oakland
(next to West Marine). Phone 510-534-5757

Ferrite Chokes

Ferrite Chokes are a hollow cylinder of a high permeability ferrite material which adds significant inductance to a wire or cable wrapped around it. They can be obtained in snap-on form, allowing easy installation on a pre-made cable. They make it energetically unfavorable for RF energy to travel down the installed cable or wire. They may be used on any wire or cable which conducts or receives spurious RF energy, such as PC interconnections, SSB control lines, or autopilot wiring.

MFJ-700B4 (at Ham Radio Outlet)
4 PACK FERRITE CHOKES FOR RG213 SIZE CABLE $13.95

Use the Proper Ferrites!

http://www.mouser.com/ProductDetail/Fair-Rite/0431164181/?qs=KmHvPbTOE4SbzMQqE%2fOkzw%3d%3d

Manufacturer:	Fair-Rite
Manufacturer Part #:	0431164181
Frequency Range:	Lower & Broadband Frequencies 1-300 MHz (31 material)
Description:	31 ROUND CABLE CORE ASSEMBLY

Taken from:SHTP_Communications_Paul_Elliott_2012.pdf

Odds and Ends, Bits and Pieces

UHF F-F
Adaptor

UHF M-M
Adaptor

UHF M-F
Right Angle
Adaptor

BNC Male-
UHF Female
Adaptor

Solder Flux Pen
Chemtronics CW8400 or similar
www.Digikey.com Part# CD8400-ND
$14.78
NO ACID FLUX!!!!

Multicore Electronic Solder
60/40 grade
www. Digikey.com #82-105-ND
$19.25

Adaptors at <u>HAM Radio Outlet</u>

Power Supply for SSB

- An SSB **DEMANDS** a clean source of "12 volt" power. The installation must be capable of supplying 30 amps as directly from the battery as possible, with minimal voltage drop. A voltage at the SSB of less than 12 volts will cause big problems, often commented on by others as "flutter".
- Use a heavy gauge wire for both conductors from the battery. AWG 8 is the lightest that should be used. Be sure to add a circuit breaker (40 amps is ok) at the battery end. There are often fuses in each leg of the wire to the power connector of the SSB supplied by the manufacturer. Leave these in place and carry spares.
- Extreme issues with RF in the boat may be helped by wiring several 0.1 uF ceramic disc capacitors (50 volt working voltage minimum) across the power connections as close to the radio as possible, and between the radio and any ferrite cores.
- Putting several snap-on ferrite beads on each power lead close to the SSB itself is a good idea to help prevent any issues with RF in the boat.
- An electrically noisy alternator can make it impossible to hear weak stations or run email traffic. It is wise to charge batteries just before running the SSB at check-in or when using email, and operate with the engine off. Keep an eye on the voltage.
- Run the SSB at reduced power level when feasible. ICOM 710 has three power levels. I find the 60 watt level (number 2- the middle one) works for most occasions. If you are having a hard time getting through, you can bump it up; it will just use more power.

SCS Pactor Modem

- A Pactor Modem is a device which takes a digital data stream generated by the Sailmail or Airmail program and converts it into a set of rapid phase, frequency, and amplitude shifted signals which can be transmitted by the SSB.
- The modem also controls transmission by using a handshaking error detection and correction protocol with the shore station to insure error free operation.
- Pactor modems are highly sophisticated, amazing devices. They are made by SCS, represented in the USA by Farallon Electronics, a local firm. http://www.farallon.us)
- Farallon Electronics will sell appropriate cable sets to interconnect almost any SSB with the modem and the computer. If you have an older modem, ask them about upgrading to at least Pactor III. It makes a big difference! This is a firmware upgrade done via the Airmail program with a purchased upgrade key.

PTC-IIIusb Pactor 3 Modem
$1,148.00

Sailmail/Airmail program

- Airmail and Sailmail are free programs which run under Windows. They are essentially identical, with modifications to allow use with the Winlink HAM email system or Sailmail, respectively. They are designed to both operate under the same icon, with a user choice of the HAM or SAILMAIL system.
- They operate like an email client (Outlook, Thunderbird, etc), with a mailbox, text editor, and so on, but they also interface with the Pactor Modem (SCS), and also Iridium and the web directly. They control the frequency of the SSB radio from drop down menus. This is essential for easy operation, and having an SSB that allows this control is really a must. Those SSBs described above do so.
- You download and install the programs from the Sailmail website (www.sailmail.com) and the Airmail website (http://siriuscyber.net/airmail/). Detailed instructions are given in the Sailmail Primer on that website. The programs must be configured for the type of controller, SSB, and the serial ports used to access them. There are baud rates, and a bunch of other fiddley parameters to set, but the Sailmail Primer does a good job of walking you through this.

Sources

- Ham Radio Outlet (www.hamradio.com), 2210 Livingston Street, OaklandPhone 510-534-5757
- Digikey (everything electronics related) www.digikey.com
- Newark Electronics (all electronics) www.newark.com
- Radio Works (Line Isolators, connectors, coax seal, etc) www.radioworks.com
- Frys Electronics (for the stuff you can't live without)
- Radio Shack (less and less about radio, but some useful stuff, like solder, etc)
- Ancor (excellent wire and cable for the marine world, Svendsen's has it) www.ancorproducts.com/en
- Blue Pelican Marine (a consignment store at Grand Marina- fabulous place for gear) http://www.bluepelicanmarine.com/
- Farallon Electronics (everything PACTOR, local) http://www.farallon.us/
- Sailmail (www.sailmail.com)
- Airmail (http://siriuscyber.net/airmail/)
- McMaster Carr (simply the BEAT source for hardware, good tools, metals, anuything really) www.mcmaster.com
- KISS Radial Ground System (http://www.kiss-ssb.com)
- FCC Marine SSB Licensing: http://wireless.fcc.gov/services/index.htm?job=licensing&id=ship_stations
- USCG Marine SSB Channels listing http://www.navcen.uscg.gov/doc/rtchan.txt
- EBAY!!! There are ICOM 710 SSBs for $600 presently offered, refurbished. Search term "ICOM SSB" http://www.ebay.com/itm/Icom-M710-HF-SSB-radio-refurbished-complete-with-all-accys-BEST-ON-EBAY-/321307170930?pt=US_Marine_Aircraft_Radios&hash=item4acf665872

Technical papers and resources

- SCS Pactor Modem cable reference: http://www.farallon.us/webstore/PTC%20modem%20cable%20ref.pdf
- Farallon Electronics Radio Installation Guide http://www.farallon.us/webstore/Pcup%20SSB.pdf
- Latitude 38 idiots Guide to SSB http://www.latitude38.com/features/SSB.html#.Ux-JWc7vh1M
- Brian Boschma on SSB http://sfbaysss.org/resource/doc/Brian-Boschma-SSB-Seminar-2010.pdf
- SHTP Communications by Paul Elliot http://sfbaysss.org/resource/doc/SHTP_Communications_Paul_Elliott_2012.pdf
- Gordon West on SSB Grounding (pre KISS system) http://sfbaysss.org/resource/doc/SeawaterGroundingFor_HF_Radios_byGordonWest.pdf
- ICOM America Download Database; a ton of manuals and information http://icomamerica.com/en/downloads/Default.aspx
- Eric Steinberg SSB SHTP Presentation http://sfbaysss.org/resource/doc/Eric_Steinberg_SSB.pdf
- Sailmail Primer in PDF form. This is the bible of SSB email and WxFAX. Lots of specific advice. http://www.sailmail.com/sailmail%20website.pdf
- Sailmail Website- a treasure trove of useful information and how-to-do it. http://www.sailmail.com/
- Winlink 2000 HAM email system (a free alternative to Sailmail for HAMs): http://www.winlink.org/
- Jim Corenman's Airmail web page: http://siriuscyber.net/airmail/

Final Thoughts

- A marine SSB adds a HUGE amount to any ocean passage. It allows you to have the warmth of human contact and to share your adventures in real time. It offers the potential for help in emergencies from other sailors, and advice for technical problems and the lovelorn. You can get weather information and send and receive email.
- The laws of physics, not good intentions, controls the outcome of any SSB installation. An installation is not rocket science, but it takes good components, time, care, and allows for **no shortcuts**. The skills needed, although not familiar to many, are not extreme and can be learned.
- Put an SWR meter in the system. Then you KNOW what is going on (or what ISN'T going on…).
- READ THE DAMN MANUALS AND PRACTICE BEFORE DEPARTURE!!! You will get better as the voyage progresses, but trying to fix the system or figure it out when seasick on day 2 is dumb. Use it before you depart!!!!!
- Ask questions from others who know more. They will be glad to help.
- Prepare frequencies of WX fax, broadcasts, schedules, etc.