Section 2 Principles of Radio Transmission

The marine radio is a source of information for many and a job for others. In an emergency at sea, a radio is a vital link for being rescued or obtaining assistance — for some it may be the difference between life and death.

In this introductory course, we want to outline to you the various aspects of radio communication which will make you more confident in using common marine radios.

Principles of radio transmission

In 1888 Heinrich Hertz designed an experiment to see if he could send a message through thin air.

Hertz demonstrated that if the sub atomic particles in the generator called electrons could be made to accelerate rapidly, radio waves would be made. In his first experiments these electrons were accelerated to 50,000,000 cycles per second. This was known as the frequency of the transmitter.

In honour of Hertz scientists named the unit of **frequency** after him instead of using "cycles per second", and we now abbreviate the frequency as Hz.

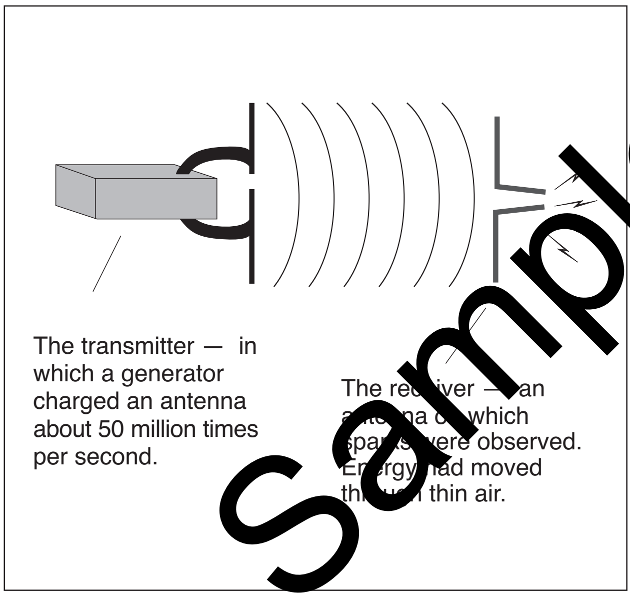


Figure 5.1 The Hertz experiment

We now know that it is possible to generate radio waves of many different frequencies over the radio spectrum.

One megahertz (MHz) is a higher frequency than one kilohertz, which in turn is a higher frequency than one hertz.

The different frequencies and their abbreviated terms are shown in Figure 5.2.

1 kilohertz = 1000 Hertz

1 Megahertz = 1000 kilohertz

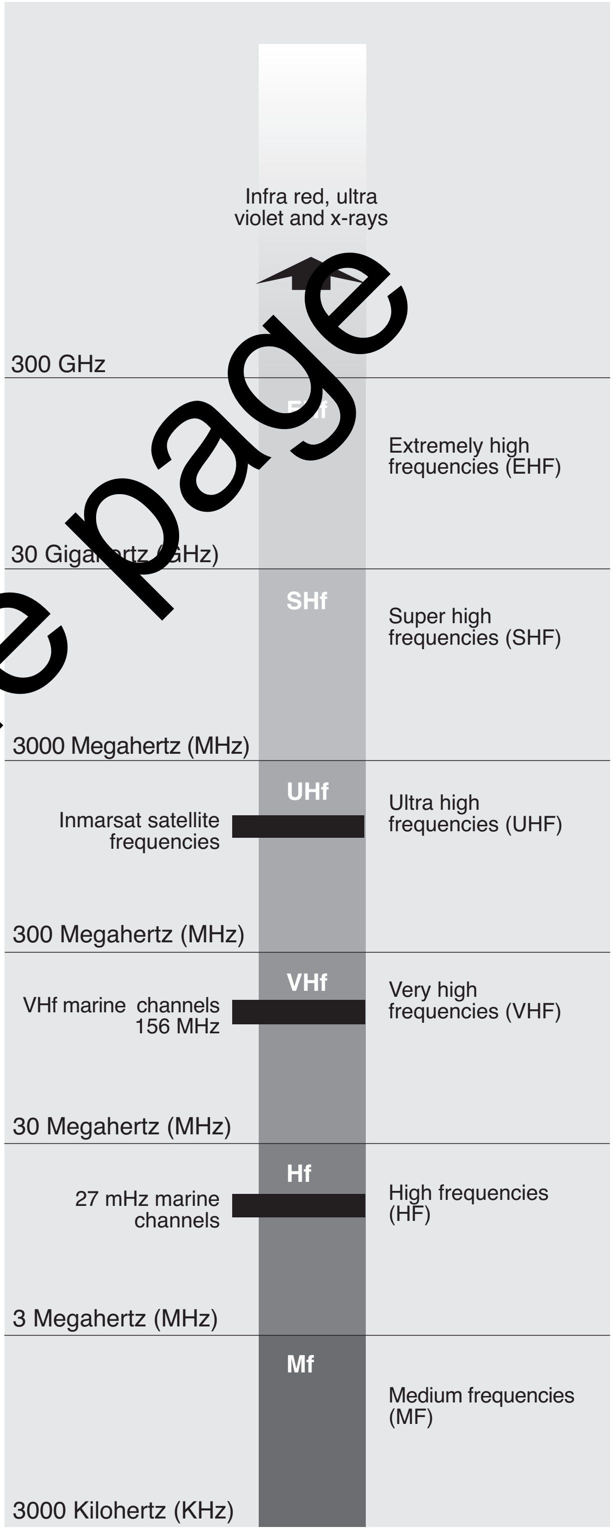


Figure 5.2 Part of the radio spectrum

Line of sight transmission

When a radio wave is sent from a base station on land, the wave travels through the air and is absorbed by the antenna of a receiver on the vessel at sea. Here it produces a small current which can be converted into voice signals and reproduced in a loud speaker.

Figure 6.1 summarises this process.

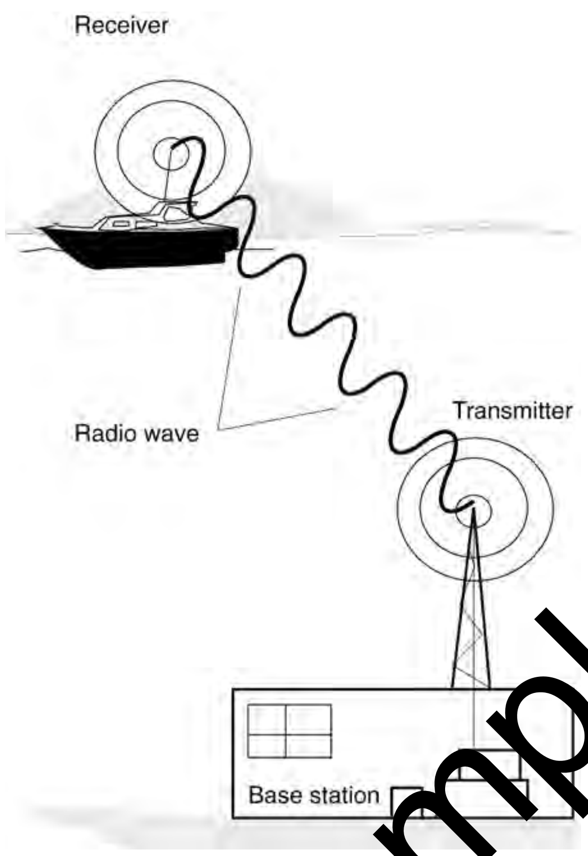


Figure 6.1 Principles of radio transmission

A **radio wave** is like a wave in the ocean. It has a top (the crest) and bottom (the trough) a height called the amplitude and a length as shown in Figure 6.2.

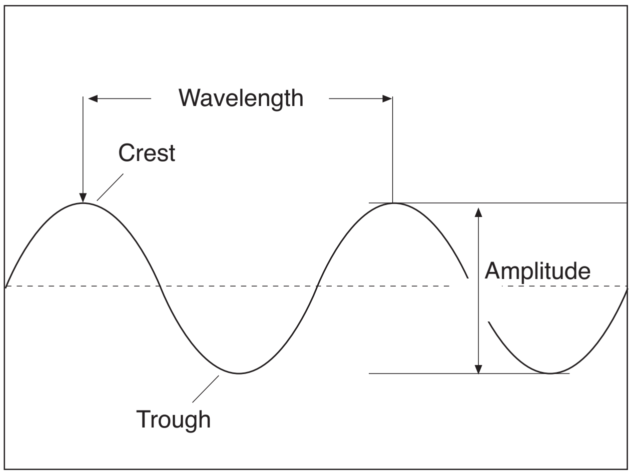


Figure 6.2 Wave characteristics

A radio wave is usually called a **carrier wave** (Figure 6.3) since it carries the information to produce the sound for the radio. You could turn the radio transmitter on and off in accordance with a recognised code, such as Morse code, and be able to convey information from the transmitter to a receiver. Today radiotelephony has replaced Morse code which is now seldom used.

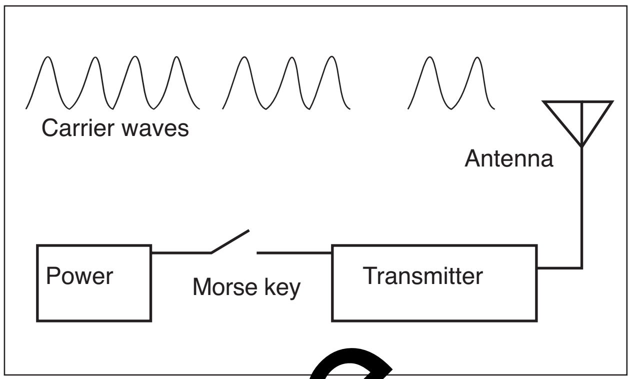


Figure 6.3 A diagram to show interrupted carrier waves

Because Morse code is difficult to learn, information exchange by radio between small vessels is usually conducted by radiotelephony (voice signals by radio). To be able to transmit voice signals by radio it is necessary to alter the carrier wave in synchronisation with the speech information to be transmitted. This is known as **modulation**.

Carrier waves may be modulated to carry speech information by altering the size (amplitude) of the wave. This is known as **amplitude modulation (AM).**

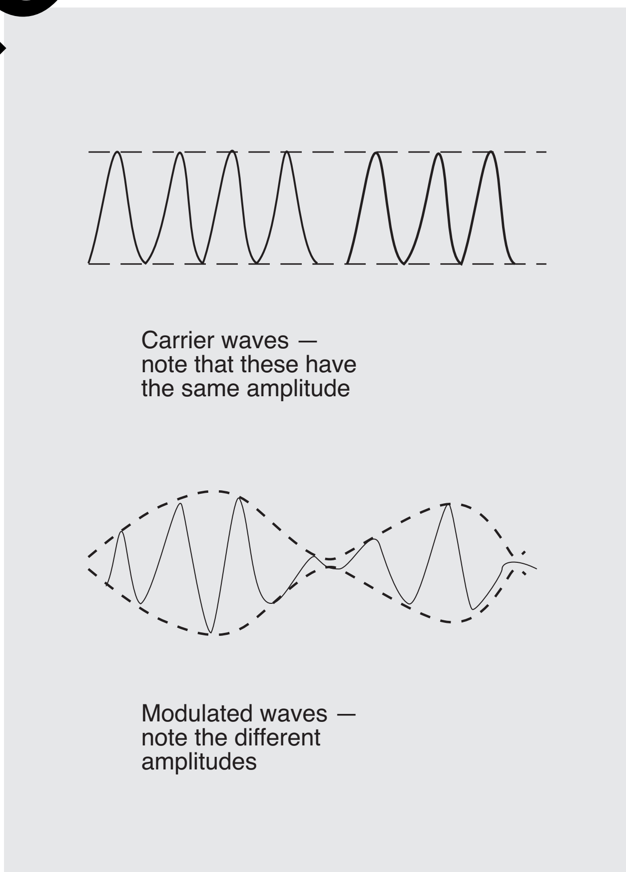


Figure 6.4 A block diagram of an AM speech transmission

Carrier waves may also be modulated by small alternations of their frequency (cycles per second or hertz). This is known as **frequency modulation (Figure 7.1).**

Both forms of modulation are used in marine radio communication.

Some marine radio equipment is also capable of a slightly different form of amplitude modulation known as single sideband (SSB). It is sufficient to understand that use of single sideband allows both the transmitter and the receiver to operate in a more efficient manner and will often improve the chances of successful communications under poor conditions or at extremes of range.

FM Frequency modulation - note that these have the same amplitude but different wave length.

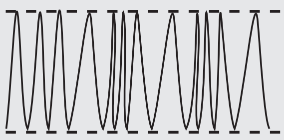


Figure 7.1 FM modulation

How radio energy travels through space

The theory of propagation, or how radio energy travels through space, is a complex and difficult subject. However, to appreciate and understand the capabilities and limitations of your marine radio transceiver, a basic understanding is necessary.

When the radio frequency energy is radiated from the antenna of marine radio equipment it can travel through space in two differing ways — ground waves and sky waves.

Sky waves

Sky wave energy travels upwards at a wide range of angles until it meets the **ionosphere**, which is that part of the earth's atmosphere that lies between 80 and 350 kilometres above the earth's surface.

As the radio frequency energy meets these ionised layers, some of it is bent or reflected back to the earth's surface. Sky waves travel much further than ground waves before they lose their energy and make it possible to communicate over very long distances.

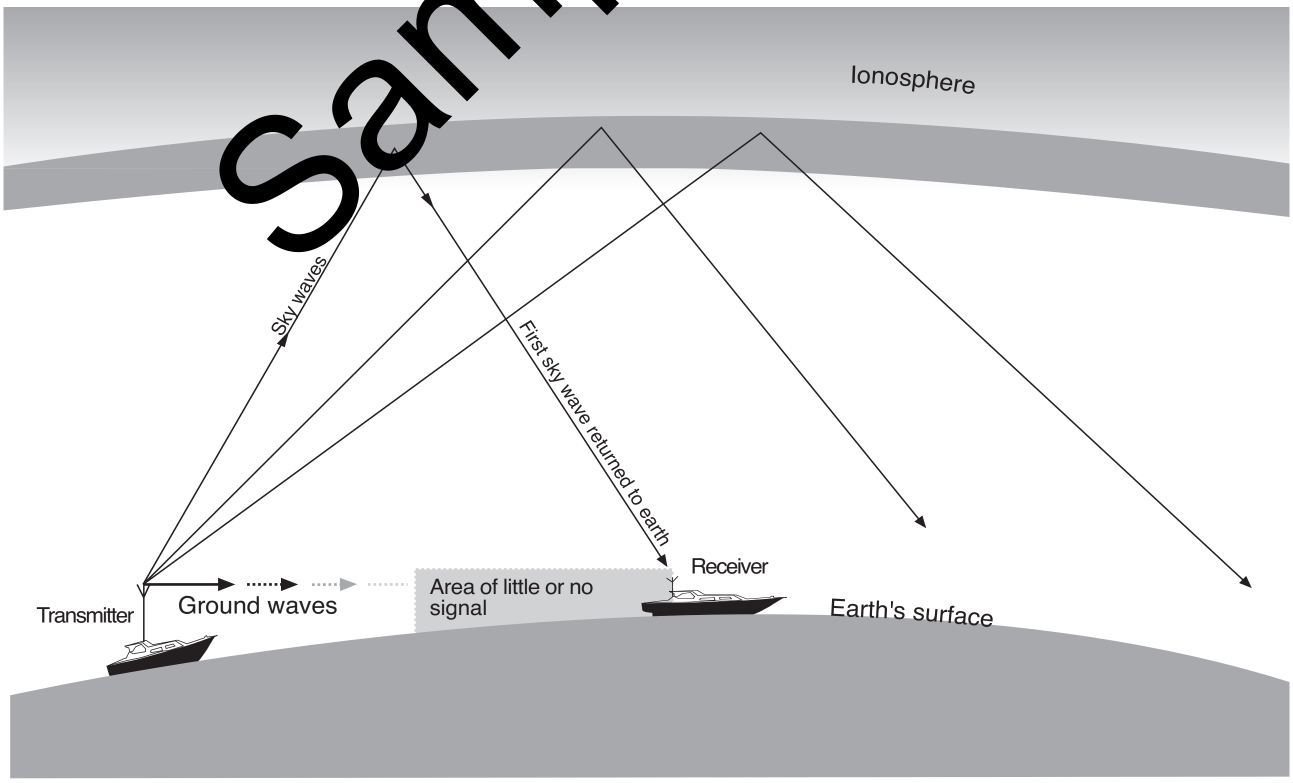


Figure 7.2 Propagation of sky waves

There are many variables which affect sky wave propagation. The time of the day or night, the seasons and sunspot activity all substantially affect the way the sky wave energy will behave. Consequently, we need to have available different channels or frequencies to suit the differing conditions and the range of communications desired. Reliable use can be made of both the ground and sky wave energy components permitting communications both at short range and over many thousands of kilometres.

Ground waves

Ground waves travel over the Earth's surface from the transmitter to the receiver.

They use up their energy quickly, particularly when travelling over large land masses, and are therefore effective for short range communications only.

Ground waves can be blocked by islands or headlands as shown by Figure 8.1

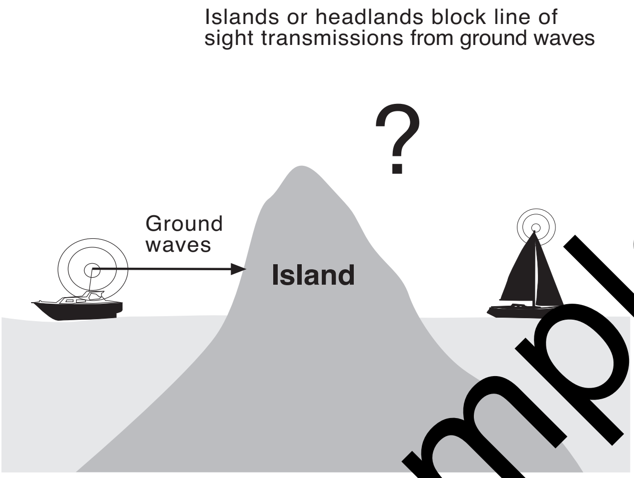


Figure 8.1 Ground waves can be affected by islands

Propagation at 27 MHz

For the majority of time, the 27 MHz sky wave is not reflected back to earth. Only ground wave communications are possible resulting in similar ranges to VHF.

However under certain atmospheric conditions the ionosphere will bend back the 27 MHz sky wave permitting communications over hundreds or thousands of kilometres (popularly referred to as 'skip').

However ground wave communications form the only reliable method of communicating frequency.

Propagation at VHF

There is no reflection of VHF radio energy from the ionosphere. Consequently, VHF communications is by ground wave only and is effective for short ranges only. As a general rule, VHF communications are 'radio line of sight' which is slightly further than visual 'line of sight'.

Propagation at MF and HF

At medium and high frequencies, reliable use can be made of ground and sky wave energy components, allowing communications over short and long ranges. MF/HF marine radio equipment will always offer the operator a selection of frequencies in different bands.

For example 2182 kHz in the 2 MHz band, 4125 kHz in the 4 MHz band, 6215 kHz in the 6 MHz band etc.

This allows the operator to select a frequency which will be suitable both for the distance over which communications are required, and the time of day and season.

One rule for frequency selection is to use the lower frequencies when close to the required station and the higher frequencies when further away.

At night, a frequency lower than that necessary during the day is more likely to be effective.

The Australian Communications Authority recommends as a very approximate guide, the use of 2 MHz band frequencies for communicating with stations within 100 km (55 nautical miles) day or night.

Teacher demonstration – let's look at sound

Figure 9.1 Ask your Physics teacher to help you set this up

Aim

To use a cathode ray oscilloscope (CRO) to investigate the radio waves

Apparatus

- small microphone
- audio amplifier
- audio oscillator
- power supply
- flute or other similar musical instrument
- cathode ray oscilloscope (CRO)
- Note: Most Science departments will have a cathode ray oscilloscope. The cathode ray oscilloscope will show the wave patterns produced by the electrical signals coming from the microphone.

Method

1. Set up the cathode ray oscilloscope according to the instructions supplied by the manufacturer.
2. When a fine continuous trace is seen on the screen set the V/cm knob to 0.[illegible] and the T/cm knob to 1ms.
3. Switch on the audio oscillator and the audio amplifier.
4. Set the audio oscillator on its lowest frequency and slowly increase the frequency. Observe the wave patterns. What happens to the number of waves seen on the screen as the frequency increases? Record the lowest frequency detected by the students in your class. Record the highest frequency detected by members of the class. Could the students detect a greater range of frequencies than the teacher?
5. Increase the loudness of the sound using the audio amplifier. How do the wave patterns change?
6. Use a flute or similar musical instrument to play a note into the microphone. Notice the wave pattern produced on the screen.
7. Have a student recite a nursery rhyme into the microphone. Notice the shape of the waves produced.

Questions

1. What frequencies can the human ear detect?

2. How can forensic science identify a suspect by their voice?

3. Discuss the wave pattern of sound on the cathode ray oscilloscope.

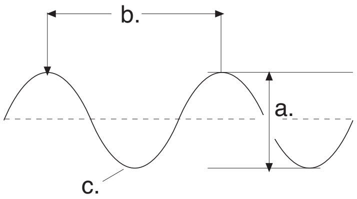
Worksheet 1 Principles of transmission

Answer the following questions

1. Describe the principles of radio transmission as discovered by Hertz in 1888.

2. What is a carrier wave?

3. Write the names of the parts of a radio wave identified a – c in the diagram of the radio wave below



a.

b.

c.

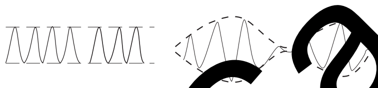
4. Define the following terms:
   a. modulation

   b. skip

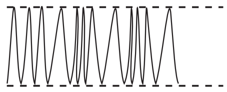
   c. radiotelephony

5. Outline the 'theory of propagation'.

6. Name the type of modulation shown below.



Modulation A



Modulation B

7. Explain why 'sky waves' travel further than 'ground waves'.

8. How might 'skip' be a problem when using a marine radio?