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# ***Reference MANUAL***

## ***Antenna and Grounding Considerations***

# FOREWORD

## **The purpose of this document**

This document is a reference guide that describes the rudimentary know-how and considerations regarding the installation of both a long wire antenna (with an antenna tuner) and an automatic tuning antenna. The document is for a salesman or a technician who will be explaining about the antennas to a land mobile, marine, or amateur equipment user.

We would like you to understand the contents of this document, and hope it will help you when advising your customer.

A radio wave is generated in a transceiver, applied to an antenna through a coaxial cable, and then radiated from an antenna. Therefore, the communication range will differ, depending on the antenna performance. This theory is well known in the communication industry.

For typical antennas, there are directional antennas such as a Yagi antenna, and non-directional antennas such as a ground plane. Because an antenna has its own resonant frequency, these antennas can only be used over a limited frequency range. Therefore, multiple antennas are required to operate multiple frequency bands. However, it is difficult to install multiple antennas especially in the HF bands, on a vehicle or a vessel where installation space is limited, considering the size of the antenna.

A long wire antenna with an antenna tuner and an automatic tuning antenna solve these problems. These are excellent antennas that can cover all HF bands through one antenna element. But these antennas require some technical know-how to install them and get good performance.

This document describes such technical know-how.

In addition, there is a danger when installing the antenna tuner and element in a high place. Also, a high level of expertise is necessary to install a copper plate ground on the outside of a marine vessel hull. Entrust the installation to a professional installer when there is such danger, or when the installation requires a high level of expertise.

**DANGER!: HIGH VOLTAGE! NEVER transmit or start tuning while installing the antenna element/wire.**

## **Guide Revisions**

Icom reserves the right to make changes to the content of this guide at any time without notice or obligation.

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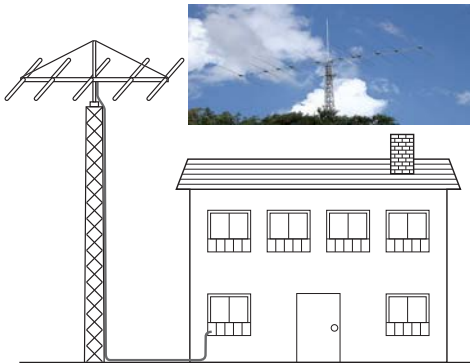
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## SECTION 1 SUITABLE ANTENNA AND ANTENNA TUNER

You can find a variety of antennas and antenna tuners to suit operating style and installation environment. This section describes a typical antenna and the antenna tuner to be used in each operating style.

### 1-1 Base station

#### ● Yagi antenna

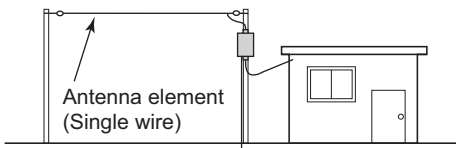


A directional antenna. This is very popular antenna in amateur radio operation. When the antenna impedance is mismatched to  $50 \Omega$ , an antenna tuner consisting of a T-type or  $\pi$ -type matching circuit is used.

In the Icom product line there is the AT-180 tuner. The same type of antenna tuner as the AT-180 is built into the IC-7600, IC-7700, and IC-7851.

NOTE: This document does not describe this type of antenna or tuner.

#### ● Long wire antenna

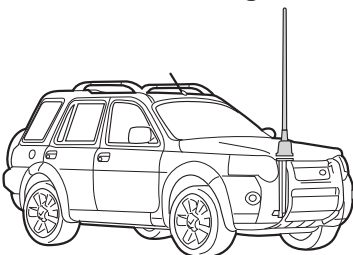


Covers a wide frequency range, and no special antenna tower or rotator are necessary. An antenna tuner is needed between the antenna element and the transceiver because the impedance of the antenna element is high. To tune the antenna, a combination of capacitors and coils inside the tuner are selected by relays.

In the Icom product line there are the AH-4 and the AT-140 tuners.

### 1-2 Mobile station

#### ● Automatic tuning antenna

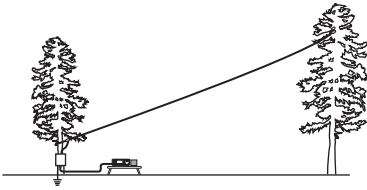


The whip type antenna element and antenna tuner are constructed as one unit. There are two types of auto tuning antennas. One tunes the antenna by using relays to select a combination of capacitors and coils, and the other one tunes the antenna by adjusting the electrical length of a coil.

In the Icom product line there are the AH-740 and the AH-760 antennas.

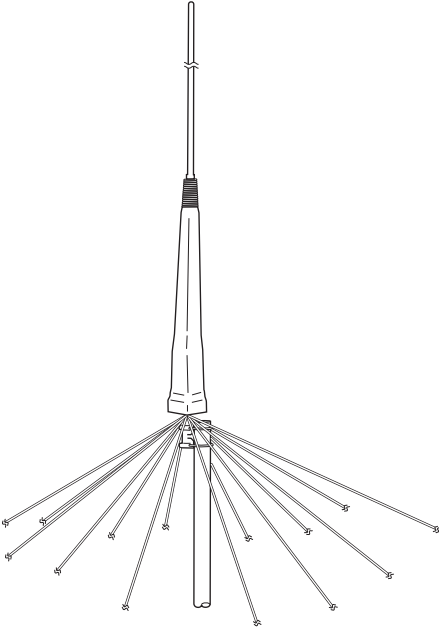
### 1-3 Field station

- Long wire antenna



A long wire antenna with an antenna tuner covers a wide frequency range from the HF low band through high band, and no special antenna tower or rotator are necessary. It can easily be used for field operations, because the antenna element is convenient to store and carry in a compact case.

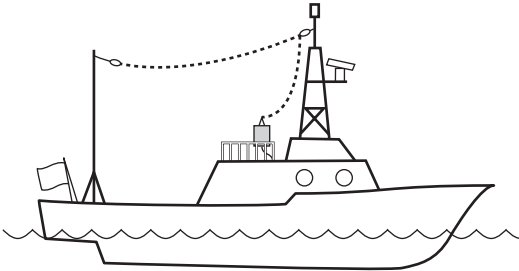
- Automatic tuning antenna



As described in 1-2 Mobile station, a whip type antenna element and antenna tuner are constructed as one unit. Because it is a temporary operation, you can use a counterpoise instead of regular grounding. In the Icom product line there are the AH-740 and AH-760 antennas. (The illustration to the left shows the AH-760.)

### 1-4 Vessel station

- Long wire antenna



A long wire antenna with an antenna tuner covers a wide frequency range. If the antenna element length meets several conditions, almost all MF/HF marine frequency bands\* are covered with one long wire.

\*Depending on the antenna element length, the antenna tuner may not tune correctly on some frequencies.

## SECTION 2 ANTENNA INSTALLATION

### 2-1 Note for antenna installation

The following four points should be noted for antenna installations.

- Installation location
- Antenna element length
- Grounding
- Effect on other equipment

Before going to the next pages, first read and understand the following rudimentary points of a long wire antenna and tuner, and an automatic tuning antenna.

Supplying radio frequency energy (RF signal) from a transceiver to an antenna, and supplying induced RF signal at the antenna to transceiver, is called "feeding." There are two feeding methods. One is current feed and another is voltage feed.

In general, the current feed method is mainly used because the feeding construction is simple.

Both the long wire antenna and tuner and the automatic tuning antenna described in this document, use the current feed method.

There is a correlation between the antenna element length and the operating frequency.

If you ignore the correlation, the communication range will significantly be less. Also ignoring the correlation can cause transmit audio distortion and/or damage the transceiver by the reflected signal. The reflected signal is the fed back RF signal component from the antenna, and occurs when the antenna is mismatched to the operating frequency. For reception, the target frequency signal will not be induced into the antenna element, so it will cause poor reception, or poor sensitivity. So, the antenna element length must be matched to the operating frequency.

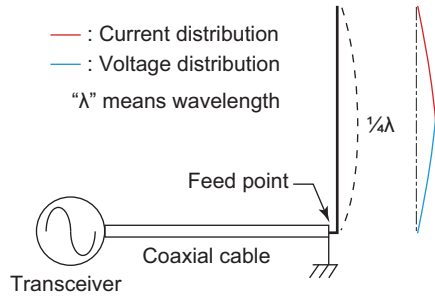
Even if you want to communicate with a particular station on the MF/HF band, the operating frequency will vary, depending on the time of day and the season. Because MF/HF bands communication uses ionospheric reflection, and the ionosphere status changes with the time of day and the season. Also, if the distance between the stations has changed, communication on the same frequency may become impossible. When communicating with a base station from the field, a vehicle, or a ship station, conditions vary greatly, so the antenna should be used in a wider frequency range is the point.

A long wire antenna with a tuner and an automatic tuning antenna can support these points. These antenna systems are called grounded antennas.

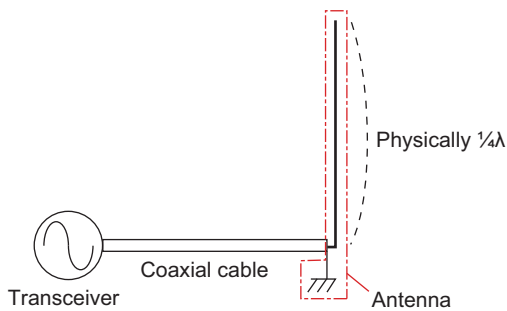
The grounded antenna element length is based on a quarter-wavelength. For example, the quarter-wavelength of the operating frequency 2.182 MHz is approximately 34 meters (approximately 112 feet), and 25.100 MHz is approximately 3 meters (approximately 9.8 feet). The actual installation of a quarter-wavelength length antenna element is physically difficult, in particular the lower the operating frequency is. To shorten the physical element length while maintaining a quarter-wavelength of the targeted operating frequency, you can insert a loading coil (inductance) on the antenna element.

The matching circuit in the antenna tuner electrically tunes to the best condition between the transceiver and the antenna element without changing the antenna element length. So, the antenna tuner functions as an adjustable loading coil, and is installed as a bottom loaded antenna.

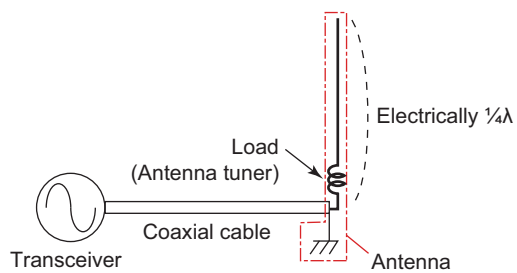
- Quarter-wavelength grounded antenna



- Full size quarter-wavelength grounded antenna



- Quarter-wavelength grounded antenna with a bottom loading coil



When using a long wire antenna, use as thick a wire as possible for the antenna element as the antenna performance is affected by the element thickness.

**Tip: About bottom loading**

A loading coil on the opposite end from the feed point is called top loading, in the middle of the element is called center loading, and near feed point is called bottom loading.

## 2-2 Antenna tuner location

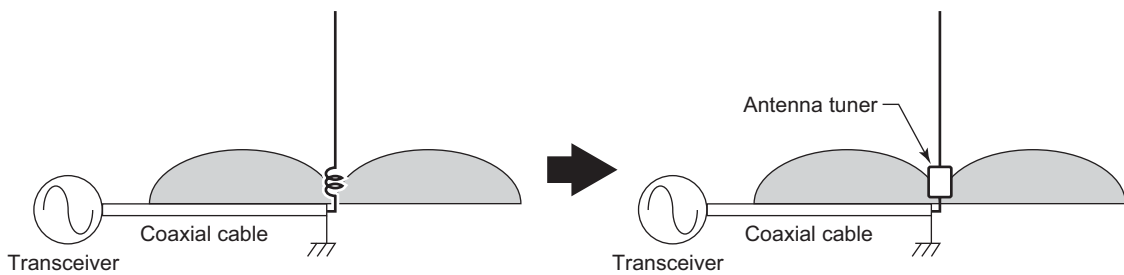
To efficiently transmit and receive RF signals, an antenna should be installed where it has a clear view with no obstructions. For a quarter-wavelength grounded antenna system, install the antenna tuner unit close to the feed point, so it tunes the transceiver and the antenna element, as described in 2-1. The antenna tuner unit functions as the bottom load of the antenna. In other word, the tuner unit is a part of the antenna that has maximum antenna performance, as shown in the figure (antenna characteristics) below.

All Icom's antenna tuners and automatic tuning antennas have weather-resistance construction.

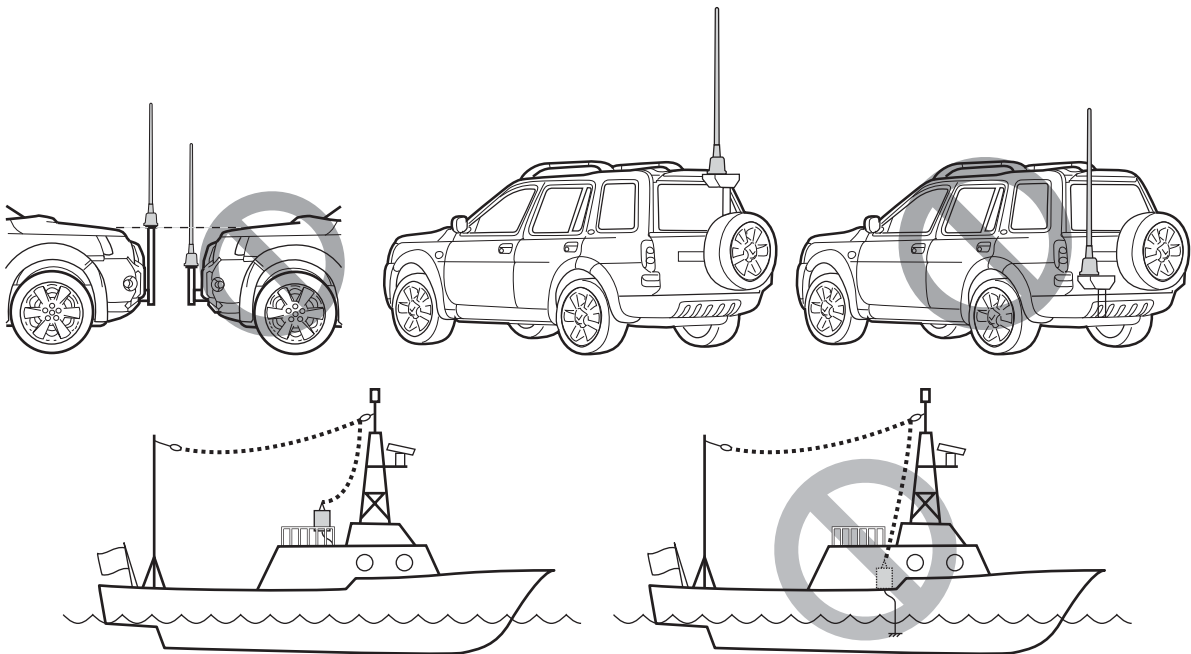
**NOTE:** Wrap the strain relief and connectors with rubber vulcanizing tape to prevent water intrusion, and then wrap electrical tape over the rubber vulcanizing tape to insure the waterproofing.

However, choose a practical installation location with consideration of the installation difficulty, the element style, and also the grounding, as described in SECTION 3.

- Antenna characteristics



- **Good and bad installation location**





### 2-3 About the antenna element length

The automatic tuning antenna specifies a usable antenna element as a whip or as NVIS. For long wire antenna operation, the desired length of the antenna element should be calculated according to the lowest operating frequency and installing location. However, the antenna element length must meet the required minimum element length, as described in the table below.

- AT-140/AT-141

The lowest operating frequency	Required Antenna element length
1.6 MHz band	At least 7 m (23 feet)
4 MHz band	At least 3 m (9.8 feet)

- AH-4

The lowest operating frequency	Required Antenna element length
3.5 MHz band	At least 7 m (9.8 feet)

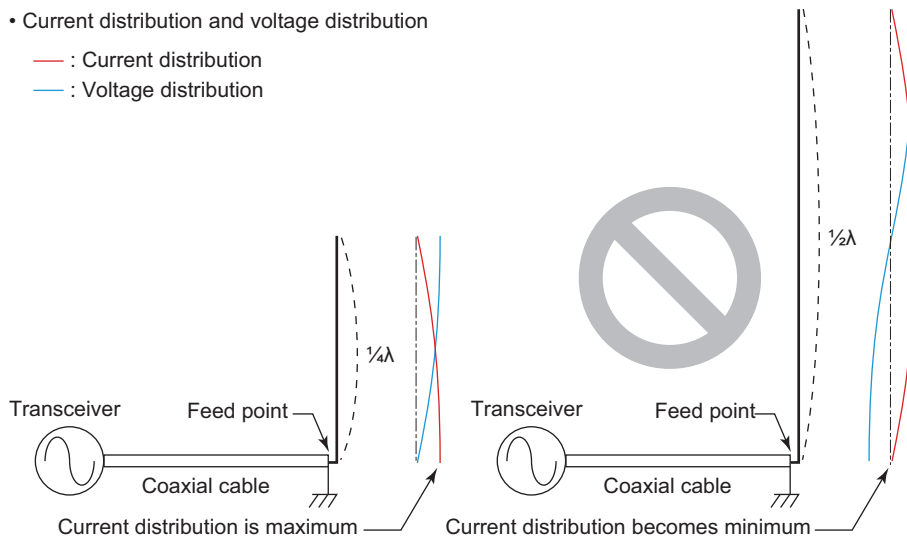
**IMPORTANT!: The antenna element length should not be a multiple of a half-wavelength.**

Because a long wire antenna is a type of grounded antenna, the antenna element length is based on a quarter-wavelength.

As described in 2-1, the antenna tuner employs the current feed method, so current distribution is maximum at the feed point. However, if the antenna element length is a multiple of a half-wave length, the current distribution at the feed point is minimum, so little RF is radiated from the antenna. In other words, the antenna will not function as an antenna.

- Current distribution and voltage distribution

— : Current distribution  
 — : Voltage distribution



The half-wavelength means half of the wavelength. The wavelength is calculated in the following formula.

$$\text{Wavelength [m]} = \text{Speed of light [m/sec.]} \div \text{Frequency [Hz]}$$

The speed of light is 300,000 km/sec. (=  $300 \times 10^6$  [m/sec.]). So, the half-wavelength is

$$\text{Half-wavelength [m]} = 300 \div \text{Frequency [MHz]} \times 1/2$$

[Example]: For 16 MHz band operation, the element length should not be:

$$\text{Element length} = 300 \div 16 \times 1/2 \times n = 9.4 \text{ m, } 18.8 \text{ m, } 28.2 \text{ m ...}$$

$n = 1, 2, 3...$

## 2-4 Distance between other antennas

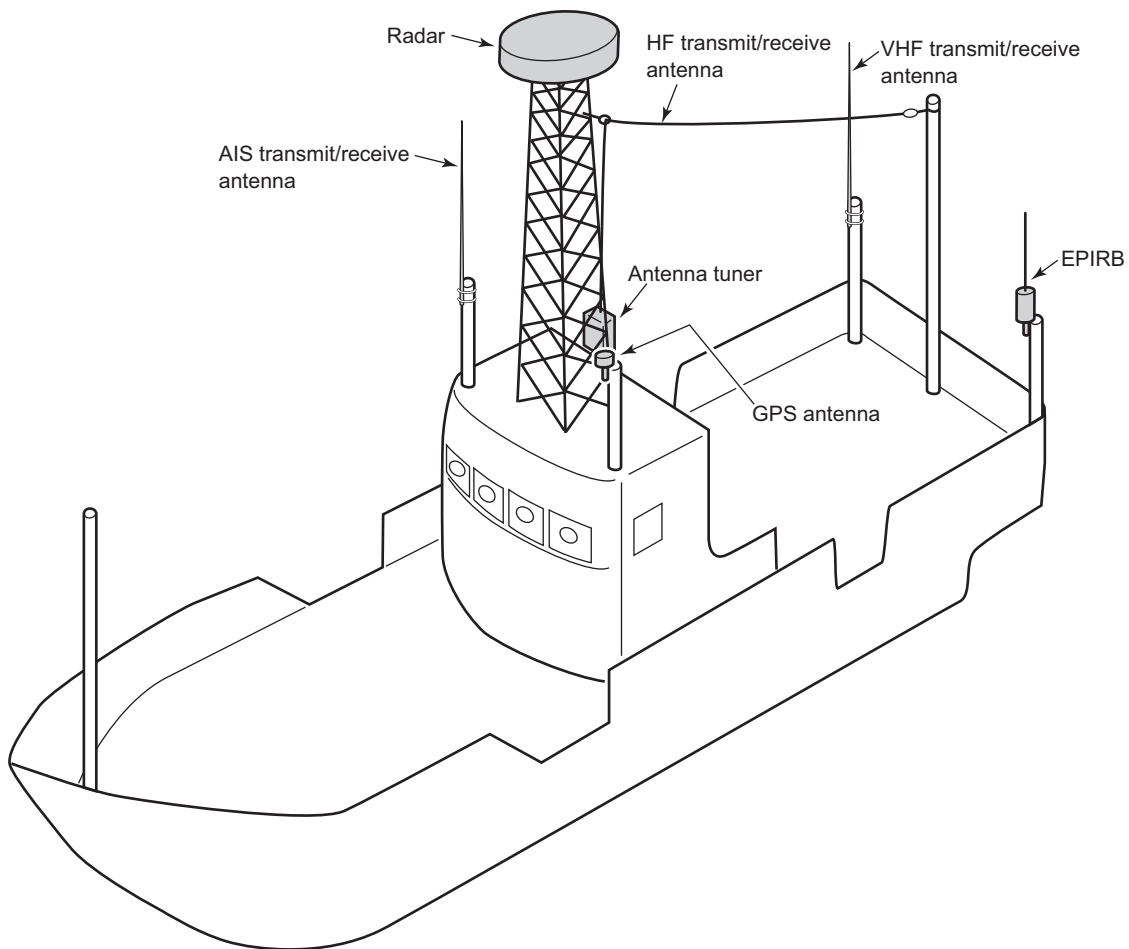
When installing several antennas, you should have no interference between the equipment that is connected to antennas.

Particularly in a vessel station, a variety of antennas such as those for radar, VHF marine transceivers, Automatic Identification Systems (AIS), Emergency Position Indicate Radio Beacons (EPIRB), and Global Positioning Systems (GPS) are installed, so each antenna should have enough distance between them.

Refer to other equipment instruction manuals, reference books, and web sites for details of the necessary distance.

If you do not have an enough distance in the horizontal direction, you may install antennas with vertical distance, but also consider the antenna directivity.

- **Installation image (example for a marine vessel)**



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## SECTION 3 ABOUT GROUNDING

### 3-1 The importance of grounding

A long wire antenna with a tuner and an automatic tuning antenna are grounded antennas, as described in SECTION 2. However, the grounding that is explained in this section is different from the grounding for regular electric appliances, such as a washing machine or a refrigerator. The grounding for regular electric appliances to prevent accidents or trouble such as an electrical shock, or noise interference. However, grounding for the grounded antenna system is RF ground, and the ground also functions as part of the antenna.

So, using a grounded antenna without proper grounding may cause following problems because it cannot be tuned properly.

[Example]

- The transmitted signal does not reach the target station
- The transmitted audio is distorted
- The transceiver is damaged
- Poor sensitivity.

And more...

Before installing a long wire antenna and tuner, or an automatic tuning antenna, read and understand about grounding and counterpoises, as described on the next pages.

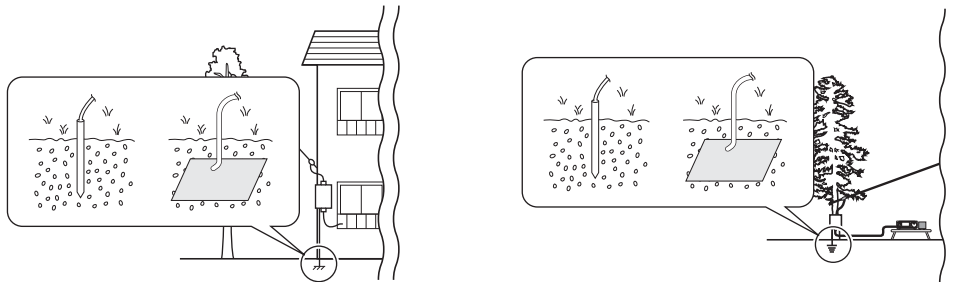
### 3-2 General grounding

The grounding method for grounded antennas is the same as the general grounding. See reference book and/or web site for grounding details not covered in this guide.

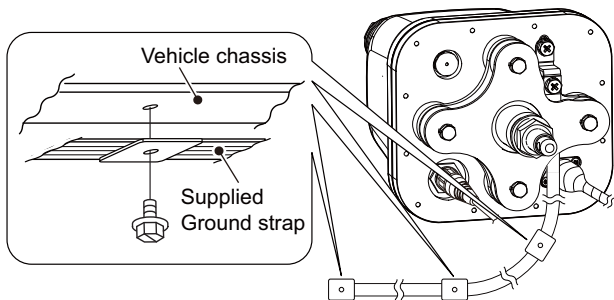
- **Base and field stations**

Use a grounding plate or grounding rod for grounding. Use 50 to 75 mm (2 to 3 inch) wide copper strap to connect the ground terminal and the grounding plate/rod. If you have difficulty of direct connecting the ground terminal and copper strap with copper strap, use thick and short copper wire between the terminal and the strap. Remove any rust or paint from the ground plate/rod, and then bury or drive it in the ground.

**DANGER!: NEVER connect the grounding wire or strap to a gas or water pipe.**



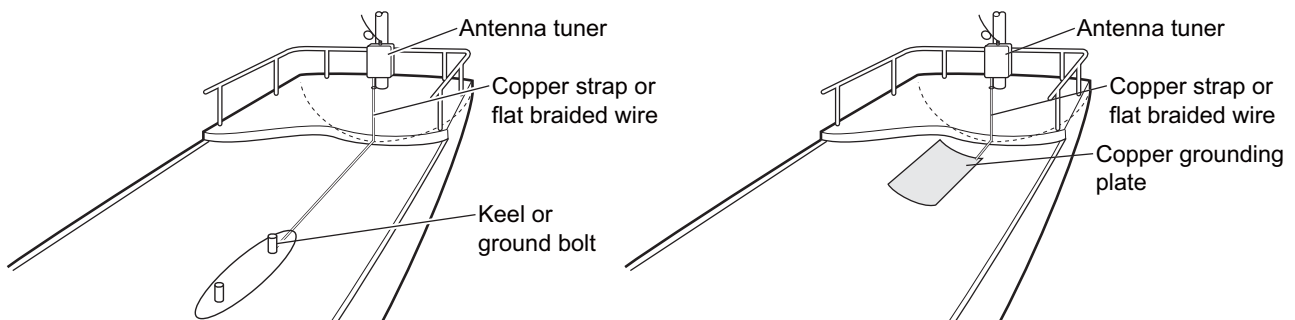
- **Vehicle grounding**



Ground to the vehicle chassis. Use a 50 to 75 mm (2 to 3 inch) wide copper strap or flat braided wire (supplied with AH-740, AH-760) for the connection between the tuner unit and the chassis. Remove any rust, paint, or oil at the points where the grounding strap or wire is attached to the chassis, and tighten all terminals on the flat braided wire. (the figure to the left shows the AH-740)

- **Vessel grounding**

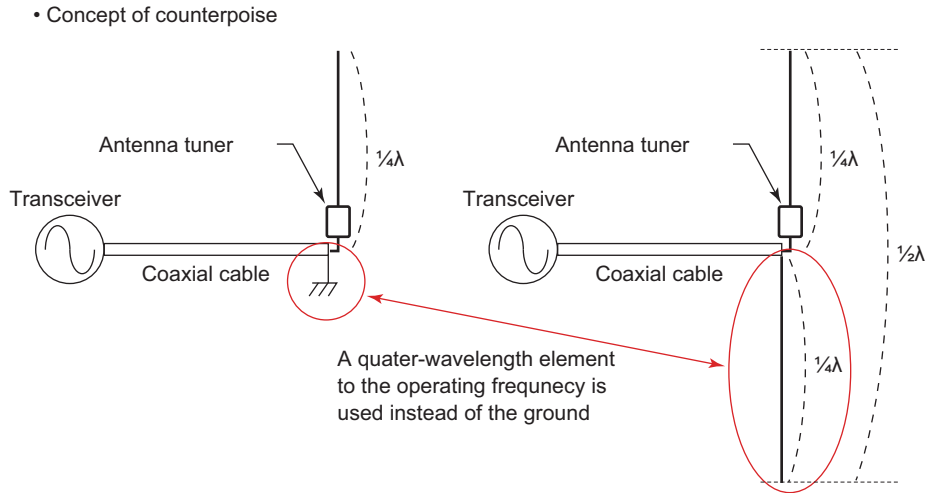
Ground to the vessel keel or ground bolt. If no keel or ground bolt is available in wood or fiberglass construction, install an external ground copper plate either inside or on the bottom of the hull. The ground copper plate should be at least 0.2 m<sup>2</sup> (2.15 ft<sup>2</sup>) and 0.5 mm (1/32 inch) thick. Use a 50 to 75 mm (2 to 3 inch) wide copper strap or flat braided wire to connect between the tuner unit and the chassis, and make the connection as short as possible.



### 3-3 About a counterpoise

When regular grounding is impossible because the grounding wire or strap is too long, or for a temporary station, a counterpoise can be used instead of regular grounding.

A quarter-wavelength element is used for the counterpoise by connecting the element to the tuner's ground terminal. In other words, use a quarter-wavelength grounded antenna as a half-wavelength dipole antenna.



A quarter-wavelength element is used for the counterpoise, so the element length can be calculated as follows.

$$\text{Element length [m]} = 300 \div \text{Frequency [MHz]} \times 1/4$$

The antenna element covers all frequency bands with only one element because the antenna tuner functions as a tunable bottom load of the quarter-wavelength grounded antenna. But a counterpoise element is only for a desired frequency band. So a number of counterpoise elements are necessary to cover all frequency bands that you operating on.

[Example]

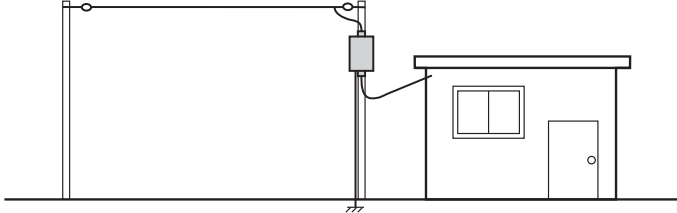
The counterpoise element lengths for the DSC distress frequencies on the MF/HF marine band are shown in the table below.

DSC frequency	Element length	DSC frequency	Element length
2.1875 MHz	34.3 m/112.5 ft	8.4145 MHz	8.9 m/29.2 ft
4.2075 MHz	17.8 m/58.5 ft	12.5770 MHz	6 m/19.6 ft
6.3120 MHz	11.9 m/39 ft	16.8045 MHz	4.5 m/14.6 ft

Refer to a reference book or website for more details of a counterpoise.

## SECTION 4 INSTALLATION EXAMPLE

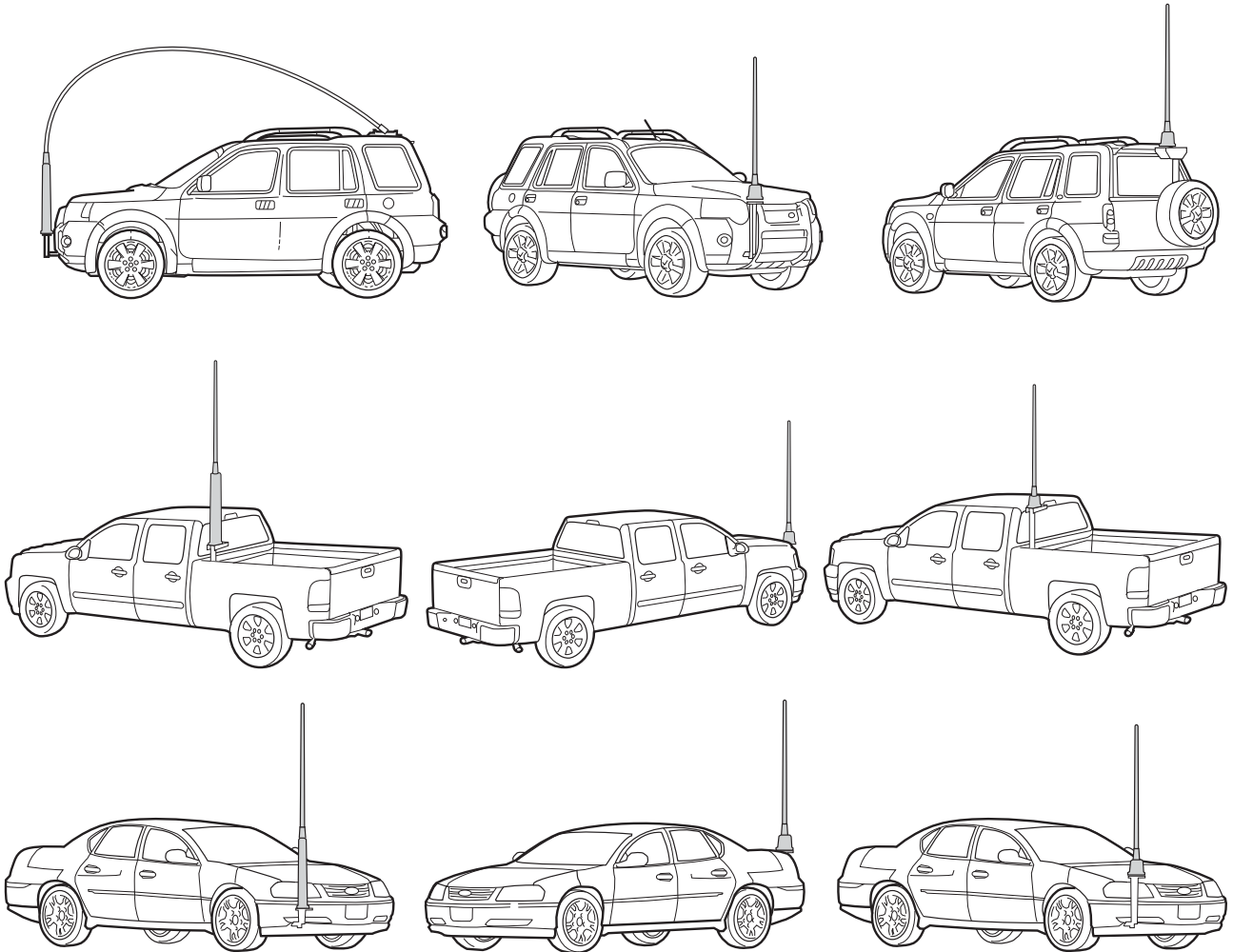
### 4-1 Base station



**[For your information]**

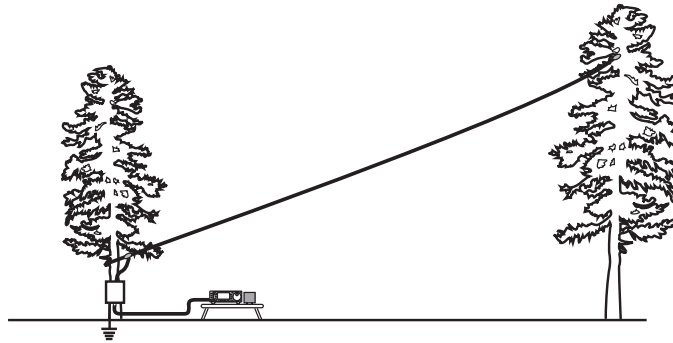
When the antenna tuner unit is installed on a metal mast, the mast can be used for the grounding. Also in this case, use a 50 to 75 mm (2 to 3 inch) wide copper strap or flat braided wire to connect between the tuner unit and the mast.

### 4-2 Vehicle station

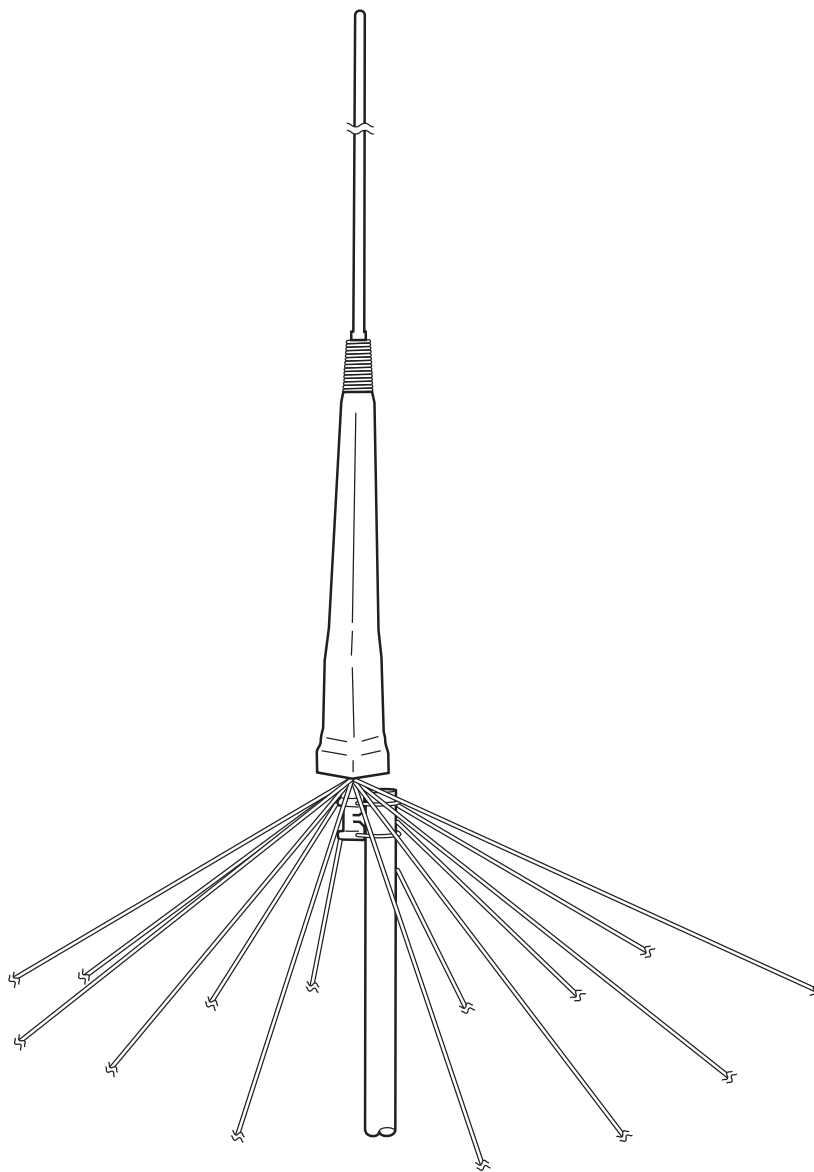


### 4-3 Field station

- Long wire



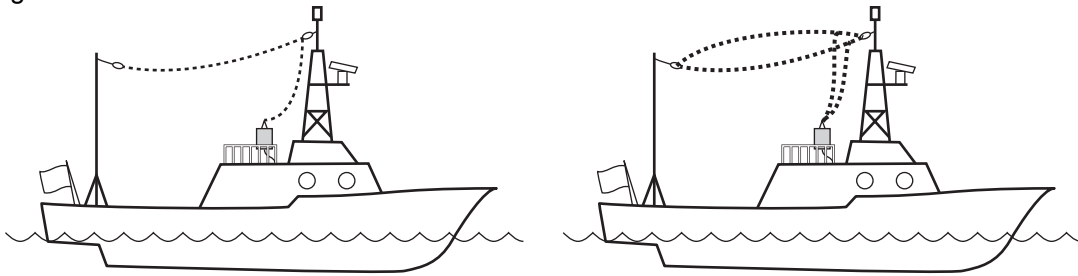
- Automatic tuning antenna (example of AH-760)



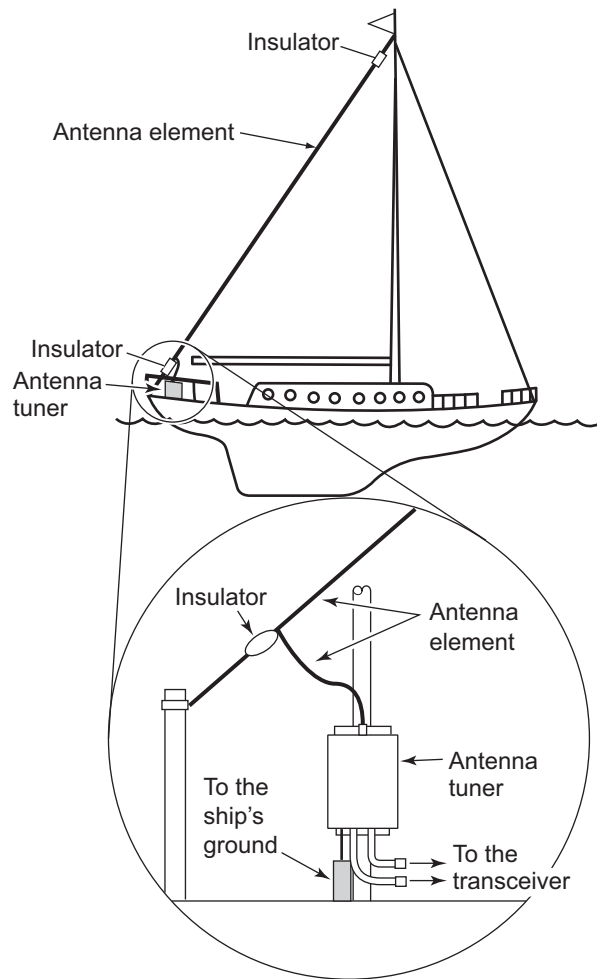
Example of a counterpoise

### 4-4 Vessel station

- Fishing boat



- Sail boat





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