Chapter 1 Objectives

At the conclusion of this chapter, the reader will be able to…

- Explain the difference between systems and subsystems.
- Describe the functional blocks in a practical radio communications system.
- Calculate the *wavelength* of a radio wave and relate it to physical antenna length.
- Define *modulation* and explain why it is needed in a radio communications system.
- List the three steps for *troubleshooting* systems.

1-1 Communication Systems

Today, every facet of our lives is touched by modern electronics. Being human, we take most of it for granted. It's easy to forget that for the largest part of recorded history, mankind has lived with no telephones, radios, televisions, or computers. Before the development of electronic communications, the speed of information travel was limited by the physical distance a runner or horseman could cover in a day. During the colonization of America, it was accepted that a letter might take several months to reach its destination across the ocean, and several more months for the reply to make the trip back. Today, the distance across the globe is measured in fractions of a second.

Electronic Communications is Everywhere!

Have you recently:

Watched a TV broadcast or listened to the radio? These are probably the most visible applications of communications technology. Analog television uses very sophisticated electronic techniques. The latest television technology, high-definition television (HDTV), uses complex digital and software technology together with advanced analog circuit techniques. These techniques are readily understood by anyone with a firm grasp of electronic fundamentals.

Used a telephone? Your voice may be sent using many different technologies. Analog transmission carries your conversation to the central office. From there, the signal is converted to digital (digitized). The digital signal is sent (along with thousands of other calls) on a beam of light through fiber-optic cables. The process is reversed at the destination. During the process, your conversation may also travel by radio wave to and from a satellite. Cellular telephones transmit and receive voice signals as streams of digital data over UHF (ultra high frequency) radio-frequency carrier signals.

Used a remote-control for a garage door, TV, or other appliance? Many remote-controls are actually tiny radio transmitters. A small microprocessor encodes digital data onto the transmitted radio wave to represent the user's commands.

Taken a commercial flight? Aircraft use numerous types of communications to ensure flight safety. Both voice and digital (data) communications are used by aircraft. Many of the communications are computer-automated. The Global Positioning System (GPS) is used to help provide accurate navigation.

Used a credit card? If so, the verification was probably done electronically. A credit card reader contains a microprocessor and a *modem* (modulator-demodulator). Your individual information record is recorded in three parallel "tracks" which are read from the card's magnetic stripe by the microprocessor. The modem allows the microprocessor to transmit the data to a host computer operated by the credit card company, typically over a telephone line.

Electronic Systems

In your previous electronic studies, you have been primarily concerned with the *theory* of circuits. For example, you might have constructed an amplifier stage with a transistor or op-amp IC (Integrated Circuit). The amplifier you built was studied for its own sake; it didn't fit into anything "bigger." This book will be your first study of *systems*.

A <u>system</u> can be defined as a group of components that work together to complete a job or task.

Many technicians are a little frightened when first asked to learn a new system. Part of this might be a natural fear of the unknown. The technician might wonder if he or she is capable of learning the necessary technical details. The best way to learn a system is to break it down into functional blocks, or *subsystems*. Upon study of these parts, the technician soon recognizes familiar circuits and principles and gains an understanding of how the system actually works.

A <u>subsystem</u> is just part of a system; it helps to complete a task. A subsystem is often shown in a *block diagram.*

Section Checkpoint

1-1 Classify each of the following as a system or subsystem:

a) A radio transmitter
b) An automobile
c) An automatic transmission?
d) A radio transmitter and receiver?

1-2 What type of diagram is used to show how systems work?

1-3 How can a technician understand a very complicated system?

1-2 A Simple Radio System

A simple radio system could be constructed as shown in the block diagram of Figure 1-1 below. This system has some severe problems, but it will serve as a good starting point.

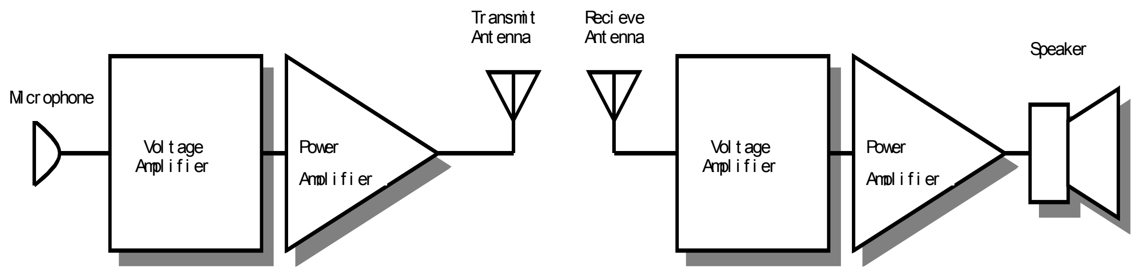

Figure 1-1 - A Simple Radio System

The radio system above begins with a *microphone*. A microphone is a type of *transducer*. It converts the pressure variations in a sound wave (such as from a speaker or musical performer) into electrical energy. A microphone has a thin plastic or paper cone connected to a coil of wire. This coil is placed within the field of a permanent magnet. When sound strikes the cone, it vibrates, moving the coil back and forth within the magnetic field. Thus, a voltage is generated in the coil that is a copy of the sound wave that entered the microphone.

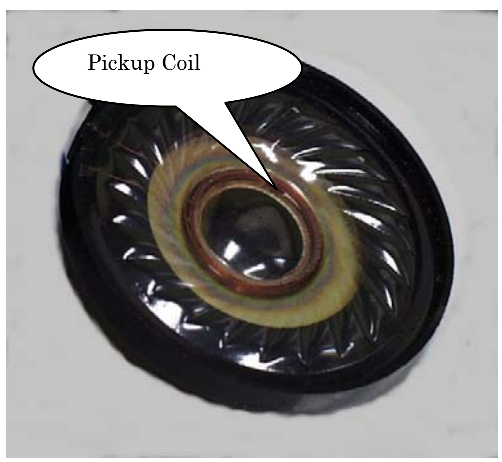

Figure 1-2: A Typical Dynamic Microphone Element

We call the electrical signal from the microphone the *intelligence* or *information* signal. The information signal is an electrical replica of the original sound wave, and has the same shape.

A transducer is any device that converts one form of energy into another.

The signal from the microphone is quite small. Most microphones produce about 10 mV (millivolts), at a power level of about 40 μW (microwatts). This isn't enough power to cross any significant distance in space, so both voltage and power (current) amplification must take place. The final power level reached at the output of the **power amplifier** depends on how far we need to communicate, and under what conditions. This power level can range from a few milliwatts (personal communications devices such as walkie-talkies) to thousands of watts (military and broadcast communications).

The transmitting *antenna* next converts the amplified information signal into a new form of energy that is capable of traveling through space. This new energy is called *electromagnetic energy*, or a *radio wave*. Electromagnetic energy consists of two fields, a voltage or electric field, and a magnetic field. It travels through space at the speed of light; in fact, visible light is itself electromagnetic energy with a very high frequency.

The energy from the radio wave moves outward from the transmitting antenna at the speed of light, which is about 3×10^8 meters/second. It spreads out over space much like an inflating balloon. By the time it reaches the receiver's antenna, it has very little energy. Imagine the thickness of a toy balloon when it is deflated; then imagine the new thickness if the balloon were inflated to a diameter of 10 miles! This is a very close to how the energy will be distributed in a radio wave. A radio receiver typically receives picowatts (1×10^{-12} Watt) or femtowatts (1×10^{-15} Watt) of energy from its antenna!

At the receiver, the antenna receives the weak signal. It will typically be just a few microvolts, which is too small for any practical use. Therefore, voltage and current amplification will be needed to bring the signal back up to a useful level. The receiver drives a *loudspeaker*, another transducer (Figure 1-3). The loudspeaker converts the electrical signal back into sound. It works by passing electrical current through a coil (the voice coil) suspended in a strong magnetic field. The electrical current causes the voice coil to become a magnet, and it is then attracted and repelled from the permanent magnet in step with the original information signal. A paper cone attached to the voice coil pushes on the air, which recreates the original sound.

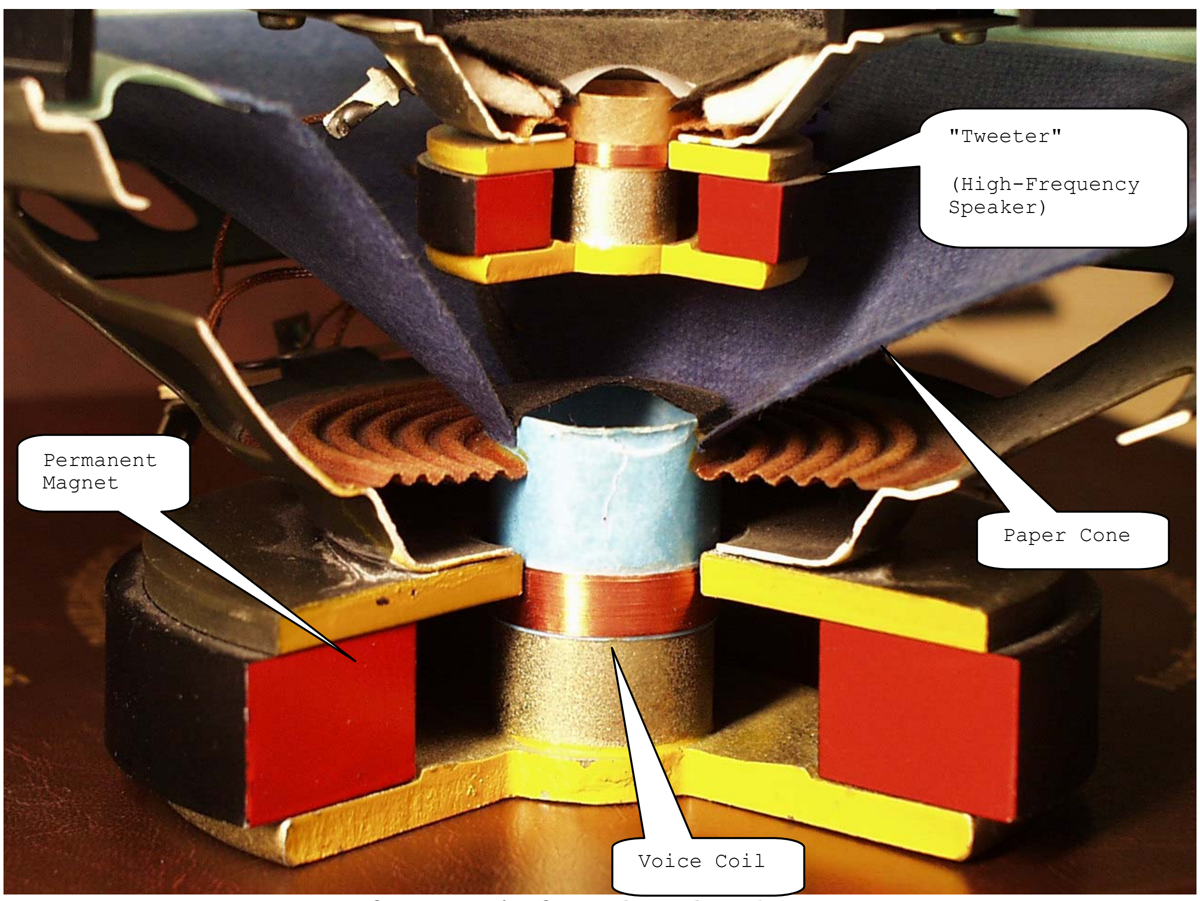

Figure 1-3: Cutaway of a Coaxial Loudspeaker