Introduction to How Cordless Telephones Work

Cordless telephones are one of those minor miracles of modern life -- with a cordless phone, you can talk on the phone while moving freely about your house or in your yard. Long before cell phones became so cheap that anyone could afford one, cordless phones gave everyone the freedom to walk and talk within the privacy of their own homes.

Cordless phones have many of the same features as standard telephones, and there are many models available. In this article, we will examine how these cordless telephones work and see why there are so many different types on the market today.

The Basics

A cordless telephone is basically a combination telephone and radio transmitter/receiver (see How Telephones Work and How Radio Works for details on these two technologies). A cordless phone has two major parts: base and handset.

- The **base** is attached to the phone jack through a standard phone wire connection, and as far as the phone system is concerned it looks just like a normal phone. The base receives the incoming call (as an electrical signal) through the phone line, converts it to an FM radio signal and then broadcasts that signal.
- The handset receives the radio signal from the base, converts it to an electrical signal and sends that signal to the speaker, where it is converted into the sound you hear. When you talk, the **handset** broadcasts your voice through a second FM radio signal back to the base. The base receives your voice signal, converts it to an electrical signal and sends that signal through the phone line to the other party.

The base and handset operate on a frequency pair that allows you to talk and listen at the same time, called duplex frequency.

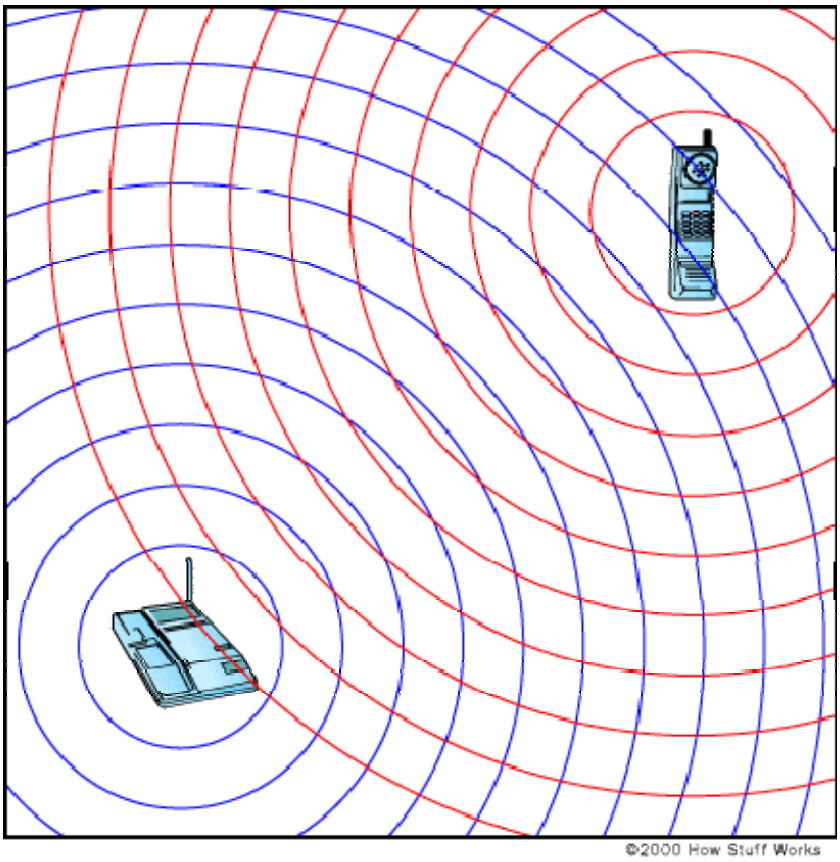


Diagram showing how the base unit and handset of the cordless phone talk to each other: Each color represents a different frequency.

A Brief History

Cordless phones first appeared around 1980. The earliest cordless phones operated at a frequency of 27 MHz. They had the following problems:

- limited range
- poor sound quality - noisy and ridden with static because walls and appliances interfered with the signals
- poor security - people could easily intercept signals from another cordless phone because of the limited number of channels

In 1986, the Federal Communications Commission (FCC) granted the frequency range of 47-49 MHz for cordless phones, which improved their interference problem and reduced the power needed to run them. However, the phones still had a limited range and poor sound quality.

Because the 43-50 MHz cordless phone frequency was becoming increasingly crowded, the FCC granted the frequency range of 900 MHz in

1990. This higher frequency allowed cordless phones to be clearer, broadcast a longer distance and choose from more channels. However, cordless phones were still quite expensive, about $400.

In 1994, digital cordless phones in the 900 MHz frequency range were introduced. Digital signals allowed the phones to be more secure and decreased eavesdropping -- it was pretty easy to eavesdrop on analog cordless phone conversations. In 1995, digital spread spectrum (DSS) was introduced for cordless phones. This technology enabled the digital information to spread in pieces over several frequencies between the receiver and the base, thereby making it almost impossible to eavesdrop on the cordless conversations.

In 1998, the FCC opened up the 2.4 GHz range for cordless phone use. This frequency has increased the distance over which a cordless phone can operate, and brought it out of the frequency range of most radio scanners, thereby further increasing security.

Anatomy of a Cordless Telephone

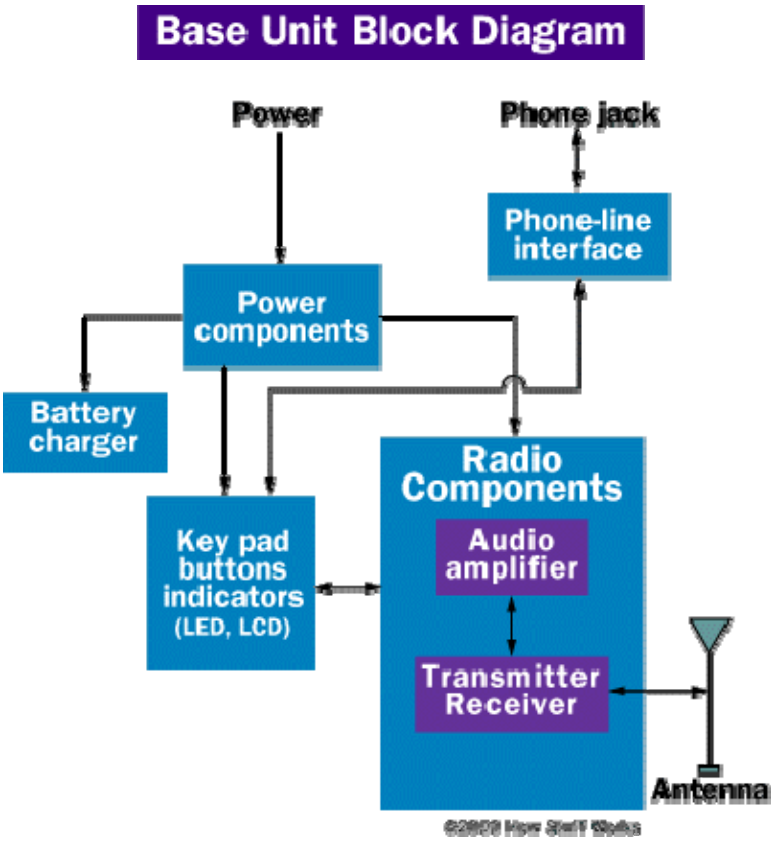
To illustrate the parts of a cordless telephone, we will show you the inside of this one from **General Electric (GE)**. It was made in 1993 and operated in the 43-50 MHz range.

GE cordless phone, including handset and base unit

As mentioned above, all cordless phones have a base and a handset. Let's look at these parts individually.

Base

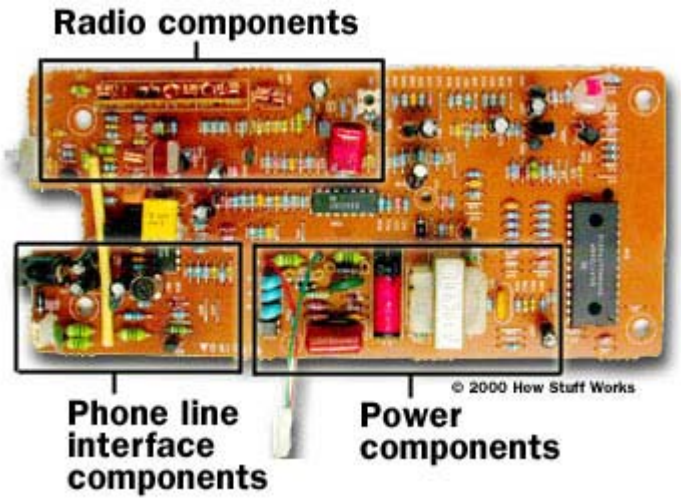
The base unit of the cordless phone is plugged into the telephone jack on your wall.



Base unit components

If you open up the base and expose the circuit board, you see several components that carry out the functions of the base:

- **phone line interface** - receives and sends telephone signals through the phone line
- **radio**
  - amplifies signals to and from phone-line interface, user controls and speaker phone (if present)
  - broadcasts and receives radio signals to and from the handset
- **power** - supplies low voltage power to the circuits and recharges the battery of the handset



Circuit board in the base of the GE cordless phone

Phone Line Interface

Phone line interface components do two things. First, they send the ringer signal to the bell (if it's on the base) or to the radio components for broadcast to the handset. This lets you know that you have an incoming call. Second, they receive and send small changes in the phone line's electrical current to and from the radio components of the base. When you talk, you cause small changes in the electrical current of the phone line, and these changes get sent to your caller. The same happens when the caller talks to you.

Radio Components

The radio components receive the electrical signals from the phone line interface and user controls (keypads, buttons). The radio components convert the signals to radio waves and broadcast them via the antenna. Radio components use quartz crystals to set the radio frequencies for sending and receiving. There are two quartz crystals, one for sending signals and one for receiving signals. Remember that the base and handset operate on a frequency pair that allows you to talk and listen at the same time (duplex). The radio components include an audio amplifier that increases the strength of the incoming electrical signals.

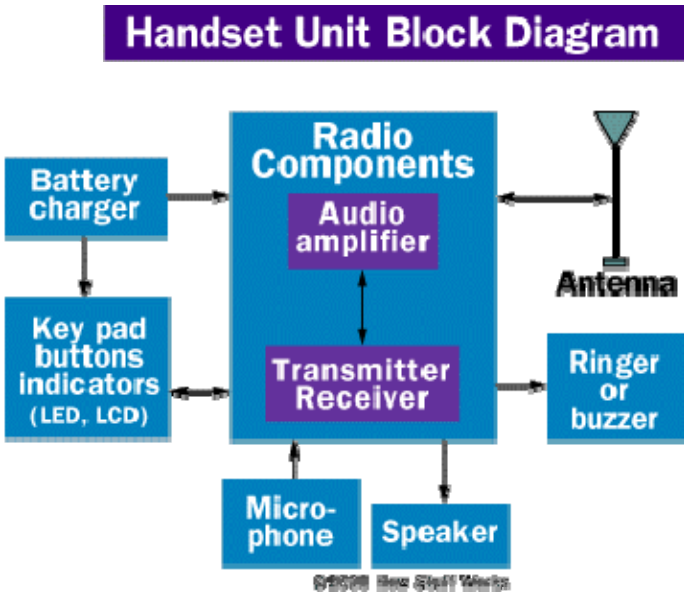
Power Components

A DC power cube transformer supplies the low voltage required by the electrical components on the circuit board. The power components on the circuit board work with the power cube to supply electrical current to re-charge the battery of the handset.

In addition to the above components, some bases also have audio amplifiers to drive speakers for speaker phone features, keypads for dialing, liquid crystal displays (LCDs) for caller ID, light-emitting diodes (LEDs) for power/charging indicators, and solid state memory for answering machine or call-back features.

Handset

You can carry the handset with you throughout the house or outside within the range of the base transmitter. The handset has all of the equipment of a standard telephone (speaker, microphone, dialing keypad), plus the equipment of an FM radio transmitter/receiver.

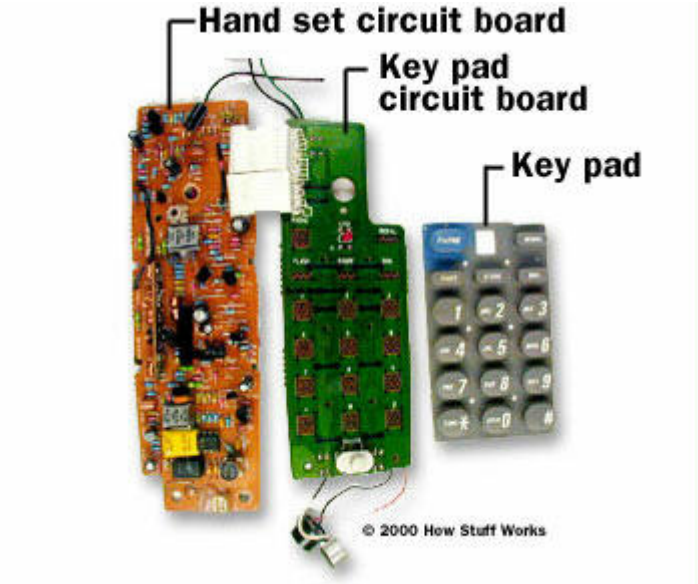


Block diagram of handset components

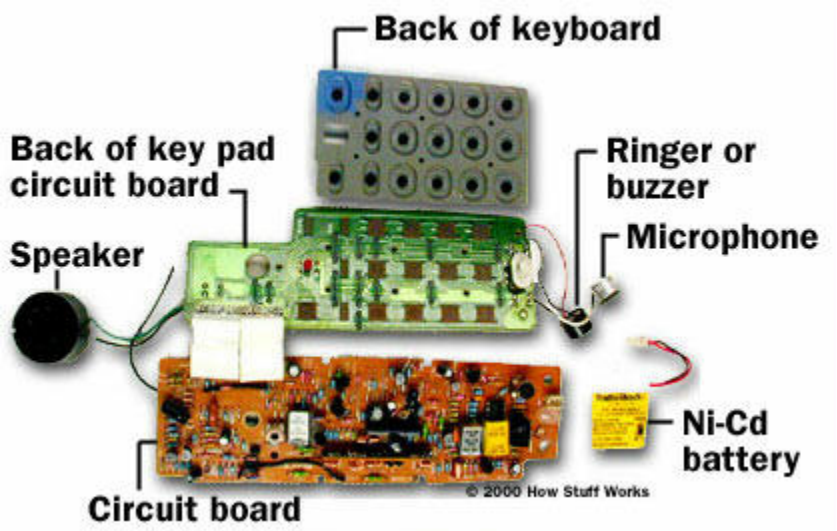
When you open up the handset, you see these components:

- **speaker** - converts electrical signals into the sound that you hear
- **microphone** - picks up your voice and changes it to electrical signals
- **keypad** - input for dialing
- **buzzer** or **ringer** - lets you know that you have an incoming call
- **radio components**
  - amplify electrical signals to and from microphone and speakers
  - send and receive FM radio frequencies
- **LCD or LED displays** - indicator lights

- **re-chargeable battery** - supplies electrical power to handset



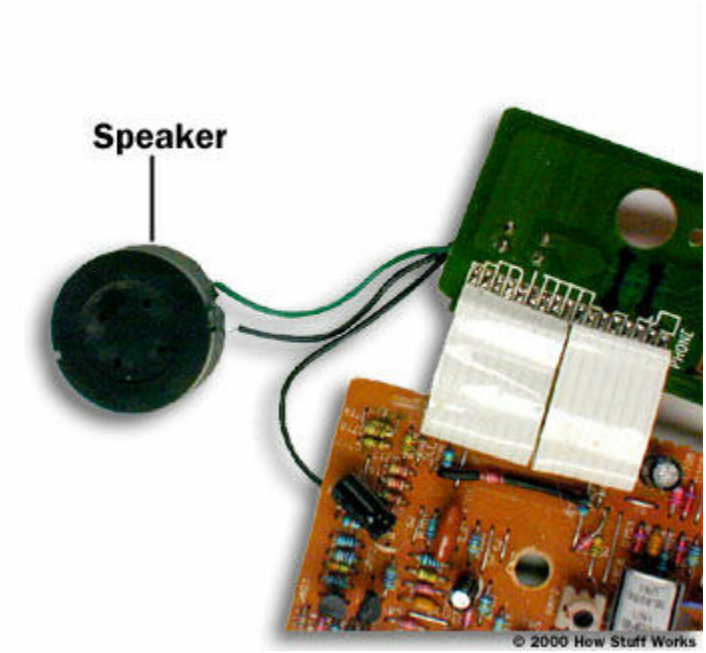
Parts of the GE cordless phone's handset, showing the fronts of the circuit boards



Parts of the GE cordless phone's handset, showing the backs of the circuit boards, the speaker, microphone, ringer and battery

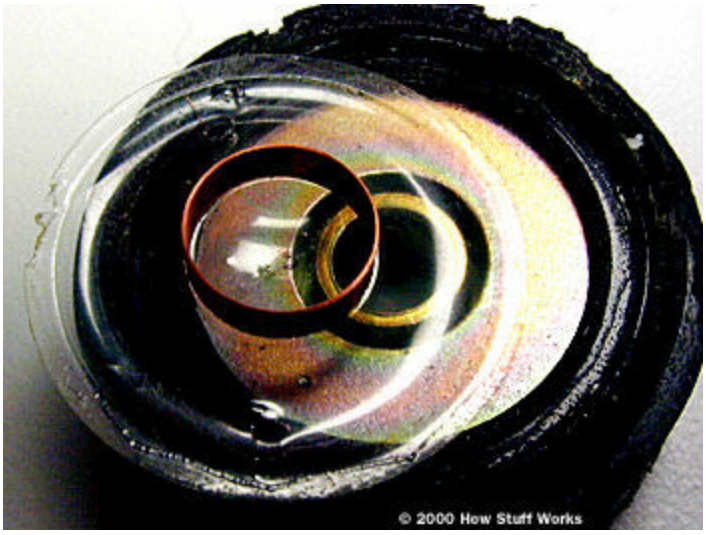
Speaker

The speaker receives the electrical signals from the audio amplifier in the radio components and converts them into sound. When you remove the cover from the speaker, you see a large round permanent magnet with a hole in the middle and a deep groove surrounding the hole. Within this deep groove is a coil of fine copper wire that is attached to a thin plastic membrane. The plastic membrane covers the magnet and coil.



Close-up view of the speaker in the GE cordless telephone handset

Close-up of the speaker with the top removed



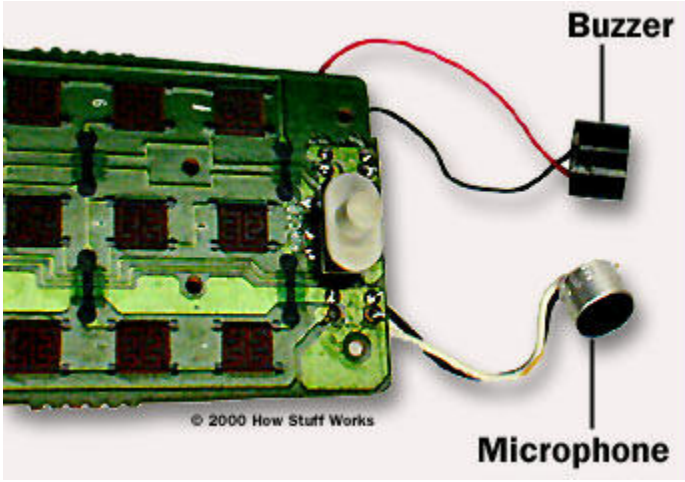
Close-up of the speaker with the plastic membrane and attached coil lifted out. The large metal disc is the magnet.

Close-up of the speaker's plastic membrane with attached wire coil

To hear sounds, the following events happen:

1. Electrical signals come from the radio components.
2. The electrical signals travel in the coil of copper wire.
3. The electrical signals induce magnetic currents in the coil of wire, thereby making it an electromagnet.
4. The electromagnetic coil moves in and out of the groove within the permanent magnet.
5. The coil moves the attached plastic membrane in and out at the same frequencies as the changes in electric currents.
6. The movements of the membrane move air at the same frequencies, thereby creating sound waves that you can hear.

Microphone
The microphone changes the sound waves from your voice into electrical signals that are sent to the audio amplifier of the radio components. A microphone is essentially a speaker that works in reverse. When sound waves from your voice move the membrane, they make tiny electric currents either by moving a coil of wire within a magnet or by compressing the membrane against carbon dust



Close-up of handset's keypad circuit board with attached microphone and buzzer

Keypad
The keypad allows you to dial a number. It transfers the pressure from your fingertip on the appropriate key into an electrical signal that it sends to the radio components. Below the rubber keypad is a circuit board with black conductive material under each button (shown above). The keypad works like a remote control. When you press a button, it makes a contact with the black material and changes its electrical conductance. The conductance sends an electrical signal to the radio components indicating that you have selected that number.

Buzzer or Ringer
When the radio components of the handset receive the ringer signal from the base, they send electrical signals to the buzzer. The buzzer changes those electrical signals into sound much like the speaker does. You hear the buzzer sound and know that someone is calling you. In some phones, the speaker is used to make the ringer sound and there is no need for a separate ringer.

Radio Components

Duplex Example

The radio components of the handset are like those of the base -- they convert electrical signals from the microphone into FM radio signals and broadcast them at the same frequency as the receiving crystal of the base unit. The radio components also receive radio signals at the same frequency as the broadcasting crystal from the base, convert them to electrical signals and send them to the speaker and/or buzzer (ringer).

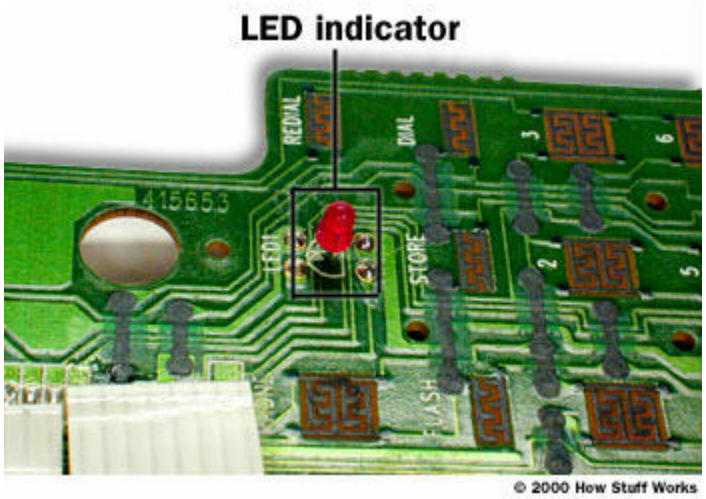
Base:
- **44.32 MHz** transmitter
- **49.28 MHz** receiver

Handset:
- **49.28 MHz** transmitter
- **44.32 MHz** receiver

Remember that the base and handset operate on a duplex frequency pair that allows you to talk and listen at the same time.

LCD or LED Displays

Most handsets have one or more light-emitting diodes (LED) that indicate various things, such as when the phone has an open line or when the battery is low.



LED indicator light on the handset of the GE cordless phone

Some handsets have an LCD that can display numbers for caller ID features, similar to a cell phone. The LCD may be reflective or backlit so that you can see it when the room light is low.

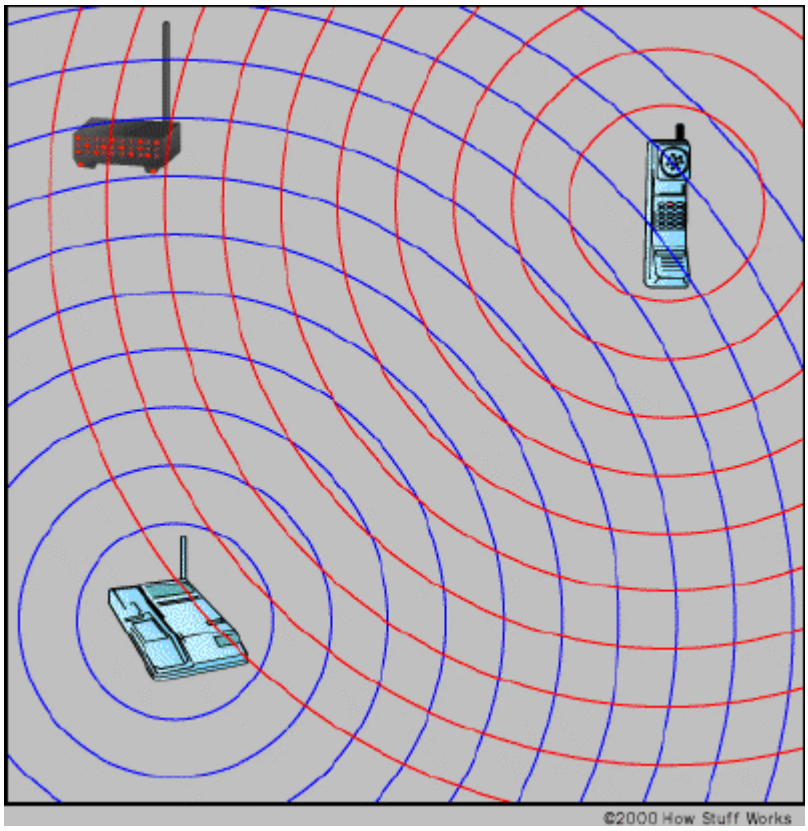
Battery

The handset's battery supplies the power for all of the electrical components in the handset. All cordless phone handsets have a rechargeable battery (nickel-cadmium, nickel-metal hydride or lithium). When the battery runs low, an indicator light on the handset usually lights up or flashes. In some

phones, a "beeping" sound may also indicate a low battery. You then recharge the battery on the base of the cordless phone.

The GE cordless phone that we dissected was from 1993. Modern cordless phones have the same functions and much of the same hardware. However, many of the electronic circuits that were once achieved with transistors, resistors and capacitors have been replaced with integrated circuits. This advancement allows the handset to be either smaller with the same functions or the same size with more functions.

In summary, a cordless phone is basically a combination of a telephone and an FM radio transmitter/receiver. Because it is a radio transmitter, it broadcasts signals over the open airways rather than specifically between the base and handset.



Many cordless phone conversations can be easily picked up by radio scanners.

Because of this open broadcast, It is possible for other people to listen to your phone conversation by using a radio scanner. So an important issue and feature to look for in a cordless phone is security -- DSS offers the best protection against eavesdropping.

Features

Cordless phones have many of the same features as standard telephones, and there are many models, offering lots of different features.

Major Features

Remember that a cordless telephone is a combination of a **telephone** and a **radio transmitter/receiver**. Because it is a radio transmitter/receiver, you have the following issues that you do not have on a standard cord phone:

- range
- sound quality
- security

The **range** is the distance that the handset can be from the base. The **sound quality** can be affected by the distance, the way the information in the radio signal is transmitted, and interfering structures such as walls and appliances. Security is an issue because the radio signals from both handset and receiver go over the open airways, where they can be picked up by other devices (other cordless phones, baby monitors, radio scanners).

The above issues relate to the following features of your cordless phone:

- radio frequency
- analog vs. digital technology
- number of channels

Frequency

Because your cordless phone is a radio transmitter/receiver, it operates on various radio frequencies, which are set by the Federal Communications Commission (FCC) as with any other radio. Cordless phones operate over three major frequency bands (base and receiver use two closely related but separate frequencies within the band so that you can talk and listen at the same time):

- 43-50 MHz
- 900 MHz
- 2.4 GHz
- 5.8 GHz

The **43-50 MHz band** was common to early cordless telephones and is still available in low-cost models. Because of the low frequency, these phones have short ranges (about 1,000 ft / 330 m) and poorer sound quality (due to

interference from structures and appliances). The 43-50 MHz phone signals can also be picked up easily on radio scanners and nearby baby monitors.

The **900 MHz** band (actually 900-928 MHz) is the most common frequency for cordless phones today. The higher frequency gives it a greater range (5,000 to 7,000 ft / 1,500 to 2,100 m) and better sound quality. However, 900 MHz signals can be picked up easily by most commercially available radio scanners.

In 1998, the FCC opened up the **2.4 GHz** range for cordless phone use. A 2.4 GHz or **5.8 GHz** cordless phone can operate over a greater distance and is above the frequencies that can be picked up by most commercially available radio scanners; therefore, it is more secure than lower frequency models.

Analog vs. Digital

Analog technology is common in cordless telephones, especially in inexpensive models. Analog signals tend to be more noisy, or prone to interference with respect to sound quality. In addition, analog signals are easily picked up and interpreted by radio scanners.

In contrast, digital technology, like that found in a CD, allows the phone signals to sound clearer. Furthermore, digital signals are more secure. In 1995, digital spread spectrum (DSS) was introduced for cordless phones. DSS spread the digital information in pieces over several frequencies between the receiver and the base, thereby making it almost impossible to eavesdrop on cordless phone conversations.

Channels

Each frequency band (43-50 MHz, 900 MHz, 2.4 GHz or 5.8 GHz) can be subdivided into different increments or channels. For example, on some models, when you're talking on your 900 MHz phone, the base searches for a pair of frequencies (channels) within that range, that is not already in use, in order to talk to the handset. So, if the base is capable of searching more increments, it can more easily find a frequency pair that is clear from interference, providing better sound quality. The number of cordless phone channels can vary as follows:

- **10 to 25 channels** - 43-50 MHz phones, some inexpensive 900 MHz phones
- **20 to 60 channels** - most 900 MHz phones
- **50 to 100 channels** - high-end 900 MHz and 2.4/5.8 GHz phones