Digital Modes

Introduction: We will look at some of the more popular Digital Modes of operation. 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.

Equipment: First, we will look at what kind of equipment is needed to operate these modes. With the exception of Packet, most digital mode activity occurs on the HF bands. This should be an incentive for those of you out there who have Technician class licenses to upgrade to General to be able to enjoy these modes of operation.

There are three pieces of equipment needed for digital mode operation. The first is a radio. Any transceiver capable of Single Sideband operation should work, even older tube models. The only concern with using an older transceiver is its switching speed, the time it takes to switch from receiver to transmit and back again. Some of the digital modes, especially PACTOR, require an extremely fast switching time. Any transceiver manufactured after the 1990's should work fine.

Another concern, especially for the newer solid-state radios is the duty cycle. The duty cycle is the ratio of transmit time to receive time. The average SSB signal has a duty cycle of only 40%. A CW signal has a duty cycle of 30% or less, depending on how slow you send. Some of the digital modes, such as RTTY, have a duty cycle of 100%. Solid state transceivers were not designed to run 100 watts at 100% duty cycle they will overheat and burn out. It is recommended to turn down your power output to 50 watts or less. Digital modes are so efficient that high output power is not necessary for reliable communications.

The second piece of equipment needed is a computer. There is good software written for both Windows and Mac operating systems, with Windows having a larger selection to choose from.

The third piece of equipment needed is some type of interface to connect the computer to the radio. There are two ways to go with this: hardware or software.

The hardware option is to buy a hard-wired device that supports the modes you want to operate. There are devices available called multimode controllers that support multiple modes of operation. The advantage of the hardware option is that the input and output levels are easier to set properly, which in some cases could be critical. The disadvantage is that if you want to try a new mode not supported by your device, you have to buy or build another hard-wired device to try it.

The software option uses the sound card built into the computer along with software for each desired operating mode. This option requires much simpler hardware circuitry to connect the computer's sound card inputs and outputs to the radio's inputs and outputs.

While a different program is needed for each operating mode, there are some programs that support several different modes. A single purpose program designed specifically for a given mode would work better, but there is a lot to be said for the convenience of having all your modes in one program, even though they might not function quite as well as a stand-alone program for each one. The advantage of the software option is that as new operating modes are developed, you only need to download software to use it no additional hardware is required. The disadvantage is that the software uses the Windows Mixer panel to control the input and output levels, which can be tricky to set properly.

Digital Modes: Now we will look at several of the more popular digital operating modes.

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 its 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 be 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 its a lot of fun!

CW is the only digital mode that can be copied by ear and sent by hand. All other digital modes require a computer and radio interface.

There are three basic groups of digital modes, according to how the signal is generated. They are: FSK, which stands for Frequency Shift Keying, MFSK, which stands for Multi-Frequency Shift Keying, and PSK, which stands for Phase Shift Keying.

In FSK, the amplitude of the carrier signal is kept constant and the information is sent by shifting the carrier frequency between two distinct frequencies. Examples of this mode are: RTTY, AMTOR, PACTOR, PACKET, and CLOVER.

In MFSK, the amplitude of the carrier signal is kept constant and the information is sent by sending multiple tones. MFSK has been tested using up to 64 different tones, but most commonly uses 16 tones. Examples of this mode are: MFSK16, Olivia, JT65, and FSK441.

In PSK, the amplitude of the carrier signal is kept constant and the information is sent by creating an audio signal that shifts its phase angle 180 degrees in sync with the data stream. Examples of this mode are: PSK31, PSK63, and MT63.

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 1â€™s and 0â€™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 Tele-printing 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 call signs. 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 computers running a terminal program are also required to run packet. There are again several computer programs available to simulate the functions of 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! This is by far the most popular of the digital modes.

MT-63: Another interesting new digital mode is called 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.

JT65: JT65 was created by Dr. Joe Taylor, hence the in the name. It was created primarily for weak signal and moon bounce use and does not lend itself to casual conversation like other modes. This is because it uses one minute transmit receive sequences, meaning that you transmit within a one minute window and then listen for one minute.

MFSK: MFSK is a type of super RTTY. Instead of using two tones as RTTY does, MFSK16 uses 16 different tones. The benefit of this mode is that it can provide reliable communications over great distances. High power is not necessary.

Olivia: Olivia was developed by SP9VRC and was named after his daughter, Olivia. It is one of the best modes to use in poor conditions. It can be decoded even when the signal is 10 to 14 dB below the noise floor. Olivia has many formats some of which are considered standard, and they all have different characteristics. It is possible to have 40 different formats that have different characteristics, speeds, and capabilities.

PACTOR: PACTOR is a mode that is different than any other mode we have talked about so far. It is the only mode that cannot be done with sound card software. It requires hardware controller and companion software. However, it essentially guarantees error-free communications. It accomplishes this by sending out the data in small chunks and waiting for a reply from the receiving station as to whether the data was received correctly. If not, the transmitting station re-sends the data until it is successfully acknowledged by the receiving station. This is also known as burst mode.

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 Get on the Air with HF Digital, written by Steve Ford, WB8IMY, from which some of the information in this presentation was taken.

Once you have your digital station up and running, a good method to check out its operation is by monitoring the daily bulletin transmissions from W1AW in Newington. They broadcast several times a day in several different digital modes, along with voice and CW. The schedule is available in QST magazine or on the league website. Are there any questions about anything I have covered tonight?