Operating Modes

Amateur radio communications is all about exchanging information. There are many different modes of sending and receiving this information. Today's lesson will be broken down into three major categories: Voice, Digital, and Image Modes.

Voice Modes: The first section we will look at is Voice Modes. The process of impressing an audio signal, like a human voice, onto an RF carrier signal is called *modulation*.
There are two basic ways of modulating an RF carrier signal: You can use the audio signal to vary the *frequency* of the carrier signal or you can use the audio signal to vary the *amplitude* of the carrier signal.

FM: The mode that uses the audio signal to vary the frequency of the carrier signal is called FM – which stands for Frequency Modulation. This is the mode that most of you are probably already familiar with and it's also the mode I am using to speak to you now.
In this mode, the *amplitude* of the carrier signal is held constant and the audio signal is used to vary the *frequency* of the carrier signal. The amount that the carrier frequency shifts at the highest audio peak is called the *deviation*. Currently the technical standard is to limit deviation to 5 kHz. This is known as Wide Band. There is also some Narrow Band coming into use. Sometimes you will hear a signal on the local repeater that sounds rough and scratchy. This is caused by over deviation. The way to solve that problem is to back away from the microphone a little or talk a little softer.

AM: The mode that uses the audio signal to vary the amplitude of the carrier signal is called AM – which stands for Amplitude Modulation. In this mode, the *frequency* of the carrier signal is held constant and the audio signal is used to vary the *amplitude* of the carrier signal. This is the mode that is used on all commercial AM radio broadcasts in the 500 kHz to 1.6 MHz range that you all are familiar with. This mode was once widely used on all frequency bands, but has lately fallen out of favor, due to the higher signal bandwidth that this type of modulation produces.

SSB Given the crowded conditions on the voice bands in the HF spectrum, a new method of producing a narrower bandwidth signal needed to be developed. This gave rise to the *single sideband* mode. Here is how it works:
When the amplitude of an RF signal is modulated by an audio signal, there are signals produced along with the carrier called *sidebands*.. A band of signals is produced equal to the carrier frequency plus the audio frequencies. This is known as the *upper sideband*..
At the same time, another band of signals is also produced equal to the carrier frequency minus the audio frequencies. This is known as the *lower sideband*.. So if we were to assume that the range of audio frequencies passed in a standard transmitter was from 300 Hz to 3 kHz, this would result in the bandwidth of each transmitted signal to be 6 kHz wide. But since the voice information is identical in both sidebands, only one sideband needs to be transmitted. One of the sidebands is removed by using a very narrow filter. Currently, the popular convention is to use the lower sideband on the 160, 80, and 40 meter bands, and to use the upper sideband on the 20 meter and above bands. Don't ask me why, that's just the way it is. Since all the information is contained in the sidebands, the carrier just goes along for the ride, so it can also be eliminated to further reduce the bandwidth of the transmitted signal. This is accomplished by using a balanced modulator, which only produces a carrier signal when an audio signal is present. The bandwidth of a standard single sideband signal is now only 3kHz wide.

Digital Modes: The next section we will look at is Digital Modes. Any mode of transmitting information to another station without using a microphone is considered a digital mode, whether by machine, computer, or even by hand.

CW: The first and oldest method of digital communication is CW. CW stands for *continuous wave*. At this point, you might be asking yourself why they call it continuous wave when it is a series of dots and dashes. Continuous refers to the fact that the carrier is generated continuously and does not have it's frequency or

amplitude changed like in other modes. CW can be generated by hand using a straight key or an electronic keyer.
The advantage of an electronic keyer is that the width of each dot or dash is held constant, thus making it easier to receive on the other end. With the advent of computers, there have been programs written to send and receive code. However, in my experience, they seem to work best when trying to decode other machine generated code. They seem to have a problem with human-sent code, due to the variations in timing of the code elements. CW is still the most reliable mode of communication. A skilled CW operator can still copy the message when band conditions are too noisy to allow a voice transmission to heard reliably. Even though the code requirement for getting your license has been lifted, I would still encourage all of you to give CW a try. All it takes is a little practice and it's a lot of fun!

RTTY: The next digital mode that we will look at is *radio teletype* or RTTY.
Originally, radio teletype machines were entirely mechanical in nature, consisting of motors, gears, cams, and levers to encode and decode the letters as they were typed on the keyboards. The code used in radio teletype is called the 5 level Baudot code. The Baudot code has each letter or number consisting of 5 elements in various unique combinations of highs and lows, or 1's and 0's called SPACE or MARK. Unlike the code used for CW, which has various combinations of 1 to 5 elements, either dots or dashes, each element in the Baudot code is the same width and is always 5 elements long.
In order to transmit the teletype code, the transmitter uses a mode called *frequency shift keying* or FSK. In this mode, the amplitude of the carrier signal is held constant and the frequency of the carrier signal is shifted a predetermined amount, normally 170 Hz.
The nominal transmitter frequency is the MARK condition. The SPACE condition causes the transmitter to shift the carrier frequency downward. Computers have eliminated the need for bulky mechanical devices. There are many good programs available for RTTY operation which require no hardware other than a sound card and suitable computer to radio interface.

AMTOR: There are some serious problems associated with RTTY. The worst of these is that the receiving station has no way of telling the transmitting station that is not receiving the signal properly, due to noise or fading. Parts of the transmission can be lost and never recovered. So a modified version of RTTY was created called AMTOR. This stands for *Amateur Teleprinting Over Radio*. AMTOR eliminates some of the problems of traditional RTTY by using a concept called time diversity. This simply means that the receiving station is given more than one opportunity to see a given transmission.
AMTOR has two different modes: Mode A (ARQ which stands for Automatic Repeat Request) and Mode B (FEC which stands for Forward Error Correcting).
In Mode A ARQ, the sending stations sends a group of three characters and then waits to hear a response from the receiving station before continuing with the next three characters of the message. In Mode B FEC, the sending station simply sends each character twice, with a small space between them to allow for noise bursts, which would interfere with the signal. By the way, this is a greatly oversimplified explanation of how this mode works. Any further information is beyond the scope of this course. If interested in pursuing this further, there is much information available in print and on the Internet.

Packet: The next step in the evolution of digital communications is Packet Radio. Packet is the first mode that allows two stations to be linked together by their callsigns. These two stations are said to be *connected*. All other stations are ignored. Since packet radios listen before they transmit, several stations connected in pairs can use the frequency at the same time without interfering with each other. Packet is also 100% error free because it uses automatic error correction. These days, most packet communication is done through a network of stations called *nodes*. Most of these stations have a bulletin board associated with them where messages to specific stations can be left for retrieval at a later time. In fact, the National Traffic System uses the bulletin board at a station in Shelton to route all NTS traffic into and out of the state of Connecticut. The main piece of hardware needed to operate packet is called a TNC, which stands for *terminal node controller*. This device performs all the complex functions associated with this mode, which are beyond the scope of this course. A dumb terminal or computer running a terminal program are also required to run packet. There are again several computer programs available to simulate the functions of a hardware TNC.
An interesting application of packet technology is called APRS, which stands for *Automatic Position Reporting System*. In this application, a radio and TNC with a GPS receiver attached can transmit its

position via unconnected packets. A central receiving station with the required software can monitor the positions of multiple transmitters in real time as they move from one location to another. This application has many uses in public service communications such as parades and races or any type of event where the real time position of multiple objects needs to be viewed. In fact, the ICRC uses this technology to assist the Boy Scouts with their annual Klondike Derby every winter. A small, self-contained unit consisting of a GPS receiver, packet encoder, HT and battery pack are placed in each sled, thereby allowing the central receiving station to keep a fix on the position of each scout troop as they navigate through the Klondike Derby course. This has helped us locate troops who have gotten lost or gone off course during the event.

PSK31: With the advent of computers, several new digital modes have been created that require only a sound card to operate. One of the more interesting ones is called PSK31, the PSK part stands for *Phase Shift Keying* and the 31 part is the bit rate. For this mode, the inventor that created it devised a new code that combined the best of Baudot and Morse codes. He called it the *Varicode*, because a varying number of bits are used for each character. He then assigned the shorter codes to the letters that most often in standard English text, thereby sending the least number of bits possible during a given transmission. This mode is used on the HF bands, mostly on 20 meters around 14.070 MHz. It's a little tricky to tune in, but I have been able to get a solid digital copy on a signal that was so far down in the noise that I was not able to hear it!

MT-63: Another interesting new digital mode is called MT-63. I'm not sure what it stands for. MT-63 is similar to RTTY and PSK-31, but the data components are spread over 64 different tones. This allows a tremendous amount of redundancy, assuring good reception even when as much as 25% of the data has been obliterated by noise, fading, or interference. However, MT-63 has a much wider bandwidth of 1 kHz, compared to PSK-31, which is only 31 Hz wide.

Image Modes: The last section we will look at is Image Modes. There are two basic image communication systems in use by the amateur community. Fast-scan television (FSTV) and Slow-scan television (SSTV).

FSTV: Fast-scan television, also referred to as amateur television or ATV, uses standard TV equipment compatible with commercial analog systems. However, due to the extremely wide bandwidth of 6 MHz, this mode of operation is restricted to the frequency bands of 420 MHz and above.

SSTV: Slow-scan television was invented to allow television pictures to be transmitted on the HF bands. In order to meet, the bandwidth requirement of 3 kHz, the frame rate had to be drastically reduced. Instead of sending 30 pictures in one second as in fast-scan TV, slow-scan TV sends one picture every 8 seconds. It's more like watching a slide show than a TV picture, but given the bandwidth limitations, it works pretty well. There are several sound card software programs available to enjoy this mode.

This brings us to the end of our discussion of Operating Modes. I hope this will encourage you to go out and try some different operating modes, especially some of the new digital ones. As I have previously stated, there are plenty of software packages available for the sound card in your computer at low cost or even for free.
There is much more information available on these topics than can be covered in this short lesson. Good sources of information are from various books published by the ARRL, including the ever-popular Handbook for the Radio Amateur. There is also a wealth of information available on the Internet.